



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



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User's Guide for AERMOD Meteorological Preprocessor (AERMET)

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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 (version 23132). Version 23132 of AERMET includes updates to version 22112 of AERMET. Note, version 23112 of AERMET is a replacement of the current regulatory version (22112) and is now considered the regulatory version of AERMET.

Hourly surface observations from the National Weather Service (NWS), Federal Aviation Administration (FAA) or other sources, NWS twice-daily upper air soundings, data from a site-specific meteorological measurement program, and data from prognostic meteorological models can be processed in AERMET. This version includes two stages for 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 reads the processed meteorological data from Stage 1 and estimates the necessary boundary layer parameters for use by AERMOD. AERMET generates two meteorological output files for input to 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.

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## 1.0 Introduction

The U. S. Environmental Protection Agency (EPA), in conjunction with the American Meteorological Society (AMS), developed the AMS/EPA Regulatory Model (AERMOD), promulgated by the EPA in 2005 as the preferred regulatory air dispersion model for predicting near-surface pollutant concentrations within 50 kilometers (km) of an emission source. AERMET, the subject of this user's guide, is the meteorological preprocessor for AERMOD and estimates the atmospheric boundary layer (BL), also called the planetary boundary layer (PBL), parameters used in the dispersion calculations in AERMOD.

In December of 2021, EPA released a draft version of AERMET, 21DRF, that represented a complete overhaul of the computer code of AERMET. The source code for AERMET was rewritten from AERMET version 19191 and 21112 and reflects updated Fortran coding practices. Differences between AERMET 21112 and 21DRF are discussed below in Section 1.4 and are applicable to AERMET 23132. EPA conducted an informal public review from December 2021 through February 2022. This user's guide for AERMET 23132, represents updates to AERMET 22112. Updates from 22112 to 23132 are discussed in Section 1.5. This version, 23132, replaces version 22112 as the current regulatory version of AERMET.

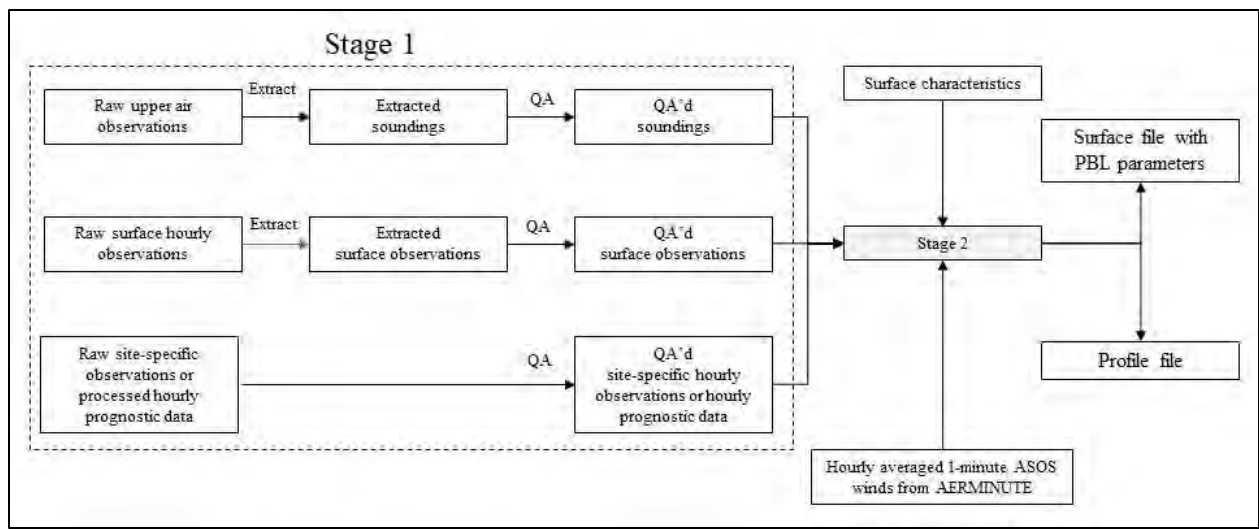
## 1.1 Overview of AERMET

AERMET processes four types of data: 1) hourly surface observations that are typically, but not exclusively, collected at airports by the National Weather Service (NWS) and/or the Federal Aviation Administration (FAA); 2) twice-daily upper air soundings collected by the NWS; 3) data collected from an on-site or site-specific measurement program; and 4) prognostic meteorological data processed through a processor such as the Mesoscale Model Interface (MMIF) (EPA, 2023a; Ramboll, 2023)<sup>1</sup>. Data processing occurs in two distinct stages that are unrelated to the type of data being processed. These stages can be run separately or together in one AERMET run; the stages are illustrated in Figure 1-1.

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<sup>1</sup> Throughout this document, site-specific references will also apply to the processing of MMIF output, which is processed in the PROG pathway in AERMET and uses the same processing as ONSITE data.





**Figure 1-1. AERMET processing steps**

The first stage extracts the surface and upper air data from files in which the data are stored in specific archive formats. The quality of the surface, upper air, and site-specific or prognostic data is also assessed during Stage 1. The second stage reads the output from Stage 1, calculates the boundary layer parameters required by AERMOD, and generates two AERMOD-ready meteorological data files.

Note that the extraction phase of the raw site-specific data or processed prognostic data is not included in Stage 1, though the data are QA'd in Stage 1. Unlike the surface and upper air data, site-specific and processed prognostic data are not stored (archived) in any specific 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 3.5. Another important point to mention with respect to Figure 1-1 is the input of 1-minute Automated Surface Observing Systems (ASOS) data into Stage 2, referred to in the figure as 'Hourly averaged 1-minute ASOS winds.' 1-minute ASOS data are surface wind data collected by the NWS/FAA with ASOS, stored as 1-minute averages, and archived separately from the hourly NWS/FAA surface data. These higher resolution wind data can be processed separately with the AERMINUTE program (EPA, 2023b) to produce 1-hour averages that are more representative than the surface wind data in the standard hourly archive formats (see Section 3.3). For more recent years (2000 to present), the hourly wind data in the standard archive formats can be replaced with the hourly values derived from

AERMINUTE output when those data are available. Refer to Section 3.3.9 for a detailed discussion on the use of 1-minute ASOS wind data. From here on, this user's guide refers to all surface data collected by the NWS and/or the FAA, including the 1-minute ASOS data, as NWS data. Surface characteristics are also input to Stage 2 and can be calculated from processors such as AERSURFACE (EPA, 2020) for observed data and from the prognostic model when processing prognostic data.

The AERMET program is designed to read a plain text file (a.k.a., the control file) which contains the processing instructions such as user-specified options and the names and locations of the input and output data files. Prior to version 18081 of AERMET, the control filename was hardcoded as 'AERMET.INP'. Beginning with version 18081, the user can specify the control filename on the command line when running AERMET. The input file can be in a different directory than the directory in which the user is working, and the full pathname or relative pathname can be entered. If no input file is provided, the hardcoded default 'AERMET.INP' is assumed and must be in the directory in which the user is working. Note that all AERMET output filenames are user-specified and are created automatically by AERMET during processing.

Prior to version 21DRF, AERMET was configured to be run in three stages (extraction and QA, data merger, and PBL calculations) with each stage run separately. Beginning with 21DRF, AERMET has been configured so that only two stages are executed (extraction and QA, and PBL calculations) and both stages can be executed in the same AERMET run. It is no longer necessary to run each stage separately, and the data merger stage has been eliminated. Therefore, existing AERMET control files created prior to version 21DRF must be revised. More details on the differences between the 21DRF version and earlier versions can be found in Section 1.4.

