United States Environmental Protection Agency

User's Guide for the AERMOD Meteorological Preprocessor (AERMET)

EPA-454/B-16-010
December 2016

User's Guide for the AERMOD Meteorological Processor (AERMET)

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Office of Air Quality Planning and Standards
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Research Triangle Park, North Carolina 27711

ED_001739_00002136-00004

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Preface

AERMET provides a general purpose meteorological preprocessor for organizing available meteorological data into a format suitable for use by the AERMOD air quality dispersion model. This user's guide provides instructions for setting up and running the AERMET preprocessor. Hourly surface observations from the National Weather Service (NWS), Federal Aviation Administration (FAA) or other sources, NWS twice-daily upper air soundings and data from a site-specific meteorological measurement program can be processed in AERMET. There are three stages to processing the data. The first stage extracts meteorological data from archive data files and processes the data through various quality assessment checks. The second stage merges all data available for 24-hour periods (NWS and site-specific data) and stores these data together in a single file. The third stage reads the merged meteorological data and estimates the necessary boundary layer parameters for use by AERMOD. Two files are written for AERMOD: a file of hourly boundary layer parameter estimates and a file of multiple-level observations of wind speed and direction, temperature, and standard deviation of the fluctuating components of the wind. AERMET was designed to allow for future enhancements to process other types of data and to compute boundary layer parameters with different algorithms.

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Acknowledgments

The AERMET User's Guide has been prepared by James O. Paumier and Roger W. Brode of MACTEC, Research Triangle Park, North Carolina. This effort was funded by the U.S. Environmental Protection Agency under Contract No. 68D70069, with Warren D. Peters as Work Assignment Manager.

The Agency wishes to acknowledge AERMIC (the **A**merican Meteorological Society/**E**nvironmental Protection Agency **R**egulatory **M**odel **I**mprovement **C**ommittee), members of which have given a considerable amount of time, energy and dedication over the last 10 years to develop the AERMOD air dispersion modeling system:

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1.0 Introduction

The U. S. Environmental Protection Agency (EPA), in conjunction with the American Meteorological Society (AMS), has developed a new air quality dispersion model, the AMS/EPA Regulatory Model (AERMOD). This model requires a preprocessor that organizes and processes meteorological data and estimates the necessary boundary layer parameters for dispersion calculations in AERMOD. The meteorological preprocessor that serves this purpose is AERMET.

1.1 Overview of AERMET

AERMET is designed to be run as a three-stage process as illustrated in Figure 1-1. AERMET operates on three types of data -- hourly surface observations typically, but not exclusively, collected at airports by the National Weather Service (NWS) and/or the Federal Aviation Administration (FAA), NWS twice-daily upper air soundings, and data collected from an on-site or site-specific measurement program such as from an instrumented tower. The first stage of AERMET extracts (retrieves) data and assesses data quality. The second stage combines (merges) the available surface, upper air, and site-specific data for 24-hour periods and writes these data to an intermediate file. The third and final stage reads the merged data file, develops the necessary boundary layer parameters for dispersion calculations by AERMOD, and outputs AERMOD-ready meteorological data files.

Note in Figure 1-1 that the extraction phase of the raw site-specific data is not included in Stage 1, though the data are QA'd. Unlike raw surface and upper air data, site-specific data are not stored (archived) in any particular format. Therefore, the data are not "extracted" from an archive file and only need to be QA'd. This is explained in more detail in Section 4.5. Another important point to make is the input of 1-minute ASOS data into Stage 2, referred to as '1-min ASOS' in Figure 1-1. 1-minute ASOS data are surface wind data collected by the NWS or FAA collected by Automated Surface Observing Systems (ASOS), stored as 1-minute averages, and archived separately from the hourly NWS/FAA surface data. These higher resolution wind data can be processed with the AERMINUTE program (EPA, 2010) to produce

1-hour averages that are more representative than the surface wind data in the standard hourly archive formats (see Section 4.3). For more recent years, the hourly wind data in the standard archive formats can be replaced with the hourly values derived from the 1-minute ASOS data when those data are available. Similar to the site-specific data, 1-minute ASOS data do not need to be extracted. The extraction and QA of the 1-minute ASOS data is performed by the AERMINUTE program (EPA, 2010). Refer to Section 4.6.2 for a detailed discussion on the use of 1-minute ASOS wind data. From here on in this user's guide, note that all surface data collected by the NWS and/or the FAA, including the 1-minute ASOS data is often generally referenced as NWS data.

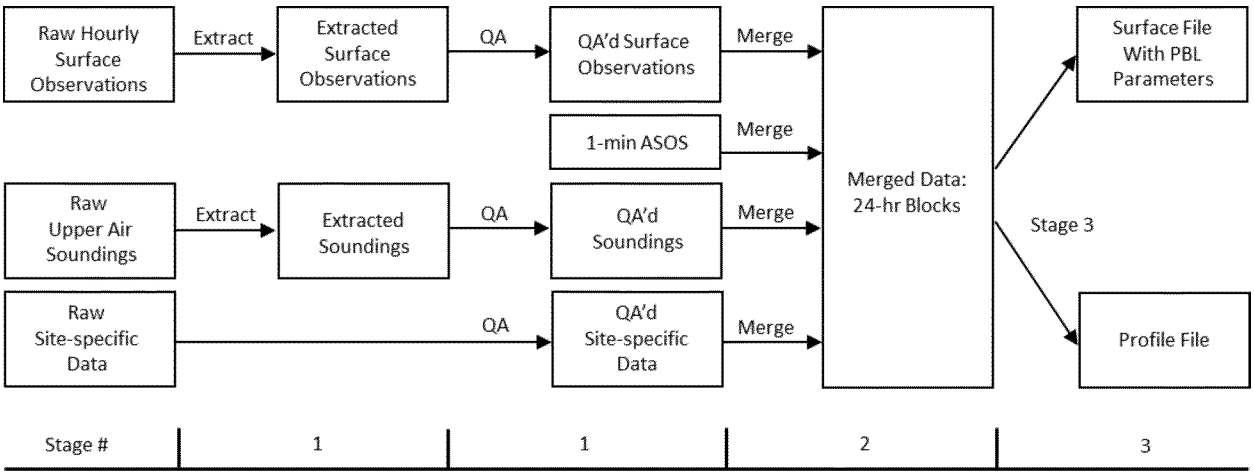

Figure 1-1. AERMET Processing

AERMET defines the ONSITE pathway (Section 4.5) for inputting hourly surface observations taken from an on-site, or site-specific meteorological tower. The *Guideline on Air Quality Models* (Appendix W to 40 CFR Part 51) was modified in April 2003 to use the term 'site-specific' in place of 'on-site,' recognizing that collection of surface meteorological data on the property of a facility does not guarantee that such data are representative for purposes of dispersion modeling, while data collected 'off-site' are not automatically precluded from being considered representative. As a result, the terms 'on-site' and 'site-specific' are used interchangeably.

The AERMET program was revised, beginning with version 06341, to use a single

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executable file, AERMET.EXE, to perform all three stages of processing, replacing the STAGE1N2.EXE and STAGE3.EXE executable files used in earlier versions of AERMET. The AERMET program is designed to read a hardcoded plain text file (a.k.a., the command input file or control file) named 'AERMET.INP' which contains the processing instructions such as user-specified options and the names and locations of the input and output data files. Note that all AERMET output filenames are user-specified with the exception of AERMOD.OUT, which is created automatically by AERMET during each of the three stages of processing. As currently configured, AERMET can only handle one processing stage at a time. There must be a separate 'AERMET.INP' file for each of the three stages, and the program is run by entering 'AERMET' at a 'DOS' command prompt, or by double-clicking the AERMET.EXE file from a folder view. Therefore, in a typical application the command line would be entered three times, once for stage 1 processing (extraction and quality assurance (QA) of the surface, upper air, and onsite data combined in a single run), a second time for stage 2 processing (merge), and a third time for stage 3 processing (met preparation). Since stage 1 processing is designed to support QA of raw input data, stage 1 may involve some iteration if data problems are encountered. Prior to running AERMET, one should review the instructions in the command input file and, as necessary, replace them with instructions appropriate to the particular application and stage of processing. Because each stage requires a separate control file named 'AERMET.INP, ' to avoid name conflicts when the files are stored in the same directory, they should each be given a unique filename originally, and then each file should be copied to a new file named 'AERMET.INP' prior to running each stage. A DOS 'batch' file (.bat) is often used to successively run each of the three stages by copying the appropriate control file to a file named 'AERMET.INP', then run AERMET. The following is an example of a DOS batch file that can facilitate running all three stages of AERMET successively:

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```
@        ECHO OFF

rem           RUNAERMET   filename

rem      This is a DOS utility program for use in running the meteorological
rem      preprocessor, AERMET.  The program is run from the DOS prompt using
rem      the following syntax:

rem      where:   RUNAERMET is entered 'as is' and
rem                   filename is the name of the input file

       :START
            IF '%1' == ''  GOTO END
            IF EXIST %1  GOTO COPY
            ECHO Error locating input file
            GOTO STOP

          :COPY
               COPY %1  AERMET.INP
               ECHO Proceed with processing
               PAUSE
               AERMET
               GOTO STOP
         :END

       ECHO ..
       ECHO ..
       ECHO     AERMET is run from the DOS prompt using the following syntax
       ECHO ..
       ECHO          RUNAERMET   filename
       ECHO ..
       ECHO     where:   RUNAERMET is entered 'as is'
       ECHO                  filename is the name of the input file
       ECHO ..
       ECHO ..
                      PAUSE

               :STOP
```

Note that some of the QA defaults presented in this guide have been revised from previous versions of AERMET due to changes in the AERMET code, including upper and lower bounds and missing indicators. These revisions are reflected in Appendix B. Additional

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details regarding revisions to the AERMET code are presented in the AERMET Model Change Bulletins (MCBs) and in Appendix G of this guide, as well as in the comments embedded in the Fortran source code.

1.1.1 Stage 1 - extraction and quality assessment

Stage 1 comprises the extraction/retrieval of data and assessment of the quality of the data. Data extraction is generally a one-time activity, while the quality assessment (QA) may be performed several times if the QA identifies problems with the data.

Typically, the NWS upper air and surface data are available from the National Oceanic and Atmospheric Administration (NOAA) in a compact format. These formats are designed to minimize the amount of space required to store the data and are not readily interpreted. Therefore, the data that are stored in archive files are first extracted (i.e., retrieved) from the archive file.

AERMET can extract upper air sounding data from two formats including: TD-6201 and the former Forecast Systems Laboratory (FSL) format. While TD-6201 is no longer in use, global upper air data in FSL format is available online from the NOAA Earth System Research Laboratory (ESRL) Radiosonde Database at http://esrl.noaa.gov/raobs/.

AERMET can extract surface hourly weather observations from several standard formats that have been used by NOAA's former National Climatic Data Center (NCDC), now the NOAA National Centers for Environmental Information (NCEI) including: Card Deck 144 (CD-144), Solar And Meteorological Surface Observation Network (SAMSON), Hourly Surface Weather Observations (HUSWO), and the Integrated Surface Hourly Database (ISHD a.k.a. ISH, ISD and DSI-3505), which are time-based (i.e., by hour) formats, and the TD-3280 format, which is an element-based (i.e., by variable), originally stored on magnetic tape. While data stored in some of the older formats (CD-144, SAMSON, HUSWO, and possibly TD-3280) may be part of users' personal archives and some formats may be available for purchase from the

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NCEI, recent U.S. and global data are available for download via File Transfer Protocol (FTP) free of charge from the NCEI at http://www.ncdc.noaa.gov/isd/data-access.

AERMET also processes the hourly surface data format available from the EPA Office of Air Quality Planning and Standards (OAQPS) Technology Transfer Network (TTN). This format is a reduced form (fewer variables) of the CD-144 format and is available from the Support Center for Regulatory Air Models (SCRAM) technical area of TTN.

There is no standard format or content for site-specific meteorological data. Site-specific data most likely will include observations made at one or more levels on an instrumented tower or from remote sensing instrumentation. Additionally, near-surface measurements such as insolation, net radiation, and temperature difference may be included in the data base. The non-standardized formats preclude storing these data in a predefined archive format; thus, AERMET does not 'extract' site-specific data. However, AERMET is designed to accept a variety of on-site data formats by having the user specify the structure of the data. The data must be in an ASCII file and able to be read with standard Fortran format statements. Additional restrictions and specification of site-specific data are discussed in more detail in Section 3.0 and Section 4.5.

Quality assessment is performed on all the data types except the 1-minute ASOS wind data. The QA process identifies occurrences of missing data, values that are outside a range of values, and inconsistences between selected variables within an observation period. Default values are defined for the upper and lower bounds and for missing values. The values can be modified through an input file created by the user that controls preprocessor actions. Some variables are checked by default (as noted in the tables in Appendix B) and the user can specify additional variables to be checked.

If AERMET detects anomalous data, a message is written to a file informing the user of the violation. At present there are no provisions for AERMET to automatically replace missing data or correct "suspect" values. The user should review the QA messages and determine if the

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value(s) require modification or if they are acceptable.

If the data require modification, the output files from Stage 1 can be edited using a text editor. However, any changes should be based on sound meteorological principles and comply with any relevant regulatory guidance. Modifications should only be done on extracted data, and not on the archive file. The archived data should never be altered, but should be maintained as delivered. Whenever changes are made, the modified data should be reprocessed through the QA process a second time. This stepwise procedure may identify new problems that, in turn, need to be addressed. When the user is satisfied that the quality of the extracted data cannot be improved further, the data are ready for the next stage.

1.1.2 Stage 2 - merging data

This stage of the processing combines the files from Stage 1, and 1-minute ASOS data if specified, into a single ASCII file. This file is organized so that each block of data contains all of the observations for a 24-hour period. This period begins with hour 1, representing the period from 0001 local standard time (LST) to 0100 LST, and ends with hour 24, representing 2301 LST to 2400 LST. If any input data to this stage of processing are physically missing for the hour (e.g., down-time for instrument maintenance), then the meteorological variables for that hour are represented by the appropriate missing value indicators (as shown in Appendix B or redefined by the user as explained in the following sections).

1.1.3 Stage 3 - creating model input files

The final stage of processing reads the merged file and, in conjunction with site-specific parameters that characterize the underlying surface, produces two input files for AERMOD. The first file contains boundary layer scaling parameters (such as surface friction velocity, mixing height, and Monin-Obukhov length) and reference-height winds and temperature. The second file contains one or more levels (a profile) of winds, temperature and the standard deviation of the fluctuating components of the wind. Generally, this latter file contains the data

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from a site-specific measurement program. In the absence of such data, a single level using NWS hourly surface observations may be used for the profile.

1.1.4 Limitations

The temperature structure of the atmosphere prior to sunrise is required by AERMET to estimate the growth of the convective boundary layer for the day. For most applications in the U.S., the 1200 Greenwich Mean Time (GMT) upper air sounding from the National Weather Service is the nearest sounding prior to sunrise.. Earlier versions of AERMET used a one hour window of time in the search to allow for the possibility of an early or late launch time. Beginning with version 11059, enhancements were made to AERMET to extend the selection of upper air soundings to better support applications of AERMOD beyond the U.S. AERMET now selects a preferred sounding based on time zone, as well as the user has the option to select the most appropriate sounding based on local sunrise. In addition the user has the option to define the search window beyond the one hour default. Refer to Section 4.7.6 and Section 4.7.7 for more information on upper air sounding selection.

1.1 General file structure

All the output files through Stage 2 have a similar structure. The files begin with header records and are followed by the data records. The header records are generated from the user-supplied input that controls AERMET's actions. An asterisk appears at the beginning of each header record in an output file. The asterisk has no other purpose than to identify the record as a header. Some of the header records have special (ASCII) characters after the asterisk for AERMET to reprocess these records in subsequent stages. This procedure frees the user from specifying the same information in subsequent runs and provides consistency from stage to stage. For example, the format of the site-specific data is specified only once because the statements that define the format are retained and reprocessed in subsequent AERMET runs. It is important that the user not change any of the header records, otherwise the data could be processed in an undesirable way or cause AERMET to fail with a processing error.

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The processed data appear after the header records. The format of these data are defined in Appendix C. The NWS surface and upper air data have been "integerized", i.e., the value is written to the output file as an integer. To retain significant digits for some of the variables, such as temperature and wind speed, the values are multiplied by 10 or 100 before writing the value to the output file. This process is reversed when the data are needed for parameter estimates. However, the site-specific data, with a nonstandard format and content, are written with the same input format specified by the user in the runstream file.

The two output files from Stage 3 contain all the necessary meteorological data required by AERMOD to perform a dispersion analysis. There are no processing header records in these files, although there is a single record at the beginning of the file with the boundary layer parameters that identifies the sites that were used in the processing. The format of these two files are defined in Appendix C.

1.2 Basic hardware requirements

With the continuing increases in speed and storage capacity of the personal computer (PC) and their ease of use, the PC has become a popular platform for dispersion model applications. As such, AERMET is designed to run on personal computers with Pentium or higher central processor unit. A minimum of 64 Mb of random access memory is recommended. The source code and executable program require approximately 4 Mb of disk space.

For AERMET to process one year of data through Stage 3 (using NWS and site-specific data) requires less than a minute on a 1.0 GHZ Pentium with 64 Mb of RAM. The amount of space required by the data files varies according to the type of data. File sizes range from 0.5 Mb (for one year of upper air soundings) to 6 Mb for a merged data file with all data types and three levels of site-specific data. The output file with the boundary layer parameters requires approximately 1 Mb for one year of data. The file containing the profile data depends on the number of levels in the profile. A single-level profile requires about 500 Kb and a three-

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level profile requires about 1.5 Mb.

1.3 Document overview

In Section 2.0, the basic requirements to run AERMET with National Weather Service data are presented in the form of a basic tutorial. The keyword approach and basic rules for constructing the input control files for each stage of processing are discussed. The AERMET system reports are reviewed. Section 3.0 presents an advanced tutorial by expanding the first example to include site-specific meteorological data. Section 4.0 discusses the keywords in more detail, many of which were not used in the tutorial. Section 5.0 discusses some of the technical aspects of AERMET such as the QA procedures and the basis for the parameter estimates in the final stage of processing.

Appendix A through Appendix D collectively form a reference guide for running AERMET. Appendix A describes the runstream file statements, while Appendix B describes the input variables and their default bounds and missing values codes. Appendix C describes the format and content of the AERMET input and output files. Appendix D describes the various error messages that may be generated by AERMET and suggests why the error message was generated. Appendix E discusses processing data archived on magnetic tape. Appendix F discusses possible future enhancements to the preprocessor. Appendix G is an historical overview of revisions that have been made to AERMET.

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2.0 Getting started - a basic tutorial

This section is designed to provide the user with a basic understanding of the requirements to run AERMET. In this section, we will:

- Explain the pathway and keyword approach, and associated syntax rules, for processing meteorological data through AERMET; and
- Present an example using NWS hourly weather observations and twice- daily upper air sounding data.

2.1 AERMET command language

Processing meteorological data with the AERMET preprocessor is divided into three stages as shown in Figure 1-1. Each stage must be run separately, though a single executable (AERMET.EXE) is now used for all three stages. A file containing a sequence of control statements is required to define the actions that AERMET is to perform and how to perform them. This file is referred to as the input control file or runstream file or, simply, runstream, and there must be a separate runstream for each of the three stages of processing. AERMET expects the runstream file for each stage of processing to be named 'AERMET.INP.'

The statements in a runstream are divided into six functional groups, or pathways:

- JOB for specifying information pertaining to the entire run;
- UPPERAIR for extracting and QA'ing NWS upper air sounding data;
- SURFACE for extracting and QA'ing NWS hourly surface observations;
- ONSITE for QA'ing user-supplied, on-site meteorological data;
- MERGE for combining (merging) the meteorological data;
- METPREP for estimating boundary layer parameters for AERMOD.

The pathway identifier appears on a line by itself and signals the beginning of a contiguous block of statements that apply only to that pathway. Depending on the stage of processing and the type of data that are being processed, there will be from two to five pathways

specified in a single AERMET runstream.

The records within a pathway make use of a keyword and parameter approach for specifying the input to AERMET. The keywords and parameters that make up this file can be thought of as a command language through which the user directs the actions by AERMET. It is the combinations of keywords and parameters that direct AERMET how to process the data. However, there are several rules of syntax that must be observed for AERMET to correctly process the data.

2.1.1 Basic rules for structuring a runstream

While the runstream has been designed to provide the user with flexibility in structuring the file, there are some basic syntax rules that must be followed. These rules standardize the format of the runstream. These rules are:

- The pathway identifier appears on a line by itself followed by all the runstream input records for that pathway. In other words, all the records for a particular pathway must be contiguous without any intervening keywords for other pathways.

- Each record in the runstream cannot exceed 132 characters in length. The record can begin in any column, so long as the entire length of the record, including leading blanks, does not exceed 132 characters. For example, records starting with keywords can be indented for readability (as is done throughout this user's guide). Each field on a record must be separated by one or more spaces or a comma and must appear in a particular order (with a few exceptions as noted later in the user's guide).

- Blank records can be included anywhere in the runstream to improve readability.

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- If asterisks appear in columns 1 and 2 (**), AERMET ignores the statement. By using the asterisks, the statement acts as a comment, which could be used to identify the purpose of the runstream or to clarify the content of an individual keyword or to ignore an action or option defined by the keyword.

- Alphabetical characters can appear in either upper or lower case letters.

- AERMET converts these characters to upper case (which is why any information echoed to an output file is all upper case) to insure exact matches on keywords and parameters. Throughout this document, the convention of using upper case letters in the runstreams will be followed. Note: For Linux/UNIX users, since file names on UNIX-based systems are case sensitive and since AERMET converts all alphabetic characters to upper case, the names of the files stored on the system would be required to be upper case.

- Some keywords are mandatory, while others are optional. A keyword is mandatory to the extent that there are data to process for the pathway and without the keyword, the eventual product from AERMET (the output files from Stage 3) could not be generated. Optional keywords are used to include or extend data processing actions. Most of the keywords used in the tutorial are mandatory. Some keywords are repeatable, such as the keywords to specify the format of any site-specific data, while others may only appear once. These terms are discussed in more detail in Section 4.0. Keywords by pathway are provided in Appendix A and are identified as mandatory or optional, repeatable or nonrepeatable.

- In general, the order of keywords within a pathway is not important, though there are a few exceptions for the ONSITE and METPREP pathways. These keywords pertain to the variables and format of the site-specific data and the site-specific surface characteristics on the METPREP pathway.

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- Filenames must conform to the naming conventions appropriate to the computing platform and cannot exceed 96 characters in length.

This section contains discussions of the basic keywords within the context of the tutorial. Section 4.0 contains a comprehensive discussion of all the keywords for each of the pathways. A summary of all of the keywords for each pathway is presented in Appendix A and is a complete reference guide for the function, syntax, and order (if applicable) of each keyword.

A text editor should be used to create the runstream files as plain text ASCII files. Word processors (e.g., Microsoft Word) can be used, but the file must be saved as a "Plain Text" file, i.e., without special format control characters that are included when the file is saved in its native format. Saving the file in a word processor's native format will introduce characters that cannot be interpreted by AERMET and prevent AERMET from processing any data.

2.2 Example 1: National Weather Service data

This first example leads the user through the steps that are necessary to generate the input runstream files for AERMET and run AERMET using only NWS data. This example is divided into four steps and a separate runstream for each of these steps is presented and discussed below. The runstreams will illustrate the basic requirements for each stage. The function and purpose of each record in the runstream will be described in the context of the desired processing.

Before reading the discussion of the keywords and output for this example, we recommend running AERMET to generate the output files - the message files, the summary reports, and the meteorological data output. The four steps and associated runstream files to generate the meteorological data for AERMOD for this example include:

1. extract and QA NWS hourly surface observations (Stage 1): EX1-SF.INP

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2. extract and QA NWS twice-daily upper air soundings (Stage 1): EX1-UA.INP

3. combine these two types of data into 24-hour blocks of data (Stage 2): EX1-MRG.INP

4. process the combined data to produce the meteorological input for AERMOD (Stage 3): EX1-ST3.INP.

AERMET is a DOS-based program and is run from the command prompt on computers running a version of Microsoft Windows. As previously stated, AERMET assumes that the filename of the runstream read by AERMET during each stage of processing is named 'AERMET.INP,' and each stage requires at least one separate runstream file. Therefore, each runstream should be stored with a unique name and copied to the filename 'AERMET.INP' prior to running each stage. In this example, there are two separate runstream files for Stage 1 in order to demonstrate the extraction and QA of the NWS surface data and upper air sounding data independently from one another. The syntax for running AERMET is:

path-to-AERMET.EXE\AERMET

where *path-to-AERMET.EXE* is the directory path to the AERMET executable file.

Table 2-1 shows the text to type at the command prompt for each step in this example. The first two can be run in either order, but steps three and four must follow the first two and run in the order shown.

Table 2-1. Command-line Entries to Run 3 Stages of AERMET for Example 1

To:	At the command prompt, type:	Meteorological input data file(s)	Output data file(s)
Extract and QA NWS hourly surface data	COPY EX1-SF.INP AERMET.INP AERMET	S1473588.144	SFEXOUT.DSK SFQAOUT.DSK

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Extract and QA NWS upper air data	COPY EX1-UA.INP AERMET.INP AERMET	14735-88.UA	UAEXOUT.DSK UAQAOUT.DSK
Merge data	COPY EX1-MRG.INP AERMET.INP AERMET	SFQAOUT.DSK UAQAOUT.DSK	MERGE.DSK
Create meteorological files for AERMOD	COPY EX1-ST3.INP AERMET.INP AERMET	MERGE.DSK	AERMET.SFC AERMET.PFL

As AERMET runs, the progress is displayed on the screen. The display is described below, after the discussion of the keywords. In addition to the output data files, each run will produce a message file (.MSG) and report file (.RPT) file. Note: the filenames and extensions are all user-defined; i.e., there are no default names or extensions.

A word of caution for this example and for all AERMET runs: all output files are opened with the Fortran file OPEN specifier of STATUS = 'UNKNOWN'. With this specifier, if the file already exists, the contents will be overwritten without any opportunity to save it.

The minimum meteorological input data requirements using only NWS data to produce the two meteorological files for input to AERMOD are:

Hourly Surface Observations:

- wind speed and direction;
- ambient temperature;
- opaque sky cover; in the absence of opaque sky cover, total sky cover;
- station pressure is recommended, but not required, since it is used only to calculate the density of dry air; AERMET will use a default value of 1013.25 millibars (sea level pressure) in the absence of station pressure.

Upper Air Soundings:

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- morning sounding (the 1200 GMT sounding for applications in the United States)

2.2.1 Stage 1 - processing hourly surface observations

Figure 2-1 shows the steps for processing the NWS hourly surface observations in Stage 1. The entire flow diagram shown in Figure 2-1 is shown here, but the steps that are not required to process the surface data do not contain any text.The first step in this example is to extract and QA the hourly surface observations from the data archive file. Figure 2-2 shows the runstream for this step, which is provided in the file EX1-SF.INP. Blank records have been inserted between records and the keywords indented to enhance legibility. The text to the right provides a short comment on the pathway or keyword and must not appear in the runstreams used to run AERMET (the comments are omitted in the files provided for this tutorial).

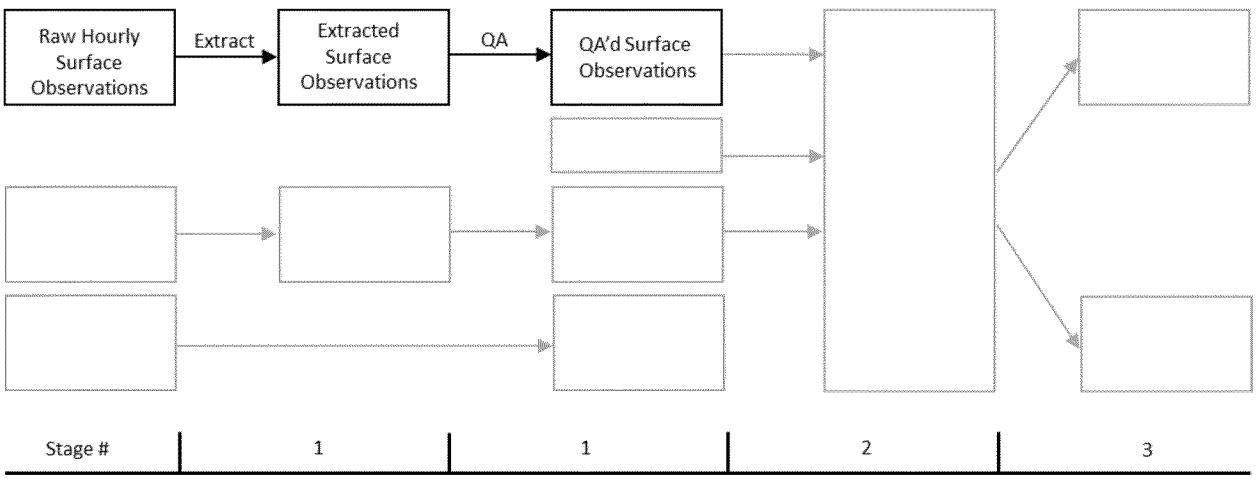

Figure 2-1. Stage 1 Processing for Hourly Surface Observations

```
JOB                                          Start of the   JOB pathway

  MESSAGES    SURFACE.MSG                    File for all messages

  REPORT      SURFACE.RPT                    File for the run summary

SURFACE                                      Start of the SURFACE pathway

  DATA        S1473588.144    CD144          Archive data file, format

  EXTRACT     SFCEXOUT.DSK                   File to which the extracted data are
                                             written
```

```
XDATES     88/3/1 TO 88/03/10              Dates to extract from the archive file

LOCATION   14735  42.75N  73.8W  0  83.8   Station identifier,
                                           latitude, longitude, and
                                           conversion to local time,
                                           station elevation (m)

QAOUT      SFQAOUT.DSK                     File for the   output from  QA
```

Figure 2-2. Example Runstream to Extract and QA NWS Surface Data (EX1-SF.INP)

2.2.1.1 JOB pathway

This pathway is common to all AERMET runs and may appear anywhere in the runstream file, but it usually appears first. The basic keywords associated with the JOB pathway are:

MESSAGES - specifies the file name where all the errors, warning and informational messages generated by AERMET are written; a mandatory keyword.

REPORT - specifies the file name where the summary of the run is written; an optional, but highly recommended, keyword. If this keyword is omitted, then the report streams to the default output device, usually the screen, and can be captured to a file using DOS redirection on a PC (discussed later in this section)

In this example, the messages are written to SURFACE.MSG and the report is written to SURFACE.RPT. The files are written in the directory in which AERMET is started. The files are ASCII files that can be viewed with any common text editor or viewing program. Both files contain information that can be used to determine if a particular run was successful or failed, and if the run failed, give possible reasons.

There are several hundred different places in AERMET that could generate a message - from an error (fatal to processing) to a warning (could cause problems) to an informational message. Messages are written at the time the runstream is processed as well as when data are processed. Appendix E contains a list of these messages with a brief explanation of each.

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Depending on the pathways and keywords defined in a particular run, this file could be very long, particularly when the data are QA'd, so it is advisable to check the size or view it prior to printing it.

One other keyword is associated with the JOB pathway:

CHK_SYNTAX - checks the syntax of the runstream file for errors, without processing any data; use this keyword to check a newly created runstream before processing any data to locate possible syntax errors.

A detailed discussion of all the keywords for the JOB pathway is provided in Section 4.0, with a synopsis of each keyword in Appendix A.

2.2.1.2 SURFACE pathway

The SURFACE statement indicates that a block of keyword statements for the SURFACE pathway are to follow. The basic keywords required to extract and assess the quality of NWS surface data are:

DATA - specifies the input file name of the archived data and the file format for the extraction process;

EXTRACT - specifies the output file name of extracted data; this keyword also specifies the input file name for the data QA;

XDATES - specifies the period of time to be extracted from the archived data file;

LOCATION - specifies the station identifier, latitude and longitude, the factor to convert the time of each data record to local standard time, and the station elevation;

QAOUT - specifies the output file name from the QA process; this keyword is also used to specify the input file name to Stage 2 - see Section 2.2.3.

The order of these keywords within the SURFACE pathway is not important. The

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presence of both the DATA and EXTRACT keywords (without error) directs AERMET to extract hourly observations from a file of archived data. The presence of both the EXTRACT and QAOUT keyword statements directs AERMET to assess the quality of the data. Therefore, in this example, the surface data will be both extracted and QA'd.

DATA and EXTRACT

The first parameter associated with the DATA keyword identifies the name of the archive data file, S1473588.144 in this example. On a PC, the file name must conform to the standard operating system naming convention and is limited by AERMET to 96 characters. The second parameter, CD144 in this example, identifies the archive format of the file. The format parameter indicates that the archive data are in NCDC's CD-144 format, which consists of all the weather observations for one hour on a single, 80-column record.

In addition to the CD144 format, AERMET can process: SCRAM,SAMSON, HUSWO, ISHD, and TD-3280. The more common format for current modeling applications that use NWS surface data is the ISHD format while TD-3280 is for data that were stored on magnetic tape (see Appendix E) and is now obsolete. These formats are discussed in detail in Section 4.3.

Note that in previous versions of AERMET the DATA keyword included 'blocking factor' and 'data type' as two optional parameters. Beginning with version 11059, these two parameters are no longer supported by AERMET, and AERMET will issue a warning message if these parameters are included on the DATA keyword.

The EXTRACT keyword specifies the name of the file to which the extracted data are to be written. It is an ASCII file. In this example, the data are written to SFEXOUT.DSK. The hourly surface data are written to the output file as integers, with some variables multiplied by 10 or 100 to retain significant digits. Information on the specific structure for NWS hourly surface observations in the extracted data file is provided in Appendix C.

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XDATES

XDATES identifies the inclusive dates, in the form YY/MM/DD, of the data to be retrieved, where YY is the year, MM is the month, and DD is the day, all specified as integers. The word "TO" is optional and is ignored during processing if it is present. The "/" between each part of the date is required. There can be no blanks in the date field, otherwise AERMET will not correctly interpret this record and will terminate with an error. In this example, NWS hourly surface observations for the period March 1, 1988 through March 10, 1988, inclusive, are extracted from the archive file. Notice that the month and day can be specified with or without leading zeros.

LOCATION

The LOCATION keyword is required and specifies station information on which data are to be extracted from the archive file. The parameters associated with this keyword are the station identifier, latitude, longitude, a time conversion factor, and the station elevation. In this example, the station identifier is 14735 and is a Weather Bureau Army Navy (WBAN) number (discussed in Section 4.0) for Albany, New York. This station identifier is carried through all the stages of processing and appears on the first record of the boundary layer parameter output file from Stage 3. The NWS station latitude and longitude are specified in decimal degrees. These coordinates can be specified in either order, but the directional specifiers (N and W in this case) are required. AERMET does not recognize "+" and "-" to distinguish between north or south and east or west; therefore, latitude and longitude should be specified as positive numbers. The LOCATION keyword also defines the number of hours required to convert the time of each data record to local standard time (LST). For stations west of Greenwich, this value is specified as a positive number. In most of the older archive formats date and time information is stored in local standard time, in which case the conversion is 0, also the default value. Therefore, if this adjustment is zero, this parameter can be omitted. If data are reported in GMT or Coordinated Universal Time (UTC), then the number of time zones west (positive number) or east (negative number) of Greenwich is specified. The archive format now used by the NCEI is the ISHD

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format in which date and time information is stored in GMT.

Beginning with version 06341, the LOCATION keyword on the SURFACE pathway also includes the station elevation as an optional last parameter. The elevation is used to estimate station pressure if omitted from the raw surface data file or for hours the station pressure is missing. A default value of 0 meters is assumed if the station elevation is omitted from the LOCATION keyword. The station elevation may be included in the surface data file, depending on the file format. AERMET will use the elevation read from the surface file rather than the elevation specified in the runstream when both are provided. Refer to Section 5.6 for a more detailed discussion of the use of the station elevation on the LOCATION keyword in SURFACE and ONSITE pathways.

QAOUT

The QAOUT keyword identifies the file where the data that have undergone the QA process are written. In this example, the output is written to SFQAOUT.DSK.

Several variables on the SURFACE pathway are checked (audited) by default. These are the total and opaque sky cover, station pressure, dry bulb temperature, and wind speed and direction. During the quality assessment process, audited variables are checked as being missing or outside a range of acceptable values. The default values for the SURFACE pathway are defined in Appendix B, Table B-2. A violation of the range or a missing value is reported in the message file, SURFACE.MSG. The variable name, value, upper or lower bound (depending on the violation) or missing value indicator, and date/time are reported in this file (the structure of the message is explained in Appendix D. The user should review the message file to determine if the violations are true errors (e.g., a temperature of 100 °C) and need correction or if they can be ignored (e.g., a temperature that is 0.1 °C higher than an upper bound of 35 °C). The total number of violations and missing values are summarized by variable in the REPORT file, SURFACE.RPT. In the message and summary files, the value and bound or missing indicator is multiplied by the same factor that was used to "integerize" the data (see the

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discussion for the EXTRACT keyword above). This "integerization" should be kept in mind when reviewing the results of the QA.

The AERMET preprocessor does not make changes to the data during the QA process. If the quality assessment identifies any problems, then either the extracted data file or the QA output file can be edited to manually correct the data in accordance with sound meteorological principles and within any relevant regulatory guidelines. If the modifications are extensive, it is recommended that the data be reprocessed through the QA to identify any problems that may be introduced as a result of the modifications.

The output file from the QA process is identical to the input file, except for the addition of a header record. The preprocessor reads the hourly data and writes the same data to the output file. One may question the need for a separate QA output file since the data are a copy of the EXTRACT output file. The answer is that this method will allow for future accommodation of automatic replacement procedures for missing values, if such procedures are established. By having the two files (identified with the EXTRACT and QAOUT keywords), the AERMET system has a logical design for assessing the data, reporting suspect or missing values, and storing the new or modified values.

There are several additional keywords for the SURFACE pathway that are optional:

AUDIT -	adds variables to the list of default variables to be tracked during QA; use the names in the Table B-2 to identify the additional variables;
RANGE -	allows the user to modify the default lower and upper QA bounds, the inclusion/exclusion of the endpoints, and the missing value indicator for the variable specified;
NO_MISSING -	suppresses the message that data are missing for variables being tracked (audited) during the QA process; this keyword is useful in reducing the size of the message file if an audited variable is missing most of the time.

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A detailed discussion of each of the valid keywords for the SURFACE pathway is provided in Section 4.0, with a synopsis of each in Appendix A.

2.2.1.3 Running STAGE 1 and reviewing the output

Once a runstream has been created, the next step is to copy the uniquely named runstream file for the stage or process you want to run to a file named 'AERMET.INP,' which was described at the beginning of this section. Remember, for this example we have divided Stage 1 into two separate runs: 1) extraction and QA of the NWS surface data and 2) the extraction and QA of the NWS upper air data. To process the NWS surface data at the command prompt, type:

```
COPY EX1-SF.INP AERMET.INP
AERMET
```

Note that it is not necessary to include the .EXE extension to invoke the executable program.

As AERMET runs, the progress is displayed on the screen. AERMET first displays which executable is running and the version date. Next, the message "Processing the Setup Information" is displayed as the runstream records are processed. If there is an error in the runstream, AERMET will display the message:

```
*********************************************************
***       AERMET Setup Finished UN-successfully      ***
*********************************************************
```

If the setup processing is successful, the data processing begins. The year, month, and day are displayed as each day is processed. Once all the data are processed, AERMET displays a message that the processing is complete and the summary report is being written. If the data were successfully processed, the following message is displayed:

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```
*********************************************************
***   AERMET Data Processing Finished Successfully   ***
*********************************************************
```

For an unsuccessful run (e.g., a period of time not included in the archive file is specified with the XDATES keyword such that no data are extracted), the following is displayed:

```
*********************************************************
***  AERMET Data Processing Finished UN-successfully ***
*********************************************************
```

In both of these latter cases, the final message displayed on the screen informs the user where to locate the summary report.

As was noted above, the REPORT keyword on the JOB pathway is optional. If the keyword is used, then the summary information will be written to the file associated with the REPORT keyword. If there is no REPORT keyword, then the summary information will be written to the standard output device, which is normally the video monitor on a PC. Since the summary fills more than one screen, the report can be sent to a destination other than the screen by redirecting the report to a file as follows:

AERMET > STAGE1.LOG

The ">" directs AERMET to send output that would be written to the screen to the file STAGE1.LOG. However, if this method is used, then <u>all</u> information displayed on the screen is captured in the file, including the lines showing the progress of the processing.

Figure 2-3 shows the message file that results from running EX1-SF.INP. Most of the messages are easily interpreted and relate to the data QA. The structure of these messages is explained in Appendix D. Briefly, the first field is either a counter, blank or a date; the second field is the pathway; the third field is a three-character code used to tabulate the messages for

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the REPORT file; the fourth field is the subroutine that generated the message; and the fifth field is the message.

```
        JOB        I19  SETUP  : "END OF FILE" ON UNIT  5 AFTER RECORD #  19
        JOB        I25   TEST  : SUMMARY: NO DATA EXTRACTION FOR UPPERAIR
        JOB        I25   TEST  : SUMMARY: NO DATA QA FOR UPPERAIR
        JOB        I27   TEST  : SUMMARY: NO DATA QA FOR ONSITE
        SURFACE    I40  SFEXT  : *** SURFACE OBSERVATION EXTRACTION ***
        SURFACE    I41 FNDCOMDT: ASOS commission date FOUND for WBAN =  14735;
                                 CALL4 = KALB; CALL3 = ALB; CommDate = 19950801
        SURFACE    I49 GETSFC  : END-OF-DATA window encountered
        SURFACE    I49  SFEXT  :   240 SURFACE records extracted
880302 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 02
880302 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 03
880302 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 04
880302 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 05
880302 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 06
880302 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 07
880303 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 19
880303 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 21
880306 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 00
880306 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 01
880306 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 02
880306 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 03
880306 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 04
880306 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 05
880306 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 06
880306 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 07
880308 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 21
880308 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 22
880309 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 00
880309 SURFACE    CLM SFQASM  : CALM WINDS FOR HR 01
        SURFACE    I49 SFQASM  : END OF FILE AFTER HOURLY OBS #   240
```

Figure 2-3. Message from Stage 1 (EX1-SF1.INP, Surface Extraction Only)

The first four messages are informational messages, as denoted by the 'I' in the first position in the third field, and pertain to the runstream setup processing. The first message indicates that 19 records (including blank and comment lines) were processed before encountering an end of file on the input runstream. This is usually the first record in the message file. The next three records indicate actions that will <u>not</u> be performed and relate to the UPPERAIR and ONSITE pathways. The remaining messages pertain to the processing of the NWS hourly surface observations. Records 5-7 indicate that data were extracted for the SURFACE pathway, the end of the extraction window (as defined by the XDATES keyword) was encountered in the input data, and that 240 records were extracted. This value can be used to determine if the correct number of records were processed. In this example, since the XDATES keyword specified the 10-day period March 1-10, one would expect that 240 records

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(10 days x 24 hours/day) should be extracted. Since 240 records were extracted, we can be reasonably certain that AERMET processed the data correctly. The QA will assist in making the final determination.

These informational messages are followed by QA messages. In this example, all the QA messages pertain to calm winds, as denoted by the 'CLM' in the third field. The number at the left of the message indicates the year, month, and day the calm wind was encountered and the hour is contained in the body of the message. The final record in this file is another informational record indicating that the end of file on the QA input file (associated with the EXTRACT keyword) was encountered after record number 240, the same number of records that were extracted. These messages do not indicate anything unusual during the processing of the hourly surface observations.

The summary report file is composed of the following general features:

- a banner identifying AERMET and the data and time the data were processed; this banner appears at the top of each new AERMET report page;
- a message enclosed by asterisks indicating the success or failure of the setup or data processing;
- a summary of information and processing in words and tables.

Figure 2-4 through Figure 2-6 show the report file that was generated. This file summarizes the input information and tabulates the messages and QA results. In Figure 2-4, the AERMET banner is followed by the message that the setup processing finished successfully. The user should look for this message to confirm that there were no problems in the setup processing. This message is followed by the runstream input summary and contains information by pathway:

1. JOB - the file names for the message and summary files;
2. UPPERAIR - AERMET determined that there were no upper air data to process in this run;

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3. SURFACE - AERMET determined that NWS hourly surface observations are to be processed and summarizes the information as follows:

   a) the station information (identifier, latitude, longitude and time conversion factor);

   b) a message on what processing AERMET performed on the data - extract and QA in this example;

   c) the input and output file names and if they were successfully opened;

   d) the extract dates;

4. ONSITE - AERMET determined that there were no site-specific data to process in this run

Compare the information in this figure to the runstream in Figure 2-2 and the message file in Figure 2-3 and you will see that this figure reflects the input runstream and records 2 through 4 of the message file (the summary of the actions that were <u>not</u> performed).

Figure 2-5 shows the summary of the QA, which begins on a new page. This table summarizes all QA messages generated by AERMET. The table includes the variable name (as defined in Table B-2) on the far left, the total number of observations of that variable, the number missing, the number of lower and upper bound violations, and the percent accepted. On the right side of the table, the values that the data were tested against are shown. Recall that all hourly observations are converted to integer format, with some values (such as wind speed and temperature) multiplied by 10 to retain significant digits. These same multipliers are applied to the values on the right side of the QA summary table. Table B-2 shows which variables have been multiplied by 10 (1000 in the case of precipitation). The user is reminded of this fact below the table.

In addition to the bounds violations and missing data, AERMET also checks for other

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anomalous data: calm winds, zero wind speed and nonzero wind direction, dew point temperature greater than ambient air temperature. The processing summary table (Figure 2-3) did not include these QA results, but are summarized below the QA summary table. Compare this summary to Figure 2-3. There are 20 messages in Figure 2-3 with the 'CLM' code, which is the number reported in this summary.

This QA summary provides a quick means of assessing the validity of the data. AERMET only performs simple data comparisons and reports its findings. It is up to the user to determine if the reported violations are indicative of an error in the data or if the limits are too restrictive. If the reported violation is due to the latter condition, the RANGE keyword can be used to define new limits and the QA can be run again (without extracting the data again, as described at the end of Section 3.0). If the reported violation is an error in the data, then the user will have to judge on how to proceed - correcting the data or changing the data to indicate that it is missing.

Figure 2-6 shows the tabulation of the messages that appear in Figure 2-3. This table starts on a new page, therefore, the AERMET banner appears at the top. The banner is followed by the message that the data processing finished successfully. This is the identical message that is displayed on the screen when AERMET completes a successful run. Next is a record indicating general processing activity (EXTRACT AND/OR QA THE METEOROLOGICAL DATA). This record is followed by the table. Below the table, any error and warning messages that appeared in the message file are redisplayed here. In this example, there were no error or warning messages.

AERMET uses the third field in a message to construct the table. Only messages that utilize the 'E', 'W', 'I', and 'Q' in the first position of the third field are tabulated. Messages with special message codes, such as 'CLM', are excluded from this tabulation. The second and third positions of the third field relate to the pathway being processed, as explained in Appendix D. While the message file contains the individual messages, this table displays the distribution of these messages.

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```
      AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                Version  15181

                    Data Processed on 17-JUN-2016 at 09:40:12

                                     Stage 1                          Page   1

             ******************************************************
             ***        AERMET Setup Finished Successfully        ***
             ******************************************************

1.  Job File Names

    Listing of Messages: SURFACE.MSG
    Summary (this file): SURFACE.RPT


2.  Upper Air Data

    AERMET Has Determined That Processing For This Pathway Includes:
         NONE, NO DATA TO BE PROCESSED ON THIS PATH



3.  NWS Surface Data

     Site ID    Latitude(deg.)   Longitude(deg.)   Time Adjustment   Elev. (m)
       14735       42.75N             73.8W               0             83.8

     Data Format: CD144

    AERMET Has Determined That Processing For This Pathway Includes:
         EXTRACT AND QUALITY ASSESSMENT

         Extract Input -    OPEN: S1473588.144
         Extract Output-    OPEN: SFCEXOUT.DSK
         QA Output     -    OPEN: SFQAOUT.DSK

         The Extract Dates Are:    Starting:  1-MAR-1988
                                     Ending: 10-MAR-1988


4.  On-site Data

    AERMET Has Determined That Processing For This Pathway Includes:
         NONE, NO DATA TO BE PROCESSED ON THIS PATH
```

Figure 2-4. First Part of the Report File - Processing NWS Surface Observations

```
       AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                Version  15181

                     Data Processed on 17-JUN-2016 at 09:40:12

                                     Stage 1                          Page   2

             ******************************************************
             ***   AERMET Data Processing Finished Successfully   ***
             ******************************************************


                       **** SUMMARY OF THE QA AUDIT ****


SURFACE DATA          |------VIOLATION SUMMARY------|   |-----TEST VALUES-----|
              TOTAL     #     LOWER  UPPER      %      MISSING   LOWER   UPPER
              # OBS  MISSING  BOUND  BOUND  ACCEPTED     FLAG    BOUND   BOUND
      TMPD     240        0      0      0    100.00      999.0, -300.0,  400.0
      WDIR     240        0      0      0    100.00      999.0,    0.0,   36.0
      WSPD     240        0      0      0    100.00      999.0,    0.0,  500.0

NOTE: Test values were also multiplied by the same factors applied to the data
      (see Appendix B of the AERMET User's Guide)


       In addition, for the   240 hourly obs, AERMET reports that there are:

            20 CALM WIND CONDITIONS (WS=0, WD=0)
             0 ZERO WIND SPEEDS WITH NONZERO WIND DIRECTIONS
             0 DEW-POINT GREATER THAN DRY BULB TEMPERATURES

       The date & time of these occurrences can be found in
       the message file  SURFACE.MSG

    THIS CONCLUDES THE AUDIT TRAIL
```

Figure 2-5. Second Part of the Report File - Processing NWS Hourly Surface Observations

```
      AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                Version  15181

                   Data Processed on 17-JUN-2016 at 09:40:12

                                   Stage 1                          Page   3

            ******************************************************
            ***   AERMET Data Processing Finished Successfully   ***
            ******************************************************

                   EXTRACT AND/OR QA THE METEOROLOGICAL DATA


                    **** AERMET MESSAGE SUMMARY TABLE ****

        0- 9   10-19   20-29   30-39   40-49   50-59   60-69   70-89   TOTAL
     ------------------------------------------------------------------------

JOB
  E      0       0       0       0       0       0       0       0       0
  W      0       0       0       0       0       0       0       0       0
  I      0       1       3       0       0       0       0       0       4

SURFACE
  E      0       0       0       0       0       0       0       0       0
  W      0       0       0       0       0       0       0       0       0
  I      0       0       0       0       5       0       0       0       5
  Q      0       0       0       0       0       0       0       0       0
     ------------------------------------------------------------------------
         0       1       3       0       5       0       0       0       9

      ****    ERROR MESSAGES    ****

             ---  NONE  ---


      ****   WARNING MESSAGES   ****

             ---  NONE  ---


  ASOS Commission Date for Surface Station    14735 (YYYYMMDD): 19950801
```

Figure 2-6. Third Part of the Report File - Processing NWS Hourly Surface Observations.

2.2.2 Stage 1 - processing twice-daily soundings

The steps required to process the upper air soundings through stage 1 are shown in Figure 2-7.

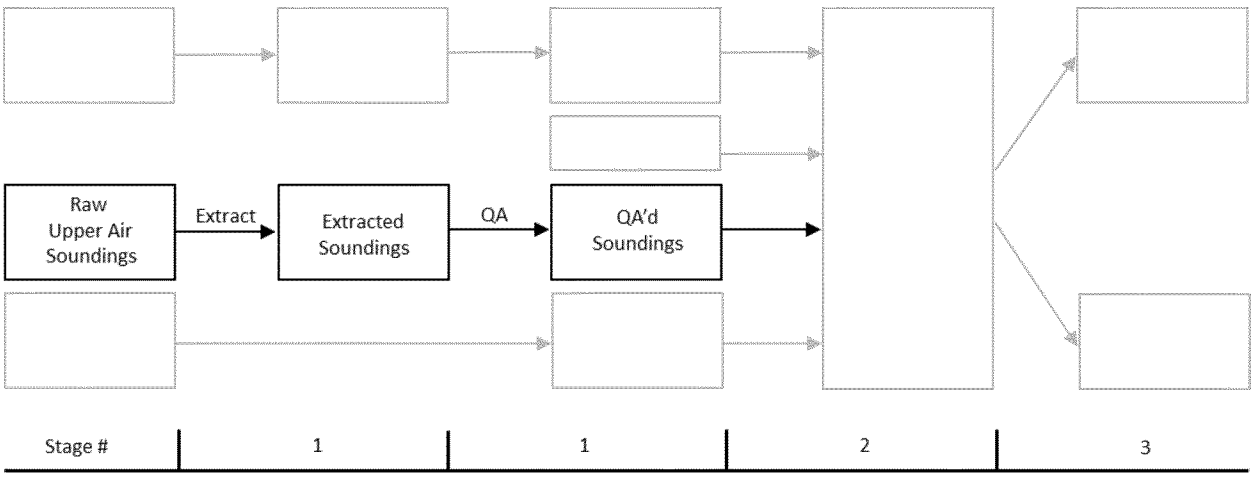

Figure 2-7. Stage 1 Processing Upper Air Soundings

The next step in this tutorial is the extraction and QA of the twice-daily upper air soundings. Figure 2-8 shows the runstream for this step and is provided in the file EX1-UA.INP. The text to the right on each record provides a short comment on the pathway or keyword and must not appear in the runstream.

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```
JOB                                     Start of the JOB pathway

  REPORT      UPPERAIR.RPT              File for all messages

  MESSAGES    UPPERAIR.MSG              File for the run summary

UPPERAIR                                Start of the UPPERAIR pathway

  DATA        14735-88.UA 6201FB        Archive data file name, format

  EXTRACT     UAEXOUT.DSK               File to which the extracted data are
                                        written

  XDATES      88/3/1 TO 88/3/10         Dates to extract from the archive file

  LOCATION    00014735  73.8W  42.75N  5  Station identifier, location, and
                                        conversion to local time

  QAOUT       UAQAOUT.DSK               File for the output from QA

  AUDIT       UATT UAWS UALR            Upper air variables to QA
```

Figure 2-8. Example Runstream to Extract and QA NWS Upper Air Sounding Data

The discussion for the JOB pathway associated with the extraction and QA of the hourly surface observations in Section 2.2.1 applies here as well. The messages and summary report for this run are written to UPPERAIR.MSG and UPPERAIR.RPT, respectively.