In a typical application, AERMET can be executed two ways: 1) two times, once for Stage 1 processing (extraction and quality assurance (QA) of the surface, upper air, and site-specific data or prognostic data combined in a single run) and a second time for Stage 2 processing (boundary layer calculations and output); 2) alternatively AERMET can be executed once, running both Stage 1 and 2 in the same AERMET run (see Section 1.4.1 for information on combined stage control files). Since Stage 1 processing is designed to support QA of raw

input data, Stage 1 may involve multiple iterations if data problems are encountered. Prior to running AERMET, the user should review the instructions in the control file and, as necessary, replace them with instructions appropriate to the specific application and stage of processing. If running each stage separately, a separate control file will be required for each stage, and each given a unique name to avoid conflicts when the files are stored in the same directory.

### 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.

In the past, 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 three formats including: TD-6201, the former Forecast Systems Laboratory (FSL) format, and beginning with 21DRF, the Integrated Global Radiosonde Archive (IGRA). 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/> and the IGRA format is available from the NOAA National Centers for Environmental Information (NCEI) at <https://www.ncei.noaa.gov/products/weather-balloon/integrated-global-radiosonde-archive>. Direct access to recent data can be found at <https://www.ncei.noaa.gov/data/integrated-global-radiosonde-archive/access/data-y2d/> or for full period of records for stations at <https://www.ncei.noaa.gov/data/integrated-global-radiosonde-archive/access/data-por/>

AERMET can extract surface hourly weather observations from several standard formats that have been used by NOAA's 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 formats (i.e., by hour). Prior to version 21DRF, AERMET could also process the TD-3280 format, which is element-based (i.e., by variable), originally stored on magnetic tape. Beginning with version 21DRF, AERMET no longer supports the TD-3280 format due to its age. While data stored in some of the older formats (CD-144, SAMSON, and HUSWO) may be part of users' personal archives and some formats may be available for purchase from the NCEI, recent U.S. and global data are available for download via File Transfer Protocol (FTP), free of charge, from the NCEI at: <https://www1.ncdc.noaa.gov/pub/data/noaa> (web browser) or <ftp://ftp.ncei.noaa.gov/pub/data/noaa> (ftp client, anonymous access).

AERMET also processes an hourly surface data format available from the EPA Office of Air Quality Planning and Standards (OAQPS). This format is a reduced form (fewer variables) of the CD-144 format and is available for 1984-1992 from the Support Center for Regulatory Air Models (SCRAM) website (<https://www.epa.gov/scram>).

There is no standard format or content for site-specific or processed prognostic meteorological data. These data most likely will include observations made at one or more levels on an instrumented tower or from remote sensing instrumentation or modeled vertical grid for prognostic data. Additionally, near-surface measurements such as insolation, net radiation, and temperature difference may be included. The non-standardized formats preclude storing these data in a predefined archive format; thus, AERMET does not 'extract' site-specific data. However, AERMET can read site-specific or processed prognostic data stored in an ASCII<sup>2</sup> file with a structure that can be described by the user with standard Fortran format statements. Additional restrictions and specification of site-specific and prognostic data are discussed in more detail in Section 3.5.3.

Quality assessment (QA) 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 inconsistencies between selected variables within an observation period.

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<sup>2</sup> American Standard Code for Information Interchange

Default values are defined for the upper and lower bounds and for missing values. The values can be modified through the control file created by the user. 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 the message 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 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 or raw data file. The archived or raw 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- PBL calculations and create model input files

The second stage of processing reads the output generated in Stage 1, computes the boundary layer scaling parameters (e.g., surface friction velocity, mixing height, and Monin-Obukhov length), and produces two input files for AERMOD. The first file contains the computed boundary layer parameters, as well as the observed surface parameters (e.g., temperature, wind speed, and wind direction). The second file contains one or more levels (a profile) of winds, temperature, and the standard deviation of the fluctuating components of the wind if provided. Site-specific monitoring programs commonly collect temperature and wind measurements at multiple levels. The prognostic data are also commonly multilevel. These multilevel data are written to the profile file. In the absence of multilevel site-specific data, a single level from site-specific or NWS hourly surface observations are written to this file.

## **1.2 Output files**

AERMET creates several files during each stage of processing. These include a report file that summarizes user options and QA results, a message file that stores errors, warnings, and detailed QA messages generated during processing, separate extraction files for the NWS surface and upper air data, and a separate data quality assessment file for NWS surface, upper air, and site-specific or prognostic data. The extraction files contain the data that are extracted from archive formats during Stage 1 and subsequently QA'd. The assessment files contain the QA'd data and are nearly identical in structure and content to the extraction files. The assessment files are input into Stage 2. As mentioned previously, site-specific (prognostic) data, processed via the ONSITE (PROG) pathway, are read, and QA'd directly from the user-supplied file.

The structure and contents of the summary and message files are discussed in the examples in Section 4.0. The structure and content of the extraction and assessment files are provided in Appendix C. It is important that the user not alter any of the header records in the assessment files since they are input into Stage 2, otherwise the data could be processed in an undesirable way or cause AERMET to fail with a processing error.

## **1.3 Document Overview**

Section 2.0 describes the running of AERMET. Section 3.0 describes the keywords for each pathway in detail and Section 4.0 presents a basic tutorial of AERMET. Section 5.0 presents technical notes about AERMET. Appendix A through Appendix D present more information about keywords (Appendix A), meteorological variables (Appendix B), file formats (Appendix C), and various messages (Appendix D). Appendix E provides a summary of the different AERMET modules and subroutines, and Appendix F summarizes AERMOD evaluations using AERMET 22112 and 21112 as part of the AERMET overhaul process.

## 1.4 Differences with older versions of AERMET

As part of the update process to AERMET, there are several differences between version 23132 of AERMET and previous versions (21112 and earlier). This section describes some of the changes, including control file changes, user options, and programming changes that will result in differences between 23132 AERMET and earlier versions (21112 and earlier).

### 1.4.1 Control file differences

As part of the update process, changes were made to AERMET that will require the user to modify existing AERMET control files. The first such change is that the XDATES keyword for each path now requires the years to be entered as 4-digit years. Previously, AERMET allowed for 2-digit or 4-digit years. Use of 4-digit years makes processing for years spanning a century crossover i.e., 1999-2004, easier. See Sections 3.3.3, 3.4.3, 3.5.2, and 3.7.6 for more information on date extractions for SURFACE, UPPERAIR, ONSITE or PROG, and METPREP processing.

As discussed in Section 1.1, beginning with version 21DRF, AERMET is now a two-stage process, instead of a three-stage process. To facilitate the use of existing AERMET input control files, AERMET 23132 will read existing control files and ignore paths and keywords that are no longer needed. To run an existing Stage 1 control file, the only change that is needed by the user is to make sure the years associated with XDATES are 4-digit years. To run Stage 2 (old Stage 3) by itself, the user can combine an existing Stage 2 and Stage 3 control file (AERMET 21112 or earlier) into one control file and remove the old Stage 3 JOB pathway and keywords. AERMET will ignore the older MERGE pathway and DATA keyword associated with the METPREP path. Additionally, the user should ensure all years associated with XDATES are 4-digit years. To run a new combined Stage 1 and 2 AERMET run, the user can combine existing Stage 1, 2, and 3 control files (AERMET 21112 and earlier) into one control file. As previously stated, AERMET will ignore the MERGE pathway and DATA keyword associated with the METPREP path. Again, the user should ensure all years associated with XDATES are 4-digit years and remove the Stage 2 and Stage 3 JOB pathway and keywords.

### 1.4.2 Other differences

The following is a list of differences between AERMET version 22112 and later with previous versions of AERMET, version 21112 and earlier. The list includes the topics discussed above in Section 1.4.1. For some changes, the user can expect to see differences in output between 23112 AERMET and previous versions (prior to 22112). Those expected differences are explained when applicable.

- AERMET is now a two-stage process instead of a three-stage process. The merge stage, Stage 2 in previous versions of AERMET has been eliminated and the previous Stage 3 is now Stage 2. If the MERGE pathway (Section 3.6) is found in the AERMET control file, AERMET will ignore the associated keywords. Likewise, if AERMET encounters the DATA keyword (Section 3.7.1) with the METPREP pathway (Section 3.7), AERMET will ignore the DATA keyword and associated file (old Stage 2 output).
- Years associated with XDATES must be 4-digit years.
- AERMET will now preserve the case (lower or upper case) of any input or output files, instead of assuming all upper case for filenames. This makes the code more portable for Linux operating systems as Linux systems are case sensitive while Microsoft Windows DOS systems are case insensitive.
- Stage 1 EXTRACT and QAOUT files have different formats between AERMET 22112 and previous versions. The ONSITE QAOUT file now has a consistent format, where before, the QAOUT file followed the format of the raw input file.
- A new averaging option for vector averaging of winds has been added to Stage 1 for sub-hourly site-specific data. The user invokes the option by specifying the word VECTOR after the number of observations per hour with the OBS\_HOUR keyword. The default averaging is a scalar average.



- A new upper air data source, the Integrated Global Radiosonde Archive (IGRA), has been added in addition to the 6201 and FSL formats.
- The 3280 format for SURFACE data has been dropped and will no longer be supported by future versions of AERMET.
- The addition of a new pathway, PROG for prognostic data. The PROG pathway is analogous to the ONSITE pathway and uses the same keywords. The PROG pathway is utilized for prognostic data to allow for processing of certain variables when the application is overwater versus overland (Section 3.5.1). When using the PROG pathway, AERMET will output a text string to the AERMET OUTPUT file (Section 3.13) in the header and for each hour denoting that the data are prognostic. This allows AERMOD to know the data are prognostic.
- In conjunction with the new PROG pathway, AERMET has additional ONSITE or PROG variables that can be used for overwater applications. See Appendix B, Table B-3, and Table B-4. See Section 3.5.1 for details on the overland or overwater assignments and treatment of variables.
- Additionally, in conjunction with overwater applications, if Monin-Obukhov length is an input variable and used for overwater applications, AERMET will use Monin-Obukhov length to determine the stability of the hour (convective or stable) instead of the solar angle approach currently used. The solar angle approach is used when Monin-Obukhov length is not available.
- AERMET now allows for the specification of year specific surface characteristics via the FREQ\_SECT, FREQ\_SECT2, AERSURF, and AERSURF2 keywords. This allows for a multi-year AERMET run for Stage 2 in one AERMET run instead of separate annual AERMET runs when surface characteristics change on an annual basis. See Section 3.7.9.5 for more details.

- For seasonal surface characteristics only, AERMET uses the primary and secondary station coordinates to determine the hemisphere of the respective station. This is used to allocate the seasonal characteristics to the appropriate months based on the hemisphere. For example, for winter characteristics, if the station is in the Northern Hemisphere, the winter characteristics are assigned to January, February, and December. If the station is in the Southern Hemisphere, then the winter characteristics are assigned to June, July, and August. This feature allows the user to enter seasonal characteristics that represent the season for the hemisphere. Thus, for applications in the Southern Hemisphere, the user does not need to assign representative summer surface characteristics to winter so that AERMET will assign the characteristics to the correct months. See Section 3.7.9 for more details.
- The no persistence keyword, NOPERS, used for cloud cover and temperature substitution for hours 23 and 24 in METPREP are now obsolete. These keywords were present because previous versions of AERMET processed each day separately within the program and previous versions could not read ahead to the next day to allow for hours 23 and 24 interpolations. Based on the recoding of AERMET, AERMET can now read the next day's observations so hours 23 and 24 can be interpolated in the same manner as other hours in the day.
- In previous versions of AERMET, when processing NWS data, if hour 24 was completely missing from the Stage 2 output, i.e., the hour was not in the raw data file in Stage 1, AERMET would copy hour 23 (if available) to hour 24 of the day. This is no longer done in AERMET version 22112 or later, so hour 24 may be missing in the final AERMET output. Additionally, temperature and cloud cover may be substituted from hour 23 of the same day and hour 1 or 2 of the next day. This change could result in differences for hours 24, 1, and 2 when comparing AERMET version 22112 and later to previous versions of AERMET.
- Hourly precipitation values may differ between 22112 AERMET and previous versions. Previous versions of AERMET do not reset hourly precipitation to zero in METPREP

before reading the precipitation from the MERGED output. This can result in precipitation values for hours that are missing in the MERGE output because previous versions of AERMET do not reinitialize the precipitation, so the previous day's value of precipitation is used for the hour. 21DRF AERMET corrects this issue.

- For applications involving site-specific or prognostic mixing heights, AERMET version 22112 and later smooths the mixing height based on the previous hour's mixing height, like when AERMET calculates mechanical mixing heights. Previous versions of AERMET did not smooth the mechanical mixing heights read from the site-specific or prognostic data.
- As part of the overhaul of AERMET with version 21DRF, the variables that are type real in FORTRAN are now double precision in AERMET. Previous versions of AERMET treated these variables as real. Due to the differences between double precision and real, some variables may have slightly different values due to rounding, and other variables may have more differences as logic code within AERMET may have different outcomes, even though the numbers used in the logic are slightly different. This could result in different processing based on the logic, leading to different output values.
- NWS wind speeds associated with variable wind directions are not corrected for truncation (Section 3.7.7.3) in Stage 2 as done in previous versions of AERMET.

## **1.5 Updates from 22112 to 23132**

Following is a list of changes made to version 22112 as part of the 23132 update:

## Formulation update

- Include subroutine COARE1 and associated subroutine and keywords for inclusion of Coupled Ocean Atmosphere Response Experiment (COARE) (Fairall, et.al., 2003) processing for ONSITE or PROG overwater data. The inclusion of COARE to AERMET replaces the need to run the standalone AERCOARE processor (EPA, 2012) for overwater applications for either observed or prognostic overwater meteorological data. Options for running COARE algorithms in AERMET can be found in Section 3.7.7.6.

## Bug fixes

- Correct format statement in subroutine NEW\_SOUND to correct issue with soundings out of sequence.
- Correct a bug in subroutine MECH\_HT to use unsmoothed mixing height when u\* is missing for the hour.
- Add a check for missing wind speed in subroutine AVG\_HR to account for negative values used as missing value indicators.
- Initialize variables and correct issues with Linux GFortran compilation.
- Correct format statement in subroutine READINP.
- Correct format in subroutine WINDS when issuing message that winds were reset to 0.28 m/s for SURFACE observations.
- Correct bug to allow primary surface characteristics keywords to be used with AERSURF2 file in subroutine AERSURF.
- Correct bug in PBL\_TEST to appropriately check for missing surface characteristics keywords.
- Correct WBAN number for Terre Haute, IN in subroutine SFC\_INIT.
- Correct bug to read ASOS flag correctly for SURFACE data in subroutine SURF\_PATH.
- Correct bug for sounding target hours when beginning of window is in previous day of sounding in subroutines PBL\_PROC and CHECK\_OBS.
- Correct bugs in PBL\_TEST for UPPERAIR location when using ONSITE/PROG mixing heights and no UPPERAIR data.

- Correct bug to only set SURFACE winds to calm if not missing.
- Correct logic bug in subroutine READ\_ISHD when getting weather codes. Affects only ISHD data.
- Correct bug in READ\_FSL, READ\_IGRA, and READ\_6201 to only decrease nsnd(3) when nsnd(3) > 2; nsnd(3) is number of valid soundings per day.
- Correct bug for pressure calculations to set NWS elevation even if not a NWS observation.
- Correct bug when writing PROFILE file to only write temperature when hour is substituted by ONSITE hours.
- Change error to warning when checking for GMT/longitude mismatch.
- Correct bug to sum ONSITE sub-hourly precipitation variables instead of averaging.
- Correct bug to check for ONSITE THRESHOLD in Stage 1 output EXTRACT or QAOUT file.
- Correct bug to write longitude east or west designation in OUTPUT (surface) header record in subroutine SFC\_HEADER.
- Set variable DATE\_HR\_STR in READ\_SAM.
- Put check for S\_LEVELS in UP\_MODIFY inside hour loop.
- Only set ndays -1 when ndays > 1 in reporting observations in OBS\_SUM.
- Correct FORMSTR in DATES\_LOC to allow for negative double digit GMT to LST (i.e., -12 hours).