2.2.2.1 UPPERAIR pathway

The UPPERAIR statement indicates that a block of keywords for the UPPERAIR pathway are to follow. The extraction and quality assessment of NWS upper air sounding data is very similar to that of NWS surface data and uses the same basic keywords. The keywords used in this example are:

DATA - specifies the input file name of the archived data, the file format for the extraction process, and the data blocking factor;

EXTRACT - specifies the output file name of extracted data; this keyword also is used for the input file name for the data to QA;

XDATES - specifies the period of time to be retrieved from the archived data file;

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LOCATION - specifies the station identifier, latitude and longitude and the factor to convert the time of each data record to local standard time;

QAOUT - specifies the output file name from the QA process; this keyword is also used to specify the input file name to Stage 2 - see Section 2.2.3;

AUDIT - this keyword is optional; since none of the UPPERAIR variables are automatically checked, then variables are QA'd on the UPPERAIR pathway only if this keyword is used to include them in the QA.

The order of these keywords within the UPPERAIR pathway is not important. The presence of both the DATA and EXTRACT keywords directs AERMET to extract soundings from a file of archived data. The presence of both the EXTRACT and QAOUT keyword statements directs AERMET to assess the quality of the sounding data. Therefore, in this example, the upper air data will both be extracted and QA'd.

DATA and EXTRACT

The first parameter associated with the DATA keyword identifies the name of the archived data file, 14735-88.UA in this example. As with any file name in a runstream, the name could include a drive and directory path so long as the length of the name does not exceed the (AERMET-imposed) 96-character limit. The second parameter, 6201FB, identifies the format of the archive data set. This parameter indicates that the data are in NCDC's TD-6201 format (the 6201 portion) and that the data are fixed-length blocks (the FB part). Sounding data in this format consist of 2876-character records with 79 levels of data per record. If there are less than 79 levels in a sounding, the record is filled out with missing data indicators. The discussion in Section 4.4 provides additional discussion on fixed-length and variable-length blocks for the UPPERAIR pathway. AERMET can extract upper air data only from the TD-6201 and NOAA/ESRL FSLformats. FSL is the more common format for upper air data processed by AERMET for current modeling applications.

The EXTRACT keyword specifies the name of the file to which the extracted data are to

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be written. It is an ASCII file. In this example, the data are written to UAEXOUT.DSK. Information on the specific structure for NWS upper air soundings in the extracted data file is provided in Appendix C. The sounding data are written to the output file as integers, with some variables multiplied by 10 or 100 to retain significant digits.

XDATES

XDATES identifies the inclusive dates, in the form YY/MM/DD, of the data to be retrieved, where YY is the year, MM is the month, and DD is the day, all specified as integers. The word "TO" is optional and is ignored during the processing of this keyword if it is present. The "/" between each part of the date is required and there can be no blanks in the date field, otherwise AERMET will terminate with an error. In this example, data for the period March 1, 1988 through March 10, 1988, inclusive, are extracted from the archive file.

LOCATION

The LOCATION keyword is required and specifies station information on which data are to be extracted from the archive file. The parameters associated with keyword are the station identifier, latitude, longitude, and the conversion of the sounding time to local standard time. In this example, the station identifier is 00014735 and corresponds to Albany, New York. Unlike the SURFACE pathway, the UPPERAIR identifier requires leading zeros because this field contains leading zeroes in the archive file and the field is read as a character variable rather than an integer. Hence, for AERMET to match the station identifier in the archive file with the identifier in the runstream, the leading zeroes are required. This station identifier is carried through all the stages of processing and appears on the first record of the boundary layer parameter output file from Stage 3.

The NWS station latitude and longitude are specified in decimal degrees. These coordinates can be specified in either order, but the directional specifiers (N and W in this case) are required. AERMET does not recognize "+" and "-" to distinguish between north or south

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and east or west. Therefore, latitude and longitude should be specified as positive numbers. The LOCATION keyword also defines the number of hours required to convert the time of each data record to local standard time. For stations west of Greenwich, a positive value for this factor must be specified. The times in the archive file are reported in GMT and this conversion factor is subtracted from GMT to obtain local standard time. The reason for performing this operation is to insure that all data for the current day are properly specified for the Stage 2 merging process. In this example, to convert the time to Eastern standard time (the time zone for 73.8 west longitude), AERMET subtracts the last parameter for this keyword (5) from GMT to get LST. For sounding dates in this archive file, this adjustment yields 1900 LST of the previous day for the 0000 GMT sounding and 0700 LST for the 1200 GMT sounding in the extracted file.

Note that beginning with version 11059, AERMET no longer supports the user-specified station elevation as a parameter on the UPPERAIR LOCATION keyword. AERMET will issue a warning message if the elevation field is included, but the user-specified elevation will be ignored and processing will continue.

QAOUT and AUDIT

The QAOUT keyword identifies the file where the data are written that have passed through the quality assessment. In this example, the output is written to UAQAOUT.DSK.

By default, no upper air variables are automatically checked (audited) in the QA process. The AUDIT keyword must be used to QA the data for missing data and range violations. The variable names, as shown in Table B-1, are specified on this statement. In this example, the temperature (UATT), wind speed (UAWS) and lapse rate (UALR) are checked. While the temperature and wind speed are in the file of extracted data, the lapse rate is computed during the QA. The lapse rate can alert the user to unusual, but possibly valid, variations in the temperature structure of the atmosphere, such as strong elevated inversions. However, it is not retained for further use (i.e., the lapse rate is not saved in the output file).

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During the quality assessment process, audited variables are checked as being missing or outside a range of acceptable values. The default values for the UPPERAIR pathway are defined in Table B-1. A violation of the range or a missing value is reported in the message file, UPPERAIR.MSG. The variable name, value, upper or lower bound (depending on the violation) or missing value indicator, and date/time are reported in this file. As with the data for the SURFACE pathway, both the value and bound or missing indicator may have been multiplied by a factor to integerize and retain significant digits. The user should review the message file to determine if the violations are errors in the data and need correction or if they can be ignored. The total number of violations and missing values are summarized by variable in the REPORT file, UPPERAIR.RPT.

AERMET does not modify the data during the QA. If the quality assessment identifies any problems, then either the EXTRACT file (UAEXOUT.DSK) or the QAOUT file (UAQAOUT.DSK) may be edited to manually correct the data in accordance with meteorological principles and within any relevant regulatory guidelines. If the modifications are extensive, the data should be reprocessed through the quality assessment procedures to identify any problems that may be introduced with the modifications.

There are several optional keywords available for the UPPERAIR pathway. These are:

RANGE - modifies the default QA bounds and missing value indicator for the variable specified;

NO_MISSING - suppresses the message that data are missing for variables being audited during the QA process; this keyword is useful in reducing the size of the message file if an audited variable is missing most of the time.

MODIFY - directs to perform automatic modifications to the upper air data as the data are extracted; these modifications are described in Section 4.0 with the discussion of this keyword.

A detailed discussion of each of the keywords on the UPPERAIR pathway is provided in Section 4.0, with a synopsis of each in Appendix A.

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2.2.2.2 Running stage 1 and reviewing the output

To run Stage 1 and extract and QA the NWS upper air data with EX1-UA.INP, execute the following commands at a command prompt[2]:

```
COPY   EX1-UA.INP   AERMET.INP
AERMET
```

The executable and version date, setup processing, and data processing are displayed on the screen as described in Section 2.2.1.3.

Figure 2-9 shows the message file that results from running EX1-UA.INP. Most of the messages are easily interpreted and are related to the data QA. The structure of these messages is explained in Appendix D.

```
        JOB        I19  SETUP  : "END OF FILE" ON UNIT  5 AFTER RECORD #  20
        JOB        I26   TEST  : SUMMARY: NO DATA EXTRACTION FOR SURFACE
        JOB        I26   TEST  : SUMMARY: NO DATA QA FOR SURFACE
        JOB        I27   TEST  : SUMMARY: NO DATA QA FOR ONSITE
        UPPERAIR   I30  UAEXT  : **** UPPER AIR EXTRACTION ****
        UPPERAIR   I39 GET620  : END-OF DATA WINDOW ENCOUNTERED
        UPPERAIR   I39  UAEXT  :  20 SOUNDINGS EXTRACTED
880302 UPPERAIR   Q39 UAQASM  : UAWS MISSING FOR HR  07 AT LEVEL  8
880302 UPPERAIR   Q39 UAQASM  : UAWS MISSING FOR HR  07 AT LEVEL  9
880302 UPPERAIR   Q39 UAQASM  : UAWS MISSING FOR HR  07 AT LEVEL 10
880304 UPPERAIR   Q37 REALQA  : LB: UALR=     -4.44 <      -2.00 FOR HR  19, LVL  08
880306 UPPERAIR   Q38 REALQA  : UB: UALR=      5.71 >       5.00 FOR HR  07, LVL  02
880306 UPPERAIR   Q38 REALQA  : UB: UALR=      5.06 >       5.00 FOR HR  07, LVL  03
880309 UPPERAIR   Q37 REALQA  : LB: UALR=     -3.00 <      -2.00 FOR HR  19, LVL  02
880310 UPPERAIR   Q38 REALQA  : UB: UALR=      5.90 >       5.00 FOR HR  07, LVL  09
        UPPERAIR   I39 UAQASM  : EOF AFTER UPPERAIR SOUNDING #    20
```

Figure 2-9. Message File from Processing NWS Upper Air Data

The first four messages are informational messages, as denoted by the 'I' in the first position in the third field, and pertain to the runstream setup processing. The first message indicates that 20 records were processed (including blank and comment lines) before encountering an end of file on the input runstream. This is usually the first record in the

[2] See Section 2.2 for a discussion on file redirection using the "<" symbol.

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message file. The next three records indicate actions that will not be performed and relate to the SURFACE and ONSITE pathways. The remaining messages pertain to the processing of the NWS twice-daily upper air data. Records 5 through 7 indicate that data were extracted for the UPPERAIR pathway and that 20 soundings were extracted. This value can be used to determine if the correct number of soundings were processed. In this example, since the XDATES keyword specified the 10-day period March 1-10, the correct number of soundings were extracted (10 days x 2 soundings/day). These informational messages are followed by QA messages, as denoted by the 'Q' in the first position of the third field. The number at the left of the message indicates the year, month, and day of the QA violation and the hour is contained in the body of the message. The final record in this file is another informational record indicating that the end of file on the input file was encountered after sounding number 20, the same number of soundings that were extracted.

The message file recorded two types of QA violations that were encountered during processing. Records 8 through 10 indicate that the wind speed, as denoted by the variable name UAWS (see Table B-3 for a list of UPPERAIR variable names), was missing for the 0700 LST sounding on March 3, 1988 at levels 8, 9 and 10. Since wind speed is not currently used in any calculations, these messages only serve as an indicator of the quality of the wind data.

Records 11 through 15 relate to the change in temperature, or lapse rate, between two levels of data, as denoted by the variable name UALR in the body of the message. For the hour and level reported, the lapse rate value was either less than the lower bound (LB) or greater than the upper bound (UB). The format of these five messages is similar for all upper and lower bound violation messages that the upper air QA generates. The messages contain the following information:

Field 1: the sounding date
Field 2: the pathway
Field 3: the message code
Field 4: the subroutine that issued the message
Field 5: the message

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- LB: = lower bound violation
- UB: = upper bound violation
- UALR= variable in question, the lapse rate in this example calculated value < lower bound or calculated value > upper bound hour of the sounding in LST between the level reported in the message and the level below

AERMET calculates the lapse rate and, if the result is outside a range of values, AERMET issues a QA message. In the first of these messages, a lapse rate of -0.0444 K/m was computed (and multiplied by 100) and compared to the default value of -0.02 K/m (also multiplied by 100 in Table B-1). Since -0.0444 < -0.02, the message was written. There are default values in AERMET (see Table B-1) but these bounds can be redefined using the RANGE keyword (as described earlier and in Section 4.4).

None of these messages indicate anything extremely unusual during the QA of the sounding data but, nonetheless, the user should review the data to confirm this assumption. Figure 2-10 through Figure 2-12 show the summary report for the run and are very similar in format and content to Figure 2-4 through Figure 2-6 for the SURFACE pathway. However, the QA summary in Figure 2-11 appears different from Figure 2-5 because there are several levels of data per sounding. The page begins with the AERMET banner and is followed by the message that the data processing finished successfully. Below this heading is a table that is divided into layer thicknesses: surface, eight layers that are 500 meters thick, and all data above 4000 meters. The reason for this division is that the height at which upper air data are reported varies from sounding to sounding, except that there is always a level at the surface. The general structure of the table is identical to the table for the summary of the QA of hourly surface observations with the variable name and violation summary on the left and the test values used for the QA on the right. Only the variables that were included with the AUDIT keywords appear in this table because none of the upper air variables are automatically QA'd. Examining the table reveals that there were three missing wind speeds in the 500-1000 meter layer, two lower bound violations and three upper bound violations, which corresponds to the number of

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individual messages written to the message file (Figure 2-9). Also note that the lapse rate is not reported for the surface. None of the variables that compute a change between layers (wind shear, lapse rates) can be reported for the surface.

Below the table is a report on several other conditions that AERMET checks: calm winds, zero wind speed and a nonzero wind direction, dew point temperature greater than ambient air temperature, and the number of soundings that do not extend to 5000 meters. The first three are identical to the checks made for the hourly surface observations. AERMET extracts sounding data from an archive file up to the first level above 5000 meters. The last check reports the number of soundings where the top of the sounding was below 5000 meters. The date and time of such a sounding is reported in the message file. In Stage 3, AERMET extrapolates the heights to 5000 meters for these "low" soundings if it becomes necessary in order to complete the boundary layer parameter estimates. This extrapolation process is explained in Section 5.7.4.

ED_001739_00002136-00060

```
      AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                Version  15181

                   Data Processed on 17-JUN-2016 at 09:40:12

                                   Stage 1                          Page   1

            ******************************************************
            ***        AERMET Setup Finished Successfully        ***
            ******************************************************

1.  Job File Names

    Listing of Messages: UPPERAIR.MSG
    Summary (this file): UPPERAIR.RPT


2.  Upper Air Data

     Site ID    Latitude(deg.)   Longitude(deg.)   Time Adjustment
    00014735       42.75N             73.8W               5

     Data Format: 6201FB

    AERMET Has Determined That Processing For This Pathway Includes:
         EXTRACT AND QUALITY ASSESSMENT

         Extract Input -    OPEN: 14735-88.UA
         Extract Output-    OPEN: UAEXOUT.DSK
         QA Output     -    OPEN: UAQAOUT.DSK

         The Extract Dates Are:    Starting:  1-MAR-1988
                                     Ending: 10-MAR-1988

         Upper Air Data Above the First Level Above 5000 Meters Not Extracted
         Upper Air Automatic Data Checks Are: OFF


3.  NWS Surface Data

    AERMET Has Determined That Processing For This Pathway Includes:
         NONE, NO DATA TO BE PROCESSED ON THIS PATH


4.  On-site Data

    AERMET Has Determined That Processing For This Pathway Includes:
         NONE, NO DATA TO BE PROCESSED ON THIS PATH
```

Figure 2-10. First Part of the Report File from Processing Upper Air Soundings

ED_001739_00002136-00061

```
        AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                  Version  15181

                     Data Processed on 17-JUN-2016 at 09:40:12

                                       Stage 1                          Page   2

              ******************************************************
              ***   AERMET Data Processing Finished Successfully   ***
              ******************************************************

                        **** SUMMARY OF THE QA AUDIT ****

   SOUNDINGS          |------VIOLATION SUMMARY------|   |-----TEST VALUES-----|
               TOTAL     #     LOWER  UPPER      %      MISSING   LOWER   UPPER
               # OBS  MISSING  BOUND  BOUND  ACCEPTED     FLAG    BOUND   BOUND
             SURFACE
      UATT      20        0      0      0    100.00    -9990.0, -350.0,  350.0
      UAWS      20        0      0      0    100.00     9990.0,    0.0,  500.0
          0 -  500M
      UATT      65        0      0      0    100.00    -9990.0, -350.0,  350.0
      UAWS      65        0      0      0    100.00     9990.0,    0.0,  500.0
      UALR      65        0      1      2     95.38    -9999.0,   -2.0,    5.0
        500 - 1000M
      UATT      46        0      0      0    100.00    -9990.0, -350.0,  350.0
      UAWS      46        3      0      0     93.48     9990.0,    0.0,  500.0
      UALR      46        0      0      0    100.00    -9999.0,   -2.0,    5.0
       1000 - 1500M
      UATT      43        0      0      0    100.00    -9990.0, -350.0,  350.0
      UAWS      43        0      0      0    100.00     9990.0,    0.0,  500.0
      UALR      43        0      1      0     97.67    -9999.0,   -2.0,    5.0
       1500 - 2000M
      UATT      49        0      0      0    100.00    -9990.0, -350.0,  350.0
      UAWS      49        0      0      0    100.00     9990.0,    0.0,  500.0
      UALR      49        0      0      1     97.96    -9999.0,   -2.0,    5.0
       2000 - 2500M
      UATT      50        0      0      0    100.00    -9990.0, -350.0,  350.0
      UAWS      50        0      0      0    100.00     9990.0,    0.0,  500.0
      UALR      50        0      0      0    100.00    -9999.0,   -2.0,    5.0
       2500 - 3000M
      UATT      31        0      0      0    100.00    -9990.0, -350.0,  350.0
      UAWS      31        0      0      0    100.00     9990.0,    0.0,  500.0
      UALR      31        0      0      0    100.00    -9999.0,   -2.0,    5.0
       3000 - 3500M
      UATT      29        0      0      0    100.00    -9990.0, -350.0,  350.0
      UAWS      29        0      0      0    100.00     9990.0,    0.0,  500.0
      UALR      29        0      0      0    100.00    -9999.0,   -2.0,    5.0
       3500 - 4000M
      UATT      20        0      0      0    100.00    -9990.0, -350.0,  350.0
      UAWS      20        0      0      0    100.00     9990.0,    0.0,  500.0
      UALR      20        0      0      0    100.00    -9999.0,   -2.0,    5.0
             > 4000M
      UATT      76        0      0      0    100.00    -9990.0, -350.0,  350.0
      UAWS      76        0      0      0    100.00     9990.0,    0.0,  500.0
      UALR      76        0      0      0    100.00    -9999.0,   -2.0,    5.0

 NOTE: Test values were also multiplied by the same factors applied to the data
       (see Appendix B of the AERMET User's Guide)

        In addition, for the   20 soundings, AERMET reports that there are:

              0 CALM WIND CONDITIONS (WS=0, WD=0)
              0 ZERO WIND SPEEDS WITH NONZERO WIND DIRECTIONS
              0 DEW POINT GREATER THAN DRY BULB TEMPERATURE
              1 SOUNDINGS THAT DO NOT EXTEND TO  5000 METERS

        The date, time and level of the occurrences for the first three
        can be found in the message file  UPPERAIR.MSG

     THIS CONCLUDES THE AUDIT TRAIL
```

Figure 2-11. Second Part of the Report File from Processing Upper Air Soundings

```
        AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                  Version  15181
```


ED_001739_00002136-00062

```
                    Data Processed on 17-JUN-2016 at 09:40:12

                                    Stage 1                          Page   3

             ********************************************************
             ***   AERMET Data Processing Finished Successfully   ***
             ********************************************************

                    EXTRACT AND/OR QA THE METEOROLOGICAL DATA


                     **** AERMET MESSAGE SUMMARY TABLE ****

        0- 9   10-19   20-29   30-39   40-49   50-59   60-69   70-89   TOTAL
     ------------------------------------------------------------------------

JOB
  E      0       0       0       0       0       0       0       0       0
  W      0       0       0       0       0       0       0       0       0
  I      0       1       3       0       0       0       0       0       4

UPPERAIR
  E      0       0       0       0       0       0       0       0       0
  W      0       0       0       0       0       0       0       0       0
  I      0       0       0       4       0       0       0       0       4
  Q      0       0       0       8       0       0       0       0       8
     ------------------------------------------------------------------------
         0       1       3      12       0       0       0       0      16

      ****    ERROR MESSAGES    ****

             ---  NONE  ---


      ****   WARNING MESSAGES   ****

             ---  NONE  ---
```

Figure 2-12. Third Part of the Report File from Processing Upper Air Soundings

2.2.3 Stage 2 - merging data

In Stage 2, the data processed in Stage 1 are merged (combined) into a single, formatted ASCII file with the data grouped in 24-hour periods (in local standard time). Figure 2-13 shows the processing flow associated with Stage 2 for this example. In this step, the NWS hourly surface observations and upper air soundings are combined. Figure 2-14 shows the runstream for Stage 2 and is provided in the file EX1-MRG.INP.

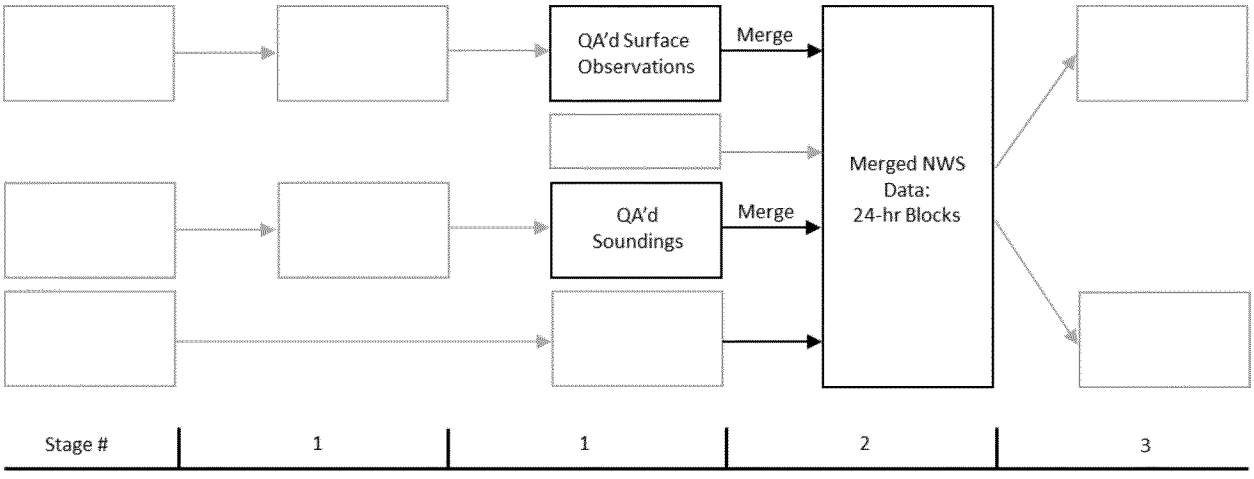

Figure 2-13. Stage 2 Processing that Merges the Hourly Surface Observations and Upper Air Soundings into a Single File

```
JOB                                       Start of the JOB pathway

  REPORT    MERGE-1.RPT                   File for all messages

  MESSAGES  MERGE-1.MSG                   File for run summary

SURFACE                                   Start of the SURFACE pathway

  QAOUT     SFQAOUT.DSK                   Input file with NWS hourly observations

UPPERAIR                                  Start of the UPPERAIR pathway

  QAOUT     UAQAOUT.DSK                   Input file with NWS upper air data

MERGE

  OUTPUT    MERGE.DSK                     Output file with merged
                                          meteorological data

  XDATES    88/03/01   88/03/04           Period to include in the output
```

Figure 2-14. Example Runstream to Merge NWS Data

ED_001739_00002136-00064

Merging data must be executed as a stand-alone process. Neither Stage 1 extraction/QA nor Stage 3 data processing can be performed with the merge. If the user attempts such a combination, AERMET issues an error message and does not process any data.

The only valid keywords for the MERGE pathway are:

OUTPUT - specifies the output file name of merged data/input file name for Stage 3;

XDATES - an optional keyword that specifies the period of time to be retrieved from the input files and merged together.

The OUTPUT keyword defines the file to which the merged data are written. It is an ASCII file. In this example, the output is written to MERGE.DSK.

The range of dates in the files that are to be combined are specified using the XDATES keyword. The syntax is identical to its usage in the extract and QA processes in Stage 1. Notice in this example the optional "TO" has been omitted. By using the XDATES keyword, a subset of the data can be merged. This is useful if the user had processed a large amount of data (e.g., one year of data), but is interested in a shorter time period for dispersion modeling. In this example, data between March 1, 1988 and March 4, 1988, inclusive, are merged (recall that data for the period March 1 - March 10 were processed in Stage 1 for both SURFACE and UPPERAIR data).

The XDATES keyword is optional and if it is omitted, then AERMET begins merging data corresponding with the earliest date found in the input data files. The ending date is always 367 days later, even if the last day of data in all the input files is prior to the 367th day. The user can determine if there are days without data by examining the summary file as explained at the end of this subsection. AERMET can MERGE multi-year data files if the XDATES keyword is specified.

ED_001739_00002136-00065

The input files to Stage 2 are specified with the QAOUT keyword for the appropriate pathway. The example in Figure 2-14 uses the two files that were created from the QA process for the SURFACE and UPPERAIR pathways above. The QAOUT keywords are the only allowable keywords for the SURFACE and UPPERAIR pathways when data are merged. The algorithms in Stage 3 require certain meteorological data to compute the boundary layer parameters. A merge cannot be performed with NWS upper air data alone. AERMET interprets this situation as an error and will not process any data.

2.2.3.1 Running stage 2 and reviewing the output

To merge the data using EX1_MRG.INP, the following commands are typed at a DOS prompt on the PC:

```
COPY   EX1-MRG.INP   AERMET.INP
AERMET
```

The executable and version date, setup processing, and data merging are displayed on the screen as described in Section 2.2.1.3.

The message file for Stage 2 (Figure 2-15) is very brief and lists the actions AERMET will not perform and reports the total number of header records processed from the input files.

```
JOB        I19  SETUP  : "END OF FILE" ON UNIT  5 AFTER RECORD #  21
JOB        I25   TEST  : SUMMARY: NO DATA EXTRACTION FOR UPPERAIR
JOB        I25   TEST  : SUMMARY: NO DATA QA FOR UPPERAIR
JOB        I26   TEST  : SUMMARY: NO DATA QA FOR SURFACE
JOB        I27   TEST  : SUMMARY: NO DATA QA FOR ONSITE
JOB        I27   TEST  : SUMMARY: NO ONSITE data to merge
    29 HEADERS PROCESSED FROM INPUT FILES
```

Figure 2-15. Message File from Merging the NWS Data

Figure 2-16 through Figure 2-18 show the summary report for the Stage 2 run. Like the previous runs, the first page of output echoes the input in a more readable format. In Figure

ED_001739_00002136-00066

2-16, notice that the station locations have been included for the SURFACE and UPPERAIR pathways even though they were not specified in the runstream (Figure 2-14). Recall that the general output file structure (Section 1.1.4) includes header records, which are the runstream records with additional characters at the beginning of each record. AERMET reads all these input file header records. If a header record contains a special character at the beginning of the record (inserted by AERMET at the time the record was written to the output file), then AERMET reprocesses the record as if it had been included in the runstream. This is the case with the LOCATION keywords for the SURFACE and UPPERAIR pathways and why this information appears in the summary of the merge process.

The second page of the output is shown in Figure 2-17 and contains a table with the number of observations merged by pathway for each day. Since only the period March 1-4 was specified with the XDATE keyword, only four days appear in this table which is also noted just above the table. The structure of this table and explanation of each line is as follows:

1) The month and day - up to 10 days per five-record grouping.

2) Number of soundings merged per day; although the soundings normally are reported twice per day, AERMET also includes the afternoon sounding from the previous day and the morning sounding for the next day. Since the upper air sounding data were extracted beginning with March 1, there is no previous afternoon sounding (on 2/29/88) to include in the merged data; hence only three soundings were merged on 3/1/88.

3) Number of hourly surface observations - since there are 24 each day, there were no days with any missing hourly surface data.

4) Number of hourly site-specific data observations - since there were no site-specific data in the data base, this line contains all zeroes.

5) Number of hourly observations derived from the 1-minute ASOS wind data – this line also contains all zeros since 1-minute ASOS data were not included in the data base.

If there are more than 10 days in the merged data file, then another group of records would have appeared below the first. One year of data requires nearly 200 records.

ED_001739_00002136-00067

Below this table is a summary of the number observations read (but not necessarily merged) from each input file. Note that AERMET read 98 hourly surface observations rather than 96 (4 days x 24 hours/day) to create the merged data file. There are two reasons for these extra observations to be read (but not merged). First, for the CD-144 format, the initial hour in the file is hour 0 on March 1, which is equivalent to hour 24 of the previous day (February 29). AERMET operates on the 1-to-24 hour clock, so the first record is read but not merged. Secondly, the first record on March 5 is read before AERMET determines that the hourly surface data are outside the period specified with the XDATES keyword, hence it is not included in the merged data file. Hence, two additional records were read to merge 96 hours (four days) of data.

The third page of the summary is shown in Figure 2-18 and contains the message summary table. Since no messages associated directly with the merge process were written to the message file, there isn't a separate block (with all 0's) for the MERGE pathway.

ED_001739_00002136-00068

```
       AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                Version  15181

                    Data Processed on 17-JUN-2016 at 09:40:12

                                     Stage 2                          Page   1

             ********************************************************
             ***        AERMET Setup Finished Successfully        ***
             ********************************************************

1.  Job File Names

    Listing of Messages: MERGE-1.MSG
    Summary (this file): MERGE-1.RPT


2.  Upper Air Data

     Site ID    Latitude(deg.)   Longitude(deg.)   Time Adjustment
    00014735       42.75N             73.8W               5

    AERMET Has Determined That Processing For This Pathway Includes:
         MERGE ONLY

         QA Output     -    OPEN: UAQAOUT.DSK


3.  NWS Surface Data

     Site ID    Latitude(deg.)   Longitude(deg.)   Time Adjustment
       14735       42.75N             73.8W               0

    AERMET Has Determined That Processing For This Pathway Includes:
         MERGE ONLY

         QA Output     -    OPEN: SFQAOUT.DSK


4.  On-site Data

    AERMET Has Determined That Processing For This Pathway Includes:
         NONE, NO DATA TO BE PROCESSED ON THIS PATH



5.  Merged Data
         Merge Output  -    OPEN: MERGE.DSK
```

Figure 2-16. First Part of the Summary File for the Merge Processing

```
       AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                Version  15181

                    Data Processed on 17-JUN-2016 at 09:40:12

                                     Stage 2                          Page   2

                        Merging the Meteorological Data


         The Merged Dates Are:    Starting:  1-MAR-1988
                                    Ending:  4-MAR-1988

                   ***** Daily Output Statistics *****
        1988 MO/DY:  3/ 1  3/ 2  3/ 3  3/ 4
NWS  Upper Air  Sdgs   2     4     4     4
NWS Sfc Observations  24    24    24    24
On-site Observations   0     0     0     0
Ave 1-min ASOS Winds   0     0     0     0


TOTAL OBSERVATIONS READ:
   Upper Air Soundings :      9
   NWS Sfc Observations:     98
   On-site Observations:      0
   1-min ASOS Wind Data:      0

                   ***** MERGE PROCESS COMPLETED *****
```

Figure 2-17. Second Part of the Summary File for the Merge Processing

```
      AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                Version  15181

                   Data Processed on 17-JUN-2016 at 09:40:12

                                   Stage 2                          Page   3

            ******************************************************
            ***   AERMET Data Processing Finished Successfully   ***
            ******************************************************


                   **** AERMET MESSAGE SUMMARY TABLE ****

        0- 9   10-19   20-29   30-39   40-49   50-59   60-69   70-89   TOTAL
     ----------------------------------------------------------------------

JOB
  E      0       0       0       0       0       0       0       0       0
  W      0       0       0       0       0       0       0       0       0
  I      0       1       5       0       0       0       0       0       6
     ----------------------------------------------------------------------
         0       1       5       0       0       0       0       0       6

      ****    ERROR MESSAGES    ****

             ---  NONE  ---


      ****   WARNING MESSAGES   ****

             ---  NONE  ---
```

Figure 2-18. Third Part of the Summary File for the Merge Processing

2.2.4 Stage 3 - estimating boundary layer parameters for AERMOD

With all the NWS meteorological data merged into one file, Stage 3 can be run to generate the two input files for AERMOD, as shown in Figure 2-19.

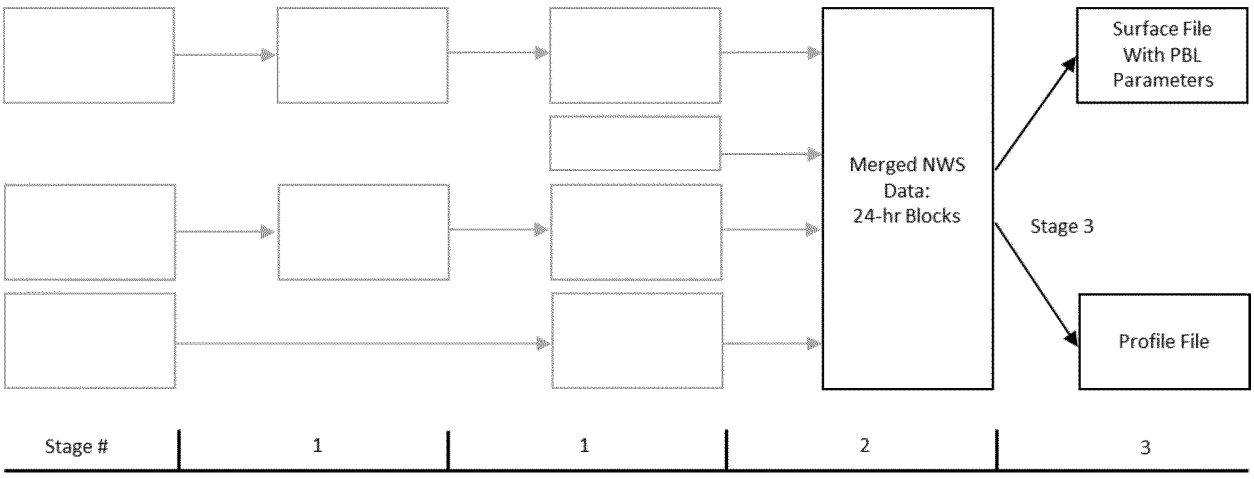

Figure 2-19. Stage 3 Processing Using the Merged NWS Data to Create the Input Meteorology for AERMOD

The meteorological data for AERMOD are generated in Stage 3. The input runstream file can only include statements for the JOB and METPREP pathways which control the Stage 3 processing. An example runstream is shown in Figure 2-20 and is provided in the file EX1-ST3.INP.

ED_001739_00002136-00072

```
JOB                                     Start of the JOB pathway

  REPORT     STAGE3-1.RPT               File for all messages

  MESSAGES   STAGE3-1.MSG               File for the run  summary

METPREP                                 Start of the   METPREP  pathway

  DATA       MERGE.DSK                  Input meteorological data file from Stage 2
  METHOD     REFLEVEL  SUBNWS           Processing method: allow substitution of NWS
                                        data

  METHOD     WIND_DIR  RANDOM           Processing method: randomize NWS wind  directions

  NWS_HGT    WIND   6.1                 NWS wind measurement height

  OUTPUT     AERMET.SFC                 Output file with boundary layer parameters

  PROFILE    AERMET.PFL                 Output   file with profile  data

  FREQ_SECT  ANNUAL  1                  Frequency and number of wind direction sectors to
                                        define the primary site characteristics

  SECTOR     1  0  360                  Definition of wind direction sectors for primary
                                        site characteristics

  SITE_CHAR  1  1  0.15  2.00  0.12     Definition of primary site characteristics by
                                        period
                                        and wind direction sector
```

Figure 2-20. Example Stage 3 Runstream to Create the Output Files for AERMOD

The keywords used in this example are:

DATA - specifies the input file name of the merged data from Stage 2;

NWS_HGT - specifies the instrument height for the variable indicated;

METHOD - defines a specific processing methodology for the secondary keyword specified with this keyword;

OUTPUT - specifies the output file of fluxes, scaling parameters, mixing height, near-surface winds and temperature;

PROFILE - specifies the output file of the multi-level observations of temperature, winds and fluctuating components of the wind;

FREQ_SECT - specifies the frequency and number of wind direction sectors for defining

ED_001739_00002136-00073

the **primary** set of characteristics of surface roughness length, albedo and midday Bowen ratio; this keyword must appear before the next two keywords;

SECTOR - specifies the lower and upper bounds of individual wind direction sectors for the **primary** set of characteristics; up to 12 sectors can be defined and the directions so specified must account for all directions;

SITE_CHAR - defines the albedo, midday Bowen ratio and surface roughness length by frequency and sector (in that order) for the **primary** set of characteristics;

Note that the LOCATION keyword under the METPREP pathway in Stage 3 is no longer used by AERMET, unless site-specific mixing heights are used without any upper air sounding data. A warning message will be generated in these cases if the LOCATION keyword is included under the METPREP pathway, and the METPREP inputs will be ignored. For applications with only site-specific mixing heights, without upper air data, the LOCATION keyword under the METPREP should be used to specify the conversion from GMT to LST.

Beginning with version 11059, AERMET requires two sets of surface characteristics (**primary** and **secondary**) when both NWS surface data (including 1-minute ASOS wind data) and site-specific data are provided. If either NWS surface data or site-specific data are omitted, only a single (primary) set of surface characteristics is required. The secondary set of surface characteristics and related parameters are specified, similar to the primary set, with the keywords FREQ_SECT2, SECTOR2, and SITE_CHAR2.

DATA, OUTPUT, and PROFILE

The input data file created by Stage 2, MERGE.DSK, is identified through the DATA keyword. The OUTPUT and PROFILE keywords define the output files that will be used as input to the AERMOD dispersion model. In this example, the two files are AERMET.SFC and AERMET.PFL, respectively. The output files are ASCII files and can be viewed with a text

ED_001739_00002136-00074

editor or file viewer. The format of these two output files is given in Appendix D. Each record of the OUTPUT file contains the surface fluxes of heat and momentum, scaling and stability parameters, boundary layer height, and the site's surface characteristics, winds and temperature that were used to compute these values. The PROFILE file usually consists of one or more levels of wind, temperature and standard deviations of the wind from a site-specific observation program or from NWS data if site-specific data are missing or not in the data base.

METHOD

The METHOD keyword and associated secondary keywords direct AERMET to process the data in a particular manner. Depending on the data in the data base and the intended use for the output, this keyword may be optional or mandatory.

In this example REFLEVEL and WIND_DIR are used. (Refer to Section 4.7.6 for a discussion of the different processing options that can be specified using the METHOD keyword.) The REFLEVEL secondary keyword takes a single parameter and the only valid parameter, SUBNWS which directs AERMET to substitute NWS data in the computations in the event there are no site-specific data to use. If there are no site-specific data in the data base, this secondary keyword becomes mandatory. If it is omitted, AERMET detects this condition (no site-specific data and do not substitute NWS data) as an error and will not process any data. If there are site-specific data in the data base, but some of the variables required for the computations are missing, then this parameter directs AERMET to use the NWS data to estimate the boundary layer parameters. Also, if the site-specific profiles of wind or temperature are missing, this parameter directs AERMET to use NWS data to create the profile of wind and/or temperature.

NWS wind directions are recorded to the nearest 10 degrees. The WIND_DIR secondary keyword directs AERMET to randomize these directions if the RANDOM parameter is specified or to leave the directions as they were extracted from the archive file if the NORAND parameter is specified. The default is not to randomize, so if this secondary keyword

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is omitted, then any NWS wind directions will appear to the nearest 10 degrees (equivalent to specifying NORAND). This example uses the RANDOM parameter and all NWS wind directions used in the computations and written to the output files are randomized. The EPA's standard table of random integers, which is built into AERMET, is used to randomize wind direction.

NWS_HGT

Many computations in AERMET require the height at which a variable was measured. The NWS_HGT keyword is used to define these heights for AERMET and is a mandatory keyword when the REFLEVEL secondary keyword is used with the SUBNWS parameter. Otherwise, the NWS_HGT keyword can be omitted. This keyword requires a secondary keyword and parameter. The secondary keyword identifies the instrument that is being referenced, and the parameter defines the height of the instrument, which must be specified in meters. Currently, the only secondary keyword is WIND. Typical measurement heights at NWS/FAA ASOS stations are 26 feet (7.9 meters) or 33 feet (10.1 meters). Heights for historical data likely differ from these. The *Local Climatological Data Annual Summaries* available from NCDC contain a historical record of instrumentation sites. In this example, the height of the anemometer that measures the wind is at 6.1 meters (20 feet).

FREQ_SECT, SECTOR, and SITE_CHAR

The algorithms in Stage 3 require characteristics about the underlying surface where the surface meteorological data were collected, including: the noon-time albedo, daytime Bowen ratio, and surface roughness length. Beginning with version 11059, AERMET requires two sets of these surface values when both site-specific and NWS surface data (including 1-minute ASOS wind data) are provided to AERMET and the SUBNWS parameter is specified. In that case, the characteristics for the site-specific location are the **primary** set, and the NWS collection site is the **secondary** set. When only site-specific or NWS surface data are used, only a **primary** set of surface characteristics is required, and they should be representative of the site

ED_001739_00002136-00076

where the data were collected. Three keywords are used to define primary set of surface characteristics: FREQ_SECT, SECTOR, and SITE_CHAR. A primary set of surface characteristics is always required. Similarly, the secondary set are defined with the keywords FREQ_SECT2, SECTOR2, and SITE_CHAR2. The secondary set is conditional as explained above.

The FREQ_SECT and FREQ_SECT2 keywords have two parameters associated with them: the first defines the frequency with which the site characteristics vary and the second defines the number of contiguous, nonoverlapping wind direction sectors that define unique upwind surface characteristics.

→ **The FREQ_SECT keyword must precede the SECTOR and SITE_CHAR keywords**. Likewise, the FREQ_SECT2 keyword must precede the SECTOR2 and SITE_CHAR2 keywords.

There are three valid time frequencies: ANNUAL, SEASONAL, or MONTHLY. For program operation, the definition of SEASONAL in AERMET follows the calendar rather than any vegetation cycles. Winter corresponds to December, January and February; spring corresponds to March, April and May; summer corresponds to June, July and August; and autumn corresponds to September, October and November. The user will have to determine how the definitions of the seasons in the tables relate to vegetation cycles for a particular application. Currently, there is no method in AERMET to specify the surface characteristics more frequently than monthly.

In this example, the surface characteristics are to be defined with a frequency of ANNUAL for one distinct wind direction sector; i.e., only the three surface characteristics are changed while the default frequency and sector definition are retained. If the maximum frequency and sectors had been defined, then it would require 144 (12 frequencies and 12 sectors) uses of the SITE_CHAR keyword to completely define the surface characteristics. An example of MONTHLY characteristics for two sectors in given in Section 3.0.

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The SECTOR and SECTOR2 keywords each define the beginning and ending directions of each sector, with one sector defined on each use of the keyword. There are several rules to follow when specifying the sectors:

1) The sectors are defined clockwise as the direction from which the wind is blowing, with north corresponding to 360°.

2) The sectors must cover the full circle, and these must be defined so that the end of one sector is the beginning of another, i.e., for multiple sector definitions, the beginning value for one sector <u>must match</u> the end value of the previous sector.

3) The beginning direction is considered part of the sector, while the ending direction is excluded from the sector.

4) The maximum number of sectors is 12.

One SECTOR keyword is required in this example because '1' was specified with the FREQ_SECT keyword. The sector must be 0° - 360° so as not to violate rule 2 above.

The surface characteristics are specified with the SITE_CHAR and SITE_CHAR2 keywords, one for each combination of periods defined by the frequency and direction sector. The parameters associated with these keywords include:

1) the time period corresponding with the frequency on the FREQ_SECT (or FREQ_SECT2) keyword;

2) wind sector index;

3) the midday albedo (nondimensional);

4) daytime Bowen ratio (nondimensional);

5) surface roughness length (meters).

These parameters are used in the computation of the fluxes and stability of the atmosphere. The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. Typical values range from 0.1 for thick deciduous forests to 0.90 for fresh snow. The Bowen ratio, an indicator of surface moisture, is the ratio of the

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sensible heat flux to the latent heat flux. Although the Bowen ratio can have significant diurnal variation, it is used to determine the planetary boundary layer parameters for convective conditions. During the daytime, the Bowen ratio usually attains a fairly constant positive value, which range from about 0.1 over water to 10.0 over desert at midday. The surface roughness length is related to the height of obstacles to the wind flow and is, in principle, the height at which the mean horizontal wind speed is zero. Values range from as small as 0.001 meter over a calm water surface to 1 meter or more over a forest or urban area.

Tables 4-1 to 4-3 (from Paine, 1987) show typical values of the albedo, Bowen ratio and surface roughness length as a function of season and land use type. The season in these tables are based on the emergence and growth of vegetation. For example, March in one part of the country may represent spring whereas in another part of the country it may well be winter. See Section 4.7.8 and Section 5.7.2 for additional discussions on the surface characteristics.

The LOCATION keyword is now a conditional keyword that is mandatory when site-specific mixing heights are used without upper air sounding data. Refer to Section 4.7.3 for more discussion on the use of the LOCATION keyword on the METPREP pathway.

Optional keywords that are available for Stage 3 processing are:

XDATES - restricts the processing to a subset of the input data;

MODEL - specifies the dispersion model for which the estimates are made; currently AERMET only generates the meteorological data for AERMOD, so this keyword is optional.

A detailed discussion of each of the keywords on the METPREP pathway is provide in Section 4.0, with a synopsis of each in Appendix A.

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2.2.4.1 Running stage 3 and reviewing the output

To run Stage 3 to create the meteorological files for AERMOD, the following command lines are used:

```
COPY   EX1-ST3.INP   AERMET.INP
AERMET
```

where EX1-ST3.INP is the example runstream file name. The discussion for redirecting output (Section 2.2) also applies to Stage 3 processing. The executable and version date, setup processing, and data processing are displayed on the screen as described in Section 2.2.1.3.

Figure 2-21 shows the message file that results from running EX1-ST3.INP. The file begins with the familiar message that the end of file was located after record number 26. This message is followed by eight messages that the boundary layer parameters were not computed for the specified date (leftmost) field and time (at the end of the message) due to calm winds. When calm wind conditions are encountered, AERMET does not perform any computations and inserts missing data indicators into the output files for the boundary layer parameters (see Figure 2-25 for an example of the output file). The final message indicates that AERMET encountered an end of file on the input meteorological data, i.e., on the merged data file, after March 4, 1988. Since March 1-4, 1988 were the only days merged, this message indicates that all the data appear to have been processed.

```
        JOB        I19  SETUP  : "END OF FILE" ON UNIT  5 AFTER RECORD #  26
        METPREP    I41 FNDCOMDT: ASOS commission date FOUND for WBAN =  14735;
                                 CALL4 = KALB; CALL3 = ALB; CommDate = 19950801
880301 METPREP     I84  MPPBL  : Upper air sounding selected for this day: 12 Z
880301 METPREP     I84  MPPBL  : UAID =   1 for HR:   7 LST
880302 METPREP     I71  MPPBL  : Calm wind - No BL calculations for hour:  02
880302 METPREP     I71  MPPBL  : Calm wind - No BL calculations for hour:  03
880302 METPREP     I71  MPPBL  : Calm wind - No BL calculations for hour:  04
880302 METPREP     I71  MPPBL  : Calm wind - No BL calculations for hour:  05
880302 METPREP     I71  MPPBL  : Calm wind - No BL calculations for hour:  06
880302 METPREP     I71  MPPBL  : Calm wind - No BL calculations for hour:  07
880302 METPREP     I84  MPPBL  : Upper air sounding selected for this day: 12 Z
880302 METPREP     I84  MPPBL  : UAID =   3 for HR:   7 LST
880303 METPREP     I71  MPPBL  : Calm wind - No BL calculations for hour:  19
```

```
880303 METPREP    I71  MPPBL  : Calm wind - No BL calculations for hour:  21
880303 METPREP    I84  MPPBL  : Upper air sounding selected for this day: 12 Z
880303 METPREP    I84  MPPBL  : UAID =   3 for HR:   7 LST
880304 METPREP    I84  MPPBL  : Upper air sounding selected for this day: 12 Z
880304 METPREP    I84  MPPBL  : UAID =   3 for HR:   7 LST
     4 METPREP    I79  FETCH  : EOF reached on input data file after 000000
```

Figure 2-21. Message File from Stage 3 for EX1-ST3.INP

The summary of the run is shown in Figure 2-22 through Figure 2-24. The first and last pages of the summary (Figure 2-22 and Figure 2-24) contain similar information as the first and last pages of the summaries generated in stages 1 and 2. The second page includes the following :

1. The names of the input and output files and whether the files were opened.
2. The name of the dispersion model for which the data are prepared.
3. The processing options.
4. The site identifiers and locations for each of the meteorological data pathways.
5. The sit6. The output file names for the dispersion model identified.

Figure 2-25 shows the first 36 hours from the boundary layer parameter file. The first record contains the latitude and longitude used in processing the meteorological data in Stage 3, the station identifiers, and the AERMET version date. The identifier after OS_ID: is a 0 because no site-specific data were processed. The OS_ID is <u>not</u> the identifier specified in the Stage 3 runstream; the three identifiers that are displayed come from the processing in Stage 1. This record is followed by one record per hour of meteorological output data. The contents of this file are:

field(s)	description
1-5	year (2-digit), month, day, Julian day, and hour
6	sensible heat flux (W/m^2)
7	surface friction velocity (m/s)
8	convective velocity scale (set to -9.0 for stable atmosphere) (m/s)
9	potential temperature gradient above the mixing height (K/m)
10	convectively-driven mixing height (-999. for stable atmosphere) (m)
11	mechanically-driven mixing height (computed for all hours) (m)
12	Monin-Obukhov length (m)

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13	surface roughness length (month and wind direction dependent) (m)
14	Bowen ratio (month and wind direction dependent) (non-dimensional)
15	albedo (month and wind direction dependent; 1.0 for hours before sunrise or after sunset) (non-dimensional)
16-18	wind speed, wind direction, and anemometer height that were used in the computations in Stage 3 (m/s degrees, m)
19-20	temperature and measurement height that were used in the computations in Stage 3 (K and m)
21	precipitation type code
22	precipitation amount (mm/hr)
23	relative humidity (%)
24	station pressure (mb)
25	cloud cover (tenths)
26	wind speed adjustment and data source flag
27	cloud cover and temperature substitution by interpolation

The format of this file is included in Appendix C. The theoretical bases for the calculations that estimate the boundary layer parameters are in Section 5.0.

Notice that for March 2, 1988, hours 2-7, the boundary layer parameters are represented by missing value indicators (the various '-9' fields). Examining either the message file or the second page of the summary report, note that the winds were calm for these time periods. The wind speed and direction (fields 16 and 17) are set to 0.0 indicating a calm wind.

In the absence of site-specific data, as in this example, AERMET substitutes the NWS data. Note that the anemometer height (field 18) is the height specified with the NWS_HGT keyword. Field 26 reports if wind speeds were adjusted for the hour to account for a bias that occurs in wind speed data collected at NWS/FAA sites that use an Automated Surface Observing System (ASOS). This field also reports the source of the wind data for the hour. In the example, though the source of the wind data for each hour is a standard NWS/FAA surface archive format (SFC), the site was not ASOS-based at the time the data were collected and the wind speeds were not adjusted (NAD). The adjustment applied to ASOS-based wind data is discussed further in Section 4.7.6.3. Field 27 indicates whether cloud cover and/or temperature for the hour was substituted using interpolation (see Section 4.7.6.5). In Section 3.0, we will see how the introduction of site-specific data affects the output in this file.

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Figure 2-26 shows the first 36 hours from the profile file. The contents of this file are:

field(s)	description
1-4	year (2-digit), month, day, and hour
5	measurement height (m)
6	indicator flag: 1=last level in profile for the hour, 0=not the last level
7-8	wind direction and speed (m/s, m)
9	temperature (°C)
10	σ_θ- standard deviation of the lateral wind direction (degrees)
11	σ_w - standard deviation of the vertical wind speed (m/s)

The format of this file is provided in Appendix C. None of the parameters in this file are computed; the only changes that may occur are conversion of the units.

For this example there is one record per hour of meteorological output data. Since there are no site-specific data in this example, AERMET constructed a one-level profile by substituting NWS data. These data match the last fields in the boundary layer parameter file, except that the temperature is expressed in different units. Since the NWS does not report the fluctuating components of the wind (the σ's), these fields are filled with the missing value indicators. In Section 3.0, we will see how the introduction of site-specific data affects the output in this file.