#### Enhancements

- Add more QA on number of observations per hour for sub-hourly data in OS\_PROC, READ\_OS, AVG\_HR, CALC\_WINDS, and CHECK\_HTS.
- Add NWS elevation to SURFACE EXTRACT and QAOUT file when derived from ISHD data.
- Check OUTPUT and PROFILE file for format overflows and NaN.

## Miscellaneous

- Modified PBL\_PROC and WRITE\_SRSS to only get target sounding hours and UPPERAIR sunrise/sunset times when UPPERAIR data is used in Stage 2.
- Add more QA checks to ONSITE/PROG heights when OSHEIGHTS not specified.
- Add warning when UPPERAIR data has GMT to LST of 0 and longitude does not indicate location is in time zone of Prime Meridian. Use GMT to LST conversion based on longitude for UPPERAIR sunrise/sunset calculations.
- Update AERMET to allow multi-level data to be out of ascending order.
- Initialize GMTLST for all data types to -9 to avoid issues when actual GMT to LST is 9 hours.
- Add COARE text string to OUTPUT file header to aid AERMOD in determining if COARE algorithms were used in AERMET.

## 2.0 Running AERMET

This section is designed to provide the user with a basic understanding of the requirements to run AERMET. This section will explain the pathway and keyword approach and associated syntax rules for processing meteorological data in AERMET.

### 2.1 AERMET execution

AERMET is a DOS-based program and is run from the command prompt on computers running a version of Microsoft Windows. AERMET can also be compiled and executed on Unix or Linux systems. On Windows systems, the syntax for running AERMET for a single stage or combined stages is:

*path-to-AERMET.EXE\AERMET*

*path-to-AERMET.EXE\AERMET input\_filename*

On Linux or Unix systems, the syntax is:

*path-to-AERMET.EXE/AERMET*

*path-to-AERMET.EXE/AERMET input\_filename*

where *path-to-AERMET.EXE* is the directory path to the AERMET executable file. When no input file name is specified, AERMET assumes the input filename is 'aermet.inp' for each stage and the file resides in the current working folder or directory. The specification of an input filename is applicable to versions of AERMET beginning with version 18081 and the filename can include a full directory pathname for the file. When running AERMET with no input filename as an argument, each stage's input file should be copied to a file named aermet.inp (case insensitive on DOS and case sensitive on Unix or Linux systems). Examples following in the rest of this document are for the latest version of AERMET.

As AERMET runs, the progress is displayed on the screen, unless the option NOPRINT (Section 3.2.4) is specified on the JOB pathway (Section 3.2). In addition to the output data files, each run will produce a message file and report file if a report file is specified. 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.

More details and examples about running AERMET are available in Section 4.0.

## 2.2 Control file

Processing meteorological data with the AERMET preprocessor is divided into two stages as shown in Figure 1-1. Each stage can be run separately or in a combined run. 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. There can be a separate control file for each stage of processing or a single control file that runs both stages in one run. The user can enter the unique name of the control file on the command line when executing AERMET from the command line as discussed in Section 2.1.

The statements in the control file 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, site-specific meteorological data;
- PROG                  for QA'ing user-supplied, prognostic meteorological data; and
- METPREP             for estimating boundary layer parameters for AERMOD.



The pathway identifier appears on a line by itself and identifies 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 two to five pathways specified in a single AERMET control file. A seventh pathway, MERGE, is a legacy of AERMET prior to the 21DRF version (AERMET version 21112 and earlier). If AERMET (21DRF and later) detects the MERGE pathway, it is ignored.

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 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.

### 2.2.1 Control file setup

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

- The pathway identifier appears on a line by itself followed by all the 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 control file cannot exceed 500 characters in length. Prior to AERMET 21DRF, the limit was 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 500 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 control file to improve readability.

- If asterisks appear in columns 1 and 2 (\*\*), AERMET ignores the statement. By using the asterisks, the statement acts as a comment, which can be used to identify the purpose of the control file, clarify the content of an individual keyword, or ignore a keyword if the user edits a control file but wants to preserve the prior content.
- Alphabetical characters can appear in either upper case 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. However, beginning with version 21DRF, AERMET retains the original case of character strings associated with filenames. This allows AERMET to work more efficiently with Linux and UNIX systems, which are case sensitive.
- 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 2) 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 3.0. 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 (PROG) and METPREP pathways. These keywords pertain to the variables and format of the site-specific (prognostic) data in Stage 1 and the surface characteristics on the METPREP pathway in Stage 2.
- Filenames must conform to the naming conventions appropriate to the computing platform and cannot exceed 300 characters in length. Prior to version 21DRF, the filenames could not exceed 96 characters in length.

### 3.0 Keyword reference

#### 3.1 Definitions and control 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 of 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 calculations. While data QA is optional in Stage 1, the keyword is mandatory if the AERMET run is not a combined Stage 1 and 2 run. A distinction will be made when the keyword type may be ambiguous. For the discussions in the following sections, the stages to which the keyword refers to 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 the keyword can appear only once (nonrepeatable) or more than once (repeatable) for the same pathway in a control file. 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 control file, but only once per pathway. For example, the QAOUT keyword defines the input file for each pathway for Stage 2 (merging data and PBL calculations). It can appear only once for each pathway, but it will appear two or three times in the control file because there is usually more than one type of data used in Stage 2.

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 control file.

The syntax descriptions in the following sections use certain conventions. The keywords are all upper case, 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.

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 control file either does not exist or can be overwritten.

## 3.2 JOB Pathway

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

### 3.2.1 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 4.0. This keyword is mandatory because the program later uses this file to summarize the processing. The syntax and type are:

<b>Syntax:</b>	MESSAGES <i>message_filename</i>
<b>Type:</b>	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 300 characters.

### 3.2.2 REPORT

At the conclusion of a run, AERMET reads the file of messages, tabulates the different types of messages (errors, warnings, etc...), and summarizes all the actions for that run in a file specified with the REPORT keyword. The REPORT file also summarizes input and output filenames, quality assurance summary (Stage 1), requested processing steps, and other inputs

such as surface characteristics. The contents of a run summary are discussed throughout the tutorial in Section 4.0. The syntax and type for this keyword are:

<b>Syntax:</b>	REPORT <i>summary_filename</i>
<b>Type:</b>	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 300 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 4.0).

### 3.2.3 CHK\_SYNTAX

AERMET processes all the statements in a control 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 control 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 control file prior to processing data. The syntax and type of the CHK\_SYNTAX keyword are:

<b>Syntax:</b>	CHK_SYNTAX
<b>Type:</b>	Optional (All), Nonrepeatable

No parameters accompany this keyword.

The user gets a full report of the processing of the control 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 the file:

THIS RUN ONLY CHECKS THE RUNSTREAM INPUT
--

### 3.2.4 NOPRINT

Beginning with version 21DRF, AERMET will suppress output to the screen. This usually is the progression of operations through each day. The syntax and type of the NOPRINT keyword are:

<b>Syntax:</b>	NOPRINT
<b>Type:</b>	Optional (All), Nonrepeatable

No parameters accompany this keyword.

### 3.2.5 DEBUG

Beginning with version 21DRF, AERMET has a debug option that will output certain calculations and messages from Stage 1 and most calculations in Stage 2 to a debug file. The syntax and type for this keyword are:

<b>Syntax:</b>	DEBUG Or DEBUG <i>debug_filename</i>
<b>Type:</b>	Optional (All), Nonrepeatable

Note that the DEBUG keyword can be followed by an optional filename. If the filename is not listed, the default filename is *aermet\_debug.txt*. When the debug keyword is used for Stage 1 processing, the following is output to the debug file:

- When calculated upper air variables, speed shear, direction shear, and lapse rate are audited, AERMET outputs the variables and calculations for those variables.
- When reading sub-hourly site-specific data, AERMET will output the values used for hourly averaging of sub-hourly variables.

When the debug keyword is used for Stage 1 processing, the following is output to the message file:

- When reading ISHD data, AERMET will output messages to the message file regarding replacement of observations with report type.

When the DEBUG keyword is used with Stage 2 processing, AERMET will output the following to the debug file:

- Upper air sounding used for each day
- Value and source of key observed variables such as winds, temperature, pressure, cloud cover, precipitation, etc.
- Values are used for temperature and cloud cover substitution
- Solar angle, critical angle, and resulting convective/stable assignment for each hour
- Calculations for variables such as surface friction velocity, convective velocity scale, mechanical and convective mixing heights, etc.

The debug option will provide output for each day and hour designated by the XDATES keyword. The debug file can become quite large so the debug option should be used with caution.

### 3.3 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 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.

#### 3.3.1 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. The syntax and type for the DATA keyword are:

<b>Syntax:</b>	DATA <i>archive_filename file_format [ASOS]</i>
<b>Type:</b>	Mandatory* (Stage 1 only; Stage 1 and 2 combined), Nonrepeatable

The *archive\_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of the *archive\_filename* is 300 characters. The keyword is mandatory under certain conditions and is optional under other conditions. The keyword is mandatory if performing Stage 1 processing (separately or in a combined Stage 1 and 2 AERMET run) and the EXTRACT keyword (Section 3.3.2) is not used or the file associated with the EXTRACT keyword is empty. The DATA keyword is optional if the EXTRACT keyword is present, and the file associated with the EXTRACT keyword is not empty. In that case, the data in the file associated with the EXTRACT keyword is the input data.

For processing archive data, the *file\_format* must be specified as one of the following: CD144, EXTRACT, SCRAM, SAMSON, HUSWO, or ISHD. Each of these formats is discussed in more detail below. Beginning with version 21DRF, a new format, EXTRACT can



be used. This can be used to read in NWS data in the format of the EXTRACT or QAOUT file generated by AERMET. Also beginning with AERMET version 21DRF, two formats, 3280VB and 3280FB are no longer supported due to their age.

AERMET includes a table of ASOS commission 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 numbers (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 3.7.7.3.

**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.

#### 3.3.1.1 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 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, so 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 a 00 - 23 clock. Hour 00 is hour 24 of the previous day. In previous versions of AERMET, when data were retrieved from an archive file for a specific period, the first hour was discarded since it was 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. This has been changed beginning with AERMET 21DRF in that the conversion from 00 – 23 to 01 – 24 takes place before comparing the data’s dates against the processing dates.

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

<u>Overpunch</u>	<u>CD-144</u>	<u>CD-144 element</u>
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 <sub>1</sub> dew
<b>9</b>	<b>41</b>	<b>1st digit of wind speed (X<sub>1</sub> speed</b>
<b>10</b>	<b>47</b>	<b>Sign of the dry bulb (X<sub>1</sub> dry bulb</b>
11	50	Sign of the wet bulb (X <sub>1</sub> wet bulb <
<b>12</b>	<b>56</b>	<b>Total sky cover</b>
13-34	57-78	Cloud data by layer

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.

### 3.3.1.2 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 NCEI (<https://www.ncei.noaa.gov/>), 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.

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 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 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.

### 3.3.2 EXTRACT

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

<b>Syntax:</b>	EXTRACT <i>extracted_data_filename</i>
	Mandatory (Stage 1 only), Nonrepeatable
<b>Type:</b>	Or
	Optional (Stage 1 and 2 combined), Nonrepeatable

The *extracted\_data\_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 300 characters. Note that when running AERMET for Stage 1 only, the EXTRACT keyword is mandatory. However, if

performing a combined Stage 1 and 2 AERMET run, the EXTRACT keyword is optional as Stage 2 will use the internal AERMET arrays to read extracted data from Stage 1.

The variables written to the EXTRACT file are those variables only needed for Stage 2 processing and are the variables that are not shaded in Table C-1 in Appendix C.

### 3.3.3 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:

<b>Syntax:</b>	<i>XDATES YB/MB/DB [TO] YE/ME/DE</i>
	Or <i>XDATES YB/MB/DB [-] YE/ME/DE</i>
<b>Type:</b>	Mandatory (Stage 1 only), Nonrepeatable
	Or Optional (Stage 1 and 2 combined), 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. Beginning with version 21DRF, the year must be entered as a four-digit integer (e.g., 1992). 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 dates can be entered in various ways. The individual components of start date or end date can be separated by spaces or the ‘/’ character or no separator at all. However, the start date cannot be separated by spaces and the end date separated by ‘/’ or vice-versa. Both dates must use the same delimiter. The complete start date and end date can be separated by a space, ‘-’, or the word “TO”. The case of the word “TO” can be upper, lower, or a mix of cases. The following are valid methods to enter the dates, using January 1, 2020 and December 31, 2020 as the dates:

- 2020/01/01 2020/12/31

- 2020/01/01 TO 2020/12/31
- 2020/01/01 – 2020/12/31
- 2020 01 01 TO 2020 12 31
- 2020 01 01 – 2020 12 31
- 2020 01 01 2020 12 31
- 20200101 20201231

The following are invalid methods to enter dates, again using January 1, 2020 and December 31, 2020 as the dates:

- 2020/01/01 2020 12 31
- 2020 01 01 2020/12/31
- 2020/01/01 - 2020 12 31
- 2020 01 01 - 2020/12/31
- 2020/01/01 TO 2020 12 31
- 2020 01 01 TO 2020/12/31

The XDATES keyword is mandatory if performing Stage 1 processing only. The XDATES keyword is optional if performing combined Stage 1 and 2 processing and XDATES is present for the METPREP pathway. If XDATES is present for the METPREP pathway, AERMET will use the METPREP dates for extraction of surface data if SURFACE EXTRACT or QAOUT files are not requested. If SURFACE EXTRACT or QAOUT files are requested, then the surface extraction uses the dates associated with XDATES on the SURFACE pathway.

### 3.3.4 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:

<b>Syntax:</b>	LOCATION <i>site_id</i> <i>NWS_lat/long</i> <i>NWS_long/lat</i> [ <i>tadjust</i> ] [ <i>elevation</i> ]
<b>Type:</b>	Mandatory (Stage 1), Nonrepeatable, Reprocessed
<b>Order:</b>	Latitude ( <i>lat</i> ) and longitude ( <i>long</i> ) 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. Prior to version 21DRF, the *site\_id* must be specified with leading zeros to fill a minimum of five characters (e.g., 3928 had to be entered as 03928) since the field was read as a type character and not an integer. This is no longer the case beginning with 21DRF, so 3928 can be entered as 3928, not 03928. However to avoid warnings in AERMOD, 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 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: N or S with the latitude and W or E with the longitude. For example, "38.4N 81.9W" will 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 parameter, *tadjust*, is an optional adjustment factor that is subtracted from 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, England, i.e., the Prime Meridian (0° longitude), *tadjust* should be specified as a positive number. Apart from 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,

apart from 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 since it will be used in the substitution hierarchy for missing station pressure (see Section 5.5).

### 3.3.5 QAOUT

One purpose of AERMET is to contribute to the quality assurance process by identifying data that are out of range or suspect so 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 control file. This keyword is also used to specify the input file to Stage 2. The syntax and type for the QAOUT keyword are:

<b>Syntax:</b>	QAOUT <i>qa'd_data_filename</i>
<b>Type:</b>	Optional (Stage 1 only; Stage 1 and 2 combined), Nonrepeatable  Mandatory (Stage 2 only) if reading SURFACE data, Nonrepeatable

The *qa\_output\_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 300 characters.