ED_001739_00002136-00083

```
        AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                  Version  15181

                    Data Processed on  2-SEP-2016 at 13:09:21

                                     Stage 3                          Page   1

              ********************************************************
              ***        AERMET Setup Finished Successfully        ***
              ********************************************************

 1.  Job File Names

     Listing of Messages: STAGE3-1.MSG
     Summary (this file): STAGE3-1.RPT


 2.  Upper Air Data

      Site ID    Latitude(deg.)   Longitude(deg.)   Time Adjustment
     00014735       42.75N             73.8W               5

     AERMET Has Determined That Processing For This Pathway Includes:
          NONE, NO DATA TO BE PROCESSED ON THIS PATH



 3.  NWS Surface Data

      Site ID    Latitude(deg.)   Longitude(deg.)   Time Adjustment   Elev. (m)
        14735       42.75N             73.8W               0             83.8

     AERMET Has Determined That Processing For This Pathway Includes:
          NONE, NO DATA TO BE PROCESSED ON THIS PATH



 4.  On-site Data

     AERMET Has Determined That Processing For This Pathway Includes:
          NONE, NO DATA TO BE PROCESSED ON THIS PATH
```

Figure 2-22. First Part of the Summary File from Stage 3

```
AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                          Version  15181

              Data Processed on  2-SEP-2016 at 13:09:21

                              Stage 3                          Page   2

        *******************************************************
        ***        AERMET Setup Finished Successfully        ***
        *******************************************************

1.  Input/Output Files

    STAGE3-1.RPT                                        OPENED SUCCESSFULLY
    STAGE3-1.MSG                                        OPENED SUCCESSFULLY
    MERGE.DSK                                           OPENED SUCCESSFULLY
    AERMET.SFC                                          OPENED SUCCESSFULLY
    AERMET.PFL                                          OPENED SUCCESSFULLY

2.  Dispersion Model for which Data Are Processed

      AERMOD

      The Processed Dates Are:    Starting:  1-MAR-1988
                                    Ending:  4-MAR-1988

      Based on the MERGE file header records.

3.  Processing Options

       Process       Scheme         Description
       -------       ------         -----------
    WIND DIRECTION   RANDOM      NWS wind directions are RANDOMIZED
    CLOUD COVER      CCVR_Sub    Missing CCVR substitutions ARE included
    TEMPERATURE      TEMP_Sub    Missing TEMP substitutions ARE included
    SBL PROCESSING   UCALST      The default (Holtslag) method is used
    ASOS ADJUSTMENT  ASOS_ADJ    ASOS wind speeds, if present, ARE adjusted for truncation
    SDG SELECTION    00Z/12Z     Sounding selection based on 12Z sdg
                                  Selection window:  -1     1
    REFERENCE LEVEL  SUBNWS      NWS WIND & TEMP data ARE SUBSTITUTED for missing ONSITE data
                                  Anemometer height(m):    6.10

4.  Locations of Meteorological Data

     Data           Site     Longitude   Latitude
    Pathway          ID      (degrees)   (degrees)
    -------         ----     ---------   ---------
    UPPERAIR     00014735       73.8W      42.75N
    SURFACE         14735       73.8W      42.75N

5.  Primary Site Surface Characteristics

      User Inputs Varied by: Annual

             Wind Sector               Bowen   Roughness
      Month   Start   End    Albedo     Ratio   Length (m)
      ---------------------------------------------------
        1        0.  360.      0.15      2.00     0.1200
        2        0.  360.      0.15      2.00     0.1200
        3        0.  360.      0.15      2.00     0.1200
        4        0.  360.      0.15      2.00     0.1200
        5        0.  360.      0.15      2.00     0.1200
        6        0.  360.      0.15      2.00     0.1200
        7        0.  360.      0.15      2.00     0.1200
        8        0.  360.      0.15      2.00     0.1200
        9        0.  360.      0.15      2.00     0.1200
       10        0.  360.      0.15      2.00     0.1200
       11        0.  360.      0.15      2.00     0.1200
       12        0.  360.      0.15      2.00     0.1200

6.  Input File(s) for   AERMOD

      Surface Meteorology:  AERMET.SFC
      Profile Data       :  AERMET.PFL
```

Figure 2-23. Second Part of the Summary File from Stage 3

```
AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                          Version  15181

              Data Processed on  2-SEP-2016 at 13:09:21
```

```
                                    Stage 3                          Page   3

             ********************************************************
             ***   AERMET Data Processing Finished Successfully   ***
             ********************************************************

              PROCESSING METEOROLOGICAL DATA FOR DISPERSION MODELING


                     **** AERMET MESSAGE SUMMARY TABLE ****

         0- 9   10-19   20-29   30-39   40-49   50-59   60-69   70-89   TOTAL
      ------------------------------------------------------------------------

 JOB
   E      0       0       0       0       0       0       0       0       0
   W      0       0       0       0       0       0       0       0       0
   I      0       1       0       0       0       0       0       0       1

 METPREP
   E      0       0       0       0       0       0       0       0       0
   W      0       0       0       0       0       0       0       0       0
   I      0       0       0       0       1       0       0      17      18
   T      0       0       0       0       0       0       0       0       0
      ------------------------------------------------------------------------
          0       1       0       0       1       0       0      17      19

       ****    ERROR MESSAGES    ****

              ---  NONE  ---


       ****   WARNING MESSAGES   ****

              ---  NONE  ---


   ASOS Commission Date for Surface Station    14735 (YYYYMMDD): 19950801


The number of CALM winds  encountered is:      8
The number of VARIABLE WD encountered is:      0
The number of miss CCVR substitutions is:      0
The number of miss TEMP substitutions is:      0
```

Figure 2-24. Third Part of the Summary File from Stage 3

ED_001739_00002136-00087

```
    42.75N     73.8W          UA_ID: 00014735  SF_ID:    14735  OS_ID:              VERSION: 15181    CCVR_Sub TEMP_Sub
88  3  1  61  1  -30.4  0.283 -9.000 -9.000 -999.  361.     66.5  0.1200   2.00   1.00    3.10  275.0    6.1  270.4    2.0     0  -9.00   999.  1003.     4 NAD-SFC NoSubs
88  3  1  61  2  -45.5  0.392 -9.000 -9.000 -999.  588.    118.1  0.1200   2.00   1.00    4.10  279.0    6.1  270.4    2.0     0  -9.00   999.  1003.     1 NAD-SFC NoSubs
88  3  1  61  3  -45.7  0.392 -9.000 -9.000 -999.  588.    117.5  0.1200   2.00   1.00    4.10  279.0    6.1  269.2    2.0     0  -9.00   999.  1003.     1 NAD-SFC NoSubs
88  3  1  61  4  -58.4  0.499 -9.000 -9.000 -999.  845.    190.0  0.1200   2.00   1.00    5.10  290.0    6.1  268.1    2.0     0  -9.00   999.  1003.     1 NAD-SFC NoSubs
88  3  1  61  5  -64.0  0.563 -9.000 -9.000 -999. 1012.    249.2  0.1200   2.00   1.00    5.70  290.0    6.1  267.5    2.0     0  -9.00   999.  1003.     0 NAD-SFC NoSubs
88  3  1  61  6  -25.7  0.218 -9.000 -9.000 -999.  407.     35.9  0.1200   2.00   1.00    2.60  295.0    6.1  267.5    2.0     0  -9.00   999.  1004.     0 NAD-SFC NoSubs
88  3  1  61  7  -59.0  0.499 -9.000 -9.000 -999.  845.    188.1  0.1200   2.00   1.00    5.10  286.0    6.1  267.0    2.0     0  -9.00   999.  1004.     0 NAD-SFC NoSubs
88  3  1  61  8    6.3  0.420  0.241  0.009   78.  658.  -1045.4  0.1200   2.00   0.38    4.10  315.0    6.1  267.5    2.0     0  -9.00   999.  1005.     6 NAD-SFC NoSubs
88  3  1  61  9   66.0  0.741  0.942  0.005  453. 1530.   -551.8  0.1200   2.00   0.24    7.20  273.0    6.1  268.1    2.0     0  -9.00   999.  1005.     7 NAD-SFC NoSubs
88  3  1  61 10  132.4  0.847  1.361  0.005  683. 1863.   -410.8  0.1200   2.00   0.19    8.20  297.0    6.1  268.1    2.0     0  -9.00   999.  1005.     6 NAD-SFC NoSubs
88  3  1  61 11  191.7  0.802  1.591  0.005  755. 1730.   -241.2  0.1200   2.00   0.17    7.70  297.0    6.1  268.8    2.0     0  -9.00   999.  1005.     2 NAD-SFC NoSubs
88  3  1  61 12  211.8  0.912  1.724  0.005  867. 2082.   -320.4  0.1200   2.00   0.16    8.80  268.0    6.1  268.8    2.0     0  -9.00   999.  1004.     0 NAD-SFC NoSubs
88  3  1  61 13  214.9  0.962  1.822  0.005 1008. 2256.   -370.0  0.1200   2.00   0.16    9.30  271.0    6.1  269.2    2.0     0  -9.00   999.  1003.     0 NAD-SFC NoSubs
88  3  1  61 14  194.9  0.753  1.821  0.005 1108. 1631.   -196.0  0.1200   2.00   0.17    7.20  306.0    6.1  269.2    2.0     0  -9.00   999.  1002.     0 NAD-SFC NoSubs
88  3  1  61 15  152.6  0.958  1.712  0.005 1177. 2240.   -514.1  0.1200   2.00   0.18    9.30  256.0    6.1  268.8    2.0     0  -9.00   999.  1002.     0 NAD-SFC NoSubs
88  3  1  61 16   90.0  0.743  1.454  0.005 1221. 1603.   -407.7  0.1200   2.00   0.22    7.20  268.0    6.1  268.8    2.0     0  -9.00   999.  1001.     0 NAD-SFC NoSubs
88  3  1  61 17   13.1  0.897  0.766  0.005 1225. 2032.  -4930.7  0.1200   2.00   0.33    8.80  270.0    6.1  267.5    2.0     0  -9.00   999.  1001.     0 NAD-SFC NoSubs
88  3  1  61 18  -64.0  0.889 -9.000 -9.000 -999. 2012.    979.8  0.1200   2.00   0.65    8.80  266.0    6.1  265.9    2.0     0  -9.00   999.  1001.     0 NAD-SFC NoSubs
88  3  1  61 19  -64.0  0.889 -9.000 -9.000 -999. 2012.    979.8  0.1200   2.00   1.00    8.80  273.0    6.1  265.4    2.0     0  -9.00   999.  1001.     0 NAD-SFC NoSubs
88  3  1  61 20  -64.0  0.670 -9.000 -9.000 -999. 1379.    419.5  0.1200   2.00   1.00    6.70  278.0    6.1  264.2    2.0     0  -9.00   999.  1002.     0 NAD-SFC NoSubs
88  3  1  61 21  -64.0  0.670 -9.000 -9.000 -999. 1317.    419.0  0.1200   2.00   1.00    6.70  285.0    6.1  263.8    2.0     0  -9.00   999.  1001.     0 NAD-SFC NoSubs
88  3  1  61 22  -53.3  0.445 -9.000 -9.000 -999.  766.    147.6  0.1200   2.00   1.00    4.60  294.0    6.1  263.1    2.0     0  -9.00   999.  1001.     0 NAD-SFC NoSubs
88  3  1  61 23  -33.4  0.278 -9.000 -9.000 -999.  382.     57.5  0.1200   2.00   1.00    3.10  220.0    6.1  262.5    2.0     0  -9.00   999.  1001.     0 NAD-SFC NoSubs
88  3  1  61 24  -26.1  0.216 -9.000 -9.000 -999.  244.     34.6  0.1200   2.00   1.00    2.60  209.0    6.1  261.4    2.0     0  -9.00   999.  1001.     0 NAD-SFC NoSubs
88  3  2  62  1   -6.9  0.076 -9.000 -9.000 -999.   71.      5.8  0.1200   2.00   1.00    1.50  289.0    6.1  260.4    2.0     0  -9.00   999.  1001.     0 NAD-SFC NoSubs
88  3  2  62  2 -999.0 -9.000 -9.000 -9.000 -999. -999. -99999.0  0.1200   2.00   1.00    0.00    0.0    6.1  259.2    2.0     0  -9.00   999.  1000.     0 NAD-SFC NoSubs
88  3  2  62  3 -999.0 -9.000 -9.000 -9.000 -999. -999. -99999.0  0.1200   2.00   1.00    0.00    0.0    6.1  258.8    2.0     0  -9.00   999.   999.     0 NAD-SFC NoSubs
88  3  2  62  4 -999.0 -9.000 -9.000 -9.000 -999. -999. -99999.0  0.1200   2.00   1.00    0.00    0.0    6.1  258.1    2.0     0  -9.00   999.   999.     0 NAD-SFC NoSubs
88  3  2  62  5 -999.0 -9.000 -9.000 -9.000 -999. -999. -99999.0  0.1200   2.00   1.00    0.00    0.0    6.1  258.8    2.0     0  -9.00   999.   999.     0 NAD-SFC NoSubs
88  3  2  62  6 -999.0 -9.000 -9.000 -9.000 -999. -999. -99999.0  0.1200   2.00   1.00    0.00    0.0    6.1  257.5    2.0     0  -9.00   999.   999.     0 NAD-SFC NoSubs
88  3  2  62  7 -999.0 -9.000 -9.000 -9.000 -999. -999. -99999.0  0.1200   2.00   1.00    0.00    0.0    6.1  257.5    2.0     0  -9.00   999.   999.     2 NAD-SFC NoSubs
88  3  2  62  8   -3.0  0.208 -9.000 -9.000 -999.  227.    268.5  0.1200   2.00   0.37    2.10  118.0    6.1  262.0    2.0     0  -9.00   999.   999.     0 NAD-SFC NoSubs
88  3  2  62  9   73.4  0.438  0.789  0.019  238.  696.   -102.0  0.1200   2.00   0.23    4.10  163.0    6.1  264.2    2.0     0  -9.00   999.   999.     0 NAD-SFC NoSubs
88  3  2  62 10  143.1  0.651  1.127  0.010  357. 1260.   -171.8  0.1200   2.00   0.18    6.20  174.0    6.1  265.9    2.0     0  -9.00   999.  1000.     5 NAD-SFC NoSubs
88  3  2  62 11  187.5  0.504  1.350  0.012  469.  881.    -60.9  0.1200   2.00   0.17    4.60  147.0    6.1  267.0    2.0     0  -9.00   999.  1000.     5 NAD-SFC NoSubs
88  3  2  62 12  217.5  0.508  1.505  0.012  560.  869.    -53.7  0.1200   2.00   0.16    4.60  165.0    6.1  269.2    2.0     0  -9.00   999.  1000.     1 NAD-SFC NoSubs
```

Figure 2-25. First 36 Hours of the Boundary Layer Parameter File, AERMET.SFC

```
88  3  1  1     6.1 1   275.0     3.10    -2.80    99.00    99.00
88  3  1  2     6.1 1   279.0     4.10    -2.80    99.00    99.00
88  3  1  3     6.1 1   279.0     4.10    -3.90    99.00    99.00
88  3  1  4     6.1 1   290.0     5.10    -5.00    99.00    99.00
88  3  1  5     6.1 1   290.0     5.70    -5.60    99.00    99.00
88  3  1  6     6.1 1   295.0     2.60    -5.60    99.00    99.00
88  3  1  7     6.1 1   286.0     5.10    -6.10    99.00    99.00
88  3  1  8     6.1 1   315.0     4.10    -5.60    99.00    99.00
88  3  1  9     6.1 1   273.0     7.20    -5.00    99.00    99.00
88  3  1 10     6.1 1   297.0     8.20    -5.00    99.00    99.00
88  3  1 11     6.1 1   297.0     7.70    -4.40    99.00    99.00
88  3  1 12     6.1 1   268.0     8.80    -4.40    99.00    99.00
88  3  1 13     6.1 1   271.0     9.30    -3.90    99.00    99.00
88  3  1 14     6.1 1   306.0     7.20    -3.90    99.00    99.00
88  3  1 15     6.1 1   256.0     9.30    -4.40    99.00    99.00
88  3  1 16     6.1 1   268.0     7.20    -4.40    99.00    99.00
88  3  1 17     6.1 1   270.0     8.80    -5.60    99.00    99.00
88  3  1 18     6.1 1   266.0     8.80    -7.20    99.00    99.00
88  3  1 19     6.1 1   273.0     8.80    -7.80    99.00    99.00
88  3  1 20     6.1 1   278.0     6.70    -8.90    99.00    99.00
88  3  1 21     6.1 1   285.0     6.70    -9.40    99.00    99.00
88  3  1 22     6.1 1   294.0     4.60   -10.00    99.00    99.00
88  3  1 23     6.1 1   220.0     3.10   -10.60    99.00    99.00
88  3  1 24     6.1 1   209.0     2.60   -11.70    99.00    99.00
88  3  2  1     6.1 1   289.0     1.50   -12.80    99.00    99.00
88  3  2  2     6.1 1     0.0     0.00   -13.90    99.00    99.00
88  3  2  3     6.1 1     0.0     0.00   -14.40    99.00    99.00
88  3  2  4     6.1 1     0.0     0.00   -15.00    99.00    99.00
88  3  2  5     6.1 1     0.0     0.00   -14.40    99.00    99.00
88  3  2  6     6.1 1     0.0     0.00   -15.60    99.00    99.00
88  3  2  7     6.1 1     0.0     0.00   -15.60    99.00    99.00
88  3  2  8     6.1 1   118.0     2.10   -11.10    99.00    99.00
88  3  2  9     6.1 1   163.0     4.10    -8.90    99.00    99.00
88  3  2 10     6.1 1   174.0     6.20    -7.20    99.00    99.00
88  3  2 11     6.1 1   147.0     4.60    -6.10    99.00    99.00
88  3  2 12     6.1 1   165.0     4.60    -3.90    99.00    99.00
```

Figure 2-26. First 36 Hours of the Profile File, AERMET.PFL

3.0 Advanced tutorial

In the example in Section 2.0, only NWS data were used to estimate the boundary layer parameters for AERMOD. In this section, a second example is presented that introduces data from a site-specific meteorological observation program into the data processing. This example builds on the data that were processed in Section 2.0 - the hourly surface observations and upper air soundings - without modification. The keywords associated with the ONSITE pathway for Stage 1 and the related required modifications to the runstreams for Stage 2 and Stage 3 are presented. At the end of this section, a short discussion on combining and separating processing steps in Stage 1 is presented.

3.1 Example 2: site-specific data

Unlike NWS data where the data are in predefined formats and the processing is reasonably straightforward, site-specific data do not come in a 'prepackaged' archive format and the user must know the structure of the data, including how missing values are reported. Processing the data becomes more complicated. Several exercises will be suggested, requiring minimal modifications to the runstreams provided with this example, so the user can see the consequence of including or excluding keywords.

The example leads the user through the steps necessary to generate the input data files for AERMOD using both NWS and site-specific meteorological data. Before reading the discussion of the keywords and output for this example, we recommend running AERMET to generate the output files - the message files, the summary reports, and the meteorological data output. For this example, it is assumed that the hourly surface and upper air data were extracted and QA'd in the first example. The three additional steps and associated runstream file names to generate the meteorological data for AERMOD are:

- QA site-specific data (Stage 1): EX2-OS.INP

- combine the surface, upper air and site-specific data into one file (Stage 2): EX2-MRG.INP

- process the combined data to produce the meteorological output for AERMOD (Stage 3): EX2-ST3.INP.

The following table shows what to type at the DOS prompt for each step in this example. These steps must be run in the order shown.

To:	At the DOS prompt, type:	Meteorological input data file(s)	Output data
QA site-specific data	COPY EX2-OS.INP AERMET.INP AERMET.EXE	ONSITE.MET	OSQAOUT.DSK
Combine data	COPY EX2-MRG.INP AERMET.INP AERMET.EXE	SFQAOUT.DSK* UAQAOUT.DSK* OSQAOUT.DSK	MERGE2.DSK
Create meteorological files for AERMOD	COPY EX2-ST3. AERMET.INP AERMET.EXE	MERGE2.DSK	AERMET2.SFC AERMET2.PFL

* - these files were generated in the first example.

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As AERMET runs, the progress is displayed on the screen. The display is described below, after the discussion of the keywords. In addition to the output data files, each run will produce a message file (.MSG) and report file (.RPT) file. Note: the file names and extensions are all user-defined; i.e., there are no default names or extensions.

A reminder: all output files are opened with the Fortran file OPEN specifier of STATUS = 'UNKNOWN'. With this specifier, if the file already exists, the contents will be overwritten without any opportunity to save it.

3.1.1 Stage 1 - processing site-specific data

Site-specific data are assumed to be from one or more levels of an instrumented tower, a remote sensor (e.g. sodar), or a combination of the two, and possibly with additional near-surface data, such as insolation and net radiation. The site-specific data that will be processed in this example come from a 100-meter meteorological tower with three levels of data - 10, 50, and 100 meters - with winds, temperature and the fluctuating components of the wind. Four new keywords are added with this example.

There is no standard archive format or content for site-specific data and, as such, places the format of the data completely under the control of the user. Therefore, since there is no archive file, there is no extraction step and the data can be QA'd immediately, as shown in Figure 3-1.

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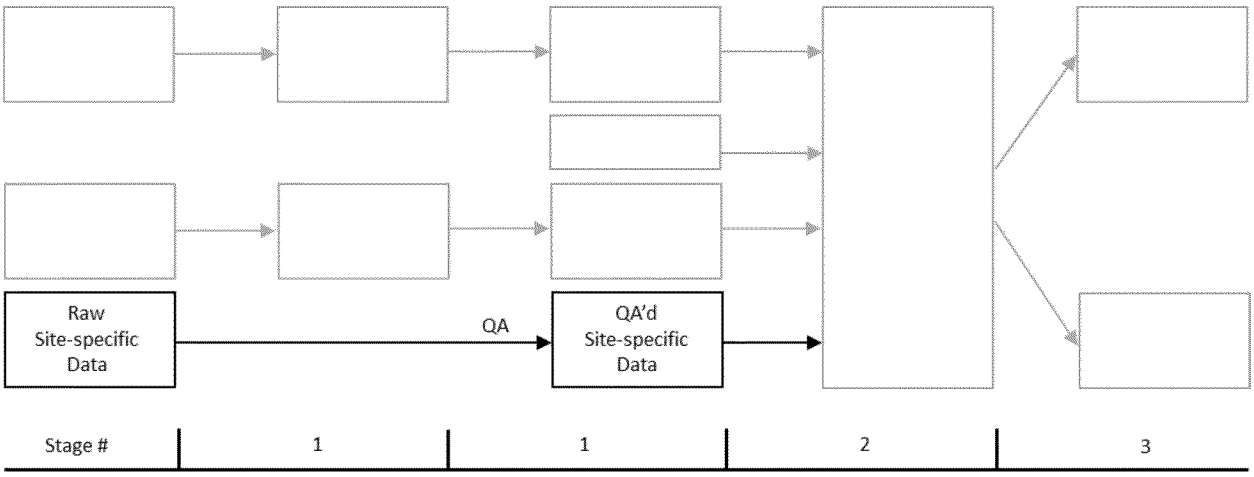

Figure 3-1. Stage 1 Processing of the Site-specific Data

Without a standard format or content, the user must specify the file format (data structure) in AERMET runstream. The format of the site-specific data is reasonably flexible, subject to the following rules:

1) The data for one observation period can be one or more data records, and the records for the period must be contiguous (for this tutorial, refer to this as an "observation group");

2) There can be up to 12 equally-spaced observation periods per hour, i.e., as frequent as every 5 minutes (see the keyword OBS/HOUR in Section 4.0 for a discussion on how to provide AERMET with the frequency of site-specific observations);

3) The same set of variables must appear for all observation periods but not all the same variables must appear on every record in the observation period;

4) The date and time information for each observation must be contained in the first record of the observation period if the observation period spans multiple records; these may occur in any order within the first record, and must be integer format; meteorological variables can also appear on the first record;

5) The variables present within each observation should be a subset of those listed in Appendix B, and Table B-4 (although the user can direct AERMET to skip fields);

6) Single-level variables (e.g., heat flux and observed mixing heights) must be read before any multi-level variables (e.g., winds and temperature); these two types of variables are described below;

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7) The file must be an ASCII text file and it must be in a form that can be read using Fortran FORMAT statements. Note that AERMET supports the free format read which simplifies how the format of the data is specified,, but all values must be read from data records for which a free format read statement is used (see Section 4.5.2).

Figure 3-2 shows a subset of the data for this example. There are three records for each observation group and the data are reported once per hour. The structure and fields are explained below under the "READ and FORMAT" heading. The connection between the rules and the data should become clearer when the keywords used to read the data are discussed.

```
1  3 88  1  0   10.0  48.7   0.110   0.64  317.50    0.80
1  3 88  1  0   50.0  14.7 -99.000   1.84  323.30    2.00
1  3 88  1  0  100.0   9.1   0.410   1.64  320.50    3.70
1  3 88  2  0   10.0  22.5   0.080   0.34  273.10    0.90
1  3 88  2  0   50.0  15.6 -99.000   1.04  304.00    1.50
1  3 88  2  0  100.0  13.4   0.340   0.74  308.50    2.50
1  3 88  3  0   10.0  63.3   0.080  -0.76  276.50    0.60
1  3 88  3  0   50.0  32.9 -99.000   0.04  331.70    1.30
1  3 88  3  0  100.0  27.0   0.390  -0.16  319.10    2.30
```

Figure 3-2. Subset of Site-specific Meteorological Data for Example 2

Figure 3-3 shows the runstream that will be used to QA the site-specific data in this example, and is provided in the file EX2-OS.INP. Several keywords for the ONSITE pathway are identical to those on the SURFACE and UPPERAIR pathways. The basic requirements to process the site-specific data are described below.

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```
JOB                                                                  Start of the JOB pathway

  MESSAGES   ONSITE.MSG                                              Message file

  REPORT     ONSITE.RPT                                              Summary report file

ONSITE                                                               Start of the ONSITE pathway

  DATA         ONSITE.MET                                            Input file with site-
                                                                     specific
                                                                     meteorological data

  XDATES       88/3/1  TO  88/3/10                                   Period of observations to QA

  LOCATION     99999  74.0W  41.3N   0  115.0                       Site identifier and location

  QAOUT        OSQAOUT.DSK                                           Output file

  READ  1  OSDY OSMO OSYR OSHR HT01 SA01 SW01 TT01 WD01 WS01        Variables to read: 1st record
                                                                     of the observation

  READ  2  HT02 SA02 SW02 TT02 WD02 WS02                             Variables to read: 2nd record

  READ  3  HT03 SA03 SW03 TT03 WD03 WS03                             Variables to read: 3rd record

  FORMAT  1  (4(I2,1X),4X,F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1X,F7.2) Format: 1st record of
                                                                     the observation

  FORMAT  2  (16X,F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1X,F7.2)      Format:  2nd record

  FORMAT  3  (16X,F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1X,F7.2)      Format: 3rd record

  RANGE  TT  -30 <  40  -99                                          Redefine QA  parameters
                                                                     for temperature

  RANGE  SA 0  <=  95    -99                                         Redefine QA  parameters for
                                                                     σθ

  RANGE  WS  0  <  50  -999                                          Redefine QA  parameters
                                                                     for wind speed

  RANGE  WD  0  <=  360  -999                                        Redefine QA  parameters
                                                                     for wind direction

  THRESHOLD  0.3                                                     Minimum wind speed below
                                                                     which site-specific winds are
                                                                     treated as calm
```

Figure 3-3. Runstream to QA Site-specific Tower Data

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3.1.1.1 JOB pathway

The JOB pathway keywords are identical to what was presented for the first example. The messages are written to the file ONSITE.MSG and the summary report is written to the file ONSITE.RPT.

3.1.1.2 ONSITE pathway

As with the SURFACE and UPPERAIR pathway statements, the ONSITE statement indicates that a block of keyword statements for the ONSITE pathway are to follow. The basic keywords to QA the site-specific data in this example are:

DATA -	specifies the input file name of the raw data;
XDATES -	specifies the period of time to be retrieved and QA'd from the data file;
LOCATION -	specifies the station identifier, latitude and longitude, the value to convert time to local standard time, and the station elevation in meters;
QAOUT -	specifies the output file name from the QA process; this keyword is also used to specify the input file name to Stage 2;
READ -	defines the order of the variables as they appear in the DATA file; this keyword is repeatable up to the number of records per observation period;
FORMAT -	defines the format of the variables as they appear in the DATA file; this keyword is repeatable;
THRESHOLD -	defines the lowest allowable wind speed in the site-specific data; any wind speeds that are less than this value are treated as calm;
RANGE -	modifies the default upper and lower QA bounds as well as the missing value indicator for the meteorological variable specified.

All of these keywords except the last one are mandatory. The order of these keywords within the ONSITE pathway is not important. Notice that there is no EXTRACT keyword since the

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data are QA'd directly from the raw data file.

DATA, LOCATION, XDATES, and QAOUT

The site-specific data are stored in a file called ONSITE.MET as shown with the DATA keyword. A file format is not required with this keyword on the ONSITE pathway because there is no standard archive format associated with site-specific data. The definition of the format is provided by the user through the READ and FORMAT keywords described below.

The XDATES, LOCATION and QAOUT keywords for the ONSITE pathway are identical in content and purpose to the same keyword for the SURFACE pathway. The only difference of note is that the site identifier for the LOCATION keyword can be any integer descriptor, with a maximum length of eight characters, since the content of this field is not checked in AERMET. However, this identifier is written to one of the AERMET output files and is, in turn, checked by AERMOD against the identifier in the AERMOD runstream. Since AERMOD reads the site identifier as an integer from the runstream, the user should specify the site identifier as an integer to avoid an error in AERMOD. In this example, the site identifier is 99999.

READ and FORMAT

The READ and FORMAT keywords, rather than a predefined format, are the keys to reading the site-specific data. There are some rules to follow in using these two keywords:

1) For every READ keyword there <u>must</u> be a corresponding FORMAT keyword in the runstream;

2) The two keywords are linked through an index immediately following the keyword to identify which data record in the observation group is being referenced.

3) Blanks in the format specification must be avoided because AERMET recognizes blanks as field delimiters on keywords.

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4) To direct AERMET to read the data as free format (i.e., list-directed), the list-directed format specifier, '*', cannot be used with the FORMAT keyword Instead, the secondary keyword FREE, along with the FORMAT keyword, is used to direct AERMET. Every value must be read from a data record specified as FREE format.

The READ keyword defines the variables present on each data record in the order they are to be read from the input file. The first parameter after the READ keyword is the index indicating the data record in the observation group the READ keyword references. The list of variables to be read follows the index.

There are two types of site-specific meteorological variables that are recognized by AERMET: single-level and multi-level. The single-level measurements are usually observed near the earth's surface. Examples of single-level variables are net radiation and sensible heat flux. Site-specific observations of mixing heights are also included in the list of single-level measurements even though they may not be near-surface for a highly convective atmosphere. The multi-level variables can be reported at multiple heights and can come from an instrumented meteorological tower, a remote sensor (e.g., sodar or lidar), or any other meteorological instrumentation that can report data at several levels in the atmosphere (e.g., tethered balloon). Examples of multi-level variables are temperature, wind direction, and wind speed. Each variable is identified by a 4-character name; the allowable names are listed in Appendix C. The complete name of multi-level variables depends on the level at which they are observed. The first two characters identify the meteorological variable and the last two characters are numeric and identify the level from which the data are reported. The naming convention for multi-level variable is described in more detail in Section 4.5.2.

The format of the variables on each data record is specified on a corresponding FORMAT keyword. This keyword contains an index number that indicates which record in the observation group the keyword references followed by the Fortran format string used to read the data, enclosed in parentheses. The format must comply with all the rules of syntax for constructing a FORMAT statement, and the parentheses are mandatory. Refer to any introductory text on Fortran programming or compiler manual for the Fortran syntax rules.

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There can be a maximum of 50 data records per observation period and a maximum of 50 variables on any one data record. Remember, however, that the maximum length of a runstream record is limited to 132 characters.

Not all of the variables present in the site-specific data file need to be read. Any superfluous data can easily be skipped over using the X, T and / descriptors in the Fortran READ statement. However, **the same format used to read the original site-specific data file is also used to write the QA file**.

If some variables are skipped (using the X and T descriptors) or entire lines of data are skipped (using the "/"), then the QA output file will contain corresponding blank fields and/or blank lines.

Referring to Figure 3-2, three records corresponding to the three measurement levels define the site-specific data for a single observation period. The observation period in this example is one hour (site-specific data may contain more than one observation period per hour; see Section 4.5.12 for a discussion of the keyword OBS/HOUR). The first data record contains the day, month, year, hour, and minute of the observation. These fields are followed by the observation height (meters), σ_θ (degrees), σ_w (meters/second), ambient air temperature (°C), wind direction (degrees), and wind speed (meters/second). The second and third records contain the same information. This structure is repeated for all hours of the data set. It is only coincidental that the same variables are repeated for each measurement height. It is entirely possible, and a situation that AERMET can handle, that different variables are measured at different levels.

In this example, 10 variables are read from the first record of the observation group in Figure 3-2. In the runstream, the variables corresponding to these data are defined on the READ keyword followed by the index 1. The first four variables are the day, month, year, and hour and are read into the integer variables OSDY, OSMO, OSYR, and OSHR, respectively (see Table B-3 and Table B-4 for the list of valid variable names). The next six variables are σ_θ, σ_w,

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temperature, wind direction, and wind speed - all at the first level. These data are read into SA01, SW01, TT01, WD01, and WS01, respectively. These variable names consist of a 2-letter prefix and a 2-digit suffix. The prefix identifies the variable, as defined in Table B-4, and the suffix identifies the measurement level. This record is read with the format defined on the FORMAT keyword that is followed by the index 1.

The second and third records of the observation period are read in a similar manner. Note, however, that the second and third data records also contain the date and time data, but that information is skipped by AERMET - no date variables are specified and the FORMAT utilized '16X' to skip the first 16 columns in the data file.

With these six statements in the runstream, the site-specific data format is completely specified. If, for any reason, the data structure changes within the file, then AERMET will stop processing data and identify where the problem was encountered.

THRESHOLD

Anemometers measuring the wind speed may not detect air movement below certain speeds, or thresholds. These thresholds are instrument-dependent. While it is hoped that winds reported in the raw data base have already accounted for this minimum, it is possible that speeds less than the threshold for the instrument appear in the data. The keyword THRESHOLD is used to define the threshold wind speed and directs AERMET to treat any site-specific wind speeds that are below this threshold as calm winds. This is a mandatory keyword - AERMET will not process the site-specific data without it. In this example, the threshold wind speed is 0.3 meters/second.

RANGE

An optional, but very useful, keyword is the RANGE keyword. This keyword can be used on the SURFACE and UPPERAIR pathways, but is most useful on the ONSITE pathway where

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indicators of missing values (e.g., -999.0) are data base dependent. AERMET has default upper and lower bounds for the QA and missing value indicator for each variable (see Table B-3 and Table B-4). The RANGE keyword allows the user to change one or all of these values for a variable. If AERMET is not made aware of the correct missing value indicator(s), then it will assume the default indicator identifies the missing data and AERMET may use invalid data in a calculation. This situation could lead to an abrupt termination of the program, such as attempting to compute the square root of a negative number, without any indications in the message and summary file as to what happened.

One RANGE keyword is required for each variable's QA parameters that the user wants to modify. The parameters associated with the RANGE keyword are:

1) variable name - for multi-level variables such as temperature and wind speed, only the first two characters are needed - the changes apply to all measurement levels;

2) lower bound;

3) symbol indicating whether the range of valid values should include (<=) or exclude (<) the endpoints (bounds);

4) upper bound;

5) missing value indicator.

Any or all of items 2 through 5 can be changed, but each of these parameters must appear with the RANGE keyword. If, for example, the missing value indicator needs to be modified but the bounds can remain the same, the default bounds for the variable defined in Table B-3 and Table B-4 should be used with the new missing indicator specified. This situation is exactly why this keyword had to be included in this example. Several of the QA bounds also were changed. Compare the parameters on the RANGE keywords to the values in Table B-4 and then examine the data for March 1, 1988, hour 11 in the file ONSITE.MET.

There are two optional keywords available for the ONSITE pathway that perform the

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same function as on the SURFACE and UPPERAIR pathways. These are:

AUDIT -	adds variables to the list of variables to be tracked and reported during QA;
NO_MISSING -	suppresses the message that data are missing for variables being audited during the QA process; this keyword is useful in reducing the size of the message file if an audited variable is missing most of the time.

Additional optional keywords specific to the ONSITE pathway include:

DELTA_TEMP -	defines the height(s), in meters, for temperature difference data, if it exists in the data base;
OSHEIGHTS -	defines the heights of the site-specific measurements; this keyword is needed if the heights are not included on each of the multi-level data records or not on the READ keywords;
OBS/HOUR -	number of observation periods per hour; required only if the number of periods exceeds 1/hour;

All the keywords are discussed in detail in Section 4.0, and a synopsis of each is provided in Appendix A.

3.1.2 Running Stage 1 and reviewing the output

To run Stage 1 to QA the site-specific meteorological data, the following command lines are used:

```
COPY   EX2-OS.INP   AERMET.INP
AERMET
```

where EX2-OS.INP is the example runstream file name.

Figure 3-4 shows a portion of the messages that result from running EX2-OS.INP. All

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the QA messages were the same, so the middle section was omitted. The 'standard' end of file and processing that was not performed precede the QA messages. These messages show how the QA violations of the multi-level data are reported.

```
        JOB        I19  SETUP  : "END OF FILE" ON UNIT  5 AFTER RECORD #  38
        JOB        I25   TEST  : SUMMARY: NO DATA EXTRACTION FOR UPPERAIR
        JOB        I25   TEST  : SUMMARY: NO DATA QA FOR UPPERAIR
        JOB        I26   TEST  : SUMMARY: NO DATA EXTRACTION FOR SURFACE
        JOB        I26   TEST  : SUMMARY: NO DATA QA FOR SURFACE
        JOB        I27 OSTEST  : Minimum and maximum ONSITE height level indices
                                 derived from data file are:    1   3
880301 ONSITE     Q59 OSQACK  : TT   missing for HR:  11; LEVEL :  1
880301 ONSITE     Q59 OSQACK  : TT   missing for HR:  11; LEVEL :  2
880301 ONSITE     Q59 OSQACK  : TT   missing for HR:  11; LEVEL :  3
880301 ONSITE     Q59 OSQACK  : WD   missing for HR:  11; LEVEL :  1
880301 ONSITE     Q59 OSQACK  : WD   missing for HR:  11; LEVEL :  2
880301 ONSITE     Q59 OSQACK  : WD   missing for HR:  11; LEVEL :  3
880301 ONSITE     Q59 OSQACK  : WS   missing for HR:  11; LEVEL :  1
880301 ONSITE     Q59 OSQACK  : WS   missing for HR:  11; LEVEL :  2
880301 ONSITE     Q59 OSQACK  : WS   missing for HR:  11; LEVEL :  3
   .     .             .                    .
   .     .             .                    .
   .     .             .                    .

880308 ONSITE     Q59 OSQACK  : TT   missing for HR:  10; LEVEL :  1
880308 ONSITE     Q59 OSQACK  : TT   missing for HR:  10; LEVEL :  2
880308 ONSITE     Q59 OSQACK  : TT   missing for HR:  10; LEVEL :  3
880308 ONSITE     Q59 OSQACK  : WD   missing for HR:  10; LEVEL :  1
880308 ONSITE     Q59 OSQACK  : WD   missing for HR:  10; LEVEL :  2
880308 ONSITE     Q59 OSQACK  : WD   missing for HR:  10; LEVEL :  3
880308 ONSITE     Q59 OSQACK  : WS   missing for HR:  10; LEVEL :  1
880308 ONSITE     Q59 OSQACK  : WS   missing for HR:  10; LEVEL :  2
880308 ONSITE     Q59 OSQACK  : WS   missing for HR:  10; LEVEL :  3
```

Figure 3-4. Portion of the Message File from Site-specific Data QA

The QA messages contain the following information:

Field 1: the observation date
Field 2: the pathway
Field 3: the message code
Field 4: the subroutine that issued the message
Field 5: the message which includes:

- the variable in question: TT = temperature, WD = wind direction, and WS = wind speed
- the problem: data are missing for the hour with the level indicated.

Figure 3-5 through Figure 3-8 show the summary report associated with running

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EX2-OS.INP. For the most part, the summary for the site-specific should look familiar to the summaries from the SURFACE and UPPERAIR processing except that only the site-specific data section contains processing information.

The second page (Figure 3-6) shows the QA summary table. Only temperature, wind speed, and wind direction are automatically QA'd, which are multi-level variables. No additional variables were specified with the AUDIT keyword for QA. The summary is reported by level and by variable within the level. Recall that 10 days were processed for a total of 240 hours. The "% accepted" exceeds 98% for all variables, except for temperature at the 50-meter level. The 41 reported missing values may cause the user to check the data to insure the data are really missing. Unlike the QA for hourly surface and upper air data, the "Test Values" at the right of the table are not multiplied by any factors.

The third page of the summary report (Figure 3-7) shows some of the important parameters that will also be used in the processing including the threshold wind speed. The 'Heights for multi-level data' shows the heights at which the site-specific data measurements were observed, but only if the OSHEIGHTS keyword was used. Otherwise, the heights are shown as 0.0.

Note that on the message summary table on the fourth page (Figure 3-8) there were 62 QA messages in the 50-59 range. Examining the message file, we see that all the missing data messages had the message code 'Q59', which were categorized into the 50-59 range.

Once the user is satisfied that there is nothing unusual in the data, the ONSITE data are ready to merge with the data from the SURFACE and UPPERAIR pathways.

```
AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                          Version  15181

            Data Processed on 17-JUN-2016 at 11:37:50

                              Stage 1                        Page   1
```

```
            ********************************************************
            ***        AERMET Setup Finished Successfully        ***
            ********************************************************

1.  Job File Names

    Listing of Messages: ONSITE.MSG
    Summary (this file): ONSITE.RPT


2.  Upper Air Data

    AERMET Has Determined That Processing For This Pathway Includes:
         NONE, NO DATA TO BE PROCESSED ON THIS PATH



3.  NWS Surface Data

    AERMET Has Determined That Processing For This Pathway Includes:
         NONE, NO DATA TO BE PROCESSED ON THIS PATH



4.  On-site Data

     Site ID    Latitude(deg.)   Longitude(deg.)   Time Adjustment   Elev. (m)
       99999        41.3N             74.0W               0            115.0

    AERMET Has Determined That Processing For This Pathway Includes:
         QUALITY ASSESSMENT ONLY

         Extract Output-    OPEN: ONSITE.MET
         QA Output     -    OPEN: OSQAOUT.DSK

         The Extract Dates Are:    Starting:  1-MAR-1988
                                     Ending: 10-MAR-1988
```

Figure 3-5. First Page of the Summary File for the Site-specific Data QA

```
       AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                Version  15181

                    Data Processed on 17-JUN-2016 at 12:16:24

                                      Stage 1                          Page   2

            ********************************************************
            ***   AERMET Data Processing Finished Successfully   ***
            ********************************************************


                      **** SUMMARY OF THE QA AUDIT ****

    THERE IS NO AUDIT TRAIL FOR SITE SCALARS


SITE VECTORS         |------VIOLATION SUMMARY------|   |-----TEST VALUES-----|
              TOTAL     #     LOWER  UPPER      %      MISSING   LOWER   UPPER
              # OBS  MISSING  BOUND  BOUND  ACCEPTED     FLAG    BOUND   BOUND
    10.00 M
      TT       240        2      0      0     99.17      -99.0,  -30.0,   40.0
```

```
   WD       240        4      0      0     98.33     -999.0,    0.0,  360.0
   WS       240        4      0      0     98.33     -999.0,    0.0,   50.0
 50.00 M
   TT       240       41      0      0     82.92      -99.0,  -30.0,   40.0
   WD       240        3      0      0     98.75     -999.0,    0.0,  360.0
   WS       240        2      0      0     99.17     -999.0,    0.0,   50.0
100.00 M
   TT       240        2      0      0     99.17      -99.0,  -30.0,   40.0
   WD       240        2      0      0     99.17     -999.0,    0.0,  360.0
   WS       240        2      0      0     99.17     -999.0,    0.0,   50.0

 THIS CONCLUDES THE AUDIT TRAIL
```

Figure 3-6. Second Page of the Summary File for the Site-specific Data QA

```
                                Version  15181

                    Data Processed on 17-JUN-2016 at 12:16:24

                                   Stage 1                          Page   3

                   THE FOLLOWING ON-SITE VALUES ARE IN EFFECT

Number of OBS/HOUR:

    1

Threshold wind speed (m/s):

   0.30

Heights for tower data (m), based on HTnn fields in data file:

  10.00   50.00  100.00
```

Figure 3-7. Third Page of the Summary File for the Site-specific Data QA

```
      AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                Version  15181

                  Data Processed on 17-JUN-2016 at 12:16:24

                                    Stage 1                          Page   4

            ********************************************************
            ***   AERMET Data Processing Finished Successfully   ***
            ********************************************************

                  EXTRACT AND/OR QA THE METEOROLOGICAL DATA


                   **** AERMET MESSAGE SUMMARY TABLE ****

        0- 9   10-19   20-29   30-39   40-49   50-59   60-69   70-89   TOTAL
     ------------------------------------------------------------------------

JOB
  E      0       0       0       0       0       0       0       0       0
  W      0       0       0       0       0       0       0       0       0
  I      0       1       5       0       0       0       0       0       6

ONSITE
  E      0       0       0       0       0       0       0       0       0
  W      0       0       0       0       0       0       0       0       0
  I      0       0       0       0       0       0       0       0       0
  Q      0       0       0       0       0      62       0       0      62
     ------------------------------------------------------------------------
         0       1       5       0       0      62       0       0      68

      ****    ERROR MESSAGES    ****

             ---  NONE  ---


      ****   WARNING MESSAGES   ****

             ---  NONE  ---
```

Figure 3-8. Fourth Page of the Summary File for the Site-specific Data QA

EXERCISE:

Remove or comment out (by placing asterisks in the first two columns, **) the RANGE keywords in EX2-OS.INP and rerun the QA for the site-specific data. Review the message file and note that the 'missing data' messages have been replaced with 'lower bound' violations. Why did the messages change? Examine the QA summary table - a similar changed occurred there, too.

EXERCISE:

Reactivate the RANGE keywords by removing the asterisks that were inserted for the previous exercise. Then, add the following to the ONSITE pathway in the runstream: NO_MISSING TT and rerun the QA for the site-specific data. Notice that the message file is much shorter and the number of QA messages reported in the message summary table (as in Figure 3-8) is less. The NO_MISSING keyword suppressed all QA messages and tallying that related to temperature.

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3.1.3 Stage 2 - merging data

Since the hourly surface observations and upper air data that were processed in Stage 1 in the first example are to be used in this example, the three QA'd data files are ready for Stage 2. Figure 3-9 shows the processing flow associated with Stage 2 and Figure 3-10 shows the runstream, which is provided in EX2-MRG.INP.

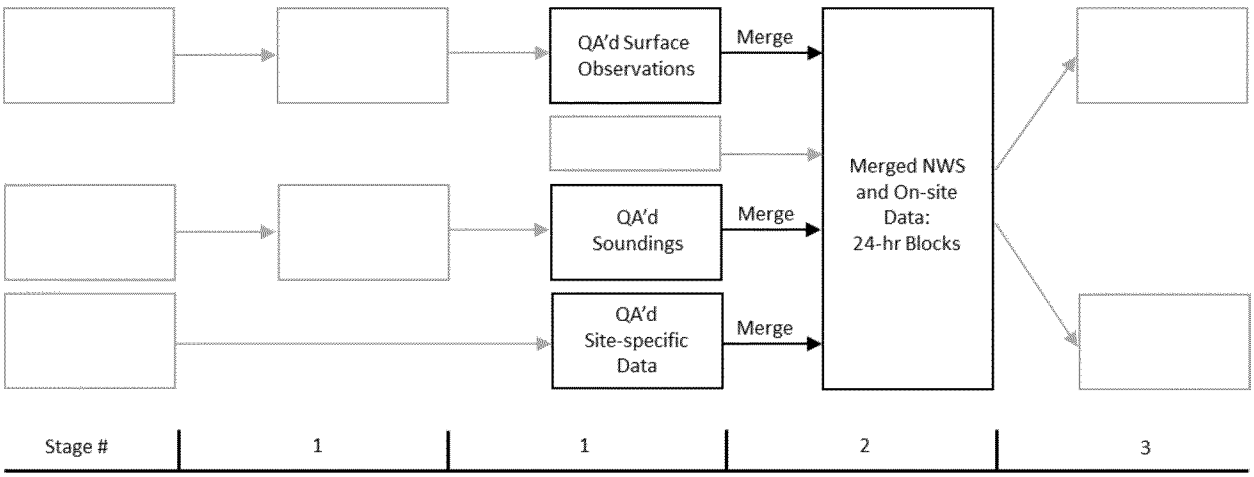

Figure 3-9. Stage 2 Processing that Merges the Surface Observations, Soundings, and Site-specific Data into a Single File

The only differences to note between this runstream and the Stage 2 runstream for Example 1 (Figure 2-14) is the inclusion of the ONSITE pathway. The output file generated in the Stage 1 QA of site-specific data, OSQAOUT.DSK, is specified with the QAOUT keyword. Also note that the file names associated with the keywords on the JOB pathway and the MERGE output were changed so as to not overwrite any of the files generated in the first example.

ED_001739_00002136-00110

```
JOB                                     Start of JOB pathway
  REPORT      MERGE-2.RPT               Report file
  MESSAGES    MERGE-2.MSG               Message file
UPPERAIR                                Start of UPPERAIR pathway
  QAOUT       UAQAOUT.DSK               UPPERAIR input file to Stage 2

SURFACE                                 Start of SURFACE pathway
  QAOUT       SFQAOUT.DSK               SURFACE input file to Stage 2

ONSITE                                  Start of ONSITE pathway
  QAOUT       OSQAOUT.DSK               ONSITE input file  to Stage   2

MERGE                                   Start of MERGE pathway
  OUTPUT MERGE2.DSK                     Output of merged meteorological data
  XDATES      88/03/01  88/03/04        Period of observations to merge
```

Figure 3-10. Runstream to Merge NWS Upper Air, Surface Data, and Site-specific Data in to a Single File

To run Stage 2 to merge the three files of meteorological data, the following command lines are used:

```
COPY   EX2-MRG.INP   AERMET.INP
AERMET
```

The message file is similar to the one generated in Example 1, so it is not shown here.

The summary report is also very similar and only the second page is shown (Figure 3-11). The only item to note is the number of site-specific observations merged each day. Rather than zero as we had in Example 1, the data base now includes 24 site-specific observation periods per day.

ED_001739_00002136-00111

```
        AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                    Version  15181

                        Data Processed on 17-JUN-2016 at 12:16:24

                                            Stage 2                     Page
2

                              Merging the Meteorological Data


                 The Merged Dates Are:    Starting:  1-MAR-1988
                                            Ending:  4-MAR-1988

                      ***** Daily Output Statistics *****
                1988 MO/DY:  3/ 1  3/ 2  3/ 3  3/ 4
        NWS  Upper Air  Sdgs   2     4     4     4
        NWS Sfc Observations  24    24    24    24
        On-site Observations  24    24    24    24
        Ave 1-min ASOS Winds   0     0     0     0


        TOTAL OBSERVATIONS READ:
           Upper Air Soundings :      9
           NWS Sfc Observations:     98
           On-site Observations:     97
           1-min ASOS Wind Data:      0

                      ***** MERGE PROCESS COMPLETED *****
```

Figure 3-11. Second Page of the Summary File

3.1.4 Stage 3 - estimating boundary layer parameters for AERMOD

With all the meteorological data merged into one file, Stage 3 can be run to generate the two input files for AERMOD, as shown in Figure 3-12.

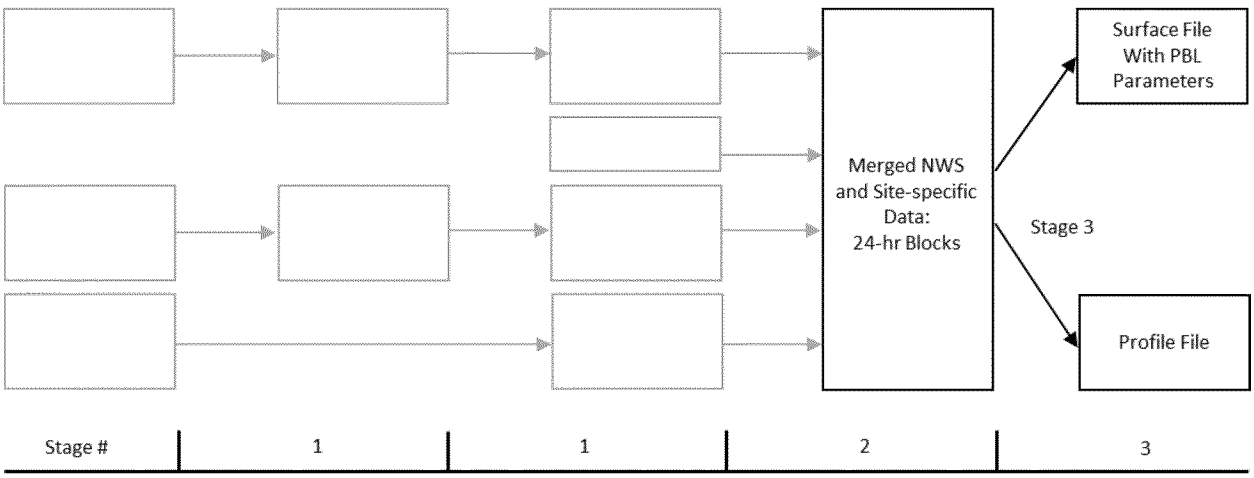

Figure 3-12. Stage 3 Processing Using the Merged NWS and Site-specific Data to Create the Input Meteorology for AERMOD

The input runstream for this example, shown in Figure 3-13, is nearly identical to the runstream for Example 1 with the exception of the file names and the surface characteristics.

ED_001739_00002136-00113