Quality assessment is an optional process, and the user does not have to perform a QA prior to using the data in PBL calculations. However, this step is recommended to identify possible errors in the data that are used to derive the boundary layer parameters. Note that when running AERMET for Stage 1 only or a combined Stage 1 and 2 run, the QAOUT keyword is optional. For a combined Stage 1 and 2 run, Stage 2 will use the internal AERMET arrays to read extracted data from Stage 1. However, if running AERMET for Stage 2 only, the QAOUT keyword is mandatory for Stage 2 to read the QA'd output. The variables written to the QAOUT file are those variables needed for Stage 2 processing plus additional variables not needed for



Stage 2 but can be used for quality assurance. The additional variables are those that are shaded in Table C-1 in Appendix C.

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 of 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 by 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 regulatory guidance, decide whether to retain or replace the value(s) 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 using the RANGE keyword, as described below. The user can also choose to QA additional weather elements by using the AUDIT keyword.

### 3.3.6 AUDIT

As mentioned in the previous section, there are only three weather elements that are tracked by default during 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:

<b>Syntax:</b>	AUDIT <i>sfname1</i> ... <i>sfnamen</i> or AUDIT ALL
<b>Type:</b>	Optional (Stage 1 or Stage 1 and 2 combined), Repeatable

where *sfname1*, ..., *sfnamen* are the internal AERMET names of the weather elements as defined in Table B-1 of Appendix B. As many names can be specified on a single keyword use, so long as they fit within the 500-character limitation of a line. This keyword is repeatable, so more than one AUDIT keyword can be used to define additional elements to track. Beginning with version 21DRF, if the user wishes to audit all variables, the user enters the word ALL after the keyword AUDIT. The case of the word ALL is case insensitive

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.

### 3.3.7 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:

<b>Syntax:</b>	RANGE <i>sfname</i> <i>lower_bound</i> <[=] <i>upper_bound</i> <i>missing_indicator</i>
<b>Type:</b>	Optional (Stage 1 or Stage 1 and 2 combined), Repeatable, Reprocessed

where *sfname* is the internal AERMET name of the weather element 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 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.

Prior to version 21DRF, data for the SURFACE pathway were written as integers with some variables being multiplied by 10 when extracted 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*. Beginning with version 21DRF, the data are written out as their actual values, i.e., recorded temperature in the EXTRACT or QAOUT file is the actual temperature, not temperature multiplied by 10.

Several weather elements have been concatenated to form a single variable in the *extracted\_data\_file*. These variables are noted in Table B-1 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.

### 3.3.8 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 by an AUDIT keyword) is missing or is equal to the

missing value on several records (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:

	NO_MISSING <i>sfname1</i> ... <i>sfnamen</i>
<b>Syntax:</b>	Or NO_MISSING ALL
<b>Type:</b>	Optional (Stage 1 or Stage 1 and 2 combined), Repeatable

where *sfname1*, ..., *sfnamen* are the internal AERMET names of the weather elements to omit from the message file. Beginning with version 21DRF, if the user wishes to suppress messaging for all variables, then the word ALL can follow the keyword NO\_MISSING. 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.

### 3.3.9 ASOS1MIN

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.

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 or 5-minute ASOS wind observations available from the NCEI at <https://www.ncei.noaa.gov/data/automated-surface-observing-system-one-minute-pg1/access/> for 1-minute data and at <https://www.ncei.noaa.gov/data/automated-surface-observing-system-five-minute/access/> for 5-minute data. 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, 2023b). Hourly-averaged wind speed and direction data derived from 1-minute or 5-minute ASOS wind data files using AERMINUTE will be referenced below 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:

<b>Syntax:</b>	ASOS1MIN <i>file_name</i>
<b>Type:</b>	Optional (Stage 2 or Stage 1 and 2 combined), Non-repeatable Must be input on the SURFACE pathway

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 3.7.7.2) must be specified with the SUBNWS parameter as a METHOD on the METPREP pathway in the Stage 2 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 to be written to the surface file (SFC) generated during Stage 2 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 2 control file.**

### 3.4 UPPERAIR

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 and are used to calculate convective mixing heights in Stage 2. 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 three formats, 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. However, for AERMET to correctly read the file, the format must follow the format described in Table C-2 in Appendix C.

### 3.4.1 DATA

NWS rawinsonde data are stored in a variety of formats. However, AERMET is designed to read only three of those formats, plus data in the format of the EXTRACT file for upper air data. As with hourly surface observations, data stored in this format are 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:

<b>Syntax:</b>	DATA <i>archive_filename file_format</i>
<b>Type:</b>	Mandatory* (Stage 1 only; Stage 1 and 2 combined), Nonrepeatable

The *archive\_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of the archive file is 300 characters. The keyword is mandatory if performing Stage 1 processing (separately or in a combined Stage 1 and 2 AERMET run) and the EXTRACT keyword (Section 3.3.2) is not used or the file associated with the EXTRACT keyword is empty. The DATA keyword is optional if the EXTRACT keyword is present, and the file associated with the EXTRACT keyword is not empty. In that case, the data in the file associated with the EXTRACT keyword are the input data.

AERMET can process upper air data in the TD-6201, FSL, and IGRA (new to versions 21DRF and later) formats in addition to the EXTRACT format. TD-6201 is now obsolete, though historical data may exist in corporate and personal archives. Neither TD-6201 or FSL format is available from the NCEI. However, historical and current upper air data in the FSL format are available for download, free of charge, from the online NOAA/ESRL Radiosonde Database (<https://ruc.noaa.gov/raobs/>). The format specifications are also available at that same web address. IGRA data can be downloaded free of charge from the NCEI ftp server (<ftp://ftp.ncei.noaa.gov/pub/data/igra>). TD-6201 data are stored either as fixed-length or variable length records, and the *file\_format* should be specified as either 6201FB or 6201VB, respectively. *file\_format* for upper air data in the FSL, IGRA, or EXTRACT format should be specified as FSL, IGRA, or EXTRACT respectively.

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.

### 3.4.2 EXTRACT

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

<b>Syntax:</b>	EXTRACT <i>extracted_data_filename</i>
	Mandatory (Stage 1 only), Nonrepeatable
<b>Type:</b>	Or
	Optional (Stage 1 and 2 combined), Nonrepeatable

The *extracted\_data\_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 300 characters. Note that when running AERMET for Stage 1 only, the EXTRACT keyword is mandatory. However, if performing a combined Stage 1 and 2 AERMET run, the EXTRACT keyword is optional as



Stage 2 will use the internal AERMET arrays to read extracted data from Stage 1. The variables written to the EXTRACT file are those variables only needed for Stage 2 processing: height, pressure, winds, temperature, and dewpoint. These are the variables that are not shaded in Table C-2 of Appendix C.

### 3.4.3 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:

<b>Syntax:</b>	<p>XDATES <i>YB/MB/DB</i> [TO] <i>YE/ME/DE</i></p> <p>Or</p> <p>XDATES <i>YB/MB/DB</i> [-] <i>YE/ME/DE</i></p>
<b>Type:</b>	<p>Mandatory (Stage 1 only), Nonrepeatable</p> <p>Or</p> <p>Optional (Stage 1 and 2 combined), Nonrepeatable</p>

*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. Beginning with version 21DRF, the year must be entered as a four-digit integer (e.g., 1992). 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 dates can be entered in various ways. The individual components of start date or end date can be separated by spaces or the ‘/’ character or no separator at all. However, the start date cannot be separated by spaces and the end date separated by ‘/’ or vice-versa. Both dates must use the same delimiter. The complete start date and end date can be separated by a space, ‘-’, or the word “TO”. The case of the word “TO” can be upper, lower, or a mix of cases. The following are valid methods to enter the dates, using January 1, 2020 and December 31, 2020 as the dates:

- 2020/01/01 2020/12/31
- 2020/01/01 TO 2020/12/31

- 2020/01/01 – 2020/12/31
- 2020 01 01 TO 2020 12 31
- 2020 01 01 – 2020 12 31
- 2020 01 01 2020 12 31
- 20200101 20201231

The following are invalid methods to enter dates, again using January 1, 2020 and December 31, 2020 as the dates:

- 2020/01/01 2020 12 31
- 2020 01 01 2020/12/31
- 2020/01/01 - 2020 12 31
- 2020 01 01 - 2020/12/31
- 2020/01/01 TO 2020 12 31
- 2020 01 01 TO 2020/12/31

The XDATES keyword is mandatory if performing Stage 1 processing only. The keyword is optional if performing combined Stage 1 and 2 processing and XDATES is present for the METPREP pathway. If XDATES is present for the METPREP pathway, AERMET will use the METPREP dates for extraction of upper air data if UPPERAIR EXTRACT or QAOUT files are not requested. If UPPERAIR EXTRACT or QAOUT files are requested, then the upper air extraction uses the dates associated with XDATES on the UPPERAIR pathway.