```
JOB                                          Start of the JOB pathway

  REPORT     STAGE3-2.RPT                    File for all messages

  MESSAGES   STAGE3-2.MSG                    File for the run  summary


METPREP                                      Start of the   METPREP  pathway

  DATA       MERGE2.DSK                      Input meteorological data file from Stage 2

  METHOD     REFLEVEL  SUBNWS                Processing method: allow substitution of NWS  data

  METHOD     WIND_DIR  RANDOM                Processing method: randomize NWS wind  directions

  NWS_HGT    WIND   6.1                      NWS wind measurement height

  OUTPUT     AERMET2.SFC                     Output file with boundary layer parameters

  PROFILE    AERMET2.PFL                     Output   file with profile  data

  FREQ_SECT  MONTHLY 2                       Frequency and number of wind direction sectors to
                                             define the site characteristics for site-specific
                                             observations (primary site)

  SECTOR      1   35  225                    Definition of 1st wind sector for site-specific
                                             observations (primary site)

  SECTOR      2  225   35                    Definition of 2nd wind sector for site-specific
                                             observations (primary site)

                                             Onsite (primary site) Surface characteristics:
  SITE_CHAR   1   1  0.350  0.800  0.300      January,   sector  1
  SITE_CHAR   2   1  0.350  0.800  0.300      February,  sector  1
  SITE_CHAR   3   1  0.350  0.800  0.300             .
  SITE_CHAR   4   1  0.250  0.400  0.500             .
  SITE_CHAR   5   1  0.250  0.400  0.500             .
  SITE_CHAR   6   1  0.120  0.200  0.700             .
  SITE_CHAR   7   1  0.120  0.200  0.700             .
  SITE_CHAR   8   1  0.120  0.200  0.700             .
  SITE_CHAR   9   1  0.200  0.600  0.500             .
  SITE_CHAR   10  1  0.200  0.600  0.500             .
  SITE_CHAR   11  1  0.200  0.600  0.500      November,  sector  1
  SITE_CHAR   12  1  0.350  0.800  0.300      December,  sector  1
  SITE_CHAR   1   2  0.500  1.500  0.750      January,   sector  2
  SITE_CHAR   2   2  0.500  1.500  0.750      February,  sector  2
  SITE_CHAR   3   2  0.500  1.500  0.750             .
  SITE_CHAR   4   2  0.250  0.700  1.000             .
  SITE_CHAR   5   2  0.250  0.700  1.000             .
  SITE_CHAR   6   2  0.150  0.300  1.500             .
  SITE_CHAR   7   2  0.150  0.300  1.500             .
  SITE_CHAR   8   2  0.150  0.300  1.500             .
  SITE_CHAR   9   2  0.200  1.000  1.250             .
  SITE_CHAR   10  2  0.200  1.000  1.250             .
  SITE_CHAR   11  2  0.200  1.000  1.250      November,  sector  2
  SITE_CHAR   12  2  0.500  1.500  0.750      December,  sector  2

  FREQ_SECT2  ANNUAL  1                       Frequency and number of wind direction sectors to
                                              define the site characteristics for NWS surface
                                              observations (secondary site)

  SECTOR2     1  0  360                       Definition of wind direction sectors for NWS surface
                                              observations (secondary site)

  SITE_CHAR2  1  1  0.15  2.00  0.12          Definition of site characteristics by period
                                              and wind direction sector for NWS surface
                                              observations (secondary site)
```

Figure 3-13. Stage 3 Runstream

In Example 1, the location where NWS surface data were collected, the tower at the airport, was designated as the primary site since site-specific data were not used in Example 1. In this example (Example 2), the surface characteristics for the airport were retained but reassigned as the secondary site as indicated by the keywords FREQ_SECT2, SECTOR2, and SITE_CHAR2. As in Example 1, SUBNWS is specified which means NWS wind data from the airport will be substituted for hours when the site-specific wind data are missing. The location where the site-specific data were collected was designated as the primary site and site characteristics are specified MONTHLY for two unique wind direction sectors, as indicated with the FREQ_SECT, SECTOR, and SITE_CHAR keywords. Note that there are 24 records with the SITE_CHAR keyword defining the surface characteristics – one record for each combination of month and sector.

The site-specific sectors defined for this example are 35°-225° and 225°-35°. Notice that the second sector crosses through north (360°). AERMET checks to make sure that the end point of one sector matches the start point of the next sector, and also compares the end point of the last sector with the start point of the first sector. These checks insure that surface characteristics are specified for all wind directions.

The SITE_CHAR (and SITE_CHAR2) keyword is followed by the period indices based on the period defined with the FREQ_SECT (and FREQ_SECT2) keyword, and the sector indices as defined with the SECTOR (and SECTOR2) keyword. Since MONTHLY was specified as the period for the primary site, the period indices range from 1 to 12 which represent January to December, respectively. In this example, the albedo ranges from 0.12 in the summer when trees are in full leaf to 0.500 in winter when there is likely to be snow on the ground, the Bowen ratio ranges from 0.2 in the summer when the flow is mostly over water east of the site to 1.5 in the winter when the flow is over the hillier terrain to the west, and the roughness length ranges from 0.3 meters in the winter when the flow is mostly over water to 1.5 meters in the summer when the flow is over the fully-leafed hills west of the site.

For each hour, AERMET attempts to locate a level of wind speed and direction from the

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site-specific measurements to define the surface characteristics. This level is defined as the lowest level with a nonmissing wind speed and direction between $7z_0$ and 100 meters (inclusive), where z_0 is the surface roughness length. If the only valid nonmissing wind speed is a calm wind, then the hour is treated as a calm and the reference level is the lowest level of nonmissing wind.

If there is no valid reference wind, then the lowest level is treated as the reference level and the reference wind is missing. However, if the option to substitute NWS data is specified in the runstream (see Section 4.7.6 for the keyword METHOD, secondary keyword REFLEVEL), then AERMET will substitute the NWS hourly wind speed observations for the reference wind speed and use the height specified with the keyword NWS_HGT (see Section 4.7.4) as the reference height. If NWS substitution is not specified, then the reference wind will be missing.

The selection of the reference temperature is independent of the selection of the reference wind. A valid reference temperature is defined as the lowest level with a nonmissing temperature between z_0 and 100 meters (inclusive). If there is no valid reference temperature in the site-specific data and the option to substitute NWS data is specified in the runstream, then AERMET will substitute the NWS hourly ambient temperature for the reference temperature.

To generate the two files of meteorological data for AERMOD, Stage 3 is run with the following command lines:

```
COPY   EX2-ST3.INP   AERMET.INP
AERMET
```

The message file that is created from this run is shown in Figure 3-14. There are several new messages that were not seen in Example 1. None of the message were fatal to the data processing, but serve as a way of making the user aware of some possible unusual conditions.

The first, and most frequent, of these messages in this example is the "REF WIND

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FROM PROFILE BELOW 20*Z0." When site-specific data are included in the data base, the definition of the reference height wind speed and direction are subject to the restrictions noted above. When the reference height for wind is below $20z_0$, then AERMET writes this warning. Record 13 in the message file indicates that AERMET could not locate site-specific data that satisfy these criteria and that NWS wind speed and direction were substituted. The presence of the METHOD keyword and secondary keyword REFLEVEL with the parameter SUBNWS included in the runstream (Figure 3-13) directed AERMET to make the substitution. Recall that all the site-specific data were missing for hour 11 on March 1, hence this message is appropriate. A little further down in the message file, there is a more explicit message that states NWS data (meaning wind and temperature) were substituted for onsite data. Of course, the substitutions are subject to the NWS data not being missing for the hour.

ED_001739_00002136-00117

```
       JOB        I19  SETUP  : "END OF FILE" ON UNIT  5 AFTER RECORD #  59
       JOB        I27 OSTEST  : Minimum and maximum ONSITE height level indices
                              derived from data file are:    1   3
       METPREP    I41 FNDCOMDT: ASOS commission date FOUND for WBAN =  14735;
                              CALL4 = KALB; CALL3 = ALB; CommDate = 19950801
880301 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  01
880301 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  02
880301 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  03
880301 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  05
880301 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  06
880301 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  07
880301 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  08
880301 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  09
880301 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  10
880301 METPREP    I81  SUBST  : NWS winds used as reference wind for hour:  11
880301 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  12
  .
  .
  .
880301 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  23
880301 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  24
880301 METPREP    I84  MPPBL  : Upper air sounding selected for this day: 12 Z
880301 METPREP    I84  MPPBL  : UAID =   1 for HR:   7 LST
880301 METPREP    I71  MPOUT  : NWS data subst'd for ONSITE profile at HR:  11
880302 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  01
880302 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  02
  .
  .
  .
880304 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  12
880304 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  13
880304 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  14
880304 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  15
880304 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  16
880304 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  17
880304 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  18
880304 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  19
880304 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  20
880304 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  21
880304 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  22
880304 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  23
880304 METPREP    I80  SUBST  : Ref level for wind below 20*Z0 for hour:  24
880304 METPREP    I84  MPPBL  : Upper air sounding selected for this day: 12 Z
880304 METPREP    I84  MPPBL  : UAID =   3 for HR:   7 LST
     4 METPREP    I79  FETCH  : EOF reached on input data file after 000000
```

Figure 3-14. Message File from Stage 3 (partial)

ED_001739_00002136-00118

The summary report file is identical in nature to the summary report for Stage 3 in Example 1. Rather than keep repeating the same or similar information about the report file, the user is left to compare the two Stage 3 report files from Examples 1 and 2.

EXERCISE:

How are the report files from Stage 3 in Examples 1 and 2 different? What are the similarities?

EXERCISE:

Remove or comment out (by placing two asterisks in columns 1 and 2) the METHOD REFLEVEL SUBNWS record in EX2-ST3.INP and rerun Stage 3 (change the output file names so the different runs can be compared). Are the NWS data substitution messages still present? Compare the boundary layer parameter output files - how have the results changed for March 1, hour 11?

EXERCISE:

In any of the runstreams that have been presented in Section 2.0 and Section 3.0, add the CHK_SYNTAX keyword to the JOB pathway and rerun the appropriate program (STAGE1N2 or STAGE3). What is displayed on screen? What are the contents of the output files?

Note: even if the only activity is to check the runstream syntax, AERMET still opens files, so it is possible that some zero-byte files will appear or files only with header records will appear. It is best to delete these files before running AERMET without the CHK_SYNTAX keyword.

ED_001739_00002136-00119

3.2 Combining or separating processing steps

These examples required several separate runs to generate the boundary layer parameters. However, several steps in Stage 1 can be combined to reduce the number of times the programs must be run, but AERMET always requires a minimum of three separate steps to process the data - one step for each stage of processing.

One example of combining steps was used throughout the tutorial - the extract and QA of data was performed in one run. Another way to combine steps is to extract and QA all available data types - hourly surface observations, upper air data, and site-specific data - in one run. It is really a concatenation of several of the runstream files above, but with one JOB pathway rather than three. The advantage to this procedure is in minimizing the number of input runstream files and the time spent in running Stage 1. The disadvantage is that an error in one data type stops the processing. Any data type(s) processed prior to the error would be completed successfully; the data type in which the error occurred is partially completed; and data type(s) that are to be processed subsequent to the error are not processed.

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```
JOB
  MESSAGES   ANYNAME.MSG
  REPORT     ANYNAME.RPT

SURFACE
  DATA       S1473588.144    CD144
  EXTRACT    SFCEXOUT.DSK
  XDATES     88/3/1 TO 88/03/10
  LOCATION   14735  42.75N  73.8W  0  83.8
  QAOUT      SFQAOUT.DSK

UPPERAIR
  DATA        14735-88.UA 6201FB
  EXTRACT     UAEXOUT.DSK
  XDATES      88/3/1 TO 88/3/10
  LOCATION    00014735  73.8W  42.75N  5
  QAOUT       UAQAOUT.DSK
  AUDIT       UATT UAWS UALR

ONSITE
  DATA         ONSITE.MET
  XDATES       88/3/1  TO  88/3/10
  LOCATION     99999  74.0W  41.3N  0  115.0
  QAOUT        OSQAOUT.DSK
  READ  1  OSDY OSMO OSYR OSHR HT01 SA01 SW01 TT01 WD01 WS01
  READ  2                      HT02 SA02 SW02 TT02 WD02 WS02
  READ  3                      HT03 SA03 SW03 TT03 WD03 WS03
  FORMAT  1  (4(I2,1X),4X,F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1X,F7.2)
  FORMAT  2  (16X,F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1X,F7.2)
  FORMAT  3  (16X,F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1X,F7.2)
  RANGE  TT  -30 <   40   -99
  RANGE  SA   0  <=  95   -99
  RANGE  WS   0  <   50  -999
  RANGE  WD   0  <= 360  -999
  THRESHOLD   0.3
```

Figure 3-15. Runstream to Extract and QA All Data Types in One Run

Another alternative in Stage 1 is to perform the extraction and QA separately, increasing the number of times AERMET is run to complete Stage 1. This can be done for the UPPERAIR and SURFACE pathways. There is only one step for the ONSITE pathway since the data can only be QA'd. This could be useful if the data are likely to be QA'd more than once. The combinations of the keywords DATA, EXTRACT, and QAOUT direct AERMET on how to process the data, as follows:

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DATA	EXTRACT	& QAOUT	→extract and QA
DATA	EXTRACT		→extract
DATA	EXTRACT	& QAOUT	→QA (UPPERAIR and SURFACE)
DATA		QAOUT	→QA (ONSITE only)

For example, in EX1-SF.INP, remove or comment out the line

```
QAOUT          SFQAOUT.DSK
```

and run AERMET. The SURFACE data are extracted but not QA'd. To QA the data, a new runstream has to be constructed. This new runstream will have a JOB pathway and a pathway for the SURFACE data. For example, the following runstream might be used:

```
JOB
MESSAGES       QAONLY.MSG
REPORT         QAONLY.MSG
SURFACE
EXTRACT        SFEXOUT.DSK
QAOUT          SFQAOUT2.DSK
```

Try running this runstream and comparing the resulting message and summary report files with the ones generated using EX1-SF.INP. Also compare the output files (notice that the name was changed here so as not to overwrite the one created with EX1-SF.INP - **AERMET will not warn you if a file is being overwritten!**). Note here that no blank lines were used and keywords are not indented in the runstream. AERMET reads this runstream without any problem, but the user might have a more difficult time.

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4.0 Keyword reference

This section provides a detailed reference for all the keywords available in AERMET, expanding the discussion of the keywords presented in Section 2.0 and Section 3.0 presenting additional keywords that were not used or mentioned. The discussion in this section assumes that the reader has a basic understanding of the pathway, keyword and parameter approach. Novice users should review Section 2.1 to obtain a basic knowledge of the approach.

The information in this section is organized by pathway, with the more commonly used keywords for that pathway discussed first. The syntax for each keyword is provided using dummy parameter names. The keyword types - mandatory or optional, repeatable or nonrepeatable, and reprocessed - are specified. The definition of these terms is discussed below. Additionally, any special requirements, such as the order within the pathway, are specified.

4.1 Definitions and runstream file processing

The terms "mandatory" and "optional" indicate whether the keyword for a particular pathway is required to run AERMET (mandatory) or if it enhances or modifies the processing (optional). Several keywords may be mandatory or optional depending on the point they are used in the processing and the data. For example, QAOUT serves two purposes: to define the output file for Stage 1 QA and to define the input file for Stage 2 merge. While data QA is optional in Stage 1, the keyword is mandatory if the data for the pathway are to be merged in Stage 2. A distinction will be made when the keyword type may be ambiguous. For the discussions in Sections 4.2 - 4.5, the stages to which the keyword refers will be in parentheses following the terms "mandatory" and "optional". If 'All' is specified, then the keyword applies to all stages of processing.

The terms "repeatable" and "nonrepeatable" refer to whether or not the keyword can appear only once (nonrepeatable) or more than once (repeatable) <u>for the same pathway</u> in a runstream. For example, the MESSAGES keyword can appear only once on the JOB pathway,

thus it is nonrepeatable. However, the RANGE keyword for assessing the validity of the data can appear multiple times on a pathway, thus it is repeatable. A nonrepeatable keyword may appear multiple times in a runstream file, but only once per pathway. For example, the QAOUT keyword defines the input file for each pathway for Stage 2 (merging data). It can appear only once for each pathway, but it will appear two or three times in the runstream because there is usually more than one type of data to merge.

When AERMET processes meteorological data in Stage 1 and Stage 2, runstream records used to control the preprocessor's actions are written at the top of the output file(s). These records are referred to as header records. Special symbols are added at the beginning of some of these records that direct AERMET to reprocess the header record when it is read from the data file, i.e., the headers are read and processed as if they had been included as a part of the current runstream. If a keyword can be reprocessed, then the keyword type includes the term "reprocessed". By allowing AERMET to reprocess a header record, the user does not have to specify certain keywords for subsequent runs. The best example of this is for the ONSITE pathway on which the user must specify the structure of the data. Specify them once and AERMET will use the information to read the data in subsequent runs.

→ **The output files specified in the runstreams are created and/or opened and the header records are written to the file(s). If a run should generate a setup error, subsequent runs after the error is corrected may reintroduce the error (due to header reprocessing). Therefore, if a run generates an error, it is recommended that the user delete the <u>output</u> files before rerunning AERMET.**

Except for a few keywords, there are no special requirements for the order of the keywords within each pathway, but it is recommended that a logical order be maintained to be able to understand the processing defined by each runstream file.

The syntax descriptions in the following sections use certain conventions. The keywords are all uppercase and the parameters are all lower case. Square brackets around a parameter indicate that the parameter is optional and a default value may be used if it is omitted.

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A word of caution that deserves repeating: for an AERMET run, all output files are opened with STATUS = 'UNKNOWN'. With this specifier, if the file already exists, AERMET will open it without providing any opportunity to save it. With the first write action to the file, the contents of an existing file are erased. Before running AERMET, the user should be certain that any output file name specified in a runstream file either does not exist or can be overwritten.

4.2 JOB pathway

The JOB pathway appears in all AERMET runstream files. The primary purpose of the JOB pathway is to specify the file names for reporting all the preprocessor actions that are performed for the particular run.

4.2.1 Messages from AERMET - MESSAGES

All error, warning, informational, and QA messages issued by AERMET are written to the file name specified with the MESSAGES keyword. The contents of this file are discussed throughout the tutorial in Section 2.0 and Section 3.0 and in Appendix D. This keyword is mandatory because the program later interrogates this file to summarize the processing. The syntax and type are:

Syntax:	MESSAGES *message_filename*
Type:	Mandatory (All), Nonrepeatable

The *message_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 96 characters.

4.2.2 Run summary - REPORT

At the conclusion of a run, AERMET interrogates the file of messages, tabulates the

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different types of messages (errors, warnings, etc...), and summarizes all the actions for that particular run in a file specified with the REPORT keyword. The contents of a run summary are discussed throughout the tutorial in Section 2.0 and Section 3.0. The syntax and type for this keyword are:

Syntax:	REPORT *summary_filename*
Type:	Optional (All), Nonrepeatable

The *summary_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 96 characters.

This keyword is optional. If it is omitted, then the summary is written to the output control device connected to logical unit 6. On a personal computer, this unit is normally the video monitor. This information can be captured using redirection (as discussed in Section 2.0).

4.2.3 Checking the runstream file for errors - CHK_SYNTAX

AERMET processes all the statements in a runstream file prior to processing any data. Incomplete information on a keyword or the omission of a keyword will cause AERMET to terminate the run. The CHK_SYNTAX keyword directs AERMET to process the runstream file and report any problems without performing any data processing. The user can review the summary and message files and correct any errors or make any changes to the runstream file prior to actually processing data. WARNING: AERMET opens all output files and writes the header records to those files, overwriting any data in the file if the file existed. The syntax and type of the CHK_SYNTAX keyword are:

Syntax:	CHK_SYNTAX
Type:	Optional (All), Nonrepeatable

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No parameters accompany this keyword.

The user gets a full report of the processing of the runstream file, i.e., the MESSAGES file and REPORT file are generated and can be reviewed. In the REPORT file, the following appears near the top of each page in the file:

```
*******************************************************
***    THIS RUN ONLY CHECKS THE RUNSTREAM SETUP      ***
*******************************************************
```

The message also appears on the screen at the conclusion of a run that only checks the syntax.

4.3 SURFACE pathway

The SURFACE pathway defines all the necessary information for processing NWS hourly surface weather observations or surrogate data that complies with an established format. These data provide information on temperature, winds, and cloud cover (particularly important) that can be used in estimating dispersion parameters. The data generally come from first order observation stations (observations 24 hours per day) located at or near airports. AERMET can read and process a variety of formats, each discussed below with the DATA keyword.

4.3.1 Retrieving archived data - DATA

Hourly NWS surface observations are stored in a variety of compact formats. Data stored in one of these formats is referred to as archived data. One of AERMET's functions is to read and interpret the archived data and to write the results in another format for later processing. The DATA keyword is used to specify the file name and define the archive file format for AERMET. The syntax and type for the DATA keyword are:

Syntax:	DATA *archive_filename file_format [ASOS]*
Type:	Mandatory (Stage 1), Nonrepeatable

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The *archive_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of the *archive_filename* is 96 characters.

For processing archive data on a PC, the *file_format* must be specified as one of the following: CD144, SCRAM, SAMSON, 3280VB, 3280FB, HUSWO, or ISHD. Each of these formats is discussed in more detail below. 3280VB and 3280FB are based on the TD-3280 format, which was originally stored on magnetic tape. AERMET could read the format as it was extracted from the tape. The last two characters, 'VB' and 'FB' refer to 'variable block' and 'fixed block' which is related to the data structure of each record.

Beginning with version 11059, AERMET includes a table of ASOS commissions dates used to identify whether NWS surface data input to AERMET are from an ASOS site. The ASOS parameter is applicable only for the ISHD format and is used to identify the data as having originated from an ASOS site for stations that are not included in the table of ASOS commission dates. **The optional ASOS parameter should only be used if the data are known to be from an ASOS site that is not included in the table of ASOS commission dates.** Wind speeds collected at ASOS sites, archived in the ISHD format, are truncated rather than rounded to whole notes (NOAA, 2008). This introduces a bias in the data toward lower wind speeds. To compensate, AERMET adds ½ knot (0.26 m/s) to all ASOS-based wind speeds. A more detailed discussion of this adjustment to ASOS wind speeds is in Section 4.7.6.3.

NOTE: In earlier versions of AERMET, the DATA keyword included the *blocking factor* and data *type* (ASCII or EBCDIC) parameters. These are no longer supported by AERMET, beginning with version 11059. The default values for these parameters are 1 for blocking factor and ASCII for data type. AERMET will issue a warning message if these parameters are included with the DATA keyword.

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4.3.1.1 CD-144 and SCRAM formats

The CD144 format is an older standard format previously used by the NCEI for archiving surface observations. Alphanumeric characters are used to represent various weather elements. All the weather elements for one hour are stored on one logical record and the length of each logical record is 79 characters.

The SCRAM format is a reduced version of the CD144 format and is available from the EPA's on the Support Center for Regulatory Air Models (SCRAM) website. Fewer weather elements are reported. Each logical record is 28 characters and includes data for cloud ceiling height, dry bulb temperature, wind speed and direction, and opaque sky cover. AERMET requires surface station pressure for some of its computations (e.g., density of air). The SCRAM format does not include station pressure and sea level pressure in a standard atmosphere (1013.25 millibars) is assumed when this format is used.

AERMET operates on a 01 - 24 clock but these two formats report data on the 00 - 23 clock. Hour 00 is hour 24 of the previous day. Thus, when data are retrieved from an archive file for a specific time period, the first hour is discarded since it is prior to the beginning time. Likewise, since the data for a day end with hour 23, the last day in the extracted data file will only have 23 hours.

AERMET reads several of the columns in the CD-144 format as character since numbers or letters could appear in those columns. AERMET then attempts to decipher/decode these columns by comparing the character it has read with a list of valid characters. If there is no match, then AERMET issues a warning on which overpunch position could not be deciphered. The following table lists the correspondence between the overpunch character and column in the CD-144 format. Note: The term 'overpunch' refers to the 'old' days when 80-column computer cards were used and the amount of information on a single card was limited. Overpunches conserved space and were produced by pressing the overpunch key and pressing a numeric value (0-9) and another key, usually the sign of the number. This overpunch technique

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generated a character rather than a numeric value, which is what AERMET is trying to decode.

Overpunch position(s)	CD-144 columns	CD-144 element
1-3	14-16	Ceiling height
4	17	First sky cover layer
5	18	Second sky cover layer
6	19	Third sky cover layer
7	20	Fourth sky cover layer
8	36	Sign of the dew point (X dew point < 0)
9	**41**	**1st digit of wind speed (X speed >100 kt)**
10	**47**	**Sign of the dry bulb (X dry bulb < 0)**
11	50	Sign of the wet bulb (X wet bulb < 0)
12	**56**	**Total sky cover**
13-34	57-78	Cloud data by layer
35	**79**	**Opaque sky cover**

The data associated with overpunches 9, 10, 12, and 35 (in bold above) may be used by AERMET, depending on the availability of other (e.g., site-specific) data. The other fields are decoded, but the weather information contained in them currently are not used by AERMET.

4.3.1.2 SAMSON format

As storage technology and capacity improved, larger amounts of data can be stored in smaller amounts of space. The NCEI made available solar and meteorological data for the first order stations in the United States for the period 1961-1990 on a set of three CD-ROMs, collectively referred to as the Solar and Meteorological Surface Observational Network (SAMSON) dataset. This disc set is still available from the NCEI, and AERMET can process the data retrieved from these CD-ROMs.

→ **AERMET cannot access the data directly on a SAMSON CD-ROM**.

Rather, the user must run the software provided with the data to retrieve the station(s), period(s) of time and variables for the site and period to be modeled. The software is a DOS-based, interactive graphical interface. The output files are written as an ASCII file on the user's local drive. It is this output that AERMET processes.

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Retrieving the meteorological data from the CD-ROM is completely under the control of the user, i.e., the user specifies which meteorological elements to retrieve from a list of 21 elements stored for each station. When processing SAMSON data with AERMET, the following elements should be retrieved: ceiling height, wind direction and speed, dry bulb temperature, opaque cloud cover, total sky cover, and station pressure. These elements result in an ASCII file of about 450 Kb for one year of meteorological data. If all 21 variables are retrieved, then a file size of about 1.2 Mb is created, although the file size will vary because precipitation data (in field 21) are reported only if there was precipitation for the hour, making some records longer than others.

When the data are retrieved from the CD-ROM, two records are written at the beginning of the file that identify the station (first record) and the variables retrieved (second record). These two initial records, or headers, begin with the tilde character (~). AERMET processes both of these records to obtain information about the station (e.g., station WBAN number) and to determine how to process the data that follow. It is imperative that the user not alter or delete these records.

If more than one year of data are retrieved from the CD-ROM, then two records beginning with the tilde appear before each year in the file. When the second set of headers is encountered, AERMET will print a warning in the message file and continue processing data. It is recommended that the user restrict data retrieved from CD-ROM to one station and one year per file or edit a multi-year file such that there is only one year per file.

The header records are followed by the data records. There is one record for each hour of the time period the user retrieved. Unlike the CD-144 format which reports the hour on the 00-23 clock, the hour is reported on the 01-24 clock, which is consistent with AERMET data processing.

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4.3.2 Saving dearchived data - EXTRACT

The EXTRACT keyword specifies the file name to which the data retrieved from the archive file are written. The syntax and type are:

Syntax:	EXTRACT *extracted_data_filename*
Type:	Mandatory (Stage 1), Nonrepeatable

The *extracted_data_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 96 characters.

4.3.3 Extracting a subset of the data - XDATES

The amount of data extracted from an archive file can be limited by using the XDATES keyword to specify the beginning and ending dates of the data to be extracted. The syntax and type are:

Syntax:	XDATES *YB/MB/DB* [TO] *YE/ME/DE*
Type:	Mandatory (Stage 1), Nonrepeatable

YB, *MB* and *DB* are the beginning year, month and day, respectively, of the data to extract and *YE*, *ME*, and *DE* are the ending year month and day, respectively. The "/" is required between each field, and there cannot be any spaces within a date group because the space is used as a delimiter between parameter fields. The year can be entered as either a two-digit or four-digit integer (e.g., 1992 or 92). The month is a one- or two-digit integer corresponding to the month of the year and the day is the one- or two-digit day of the month. The word "TO" is optional and only serves to make the statement a little more readable. It is ignored by AERMET when this keyword is processed.

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4.3.4 Identifying the station - LOCATION

The LOCATION keyword identifies the meteorological station by the station's identifier, latitude and longitude of the station, and a time adjustment factor used to adjust the data to local standard time. The syntax and type are:

Syntax:	LOCATION *site_id* *NWS_lat/long* *NWS_long/lat* [*tadjust*] [*elevation*]
Type:	Mandatory (Stage 1), Nonrepeatable, Reprocessed
Order:	Latitude (lat) and longitude (long) can appear in either order

The *site_id* is a five to eight character alphanumeric specifier that identifies the station for which data are to be extracted. For the standard formats listed on the DATA keyword, these identifiers are five-digit WBAN (Weather Bureau Army Navy) numbers. The *site_id* must be specified with leading zeros to fill a minimum of five characters (e.g., 03928 must be entered as 03928) since the field is read as a type character and not an integer. However, all characters of the *site_id* should be numeric as AERMOD expects a numeric value in the AERMOD control file which should match the ID of the SURFACE station identifier in the surface file generated by AERMET. A master list of WBAN numbers for stations throughout the world can be obtained from the NCEI.

The NWS station latitude (*lat*) and longitude (*long*) can be entered in either order because AERMET distinguishes between the two by the suffix on each: an N or S with the latitude and W or E with the longitude. For example, "38.4N 81.9W" would be interpreted the same as "81.9W 38.4N" in AERMET. AERMET cannot use, nor does it recognize, "+" or "-" to discriminate between north and south and east and west. Therefore, the latitude and longitude should always be specified as positive numbers. The NWS latitude and longitude on the SURFACE pathway are not used for any purpose at this time. They are simply another way to identify the NWS station being processed.

The parameter, *tadjust*, is an optional adjustment factor with a that is subtracted from

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the reported hour to convert the time to local standard time. The default value is zero if omitted from the LOCATION keyword on the SURFACE pathway. Though optional, it should be included when the offset to local standard time is non-zero and when the last parameter, *elevation,* is specified, which is also optional. For stations west of Greenwich, *tadjust* should be specified as a positive number. With the exception of ISHD, the standard NWS surface data formats processed by AERMET report the time as local standard time. Therefore, *tadjust* is zero for all standard NWS formats processed by AERMET, with the exception of the ISHD format, unless the data are known to be reported for a time zone that is not local standard.

The final parameter, *elevation,* refers to the station elevation above mean sea-level (MSL), in meters, and is also optional with a default value of zero meters. Station elevation should be included, however, when the actual station elevation is non-zero because it will be used in the substitution hierarchy for missing station pressure (see Section 5.6).

4.3.5 How good are the data? - QAOUT

One purpose of AERMET is to contribute to the quality assurance process by identifying data that are out of range or suspect such that the user can determine appropriate steps to accept, modify, or reject the data. The quality assessment (QA) is performed by including the QAOUT keyword in the runstream. This keyword is also used to specify the input file to Stage 2. The syntax and type for the QAOUT keyword are:

Syntax:	QAOUT *qa_output_filename*
Type:	Optional (Stage 1), Nonrepeatable Mandatory (Stage 2) if there are data to merge, Nonrepeatable

The *qa_output_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 48 characters. For one year of data, the size of the output file is approximately 1.3 Mb.

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Quality assessment is an optional process and the user does not have to perform a QA prior to merging the data. However, this step is recommended to identify possible errors in the data that are used to derive the boundary layer parameters.

AERMET's QA procedures include verifying that the values of the weather elements are not outside a range of 'acceptable' values and keeping track of the number of missing values. These checks operate on one observation period at a time, i.e., temporal variations of the data are not checked.

On the SURFACE pathway, when a quality assessment is performed, several of the weather elements are automatically tracked (audited) and included in a summary of the QA process. These elements are: dry bulb temperature, wind speed, and wind direction. The hourly value of each variable is compared to a missing value indicator and if the value is not missing, then the value is compared to an upper and lower bound that define the range of acceptable values. Each time a value is missing or violates one of the bounds, a message is written to the message file defined by the MESSAGES keyword. The message includes the value, the violation, and the date and time of the meteorological record where the violation occurred. The date is reported in the first field in the message. The number of times the weather element is missing, exceeds the upper bound and exceeds the lower bound is tallied and reported in the summary file defined on the REPORT keyword.

In the current version of AERMET there are no provisions for automatically replacing missing values or adjusting values that are outside the range of acceptable values. It is up to the user to review the QA summary information and, using sound meteorological principles and any regulatory guidance, either retain or replace the value in question.

There are default upper and lower bounds in AERMET, as well as a default missing value indicator. These values can be changed by the user through the use of the RANGE keyword, as described below. Also, the user can QA additional weather elements by using the AUDIT keyword.

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4.3.6 Adding weather elements to the QA - AUDIT

As mentioned in the previous section, there are only three weather elements that are tracked by default during a QA. The user can track additional weather elements for a particular AERMET run by specifying the element name with the AUDIT keyword. The syntax and type for this keyword are:

Syntax:	AUDIT *sfname*1 ... *sfname*n
Type:	Optional (Stage 1), Repeatable

where *sfname*1, ..., *sfname*n are the internal AERMET names of the weather elements as defined in Table B-2 of Appendix B. As many names can be specified on a single keyword that will fit within the 132-character limitation of a keyword. Since this keyword is repeatable, more than one AUDIT keyword can be used to define all the additional elements to track.

While the AUDIT keyword can add weather elements to the QA, there is no method to remove any of the default weather elements from the QA. They are always reported.

4.3.7 Changing the default values for the QA - RANGE

The user can modify the upper or lower bound limits for the QA if the values are not appropriate for the data. The missing value indicator can be changed as well and is the most likely reason this keyword is used. These changes are accomplished using the RANGE keyword. The syntax and type for the RANGE keyword are:

Syntax:	RANGE *sfname lower_bound* <[=] *upper_bound missing_indicator*
Type:	Optional (Stage 1), Repeatable, Reprocessed

where *sfname* is the internal AERMET name of the weather element as defined in Table B-2 of Appendix B, *lower_bound* and *upper_bound* are the new lower and upper bounds to be used in

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the QA, and *missing_indicator* is a new missing value code. The special symbol "<" and the optional "=" indicate whether to exclude (<) or include (<=) the lower and upper bound values in the QA, i.e., exclude or include the endpoints of the acceptable range of values. All parameters must be specified for this keyword; if a parameter is not changing, the default value should be specified.

Data for the SURFACE pathway are written as integers with some variables having been multiplied by 10 when extracted to retain significant digits. Table B-2 provides information on which variables use a multiplier. The default upper and lower bounds are multiplied also, therefore, the user must multiply any new upper and lower bounds by the same multiplier when entering the data on the RANGE keyword. However, the multiplier is not applied to the *missing_indicator*.

Several weather elements have been concatenated to form a single variable in the *extracted_data_file*. These variables are noted in Table B-2 and are related to cloud cover, weather type and height (locate the double slash (//) in the descriptions). If the user wants to modify the bounds and the missing value indicator through a RANGE keyword, these values must be concatenated, also.

4.3.8 Reducing the number of QA messages - NO_MISSING

Every time a bound is violated or a value is missing, a message is written to the message file (defined with the MESSAGES keyword). If one weather element that is tracked for reporting (either by default or defined on an AUDIT keyword) is missing most of the time (e.g., station pressure in a SCRAM archive file), the message file could become very large. To reduce the number of missing value messages and the size of the message file, the NO_MISSING keyword can be included for the QA. The syntax and type are:

Syntax:	NO_MISSING *sfname*1 ... *sfname*n
Type:	Optional (Stage 1), Repeatable

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where *sfname*1, ..., *sfname*n are the internal AERMET names of the weather elements to omit from the message file. Though the NO_MISSING keyword suppresses messages written to the message file, a count of missing values for audited variables are still tallied and included in the summary report file.

4.4 UPPERAIR pathway

The UPPERAIR pathway defines all the necessary information for processing NWS rawinsonde (sounding) data. These data provide information on the vertical structure of the atmosphere. The height, pressure, dry bulb temperature, relative humidity (which is used to obtain dew point temperature) and winds are reported. There are about 50 stations around the United States, and most countries in the world have an upper air observation program. The data are generally collected twice-daily, at 0000 GMT and 1200 GMT (these times are also referred to as 00Z and 12Z, respectively).

AERMET can read and process one format, as discussed below with the DATA keyword. However, surrogate data can be used if the user can reformat data into a format that is ready for Stage 1 QA (i.e., skip the extraction process). AERMET has been designed to accept 24 soundings per day. Note though, for AERMET to correctly read the file, a minimum of one header record consisting of three asterisks (in columns 1-3) <u>must</u> appear on a separate record before the data (these asterisks inform AERMET that there are no more headers to process).

<u>4.4.1 Retrieving archived data - DATA</u>

NWS rawinsonde data are stored in a variety of formats. However, AERMET is designed to read only a couple of those formats. As with hourly surface observations, data stored in this format is referred to as archived data. AERMET reads and interprets the sounding data and writes it to a separate file for later processing. The DATA keyword is used to specify the file name and define the archive file format for AERMET. The syntax and type for the DATA keyword are:

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Syntax:	DATA *archive_filename file_format*
Type:	Mandatory (Stage 1), Nonrepeatable

The *archive_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of the archive file is 96 characters.

AERMET can process upper air data in the TD-6201 and FSL formats as mentioned previously. TD-6201 is now obsolete, though historical data may exist in corporate and personal archives. Neither format is available from the NCEI; however, historical and current upper air data in the FSL format is available for download, free of charge, from the online NOAA/ESRL Radiosonde Database (http://esrl.noaa.gov/raobs/). The format specifications are also available at that same web address. TD-6201 data are stored either as fixed-length or variable length records, and the *file_format* should be specified as either 6201FB or 6201FB, respectively. *file_format* for upper air data in the FSL format should be specified as FSL.

Note that beginning with version 11059, the *blocking_factor* and data *type* (ASCII or EBCDIC) parameters have been removed from the DATA keyword specifications, and AERMET no longer supports their use if specified by the user. A value of '1' for *blocking_factor* and 'ASCII' for data *type* have been coded into AERMET. AERMET will issue a warning message if these parameters are included on the DATA keyword.

4.4.2 Saving dearchived data - EXTRACT

The EXTRACT keyword specifies the file name to which the data retrieved from the archive file are written. The syntax and type are:

Syntax:	EXTRACT *extracted_data_filename*
Type:	Mandatory (Stage 1), Nonrepeatable

The *extracted_data_filename* must conform to the naming conventions appropriate to the

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computing platform. The maximum length of this file name is 96 characters.

4.4.3 Extracting a subset of the data - XDATES

The amount of data extracted from an archive data file can be limited by using the XDATES keyword to specify the beginning and ending dates of the data to be extracted. The syntax and type are:

Syntax:	XDATES *YB/MB/DB* [TO] *YE/ME/DE*
Type:	Mandatory (Stage 1), Nonrepeatable

YB, *MB* and *DB* are the beginning year, month and day, respectively, of the data to extract and *YE*, *ME*, and *DE* are the ending year month and day, respectively. The "/" is required between each field and there cannot be any spaces within a date group since a space is used as a delimiter between parameter fields. The year can be entered as either a two-digit or four-digit integer (e.g., 1992 or 92). The month is a one- or two-digit integer corresponding to the month of the year and the day is the one- or two-digit day of the month. The word "TO" is optional and only serves to make the statement a little more readable. It is ignored by AERMET when this keyword is processed.

4.4.4 Identifying the station - LOCATION

The LOCATION keyword identifies the upper air station by the station's identifier, latitude and longitude of the station, and a time adjustment factor used to adjust the data to local standard time. The syntax and type are:

Syntax:	LOCATION *site_id* *NWS_lat/long* *NWS_long/lat* [*tadjust*]
Type:	Mandatory (Stage 1), Nonrepeatable, Reprocessed
Order:	Latitude (lat) and longitude (long) can appear in either order

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The *site_id* is a five to eight character alphanumeric specifier that identifies the station for which data are to be extracted. For the standard format listed on the DATA keyword, these identifiers are five-digit WBAN numbers. However, the *site_id* should entered to match the form of the identifier of the upper air station as it is recorded in the upper air file. For instance, 6201FB and 6201VB formats include a five-digit WBAN with leading zeros to fill the entire eight-character field (e.g., 14735 is recorded as 00014735) and should be specified as such on the LOCATION keyword in the UPPERAIR pathway since the field is read as type character and not as an integer. On the other hand, the WBAN in the FSL format is recorded as a five-digit number (14735) and should be specified on the LOCATION keyword with only five digits to match the WBAN in the FSL file. A mismatch in the station identifiers between the AERMET control file and the upper air file will generate a warning message, but processing will continue. As in the case of the *site_identifier* for the LOCATION keyword on the SURFACE pathway, AERMOD expects all characters to be numeric.

The NWS station latitude (*lat*) and longitude (*long*) can be entered in either order because AERMET distinguishes between the two by the suffix on each: an N or S with the latitude and W or E with the longitude. For example, "38.4N 81.9W" would be interpreted the same as "81.9W 38.4N" in AERMET. AERMET cannot use, nor does it recognize, "+" or "-" to discriminate between north and south and east and west. Therefore, the latitude and longitude should always be specified as positive numbers. The latitude and longitude of the upper air station are used by AERMET to select the most appropriate sounding available in the upper air data file. Refer to Sections 4.7.6.6 and 4.7.7 for information on AERMET's options for upper air sounding selection.

The final parameter for this keyword, *tadjust*, is optional and is an adjustment factor to convert the time of each observation in the input data file from the reported time to local standard time. The default value for *tadjust* is zero. For NWS upper air data processed by AERMET, the reported time is GMT. The value for *tadjust* is subtracted from GMT to obtain local standard time. Therefore, in the United States, which is west of Greenwich, the value 5 is specified to convert GMT to Eastern Standard Time, 6 is specified to convert GMT to Central

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Standard Time, 7 is specified to convert GMT to Mountain Standard Time, and 8 is specified to convert GMT to Pacific Standard Time.

Note that beginning with version 11059, AERMET no longer supports the user-specified station elevation as a parameter on the UPPERAIR LOCATION keyword. AERMET will issue a warning message if the elevation field is included. The user-specified elevation will be ignored and processing will continue. Refer to Section 5.6 for more detailed information about the history and use of the station elevation in the UPPERAIR, SURFACE, and ONSITE pathways.

4.4.5 How good are the data? - QAOUT

One purpose of AERMET is to contribute to the quality assurance process by identifying data that are out of range or suspect such that the user can determine appropriate steps to accept, modify, or reject the data. The QA is performed by including the QAOUT keyword in a runstream. This keyword is also used to specify the input file for Stage 2. The syntax and type for the QAOUT keyword are:

Syntax:	QAOUT *qa_output_filename*
Type:	Optional (Stage 1), Nonrepeatable Mandatory (Stage 2) if there are data to merge, Nonrepeatable

The *qa_output_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 96 characters.

Quality assessment is an optional process and the user does not have to perform a QA prior to merging the data. However, this step is recommended to identify any potential problems in the data that are used to derive the dispersion parameters.

Presently, AERMET's capabilities in this area are limited to verifying the values of the upper air data are not outside a range of acceptable values and keeping track of the number of

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missing values. These checks operate one sounding at a time, i.e., sounding to sounding variations are not checked.

Unlike the SURFACE pathway, there are no variables that are tracked (audited) automatically on the UPPERAIR pathway. The user must specify variables to QA through the AUDIT keyword, as discussed below. For each of the specified variables, the value of each variable at each level is compared to a missing value indicator and if the value is not missing, then the value is compared to an upper and lower bound that define the range of acceptable values. Each time a value is missing or violates one of the bounds, a message is written to the message file containing the value, the violation, the date and time of occurrence and the sounding level. The number of times the variable is missing, exceeds the upper bound and exceeds the lower bound is tallied and reported in the summary file (defined on the REPORT keyword).

The number of levels in a sounding and the heights at which the data are recorded vary from sounding to sounding. It is impractical to report on every level. AERMET divides the atmosphere into 10 regions in which to summarize the QA information for the soundings. These regions are based on the thickness increment defined to be 500 meters (in the variable UAINC in the file BLOCK1.INC). These regions are: surface (the first level in the sounding), every 500 meters up to 4000 meters and everything above 4000 meters. By changing the value of UAINC (and recompiling the software), these regions could be increased or decreased.

In the current version of AERMET there are no provisions for automatically replacing missing values or adjusting values that are outside the range of acceptable values. It is up to the user to review the QA summary information and, using sound meteorological principles and any regulatory guidance, either replace the value in question or leave it alone.

There are default upper and lower bounds in AERMET, as well as a default missing value indicator for each variable. These values can be changed by the user through the use of the RANGE keyword, as described below.

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4.4.6 Adding upper air variables to the QA - AUDIT

As mentioned above, there are no upper air variables that are tracked by default during a QA. The user can track some or all variables for a particular AERMET run by specifying the variable names on an AUDIT keyword. The syntax and type for this keyword are:

Syntax:	AUDIT *uaname*1 ... *uaname*n
Type:	Optional (Stage 1), Repeatable

where *uaname*1, ..., *uaname*n are the upper air variable names as defined in Table B-1 of Appendix B. As many variable names can be specified on a single keyword that will fit within the 132-character limitation of a keyword. Since this keyword is repeatable, more than one AUDIT keyword can be used to define the variables to track.

4.4.7 Changing the default values for the QA - RANGE

The user can modify the upper and lower bound limits for the QA if the values are not appropriate for the data. The missing value indicator can be changed as well. These changes are accomplished using the RANGE keyword. The syntax and type for the RANGE keyword are:

Syntax:	RANGE *uaname lower_bound* <[=] *upper_bound missing_indicator*
Type:	Optional (Stage 1), Repeatable, Reprocessed

where *uaname* is the upper air variable as defined in Table B-1 of Appendix B, *lower_bound* and *upper_bound* are the new lower and upper bounds to be used in the QA, and *missing_indicator* is a new missing value indicator. The special symbol "<" and the optional "=" indicate whether to exclude (<) or include (<=) the lower and upper bound values in the QA, i.e., exclude or include the endpoints of the acceptable range of values. All parameters must be specified for this keyword even if a parameter is not changing; if a parameter is not

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changing, the default value should be specified.

Data for the UPPERAIR pathway are written as integers to the output file with some variables having been multiplied by 10 to retain significant digits. Table B-1 provides information on which variables use a multiplier. The default upper and lower bounds are multiplied as well, therefore, the user must multiply any new upper and lower bounds by the same multiplier when entering the data on the RANGE keyword. However, the multiplier is not applied to the *missing_indicator*.

4.4.8 Reducing the number of QA messages - NO_MISSING

Every time a bound is violated or a value is missing, a message is written to the message file (defined on the MESSAGES keyword). If a variable that is tracked is missing most of the time, the message file could become very large. To reduce the number of missing value messages and the size of the message_file, the NO_MISSING keyword can be included for the QA. The syntax and type are:

Syntax:	NO_MISSING *uaname*1 ... *uaname*n
Type:	Optional (Stage 1), Repeatable

where *uaname*1, ..., *uaname*n are the variable names of the weather variables to omit from the message file. The missing values are tallied and the count is included in the report file but the individual message each time there is an occurrence is not included in the report or the message file

4.4.9 Adjusting sounding data - MODIFY

AERMET has been designed to check for other problems with the upper air data and correct them if the MODIFY keyword is used. The MODIFY keyword directs AERMET to 'turn on' the process and perform some preliminary quality control as the data are extracted. The syntax and type of the keyword are:

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Syntax:	MODIFY
Type:	Optional (Stage 1), Nonrepeatable

This keyword does not have any parameters associated with it. By specifying this keyword, the following actions occur:

- Some mandatory levels are deleted from the sounding;
- A nonzero wind direction is set to 0 if the wind speed is 0;
- Missing ambient and dew point temperatures are replaced by interpolated values.

If a mandatory sounding level is within one percent of a significant level (with respect to pressure) then the mandatory level is deleted. This modification is performed to reduce the possibility of reporting large gradients during the quality assessment (if the user opts to QA those gradients). There is little loss of information in the sounding since mandatory levels are derived from significant levels. However, the deletion process takes place after the data are extracted from the archive data and reduces the number of levels extracted. AERMET does not attempt to read more levels after deleting a level.

The wind speed and wind direction at each level are checked to insure that there are no levels with a zero wind speed and a non-zero wind direction. If one is found, the wind direction is set to zero to represent calm conditions. The winds from the soundings are not used in any boundary layer parameter estimates.

If the dry-bulb or dew-point temperature is missing at some level, then an estimate for the missing temperature is made by linearly interpolating to the level in question. The data from the level immediately below and above the level in question are used. If the data that are required for the interpolation are also missing, then no interpolation is performed.

4.5 ONSITE pathway

The ONSITE pathway provides a means of including data recorded during an

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observation program such as might be required for dispersion modeling for a facility. Such a program may utilize an instrumented tower (with data from several levels), a remote sensing device (such as lidar), and instrumentation at or near ground level (such as measuring fluxes). Much of this type of data can be used in AERMET to provide better estimates of the boundary layer parameters than using NWS data alone.

There are several keywords that are nearly identical to those found on the SURFACE and UPPERAIR pathways, and there are several keywords that are unique for this type of data. The only additional statements that must be included for site-specific data are those required to describe the structure of the data and a minimum detectable wind speed. All other statements are optional and could be omitted.

4.5.1 Retrieving archived data - DATA

The file containing the site-specific data is specified on the DATA keyword. Unlike the SURFACE and UPPERAIR pathways, there is no standard format or content for site-specific data. Thus, only the file name is specified on this keyword. The syntax and type for the DATA keyword are:

Syntax:	DATA *data_filename*
Type:	Mandatory (Stage 1), Nonrepeatable

The *data_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 96 characters.

4.5.1.1 Where is the EXTRACT keyword?

Unlike SURFACE and UPPERAIR data, site-specific data are not stored (archived) in any particular format. Therefore, the data are not "extracted" from an archive file, and there is no need for the EXTRACT keyword. The processing can begin with the quality assessment. Thus, the input file to the QA is defined on the DATA keyword.

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4.5.2 Defining the file structure - READ and FORMAT

One of the more difficult challenges for many users attempting to run the AERMET meteorological processor is to specify the inputs necessary to read and process site-specific, or ONSITE, meteorological data. Since the AERMOD dispersion model was designed to utilize a wide range of site-specific meteorological variables, including wind, temperature and turbulence data from a multi-level tower and/or SODAR, it is not practical to specify a standard format for site-specific data being input to AERMET. Also, since AERMET was written using the Fortran programming language, part of the challenge may be for users to understand some of the basic rules and concepts for reading data based on the Fortran language. This section describes the process for defining ONSITE meteorological inputs for AERMET, including enhancements introduced with version 11059 of AERMET that may simplify this process, and also provide better error handling and reporting if problems are encountered.

The key to reading site-specific meteorological data correctly in AERMET is to define what data variables are present and specify the format for reading the data. This task is accomplished with two related keywords on the ONSITE pathway: 1) the READ keyword, which defines the list and order of variables present on a data record; and 2) the FORMAT keyword, which defines the format of the data on each record. As noted above, these two statements together operate much like reading or writing data in a Fortran program. The syntax and type of these two keywords are as follows:

Syntax:	READ *record_index osname*1 *osname*2 ... *osname*n
Type:	Mandatory (Stage 1 ONSITE pathway), Repeatable, Reprocessed
Syntax:	FORMAT *record_index Fortran_format*
Type:	Mandatory (Stage 1 ONSITE pathway), Repeatable, Reprocessed

Each READ keyword is paired with a corresponding FORMAT keyword through the *record_index* field. This index refers to one "record" of data for an observation period, although the READ can span multiple records within the data file. The indices are numbered

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sequentially beginning with 1. There can be up to 50 variables on any one data record and up to 50 "records" (or READs) per observation period. There is no fixed limit on the record length for each physical record within the data file; however some of the error handling and reporting performed by AERMET for ONSITE data is limited to the first 500 characters of a given data record.

The *osname*1, *osname*2, … *osname*n fields on the READ keyword are the variable names for the variables included in the ONSITE data file for a particular data record, in the order in which they are to be read. The variable names available for ONSITE data are described in Table B-3 for "scalar" (single-level) variables and Table B-4 for "vector" (multi-level) variables. The *Fortran_format* field on the FORMAT keyword is normally the Fortran format statement that will be used to read the data from the corresponding READ keyword. However, beginning with version 11059, users can specify 'FREE' (without quotes and not case-sensitive) for the *Fortran_format* to indicate that the variables for a particular data record should be read as free-formatted data, in accordance with Fortran language standards. Free-formatted, also called list-directed data, are read as a list of values which are separated by at least one blank space or by a comma. The user has the option to specify FREE format for some data records, while specifying the Fortran FORMAT explicitly for other data records. The FREE format option may simplify the process of specifying the READ and FORMAT inputs for some users, but still requires an understanding of some basic rules to ensure that the data are input properly to AERMET.

The structure and format of the site-specific data is reasonably flexible, but subject to the following restrictions:

(1) The data for one observation period can be spread across several records (up to 50), but the records for one data period must be contiguous;

(2) The same variables must appear for all observation periods, even if the values for those variables are missing (i.e., filled with a missing value indicator) for certain hours;

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(3) The ONSITE data file must be an ASCII text file and it must be in a form that can be read using Fortran FORMAT statements or as FREE format;

(4) The date and time information for each observation must be on the first record of the observation period; these may occur in any order within the first record, and are read as INTEGER format (Fortran "I" format or FREE format);

(5) The (non-date) data variables on the READ keywords must be a subset of those listed in Appendix B, Table B-3 and Table B-4, and are read as REAL format (Fortran "F" or "E" format or as FREE format);

(6) Using an "F" or "E" (REAL) Fortran format specifier to read a date/time variable will cause an AERMET runtime error; and using an "I" (INTEGER) format specifier to read a data variable will also cause an AERMET runtime error.

When specifying the multi-level variables, such as wind or temperature observations from an instrumented tower, the variable name is composed of a two-character prefix that identifies the atmospheric quantity and a two-character (numeric) suffix that identifies the level. For example, height, temperature and wind speed from the first level would appear as HT01, TT01 and WS01 on the READ keyword, as HT02, TT02 and WS02 for the second level, and so on. The same variables do not have to appear for each level of data. For example, winds may appear at three levels but temperature only at two levels. However, multi-level data **must** be entered in ascending height order. The different methods available for specifying the measurement heights for ONSITE data processed through AERMET are discussed in detail in Section 4.5.9.

Unless FREE format is specified for a particular READ, the *Fortran_format* on the corresponding FORMAT keyword is a character string that AERMET uses directly within the program to read the data. Hence, the string must comply with all the rules of Fortran for creating a format statement. The format must begin with an open parenthesis and end with a closing parenthesis. Any book on the Fortran programming language can provide guidance on

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constructing a format statement, but here are some important points to remember:

- The Fortran "I" format specifier for integer constants consists of "I" followed by the width of the data field, such that a format of "I4" will read a 4-character data string as an integer number;

- A read error will be generated if a non-numeric character (other than a leading "+" or "-"), including a decimal ("."), occurs within the date field being read with an "I" format;

- The Fortran "F" format specifier for real constants consists of "F" followed by the width of the field and number of places after the decimal point (F*w.d*), such that a format of "F5.2" will read a 5-character data string, including the decimal, as a real number, with 2 places after the decimal point;

- Data being read as real constants using the "F" format specifier are not required to include decimal places within the data string; however, users must be aware of the rules for assigning values using the "F" format specifier in such cases:

  - If the data string includes a decimal place, then the value assigned to the REAL variable will reflect the number of decimal places specified; e.g., reading the string "10.23" as F5.2, F5.1, or F5.0 will all assign the value 10.23 to the variable.

  - However, if the data string does not include a decimal point the number of decimal places assigned will be based on the "F" format specifier, such that reading the string "*b*1023" (where "*b*" represents a blank) as F5.2, F5.1, or F5.0 will assign the values 10.23, 102.3, and 1023. to the variable, respectively.

- Data being read as REAL constants using the "FREE" format option will reflect the values as specified in the data file, such that a string of "10.23" will be assigned a value of 10.23, whereas a string of "1023" will be assigned a value of 1023;

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- Reading date variables as INTEGER constants using the "FREE" format option will not result in a read error if a decimal (".") occurs within the data field being read, but any data after the decimal point will be ignored, such that a data field of "4.8" will be read as an INTEGER value of 4. However, any other non-numeric character in the data field (other than a leading "+" or "-") will result in a Fortran read error.

The fourth bullet above related to the number of decimal places reflected in the data highlights one of the more significant problems that could arise with reading ONSITE data in AERMET, since the value assigned to the variable may not be the value intended by the user. This situation may arise if the ONSITE data file has been generated by exporting data from a spreadsheet program. In such cases the data values for a particular parameter may have a varying number of decimal places, including values with no decimal places for some records, since the spreadsheet program may output a fixed number of significant digits rather than a fixed number of digits after the decimal. While this issue could occur with any ONSITE data variables, it may be more likely for parameters that vary over a large range, such as solar radiation data. Given the potential problems that could arise if the data values being read by AERMET may not match the values intended, users are strongly encouraged to review the QAOUT file for the ONSITE data to ensure that the data have been read properly by AERMET. The QA audit statistics on values exceeding the upper and lower bounds for a given parameter may also highlight potential problems with the data. For cases when the “raw” ONSITE data include a variable number of decimal places, using the "FREE" format option or using "F*w*.0" as the Fortran format specifier may avoid the issue described above.

Beginning with version 11059, AERMET performs additional checks related to the processing of ONSITE data which may help the user to identify and avoid potential problems. One such check compares the number of decimals included in the data string for ONSITE data with the number of REAL variables being read. Warning messages are generated if the number of decimals found is less than the number of REAL variables, and if the number of decimals changes from one data record to another. Another issue that may arise with processing ONSITE data is that the missing data code used within the data file does not match the default missing

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code used by AERMET (shown in Table B-3 and Table B-4). AERMET will process the "missing" value as valid data in such cases, which may produce errors or anomalous results. The user can specify missing indicators that differ from the default using the RANGE keyword on the ONSITE pathway, and the QA audit statistics on values exceeding the upper and lower bounds may also highlight if such a problem exists. In addition, AERMET will issue warning messages, which are included in the REPORT files, for cases when the upper and lower bounds are exceeded by an amount larger than one half the range defined by UPPER-LOWER, which may flag this issue in some cases.

It may be the case that not all of the variables present in the site-specific data file need to be read. Any superfluous data can easily be skipped over using the "X", "T", and "/" specifiers in the Fortran FORMAT statement. However, the "FREE" format option does not allow for skipping values within the data record and assigns values to the variables based on the order of variables within the data file. Also, users should note that:

→ **the same format used to read the original site-specific data file is also used to write the QA output (QAOUT) file.**

If some variables or entire lines of data are skipped, then the QA output file will contain corresponding blank fields and/or blank lines.

Once the variables and formats have been defined, the user does not need to specify them for any subsequent AERMET runs (e.g., for Stage 3 processing) as long as the information remains in the header records of the QAOUT file generated in Stage 1 and the MERGE file generated in Stage 2. AERMET reprocesses these records as needed whenever the data are used in subsequent processing stages, saving the user the time required to setup that portion of a runstream file and avoiding introducing errors on these two keywords.Processing a Subset of the Data - XDATES.

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4.5.3 Processing a subset of the data - XDATES

The amount of data processed can be limited by using the XDATES keyword to specify the beginning and ending dates of the data to be extracted. The syntax and type are:

Syntax:	XDATES *YB/MB/DB* [TO] *YE/ME/DE*
Type:	Mandatory (Stage 1), Nonrepeatable

YB, *MB* and *DB* are the beginning year, month and day, respectively, of the data to process and *YE*, *ME*, and *DE* are the ending year month and day, respectively. The "/" is required between each field and there cannot be any spaces within the date group. The year can be entered as either a two-digit or four-digit integer (e.g., 1992 or 92). The month is a one- or two-digit integer corresponding to the month of the year and the day is the one- or two-digit day of the month. The word "TO" is optional and only serves to make the statement a little more readable. It is ignored by AERMET when this keyword is processed.

4.5.4 Identifying the station - LOCATION

AERMET requires location information about the site where the measurements are taken. The LOCATION keyword specifies the station identifier, latitude and longitude, and a time adjustment factor. The syntax and type are:

Syntax:	LOCATION *site_id* *site_lat/long* *site_long/lat* [*tadjust*] [*elevation*]
Type:	Mandatory (Stage 1), Nonrepeatable, Reprocessed
Order:	Latitude (lat) and longitude (long) can appear in either order

The *site_id (up to eight characters)* is an alphanumeric specifier that identifies the site. Since data are not extracted from archived data, this identifier is used only to identify the site in the output files (reports and from Stage 3). However, as with the LOCATION keyword on the UPPERAIR and SURFACE pathways, all characters entered that make up the *site_id* should be

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numeric as AERMOD expects a numeric value entered in the AERMOD runstream. AERMOD processing will abort if the value is not numeric.

The measurement site latitude and longitude can be entered in either order because AERMET distinguishes between the two by the suffix on each: an N or S with the latitude and W or E with the longitude. For example, "38.4N 81.9W" would be interpreted the same as "81.9W 38.4N". AERMET cannot use, nor does it recognize, "+" or "-" to discriminate between north and south and east and west. The site latitude and longitude for the ONSITE pathway are not used at this time. They are simply another way to identify the site being processed.

The parameter, *tadjust* is optional with a default value of zero and is an adjustment factor to convert the time of each observation in the input data file from the reported time to local standard time. Note, however, *tadjust* must be specified when also specifying the last parameter for the LOCATION keyword, *elevation.* The adjustment factor is subtracted from the reported hour. Since there is no standard format for site-specific data, the time reported could be relative to any time frame. For example, one time frame the user should verify is if the data are reported in local daylight time. If this is the case, then *tadjust* could be specified as 1 to return the data to local standard time, assuming that daylight time was used throughout the entire data period.

The final parameter, *elevation,* refers to the station elevation above MSL (in meters) and is also optional with a default value of zero meters. Station elevation should be included when the actual station elevation is non-zero because it will be used in the substitution hierarchy for missing station pressure (see Section 5.6).

4.5.5 How good are the data? - QAOUT

As with the UPPERAIR and SURFACE pathways, AERMET can assess the quality of the site-specific data by including the QAOUT keyword in the runstream. This keyword is also used to specify the input file name to Stage 2. The syntax and type for the QAOUT keyword

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are:

Syntax:	QAOUT *qa_output_filename*
Type:	Optional (Stage 1), Nonrepeatable Mandatory (Stage 2), Nonrepeatable

The *qa_output_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 96 characters.

Quality assessment is an optional process and the user does not have to perform a QA prior to merging the site-specifc data. However, this step is recommended to identify any possible problems with the data that are used to derive the boundary layer parameters.

Presently, AERMET's capabilities in this area are limited to verifying the values of the site-specific data are not outside a range of acceptable values and keeping track of the number of missing values. These checks operate one observation period at a time, i.e., variations over a period of time are not checked.

Site-specific data may be reported more frequently than once per hour (see the OBS/HOUR keyword discussed below in Section 4.5.12). For observations more frequent than once per hour, the QA procedures operate on the subhourly data. There is no QA on the one-hour averaged data.

When a quality assessment is performed on the site-specific data, several of the variables are automatically tracked (audited) and included in a summary of the QA process. These variables are: temperature, wind speed and wind direction. The value of each variable at each level is compared to a missing value indicator and if the value is not missing, then the value is compared to an upper and lower bound that define the range of acceptable values. Each time a value is missing or violates one of the bounds, a message is written to the message file defined on the MESSAGES keyword, which identifies the variable, the violation, and data and time of

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occurrence. The number of times the variable is missing, exceeds the upper bound and exceeds the lower bound is tallied and reported in the summary file defined by the REPORT keyword.

There are no provisions for automatically replacing missing site-specific values in AERMET, or adjusting values that are outside the range of acceptable values. It is up to the user to review the QA summary information and, using sound meteorological principles and any regulatory guidance, either replace the value in question or leave it alone.

There are default upper and lower bounds in AERMET, as well as a default missing value indicator for each variable. These values can be changed by the user through the use of the RANGE keyword, as described below (Section 4.5.7). The user can QA additional variables by using the AUDIT keyword.

4.5.6 Adding site-specific variables to the QA - AUDIT

As stated, only site-specific temperature, wind speed, and wind direction are tracked by default during the QA. The user can track additional variables for a particular AERMET run by specifying the variable name on an AUDIT keyword. The syntax and type for this keyword are:

Syntax:	AUDIT *osname*1 ... *osname*n
Type:	Optional (Stage 1), Repeatable

where *osname*1, ..., *osname*n are the site-specific variable names as defined inTable B-3 and Table B-4. For the multi-level variables (e.g., temperature) only the two leading alphabetic characters can be specified (e.g., TT), otherwise AERMET will terminate with an error. Every level where the variable appears will be QA'd. As many variable names can be specified on a single keyword that will fit within the 132-character limitation of a keyword. Since this keyword is repeatable, more than one AUDIT keyword can be used to define additional variables.

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4.5.7 Changing the default values for the QA - RANGE

The user can modify the upper and lower bound limits for the QA if the values are not appropriate for the data. The missing value indicator can be changed as well. These changes are accomplished using the RANGE keyword. The syntax and type for the RANGE keyword are:

Syntax:	RANGE *osname lower_bound* <[=] *upper_bound missing_indicator*
Type:	Optional (Stage 1), Repeatable, Reprocessed

where *osname* is the site-specific variable as defined in Table B-3, *lower_bound* and *upper_bound* are the new lower and upper bounds to be used in the QA, and *missing_indicator* is a new missing value code. The special symbol "<" and the optional "=" indicate whether to exclude (<) or include (<=) the lower and upper bound values in the QA, i.e., exclude or include the endpoints of the acceptable range of values. All parameters must be specified for this keyword even if a parameter is not changing; if a parameter is not changing, the default value should be specified. For the multi-level variables (e.g., wind speed and temperature), only the first two characters should be specified (e.g., WS and TT).

Unlike data for the SURFACE and UPPERAIR pathways, the site-specific data are written to the output file as real and integer values without multipliers because of the variety of data and user-defined formats. The exceptions to this rule are the surface variables shared with the SURFACE pathway.

4.5.8 Reducing the number of QA messages - NO_MISSING

Every time a bound is violated or a value is missing, a message is written to the message file (defined on the MESSAGES keyword). If a variable that is tracked is missing most of the time, the message file could become very large. To reduce the number of missing value messages and the size of the message file, the NO_MISSING keyword can be included for QA.

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The syntax and type are:

Syntax:	NO_MISSING *osname*1 ... *osname*N
Type:	Optional (Stage 1), Repeatable

where *osname*1, ..., *osname*N are the variable names of the weather variables to omit from the message file. The missing values are tallied and the count is included in the report file but the individual message each time there is an occurrence is not included in the report or the message file.

4.5.9 An alternate specification of measurement heights - OSHEIGHTS

AERMET provides two options for specifying the measurement heights for the multi-level profile data input through the ONSITE pathway. One option is to explicitly specify the measurement heights within the input data file, using the 'HTnn' variable on the READ keyword, where 'HT' refers to the height variable and 'nn' refers to the level at which the observation was taken, beginning with '01' for the first (lowest) level, '02 for the next lowest level, up to the highest level (see Table B-4). With this option the 'HTnn' variables would need to be included for each observation period within the data file. While AERMET allows the measurement heights to vary from one observation to the next with the 'HTnn' option (which is normally not the case), the number of levels must be the same for each data period, and the heights must be defined in increasing order from lowest height (HT01) to the highest height. Under this option, if measurement heights are found to decrease with height or be duplicated, all multi-level data for that observation period will be set as missing.

The OSHEIHGTS keyword on the ONSITE pathway provides an alternative approach for specifying measurement heights for multi-level profile data. The syntax and type for the OSHEIGHTS keyword are as follows:

OSHEIGHTS *height1 height2 ... heightn*

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Type:	Optional if height information is provided in the data; otherwise mandatory (Stage 1), Repeatable, Reprocessed

The *height1*, *height2*, … *heightn* variables are the measurement heights in meters, ordered from lowest to highest. If the OSHEIGHTS keyword is specified and the 'HTnn' variables are also defined on the READ keywords, AERMET will use the heights based on the OSHEIGHTS keyword to override the height variables that may be present in the data file. For example, if the heights in the data file are 10.0, 50.0 and 100.0 meters, but the user knows that the heights are really 9.0, 50.0 and 100.0 meters, rather than modify the data file, the OSHEIGHTS keyword can be used to rectify the problem.

4.5.10 Temperature differences - DELTA_TEMP

In addition to measuring ambient temperature directly, a site-specific data program may measure differences in temperature. These measurements can be either between the levels where the ambient temperature is measured or independently of these levels. Temperature difference near the surface can be used to infer sensible heat flux. Measured temperature differences are not the same as the ambient temperature difference between two levels. A true temperature difference utilizes an instrument, such as a thermocouple, that couples two levels of data, whereas ambient temperature at two levels most likely is measured by two independent instruments.

The ONSITE data pathway has provisions for up to three temperature differences, which are defined through the three variables DT01, DT02 and DT03 (see Table B-4). The heights that define the temperature difference cannot be entered directly through the READ and FORMAT keywords. The special keyword DELTA_TEMP defines the two levels that comprise the temperature difference. The syntax and type are:

Syntax:	DELTA_TEMP *index lower_height upper_height*
Type:	Optional (Stage 1), Repeatable, Reprocessed

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Each statement includes an index that corresponds to the temperature difference represented by the *lower_* and *upper_heights*. The *index* can range from one to three.

At present, none of the processing options in Stage 3 utilizes temperature difference. Methods may be incorporated in future versions of AERMET that require these values, and the structure for processing such data will already exist.

4.5.11 Threshold wind speeds - THRESHOLD

The threshold wind speed, the minimum wind speed required to detect air flow varies, from anemometer to anemometer. The user must specify the minimum detectable (threshold) wind speed of the site-specific anemometer. There is no default value. The THRESHOLD keyword is used for this purpose. The syntax and type for this keyword are:

Syntax:	THRESHOLD *threshold_wind_speed*
Type:	Mandatory (Stage 1), Nonrepeatable, Reprocessed

→ **The THRESHOLD keyword must be included when site-specific data are processed.**

The threshold can be no greater than 1.0 m/s. A value greater than 1.0 generates an error condition and AERMET does not process any data. For threshold values above 0.5 m/s, AERMET writes a warning message.

AERMET also imposes a minimum allowable wind speed for defining the wind speed to use in estimating the boundary layer parameters. This minimum is independent of the threshold wind speed and is defined as $2^{1/2} * \sigma_{vmin}$, where $\sigma_{vmin} = 0.2$ m/s.

4.5.12 Multiple observation periods for each hour - OBS/HOUR

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Site-specific data may be reported more frequently than once per hour. If the data include more than one equally-spaced observation period each hour, the keyword OBS/HOUR is used to specify the number of observations that AERMET should expect each hour. AERMET currently allows up to 12 observation periods per hour (i.e., every 5 minutes) and will calculate the average over all periods within the hour to produce an hourly average. At least half the observations for a variable must not be missing for AERMET to compute the average, otherwise the value for the hour is set to missing. A discussion on how the average is computed for each variable is in Section 5.4. If there is one observation period per hour, this keyword is optional. The syntax and type for this keyword are:

Syntax:	OBS/HOUR *n_obs*
Type:	Mandatory for data with more than 1 observation per hour (Stage 1), Nonrepeatable

All variables specified on the READ keywords must be reported at the same number of observations per hour, e.g., one variable cannot be reported once per hour and the remaining variables reported four times per hour.

Each hour of data must contain the same number of observation periods per hour. For example, if the user specifies 4 OBS/HOUR, but there are only two observation periods for one hour in the middle of the file, AERMET will not detect this condition and will not correctly compute the hourly averages for all subsequent hours.

4.6 MERGE pathway

This pathway is referred to as Stage 2 processing, which involves combining the different sources of data into one file composed of blocks of 24-hour data. This is an intermediate, but necessary, step between extracting and QA'ing archived data and estimating boundary layer parameters. As such, there are only two keywords related directly to this pathway.

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4.6.1 Output file - OUTPUT

As the data are combined/merged together in 24-hour blocks, the result is written to an ASCII text output file. The file is specified on the OUTPUT keyword. The syntax and type for OUTPUT are:

Syntax:	OUTPUT *merged_data_filename*
Type:	Mandatory, Nonrepeatable

The *merged_data_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 96 characters.

The input data are provided by the three data pathways through the QAOUT keyword when such data are available. For example, if there are no site-specific data to merge, then only the QAOUT keywords for the SURFACE and UPPERAIR pathways are required.

4.6.2 Substitution of NWS/FAA surface wind data with 1-minute ASOS wind data

Beginning with version 11059, several modifications have been made to AERMET related to the processing of surface observations from Automated Surface Observing Systems (ASOS) used to collect weather measurements at airports located within the U. S. The U.S. NWS and FAA began an effort in 1992 to replace the traditional observer-based system for collecting and reporting weather data with an automated system. As of 2010, there were over 900 ASOS stations located at airports across the U.S. The transition from the observer-based system to an automated system has presented both challenges and opportunities in relation of the use of such data to support dispersion modeling applications (EPA, 1997). This section describes several modifications to AERMET to address some of these challenges, as well as to take advantage of the opportunities, and the most significant changes are related to processing of ASOS wind data.

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4.6.2.1 Use of 1-minute ASOS wind data

In addition to the standard archives of surface observations based on ASOS, the NCEI began routinely archiving 1-minute ASOS wind data (TD-6405), beginning with data for January 2000 for first-order NWS ASOS stations, and beginning with data for March 2005 for all other ASOS stations. The 1-minute ASOS wind data files include the 2-minute average wind speed and direction reported every minute, i.e., the files consist of 60 overlapping 2-minute averages for an hour. By contrast, the standard archives of surface observations based on ASOS include a single 2-minute average wind speed, usually reported within 10 minutes before the hour. The values included in the 1-minute ASOS wind data files are reported to the nearest degree for wind direction and whole knots for wind speed. More importantly, whereas the standard ASOS archives report any wind speed below 3 knots as 0 knots to represent a calm, consistent with the METAR standard adopted in July 1996, the 1-minute ASOS wind data files include values for 1 knot and 2 knots.

The use of hourly-averaged wind speed and direction provides a more appropriate input for the AERMOD dispersion model than a single 2-minute average. Utilizing wind data for the full hour will typically result in a more complete data set since many hours classified as calm or variable (with a non-missing wind speed up to 6 knots, but missing wind direction) based on a single 2-minute average will be filled in with hourly averages derived from the 1-min ASOS wind data. Furthermore, the use of hourly averaged wind direction, derived from 2-minute averages reported to the nearest degree, eliminates the need to randomize wind directions as done for the standard observations which are reported to the nearest 10 degrees.

Beginning with version 11059, AERMET was updated to accept hourly averages of wind speed and wind direction derived from 1-minute ASOS wind observations available from the NCEI at ftp://ftp.ncdc.noaa.gov/pub/data/asos-onemin/. The hourly-averaged wind speed and wind direction files input to AERMET should be generated using EPA's 1-minute ASOS wind data processor, AERMINUTE (EPA, 2010). Hourly-averaged wind speed and direction data derived from 1-minute ASOS wind data files using AERMINUTE will be referenced below

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as "1-minute ASOS wind data."

The 1-minute ASOS wind data are read by AERMET during the Stage 2 merge processing. AERMET is instructed to include these data in the merged output by adding the ASOS1MIN keyword followed by the filename of the 1-minute ASOS wind data file on the SURFACE pathway in the Stage 2 control file using the following format:

Syntax:	ASOS1MIN *file_name*
Type:	Optional, Non-repeatable

When provided, 1-minute ASOS wind data can be used to substitute for missing ONSITE wind data or replace wind data from standard NWS or FAA SURFACE data formats when ONSITE data are not included. To substitute for missing ONSITE winds or replace standard SURFACE winds, the secondary keyword REFLEVEL (Section 4.7.6.2) must be specified with the SUBNWS parameter as a METHOD on the METPREP pathway in the Stage 3 control file.

When SUBNWS is specified, AERMET uses the following hierarchy, based on data availability for each hour, to select the wind data used to calculate boundary layer scaling parameters, and ultimately written to the surface file (SFC) generated during Stage 3 processing:

1. ONSITE winds,
2. 1-min ASOS winds; then
3. standard SURFACE winds.

Neither NWS SURFACE wind data nor 1-min ASOS wind data will be used to substitute for missing ONSITE wind data if the 'REFLEVEL SUBNWS' option under the METHOD keyword is omitted from the Stage 3 runstream.

Wind speeds from 1-minute ASOS wind data files are extracted and merged during Stage 2 processing. AERMET checks the observation date for consistency with the ASOS commission date, and if the 1-minute ASOS wind date precede the commission date the

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reference wind speed and direction are set to missing and an error message is generated (see Section 5.2 for more details).

4.6.2.2 Threshold wind speed for 1-minute ASOS winds

In 2003, NWS began replacing the traditional cup and vane wind instruments at ASOS stations with more sensitive sonic anemometers (NOAA, 2003). Unlike the standard cup anemometer, which has a nominal starting threshold of about 2 knots, sonic anemometers have virtually no starting threshold. As a result, the hourly-averaged winds processed through AERMINUTE based on sonic data will not include any calm hours (defined as wind speeds below the starting threshold of the anemometer).

Beginning with version 12345, a new THRESH_1MIN keyword was added for stage Stage 3 processing to specify a threshold wind speed for the 1-minute ASOS data. This threshold value only applies to the hourly averaged winds derived from the 1-minute ASOS data and does not apply to the standard hourly NWS weather observations. Since the minimum acceptable wind speed threshold for site-specific meteorological monitoring is 0.5 m/s under current EPA guidance (EPA, 2000), user's may specify the same threshold wind speed for winds derived from 1-minute ASOS data.to avoid imposing a more stringent requirement on data derived from 1-minute ASOS data than would be required for a site-specific monitoring program,

The new THRESH_1MIN keyword uses the following syntax:

Syntax:	THRESH_1MIN *threshold_speed*
Type:	Optional, Non-repeatable

where *threshold_speed* is the threshold wind speed in m/s. If the user specifies a threshold speed greater than 0.5 m/s, a warning is issued by AERMET. If a threshold wind speed greater than 1.0 m/s is specified, AERMET considers this a fatal error, will issue an error message and will not process data through Stage 3. The Stage 3 report file documents whether the

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THRESH_1MIN option has been used, and also specifies the number of calm winds identified based on the specified threshold value.

4.6.3 Merging a subset of the data - XDATES

As with the other data pathways, the amount of data merged can be limited by using the XDATES keyword to specify the beginning and ending dates of the data to be merged. The syntax and type are:

Syntax:	XDATES *YB/MB/DB* [TO] *YE/ME/DE*
Type:	Optional, Nonrepeatable

YB, *MB* and *DB* are the beginning year, month and day, respectively, of the data to extract and *YE*, *ME*, and *DE* are the ending year month and day, respectively. The "/" is required between each field and there cannot be any spaces within a date group. The year can be entered as either a two-digit or four-digit integer (e.g., 1992 or 92). The month is a one- or two-digit integer corresponding to the month of the year and the day is the one- or two-digit day of the month. The word "TO" is optional and only serves to make the statement a little more readable. It is ignored by AERMET when this keyword is processed.

If the XDATES keyword is omitted, then the preprocessor searches all the input files to this stage and determines the earliest date in the files. AERMET then merges the data beginning with this date and continuing for 367 days even if all the data are exhausted in the input files.

4.7 METPREP pathway

This pathway is also referred to as Stage 3, when the boundary layer parameters are estimated that will be used by the dispersion model. This is the third and final step in the sequence of steps that began with extracting data from archived data files.

Several of the keywords seen on the previous pathways are also used on this pathway in

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a nearly identical manner.

4.7.1 Input data file - DATA

Like all the previous stages, this stage requires input data. The data file generated by the Stage 2 processing - merging data - is the required file and is defined with the DATA keyword. The syntax and type are:

Syntax:	DATA *merged_data_filename*
Type:	Mandatory, Nonrepeatable

The *merged_data_filename*, which is an ASCII file, must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 96 characters.

4.7.2 Choosing a dispersion model - MODEL

Although AERMET currently only estimates parameters for the AERMOD dispersion model, it is designed with the capability to estimate parameters for other dispersion models. The MODEL keyword informs AERMET for which model to process the data. The syntax and type are:

Syntax:	MODEL *model_name*
Type:	Optional, Nonrepeatable

where *model_name* identifies the dispersion model. The AERMOD model is the default model, making this keyword optional.

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4.7.3 Identifying the site - LOCATION

Past versions of AERMET required the LOCATION keyword under the METPREP pathway in Stage 3. The METPREP LOCATION keyword had been used as the location for determining the time of sunrise which is needed for convective mixing height calculations. Beginning with version 11059, AERMET was modified to use the location of the primary surface station (i.e., the ONSITE station or the NWS surface station) specified in Stage 1 to determine the time of sunrise for mixing height calculations. The METPREP LOCATION keyword is now only needed when site-specific mixing heights are provided during Stage 1 and upper air sounding data are omitted from the processing. Otherwise, a warning message will be generated if the LOCATION keyword is included under the METPREP pathway, and the LOCATION parameters will be ignored. For applications with only site-specific mixing heights, without upper air data, the METPREP LOCATION keyword is needed for the conversion from GMT to LST, since the time zone specified on the ONSITE pathway is likely referenced to local time.

For those applications of AERMET when the METPREP LOCATION keyword is needed, it is identical in all respects to its usage on other pathways: the site identifier, latitude and longitude, and a time adjustment factor. The syntax and type are:

Syntax:	LOCATION *site_id* *source_lat/long* *source_long/lat* [*tadjust*]
Type:	Conditional, Nonrepeatable
Order:	Latitude (lat) and longitude (long) can appear in either order

The *site_id* is an eight character alphanumeric specifier that identifies the site. This field is simply a means to identify the site and is not used otherwise.

The latitude (*lat*) and longitude (*long*) on the METPREP pathway should reflect the location of the source, i.e., the location where the dispersion model is to be applied. Latitude and longitude can be entered in either order because AERMET distinguishes between the two

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by the suffix on each: an N or S with the latitude and W or E with the longitude. For example, "38.4N 81.9W" would be interpreted the same as "81.9W 38.4N". AERMET cannot use, nor does it recognize, "+" or "-" to discriminate between north and south and east and west.

The final parameter for this keyword, *tadjust*, is required and is an adjustment factor to convert GMT to LST. The value of this parameter should be entered as a positive number for sites west of Greenwich such as in the U.S.

4.7.4 Instrumentation heights for NWS data - NWS_HGT

When various parameters are computed for the dispersion models, the height of the instruments is usually required. With site-specific meteorological data, the heights of the measurements are generally available and entered through the READ or OSHEIGHTS keywords on the ONSITE pathway in the Stage 1 runstream. If there are no site-specific data, or for isolated hours when there are site-specific data, then NWS data may be substituted for the computations. However, instrument height is not one of the reported parameters. The NWS_HGT keyword is used to provide this information. The syntax and type are:

Syntax:	NWS_HGT *variable_name* *instrument_height*
Type:	Mandatory, Repeatable

The *variable_name* specifies which meteorological instrument is being referenced and is followed by the *instrument_height* in the appropriate units. Currently, there is only one variable name: WIND. Prior to the conversion to ASOS, the height of the wind instrument (anemometer) was about 20 feet (6.7 meters) or 30 feet (9.1 meters). The height of wind instrumentation at ASOS sites is typically 33 feet (10.1 meters) or 26 feet (7.9 meters). Annual local climatological data are available from the NCEI and contain a historical record of instrumentation sites and heights for the stations. The user should consult a reference such as

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the annual summaries prior to running Stage 3 to obtain the correct height to use with this keyword. AERMET requires the anemometer height in meters.

4.7.5 Processing a subset of the merged data - XDATES

Like all previous pathways, the amount of data processed can be limited by using the XDATES keyword to specify the beginning and ending dates of the data to be merged. The syntax and type are:

Syntax:	XDATES *YB/MB/DB* [TO] *YE/ME/DE*
Type:	Optional, Nonrepeatable

YB, MB and DB are the beginning year, month and day, respectively, of the data to extract and YE, ME, and DE are the ending year month and day, respectively. The "/" is required between each field and there cannot be any spaces within the date group. The year can be entered as a two-digit or four-digit integer (e.g., 1992 or 92). The month is a one- or two-digit integer corresponding to the month of the year and the day is the one- or two-digit day of the month. The word "TO" is optional and only serves to make the statement a little more readable. It is ignored by AERMET when this keyword is processed.

If the XDATES keyword is omitted, then the AERMET processes all the data in the input file specified on the DATA keyword.

4.7.6 Processing options - METHOD

The METHOD keyword is used to define processing methods for the input data including: data substitution, special treatment of ASOS wind data, stable boundary layer treatment, and upper air sounding selection. This METHOD keyword requires a secondary keyword (*process*) to identify the particular meteorological variables that are affected and the option (*parameter*) to use. The syntax and type are:

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Syntax:	METHOD *process* *parameter*
Type:	Optional, Repeatable

The list of valid secondary keywords for the METHOD keyword has grown substantially with the more recent updates to AERMET. The following is a list of valid secondary keywords that will be discussed in the subsections that follow: WIND_DIR, REFLEVEL, ASOS_ADJ, UASELECT, STABLEBL, CCVR , and TEMP.

4.7.6.1 Randomization of NWS wind directions – WIND_DIR

National Weather Service wind directions are reported to the nearest 10°. The secondary keyword WIND_DIR is used to enable and disable a randomization procedure which adjusts NWS wind directions to yield directions to the nearest degree. The randomization procedure is enabled or disabled by specifying RANDOM or NORAND, respectively, after the WIND_DIR keyword. Randomization is disabled by default if the secondary keyword WIND_DIR is not specified. However, if the user wants a reminder as to how the data were processed, the NORAND parameter can be specified. WIND_DIR is included in the METPREP pathway using the following format:

Syntax:	METHOD WIND_DIR RANDOM or NORAND
Type:	Optional, Non-repeatable

Randomization is accomplished by using a single-digit random number, with a separate random number predefined for each hour of the year. This array of numbers is static and is the EPA standard set of random numbers used to randomize wind directions. The random number is added to the wind direction (which is first multiplied by 10) and 4 is subtracted from the result to yield a direction to the nearest degree. The array of random numbers is internal to AERMET; therefore, a separate file of these standard random numbers is not necessary.

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This keyword has no effect when site-specific data are available for the hour. It is assumed that the site-specific wind direction is reported to the nearest degree and does not need randomizing.

4.7.6.2 NWS data substitution - REFLEVEL

The secondary keyword REFLEVEL directs AERMET to substitute NWS data in the computations in the event site-specific data are missing for the hour. The only valid parameter is SUBNWS which enables data substitution to estimate boundary layer parameters. If there are no site-specific data in the data base, i.e., only NWS hourly observations and upper air soundings were merged, this secondary keyword REFLEVEL becomes mandatory, and if it is omitted, AERMET detects this condition (i.e., no site-specific data and do not substitute NWS data) as an error and will not process any data. If there are site-specific data in the data base, but some of the variables required for the boundary layer computations are missing, then this parameter directs AERMET to SUBstitute NWS data so the boundary layer parameters can be calculated. Also, if the site-specific profiles of wind and/or temperature are missing for an hour, this parameter directs AERMET to use NWS data to create a single-level profile of wind and/or temperature. The format for enabling NWS substitution using the METHOD keyword in the METPREP pathway is as follows:

Syntax:	METHOD REFLEVEL SUBNWS
Type:	Optional, Non-repeatable

4.7.6.3 Adjustment to truncated ASOS wind speeds – ASOS_ADJ

Beginning with version 11059, AERMET was been modified to add ½ knot (0.26 m/s) to all ASOS-based wind speeds in order to compensate for the bias introduced due to the wind speeds being truncated, rather than rounded, to whole knots (NOAA, 2008). There are two sources of ASOS wind data that can be input to AERMET: 1) NWS data in one of the standard NWS surface data formats; and 2) hourly-averaged wind speed and direction derived from

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1-minute ASOS wind data files generated with AERMINUTE (EPA, 2010).

The ½ knot ASOS wind speed adjustment is applied, by default, during Stage 3 processing to wind speeds substituted from 1-minute ASOS wind data as well as those substituted from standard NWS/FAA surface data determined to be ASOS winds based on the ASOS commission date. The user can override the default truncation adjustment by adding the ASOS_ADJ method and NO_ADJ keyword to the Stage 3 METPREP pathway using the following format:

Syntax:	METHOD ASOS_ADJ NO_ADJ
Type:	Optional, Non-repeatable

In order to document the source of the wind data in the Stage 3 SFC file output by AERMET, and identify whether the wind speed was adjusted, a two-part code is appended to the end of each record. The first part of the code indicates whether the wind speed was or was not adjusted with either "ADJ" or "NAD," respectively. The source of the wind data for each record is encoded as either "OS", "SFC", or "A1" to indicate the use of ONSITE, SURFACE, or 1-minute ASOS winds, respectively. The two parts of the code are separated by a hyphen, and if no wind data are available for a particular hour, the second part of the code is blank.

4.7.6.4 BETA option to adjust ustar under low wind/stable conditions - STABLEBL

Beginning with version 12345, the AERMET program includes a non-Default BETA option in Stage 3 processing to adjust the surface friction velocity (u* or ustar) for low wind speed stable conditions, based on Qian and Venkatram (2011). The option is selected by including the METHOD STABLEBL ADJ_U* keyword on the METPREP pathway in the Stage 3 input file. In addition, beginning with version 13350, AERMET has incorporated a new ADJ_U* option for applications that utilize the Bulk Richardson Number (BULKRN) option for estimating the stable boundary layer u* using low-level temperature difference (delta-T) data based on Luhar and Rayner (2009)). The syntax of the ADJ_U* BETA option is as follows:

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Syntax:	METHOD STABLEBL ADJ_U*
Type:	Optional, Non-repeatable

The ADJ_U* "BETA" option is considered to be a non-Default option and is therefore subject to the alternative model provisions in Section 3.2 of Appendix W (40 CFR Part 51). Users should coordinate with the appropriate reviewing authority regarding the procedures and requirements for approval of this BETA option for regulatory modeling applications. Although AERMET does not include a regulatory default switch, use of this option also requires the user to include the BETA option on the CO MODELOPT keyword in the AERMOD input file.

4.7.6.5 Substitutions for missing cloud cover and temperature – CCVR, TEMP

Beginning with version 13350, the AERMET program includes substitutions for missing cloud cover and temperature data based on linear interpolation across gaps of 1 or 2 hours. Linear interpolation across short gaps is a reasonable approach for these variables since ambient temperatures tend to follow a diurnal cycle and do not vary significantly from hour to hour, and AERMOD is relatively insensitive to hourly fluctuations in cloud cover, especially during convective hours since the heat flux is integrated across the day. Furthermore, gaps of 1 or 2 hours for these parameters near the early morning transition to a convective boundary layer may result in all convective hours for that day being missing.

The cloud cover and temperature substitutions are applied by default, unless the application involves both NWS and ONSITE surface data. However, beginning with version 14134, substitutions will be applied by default if the parameter is only available for one type of data (NWS or ONSITE). For example, for cases with ONSITE data that includes temperature data but no cloud cover data, the cloud cover substitutions will be applied to the NWS data by default, but the temperature substitutions will not be applied unless the user specifies the TEMP SUB_TT option on the METHOD keyword in Stage 3. Options have also been incorporated in AERMET during Stage 3 that allow users to disable cloud cover and/or temperature substitutions, irrespective of the type(s) of data being processed. These Stage 3 options also

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allow users to activate these substitutions for cases with both NWS and ONSITE data; however this could result in substitutions based on interpolation between NWS and ONSITE values on either side of the gap.

As noted above, the substitutions are based on linear interpolation across gaps of 1 to 2 hours. Interpolations are only made based on non-interpolated values on both sides of the data gap. In addition, beginning with version 14134 substitutions for missing ONSITE temperature data are only applied for values from the same measurement level, if multi-level temperature data are available. Valid data available for hours 23 and 24 of the previous day are used to substitute for missing data for hours 1 and 2. However, since AERMET has not been modified to read ahead to extract data for the next day, substitutions for missing data for hour 24 (and hour 23 if hour 24 is also missing) are based on persistence.

The options for users to disable or activate the cloud cover (CCVR) and temperature (TEMP) substitutions are included under the METHOD keyword in Stage 3. Beginning with version 14134, AERMET also allows users to disable interpolations for hours 23 and 24 that are based on persistence for CCVR, TEMP or both. The syntax of these options is as follows:

Syntax:	METHOD CCVR SUB_CC or	(activates CCVR substitutions)
	METHOD CCVR NO_SUB or	(disables CCVR substitutions)
	METHOD CCVR NOPERS for	(disables CCVR substitutions hours 23 and 24 that are based on persistence)
	METHOD TEMP SUB_TT or	(activates TEMP substitutions)
	METHOD TEMP NOTSUB	(disables TEMP substitutions)

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	or	
	METHOD TEMP NOPERS	(disables TEMP substitutions for hours 23 and 24 that are based on persistence)
Type:	Optional, Non-repeatable (for a given option of CCVR of TEMP)	

4.7.6.6 Upper air sounding selection by sunrise - SUNRISE

The AERMET meteorological preprocessor was originally developed to work with NWS upper air sounding data available in the United States and North America. Since that time, AERMET has been increasingly applied in areas outside North America. If observed ONSITE mixing heights are not available, AERMET requires a morning sounding to compute the hourly convective mixing heights for AERMOD. The preferred sounding time is prior to sunrise, before the convective mixed layer begins to develop. In North America, this generally means the 1200 GMT sounding (also referred to as the 12Z sounding). In other parts of the world this means the 0000 GMT (or 00Z) sounding. Originally, AERMET was designed to automatically select the 12Z sounding, consistent with the primary focus of the AERMOD model development to support modeling applications within the U.S. Since the reported upper air observation time is known to vary slightly, AERMET also defined a default "sounding window" of ±1 hour, i.e., AERMET accepted the 11Z, 12z, or 13Z sounding. Beginning with version 11059, AERMET was enhanced to select an upper air sounding that is more appropriate for the location where AERMET is being applied.

The world is divided into 24 time zones, but most zones do not follow a straight north-south line of longitude (see Figure 4-1). As a result, the time zone adjustment parameter on the LOCATION keyword on the Stage 1 UPPERAIR pathway is not a reliable indicator for selecting the appropriate sounding time. Beginning with version 11059, the default approach in AERMET has been enhanced to search for an appropriate sounding for all locations based on the longitude entered on the LOCATION keyword under the UPPERAIR pathway by

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computing a 'pseudo' time zone based on this longitude. The longitude is divided by 15 with the result rounded to the nearest integer. For example, 156.76° West yields a time zone of -10 (in keeping with the standard convention that west longitudes are negative). It is worth noting that in Alaska, the time zone is -9 for the entire state but the state actually spans pseudo-zones -9, -10, and -11 based on longitude. This is not an uncommon occurrence.

Table 4-1 shows which default sounding AERMET will use based on the longitude-dependent 'pseudo' time zone (note that time zones -12 and +12 refer to the same zone). The values shown in the table are also shown across the top of Figure 4-1. A sounding time of -12 indicates the use of the 1200 GMT (12Z) sounding from the previous day and is primarily used in the Far East, southeast Asia, Australia, and New Zealand.

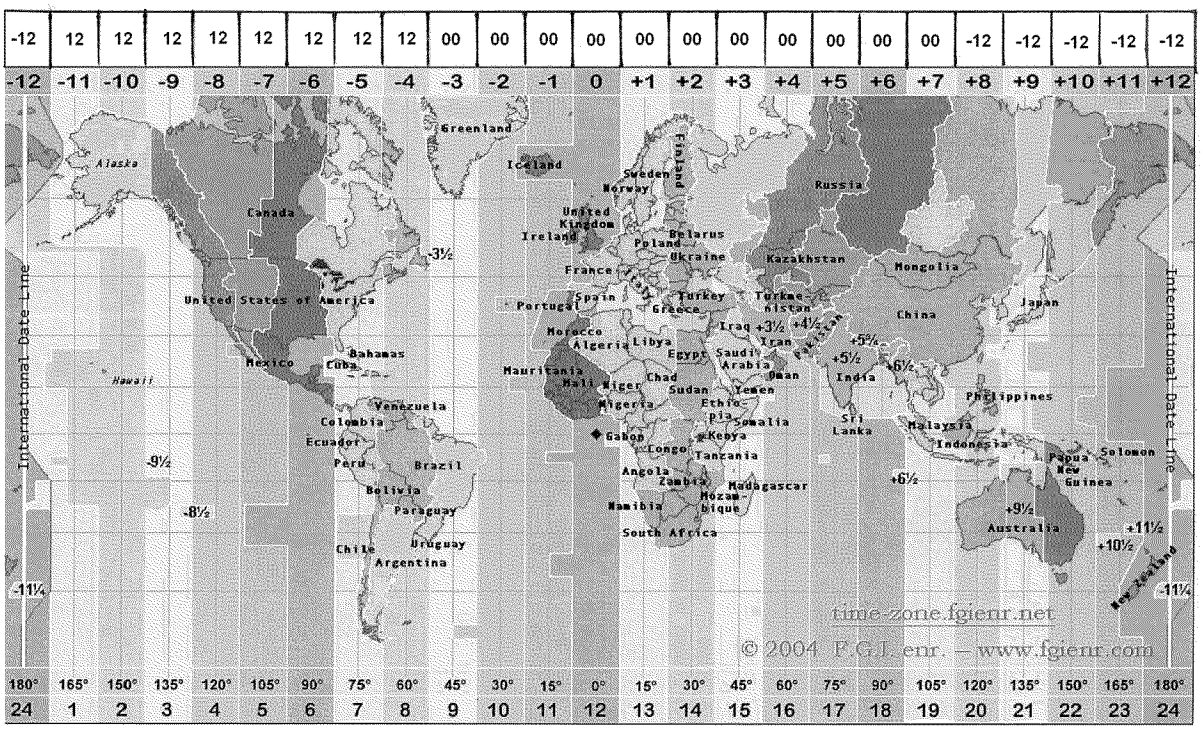

Figure 4-1. Time Zone Boundaries (with preferred sounding time across top).

Table 4-1. Sounding Selection by Time Zone

Time Zone	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
Sounding	-12	12	12	12	12	12	12	12	12	00	00	00	00
Time Zone	1	2	3	4	5	6	7	8	9	10	11	12	--
Sounding	00	00	00	00	00	00	00	-12	-12	-12	-12	-12	--

AERMET has also been enhanced to include an optional method to search for the morning sounding based on the local time of sunrise at the UPPERAIR station location. Using the new method, SUNRISE, AERMET can search for the sounding nearest to sunrise rather than looking for a 00Z or 12Z sounding. By default, when this option is specified, AERMET attempts to find a sounding within 6 hours before sunrise, and if that search fails, it searches up to 2 hours after sunrise. This search window, as well as the default search window when the SUNRISE method is not enabled, can be extended in either direction using the new keyword UAWINDOW, described below in Section 4.7.7. When search for a sounding using the SUNRISE method, priority is given to soundings prior to and including sunrise, such that a sounding that is 4 hours before sunrise is preferred, and selected, over a sounding that is 1 hour after sunrise.

To invoke this search, a new option for the METHOD keyword under the METPREP pathway in Stage 3 has been defined: UASELECT. The syntax of the new UASELECT option is as follows:

Syntax:	METHOD UASELECT SUNRIS(E)
Type:	Optional, Non-repeatable

Note that the 'E' on 'SUNRISE' is optional and can be omitted.

4.7.7 Adjusting the default sounding window - UAWINDOW

By default, AERMET uses a 1-hour window before and after the preferred sounding time as the search window to locate a sounding to use. Beginning with version 11059, the user can expand (or contract) this window by using the optional UAWINDOW keyword under the METPREP pathway in Stage 3. The syntax of the UAWINDOW keyword is as follows:

Syntax	UAWINDOW *window_begin window_end*

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:
Type: Optional, Non-repeatable

where w*indow_begin* represents the beginning of the sounding window and w*indow_end* represents the end of the sounding window, entered as the number of hours relative to the preferred sounding time (whether it be 12Z or 00Z). A negative number indicates the number of hours before the reference sounding, and a positive number indicates the number of hours after the sounding. The default sounding window would be input as: UAWINDOW -1 +1 (note that the plus sign in not required). The sounding window does not have to be symmetric about the sounding time. For example if the user wants to search more hours before the sounding time and fewer after, the following could be used: UAWINDOW -5 +2. To force AERMET to accept only soundings corresponding to the reference sounding time, the user would input: UAWINDOW 0 0. If multiple soundings are available within the upper air sounding window, AERMET will select the sounding closest in time to the reference sounding, with a preference for soundings prior to and including the reference sounding time. For example, if UAWINDOW -5 +2 is specified, and soundings are available for 9Z, 12Z, and 15Z, AERMET would select the 12Z sounding. However, if soundings were available for 9Z and 13Z, AERMET would select the 9Z sounding.

As with the 12Z/00Z sounding search, the user can expand or contract the search window for the SUNRISE option (-6 to +2 hours by default) using the UAWINDOW keyword. The syntax for the UAWINDOW keyword is the same in both cases. When used UAWINDOW is used in conjuction with the SUNRISE method, w*indow_begin* and w*indow_end* represent the number of hours before and after sunrise to conduct the search. For purposes of applying the sounding window, sunrise is defined as the beginning of the hour during which the sun rises. For example, if sunrise is calculated to occur at 06:45 local time, AERMET will define sunrise as 0600 and preference will be given to a sounding at 0600 vs. a sounding at 0700.

4.7.8 Surface characteristics - FREQ_SECT(2), SECTOR(2), and SITE_CHAR(2)

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Surface conditions at the measurement site, referred to as the surface characteristics, influence boundary layer parameter estimates. Obstacles to the wind flow, the amount of moisture at the surface, and reflectivity of the surface all affect the estimates. These influences are quantified through the surface albedo, Bowen ratio and roughness length (z_0). AERMET was revised, beginning with version 11059, to require two sets of surface characteristics (primary and secondary) in the METPREP pathway of the Stage 3 control file when the SUBNWS option is specified and both ONSITE and SURFACE data are provided (including 1-minute ASOS wind data). If either ONSITE data or SURFACE data are omitted, only a single (primary) set of surface characteristics is required.

The primary set of surface characteristics are defined for AERMET through the three keywords FREQ_SECT, SECTOR and SITE_CHAR used to specify the temporal frequency, number of sectors, and the site characteristics (albedo, Bowen ratio, and effective surface roughness length), respectively. The secondary set of site characteristics are specified using similar keywords, FREQ_SECT2, SECTOR2, and SITE_CHAR2. These keywords for the secondary set should be added to the METPREP pathway immediately after the primary set of characteristics when defining both a primary and secondary set of surface characteristics.

The FREQ_SECT and FREQ_SECT2 keywords define how often the surface characteristics change (the *frequency*), or alternatively, the period of time over which these characteristics remain constant, and the number of non-overlapping sectors into which the 360°-compass is divided (*number_of_sectors*).

→ **The FREQ_SECT and FREQ_SECT2 keywords can appear only once and must appear before the SECTOR (SECTOR2) and SITE_CHAR (SITE_CHAR2) keywords**.

The syntax and type for the FREQ_SECT and FREQ_SECT2 keywords are as follows:

Syntax:	FREQ_SECT **or** *frequency number_of_sectors* FREQ_SECT2

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Type:	Mandatory (Stage 3), Nonrepeatable, Reprocessed
Order:	These keywords must appear before SECTOR (SECTOR2) and SITE_CHAR (SITE_CHAR2)

The *frequency* can be ANNUAL, SEASONAL or MONTHLY, corresponding to 1, 4, or 12 periods, respectively. ANNUAL and MONTHLY are straightforward: the site characteristics are the same for all months of the year, or the site characteristics vary from month to month, respectively. When SEASONAL is specified, then the site characteristics are distributed by month as follows:

Season #	Season	Months
1	Winter	December, January, February
2	Spring	March, April, May
3	Summer	June, July, August
4	Autumn	September, October, November

The number before the season represents the *frequency-index* that is specified for that season on the SITE_CHAR keyword.

A minimum of 1 and a maximum of 12 can be specified for the *number_of_sectors*.

A SECTOR statement defines the beginning and ending wind direction sector for which the surface characteristics apply. The syntax and type of this keyword are:

Syntax:	SECTOR *sector_index beginning_direction ending_direction* or SECTOR2 *sector_index beginning_direction ending_direction*
Type:	SECTOR: Mandatory, SECTOR2: Conditional (Stage 3), Repeatable, Reprocessed

One sector is defined per keyword, with the *sector_index* linking a specific sector to a set of site characteristics. The sectors are defined clockwise, they must cover the full circle, and

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these must be defined so that the end of one sector corresponds to the beginning of another. The *beginning_direction* is considered part of the sector, while the *ending_direction* is excluded from the sector. The directions reference the direction from which the wind is blowing. A sector can cross through north (e.g., 345 - 15) or can start and stop at north (e.g., 0 - 30 and 270 - 360). AERMET will verify that the entire 360° circle is covered. See Section 3.1 and Section 5.7.2 for additional discussions on defining the wind direction sector and the associated surface characteristics.

The site characteristics are specified on the SITE_CHAR and SITE_CHAR2 keywords, with one statement for each combination of time period and wind sector. The syntax and type for these keywords are:

Syntax:	SITE_CHAR or *frequency_index sector_index albedo Bowen roughness* SITE_CHAR2
Type:	Mandatory (Stage 3), Repeatable, Reprocessed

The *frequency_index* varies from one to the number of time periods corresponding to the frequency defined on the FREQ_SECT (or FREQ_SECT2) keyword. The *sector_index* varies from one to the number of sectors defined on the FREQ_SECT (or FREQ_SECT2) keyword. These indices are followed by the albedo, Bowen ratio and roughness length for the frequency/sector combination. If the maximum frequency (MONTHLY) and maximum number of sectors were defined (12), then it would require 144 (12 frequencies and 12 sectors) SITE_CHAR (or SITE_CHAR2) statements to completely define the site characteristics.

The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. Typical values range from 0.1 for thick deciduous forests to 0.90 for fresh snow. The daytime Bowen ratio, an indicator of surface moisture, is the ratio of the sensible heat flux to the latent heat flux and is used for determining planetary boundary layer parameters for convective conditions. While the diurnal variation of the Bowen ratio may be significant, the Bowen ratio usually attains a fairly constant value during the day. Midday

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values of the Bowen ratio range from 0.1 over water to 10.0 over desert. The surface roughness length is related to the height of obstacles to the wind flow and is, in principle, the height at which the mean horizontal wind speed is zero. Values range from less than 0.001 m over a calm water surface to 1 m or more over a forest or urban area.