#### 3.4.4 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:

<b>Syntax:</b>	LOCATION <i>site_id</i> <i>NWS_lat/long</i> <i>NWS_long/lat</i> [ <i>tadjust</i> ]
<b>Type:</b>	Mandatory (Stage 1 only; Stage 1 and 2 combined), Nonrepeatable, Reprocessed
<b>Order:</b>	Latitude ( <i>lat</i> ) and longitude ( <i>long</i> ) 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. Prior to version 21DRF, 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 was read as a type character and not an integer. This is no longer required beginning with 21DRF so 3928 can be entered as 3928, not 03928. However to avoid warnings in AERMOD, 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 UPPERAIR 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: N or S with the latitude and W or E with the longitude. For example, "38.4N 81.9W" will 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 parameter, *tadjust*, is an optional adjustment factor that is subtracted from 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. For stations west of Greenwich, England, i.e., the Prime Meridian (0° longitude), *tadjust* should be specified as a positive number. Apart from EXTRACT, the standard NWS upperair data formats processed by AERMET report the time as GMT. Therefore, *tadjust* should be non-zero for all standard NWS formats processed by AERMET, apart from the EXTRACT format, unless the data are known to be reported for a time zone that is not local standard. Beginning with version 23132, if the GMT

to LST conversion is zero, AERMET will use the longitude on the LOCATION keyword line to approximate the GMT to LST conversion for the sunrise/sunset times and if the approximated conversion is greater than 1, AERMET will issue a message that the approximate conversion will be used for sunrise and sunset times. Therefore, care should be taken when using a GMT to LST conversion of zero as the approximated conversion may not be the actual conversion associated with the longitude.

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.

### 3.4.5 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 control file. This keyword is also used to specify the input file to Stage 2. The syntax and type for the QAOUT keyword are:

<b>Syntax:</b>	QAOUT <i>extracted_data_filename</i>
<b>Type:</b>	Optional (Stage 1 only; Stage 1 and 2 combined), Nonrepeatable Mandatory (Stage 2 only) if reading UPPERAIR data, Nonrepeatable

The *qa\_output\_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 300 characters.

Quality assessment is an optional process, and the user does not have to perform QA prior to using the data in PBL calculations. However, this step is recommended to identify possible errors in the data that are used to derive the boundary layer parameters. Note that when running AERMET for Stage 1 only or a combined Stage 1 and 2 run, the QAOUT keyword is

optional. For a combined Stage 1 and 2 run, Stage 2 will use the internal AERMET arrays to read extracted data from Stage 1. However, if running AERMET for Stage 2 only, the QAOUT keyword is mandatory for Stage 2 to read the QA'd output from Stage 1. The QAOUT file contains the same variables as the EXTRACT file plus any other variables that are audited. The additional variables are wind speed shear (UASS), wind direction shear (UADS), temperature lapse rate (UALR) and dewpoint deviation (UADD) and are shaded in Table C-2 of Appendix C. These four additional variables are not needed for Stage 2 processing but can be audited and used for quality assurance purposes. Therefore, they are not written to the EXTRACT file but are written to the QAOUT file.

AERMET's QA procedures include verifying that the values of the weather elements are not outside a range of 'acceptable' values and to keep 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.

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 layers in which to summarize the QA information for the soundings. These layers are based on the thickness increment defined to be 500 meters (in the variable UP\_INC in module UPPERAIR). These layers 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 UP\_INC (and recompiling the software), these layers 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 retain or replace the value(s) 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 using the RANGE keyword, as described below. Also, the user can QA additional weather elements by using the AUDIT keyword, described below.

#### 3.4.6 AUDIT

As mentioned in the previous section, there are no upper air variables that are tracked by default during QA. The user can track some or all variables for a particular AERMET run by specifying the element name with the AUDIT keyword. The syntax and type for this keyword are:

<b>Syntax:</b>	AUDIT <i>uaname1</i> ... <i>uanamen</i> or AUDIT ALL
<b>Type:</b>	Optional (Stage 1 or Stage 1 and 2 combined), Repeatable

where *uaname1*, ..., *uanamen* are the internal AERMET names of the weather elements as defined in Table B-2 in Appendix B. As many names can be specified on a single keyword that will fit within the 500-character limitation of a line. Since this keyword is repeatable, more than one AUDIT keyword can be used to define all the additional elements to track. Beginning with version 21DRF, if the user wishes to audit all variables, the user enters the word ALL after the keyword AUDIT. The case of the word ALL is case insensitive.

### 3.4.7 RANGE

The user can modify the upper or lower bound limits for QA if the default 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:

<b>Syntax:</b>	RANGE <i>uaname lower_bound</i> <[=] <i>upper_bound missing_indicator</i>
<b>Type:</b>	Optional (Stage 1 or Stage 1 and 2 combined), Repeatable, Reprocessed

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

Prior to version 21DRF, data for the UPPERAIR pathway were 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*. Beginning with version 21DRF, the data are written out as their actual values, i.e., recorded temperature in the EXTRACT or QAOUT file is the actual temperature, not temperature multiplied by 10.

### 3.4.8 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 by an AUDIT keyword) is missing several times

throughout the model run (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:

<b>Syntax:</b>	NO_MISSING <i>uaname1</i> ... <i>uanamen</i>
	Or
	NO_MISSING ALL
<b>Type:</b>	Optional (Stage 1 or Stage 1 and 2 combined), Repeatable

where *uaname1*, ..., *uanamen* are the internal AERMET names of the weather elements to omit from the message file. Beginning with version 21DRF, if the user wishes to suppress messaging for all variables, then the word ALL can follow the keyword NO\_MISSING. 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.

### 3.4.9 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:

<b>Syntax:</b>	MODIFY
	MODIFY ALL
	MODIFY <i>action1..action3</i>
<b>Type:</b>	Optional (Stage 1; Stage 1 and 2 combined), Repeatable

By specifying this keyword, the following *actions* occur:

- DELMAND: Some mandatory levels are deleted from the sounding;
- CALMDIR: A nonzero wind direction is set to 0 if the wind speed is 0;



- SUB\_TTTD: 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 ensure 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.

Prior to version 21DRF, this keyword had no parameters associated with it. When the keyword was specified, all three of the actions described above occurred. Beginning with version 21DRF, there are several options to specifying the keyword. To invoke all three actions, the keyword can be specified without any parameters, listing the word ALL after the MODIFY keyword, or specifying all three actions (DELMAND, CALMDIR, and SUB\_TTTD). To specify one or two actions, those actions are specified after the MODIFY keyword.

### **3.5 ONSITE or PROG**

The ONSITE pathway provides a means of including data recorded during an observation program, such as what might be required for dispersion modeling of 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. As previously noted, the ONSITE pathway is also used to process prognostic data processed via MMIF output in AERMET. Beginning with version 21DRF, a new data path, PROG was added to AERMET. The PROG pathway is used when processing prognostic meteorological data. Prior to version 21DRF, prognostic data was processed in AERMET via the ONSITE pathway. To facilitate the use of prognostic meteorological data over water and to let AERMOD know prognostic data are being used, the PROG pathway has been added to AERMET. The two pathways, ONSITE and PROG use the same keywords, so instructions and descriptions are generally applicable to both pathways. Throughout the remainder of this section, when referring to the ONSITE pathway, it is understood it applies to the PROG pathway as well. Note that if AERMET encounters both the SURFACE and PROG pathways in a control file, AERMET will issue an error and abort processing. The SURFACE pathway can only be used in conjunction with the ONSITE pathway. The UPPERAIR pathway can be used with either the ONSITE or PROG pathway.