Table 4-2 through Table 4-6, from Paine (1987), provide some guidance on specifying these values by land use type and season. In these tables, the seasons do not correspond to a particular group of months, but more on latitude and the annual vegetative growth cycles. Spring refers to the period when vegetation is emerging or partially green and applies to the 1-2 months after the last killing frost. The term summer applies to the period when vegetation is lush. The term autumn refers to the period of the year when freezing conditions are common, deciduous trees are leafless, soils are bare after harvest, grasses are brown and no snow is present. Winter conditions apply to snow-covered surfaces and subfreezing temperatures. For example, March in the southern United States is spring, but it is still winter in much of New England. It is up to the user to determine how to apply this information.

Table 4-2. Albedo of Ground Covers by Land Use and Season

Land-Use	Spring	Summer	Autumn	Winter
Water (fresh and sea)	0.12	0.10	0.14	0.20
Deciduous Forest	0.12	0.12	0.12	0.50
Coniferous Forest	0.12	0.12	0.12	0.35
Swamp	0.12	0.14	0.16	0.30
Cultivated Land	0.14	0.20	0.18	0.60
Grassland	0.18	0.18	0.20	0.60
Urban	0.14	0.16	0.18	0.35
Desert Shrubland	0.30	0.28	0.28	0.45

The Bowen ratio for winter in the next three tables depends on whether a snow cover is present continuously, intermittently or seldom. For seldom snow cover, the values between autumn and winter may be more applicable; for continuous snow cover, the values for winter are

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applicable. For bodies of water, it is assumed that the surface is frozen.

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Table 4-3. Daytime Bowen Ratio by Land Use and Season – Dry Conditions

Land-Use	Spring	Summer	Autumn	Winter
Water (fresh and sea)	0.1	0.1	0.1	2.0
Deciduous Forest	1.5	0.6	2.0	2.0
Coniferous Forest	1.5	0.6	1.5	2.0
Swamp	0.2	0.2	0.2	2.0
Cultivated Land	1.0	1.5	2.0	2.0
Grassland	1.0	2.0	2.0	2.0
Urban	2.0	4.0	4.0	2.0
Desert Shrubland	5.0	6.0	10.0	10.0

Table 4-4. Daytime Bowen Ration by Land Use and Season - Average Moisture Conditions

Land-Use	Spring	Summer	Autumn	Winter
Water (fresh and sea)	0.1	0.1	0.1	1.5
Deciduous Forest	0.7	0.3	1.0	1.5
Coniferous Forest	0.7	0.3	0.8	1.5
Swamp	0.1	0.1	0.1	1.5
Cultivated Land	0.3	0.5	0.7	1.5
Grassland	0.4	0.8	1.0	1.5
Urban	1.0	2.0	2.0	1.5
Desert Shrubland	3.0	4.0	6.0	6.0

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Table 4-5. Daytime Bowen Ratio by Land Use and Season - Wet Conditions

Land-Use	Spring	Summer	Autumn	Winter
Water (fresh and sea)	0.1	0.1	0.1	0.3
Deciduous Forest	0.3	0.2	0.4	0.5
Coniferous Forest	0.3	0.2	0.3	0.3
Swamp	0.1	0.1	0.1	0.5
Cultivated Land	0.2	0.3	0.4	0.5
Grassland	0.3	0.4	0.5	0.5
Urban	0.5	1.0	1.0	0.5
Desert Shrubland	1.0	1.5	2.0	2.0

Table 4-6. Surface Roughness Length, in Meters, by Land Use and Season

Land-Use	Spring	Summer	Autumn	Winter
Water (fresh and sea)	0.0001	0.0001	0.0001	0.0001
Deciduous Forest	1.00	1.30	0.80	0.50
Coniferous Forest	1.30	1.30	1.30	1.30
Swamp	0.20	0.20	0.20	0.05
Cultivated Land	0.03	0.20	0.05	0.01
Grassland	0.05	0.10	0.01	0.001
Urban	1.00	1.00	1.00	1.00
Desert Shrubland	0.30	0.30	0.30	0.15

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An additional source of information for surface roughness length can be found in Stull (1988). Surface characteristics used in AERSURFACE may be more appropriate than those shown above and can be found in the AERSURFACE User's Manual (EPA, 2008).

The following shows the format for defining both a primary and a secondary set of surface characteristics in the METPREP pathway:

```
** Primary Surface Characteristics
   FREQ_SECT     frequency   number_of_sectors
   SECTOR        sector_index   beginning_direction   ending_direction
   SITE_CHAR     frequency_index   sector_index   albedo Bowen roughness

** Secondary Surface Characteristics
   FREQ_SECT2    frequency   number_of_sectors
   SECTOR2       sector_index   beginning_direction   ending_direction
   SITE_CHAR2    frequency_index   sector_index   albedo Bowen roughness
```

The primary set of characteristics will be applied for those hours in which the data are used when the data are provided. Likewise, the primary characteristics will be applied to the NWS surface data if onsite data are omitted from the application and only one set of surface characteristics is required. If both onsite data and NWS surface data (including 1-minute ASOS) are provided, along with the SUBNWS option to allow substitution of NWS surface data for missing onsite wind and temperature data, the primary surface characteristics will be applied to the onsite data for those hours in which onsite wind data are used, and the effective surface roughness from the secondary set will be applied for those hours in which wind data from the NWS surface file or 1-minute ASOS wind data file are substituted for missing or calm onsite data. **Note: The albedo and Bowen ratio from the primary set of surface characteristics are always applied regardless of whether ONSITE or SURFACE data are used for a given hour. The albedo and Bowen ratio from the secondary set are not used at this time, but values must be included to maintain consistency in the formats for reading the data.**

AERMET includes optional keywords, AERSURF and AERSURF2 under the METPREP pathway, which can be used to specify separate external files which contain the

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necessary AERMET keyword inputs to specify surface characteristics for the primary and secondary site, respectively. These keywords facilitate the use of surface characteristics based on the AERSURFACE tool (EPA, 2008), without the requiring the user to copy-and-paste the results into the AERMET input file. The syntax of the new AERSURF and AERSURF2 keywords is as follows:

Syntax:	AERSURF *primary_surfchar_filename* AERSURF2 *secondary_surfchar_filename*
Type:	Optional, Non-repeatable

where *primary_surfchar_filename* and *secondary_surfchar_filename* refer to the names of the files containing the surface characteristics for the primary and secondary sites, respectively.

Note that surface characteristics included in an AERSURF file are interpreted by AERMET to be for the primary surface observation site, and setup errors will occur if keywords for the secondary surface characteristics site (FREQ_SECT2, SECTOR2, or SITE_CHAR2) are encountered. On the other hand, data included in the AERSURF2 file are interpreted by AERMET to be for the secondary site, and will be processed as if the FREQ_SECT2, SECTOR2, and SITE_CHAR2 keywords were used, even if the primary site keywords are specified. This allows for the use of an AERSURFACE output file for the AERSURF2 keyword without requiring the user to edit the AERSURFACE file to modify the keywords.

4.7.9 Output from Stage 3 - OUTPUT and PROFILE

AERMET Stage 3 processing creates two output files for the AERMOD dispersion model. The first of these files contains the boundary layer parameters and some of the data that went into computing these parameters. These parameters are stored in the file defined on the OUTPUT keyword, with the following syntax and type:

Syntax:	OUTPUT *parameter_filename*

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Type:	Mandatory, Nonrepeatable

The *parameter_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 96 characters.

There is one record for each hour processed. These data are written with at least one space between each element, i.e., "free format". The exact format of this file is in Appendix C. The contents of this file are:

- Year
- Month (1 - 12)
- Julian Day (1 - 366)
- Hour (1 - 24)
- Sensible heat flux, H (Watts/meter^2)
- Surface friction velocity, u* (meters/second)
- Convective velocity scale, w* (meters/second)
- Vertical potential temperature gradient in the 500 m layer above the planetary boundary layer (kelvin/meter)
- Convective mixing height, z_{ic} (meters)
- Mechanical mixing height, z_{im} (meters)
- Monin-Obukhov length, L (meters)
- Surface roughness length, z_o (meters)
- Bowen ratio, B_o
- Albedo, r (φ)
- Wind speed - used in estimating the boundary layer parameters (meters/second)
- Wind direction - direction wind is blowing from (degrees)
- Height at which the wind was measured (meters)
- Temperature - used in estimating boundary layer parameters (kelvin)
- Height at which the temperature was measured (meters)

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- Precipitation type code (0=none, 11=liquid, 22=frozen, 99=missing)
- Precipitation amount (millimeters/hour)
- Relative humidity (%)
- Station pressure (millibars)
- Cloud cover (tenths)
- Wind speed adjustment flag for adjustment of ASOS wind speed data

(ADJ = adjust, NAD = not adjusted)

- Wind data source flag

(OS = ONSITE pathway input file, SFC = SURFACE pathway input file)

A second file is written during Stage 3 - a file of profile (multilevel) data as identified on the PROFILE keyword. The syntax and type are:

Syntax:	PROFILE *profile_filename*
Type:	Mandatory, Nonrepeatable

The *profile_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 96 characters.

There are one or more records for each hour processed. The data are written with at least one space between each element, i.e., the data are free format. The exact format of this file is in Appendix C. The contents of this file are:

- Year
- Month (1 - 12)
- Day (1 -31)
- Hour (1 - 24)
- Measurement height (meters)
- Top flag = 1, if this is the last (highest) level for this hour
- 0, otherwise

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- Direction the wind is blowing from for the current level (degrees)
- Wind speed for the current level (meters/second)
- Temperature at the current level (degrees Celsius)
- Standard deviation of the wind direction fluctuations, σ_Θ (degrees)
- Standard deviation of the vertical wind speed fluctuations, σ_w (meters/second)

The data in this latter file are the multilevel (e.g., tower) site-specific meteorological data if site-specific data are available. If there are no data for a particular variable for an hour, either at one or all levels, then the field is filled with a missing value indicator. Only the variables listed above are in this output file. Additional variables that may be specified on the ONSITE pathway (e.g., the standard deviation of one of the horizontal components of wind) are not written to this file.

AERMET was designed to be able to perform these dispersion parameter calculations with NWS data only, i.e., no site-specific data. In this case, the NWS winds and temperature are used to create a one-level "profile". The NWS data are also used in the event that all the variables at all levels for a given hour are missing. However, this substitution depends on the specification of the METHOD REFLEVEL keyword described in Section 4.7.6.

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5.0 Technical notes

This section provides a technical description of the processing methods employed by AERMET. This includes quality assessment procedures beyond the simple check against upper and lower bounds, the averaging method used to produce hourly values when site-specific data contains more than one observation period each hour, and modifications that can be made to NWS upper air data. The section concludes with a discussion of the estimates of the boundary layer parameters written to the OUTPUT file.

5.1 Quality assessment procedures

The main quality assessment procedures are similar for all types of data. Each variable is checked to see if it is missing (its value matches the missing value code), and if not missing, the value is checked to see if it is between the lower and upper bounds. Appendix B lists the variables for each type of data, their units, default bounds and missing value codes. A violation does not necessarily indicate an error in the data. For example, it could mean the bounds are not reasonable for a particular time of year or location. It is up to the user to determine if the reported violations constitute errors in the data.

For NWS hourly surface observations, several additional checks between variables are also performed. NWS surface data are checked for dew-point temperature exceeding dry-bulb temperature (DPTP > TMPD), and having a zero wind speed (WSPD = 0), indicating calm conditions, but a non-zero wind direction (WDIR), indicating non-calm conditions, or vice versa. The number of occurrences of calm wind conditions are also reported.

AERMET estimates the heights reported in the sounding using the hypsometric equation

where z_1 and p_1 are the height and pressure at the lower level, z_2 and p_2 are the height and pressure at the upper level, R_d is the dry gas constant, T_v is the mean virtual temperature through the layer, and g is the gravitational acceleration. The recomputed height is compared to the reported height. If the difference exceeds 50 meters, then a message is written to the message file (defined on the MESSAGES keyword). If the surface height is missing, then this check is skipped.

NWS upper air sounding data contain data for multiple levels, so AERMET will examine the *gradient* of several variables within the sounding. AERMET checks four different between- level gradients. Each is expressed as the change over a 100-meter layer because the change per meter is usually very small. It is important to remember this distinction if the user needs to change the default lower or upper bounds. The parameter and associated variable name in AERMET and the default lower and upper bounds are shown in the table below.

Parameter	Variable name in AERMET	Default lower bound	Default upper bound
Ambient temperature gradient	UALR	-2.0 °C	+5.0 °C
Wind speed shear	UASS	0.0 m/s	| 5.0 m/s |
Wind direction shear	UADS	0.0 degrees	| 90.0 degrees |
Dew point temperature gradient	UADD	0.0 °C	2.0 °C

The vertical gradient of the wind velocity, the wind *shear*, is a vector quantity. In AERMET, the shear is computed separately for the *speed shear* (UASS) and *direction shear* (UADS). The wind speed shear is computed as the absolute difference in the speeds between adjacent levels. Since it is an absolute difference, it is always non-negative. The wind direction shear is also an absolute difference.

The vertical gradient of the dew point temperature, unlike the other gradients, is computed using <u>three</u> consecutive levels. An estimate of the dew point at each intermediate height is found using linear interpolation between the dew points for the adjacent upper and

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lower heights. The gradient of the dew point temperature is defined as the absolute difference between the estimated and the observed dew point temperature at this intermediate level divided by the difference between the upper and lower heights.

The QA on the gradients is summarized with the QA of the observed sounding data. Because there may be a variable number of levels in a sounding, and the heights of the levels may differ from sounding to sounding, the results are accumulated into ten height categories. These are defined as surface, 500 meter layers up to 4000 meters, and above 4000 meters. Thus the categories are: surface, 0 -500, 500 -1000, ..., 3500 -4000, and 4000+, where each intermediate category includes the upper but not the lower height. (The "thickness" of the categories is controlled by the internal variable UAINC. This is specified in a DATA statement in BLOCK1.INC, and cannot be changed without also recompiling and relinking AERMET.)

Lapse rate and shear violations are tallied in the category containing the upper height, while those of the dew-point gradient are tallied in the height category of the middle (intermediate) point. In the absence of missing data and with *N* levels in a sounding, there should be *N*-1 lapse rate and shear calculations, and *N*-2 dew-point gradient calculations. All range violations and instances of missing values are reported in the MESSAGES file and summarized in the general report.

5.2 Identifying ASOS observations

In order to implement the ASOS wind speed adjustment described in Section 4.7.6.3, AERMET must determine whether surface wind observations are ASOS or not. Wind data in the standard NWS surface formats read by AERMET are identified as ASOS based on the published commission date of the ASOS equipment for the WBAN number reported in either the header of the NWS surface file or the first observation, or the 3- or 4-character station call letters included in the observations, depending on the format input to AERMET. A table of commission dates was added to AERMET to support the determination of whether an observation was measured by ASOS instrumentation. As each observation is extracted from the

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NWS surface file during Stage 1 processing, the observation date and time are temporarily converted to LST and the 1-24 hour convention, then the converted date is compared to the ASOS commission date. Those records for which the observation date falls on or after the ASOS commission date are identified as ASOS by appending an "A" to the extracted record in the Stage 1 surface extraction and surface QA files. If a commission date is not found or the observation occurred before the commission date, the record is tagged with an "N" to indicate it is not an ASOS observation. For those formats that report hours using the 00-23 hour convention, the 00 hour becomes hour 24 on the previous day. Thus, data reported for hour 00 on the ASOS commission date, after the date and time is converted, will not be recognized as an ASOS hour.

For those NWS surface formats that include a data field to indicate that measurements were made with ASOS instrumentation (HUSWO, TD-3280, and in some cases ISHD), a validation is performed on each record to check the consistency between the ASOS flag in the raw data file with the ASOS flag set by AERMET based on the commission date. If the ASOS flag in the raw data file indicates an ASOS observation, the record in the extracted file will be appended with an "A" to indicate an ASOS observation, but a warning will be included in the Stage 1 message file if the station is not found on the ASOS commission list, or if the station is found but the data period precedes the commission date contained within AERMET.

To address cases where an ASOS station is not included in the ASOS commission list in AERMET but the station is known to be an ASOS site, AERMET includes an optional parameter on the DATA keyword under the SURFACE pathway allowing the user to specify that the data are ASOS. Note that this optional 'ASOS' parameter is only allowed for surface data in the ISHD format, and should only be used if the station is known to be ASOS, but is not included in the ASOS commission list within AERMET (see Table A-6 for a description of the DATA keyword format).

The ASOS commission date and the count of extracted ASOS records are reported in the Stage 1 message file. Similarly, the surface records are marked with either an "A" or an "N", as

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appropriate, in the Stage 2 merge file to facilitate the ASOS wind speed truncation adjustment applied in Stage 3. Since 1-minute ASOS wind data are presumed to be ASOS by definition, the ASOS flag is not included on the 1-minute ASOS wind data in the merge file.

<u>NOTE:</u> Beginning with version 11059, Stage 2 processing requires the presence of the ASOS flag appended to each surface record in the Stage 1 surface extraction and QA files. Similarly, Stage 3 processing requires the presence of the ASOS flag appended to applicable records in the Stage 2 merge file. If the ASOS flag is omitted from either of these files, a fatal error is issued and processing is aborted. Therefore, version 11059 of AERMET, or later, will not process surface extraction or merge files generated with an earlier version of AERMET.

5.3 Validation of NWS surface format by active data range

Validations were incorporated in AERMET, beginning with version 11059, to check for consistency between the date of the observation in the NWS surface file and the range of dates for which the NWS format is considered to be active and valid. A file that contains data outside the format's valid date range is assumed to have been reformatted from some other data format and its use in AERMET may result in inconsistencies with data processed for the same station and dates input in their native format. Use of reformatted data files in AERMET is discouraged, and AERMET results based on processing reformatted data should be used with caution.

The date consistency check is performed for each hour of data extracted from the NWS surface file, until an observation is found that is outside the valid date range. Once an observation is encountered that is outside the valid date range, a variable is set to indicate the data was likely reformatted, and a warning is issued in the Stage 1 message file when the data extraction is complete. Table 5-1 lists the active dates for each of the NWS surface formats read by AERMET as currently implemented in AERMET. Note that ISHD and TD-3280 are currently active formats and the validation is not performed against either of those formats.

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Table 5-1. Format Active Dates

NWS Surface Format	Start Date	End Date
CD-144	---	12/31/1995
HUSWO	1/1/1990	12/31/1995
ISHD	---	---
SAMSON	1/1/1961	12/31/1990
SCRAM	1/1/1984	12/31/1992
TD-3280	---	---

5.3.1 Validation of WBAN between Stage 1 control file and NWS surface data file

Another validation was incorporated into AERMET, beginning with version 11059, to ensure consistency in the WBAN number specified by the user on the LOCATION card in the Stage 1 SURFACE pathway and the NWS surface data file. The WBAN number from the control file is compared to the WBAN number stored on the header record of the NWS surface file (SAMSON) or the WBAN number recorded for the first observation for those formats without a header record that repeat the WBAN number on each observation record (CD-144, HUSWO, SCRAM, and TD-3280). When the WBAN number from the control file is found to be different from that recorded in the NWS surface file, a fatal error is issued and processing is aborted. This validation is performed for all NWS surface formats read by AERMET with the exception of the ISHD format since ISHD includes many stations located within the U.S. and internationally for which a WBAN number has not be assigned.

For those formats in which the WBAN number is repeated on each observation record, an additional validation is performed to check for internal consistency across all observation records in the surface file. If a mismatch is encountered, a fatal error is issued and processing is aborted. Note: This check for internal consistency is performed for the ISHD format as well as

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the other applicable formats; however, since the WBAN number is not consistently included in ISHD files a fatal error will only be issued and processing aborted if a mismatch occurs between two non-missing (i.e., not '99999') WBAN numbers. For the ISHD format, the validation is applied to the 5-digit ID stored in positions 11-15 on each record. The first non-missing (not '99999') WBAN number encountered is stored and used to compare against each subsequent record.

5.3.2 ASOS cloud cover from SCRAM and SAMSON set to missing

Due to the difficulties that arise when attempting to reformat cloud cover information collected with ASOS instrumentation to the SAMSON and SCRAM formats, there are concerns over the validity of the representation of ASOS clouds in these older pre-ASOS formats. For this reason, AERMET was modified (beginning with version 11059) to set opaque and total cloud cover to missing for observations extracted from SAMSON and SCRAM formats for which the observation date falls on or after the ASOS commission date. For each hour this condition is encountered, opaque and total cloud cover are set to missing and warning (up to 24) or informational messages are issued in the Stage 1 message file. Note that this also applies to SCRAM-formatted data available on the EPA SCRAM website for a few stations that were commissioned as ASOS during the last four months of 1992, the last year of data archived in the SCRAM format.

5.4 Site-specific data - averaging subhourly values

By default, AERMET assumes that there is one observation period per hour. However, the on-site data could contain several observation periods during each hour (AERMET allows up to 12). Since AERMET only computes the boundary layer parameters for one hour averages, AERMET converts the subhourly observations to an hourly average. The user must tell AERMET the number of observation periods per hour that are in the site-specific data through the use of the OBS/HOUR keyword. See Section 4.5.12 for a discussion on how to use this keyword. The site-specific meteorological guidance document (EPA, 1987) suggests at least

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half of this number must be present to calculate an average for the hour. AERMET follows this guidance and computes an average only when half or more of the subhourly values are not missing.

For most variables, the hourly value is computed as the arithmetic mean. However, the wind speed and direction are treated differently to differentiate between cases when values are missing and cases when values are present but below an instrument's threshold. This value is defined by the user through the mandatory THRESHOLD keyword. Wind speeds less than the threshold are given a value of one-half the threshold wind speed and the wind direction is set to missing. The hourly wind speed is then computed as an arithmetic mean, while the hourly wind direction is computed according to the method given in Section 6.1 of the on-site meteorological guidance document (EPA, 1987) to properly account for the 0°-to-360° crossover.

To obtain a one-hour average of the standard deviation of the horizontal wind direction, σ_θ, the procedure outlined in the *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV* (EPA, 1989) is followed. This procedure accounts for both the standard deviation within each subhourly interval and the meander in the wind direction over the entire hour. The hourly average is given by

where $\sigma_{\theta i}$ is the standard deviation of the horizontal wind for period I, WD_i is the average wind

direction for period I, *ís* the average wind direction over all periods in the hour, and n is the

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number of subhourly periods specified on the OBS/HOUR keyword.

5.5 Upper air data modifications

During the extraction of upper air soundings from the raw input DATA file, AERMET can check for possible errors and reduce the impact of strong gradients in each sounding. If the MODIFY keyword (Section 4.4.9) is included, the following modifications are performed:

- A mandatory level within 1 percent (with respect to pressure) of a significant level is deleted;

- For a non-zero wind direction with a corresponding zero wind speed, the wind direction is replaced with zero;

- Missing values of dry bulb and dew-point temperature are replaced by an interpolated value if the data for the levels immediately above and below are not missing;

There is no way to turn on individual actions. Either all the actions are performed or none of them are performed. Warning messages are written if the data are modified.

5.5.1 Mandatory levels

If a mandatory sounding level is within one percent of a significant level (with respect to pressure) then the mandatory level is deleted, with little of information about the structure of the atmosphere. If the maximum number of levels of data were extracted (currently set at 30 and is defined in the variable UAML in UA1.INC), then a sounding may have fewer than the maximum number of levels because the deletion process takes place after the data in a sounding are extracted from the archived data file. AERMET does not attempt to read more levels after deleting a level.

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5.5.2 Calm wind conditions

The wind speed and wind direction at each level are checked to insure that there are no levels with a zero wind speed and a non-zero wind direction. If one is found, the wind direction is set to zero to represent calm conditions.

5.5.3 Missing dry bulb and dew-point temperatures

If the dry-bulb or dew-point temperature is missing at some level, then an estimate for the missing temperature is made by linearly interpolating to the level in question. The data from the level immediately below and above the level in question are used. If the data that are required for the interpolation are also missing, then no interpolation is performed.

5.6 Station elevations

Beginning with version 06341, AERMET included the option to specify station elevation above MSL as the last field on the LOCATION keyword in the UPPERAIR, SURFACE, and ONSITE pathways in the Stage 1 control file, and the METPREP pathway in the Stage 3 control file. However, this optional station elevation was only used under version 06341 when processing ISHD data on the SURFACE pathway and all other occurrences of user-specified station elevations were ignored. Beginning with version 11059, AERMET was revised to make full use of user-specified station elevations for the SURFACE and ONSITE pathways to estimate station pressure if station pressure is missing, but to no longer allow station elevation on the UPPERAIR pathway. The LOCATION keyword has also been removed from the METPREP pathway beginning with version 11059, except for one circumstance. The METPREP LOCATION keyword is now only needed when site-specific mixing heights are provided during Stage 1 and upper air sounding data are omitted from the processing. Otherwise, a warning message will be generated if the LOCATION keyword is included under the METPREP pathway, and the LOCATION parameters will be ignored. AERMET will issue a warning message if the elevation field is included on the UPPERAIR

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LOCATION keyword, but the user-specified elevation will be ignored and processing will continue.

The handling of station elevation within AERMET, beginning with version 11059, is summarized below:

1. A non-fatal warning message will occur if the station elevation is encountered on the LOCATION keyword on the UPPERAIR (Stage 1) pathway, or if the LOCATION keyword is included on the METPREP (Stage 3) pathway, but the inputs will be ignored and processing will continue.

2. The station elevation is allowed as an optional argument on the LOCATION keyword for the SURFACE and ONSITE pathways in Stage 1.

3. If the station elevation is included in the raw SURFACE input file to Stage 1 (ISHD or SAMSON formats), then the elevation from the data file is used; otherwise the user-specified station elevation is used, if available.

4. If the station elevation is not specified on the SURFACE pathway and is not in the raw surface data input file for Stage 1, then 0 meters (sea-level) is used for the SURFACE station elevation.

5. If the station elevation is not specified on the ONSITE pathway in Stage 1, then 0 meters (sea-level) is used for the ONSITE station elevation.

Station elevation is used within Stage 3 of AERMET processing in the substitution for missing station pressure. While station elevation is currently an optional parameter on the LOCATION keyword under the SURFACE and ONSITE pathways, users are encouraged to include station elevation since it may improve the representativeness of the station pressure used by AERMET if station pressure is missing. The following hierarchy is used for determining station pressure, based on the availability of ONSITE and/or SURFACE station pressure, sea-level pressure and station elevation and depending on the source of ambient temperature data:

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1. If ONSITE temperature data are used, then:

    a. Use ONSITE station pressure, if available;

    b. Adjust ONSITE sea-level pressure to ONSITE station elevation, if provided on the LOCATION keyword in the ONSITE pathway;

    c. Adjust NWS/FAA station pressure to ONSITE station elevation, if station elevation is available for both the SURFACE and ONSITE data;

    d. Adjust NWS/FAA sea-level pressure to ONSITE station elevation if ONSITE station elevation is provided;

    e. Use NWS/FAA station pressure, if available, without adjustment;

    f. Adjust NWS/FAA sea-level pressure to SURFACE station elevation, if available;

    g. Estimate station pressure based on standard atmosphere using ONSITE station elevation, if available;

    h. Estimate station pressure based on standard atmosphere using SURFACE station elevation, if available;

    i. Assign ONSITE sea-level pressure to station pressure if no ONSITE station elevation is available;

    j. Assign SURFACE sea-level pressure to station pressure if no SURFACE station elevation is available; or

    k. Assign standard sea-level pressure of 1013.25 millibars (mb) to station pressure.

2. If SURFACE temperature data are used, then:

    a. Use SURFACE station pressure, if available;

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b. Adjust SURFACE sea-level pressure to SURFACE station elevation, if provided on the LOCATION keyword in the SURFACE pathway or in the SURFACE data file;

c. Adjust ONSITE station pressure to SURFACE station elevation, if station elevation is available for both the SURFACE and ONSITE data;

d. Adjust ONSITE sea-level pressure to SURFACE station elevation, if SURFACE station elevation is provided;

e. Use ONSITE station pressure, if available, without adjustment;

f. Adjust ONSITE sea-level pressure to ONSITE station elevation, if available;

g. Estimate station pressure based on standard atmosphere using SURFACE station elevation, if available;

h. Estimate station pressure based on standard atmosphere using ONSITE station elevation, if available;

i. Assign SURFACE sea-level pressure to station pressure if no SURFACE station elevation is available;

j. Assign ONSITE sea-level pressure to station pressure if no ONSITE station elevation is available; or

k. Assign standard sea-level pressure of 1013.25 mb to station pressure.

5.7 Boundary layer parameter estimates in stage 3

AERMOD uses several different boundary layer parameters to model how pollutants disperse in the atmosphere. Many of these parameters are not observed, but are estimated from other variables that are more easily measured. To make these estimates, observed near-surface wind and temperature (the 'reference' wind and temperature) and site-specific surface

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characteristics are required. The surface characteristics are discussed in detail in Section 2.0 and Section 3.0, but because of the importance in estimating boundary layer parameters, they are reviewed below. First, however, is a discussion on the criteria for defining the reference wind and temperature.

5.7.1 Reference wind and temperature

If there are site-specific data in the meteorological input to Stage 3, then AERMET searches these data for near-surface wind and temperature with which to estimate the boundary layer parameters such as friction velocity and heat flux.

A valid reference wind is defined as the lowest level with a non-missing wind speed and direction between $7z_0$ and 100 meters (inclusive), where z_0 is the surface roughness length. If the only valid non-missing wind speed is a calm wind, then the hour is treated as a calm and the reference level is the lowest level of non-missing wind.

If there is no valid reference wind, then the lowest level is treated as the reference level and the reference wind is missing. However, if the option to substitute NWS data is specified in the runstream (see Section 4.7.6.2 for the keyword METHOD, secondary keyword REFLEVEL), then AERMET will substitute the NWS hourly wind speed observations for the reference wind speed and use the height specified with the keyword NWS_HGT (see Section 4.7.4) as the reference height. If NWS substitution is not specified, then the reference wind will be missing.

The selection of the reference temperature is independent of the selection of the reference wind. A valid reference temperature is defined as the lowest level with a non-missing temperature between z_0 and 100 meters (inclusive). If there is no valid reference temperature in the site-specific data and the option to substitute NWS data is specified in the runstream, then AERMET will substitute the NWS hourly ambient temperature for the reference temperature.

In the absence of site-specific data, the METHOD keyword with the REFLEVEL

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secondary keyword must be specified for AERMET to utilize NWS wind and temperature data for the reference level data (see Section 4.7.6.2). NWS data currently are not subject to the criteria above for either wind or temperature.

5.7.2 Surface characteristics

The atmospheric boundary layer is that region between the earth's surface and the overlying, free flowing (geostrophic) atmosphere. The fluxes of heat and momentum drive the growth and structure of this boundary layer. The depth of this layer, and the dispersion of pollutants within it, are influenced on a local scale by surface characteristics, such as the roughness of the underlying surface, the reflectivity of the surface (or albedo), and the amount of moisture available at the surface. From these input parameters and observed atmospheric variables, AERMET calculates several boundary layer parameters that are important in the evolution of the boundary layer, which, in turn, influences the dispersion of pollutants. These parameters include the surface friction velocity u_*, which is a measure of the vertical transport of horizontal momentum; the sensible heat flux H, which is the vertical transport of heat to/from the surface; the Monin-Obukhov length L, a stability parameter relating u_* and H; the daytime mixed layer height z_i and the nocturnal surface layer height h; and w_*, the convective velocity scale that combines z_i and H. These parameters all depend on the characteristics of the underlying surface.

Although very general default values exist in AERMET, the user should specify the albedo (r), which is the fraction of radiation reflected by the surface; the daytime Bowen ratio, B_0, which is the ratio of the sensible heat flux H to the heat flux used in evaporation λE; and the surface roughness length z_0, which is the height above the ground at which horizontal wind velocity is typically zero. These measures depend on land-use type (e.g., urban area, deciduous/coniferous forest, cultivated land, calm waters) and vary with the seasons (See Table 4-2 through Table 4-6) and wind direction.

The user specifies these values on SITE_CHAR keyword statements for one, four or 12

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(ANNUAL, SEASONAL, or MONTHLY) time periods per year, and 1 - 12 non-overlapping, contiguous wind direction sectors that cover the full 360°. The user is referred to Section 2.2.4, Section 3.1.3, and Section 4.7.8 for detailed discussions on these parameters.

5.7.2.1 Choice of sector-dependent surface characteristics

In defining sectors for surface characteristics, Irwin (1994) and EPA (2000) suggest that a user specify a sector no smaller than a 30-degree arc. The expected wind direction variability over the course of an hour, as well as the encroachment of characteristics from the adjacent sectors with travel time, make it hard to preserve the identity of a very narrow sector's characteristics. However, using a weighted average[3] of characteristics by surface area within a 30-degree sector makes it possible to have a unique portion of the surface significantly influence the properties of the sector that it occupies.

The length of the upwind fetch for defining the nature of the turbulent characteristics of the atmosphere at the source location has been defined as 3 kilometers in EPA's *Guideline on Air Quality Models*, which is published as Appendix W to 40 CFR Part 51 (as revised), for the purpose of defining urban versus rural dispersion characteristics. This specification results from a paper by Irwin (1978), which also cites a study by Högström and Högström (1978). The basic premise is that when the wind blows over an area with a change in its surface characteristics, a new "boundary layer" with the turbulent characteristics of the underlying surface develops and deepens along the wind direction. Högström and Högström present tabular results for the boundary layer growth as a function of roughness length in rural areas. Irwin (1978) noted that the region of enhanced turbulence with a depth of 400 meters was reported by Shea and Auer (1978) for St. Louis, and curves based on the Högström and Högström data indicate that a 3-km fetch would attain this boundary layer height. The resulting 3-km fetch was also adopted by METPRO (Paine, 1987), the CTDMPLUS meteorological pre-processor for its definition of sector-specific surface characteristics.

[3] Weighting should be based on wind direction frequency, such as determined from a wind rose

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For a surface with a large roughness, however, the rate of the boundary layer growth as defined by Högström and Högström (1978) could be sufficiently rapid so as to grow to a depth of 400 meters within 1 kilometer downwind. In the case of a lower boundary layer depth, such as 100 meters, the Högströms calculate that the distance needed to attain an urban-influenced boundary height of just 100 meters with a surface roughness ranging from 0.5 to 1.5 meters is only about 250 meters for unstable (convective) conditions, 700 meters for neutral conditions, and 1330 meters for slightly stable conditions.

For AERMET applications, an upwind fetch distance of 3 kilometers is recommended for defining user-specified values such as albedo, Bowen ratio, and surface roughness. In each sector, it is likely that a mixture of land use is present, and the resulting user input should be a weighted average of the values selected for each land use type. For urban areas or areas with a very large roughness length, consideration can be given for a smaller upwind fetch distance for defining the user-specified surface characteristics. The actual fetch length selected would be a function of the expected plume height, the roughness length, and any urban heat flux that would tend to minimize the presence of stable conditions in the surface layer. Högström and Högström (1978) can be used as guidance in these cases.

5.7.3 Estimates for the unstable atmosphere

As defined in AERMET, the atmosphere is unstable if the flux of sensible heat is upward at the surface, and the time of day is approximately between sunrise and sunset. During daytime convective conditions, the surface of the earth is heated, resulting in an upward transport of heat. Hourly estimates of this heat flux are required to estimate the daytime mixed layer height. The estimates here follow the development of Holtslag and van Ulden (1983). Beginning with the surface energy balance, the sensible heat flux is determined hour-by-hour from the net radiation and Bowen ratio. AERMET first looks for net radiation (from the site-specific data) and uses it if found. If there is no net radiation, then AERMET looks for solar radiation (again from the site-specific data) and uses it with temperature and opaque cloud cover (from the NWS) to estimate net radiation. If there is no solar radiation, then it is estimated as described

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below from cloud cover and surface temperature (using site-specific observations if available, NWS data if not), Bowen ratio, and albedo. Once the heat flux is computed, u_* and L are determined through an iterative procedure using surface layer similarity. While u_* and L change with each iteration, the hourly heat flux remains fixed.

A simple equation that expresses the energy balance at the earth's surface for rural applications is:

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where R_n is the net radiation, λE is the latent heat flux, and F_G is the flux of heat into the ground. Following Holtslag and van Ulden (1983), $F_G = 0.1\ R_n$. Using this estimate for F_G and the Bowen ratio ($B_0 = H/\lambda E$) yields the following expression for H:

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Net radiation R_n can either be an observed quantity from site-specific data (variable

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NRAD) or it can be estimated from the total incoming solar radiation, R (variable INSO), as follows:

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where $r(\varphi)$ is the surface albedo as a function of solar elevation angle (φ), and I_n is the net long-wave radiation at the earth's surface.

In the general case in which clouds are present, R is computed using the following estimate from Kasten and Czeplak (1980)

)

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where R_0 is the incoming solar radiation at ground level for clear skies, and n is the fractional opaque cloud cover (variable TSKC). The empirical coefficients b_1 and b_2 are assigned the values of -0.75 and 3.4, respectively (from Holtslag and van Ulden, 1983). If cloud cover and

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observed net radiation are missing for a particular hour, no further calculations can be made for that hour. A warning message is written in this case.

The incoming solar radiation for clear skies R_0 is given by

55

where φ is the solar elevation angle, a_1 = 990 Wm^{-2} and a_2 = -30 Wm^{-2} The constants a_1 and a_2 account for attenuation of the short wave radiation by water vapor and dust in the atmosphere. The values used by AERMET are appropriate for mid-latitudes (Holtslag and van Ulden (1983)).

Substituting Eqs. 5.4 and 5.5 into 5.3 and parameterizing the net long-wave radiation as a function of temperature (T) and cloud cover (n), Holtslag and van Ulden (1983) estimate the net radiation as:

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where σ_{SB}= 5.67 × 10^{-8} W m^{-2} K^{-4} is the Stefan-Boltzmann constant and the other empirical constants are as follows: c_1 = 5.31 × 10^{-13} W m^{-2} K^{-6}, c_2 = 60 W m^{-2}, c_3 = 0.12.

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The surface albedo supplied by the user should be for solar elevation angles above 30°, for which the albedo is relatively constant. However, the albedo increases for lower angles (Coulson and Reynolds (1971) and Iqbal (1983)). An empirical expression for the albedo as a function of solar elevation angle is given by

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(Paine, 1987) where r' is the albedo for the sun on the meridian as entered by the user as a site-specific surface characteristic, φ is the solar elevation angle, $a = -0.1$, and $b = -0.5\ (1 - r')^2$.

With an estimate of the heat flux, AERMET next estimates the surf ace friction velocity u_* and the Monin-Obukhov length L for the convective boundary layer (CBL) through an iterative procedure. (The technique used is similar to that used in the METPRO meteorological preprocessor (Paine, 1987). The two equations for u_* and L used in the iteration algorithm are:

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where:

k is the von Karman constant (0.4),

u is the reference height wind speed (meters/second),

z_{ref} is the wind speed and direction reference height (as discussed in Section 3.1.4),

z_0 is the surface roughness length (meters),

ρ is the density of dry air (kilograms/cubic meter),

c_p is the specific heat capacity of air (Joules/kilogram/kelvin),

T is ambient temperature (kelvin), and

g is the acceleration due to gravity (meters/second/second).

The Ψ terms are given by:

510

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and

512

513

This procedure requires an initial guess for u_*, which is found by initially setting the Ψ terms to zero. The iteration continues until consecutive values of L differ by 1% or less.

The estimate of the convectively-generated (or convective) mixing height (z_{ic}) is based on the formulation by Carson (1973) and modified by Weil and Brower (1983). The Carson model is based on a one-dimensional (height) energy balance approach, in which the heat flux in the base of the elevated temperature inversion, and an increase of the energy of the boundary layer air. The original Carson model is based on an initial (early morning) potential temperature profile that is assumed to be linear with height. Weil and Brower (1983) extended Carson's model to an arbitrary initial temperature distribution with height and allowed for stress-induced mixing at top of the PBL. The latter can be important when the heat flux is small, e.g., in the early morning or on overcast days. In AERMET, the stress-induced mixing at the top of the

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mixed layer is ignored. An operational advantage of the arbitrary temperature distribution is the ease of adapting it to initial profiles that are very irregular, as is sometimes found in early morning rawinsondes.

Weil and Brower find z_{ic} implicitly from the following equation:

514

where $\theta(z)$ is the initial potential temperature distribution (from the selected morning sounding) and the right-hand-side represents the cumulative heat flux input at $z = 0$, and A = 0.2 (Deardorff, 1980). AERMET restricts the growth of the convective mixing height to 4000 meters.

Once z_{ic} is found, the turbulent velocity scale w_* can be found from the following definition:

515

5.7.4 Estimates for the stable atmosphere

The stable boundary layer (SBL) calculations, based on an approach outlined by

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Venkatram (1980), are straight-forward and do not require an iterative process as is used in the CBL calculations. Estimates of u_* and θ_*, a temperature scale, are made from cloud cover, wind speed and temperature, which, in turn, provides an estimate of the heat flux. The Monin-Obukhov length then is computed directly from Eq. 5.9.

Using $H = -D\, c_p\, u_*\, \theta_*$ in Eq. 5.9 and

the friction velocity is obtained from

516

where C_D is the neutral drag coefficient given by

,

517

u_0 is

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518

and $\beta_m = 4.7$ is a dimensionless constant. An estimate for the temperature scale θ_* (in kelvin) is given by

519

where n is the fractional opaque cloud cover.

To obtain real-valued solutions for u_*, the following condition must be true:

520

Equality in the above condition corresponds to a minimum (critical) wind speed, u_{cr}. For wind

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speeds equal to or greater than u_{cr}, a real-valued solution to Eq. 5.16 is obtained. The critical wind speed is given by

521

For this value, there is a corresponding friction velocity, u_{*cr}, such that

522

For wind speeds less than this critical value, Eq. 5.16 no longer yields a real-valued solution. It is desirable to have $u_* \rightarrow 0$ as $u \rightarrow 0$. Therefore, for $u < u_{cr}$, u_{*cr} is scaled by the ratio u / u_{cr}, and u_* is calculated as

523

For $u < u_{cr}$, van Ulden and Holtslag (1985) showed that there is a near-linear variation of θ_* with u_*. Therefore, θ_* is scaled similarly as

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524

where θ_{*cr} is given by 5.19.

With u_* from Eq. 5.16 or 5.23 and θ_* from Eq. 5.19 or 5.24, the heat flux for the stable atmosphere is computed from

.

525

Finally, using these estimates of u_* and H, L is computed from Eq. 5.9.

In the case of strong winds, H may become unrealistically large. Therefore, a limit of -64 Wm^{-2} is placed on the heat flux, which forces a limit on the product $u_* \theta_*$. This yields a cubic equation in u_*, which is solved to obtain a new u_*. With this value for u_* and H = -64 Wm^{-2}, L is recomputed from Eqs. 5.9 and 5.25.

The mechanically-generated (or mechanical) mixing height (z_{im}) is found from the diagnostic expression given by Venkatram (1980):

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Since w_* is a scaling parameter for convective conditions, it is not computed for the stable atmosphere.

5.7.5 More on mixing heights

Mixing heights in AERMET are given special attention. During stable conditions, when $L > 0$, the mechanical mixing height is computed. During unstable conditions, defined when $L < 0$, both the convective and mechanical mixing heights are computed. As long as no data are missing to make the computations, this procedure yields a continuous record of mechanical mixing heights while the record for convective mixing heights is restricted to daytime hours of upward heat flux.

The mechanical mixing heights are smoothed so that the effect of any large hour-to-hour fluctuations of the surface friction velocity on z_{im} is reduced. The smoothing is performed for all hours - stable and unstable. The smoothed mechanical mixing height for the current hour $(t+\Delta t)$ is given by:

527

where

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and $\beta_\tau = 2.0$. The term with the overbar on the right hand side of Eq. 5.27 is the smoothed mechanical mixing height for the previous hour (t), $z_{im}(t+\Delta t)$ is the unsmoothed mechanical mixing height for the current hour $(t+\Delta t)$ as determined from Eq. 5.26, and $u_*(t+\Delta t)$ is the surface friction velocity for the current hour. If $(t+\Delta t)$ is the first hour in the data base, then no smoothing is performed. Furthermore, if a missing mixing height occurs at time t, then the smoothing restarts at time $(t+\Delta t)$.

Both the smoothed mechanical and convective mixing heights are written to the output file for AERMOD.

The convective mixing height relies on the selected morning sounding. AERMET retrieves data up to and including the first measurement level above 5000 meters. Occasionally, the sounding is lost at a low level (well below 5000 meters). When this situation happens, there may not be sufficient upper air data to allow AERMET to calculate the convective mixing height for all the daytime hours, particularly the late afternoon hours. To alleviate problems such as this, AERMET extends the sounding to 5000 meters by computing the potential temperature gradient in the upper 500 meters of the sounding and extends the sounding to 5000 meters as follows:

where z_{top} is the height of the original sounding and $d\theta/dz|_{500}$ is the potential temperature gradient in the upper 500 meters of the sounding. Messages are written to the message file at various stages: reports of soundings that do not extend to 5000 meters are reported in the Stage 1 QA; in Stage 3, the height of the original sounding and the potential temperature gradient that is used to extend the sounding is reported, as well as those periods when the sounding extension was required to compute a convective mixing height.

6.0 References

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Appendix A. Functional keyword/parameter reference

This appendix provides a functional reference for the keywords and parameters used by the input runstream files for AERMET. The keywords are organized by functional pathway and within each pathway the order of the keywords is alphabetical, excluding the keyword that identifies the start of a pathway. The pathways used by AERMET are as follows, including the applicable AERMET processing stages and the in the order in which they appear in the tables that follow:

JOB - for specifying overall **JOB** control options (all stages);

UPPERAIR - for processing NWS **UPPER AIR** data (Stages 1 and 2);

SURFACE - for processing NWS hourly **SURFACE** data (Stages 1 and 2);

ONSITE - for processing **ONSITE** meteorological data (Stages 1 and 2);

MERGE - to **MERGE** the three data types into one file, including 1-minute ASOS wind data, if available (Stage 2);

METPREP - for **MET**eorological data **PREP**aration for use in a dispersion Model (Stage 3).

Two types of tables are provided for each pathway. The first table lists all of the keywords for that pathway, identifies each keyword as to its type (either mandatory or optional, either repeatable or non-repeatable, and if it is reprocessed), and provides a brief description of the function of the keyword. The second type of table, which may take up more than one page, describes each parameter in detail.

The following conventions are used in these tables. The parameter names are intended to be descriptive of the input variable being represented. Square brackets around a parameter indicate that the parameter is optional for that keyword. The default that is used when an

optional parameter is left blank is explained in the discussion for that parameter.

Beginning with version 11059, the maximum record length for the AERMET runstream input file has been increased from 80 to 132 characters. Another important enhancement introduced with version 11059 of AERMET, which applies across all pathways, is that the maximum field length for filenames has been increased from 48 to 96 and the use of double quotes (“) as field delimiters for filenames is allowed to support filenames with embedded spaces

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Table A-1. Description of Job Pathway Keywords

Keyword	Type	Description
JOB	Optional, Non-repeatable	Start of JOB pathway. This statement is optional if the statements associated with this block appear first in the input control file.
CHK_SYNTAX	Optional, Non-repeatable	Flag indicating that only the syntax of the input statements should be checked for errors, i.e., no data are processed.
MESSAGES	Mandatory, Non-repeatable	Identifies the warning/error messages file.
REPORT	Optional, Non-repeatable	Identifies the general report file.

Table A-2. Description of Keyword Parameters for the JOB Pathway

Keyword	Parameters	
CHK_SYNTAX	<none>	
MESSAGES	message_filename	
where:	message_filename	The name of the file where all source-code-generated messages are written
REPORT	summary_filename	
where:	summary_filename	The name of the file where AERMET writes a summary of all preprocessor activity for the current run

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Table A-3. Description of UPPERAIR Keywords

Keyword	Type	Description
UPPERAIR	Conditional, Non-repeatable	Start of UPPERAIR pathway.
AUDIT	Optional, Repeatable	Identify variables to be audited. These are in addition to any automatically audited variables.
DATA	Mandatory, Non-repeatable, Reprocessed	File name of raw upper air data.
EXTRACT	Mandatory, Non-repeatable	File name of extracted upper air data.
LOCATION	Mandatory, Non-repeatable, Reprocessed	Site ID and location information. Required only for extraction processing.
MODIFY	Optional, Non-repeatable, Reprocessed	Flag indicating corrections should be made to the sounding data when extracted. See '5 for a discussion of these corrections
NO_MISSING	Optional, Repeatable	Identifies those variables to QA and summarize the messages only; detailed message identifying the violation and date is suppressed
QAOUT	Mandatory, Non-repeatable	File name of upper air data for quality assessed output/ merge input
RANGE	Optional, Repeatable, Reprocessed	Set new upper and lower bounds and missing values for QA of the variable listed.
XDATES	Mandatory, Non-repeatable	Inclusive dates identifying the period of time to extract from the archive data file.

Table A-4. Description of Keyword Parameters for the UPPERAIR Pathway

Keyword	Parameter(s)	
AUDIT	uaname1 ... uanameN	
where:	uaname1 ... uanameN	Name(s) of variables that are to be tracked and reported during quality assessment (as defined in Table B-1 of Appendix B).

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DATA	archive_filename file_format	
where:	archive_filename	The name of the file containing the archive of upper air data
	file_format	Archive file format; valid parameters are: **6201FB** (TD-6201 fixed-length blocks) or **6201VB** (TD-6201 variable-length blocks) or **FSL** for data retrieved from National Centers for Environmental Information (NCEI) web site. Also available on the 'Radiosonde Data of North America' CD-ROM and online from the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory (ESRL) Radiosonde Database at http://esrl.noaa.gov/raobs/. **NOTE:** The blocking factor and data type (ASCII or EBCDIC) parameters are no longer supported by AERMET, beginning with version 11059. The default values for these parameters are 1 for blocking factor and ASCII for data type. AERMET will issue a warning message if these parameters are included on the DATA keyword.
EXTRACT	extracted_data_filename	
where:	extracted_data_filename	Name of the output file for data extracted from an archive data file and the name of the input file for upper air data QA
LOCATION	site_id lat(long) long(lat) [tadjust]	

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where:	site_id	Site identifier for which data are to be processed.
	lat(long)	Station latitude (or longitude) in decimal degrees with the suffix N for sites north of the equator, S for sites south of the equator (or W for sites west of Greenwich, E for sites east of Greenwich).
	long(lat)	Station longitude (or latitude) in decimal degrees with the suffix W for sites west of Greenwich, E for sites east of Greenwich (or N for sites north of the equator, S for sites south of the equator).
	[tadjust]	An integer used to convert the time reported in the database to local Standard time. For standard upper-air data reported in Greenwich Mean Time (GMT), the value is the same as the time zone for the station (e.g., a value of 5 for the Eastern time zone). <u>NOTE:</u> Beginning with version 11059, the optional station elevation parameter is no longer supported on the UPPERAIR pathway.
MODIFY	<none>	
NO_MISSING	uaname1 . . . uanameN	
where:	uaname1 . . . . . . uanameN	Suppresses missing data messages for the upper air variables specified, as defined in Appendix B; the number of times the variable is missing is not tallied
QAOUT	qa_output_filename	
where:	qa_output_ filename	Name of the output file from the QA/input to merge data
RANGE	uaname lower_bound <[=] upper_bound missing_indicator	
where:	uaname	Variable name, as defined in Table B-1
	lower_bound	Minimum value of the valid range of values for uaname
	<[=]	Exclude (<) or include (<=) the lower and upper bounds (the endpoints) in the QA
	upper_bound	Maximum value of the valid range of values for uaname

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	missing_indicator	Value to indicate the value is missing
XDATES	YB/MB/DB [TO] YE/ME/DE	
	YB/MB/DB	Beginning year, month and day to extract; the slash (/) between each part of the date field is required; there can be no blanks in this parameter
	[TO]	Optional; used to make this record more readable
	YE/ME/DE	Ending year, month and day to extract; the slash (/) between each part of the date field is required; there can be no blanks in this parameter

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Table A-5. Description of SURFACE Pathway Keywords

Keyword	Type	Description
SURFACE	Conditional, Non-repeatable	Start of SURFACE pathway.
ASOS1MIN	Optional, Non-repeatable	File name for 1-minute ASOS wind data to be merged in Stage 2
AUDIT	Optional, Repeatable	Identify variables to be audited. These are in addition to any automatically audited variable.
DATA	Mandatory, Non-repeatable, Reprocessed	Input file name of raw surface data.
EXTRACT	Mandatory, Non-repeatable	File name of extracted surface data.
LOCATION	Mandatory, Non-repeatable, Reprocessed	Site ID and location information.
NO_MISSING	Optional, Repeatable	Identifies those variables to QA and summarize the messages only; detailed message identifying the violation and date is suppressed.
QAOUT	Mandatory, Non-repeatable	File name for hourly surface data for quality assessed output/merge input.
RANGE	Optional, Repeatable, Reprocessed	Set new upper and lower bounds and missing values for QA of the variable listed.
XDATES	Mandatory, Non-repeatable	Inclusive dates identifying the period of time to extract from the archive data file.

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Table A-6. Description of Keyword Parameters for the SURFACE Pathway

Keyword	Parameter(s)	
ASOS1MIN	asos1min_filename	
where:	asos1min_filename	Filename for hourly-averaged wind speed and direction derived from 1-minute ASOS wind data (TD-6405), to be merged in Stage 2
AUDIT	sfname1 ... sfnameN	
where:	sfname1 ... ... sfnameN	Name(s) of variables that are to be tracked and reported during quality assessment (as defined in Table B-2 of Appendix B).
DATA	archive_filename file_format [ASOS]	
where:	archive_filename	The name of the file containing the archive of hourly surface observations
	file_format	Archive file format; valid parameters are: **CD144** or **SCRAM** or **SAMSON** (data retrieved from SAMSON CD-ROM) or **3280VB** and **3280FB** or **HUSWO** (data retrieved from HUSWO CD-ROM; <u>assumes metric units</u>) or **ISHD** (data in the full archival TD-3505 format)
	[ASOS]	Optional parameter to indicate that ISHD data are from an Automated Surface Observing System (ASOS) site. This parameter is only allowed with the ISHD file format, and instructs AERMET to apply the wind speed truncation adjustment to all hours (see Section 2.3.2). Beginning with version 11059, AERMET includes a table of ASOS commission dates, which is used to identify whether surface data input to AERMET are from an ASOS site. ***The optional 'ASOS' parameter for ISHD data should only be used if the data are known to be from an ASOS site which is not included in the ASOS station list within AERMET.***

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		NOTE: The blocking factor and data type (ASCII or EBCDIC) parameters are no longer supported by AERMET, beginning with version 11059. The default values for these parameters are 1 for blocking factor and ASCII for data type. AERMET will issue a warning message if these parameters are included on the DATA keyword.

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Keyword	Parameter(s)	
EXTRACT	extracted_data_filename	
where:	extracted_data_filenam e	Name of the output file for data extracted from an archive data file
LOCATION	site_id lat(long) long(lat) [tadjust] [elevation]	
where:	site_id lat(long) long(lat) [tadjust] [elevation]	Site identifier for which data are to be processed. Station latitude (or longitude) in decimal degrees with the suffix N for sites north of the equator, S for sites south of the equator (or W for sites west of Greenwich, E for sites east of Greenwich). Station longitude (or latitude) in decimal degrees with the suffix W for sites west of Greenwich, E for sites east of Greenwich (or N for sites north of the equator, S for sites south of the equator). An integer used to convert the time reported in the database to local Standard time. For most surface databases, the value is 0. For TD-3505 (ISHD) data, which is reported in GMT, the value is the same as the time zone for the station (e.g., a value of 5 for the Eastern time zone). Station elevation (m above sea-level); default of 0m if omitted.
NO_MISSING	sfname1 . . . sfnameN	
where:	sfname1 . . . . . . sfnameN	Suppresses missing data messages for the surface variables specified, as defined in Appendix B; the number of times the variable is missing is not tallied
QAOUT	qa_output_filename	
where	qa_output_filename	Name of the output file from the QA/input to merge data
RANGE	sfname lower_bound <[=] upper_bound missing_indicator	
where	sfname lower_bound <[=] upper_bound missing_indicator	Variable name, as defined in Table B-2 Minimum value of the valid range of values for sfname Exclude (<) or include (<=) the lower and upper bounds in the QA Maximum value of the valid range of values for sfname Value to use to indicate the observed variable is missing
XDATES	YB/MB/DB [TO] YE/ME/DE	
where:	YB/MB/DB [TO] YE/ME/DE	Beginning year, month and day to extract; the slash (/) between each part of the date field is required; there can be no blanks in this parameter Optional; used to make this record more readable Ending year, month and day to extract; the slash (/) between each part of the date field is required; there can be no blanks in this parameter

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Table A-7. Description of ONSITE Pathway Keywords

Keyword	Type	Description
ONSITE	Mandatory, Non-repeatable	Start of ONSITE pathway.
AUDIT	Optional, Repeatable	Identify variables to be audited. These variables are in addition to any automatically audited variables.
DATA	Mandatory, Non-repeatable, Reprocessed	Input file name of site-specific data.
DELTA_TEMP	Optional, Repeatable, Reprocessed	Define heights (meters) for temperature differences.
FORMAT	Mandatory, Repeatable, Reprocessed	FORTRAN format for reading one site-specific data record.
LOCATION	Mandatory, Non-repeatable, Reprocessed	Site ID and location information.
NO_MISSING	Optional, Repeatable	Identifies those variables to QA and summarize the messages only; detailed message identifying the violation and date is suppressed.
OBS/HOUR	Optional*, Non-repeatable	Number of observations each hour. *Mandatory only if the observations are more frequent than once per hour.
OSHEIGHTS	Optional*, Repeatable, Reprocessed	Define heights of the site-specific measurements. *Mandatory if the heights are not defined in the data file.
QAOUT	Mandatory, Non-repeatable	File name of site-specific data for quality assessment output/merge input
RANGE	Optional, Repeatable, Reprocessed	Set new upper and lower bounds and missing values for QA of the variable listed.
READ	Mandatory, Repeatable, Reprocessed	Defines the name and order of variables as they appear in the site-specific DATA file.
THRESHOLD	Mandatory, Non-repeatable, Reprocessed	Sets the minimum wind speed (meters/second) below which the wind is treated as calm.
XDATES	Optional, Non-repeatable	Inclusive dates for data processing.

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Table A-8. Description of Keyword Parameters for the ONSITE Pathway

Keyword	Parameter(s)	
AUDIT	osname1 . . . osnameN	
where:	osname1 . . . . . . osnameN	Name(s) of variables, as defined in Table B-3 of Appendix B, that are to be tracked during the quality assessment
DATA	Filename	
where:	Filename	The name of the file containing the ONSITE data
DELTA_TEMP	index lower_height upper_height	
where:	index lower_height upper_height	Index for the ith temperature difference measurement Lower measurement height for the ith temperature difference Upper measurement height for the ith temperature difference
FORMAT	record_index Fortran_format	
where:	record_index Fortran_format	Specifies the record # in the ONSITE data to which the Fortran format refers; linked to record_index on corresponding READ keyword The Fortran format used to read the ONSITE data record: May be defined using a Fortran format specifier or as free-formatted (also called list-directed) data using the optional 'FREE' parameter (without quotes and not case-sensitive). The Fortran format specifier must include open and close parentheses and must fit within the record length of the runstream image (up to 132 characters including keyword and record index), and may include embedded spaces. Note that date variables are read as INTEGER format (Fortran 'I' format) and all other data variables are read as REAL format (Fortran 'F' or 'E' format). Using an 'F' or 'E' format specifier to read date variables or 'I' format specifier to read other data variables will cause an AERMET runtime error. See Section 2.4 for a more detailed discussion of the READ and FORMAT keywords.
LOCATION	site_id lat(long) long(lat) [tadjust] [elevation]	
where:	site_id lat(long)	Site identifier for which data are to be processed. Station latitude (or longitude) in decimal degrees with the suffix N for

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		sites north of the equator, S for sites south of the equator (or W for sites west of Greenwich, E for sites east of Greenwich).
	long(lat)	Station longitude (or latitude) in decimal degrees with the suffix W for sites west of Greenwich, E for sites east of Greenwich (or N for sites north of the equator, S for sites south of the equator).
	[tadjust]	An integer used to convert the time reported in the database to local Standard time. For most onsite databases, the value is 0.
	[elevation]	Station elevation (m above sea-level); default of 0m if omitted.
NO_MISSING	osname1 . . . osnameN	
where:	osname1 . . . osnameN	Suppresses missing data messages for the ONSITE variables specified, as defined in Appendix B; the number of time the variable is missing is not tallied
OBS/HOUR	n_obs	
where:	n_obs	Number of time periods per hour the ONSITE data are reported; for example if the data are recorded every 15 minutes, then n_obs = 4. Maximum value is 12, corresponding with 5-minute averages. If OBS/HOUR is not specified, AERMET will assume 1 observation per hour.
OSHEIGHTS	height1 ... heightN	
where:	height1 . . . heightN	Heights of the ONSITE data measurements; can be used to specify heights if they are not included in the data file. Must be in ascending order from lowest to highest height. If the OSHEIGHTS keyword is specified and heights are also defined in the data file, the OSHEIGHTS input will be used and values in the data file (HT01, HT02, etc.) will be ignored. See Section 2.5 for a more detailed discussion about specifying measurement heights.

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Keyword	Parameter(s)	
QAOUT	qa_output_filename	
where:	qa_output_filename	File name of the quality assessment output/merge input.
RANGE	osname lower_bound <[=] upper_bound missing_indicator	
where:	osname	Variable name, as defined in Table B-3.
	lower_bound	Minimum value of the valid range of values for osname.
	<[=]	Determines whether to include (<=) or exclude (<) the lower and upper bounds in the range of acceptable values Exclude (<) or include (<=) the lower and upper bounds (the endpoints) in the QA.
	upper_bound	Maximum value of the valid range of values for osname.
	missing_indicator	Value to use to indicate the value is missing. **NOTE**: Beginning with version 11059, AERMET allows the use of REAL values for lower_bound, upper_bound, and missing_indicator.
READ	record_index osname1 . . . osnameN	
where:	record_index	Links the list of variables named on this keyword statement to a Fortran format defined on a FORMAT keyword statement. While the corresponding Fortran format specifier must fit within a single record in the runstream input file (up to 132 characters total per record), multiple READ keywords can be used to list variables for a single read by repeating the same record_index.
	osname1 ... osnameN	Specifies the list and order of variables in the ONSITE data file that are to be read. See Appendix B for ONSITE variable names. See Section 2.4 for a more detailed discussion of the READ and FORMAT keywords.

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Keyword	Parameter(s)	
THRESHOLD	threshold_wind_speed	
where:	threshold_wind_speed	Minimum valid wind speed for the ONSITE measurements; cannot exceed 1.0 ms^{-1}
XDATES	YB/MB/DB [TO] YE/ME/DE	
where:	YB/MB/DB	Beginning year, month and day to QA; the slash (/) between each part of the date field is required; there can be no blanks in this parameter.
	[TO]	Optional; used to make this record more readable.
	YE/ME/DE	Ending year, month and day to QA; the slash (/) between each part of the date field is required; there can be no blanks in this parameter.

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Table A-9. Description of MERGE Pathway Keywords

Keyword	Type	Description and Usage
MERGE	Mandatory, Non-repeatable	Start of MERGE pathway.
OUTPUT	Mandatory, Non-repeatable	File identifier for merged data.
XDATES	Optional, Non-repeatable	Inclusive dates for data processing. If omitted, the earliest date found in the data is used as the beginning date and the ending date is 367 days later. However, AERMET can MERGE multi-year data files if the XDATES keyword is specified.

Table A-10. Description of Keyword Parameters for the MERGE Pathway

Keyword	Parameter(s)	
OUTPUT	merged_data_filename	
where:	merged_data_filename	Name of the output file from STAGE 2.
XDATES	YB/MB/DB [TO] YE/ME/DE	
where:	YB/MB/DB	Beginning year, month and day to merge; the slash (/) between each part of the date field is required; there can be no blanks in this parameter.
	[TO]	Optional; used to make this record more readable.
	YE/ME/DE	Ending year, month and day to merge; the slash (/) between each part of the date field is required; there can be no blanks in this parameter.

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Table A-11. Description of METPREP Pathway Keywords

Keyword	Type	Description and Usage
METPREP	Mandatory, Non-repeatable	Start of METPREP pathway.
AERSURF	Optional, Non-repeatable	Specify file name for ***primary*** surface characteristics, such as output file from AERSURFACE; contains FREQ_SECT, SECTOR, and SITE_CHAR keyword inputs.
AERSURF2	Optional, Non-repeatable	Specify file name for ***secondary*** surface characteristics, such as output file from AERSURFACE; inputs in the AERSURF2 file are interpreted as secondary site characteristics, and may contain FREQ_SECT2, SECTOR2, and SITE_CHAR2 keyword inputs, or FREQ_SECT, SECTOR, and SITE_CHAR keywords. This allows users to include data from an AERSURFACE output file as secondary site characteristics without having to edit the file to change the keywords.
DATA	Mandatory, Repeatable	Input filename of merged data.
FREQ_SECT	Mandatory, Repeatable, Reprocessed	Number of surface characteristics by wind direction sector and time period for the ***primary*** location. Must precede SECTOR and SITE_CHAR statements, and also must precede secondary site keywords, if provided.
FREQ_SECT2	Conditional*, Repeatable, Reprocessed	Number of surface characteristics by wind direction sector and time period for the ***secondary*** location. *Must be specified if both ONSITE and NWS winds are included, and must precede SECTOR2 and SITE_CHAR2 statements.

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LOCATION	Conditional*, Non-repeatable	The LOCATION keyword under the METPREP pathway in Stage 3 is no longer used by AERMET, unless ONSITE mixing heights are used without any UPPERAIR data.
	If UPPERAIR data are available (with or without ONSITE mixing heights): OBSOLETE	For applications with UPPERAIR data, sunrise for CBL height calculations is based on the primary surface station location in Stage 1; either the ONSITE pathway, if available, or the SURFACE pathway. A warning message will be generated in these cases if the LOCATION keyword is included under the METPREP pathway, and the METPREP inputs will be ignored.
	Beginning with AERMET version 13350, if ONSITE mixing heights are used without UPPERAIR data: Mandatory	For applications with only ONSITE mixing heights, without UPPERAIR data, the LOCATION keyword under the METPREP should be used to specify the conversion from GMT to LST.
METHOD	Conditional*, Repeatable	Specify processing methodology used for a particular variable. * whether or not this keyword is mandatory depends on the processing to be performed and the types of data included in the merged database
MODEL	Optional, Non-repeatable	Name of model for which data are processed. Default: AERMOD
NWS_HGT	Conditional*, Non-repeatable	NWS instrument height, in meters, for the specified variable. * Mandatory if METHOD REFLEVEL SUBNWS is specified
SECTOR	Mandatory, Repeatable, Reprocessed	Defines a wind direction sector in degrees for the ***primary*** location. See also FREQ_SECT and SITE_CHAR.
SECTOR2	Conditional**, Repeatable, Reprocessed	Defines a wind direction sector in degrees for the ***secondary*** location. See also FREQ_SECT2 and SITE_CHAR2.

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SITE_CHAR	Mandatory, Repeatable, Reprocessed	Define the direction-dependent surface characteristics of albedo, Bowen ratio, and surface roughness length (meters) for the ***primary*** location. See also FREQ_SECT and SECTOR.
SITE_CHAR2	Conditional**, Repeatable, Reprocessed	Define the direction-dependent surface characteristics of albedo, Bowen ratio, and surface roughness length (meters) for the ***secondary*** location. See also FREQ_SECT2 and SECTOR2.
THRESH_1MIN	Optional, Non-repeatable	Option to specify a wind speed threshold for winds derived from 1-minute ASOS wind data processed through AERMINUTE.
UAWINDOW	Optional, Non-repeatable	Specifies the time window to use for selecting upper air sounding.
XDATES	Optional, Non-repeatable	Inclusive dates for data processing.

** Surface characteristics for the ***secondary*** site (SECTOR2 and SITE_CHAR2) are required for applications with ONSITE data and with the REFLEVEL SUBNWS option under the METHOD keyword to substitute for missing ONSITE wind data.

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Table A-12. Description of Keyword Parameters for the METPREP Pathway

Keyword	Parameter(s)	
AERSURF	primary_surfchar_filenam	*(for primary surface data location)*
AERSURF2	secondary_surfchar_filenam	*(for optional secondary surface data location)*
where:	primary_surfchar_filenam	The name of the file containing the surface characteristic inputs for the ***primary*** surface data location (FREQ_SECT, SECTOR, and SITE_CHAR keywords)
	secondary_surfchar_filenam	The name of the file containing the surface characteristic inputs for the ***secondary*** surface data location (FREQ_SECT2, SECTOR2, and SITE_CHAR2 keywords)
DATA	merged_data_filename	
where:	merged_data_filename	The name of the file containing the merged NWS and, if any, site-specific data
FREQ_SECT	frequency number_of_sectors	*(for primary surface data location)*
FREQ_SECT2	frequency number_of_sectors	*(for optional secondary surface data location)*
where:	frequency	Specifies how often the surface characteristics change; valid parameters are: **MONTHLY** - every calendar month **SEASONAL** - where the seasons are defined as: Spring = March, April, May Summer = June, July, August Autumn = September, October, November Winter = December, January, February **ANNUAL** - constant for the entire year
	number_of_sectors	Specifies the number of wind direction sectors by which the surface characteristics vary

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Keyword	Parameter(s)	
LOCATION	site_id lat(long) long(lat) [tadjust] [elevation]	
where:	site_id	Site identifier for which data are to be processed.
	lat(long)	Station latitude (or longitude) in decimal degrees with the suffix N for sites north of the equator, S for sites south of the equator (or W for sites west of Greenwich, E for sites east of Greenwich).
	long(lat)	Station longitude (or latitude) in decimal degrees with the suffix W for sites west of Greenwich, E for sites east of Greenwich (or N for sites north of the equator, S for sites south of the equator).
	[tadjust]	An integer used to convert the time reported in the database to local Standard time. For standard upper-air data reported in Greenwich Mean Time (GMT), the value is the same as the time zone for the station (e.g., a value of 5 for the Eastern time zone).
	[elevation]	Station elevation (m above sea-level); default of 100m if omitted. Note: The optional station elevation on the UPPERAIR pathway is currently not used by AERMET. NOTE: The LOCATION keyword under the METPREP pathway is obsolete for applications that include UPPERAIR data, and inputs will be ignored; however, applications that use **only** ONSITE mixing heights, without UPPERAIR data, should still use the LOCATION keyword under the METPREP pathway to specify the conversion from GMT to LST.
METHOD	atmos_variable option	
where:	atmos_variable	Identifies the variable that will be processed: **UASELECT** – selecting upper air sounding. **WIND_DIR** – processing of NWS wind directions. **REFLEVEL** – substitution of NWS data **STABLEBL** – specify option for SBL processing **ASOS_ADJ** – adjustment of ASOS wind speeds for truncation **CCVR** – option to substitute for missing cloud cover **TEMP** – option to substitute for missing temperature

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	option	Processing options: For **UASELECT**, valid parameters are: **SUNRIS(E)** – select upper air sounding based on local sunrise For **WIND_DIR** (not applicable to 1-min ASOS data), valid parameters are: **NORAND** – leave NWS wind directions to the nearest 10° (default) or **RANDOM** – randomize NWS wind directions. For **REFLEVEL**, valid parameters are: **SUBNWS** – allows substitution of NWS data for missing ONSITE wind and/or temp data (other parameters automatically substituted); **NOTE**: this option **must** be used if no ONSITE data are provided. For **STABLEBL**, valid parameters are: **BULKRN** – Bulk Richardson Number - This option requires onsite measurements of temperature difference. **ADJ_U*** – Non-Default/BETA option to adjust U* (surface friction velocity) for low wind/stable conditions. For applications without the BULKRN option, the ADJ_U* option is based on Qian and Venkatram (2011). For applications with the BULKRN option, the ADJ_U* option is based on Luhar and Rayner (2009). For **ASOS_ADJ**, valid parameters are: **NO_ADJ** – do not adjust ASOS wind speeds for truncation. For **CCVR**, valid parameters are: **SUB_CC** – select option to substitute for missing cloud cover **NO_SUB** – disable option to substitute for missing cloud cover **NOPERS** – disable subs for hrs 23 and 24 based on persistence For **TEMP**, valid parameters are: **SUB_TT** – select option to substitute for missing temperature **NOTSUB** – disable option to substitute for missing temperature (**NO_SUB** can also be used for **TEMP**) **NOPERS** – disable subs for hrs 23 and 24 based on persistence NOTE: The CCVR and TEMP substitutions are used by default, unless the application involves both NWS and ONSITE surface data, or only ONSITE data with NRAD or with INSO data and the BULKRN option. Substitutions can be disabled, and can also be activated for cases with both NWS and ONSITE data by specifying the appropriate parameters.

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		Substitutions are based on linear interpolation across gaps of 1 to 2 hours, unless the missing data are for hours 23 or 24, where persistence is assumed. Interpolations are only made based on non-interpolated values on both sides of the data gap.
MODEL	model_name	
where:	model_name	Name of the dispersion model which uses the output files generated by AERMET. Allowable names are: **AERMOD**
NWS_HGT	variable_name instrument_height	
where:	variable_name	Weather variable that requires an instrument height to be defined; valid names are: **WIND** (to specify anemometer height)
	instrument_height	Height of the instrument above ground, in meters.
OUTPUT	parameter_filename	
where:	parameter_filename	Name of the output file from STAGE 3, with one record per hour
PROFILE	profile_filename	
where:	profile_name	Name of the output file containing multi-level onsite data, or single level wind and temperature data from NWS site
SECTOR	sector_index beginning_direction ending_direction	*(for primary data location)*
SECTOR2	sector_index beginning_direction ending_direction	*(for optional secondary data location)*
where:	sector_index	Index that links a specific set of site characteristics to a specific wind sector.
	beginning_direction	Specifies the beginning wind direction of the sector, and is considered a part of this sector.
	ending_direction	Specifies the ending wind direction of the sector, and is NOT considered a part of the sector NOTE: The end of one sector must be the same as the beginning of the next sector.

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SITE_CHAR	frequency_index sector_index albedo Bowen roughness		*(for primary data location)*
SITE_CHAR2	frequency_index sector_index albedo Bowen roughness		*(for secondary data location)*
where:	frequency_index	Index of the time period for which the surface characteristics apply; for **ANNUAL** on FREQ_SECT keyword, valid values: 1 (for the entire year) for **MONTHLY** on FREQ_SECT keyword, valid values: 1 ... 12 (corresponding to each month of the year) for **SEASONAL** on FREQ_SECT keyword, valid values: 1 = Winter = December, January, February 2 = Spring = March, April, May 3 = Summer = June, July, August 4 = Autumn = September, October, November	
	sector_index	Sector corresponding to direction from which the wind is blowing.	
	albedo	Albedo for the frequency index and sector index specified.	
	Bowen	Bowen ratio for the frequency index and sector index specified.	
	roughness	Surface roughness for the frequency index and sector index specified.	
THRESH_1MIN	threshold_speed		
where:	threshold_speed	Threshold wind speed in m/s for wind speeds derived from 1-minute ASOS wind data processed through the AERMINUTE program. If the user specifies a threshold speed greater than 0.5 m/s, a warning is issued by AERMET. If a threshold wind speed greater than 1.0 m/s is specified, AERMET considers this a fatal error, will issue an error message and will not process data through Stage 3.	
UAWINDOW	window_begin window_end		
where:	window_begin	Beginning of the sounding window, entered as the number of hours relative to the preferred sounding time (12Z, 00Z or -12Z for the default selection; or local sunrise for the UASELECT SUNRIS option)	
	window_end	Ending of the sounding window entered as the number of hours relative to the preferred sounding time <u>NOTE:</u> A negative number indicates the number of hours before the reference sounding (or sunrise), and a positive number indicates the number of hours after the sounding (or sunrise)	
XDATES	YB/MB/DB [TO] YE/ME/DE		

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where:	YB/MB/DB	Beginning year, month and day to process; a slash (/) between each part of the date field is required; with no blanks
	[TO]	Optional; used to make this record more readable
	YE/ME/DE	Ending year, month and day to process; a slash (/) between each part of the date field is required; with no blanks

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Appendix B. Variable names and default QA values

This appendix lists the variable names for each type of data and provides a short description of and the units for each variable, and gives the default bounds and missing value codes. This information is presented in the tables that follow (Table B-1, Table B-2,

Table B-3, and Table B-4), with each table divided into the following fields:

Variable Name

This is the four-character name that can be used on RANGE, AUDIT, and READ statements. An asterisk (*) indicates that the variable is automatically included in the QA for the path and need not be specified on an AUDIT record in the control file.

Description and Units

A brief description of each variable and the units follow the name. For UPPERAIR and SURFACE, real variables are stored as integers, in which case the units include a multiplier, such as *10 or *100, in order to maintain additional significant digits. For example, if the units are °C*10, then 1.5 °C is stored and referenced as 15.

Type of Check

The type of check determines whether to include (<=) or exclude (<) the lower and upper bounds in the range of acceptable values, and can be changed on a RANGE statement for specific variables.

Missing Value Code

The missing value code is the value that AERMET interprets to mean that a value is not present. It is also the value written/stored by AERMET when the variable is not present or cannot be calculated.

Bounds

The last two fields are the lower and upper bounds that determine the interval of acceptable values. The value of the variable is accepted if it lies within this interval, where the endpoints

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are either included or excluded according to the Type of Check. Note that the multiplier, if present, must also be applied to these values.

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Table B-1. Variable and QA Defaults for the UPPERAIR Variables

Variable Name	Description	Units	Type *	Missing Indicator	Lower Bound	Upper Bound
UAPR	Atmospheric pressure	millibars*10	<	99999	5000	10999
UAHT	Height above ground	meters	<=	99999	0	5000
UATT	Dry bulb temperature	ºC*10	<	9990	350	+350
UATD	Dew point temperature	ºC*10	<	9990	350	+350
UAWD	Wind direction	degrees from north	<=	999	0	360
UAWS	Wind speed	meters/second *10	<	9990	0	500
UASS	Wind speed shear	(m/s)/(100 meters)	<=	9999	0	5
UADS	Wind direction shear	degrees/(100 meters)	<=	9999	0	90
UALR	Temperature lapse rate	ºC/(100 meters)	<=	9999	2	5
UADD	Dew point deviation	ºC/(100 meters)	<=	9999	0	2

* Type determines whether to include (<=) or exclude (<) the lower and upper bounds in the range of acceptable values, and can be changed on a RANGE statement.

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Table B-2. Variable and QA Defaults for SURFACE Variables

Variable Name	Description	Units	Type	Missing Indicator	Lower Bound	Upper Bound
PRCP	Precipitation amount	millimeters*100	<=	-9	0	25400
SLVP[†]	Sea level pressure	millibars*10	<	99999	9000	10999
PRES	Station pressure	millibars*10	<	99999	9000	10999
CLHT	Ceiling height	kilometers*10	<=	999	0	300
TSKC	Total//opaque sky cover	tenths//tenths	<=	9999	0	1010
ALC1[a]	Sky cond//height, level 1	code//hundredths ft	<=	09999	0	07300
ALC2[a]	Sky cond//height, level 2	code//hundredths ft	<=	09999	0	07300
ALC3[a]	Sky cond//height, level 3	code//hundredths ft	<=	09999	0	07300
ALC4[b]	Sky cond//height, level 4	code//hundredths ft	<=	09999	0	07850
ALC5[b]	Sky cond//height, level 5	code//hundredths ft	<=	09999	0	07850
ALC6[b]	Sky cond//height, level 6	code//hundredths ft	<=	09999	0	07850
PWVC	Present weather (vicinity)		<=	9999	0	9800
PWTH	Precipitation type		<=	9999	0	9800
ASKY[c]	ASOS Sky condition	tenths	<=	99	0	10
ACHT[d]	ASOS Ceiling	kilometers*10	<=	999	0	888
HZVS	Horizontal visibility	kilometers*10	<=	99999	0	1640
TMPD[*]	Dry bulb temperature	ºC*10	<	999	-300	360
TMPW	Wet bulb temperature	ºC*10	<	999	-650	350
DPTP	Dew-point temperature	ºC*10	<	999	-650	350
RHUM	Relative humidity	whole percent	<=	999	0	100
WDIR[*]	Wind direction	tens of degrees	<=	999	0	36
WSPD[*]	Wind speed	meters/second*10	<=	999	0	500

[*] Automatically included in audit report.

[†] A value < 800 in CD144 files is converted to SLVP/10.0 + 1000.0

// The two variables have been combined to form one variable; the missing value flags, as well as the upper and lower bounds have also been concatenated.

[a] ASOS sky condition (code table) and height (hundredths of feet) for levels 1-3

[b] ASOS sky condition (code table) and height (hundredths of feet) for levels 4-6 (for augmented sites)

[c] ASOS sky condition (tenths), derived from layer data.

[d] ASOS ceiling (kilometers *10), derived from layer data.

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Table B-3. Variable and QA Defaults for the ONSITE (Site-specific) Single-value and Date/Time Variables

Variable Name	Description	Units	Type*	Missing Indicator	Lower Bound	Upper Bound
HFLX	Surface heat flux	watts/square meter	<	-999	-100	800
USTR	Surface friction velocity	meters/second	<	-9	0	2
MHGT	Mixing height	meters	<	9999	0	4000
ZOHT	Surface roughness length	meters	<	999	0	2
SAMT	Snow amount	centimeters	<=	999	0	250
PAMT	Precipitation amount	centimeters	<=	999	0	25
INSO	Insolation	watts/square meter	<=	9999	0	1250
NRAD	Net radiation	watts/square meter	<	999	-100	800
DT01	Temperature diff.(U - L)1	°C	<	9	-2	5
DT02	Temperature diff.(U - L)1	°C	<	9	-2	5
DT03	Temperature diff.(U - L)1	°C	<	9	-2	5
US01	User's scalar #1	user's units	<	999	0	100
US02	User's scalar #2	user's units	<	999	0	100
US03	User's scalar #3	user's units	<	999	0	100
PRCP	Precipitation	millimeters*100	<=	-9	0	25400
SLVP	Sea level pressure	millibars*10	<	99999	9000	10999
PRES	Station pressure	millibars*10	<	99999	9000	10999
CLHT	Ceiling height	kilometers*10	<=	999	0	300
TSKC	Sky cover (total or opaque)	tenths	<=	99	0	10
OSDY	Day		<=	-9	1	31
OSMO	Month		<=	-9	1	12
OSYR	Year		<=	-9	0	99
OSHR	Hour		<=	-9	0	24
OSMN	Minutes		<=	-9	0	60

[1] (U - L) indicates (upper level) - (lower level).

* Type determines whether to include (<=) or exclude (<) the lower and upper bounds in the range of acceptable values, and can be changed on a RANGE statement.

Note: Shaded parameters are not currently used in AERMET.

Table B-4. Variable and QA Defaults for the ONSITE (Site-specific) Multi-level Variables

Variable Name	Description	Units	Type	Missing Indicator	Lower Bound	Upper Bound
HTnn	Height	meters	<	9999	0	4000
SAnn	Std. dev. horizontal wind	degrees	<	99	0	35
SEnn	Std. dev. vertical wind	degrees	<	99	0	25
SVnn	Std. dev. v-comp. of wind	meters/second	<	99	0	3
SWnn	Std. dev. w-comp. of wind	meters/second	<	99	0	3
SUnn	Std. dev. u-comp. of wind	meters/second	<	99	0	3
TTnn*	Temperature	°C	<	99	-30	40
WDnn*	Wind direction	degrees from north	<=	999	0	360
WSnn*	Wind speed	meters/second	<=	99	0	50

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VVnn	Vertical wind component	meters/second	<	999	0	5
DPnn	Dew-point temperature	°C	<	99	-65	35
RHnn	Relative humidity	whole percent	<=	999	0	100
V1nn	User's vector #1	user's units	<	999	0	100
V2nn	User's vector #2	user's units	<	999	0	100
V3nn	User's vector #3	user's units	<	999	0	100

'nn' in variables HT to V3 refers to the level at which the observation was taken; e.g., TT01 is the temperature at the first level and WS02 is wind speed at the second level.

*Automatically included in audit report.

Note: Shaded parameters are not currently used in AERMET.

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Appendix C. Data File Formats

This appendix describes the format of the data files created by AERMET. This includes the EXTRACT and QA files of NWS upper air and surface data, the merged file, and the OUTPUT and PROFILE files that will be input to AERMOD. It does not describe the QA file for site-specific data since this file is written with the same user-specified format used to read the original site-specific file.

The format of the files is given in terms of the FORTRAN READ statements that must be used to input the data for each observation. Variable names shown in capital letters correspond to those given in Appendix B. Variable names shown in lower case italics are "local" variables that do not correspond to any in Appendix B.

C.1 Upper air soundings

Each upper air sounding in both the EXTRACT and QA files is composed of two parts: (1) an identifying header record consisting of the year, month, day, hour, and the number of sounding levels; and (2) a sounding record composed of pressure, height above ground level, temperature, dew-point temperature, wind speed, and wind direction, which is repeated for each level.

Upper air header record:

READ( )	year, month, day, hour, # levels
FORMAT	(1X, 4I2, I5)

where *hour* is expressed in local standard time (LST) and *# levels* is the number of levels in this sounding. If no soundings were extracted or there are no levels to the data, then *# levels* is zero.

Upper air sounding level data (if # *levels* > 0), repeated # *levels* times.

READ( )	UAPR, UAHT, UATT, UATD, UAWD, UAWS		
FORMAT	(6(1X,I6))		
where	UAPR	=	atmospheric pressure (millibars), multiplied by 10
	UAHT	=	height above ground level (meters)
	UATT	=	dry bulb temperature (°C), multiplied by 10
	UAWD	=	wind direction (degrees from north)
	UAWS	=	wind speed (meters/second), multiplied by 10

All values on the upper air pathway are written as integers. Several of the values were multiplied by 10, as noted above, to retain one significant digit after the decimal point prior to rounding the result to the nearest whole number. The values are divided by 10 prior to any usage in Stage 3.

C.2 Surface observations

Each hourly surface observation in both the EXTRACT and QA files is written as two records. As with the upper air data, all values are reported as integers with several variables multiplied by 10 or 100 to retain significant digits. Several of the variables are two variables combined and stored as one integer value. These are recognized by the // in the variable name and units below.

The first record of a surface observation is written as follows:

READ( )	*year, month, day, hour*, PRCP, SLVP, PRES, CLHT, TSKC, C2C3, CLC1, CLC2, CLC3, CLC4		
FORMAT	(1X, 4I2, 4(1X,I5), 6(1X,I5.5))		
where	*hour*	=	hour in LST

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PRCP	=	precipitation amount (millimeters), multiplied by 1000
SLVP	=	sea level pressure (millibars), multiplied by 10
PRES	=	station pressure (millibars), multiplied by 10
CLHT	=	cloud ceiling height (kilometers), multiplied by 10
TSKC	=	sky cover, total//opaque (tenths//tenths)
C2C3	=	sky cover, 2//3 layers (tenths//tenths)
CLC*n*	=	sky condition//coverage, layer *n* = 1,2,3,4 (- -//tenths)

The second record of a surface observation is written as follows:

READ( )	CLT1, CLT2, CLT3, CLT4, PWTH, HZVS, TMPD, TMPW, DPTP, RHUM, WDIR, WSPD, ASOSFLG
FORMAT	(8X, 5(1X,I5.5), 7(1X,I5),2X,A1)

where CLT*n* = cloud type//height, *n*=1,2,3,4 (- -//kilometers), multiplied by 10

PWTH	=	present weather, liquid//frozen (no units, see codes below)
HZVS	=	horizontal visibility (kilometers), multiplied by 10
TMPD	=	dry bulb temperature (°C), multiplied by 10
TMPW	=	wet bulb temperature (°C), multiplied by 10
DPTP	=	dew-point temperature (°C), multiplied by 10
RHUM=	relative humidity (percent)	
WDIR	=	wind direction (tens of degrees from north)
WSPD	=	wind speed (meters/second), multiplied by 10
ASOSFLG	=	flag indicating whether observation is ASOS (‘A’) or non-ASOS (‘N’)

All reports of sky conditions (CLC*n*), cloud types or obscuring phenomena (CLT*n*) and

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present weather (PWTH) are stored using the TD-3280 numeric codes. This requires converting the appropriate variables in the CD-144 formatted file as a part of the extraction process. Since SCRAM uses the same convention, this discussion applies to that format as well. The following tables relate the TD-3280 codes to the CD-144 codes. Overpunch characters in the tables below for the CD-144 formats are represented by an ASCII character, which also appears in the data file. An "n.e." indicates that there is "no equivalent" in the CD-144 format. Only weather producing liquid and/or frozen precipitation are reported in the PWTH variable.

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Table C-1. Sky Conditions

TD-3280	CD-144	Description of Sky Conditions
00	0	clear or less than 0.1 coverage
01	1	thin scattered 0.1 to 0.5 coverage
02	2	scattered 0.1 to 0.5 coverage
03	4	thin broken 0.6 to 0.9 coverage
04	5	broken 0.6 to 0.9 coverage
05	7	thin overcast 1.0 coverage
06	8	overcast 1.0 coverage
07	X or -	obscuration 1.0 coverage
08	Blank	partial obscuration <1.0 coverage
09		unknown

Table C-2. Cloud Types

TD-3280	CD-144	Description of Cloud Types
00	0	none
11	4	cumulus
12	n.e.	towering cumulus
13	K	stratus fractus
14	n.e.	stratus cumulus lenticular
15	3	stratus cumulus
16	2	stratus
17	M	cumulus fractus
18	5	cumulonimbus
19	N	cumulonimbus mammatus
21	6	altostratus
22	O	nimbostratus
23	7	altocumulus
24	n.e.	altocumulus lenticular
28	P	altocumulus castellanus
29	n.e	altocumulus mammatus
32	8	cirrus
35	n.e.	cirrocumulus lenticular
37	9	cirrostratus
39	R	cirrocumulus

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Table C-3. Obscuring Phenomena

TD-3280	CD-144 (cols. 30, 31)	Description of Obscuring Phenomena
01	6	blowing spray
03	3	smoke and haze
04	1	smoke
05	2	haze
06	4	dust
07	4	blowing dust
30	5	blowing sand
36	5	blowing snow
44	3	ground fog
45	1	fog
48	2	ice fog
50	n.e.	drizzle
60	n.e.	rain
70	n.e.	snow
76	n.e.	ice crystals
98	X or -	obscuring phenomena other than fog (prior to 1984)

The code definitions for present weather conditions (PWTH) are presented below. They are divided into nine general categories that are subdivided into specific weather conditions. Dashes in a field indicate that there is no definition for that code. The 8-digit CD-144 format for weather conditions is converted to the 2-digit TD-3280 categories. Up to two different types of weather may be stored in the PWTH variable in AERMET; however, only weather producing liquid (codes 20-39) and/or frozen (codes 40-69) precipitation are retained in the PWTH variable as liquid//frozen precipitation. The SAMSON codes for present weather are identical to the TD-3280 codes.

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Table C-4. Present Weather

TD-3280	CD-144 (col. 24)	Thunderstorm, Tornado, Squall
10	1	thunderstorm - lightning and thunder
11	2	severe thunderstorm - frequent intense lightning and thunder
12	3	report of tornado or water spout
13	5	light squall
14	n.e.	moderate squall
15	n.e.	heavy squall
16	n.e.	water spout
17	n.e.	funnel cloud
18	n.e.	tornado
19	n.e.	unknown
TD-3280	CD-144 (col. 25)	Rain, Rain Shower, Freezing Rain
20	1	light rain
21	2	moderate rain
22	3	heavy rain
23	4	light rain showers
24	5	moderate rain showers
25	6	heavy rain showers
26	7	light freezing rain
27	8	moderate freezing rain
28	9	heavy freezing rain
29	n.e.	unknown
TD-3280	CD-144 (col. 26)	Rain Squall, Drizzle, Freezing Drizzle
30	n.e.	light rain squalls
31	n.e.	moderate rain squalls
32	n.e	heavy rain squalls
33	4	light drizzle
34	5	moderate drizzle
35	6	heavy drizzle
36	7	light freezing drizzle
37	8	moderate freezing drizzle
38	9	heavy freezing drizzle
39	n.e.	unknown
TD-3280	CD-144 (col. 27)	Snow, Snow Pellets, Ice Crystals

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40	1	light snow
41	2	moderate snow
42	3	heavy snow
43	4	light snow pellets
44	5	moderate snow pellets
45	6	heavy snow pellets
46	n.e.	light snow crystals
47	8	moderate snow crystals
48	n.e.	heavy snow crystals
49	n.e.	unknown
TD-3280	CD-144 (col 28)	Snow Shower, Snow Squalls, Snow Grains
50	1	light snow showers
51	2	moderate snow showers
52	3	heavy snow showers
53	n.e.	light snow squalls
54	n.e.	moderate snow squalls
55	n.e.	heavy snow squalls
56	7	light snow grains
57	8	moderate snow grains
58	9	heavy snow grains
59	n.e.	unknown
TD-3280	CD-144 (col. 29)	Sleet, Sleet Shower, Hail
60	n.e.	light ice pellet showers
61	n.e.	moderate ice pellet showers
62	n.e.	heavy ice pellet showers
63	n.e.	light hail
64	5	moderate hail
65	n.e.	heavy hail
66	8	light small hail
67	n.e.	moderate small hail
68	n.e.	heavy small hail
69	n.e.	unknown

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TD-3280	CD-144 (col. 30)	Fog, Blowing Dust, Blowing Sand
70	1	fog
71	2	ice fog
72	3	ground fog
73	4	blowing dust
74	5	blowing sand
75	n.e.	heavy fog
76	n.e.	glaze
77	n.e.	heavy ice fog
78	n.e.	heavy ground fog
79	n.e.	unknown
TD-3280	CD-144 (col. 31)	Smoke, Haze, Blowing Snow, Blowing Spray, Dust
80	1	smoke
81	2	haze
82	3	smoke and haze
83	4	dust
84	5	blowing snow
85	6	blowing spray
86	n.e.	dust storm
87		- -
88		- -
89	n.e.	unknown
TD-3280	CD-144 (col. 29)	Ice Pellets, Hail Showers, Small Hail/Snow Pellet Showers, Fog
90	1	light ice pellets
91	2	moderate ice pellets
92	3	heavy ice pellets
93		hail showers (begins July 1996)
94		small hail/snow pellet showers
95		(begins7/96)
96		partial fog (begins 7/96)
97		patches fog (begins 7/96)
98		low drifting snow (begins 7/96)
99	n.e.	- -
		unknown

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C.3 MERGE output

The merged data file contains a block of records that are the cumulative header records of all input files to Stage 2. These records are followed by blocks of records for each day of observations. Each block of records contains a header record identifying how many records there are in the block for each of the three types of data present. Each block is subdivided into three blocks of records, where each sub-block contains all of the observations for that day for a particular type of data.

The records within a block are written with an 8(I8,1X) format, except for the multi-level site-specific records that are written with a 6(F14.6,1X) format. The 22 NWS surface variables, plus the date and time, for each hour are split across four records. Also, if there are more than eight single-level or six multi-level variables on a particular READ statement, then these records will also be divided across more than one record.

Daily Master Header Record

READ( )		year, month, day, j_day, n_ua, n_prv, n_curr, n_sfc, n_os, n_1min
FORMAT		(7(I8,1X))
where		
j_day	=	the Julian date for year/month/day.
n_ua	=	number of total NWS upper air observations (n_prv + n_curr).
n_prv	=	number NWS upper air observations from previous day.
n_curr	=	number of NWS upper air observations from current day.
n_sfc	=	number of NWS surface observations.
n_os	=	number of site-specific observations.
n_1min	=	number of 1-hour averages derived from of 1-minute ASOS data

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Upper Air Records

Upper air data are stored in the same order as in upper air extract/QA files.

Surface Records

For each hour, there is a header record with the year, month, day and hour followed by three data records. The 22 variables are written in the same order as shown in Section C.2, with a maximum of 8 variables per record.

Site-specific Records

Single-level Variables

Single-level variables are written in the same order and on multiple records just as they were given on the Stage 1 ONSITE READ statements, but using an 8(I8,1x) format instead of that given on the corresponding FORMAT statements.

Multilevel Variables

Like the single-level variables, the multilevel variables are also written in the same order and on multiple records just as they were given on the Stage 1 ONSITE READ statements, but using a 6(F14.6,1x) format.

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C.4 AERMOD files

Two files are produced for input to the AERMOD dispersion model. The surface OUTPUT contains observed and calculated surface variable, one record per hour. The PROFILE file contains the observations made at each level of a site-specific tower, or the one level observations taken from NWS data, one record per level per hour. The contents of these files can also be written to the general report by including a LIST statement in the METPREP block.

SURFACE OUTPUT

Beginning with version 06341, the AERMET program includes additional meteorological parameters in the surface file that are needed to support application of the deposition algorithms in AERMOD. The additional variables include the precipitation code, precipitation rate, relative humidity, surface pressure, and cloud cover. These additional variables are automatically included after the standard variables for each hour, and do not require any additional user input. The precipitation data needed for wet deposition calculations in AERMOD can be obtained from ONSITE data, or from SURFACE data in the SAMSON, HUSWO or ISHD (TD-3505) formats supported by AERMET. A description of the revised surface file format is provided below:

Header record:

READ( ) *latitude, longitude, UA identifier, SF identifier, OS identifier, Version date*

FORMAT (2(2X,A8), 8X,' UA_ID: ',A8, ' SF_ID: ',A8, ' OS_ID: ',A8, T85, 'VERSION:', A6)

where

latitude = latitude specified in Stage 1 for primary surface station

longitude = longitude specified in Stage 1 for primary surface station

UA identifier = station identifier for upper air data; usually the WBAN

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		number used to extract the data from an archive data set
SF identifier	=	station identifier for hourly surface observations; usually the WBAN number used in extracting the data
OS identifier	=	site-specific identifier
Version date	=	AERMET version date; this date also appears in the banner on each page of the summary reports

Note that the ‘ ??_ID: ’ fields in the FORMAT statement above include two spaces before the 2-character pathway ID and one space after the colon.

Data records:

READ( ) *year, month, day, j_day, hour, H,* u_*, w_*, *VPTG, Zic, Zim, L,* z_o, B_o, *r,* W_s, W_d, z_{ref}, *temp,* z_{temp}, *ipcode, pamt, rh, pres, ccvr, WSADJ*

FORMAT (3(I2,1X), I3,1X, I2,1X, F6.1,1X, 3(F6.3,1X), 2(F5.0,1X), F8.1,1X, F7.4,1X, 2(F6.2,1X), F7.2,1X, F5.0, 3(1X,F6.1), 1X,I5, 1X,F6.2, 2(1X, F6.0), 1X, I5, 1X, A7)

where

j_day	=	Julian day
H	=	sensible heat flux (W/m^2)
u_*	=	surface friction velocity (m/s)
w_*	=	convective velocity scale (m/s)
VPTG	=	vertical potential temperature gradient above *Zic* (K/m)
Zic	=	height of convectively-generated boundary layer (m)
Zim	=	height of mechanically-generated boundary layer (m)
L	=	Monin-Obukhov length (m)
z_0	=	surface roughness length (m)
B_0	=	Bowen ratio

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r	=	Albedo
W_s	=	reference wind speed (m/s)
W_d	=	reference wind direction (degrees)
z_{ref}	=	reference height for wind (m)
temp	=	reference temperature (K)
z_{temp}	=	reference height for temperature (m)
ipcode	=	precipitation type code
		(0=none, 11=liquid, 22=frozen, 99=missing)
pamt	=	precipitation amount (mm/hr)
rh	=	relative humidity (percent)
pres	=	station pressure (mb)
ccvr	=	cloud cover (tenths)
WSADJ	=	wind speed adjustment and data source flag

When site-specific data are included in the data base, the definition of the reference height wind speed and direction are subject to the following restrictions:

- the wind speed, W_s, must be greater than or equal to the site-specific data threshold wind speed;
- the measurement height must be at or above $7*z_0$, where z_0 is the surface roughness length;
- the height must be less than or equal to 100 meters;

If AERMET is run only with NWS data, i.e. no site-specific data are in the data base, then the restrictions above do not apply and the reference winds are taken to be the NWS winds independent of the height at which the winds were measured.

Ambient air temperature is subject to a similar, but less restrictive, selection process:

- the measurement height must be above z_0; and

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- the height must be less than or equal to 100 meters.

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PROFILE OUTPUT

READ( ) *year, month, day , hour*, height, top, WD*nn*, WS*nn*, TT*nn*, SA*nn*, SW*nn*

FORMAT (4(I2,1X), F7.1,1X, I1,1X, F7.1,1X, F8.2,1X, F8.2,1X, F8.2,1X, F8.2)

where,

height	=	measurement height (m)
top	=	1, if this is the last (highest) level for this *hour*, or 0 otherwise
WD*nn*	=	wind direction at the current level (degrees)
WS*nn*	=	wind speed at the current level (m/s)
TT*nn*	=	temperature at the current level (°C)
SA*nn*	=	σ_θ (degrees)
SW*nn*	=	σ_w (m/s)

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Appendix D. Summary of messages

During the processing of the runstream input and data files, AERMET writes messages to the file defined through the MESSAGES keyword on the JOB pathway. Each message has the form:

$$n \;\; block \;\; a_1 n_1 n_2 \;\; ssssss: \;\; message$$

where

n	=	counter, date (in the form yymmdd), or blank
block	=	program block name
$a_1 n_1 n_2$	=	message code
ssssss:	=	subroutine name in which the message was generated
message	=	message (limited to 48 characters)

The counter *n* is either the sequence number of the keyword statement generating the message, zero when irrelevant, the Julian day plus the hour of an observation with a QA violation or the number of observations when processing is completed. If it is a sequence number, it may be relative to either the current runstream file or to the header statements of a file.

The message code is composed of a letter (a_1) and a 2-digit code ($n_1 n_2$). The letter can be one of the following:

E Indicates a fatal error; if the error occurs during processing of keyword statements, the remaining statements are processed for syntax only. If the error occurs during the processing of data, processing ceases for the run.

W Indicates a potential problem that the user should check. Runstream and data processing continues.

I Provides information on the status of the processing; these messages report on the progress of an AERMET run.

Q Indicates a quality assessment violation; a value for a variable was either outside the interval defined by the upper and lower bounds or it was missing.

The 2-digit codes are grouped into general categories corresponding to the processing in Stages 1, 2, and 3. These categories are:

00 – 29 Input statement processing, file header and general processing that is applicable to all pathways;

30 – 39 Upper air sounding processing (Stage 1);

40 – 49 Surface observation processing (Stage 1);

50 – 59 On-site observation processing (Stage 1);

60 – 69 Merge processing (Stage2);

70 – 89 Stage 3 processing

These codes only provide an indication of the processing (runstream or data) that was occurring. They cannot completely specify the reason for the message. Further explanation is left to the 80 character message.

D.1 Interpreting error messages

AERMET can generate many messages in a single run. This section discusses the interpretation of a few of the error messages.

Anyone who has written software knows that a single syntax error in the source code can generate several error messages when the program is compiled. AERMET also may generate several error messages for an error in a runstream. The following is an example of such a

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situation that could occur in defining the surface characteristics in Stage 3.

Runstream fragment for the METPREP pathway:

```
FREQ_SECT      ANNUAL      1
SECTOR               1     0     360
CHARS                1     1     0.250 0.750 0.006
```

The message file would contain something like:

```
18 METPREP    E03  SETUP  : KEYWORD UNKNOWN:                CHARS
   JOB        I19  SETUP  : "END OF FILE" ON UNIT  5 AFTER RECORD #  20
   METPREP    E99  MPFIN  : SITE_CHAR inputs missing for MONTH index  1 and SECT index  1!
   METPREP    E99  MPFIN  : SITE_CHAR inputs missing for MONTH index  2 and SECT index  1!
   METPREP    E99  MPFIN  : SITE_CHAR inputs missing for MONTH index  3 and SECT index  1!
   METPREP    E99  MPFIN  : SITE_CHAR inputs missing for MONTH index  4 and SECT index  1!
   METPREP    E99  MPFIN  : SITE_CHAR inputs missing for MONTH index  5 and SECT index  1!
   METPREP    E99  MPFIN  : SITE_CHAR inputs missing for MONTH index  6 and SECT index  1!
   METPREP    E99  MPFIN  : SITE_CHAR inputs missing for MONTH index  7 and SECT index  1!
   METPREP    E99  MPFIN  : SITE_CHAR inputs missing for MONTH index  8 and SECT index  1!
   METPREP    E99  MPFIN  : SITE_CHAR inputs missing for MONTH index  9 and SECT index  1!
   METPREP    E99  MPFIN  : SITE_CHAR inputs missing for MONTH index 10 and SECT index  1!
   METPREP    E99  MPFIN  : SITE_CHAR inputs missing for MONTH index 11 and SECT index  1!
   METPREP    E99  MPFIN  : SITE_CHAR inputs missing for MONTH index 12 and SECT index  1!
   METPREP    E99  MPFIN  : Errors in SITE_CHAR Array; Number of missing values
                            (< 0.0) = 12
```

In the example above, the correct keyword, SITE_CHAR, was not used to define the surface characteristics. CHARS was used instead. As AERMET processes the runstream, it checks to make sure that each record conforms to all the rules of syntax which include the use of valid keywords. The first message above indicates that an unknown keyword was encountered in the runstream (by subroutine SETUP) at record 18. Once the runstream is processed, as noted by the "END OF FILE" message, AERMET then checks to ensure all the required information to process the data was included in the runstream. During this portion of the setup processing AERMET may detect additional problems such as missing keywords that are required or other information that is required based on the options specified or the existence of other keywords in the runstream. Based on the FREQ_SECT keyword in the example above, AERMET expected to find the SITE_CHAR keyword which should define the surface characteristic values for a single wind sector that covers all directions. Error messages were generated (messages 3 through 14), which indicate AERMET did not find a valid SITE_CHAR keyword. The final message indicates that there are values missing in the SITE_CHAR array, since none were specified in the runstream with a valid keyword.

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One might argue that the number of error messages is excessive for such a minimal configuration for the surface characteristics. Remember that there can be up to 12 SECTOR keywords and 144 SITE_CHAR keywords, so AERMET provides the user with additional information to assist in identifying the exact location of the problem.

Another error that causes multiple error messages occurs when a pathway is misspelled. Depending on the location in the runstream, AERMET reports it as an unknown pathway/keyword (the syntax and structure of the runstream makes it impossible to determine which). Since the pathway is not correctly defined, the keywords that follow it would be reported as invalid for the previous pathway.

Another error that a user could introduce is a misspelling of an input data file name. AERMET opens and processes file headers, if any, before processing any data. If a nonexistent file is opened, the file is created and is 0 bytes long. If there is critical information that is to be reprocessed from the header records of the correctly spelled file, then AERMET will not find that information in the incorrectly spelled file and report an error. Unfortunately, the message resulting from such an error is misleading. There is no way to recognize a 'zero-length' file using ANSI-standard Fortran at the point AERMET checks for sufficient information to process the data. For example, in merging data, if the input file name for the site-specific data (specified on the keyword QAOUT) is misspelled, then AERMET creates the (misspelled) file, reads from the file (and immediately encounters an end of file), and reports that there are no READ/FORMAT keywords to define the data structure.

Most error messages are reasonably straightforward to interpret. However, from these few examples, one can see that it may take a little more than a casual glance at the message file if AERMET detects any errors during setup.

In the discussion of the error messages, the term 'decode' (or a variant) is used. In Fortran, this term means that the program is translating data and transferring data between variables in internal storage rather than transferring data from an external file to variables. The term 'internal read' may also be seen in this context.

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D.2 Runstream and file header processing, 00 – 29

Any messages that pertain to the setup of a run are included in this category.

ERRORS

E00 Reserved - this code is used to report internal programming errors.

E01 AERMET was not able to read a record in the runstream.

E02 Error defining the pathway - the conditions that may result in this error are:

1) Subr.FDPATH, in a call to subr.GETWRD, was not able to determine the pathway for the runstream record number indicated;

2) Invalid pathway for the stage of processing;

3) Duplicate pathway specified.

The message identifies which condition was encountered.

E03 Error defining a keyword - the conditions that may result in this error are:

1) The keyword did not match any of the keywords recognized by AERMET. This error is independent of pathway;

2) The keyword is not valid for the pathway;

3) The keyword was duplicated for the pathway; only selected keywords are repeatable.

The message identifies which condition was encountered. See the tables in Appendix A for the list of keywords by pathway.

E04 Incomplete or superfluous information for a keyword. See the tables in Appendix A for

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the syntax of the keyword.

E05 This may indicate an invalid combination of processing options or problems with the merge file headers.

E06 The parameter associated with a keyword is in error. This error can be generated for multiple reasons. For example, if AERMET could not match a variable name on a keyword with the list of valid variable names, then this error code is used. Also, if AERMET has a 'decoding' error, then this code is used. A parameter on a keyword statement is not within bounds, is not known, or does not match any of the valid secondary keywords or parameters for this keyword.

E07 An error occurred in subroutine GETWRD or an error condition was returned to the calling routine. This subroutine retrieves the value of a field, whether it be a pathway, keyword, or parameter field, for additional processing.

E08 Error opening a file or the file name was previously specified for another file that is already open.

E12 Processing cannot be completed because a required keyword statement for the specified block is either missing or in error.

E15 A problem was encountered with the site-specific surface characteristics defined in Stage 3. Possible errors include that the keywords were not specified in the correct order, or that surface characteristics for the secondary location are missing with the SUBNWS option (beginning with version 11059). While most keywords can appear in any order for a pathway, the surface characteristics must appear in a particular order. See Section 4.7.8 for a discussion of the keywords.

E19 The chronological day was not computed correctly from the year, month and day (in SUBR.CHROND); or the year, month and day was not computed correctly from the chronological day (in SUBR.ICHRND).

E20 Error reading a header record from a file (including temporary files). This error could occur while reading through the header records of a file in an attempt to locate the first data record.

E21 Error writing a header record to a file.

E22 End of file encountered reading and existing file's header records. This condition indicates that there are no data to process.

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E23 Error re-reading an existing file's header records written that had been written to an output file.

E24 Error conditions were detected for the JOB pathway; this message is issued during the final check after the setup processing.

E25 Error conditions were detected for the UPPERAIR pathway; this message is issued during the final check after the setup processing.

E26 Error conditions were detected for the SURFACE pathway; this message is issued during the final check after the setup processing.

E27 Error conditions were detected for the ONSITE pathway; this message is issued during the final check after the setup processing.

E28 Error conditions were detected for the MERGE pathway; this message is issued during the final check after the setup processing.

E29 Error conditions were detected for the METPREP pathway; this message is issued during the final check after the setup processing.

WARNINGS

W02 The input runstream record exceeds the maximum number of characters of 132. This may result in errors processing the runstream file. The message also includes a portion of the information beyond column 132, out to column 500.

W03 Beginning with version 11059, the LOCATION keyword is no longer valid on the METPREP pathway in Stage 3, and the information on the METPREP LOCATION keyword will be ignored. The location used for determining sunrise for convective mixing height calculations is the primary surface station location in Stage 1, i.e., the ONSITE location if available, otherwise the SURFACE location.

W04 Too many fields are included on the DATA keyword. Beginning with version 11059 some fields on the DATA keyword are no longer supported. This also applies to the station elevation on the DATA keyword for UPPERAIR data.

W06 Value on an input statement may be unreasonable, but processing continues with this value.

W15 Two sets of surface characteristics specified when only one set is needed. The secondary

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set will be ignored.

W19 The specified ONSITE data variable is currently not used by AERMET.

W20 Auditing a variable for QA is disabled for the ONSITE variable specified. The variable appeared on an AUDIT keyword statement but did not appear with any READ keywords.

W21 OSHEIGHTS keyword and HTnn height variables are both defined for ONSITE data. The OSHEIGHTS keyword will be used to define measurement heights and the HTnn variables will be ignored.

W22 The OSMN variable for ONSITE observation minute is specified on the READ keyword, but OBS/HOUR = 1. The OSMN variable will be ignored.

INFORMATIONAL

I19 End of file encountered on the input runstream file.

I25 No data are to be extracted, QA'd, or merged for UPPERAIR pathway.

I26 No data are to be extracted, QA'd, or merged for SURFACE pathway.

I27 No data are to be QA'd or merged for ONSITE pathway.

D.3 Upper air processing, 30 – 39

Any messages that pertain to the UPPERAIR pathway and issued after the input statements are processed are in this category. A word of caution: if a problem requires examining the unprocessed TD-6201 (archive) data, be very careful if you edit the file with a text editor. Some editors could potentially modify the structure, rendering the file unreadable by AERMET. A better option would be to use a file viewer that cannot alter a file.

ERRORS

E30 An error occurred computing the chronological day number.

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E31 No soundings were extracted and there were no errors that did not allow AERMET to extract any of the soundings specified in the runstream. Compare the station ID and the dates in the runstream to the station and dates in the input data file.

E32 An error occurred reading a block of data. A block of data contains all or part of a single sounding. Depending on the data structure of the archive data (fixed- or variable-length block), there can be up to 2876 characters in one block of data. An error reading a block is considered severe enough to stop processing the upper air data since the nature of the error cannot be ascertained very easily. The user will have to carefully examine the data to determine the cause of the error.

E33 An error was encountered decoding the portion of the block that contains the station identifier and date group, or an error occurred decoding a level of data in the sounding. In the former case, AERMET will stop processing the upper air data. In the latter case, AERMET will allow up to five such errors decoding sounding levels before processing of upper air data ceases. If AERMET cannot decode a sounding level, then it continues to the next level.

E34 The first character of the station ID is blank in the archive data file, indicating that the entire field likely is blank in the file. In the archive file, the station ID is supposed to fill the entire 8-character field, with leading 0's to fill out the field if the ID is shorter than eight characters. Either the process of reading the data is no longer synchronized with the data, or the station ID field is not what AERMET expects.

E35 At least one sounding was extracted, but error(s) occurred that did not allow AERMET to finish extracting all the soundings specified in the runstream.

E36 No soundings were extracted and error(s) occurred that did not allow AERMET to extract any of the soundings specified in the runstream.

E38 An error occurred while reading a sounding during the QA process. The data in the input file for QA should already be in a standard AERMET format (see Appendix C), but AERMET was unable to read the data from the file. Since AERMET reads and writes one sounding at a time, check the output file to see where the error occurred (the sounding after the last one in the file being written by the QA process).

WARNINGS

W33 Error decoding a level of data, but the maximum number of errors allowed (five) has not been exceeded.

W34 Surface elevation (elevation of the first sounding level) is missing or less than zero. The

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sounding levels in the archive file are reported as height above mean sea level. AERMET adjusts all soundings to be referenced relative to the local elevation rather than sea level. If AERMET cannot determine the surface elevation because it is missing (or below mean sea level), then this message is issued. Once the surface elevation is determined, that elevation is used to adjust all subsequent soundings.

W35 The process of decoding the levels of data in a sounding failed at the first level. It is likely that only a header record is present in the output file from the extract process. The user will have to examine the input data more closely to determine the cause of the problem.

W36 The first level of FSL upper air data is not the correct type and was skipped.

INFORMATIONAL AND QA

I30 Beginning UPPERAIR data processing.

I31 Data modifications for upper air soundings is enabled. See Section 5.5 for a discussion of these modifications.

I32 With the data modifications enabled, a level of data was deleted or modified from a sounding.

I39 End of file was encountered on the input file.

Q34 A vertical gradient cannot be computed at because at least one of the heights are missing.

Q35 The difference between the reported height and recomputed height exceeds 50 meters.

Q36 The heights have not been recomputed due to missing data.

Q37 A lower bound quality assessment violation for the variable indicated.

Q38 An upper bound quality assessment violation for the variable indicated.

Q39 The data value for this period and variable is missing.

ED_001739_00002136-00285

D.4 Surface observations processing, 40 – 49

Any messages that pertain to the SURFACE pathway and issued after the input statements are processed are in this category.

ERRORS

E40 An error occurred computing the chronological day number.

E41 An end of file was encountered in the input file and no hourly observations were extracted. Compare the station ID and dates in the runstream to the station and dates in the input file to determine if there is a mismatch.

E42 The maximum number of errors allowed reading a block of data from the archive data file has been exceeded. The limit is five errors.

E43 An internal read (decode) failed while trying to resolve the station ID or date group in the archive input data.

E44 The first character of the station ID is blank in the archive data file, indicating that the entire field likely is blank. Check the input file and make sure the file structure conforms to the format specified on the DATA card (e.g., if CD144 is specified on the DATA keyword, then the format of the file is the 80-character per observation format).

E45 No data fields useful to AERMET were defined when data were retrieved from the SAMSON CD. AERMET expects that the data the user retrieved from the SAMSON CD contains information that is required to calculate boundary layer parameters. This message is issued during the setup phase of the processing.

E46 An error occurred converting the variable ID number in a SAMSON input file from a string to an integer. The second record of the data retrieved from the SAMSON CD contains a list of integers that correspond to the weather variables that appear in the file. The integers range from 1 through 21. Without a correct interpretation of these integers, AERMET cannot process the data.

E47 The station ID in the SAMSON file does not match the station ID on the LOCATION keyword. See also E41; since the SAMSON data are processed slightly differently than the CD144 and SCRAM formats, a separate message is issued when no data are retrieved.

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E48 An error was encountered while reading the hourly observation from the QA input file. Since AERMET reads and writes one observation at a time, check the output file to see where the error occurred (the observation after the last one in the file being written by the QA process).

WARNINGS

W40 SURFACE data is outside the valid range of dates for the specified data format, and cloud cover will be set to missing for ASOS records.

W41 Cloud cover set to missing for ASOS observations from reformatted SURFACE file format outside the valid date range for the format, for SAMSON and SCRAM data.

W42 Error reading/decoding the hourly observations, but the maximum number of errors allowed was not exceeded.

W43 An error occurred decoding an overpunch character - the missing value code for that variable will be substituted in the output file. See Section 4.3.1.1 for a discussion on overpunches. The number of the overpunch is reported (there are 35 overpunches possible, but AERMET does not examine all of them), and the table in Section 4.3.1.1 can be used to identify the position in the record that caused the error.

W44 A problem occurred with extracting SURFACE data in the HUSWO format.

W45 AERMET has encountered a second set of SAMSON header records (the records beginning with the tilde (~)). These header records are not processed and the extraction of hourly surface observations stops.

W46 Various messages related to SURFACE station elevations, whether specified by the user or included in the SURFACE data file.

W47 Various messages related to consistency checks between SURFACE station ID specified by the user and station ID included in the SURFACE data file.

W48 Various messages associated with ISHD data.

W49 Various messages regarding the processing of the ASOS commissioning date and the ASOS data flags.

INFORMATIONAL AND QA

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I40 Processing of the SURFACE data can begin.

I41 Cloud cover set to missing for ASOS observations from reformatted SURFACE file format outside the valid date range for the format, for SAMSON and SCRAM data; first 24 occurrences are issued as warnings (W41).

I45 Message related to precipitation accumulation for SAMSON data.

I47 The SAMSON data identified with this message were modeled rather than observed when the data were imprinted on the CD.

I48 Report number of records extracted.

I49 End of file was encountered on the input file.

Q47 A lower bound quality assessment violation for the variable indicated.

Q48 An upper bound quality assessment violation for the variable indicated.

Q49 The data value for this period and variable is missing.

D.5 On site data processing, 50 – 59

Any messages that pertain to the ONSITE pathway and issued after the input statements are processed are in this category.

ERRORS

E50 Error reading an input file header.

E51 Error reading input file header record. This message would occur only if a file is QA'd more than once since there isn't an extract process for site-specific data and there usually aren't any headers in the site-specific data file prior to the first time the data are QA'd.

E52 The maximum number of errors allowed reading/decoding the input data has been exceeded. The limit is five errors.

E53 Error writing data to the output file defined on the QAOUT keyword statement.

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E54 The observations are not sequential in time.

E55 The number of observations exceeds the number expected for the hour (by default, 1 or the value specified on the OBS/HOUR keyword statement).

E56 End of file on the input data was encountered before a complete observation (block of records) was read.

E57 A duplicated observation period was found in the ONSITE data.

E59 A gap of more than 1 year was found in the ONSITE data.

WARNINGS

W50 The measurement heights for ONSITE data vary within the data period processed.

W51 No station elevation specified on the ONSITE LOCATION keyword. Users are encouraged to specify station elevation for use in substitution hierarchy for missing station pressure.

W52 Various messages related to reading ONSITE date records.

W55 Total ONSITE precipitation is based on less than the half the number of values for subhourly data.

W59 A data gap occurred within the ONSITE data file.

INFORMATIONAL

I55 The number of subhourly ONSITE values is less than the minimum to calculate an hourly average.

I59 An end of file was encountered on the input file.

Q57 A lower bound quality assessment violation for the variable specified (for more than one observation per hour, this check is made after the subhourly values have been averaged).

Q58 An upper bound quality assessment violation for the variable specified (for more than one observation per hour, this check is made after the subhourly values have been averaged).

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Q59 The data value for this variable and observation period is missing.

D.6 Merge processing, 60 – 69

Any messages pertaining to merging the three data types and issued after the input statements are processed are in this category.

ERRORS

E60 Error computing the chronological day from Julian day and year.

E61 Error computing the Julian day and year from the chronological day.

E62 Error reading the UPPERAIR data.

E63 Error reading the SURFACE data.

E64 Error reading the ONSITE data.

E65 Error writing the ONSITE QA'd data to the OUTPUT file.

E66 Error processing an input file's headers.

E67 No data to merge - either the merge program or the setup have determined that there are no data to merge. AERMET will 'merge' data even if there is only one type of data (upper air, surface, or site-specific), but since no data are available to merge processing will aborted.

E68 The ASOS flag is missing or invalid in the SURFACE QAOUT file. This could indicate that the QAOUT file is from an old version of AERMET, prior to version 11059 when the ASOS flag was added to the QAOUT file.

WARNINGS

W66 Various messages regarding the use of 1-minute ASOS wind data.

W69 Message regarding non-standard MERGE, e.g., UA and OS data only, or SF and OS data only.

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INFORMATIONAL

I66 The WBAN for the 1-minute ASOS wind data matches the WBAN for the SURFACE data.

I67 No XDATES statement ! the beginning chronological day was computed as the earliest available date on the three pathways, and the ending chronological day was computed as the beginning day + 367. Without an XDATES keyword, AERMET has no knowledge of what data are in the input file(s), therefore, the zeroes are displayed in the report file for the dates to merge.

D.7 Stage 3 processing, 70 – 89

Any messages that pertain to Stage 3 processing and issued after the input statements are processed are in this category.

ERRORS

E70 Error reading the master header from the merged data file for the Julian day shown. In the merged data file, there is a master header that precedes the data for each 24-hour block of data. AERMET was unable to read this record.

E71 There was an end-of file or error encountered reading the merged upper air data.

E72 There was an end-of file or error encountered reading the merged hourly surface observations.

E73 There was an end-of file or error encountered reading the merged site-specific data.

E74 The data are not on a 1-to-24 hour clock. This message can appear for surface or site-specific data. Although the program to merge the data should write the data on a 1-to-24 hour clock, there appears to be an hour outside this window, possibly an hour labeled 0.

E75 There was an error converting the latitude and longitude in the runstream file from character to numeric.

E76 The hour in the merged data is defined as missing. For an unknown reason, the value for the hour was set to -9 in the merged data file.

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E77 Bad wind sector specified (this is a second check on the wind direction sector).

E78 Upper air station location is blank.

E79 Error occurred assigning met variables in SUBST for hour.

E80 Input data are incomplete, either no UA data and no OS mixing heights, or no SURFACE data and no ONSITE data.

E81 ASOS flag is invalid, check the MERGED data.

E89 Error assigning location for Stage 3 based on SURFACE location or ONSITE location, could indicate a programming flaw.

E90 Error getting surface roughness; could indicate a programming flaw.

E91 Missing sky cover in subroutine NETRAD; could indicate a programming flaw.

WARNINGS

W70 The LST to GMT conversion appears to be incorrect. Based on the longitude provided, the (elementary) computation of the time zone does not agree with the conversion parameter (tadjust) on the LOCATION keyword.

W72 The upper air sounding cannot be extended because

- the maximum number of levels are in the sounding;
- the top of the sounding is too low (< 600 meters);
- could not identify two levels with which to calculate the potential temperature gradient required to extend the sounding.

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W73 Convective boundary layer parameters not computed because

- no upper air data, especially the 12Z sounding, reported on this day
- other data required for the computation of the daytime planetary boundary layer height are missing.

W76 A minimum value of 0.001 m/s has been assigned to w*, since it was calculated to be less than 0.001.

W78 Calculated value for density is out of range (relative to lower and upper bounds specified at the point this check is made).

W79 Site-specific mixing heights are in the data base, but are missing for the hour; AERMET will calculate the mixing height.

W81 The reference wind speed from the NWS data are above the threshold wind speed but less than $2^{1/2} * \sigma_{v,min}$ (where $\sigma_{v,min} = 0.2$ m s^{-1}). This condition is not likely to occur unless 1-minute ASOS wind data are used, since the minimum wind speed routinely reported by NWS is 3 knots (about 1.5 m s^{-1}), excluding calm winds.

W82 The default pressure of 1013.25 mb is being used since there were no site-specific or NWS pressure reported.

W83 Anemometer height from ASOS list differs from user-specified height.

W86 Delta-T height range may not be appropriate for BULKRN method.

W98 The data period for 1-minute ASOS wind data predates 2000, the earliest data period available for 1-minute ASOS data.

INFORMATIONAL

I70 Hour 23 data was swapped in for hour 24 data for NWS surface data.

I71 Cloud clover is missing for a nighttime hour or both cloud cover (NWS) and net radiation (site-specific) are missing for a daytime hour, prohibiting calculation of all boundary layer parameters in AERMET.

I77 Net radiation is negative during a daytime hour or positive during the nighttime (relative to sunrise and sunset).

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I78 Sky cover is missing for a stable hour, no SBL estimates are calculated.

I79 The end of the processing window, defined by the XDATES statement for the METPREP block, was encountered or, if no window was specified, the end of file was encountered.

I80 The conditions that produce this message are:

1) The reference wind speed from the site-specific data are above the threshold wind speed but less than $2^{1/2} * \sigma_{v,min}$ (where $\sigma_{v,min} = 0.2$ m s^{-1}), or

2) The reference wind speed height is above $7z_0$ but below $20z_0$, where z_0 is the surface roughness length. See the Site-specific Meteorological Program Guidance (EPA, 1987) for additional discussion on specifying the height to use in calculating boundary layer parameters.

I81 In defining the reference wind speed, there were no site-specific winds that met the criteria and 1-minute ASOS or standard NWS winds were used for the reference wind speed.

I82 In defining the reference temperature, there was no site-specific temperature that met the criteria and NWS temperature was used for the reference wind speed.

I83 In defining the station pressure, there was no site-specific pressure and NWS winds were used for the reference wind speed. This message is seen only if the user indicates that there is pressure in the data base.

I85 Only the ONSITE reference temperature will be used, rather than the full profile of ONSITE temperatures, because the reference ONSITE wind is missing.

I86 BULKRN option for delta-T was not used due to missing ONSITE wind data.

I87 The reference wind speed is missing for the specified hour.

I88 The external file of surface characteristics for the AERSURF or AERSURF2 keyword was successfully opened.

I98 The data period for 1-minute ASOS wind data predates 2000, the earliest data period available for 1-minute ASOS data; the first 24 occurrences are issued as warnings (W98).

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Appendix E. Processing NWS data from magnetic tape

Extracting data from magnetic tape as it pertains to the AERMET command language is discussed in this appendix. This discussion is primarily for users who run AERMET on computer platforms that can access magnetic tape drives, such as Digital Equipment Corporation's VAX computers. There is no attempt to describe the system control language required to mount tapes and assign file names. The user is directed to the appropriate system user's manuals for such information.

The only data that is considered here is the National Weather Service data; no attempt is made to read site-specific data directly from magnetic tape. When running AERMET on a computer that can access a magnetic tape drive, the user only needs to be aware of a few changes and additions to the AERMET command language. These modifications have to do with the DATA keyword for the SURFACE and UPPERAIR pathways.

E.1 SURFACE pathway

Recall the syntax of the keyword statement:

Syntax:	DATA *archive_filename file_format factor* [*type*]
Type:	Mandatory (Stage 1), Nonrepeatable

where the *archive_filename* is the name of the file and must conform to the naming conventions appropriate to the computing platform. The maximum length of the *archive_filename* is 48 characters. For processing data from tape, the *archive_filename* is the "name" of the tape, however that name is specified or defined for the computing platform. For example, the name of the tape on a VAX is defined in the system control language that is used to mount the tape on the tape drive.

An additional data format is accessible when working with magnetic tapes. AERMET can process the TD-3280 format available from NCDC. This format is an element-based format in which the data for an entire day is reported one element (weather variable) at a time. To

process NWS hourly surface observations in this format, the parameter 3280VB or 3280FB is specified for the *file_format*. The suffixes VB and FB refer to **v**ariable-length and **f**ixed-length **b**lock records, respectively. For variable-length data, each logical record contains one station's hourly data values for one meteorological element (weather variable) for as many hourly values as occur in the day. For fixed-length data, each logical record contains one station's hourly data values for on meteorological element for 24 hourly values representing one full day of observations. Specification of this suffix depends on how the data were ordered from NCDC. The data are archived at NCDC in the variable-length format and usually supplied to the user in that format, but the user can request NCDC to supply the data in the fixed-length format.

In addition to the TD-3280 format, AERMET can process the CD-144 data discussed in Section 2.0 and Section 3.0 if it is received on magnetic tape. The *file_format* for this data format is CD144FB, just as if the data are on disk, where the FB indicates that there is a fixed number of characters per logical record. There is no variable-length block option for the CD-144 data format.

The parameter *factor* defines the number of logical records per physical record (or blocking factor), i.e., the number of logical records to process before reading from the tape again. The specification of this factor depends, in part, on the data request submitted to the NCDC. For the TD-3280 format, this factor is 1. For the CD-144 data format, this factor is usually 10. One logical record contains one hour of surface meteorological observations; therefore, a *factor* of 10 indicates that there are 10 logical records, or 10 hours of data, per physical record. If data on tape from NCDC are used, the blocking factor for the particular data format must be specified correctly for AERMET to properly extract the data from magnetic tape. Otherwise, an error reading the physical record may occur (for a factor that is too large) or there will be skips in the data record (for a factor that is too small).

The *type* refers to whether the data on the tape are ASCII or EBCDIC. The default for this field is ASCII. In this version of AERMET, EBCDIC is not functional; therefore, processing data on an IBM mainframe is not an option.

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E.2 UPPERAIR Pathway

The syntax for the DATA keyword statement for the UPPERAIR pathway is the same as shown above for the SURFACE pathway. The discussion for the *archive_filename* on the SURFACE pathway applies here as well.

The only upper air data format that AERMET currently processes, whether the data are on diskette or magnetic tape, is the TD-6201 data series. For data on magnetic tape, the data are usually ordered from NCDC as **v**ariable-length **b**locks. To process NWS twice-daily soundings in this format, the *file_format* is specified as 6201VB. Each logical record in the variable-length format contains the upper air observations from one station. Like the TD-3280 format, the user can request that the upper air data be supplied in the fixed-length format, in which case the file format is specified as 6201FB, just as for data on diskette.

For the upper air data, the *factor* defines the number of logical records (soundings) per physical record. As with the SURFACE pathway, this value specifies the number of logical records to process before reading from the tape again. The specification of this factor depends, in part, on the data request submitted to the NCDC.

As for the SURFACE pathway, the *type* refers to whether the data on the tape are ASCII or EBCDIC. The default for this field is ASCII. In this version of AERMET, EBCDIC is not functional; therefore, processing data on an IBM mainframe is not an option.

E.3 Data on diskette and tape

There may be occasions when the surface and site-specific data are on a personal computer, but the upper air data are on magnetic tape on a mainframe. There are three options to unite these three data types.

One option is to upload the AERMET source code to the second computing platform to process the upper air data. However, there is some PC-specific code that would require modification. The code has to do with the system date and time and opening files. The user

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should consult the appropriate user's manual on what changes or additions to make for the specific computing platform. Once the AERMET system is operational, the upper air data can be processed from tape and then downloaded to the user's personal computer where the remaining processing can be performed.

A second option involves the same operation as above - uploading the AERMET source code - as well as uploading the surface and site-specific data and processing all the data on the second computing platform.

The third option is the reverse of the first two options - download the upper air data to the personal computer. The first step is to copy the data from the magnetic tape to a file on the second computing platform's mass storage without changing the structure of the data. This file of data can then be downloaded to the user's personal computer. However, the size of the file may be a limitation. The user should first determine how much space is required on a personal computer to store the file before downloading it. Some judicious and very careful editing to remove unnecessary records may be necessary on the second computing platform before downloading. Once on the user's personal computer, the file can be processed just as if the data resided on magnetic tape because the structure of the data has not changed. If the user keeps in mind that the structure is the same whether it is "strung out" on a tape or on a disk file, then there should be no problem processing as if it is on tape. If the user did something to change the structure during the copy process, editing process (if that became necessary) or download process, AERMET may not be able to extract any data.

There is not be a preferred option, and there may be other viable options that have not been explored. The user should choose whichever option is easiest to implement.

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Appendix F. AERMET enhancements

In this appendix, possible enhancements to the AERMET meteorological preprocessor are discussed. These enhancements include the use of the afternoon sounding to adjust the daytime mixing height estimates, an objective scheme to estimate the Bowen ratio, incorporating the effects of anthropogenic heat flux, and estimates of the urban mixing height.

F.1 Daytime mixing height adjustments

The mixing height computation currently in AERMET uses the morning (12Z) sounding and the accumulated sensible heat flux to determine the growth of the convective boundary layer. However, changes in the atmospheric sounding during the daytime hours are not accounted for by this scheme. Half of all of the routine soundings now taken are ignored (i.e., the 00Z soundings). Mixing height predictions in the afternoon would be improved by using the 00Z soundings (in the United States) to adjust the computation of this height based upon the morning sounding.

To implement such an enhancement, it is necessary to devise an objective algorithm to find the height of an elevated inversion in the 00Z sounding. This algorithm should ignore any shallow surface-based inversion that could have recently formed if the sounding is taken near or after the hour of sunset. A search is performed for a height interval over which the potential temperature gradient exceeds a user-specified gradient. The height interval examined should probably span at least three sounding points so that a bad data point does not lead to a false detection of the elevated inversion. A preliminary suggestion for the height interval is 200 meters. The potential temperature gradient that corresponds to an elevated inversion would be expected to be at least as stable as isothermal.

Given that an estimate of the afternoon mixed layer height is available, AERMET would then adjust the estimates obtained from the morning sounding and hourly sensible heat flux estimates. If no determination of the afternoon mixing height from the 00Z sounding can be made, then no adjustment would be made to the calculated values currently provided.

Otherwise, the afternoon maximum mixing height (at a time estimated to be at a point 75% of the way between sunrise and sunset) would be assigned to the value obtained from the 00Z sounding, and this value would be persisted until sunset. The adjustment of the mixing heights before the time of the afternoon maximum would then be done linearly, with a zero adjustment at the time of the first upward sensible heat flux in the morning, up to the required adjustment at the time of the afternoon maximum to be consistent with the 00Z sounding. The adjustment would be limited to a factor of two.

F.2 An objective determination of the Bowen ratio

In this version of AERMET, the user specifies a monthly daytime Bowen ratio, chosen from one of three possible values representing the wet and dry extremes, or a typically normal moisture value. These values are a function of the type of surface cover in the particular sector for that month (see Section 5.0 for a discussion of wind direction sectors). The "dry" Bowen ratio value represents a moisture deficit condition in which the vegetation is under stress. The "normal" Bowen ratio reflects a condition of average rainfall, with sufficient moisture supplied to the vegetative cover to support normal transpiration rates. The "wet" Bowen ratio condition is one of excessive moisture, leading to extra evaporation from surface wetness in addition to the normal transpiration rates. An assumption is made that in the long run, the loss of water to the atmosphere by evaporation is roughly equal to the precipitation gained, and that the appropriate vegetative cover to maintain this steady state is established. The values for the Bowen ratio are chosen for each month as a function of the type of vegetation and its maturity (e.g., leaves emerging in spring, full maturity in summer, or leaves dropping in autumn).

The specification of just one monthly value for the Bowen ratio results in poor temporal variation. The moisture availability can fluctuate significantly within the month. The revised algorithm described here assumes that AERMET is provided with the three moisture-dependent Bowen ratio values for each month, reflecting extremes from wet to dry. The revised method would select one of the values for each day as being the most appropriate.

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This new method for AERMET is based in concept on estimates of the daytime sensible heat flux from standard meteorological measurements made by Holtslag et al. (1980). These authors used a modified Priestly-Taylor (1972) model of the energy budget in which the moisture availability (or the daytime Bowen ratio) was empirically found to be a function of the rainfall in the previous 5 days at Cabauw in the Netherlands. This area features a grass cover of approximately 8 cm in length. In the case of little or no rainfall, evaporation rates were substantially reduced, with a correspondingly high Bowen ratio. During periods of normal rainfall, evaporation rates typical of normal transpiration condition were found.

For AERMET, a decision concerning the choice of a wet, dry, or normal Bowen ratio value is analogous to the choice of a moisture availability value by Holtslag et al. The decision for each day would be based upon the previous five days' precipitation total as compared to an average rainfall for the same five-day period. This average rainfall could be the 30-year average or other appropriate period. Similar to the METPRO (Paine, 1987) technique, a five-day rainfall amount that is at least twice the average will result in a "wet" designation. Rainfall less than half the average will result in a "dry" designation. Amounts of rainfall in between these extremes will earn a "normal" designation. For each day, a new running five-day total precipitation total and average would be computed. The Bowen ratio determined with this method will thus be subject to daily fluctuations. However, the Bowen ratio would be the same value for the entire daytime period for any given day.

The required input data to AERMET would consist of hourly precipitation data (as provided on the Solar and Meteorological Surface Observation Network (SAMSON) data, monthly average precipitation, and the three monthly Bowen ratio values (dry, normal, wet).

F.3 Urban effects

AERMET uses an energy balance formulation to determine 1) whether stable or unstable conditions are present, and 2) to quantitatively determine for unstable conditions the surface heat flux and other boundary layer values. A simple formula, appropriate for rural areas, is

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$$R_n = Q_h + Q_e + Q_g,$$

where

R_n is the net radiation,

Q_h is the sensible heat flux,

Q_e is the latent heat flux, and

Q_g is the soil heat flux.

To date, Q_g has been parameterized in AERMET as 0.1 R_n (after Holtslag and van Ulden, 1983) and Q_h and Q_e are determined from an estimate of the daytime Bowen Ratio (= Q_h/Q_e). The sign of the net radiation is used to determine the sign of the Monin-Obukhov length. This choice is important in AERMOD due to the selection of dispersion algorithms.

A more general expression for the energy balance accounts for anthropogenic heat flux (Q_a) as well as allowing G to be a variable fraction (c_g) of R_n:

$$R_n + Q_a = Q_h + Q_e + c_g R_n,$$

The flux of heat into the ground during the daytime will be parameterized as a fraction (range: 0 to 1.0) of the net radiation. Holtslag and van Ulden (1983) obtained a value of c_g of 0.1 for a grass covered surface in the Netherlands. Oke (1982) indicates that typical ranges for c_g are 0.05 to 0.25 in rural areas, 0.20 to 0.25 in suburban areas, and 0.25 to 0.30 in urban regions.

The anthropogenic heat flux can be neglected except in highly urbanized locations. Table F-1. Average Anthropogenic Heat Flux (Qa) and Net Radiation (Rn) for Several Urban Areas (from Oke, 1978), taken from Oke (1978), provides estimates for urban areas.

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Table F-1. Average Anthropogenic Heat Flux (Qa) and Net Radiation (Rn) for Several Urban Areas (from Oke, 1978)

Urban area/ latitude/period	Population (x 106)	Population density (persons/km2)	Per capita energy usage (MJx103/yr)	Qa (W/m2)	Rn (W/m2)
Manhattan (40°N)					
annual	1.7	28,810	128	117	93
summer				40	
winter				198	
Montreal (45°N)					
annual	1.1	14,102	221	99	52
summer				57	92
winter				153	13
Budapest (47°N)					
annual	1.3	11,500	118	43	46
summer				32	100
winter				51	-8
Sheffield (53°N)					
annual	0.5	10,420	58	19	56
West Berlin (52°N)					
annual	2.3	9,830	67	21	57
Vancouver (49°N)					
annual	0.6	5360	112	19	57
summer				15	107
winter				23	6
Hong Kong (22°N)					
annual	3.9	3,730	34	4	~11
Singapore (1°N)					
annual	2.1	3,700	25	3	~11
Los Angeles (34°N)					
annual	7.0	2,000	331	21	108
Fairbanks (64°N)					
annual	0.03	810	740	19	18

In addition to the anthropogenic heat flux, an accurate specification of the surface roughness length appropriate for cities would have the effect of increasing the Monin-Obukhov length to account for the near surface shear effects due to building obstacles. Representative values for various urban environments are shown in Table F-2.

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Table F-2. Surface Roughness Length for Urban Environments (from Stull, 1988)

Environment	Roughness length (meters)
Many trees and hedges, few buildings	0.2 - 0.5
Outskirts of towns	0.4
Center of small towns	0.6
Center of large towns and small cities	0.7 - 1.0
Center of large cities with tall buildings	1.0 - 3.0

F.4 Urban mixing heights

For urban areas, the additional heating due to anthropogenic sources creates a higher convective mixed layer during the day. This effect will be accommodated in a future version of AERMET by a higher sensible heat flux input to the modified Carson model. At night (when a negative net radiation is measured or parameterized), a well-mixed layer is observed near the surface over the built-up areas of cities of all sizes. This layer is caused by reduced upward radiation due to the presence of buildings, as well as the anthropogenic heat flux. The depth of the layer is observed to be on the order of 50-100 meters for small cities, 150-200 meters for moderately large cities, and 300-400 meters over large cities. These observations are consistent with a model proposed by Summers (1965):

where

H_a is the anthropogenic heat flux,

x is the upwind fetch length over the urban area, and

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$d\theta/dz$ is the vertical potential temperature gradient at the top of the mixed layer.

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In a future version of AERMET, H_a and x would be specified by the user as a function of month and (in the case of x) by direction sector. The value of $d\Theta/dz$ would be derived from the rural stable Θ_* value using boundary layer parameterizations.

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Appendix G. Overview of AERMET revisions

Several sets of AERMET revisions are included in this Addendum:

1. The first set of revisions, introduced with version 06341 of AERMET, includes modifications to address several problems associated with extraction and processing of National Weather Service (NWS), Federal Aviation Administration (FAA), or other airport data in the Integrated Surface Hourly Data (a.k.a., ISHD, ISH, ISD, TD-3505) format, including:

    a. corrections to the procedure for selecting which record to process for hours with multiple records;

    b. corrections to code for processing of sky cover fields;

    c. addition of code for identifying "variable" winds, introduced on July 1, 1996, with adoption of the METAR reporting standard, with valid wind speed but missing wind direction (formerly flagged as calms);

    d. code for initializing the "additional" character variable to avoid data fields from previous hours being used; and

    e. code for handling mixed-format ISHD data files with full and condensed archival formats (note that 'condensed' format refers to ISHD data without the location and elevation fields on each record, which is not the same as the 'abbreviated' format for ISHD data, which is not supported by AERMET).

    Version 06341 also introduced the inclusion of an optional station elevation parameter on the LOCATION keyword for the UPPERAIR, SURFACE, ONSITE, and METPREP pathways; and modifications to use a single executable file, AERMET.EXE, to perform all three stages of processing, replacing the STAGE1N2.EXE and STAGE3.EXE files (additional information is provided in Model Change Bulletin (MCB) #1 provided on the SCRAM AERMET webpage); and

2. The second set of revisions, introduced with version 11059 of AERMET (additional information is provided in Model Change Bulletin (MCB) #2 provided on the SCRAM AERMET webpage), includes:

    a. further enhancements to the use of user-specified station elevations for surface stations to substitute for missing station pressure;

    b. enhancements to increase the maximum record length for the runstream input file from 80 to 132 characters, increase the maximum field length for filenames from 48 to 96, and allow use of double quotes (") as field delimiters for filenames to support filenames with embedded spaces;

    c. enhancements to the selection of upper air sounding to support applications of AERMOD beyond the U.S., and including an option to select the most appropriate sounding based on local sunrise;

d. enhancement to allow the use of hourly averaged winds derived from 1-minute ASOS wind data (TD-6405);

e. adjustment of ASOS-based wind speeds (including winds derived from 1-minute ASOS data) to account for reported ASOS wind speeds being truncated (rather than rounded) to whole knots;

f. enhancements to the error handling and reporting related to processing ONSITE data, including an option to use 'FREE' format to read the data and the option to specify missing data codes and upper/lower bounds for ONSITE data as REAL variables;

g. an option/requirement to specify a secondary set of surface characteristics for use when NWS winds are substituted for missing on-site winds; and

h. enhancements to utilize on-site precipitation and relative humidity data, if available.

3. The third set of revisions, introduced with version 12345 of AERMET (additional information is provided in Model Change Bulletin (MCB) #3 provided on the SCRAM AERMET webpage), includes:

a. Modified subroutine DOCLDS to correct for errors that result when blank spaces occur between the cloud cover and ceiling height fields for HUSWO surface data. Also modified DOCLDS to no longer accept invalid ASOS cloud cover codes for HUSWO surface data. These bug fixes should not affect results for HUSWO surface data that were extracted from the HUSWO CD, but could affect results significantly for applications using surface data that were reformatted to the HUSWO format from another data format;

b. Modified subroutine CBLHT to correct an error in the calculation of the convective mixing height. Previous versions of AERMET may have underestimated convective mixing heights, and in turn the convective velocity scale (w*), due to this error. The magnitude of the errors would tend to be larger for cases where the vertical temperature profile based on the upper air sounding was based on fewer sounding levels. However, due to the widespread nature of these convective mixing height errors, AERMOD modeling results are likely to be affected to some degree by this AERMET bug fix in most cases. The magnitude and direction of changes in AERMOD model results due to this convective mixing height bug fix will vary depending on the resolution of the upper air data and the characteristics of the sources and terrain included in the AERMOD model application;

c. Modified subroutines CBLHT, MPPBL, MPMET, and SETUP to check for ONSITE mixing heights (OSMIX) in the determination of data completeness, and adjusted warning messages to account for possible presence of both ONSITE mixing heights and UPPERAIR data;

d. Added a new THRESH_1MIN keyword to Stage 3 processing. This optional

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keyword allows the user to specify a threshold wind speed below which winds reported in the 1-minute ASOS data processed through AERMINUTE, if in use, are considered calm. There is no default value; however, a warning message will be generated if the user-specified threshold is greater than 0.5 m/s, and a fatal error message will be generated if the user-specified threshold is less than zero or greater than 1.0;

e. Incorporated a new "BETA" option to adjust u* (ustar) for low wind speed stable conditions, based on Qian and Venkatram (2011). The new option is selected by including the METHOD STABLEBL ADJ_U* keyword on the METPREP pathway in the Stage 3 input file. The ADJ_U* "BETA" option is considered to be a non-Default option and is therefore subject to the alternative model provisions in Section 3.2 of Appendix W (40 CFR Part 51). Users should coordinate with the appropriate reviewing authority regarding the procedures and requirements for approval of this BETA option for regulatory modeling applications. Use of this option also requires the user to include the BETA option on the CO MODELOPT keyword in the AERMOD input file;

f. The value used to adjust ASOS wind speeds to account for bias due to wind speeds being truncated to whole knots was modified to include three significant digits (from 0.26 m/s to 0.257 m/s, based on 0.5 kt). This modification avoids potential for mischaracterization of calm vs. non-calm due to precision issues associated with the truncation adjustment under the new THRESH_1MIN option; and

g. Modified subroutine GETFSL to issue a non-fatal warning instead of a fatal error message when the UA station ID specified on the UA LOCATION keyword does not match the UA station ID in the data file. This change will accommodate substitutions for missing UA soundings using data from other representative UA stations, and will document when such substitutions were made in the Stage 1 report file. Since all convective hours will be missing on days when the UA sounding is missing, this will allow users to minimize the number of missing hours in the AERMET-processed surface file due to missing UA soundings, while maintaining a record of when such substitutions were made and identifying which alternative sites were used.

4. The fourth set of revisions, introduced with version 13350 of AERMET (additional information is provided in Model Change Bulletin (MCB) #4 provided on the SCRAM AERMET webpage), includes:

   a. Modified subroutine UCALST to incorporate AECOM's recommended corrections to theta-star under the ADJ_U* Beta option;

   b. Modified subroutine MPMET to correct assignment of time-zone adjustment (ZONE) to be based on the upper air time-zone (UALST) for cases where both upper-air data and ONSITE mixing heights are available;

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c. Modified subroutine SBLHT to correct the coefficient for the mechanical mixing height from 2300 to 2400 based on the original Venkatram reference (BLM, 2009);

d. Modified subroutine MPPBL to correct the initialization of the NO_SKY variable for missing on-site cloud cover to use the OSTSKY(2) value based on the missing data code input by the user, instead of a value of 99. This error could have resulted in on-site cloud cover being flagged as missing inappropriately in previous versions;

e. Modified subroutine O3NEXT to remove the conversion of delta-T values to lapse rate values (delta-T/delta-z) before calling subroutine REALQA, which compares the value to upper and lower bounds based on delta-T values. This could have resulted in a large number of spurious QA warnings for delta-T values out-of-range;

f. Modified subroutine RDISHD to correct the processing of ASOS cloud cover data based on the GA1-GA6 codes to avoid inadvertently assigning a missing code to the ASKY variable. Also modified subroutine RDISHD to move the check for hour 0 (zero) later in the processing in order to avoid using a "special" ISHD observation that occurs on the hour instead of a "non-special" observation that occurs earlier;

g. Modified subroutine MPFIN to include additional error checking and reporting regarding the completeness of the surface characteristics arrays. Errors in processing user- specified surface characteristics (i.e., not generated by AERSURFACE) may have occurred in previous versions;

h. Modified several subroutines to allow the use of on-site mixing heights only (OSMIX), without requiring upper air data. In these cases, the LOCATION keyword on the METPREP pathway should be used to specify the time zone adjustment from local time to GMT, since the time zone specified on the ONSITE pathway is likely to be for local time. Otherwise, AERMET would assume GMT as local time and results would be incorrect (unless local time actually was GMT);

i. Modified subroutine MPPBL to correct the error message associated with missing station pressure (FORMAT 1022) which was also used for missing sky cover data. A new FORMAT statement (1021) was added for use with missing station pressure. Also removed several FORMAT statements in MPPBL that were not used.

j. Modified subroutine BULKRI to incorporate a modified Bulk Richardson Number approach under the ADJ_U* Beta option, based on Luhar and Rayner (2009). As with the ADJ_U* Beta option incorporated in UCALST for applications which do not employ the BULKRN option, this method is considered a non-DFAULT option requiring approval as an alternative model for use in regulatory applications.

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k. Modified subroutines MPPBL, SUBST, VRCARD, and MPTEST to include substitutions for missing cloud cover data and/or missing ambient temperature by interpolating across 1 or 2-hour gaps in the input data. New subroutines (GETCCVR and GETTEMP) were also created to facilitate this enhancement. The default option is for AERMET to apply the substitution for both missing cloud cover and temperature, unless the user has specified both SURFACE and ONSITE data. New options have been added to the METHOD keyword on Stage 3 that allow the user to disable the cloud cover and/or temperature substitution(s) in cases where only SURFACE or ONSITE data are available, or to activate the options in cases where both SURFACE and ONSITE data are available. Subroutines MPMET and MPOUT were also modified to include appropriate flags in the surface output file indicating when these options have been utilized.

5. The fifth set of revisions, introduced with version 14136 of AERMET (additional information is provided in Model Change Bulletin (MCB) #5 provided on the SCRAM AERMET webpage), includes:

a. Modified subroutines SUBST and MPPBL to correct potential issues associated with the options introduced in version 13350 to substitute for missing cloud cover (CCVR) and/or temperature (TEMP) by linear interpolation across 1 or 2-hour gaps. This included an error that may have resulted in substituted CCVR values larger than 10 based on in and which may have resulted in NaN ("not a number") for some calculated variables; Issues with CCVR substitutions may also have occurred for applications using ONSITE meteorological data only, with ONSITE net radiation (NRAD) or with solar radiation (INSO) and delta-T (DT01) data using the Bulk Richardson Number (BULKRN) option. In these cases AERMET calculates equivalent cloud cover values that are included in the surface output file, but no substitutions for missing values should be included;

b. Modified subroutine SUBST to remove the initialization of the GOT_OSTMP logical variable to .FALSE. for the current hour. The GOT_OSTMP variable is assigned a value in subroutine GETTEMP prior to the call to subroutine SUBST. This error may have affected calculations of station pressure and relative humidity for applications with ONSITE data, including relative humidity values greater than 100 for applications with both SURFACE and ONSITE data;

c. Modified subroutine GETTEMP to reinitialize the LTZMAX4T variable to .TRUE. within the hour loop, indicating that the maximum height for ONSITE temperature had not been reached yet. The ONSITE temperature may have been incorrectly interpreted as being missing in version 13350 for some cases;

d. Modified subroutines GETTEMP and SUBST to ensure that substitutions for missing ONSITE temperature data are only based on values from the

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same measurement level if multiple levels of temperature are available.

e. Modified subroutine MPPBL to address issues associated with the selection of the appropriate upper air sounding time. This includes use the INT function instead of NINT when assigning 'MyZone' to determine the reference sounding time based on the longitude of the location for the default option. Subroutine MPPBL was also modified to use an integer variable (ICHRND_UASRISE) instead of a real variable (CHRND_UASRISE) for assigning the 'START_WINDOW' when the UASELECT SUNRISE option is used.

f. Modified subroutines FLOPEN and WRTCRD to use STATUS='REPLACE' instead of STATUS='SCRATCH' when opening the DEV70 and DEV75 "temporary" files to store the header records in the ".IQA", ".OQA", and MERGE data files that contain information for reprocessing of input options during subsequent stages of AERMET processing. This modification addresses issues that were encountered where AERMET was not able to locate the 'SCRATCH' files when applying a 64-bit version of AERMET.

g. Modified subroutines SUMHF and SUNDAT to eliminate integer/real mixed-mode calculations in summing the hourly heat fluxes, and in calculating sunrise/sunset times and solar elevation angles.

h. Modified subroutine BULKRI to include the THSTAR adjustment for low solar elevation angles under the original BULKRN method and for the non-Default/BETA ADJ_U* option associated with the BULKRN option. Subroutine BULKRI was also modified to avoid an array subscript out-of-bounds error in cases where the iterative approach does not converge within the specified loop limits.

i. Modified subroutine MPFIN to include additional error handling and reporting associated with processing of surface characteristics

j. Modified subroutines VRCARD, SUBST, MPPBL, and MPOUT to allow users to disable substitutions for missing CCVR and/or TEMP data that are based on persistence for hours 23 and 24. Additional flags have been added to the surface output file to identify when this option is applicable. These changes also allow users to specify either the NO_SUB or NOTSUB keyword to disable TEMP substitutions.

k. Subroutine OSDTCD was modified to include logical variables to identify the availability of ONSITE data for ambient temperature, solar radiation/insolation, cloud cover, net radiation, delta-T, and/or mixing heights. Several other subroutines were modified, including MPPBL, MPMET, MPFIN, and MPTEST to track whether substitutions for missing temperature and/or cloud cover should be implemented by default, based on whether only ONSITE data or only SURFACE data are available for a given

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parameter. Cloud cover and temperature substitutions were not implemented by default in v13350 if both SURFACE and ONSITE data were available, irrespective of whether the substituted parameter was included in both SURFACE and ONSITE data inputs. Version 14134 will apply CCVR and/or TEMP substitutions by default if the parameter is only included in the SURFACE or ONSITE data. However, the user options to disable substitutions are still available.

l. Modified subroutines MPPBL, SUBST, and EQ_CCVR to address potential issues with the use of ONSITE solar radiation and delta-T data in lieu of cloud cover (utilizing the delta-T based Bulk Richardson Number (BULKRN) method for stable conditions) or if delta-T/BULKRN is being applied with ONSITE or NWS cloud cover. These modifications were focused especially on the transition from nighttime stable conditions (controlled by delta-T/BULKRN) and daytime convective conditions (controlled by solar radiation data). The BULKRN/delta-T method will be used if valid delta-T and ONSITE wind data are available and if the delta-T lapse rate is stable, or if the cloud cover or insolation data is missing, or if the cloud cover is an "equivalent" cloud cover derived from solar radiation data when the solar elevation angle is less than the critical elevation angle for convective conditions. The critical solar elevation angle was also modified to use an average of the previous 24-hours of temperature data (with at least 75% data capture), instead of a default value of 288 K, for hours when the temperature is missing. An assumption of 5/10 cloud cover is also used in the calculation of critical solar elevation angle for hours when cloud cover is missing. Since the model will not compute concentrations for these hours due to missing temperature and/or cloud cover the effect of these changes on modeled concentrations is likely to be minimal. Furthermore, this approach should provide a reasonable estimate of early morning heat fluxes, and treating these hours as missing in terms of heat flux could result in the entire convective portion of the day being missing

m. Subroutine EQ_CCVR was modified to account for cases when the clear sky insolation value, QRNOT, is less than or equal to 0. The equivalent CCVR is set to 0 in these cases.

n. Modified subroutines MPMET, MPFIN, MPOUT, and AERSURF to track and report the use of MMIF-generated inputs, in the form of pseudo-ONSITE data alone (including "ONSITE" mixing heights) or as pseudo-ONSITE and UPPERAIR data. The use of MMIF-generated inputs is gleaned from information in the AERSURF input file of surface characteristics if it is used in Stage 3. The use of MMIF data is flagged in the header record of the surface file and by the use of the 'MMIF-OS' flag instead of the hourly NAD-OS, ADJ-SFC, etc., flags associated with ONSITE and/or SURFACE data. Subroutines MPMET, MPFIN, and MPOUT were also modified to track and report the use of the Bulk Richardson Number (BULKRN) option based on

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delta-T measurements, in lieu of cloud cover, for stable conditions. For applications using the BULKRN option, the header record of the surface file will include the 'BULKRN' flag. An additional 'MMIF' flag will be included if the BULKRN option is associated with use of MMIF data

o. Modified subroutine GET620 to allow the user to specify a standard 5-digit WBAN, instead of an 8-digit number with 3 leading 0's, for processing upper air data in the 6201 format. Checks have also been included to identify issues that may occur when users specify the 6201VB (TD-6201 variable-length block) format for upper air data.

p. Modified subroutine GETFSL to read the WMO number from upper air data in the FSL format, in addition to reading the WBAN, and assign the WMO number to the BUF08(1) variable if WBAN = '99999' to support non-US applications.

q. Modified subroutines SETUP, MPPROC, OSCARD, MRCARD, WRTCRD, and HEADER to allow re-processing of the XDATES information from the MERGE file header records. This information is included in the Stage 3 report, unless the user has specified XDATES in the Stage 3 input file. Also modified subroutine MERGE to use a consistent form for reporting the extract dates in the report files across all three stages. Subroutine CHROND was modified to fully support 4-digit years and subroutine XDTCRD was modified to use 4-digit years for extract dates in the report files instead of 2-digit years.

6. The sixth set of revisions, introduced with version 15181 of AERMET (see Model Change Bulletin (MCB) #6 provided on the SCRAM AERMET webpage), includes:

a. Modified subroutines UCALST and MPPBL to incorporate a constant value of THSTAR of 0.08, full inclusion of the displacement height, and a modified formulation for Monin-Obukhov length for the ADJ_U* option based on Qian and Venkatram (BLM, v138, 2011). Subroutine UCALST was also modified to adjust USTAR for wind speeds below the "critical" wind speed.

b. Modified subroutine BULKRI to correct the calculation of CDN to use ZREF(IHR)/Z0(IHR) instead of Z2/Z0(IHR). Subroutine BULKRI was also modified to use BETAM = 0.5 for the ADJ_U* option instead of 0.47.

c. Modified subroutine BULKRI to incorporate additional refinements to the ADJ_U* Beta option in conjunction with the Bulk Richardson Number (BULKRN) option, based on Luhar and Raynor (BLM, v132, 2009), including a more refined method for calculating THSTAR, and extending its applicability for very stable/low wind conditions.

d. Modified subroutine MERGE to include the year in the Stage 2 table of Daily Output Statistics.

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e. Subroutine GET620 was modified to issue a message if the UALOC in the upper data file does not match UALOC specified on the LOCATION keyword. This allows users to track when data from alternative representative upper air stations are used in conjunction with the UPPERAER tool.

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United States Environmental Protection Agency	Office of Air Quality Planning and Standards Air Quality Assessment Division Research Triangle Park, NC	Publication No. EPA-454/B-16-010 December 2016