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.

### 3.5.1 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:

<b>Syntax:</b>	DATA <i>data_filename</i> [ <i>land water flag</i> ]
<b>Type:</b>	Mandatory (Stage 1; Stage 1 and 2 Combined), Nonrepeatable

The *data\_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 300 characters.

Beginning with version 21DRF, there is an optional land/water flag that can be used in conjunction with the DATA keyword. This flag denotes if the data are land based (OL) or water based (OW). If there is no flag present with the DATA keyword, the data are considered land based. Prior to AERMET version 23132, if the 'OW' flag is indicated and the pathway is ONSITE, then AERMET would issue an error and abort. However, beginning with version 23132, and the addition of the COARE algorithms (Section 3.7.7.6) in METPREP, the flag can be 'OW' for both ONSITE and PROG. The flag can be 'OL' with ONSITE or PROG.

The purpose of the overland or overwater flag is for boundary layer calculations in Stage 2. For prognostic data, certain input variables such as Monin-Obukhov length,  $w^*$ , potential temperature lapse rate, hourly surface characteristics ( $z_0$ , albedo, and Bowen ratio), sensible heat flux,  $u^*$ , and cloud cover are only used if the data are over water. If the data are over land and these variables are present in the prognostic input data, then they are ignored in Stage 2 and they are calculated as if they were not present in the input data. AERMET will issue a message in Stage 1 that the variables will be read but not used and Stage 2 will also do the same if Stage 2 is run separately from Stage 1. See Table B-3 and Table B-4 in Appendix B for a list of variables that are used over water. Beginning with version 22112, surface friction velocity,  $u^*$ , and sky cover are not used when the data are input with the PROG pathway and the data are overland. However, they can be used for an overland location if the ONSITE pathway is used or if the PROG pathway is used and the data are overwater and COARE algorithms are not invoked. For observed data over water, the overwater flag is coupled with the use of the COARE algorithms for boundary layer calculations.

This new feature of AERMET is used in conjunction with the Mesoscale Model Interface, or MMIF (Ramboll, 2023) version 4.0 or later. Previous versions of MMIF will not output the variables that are used for overwater. Guidance on applications involving the overland or overwater flag can be found in the MMIF guidance document (EPA, 2023a)

### 3.5.2 EXTRACT

Unlike SURFACE and UPPERAIR data, site-specific data are not stored (i.e., 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 quality assessment, which reads the input file from the DATA keyword.

### 3.5.3 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 for input into 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 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 in a data record; and 2) the FORMAT keyword, which defines the format of the data in 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:

<b>Syntax:</b>	READ <i>record_index</i> <i>osname1</i> <i>osname2</i> ... <i>osnamen</i>
<b>Type:</b>	Mandatory (Stage 1 or combined Stage 1 and 2 ONSITE pathway), Repeatable, Reprocessed
<b>Syntax:</b>	FORMAT <i>record_index</i> <i>Fortran_format</i>
<b>Type:</b>	Mandatory (Stage 1 or combined Stage 1 and 2 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 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 *osname1*, *osname2*, ... *osnamen* 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 READ and FORMAT inputs for some users, but still requires an understanding of some basic rules to ensure that the data are read properly into AERMET.

The structure and format of the site-specific data are 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.
- (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). The date and time information can be listed on subsequent records for the period indicated on the first line of the observation as well.
- (5) The (non-date) data variables on the READ keywords must be a subset of those listed in Table B-3 and Table B-4 in Appendix B, 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 will 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 if each input record is a different height. The different methods available to specify the measurement heights for ONSITE data processed through AERMET are discussed in Section 3.5.10.

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 Fortran rules for creating a format statement. The format must begin with an open parenthesis and end with a closing parenthesis. Any Fortran programming language reference can provide guidance on 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 data 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 (*Fw.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 "b1023" (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.
- 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.

Reading the correct number of decimal places is important to accurately reflect the ONSITE data. Not reading the data format correctly could lead to significant problems. This situation may arise if the ONSITE data file was generated by a spreadsheet program (i.e., Microsoft Excel). 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 do 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 "Fw.0" as the Fortran format specifier may avoid the issue described above.

Another issue that may arise while processing ONSITE data is that the missing data code used within the data file may not match the default missing code used by AERMET (shown in Table B-3 and Table B-4 in Appendix B). AERMET will process these “missing” values as valid data in such cases, which may produce errors or anomalous results. The user can specify missing value indicators that differ from the default using the RANGE keyword on the ONSITE pathway. 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 variables present in the site-specific data file need to be read. Any superfluous data can easily be skipped 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.

### 3.5.4 XDATES

The amount of data extracted from a 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:

<b>Syntax:</b>	<p><i>XDATES YB/MB/DB [TO] YE/ME/DE</i></p> <p>Or</p> <p><i>XDATES YB/MB/DB [-] YE/ME/DE</i></p>
<b>Type:</b>	<p>Mandatory (Stage 1 only), Nonrepeatable</p> <p>Or</p> <p>Optional (Stage 1 and 2 combined), Nonrepeatable</p>

*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. Beginning with version 21DRF, the year must be entered as a four-digit integer (e.g., 1992). 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 individual components of the start date or end date can be separated by spaces or the '/' character or no separator at all. However, the start date cannot be separated by spaces and the end date separated by '/' or vice-versa. Both dates must use the same delimiter. The complete start date and end date can be separated by a space, '- ', or the word "TO". The case of the word "TO" can be upper, lower, or a mix of cases. The following are valid methods to enter the dates, using January 1, 2020 and December 31, 2020 as the dates:

- 2020/01/01 2020/12/31
- 2020/01/01 TO 2020/12/31
- 2020/01/01 – 2020/12/31
- 2020 01 01 TO 2020 12 31
- 2020 01 01 – 2020 12 31
- 2020 01 01 2020 12 31
- 20200101 20201231

The following are invalid methods to enter dates, again using January 1, 2020 and December 31, 2020 as the dates:

- 2020/01/01 2020 12 31
- 2020 01 01 2020/12/31
- 2020/01/01 - 2020 12 31
- 2020 01 01 - 2020/12/31
- 2020/01/01 TO 2020 12 31
- 2020 01 01 TO 2020/12/31

The XDATES keyword is mandatory if performing Stage 1 processing only. The keyword is optional if performing combined Stage 1 and 2 processing and XDATES is present in the METPREP pathway. If XDATES is present for the METPREP pathway, AERMET will use the METPREP dates for extraction of site-specific or prognostic data if the ONSITE or PROG QAOUT files are not requested. If ONSITE or PROG QAOUT files are requested, then the site-specific or prognostic extraction uses the dates associated with XDATES in the ONSITE or PROG pathway.

### 3.5.5 LOCATION

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

<b>Syntax:</b>	LOCATION <i>site_id</i> <i>NWS_lat/long</i> <i>NWS_long/lat</i> [ <i>tadjust</i> ] [ <i>elevation</i> ]
<b>Type:</b>	Mandatory (Stage 1), Nonrepeatable, Reprocessed
<b>Order:</b>	Latitude ( <i>lat</i> ) and longitude ( <i>long</i> ) 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. Since data are not extracted from archived data, this identifier is used only to identify the site in the output files (reports from Stage 2). Prior to version 21DRF, 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 was read as a type character and not as an integer. This is no longer the case beginning with 21DRF so 3928 can be entered as 3928, instead of 03928. However, to avoid warnings in AERMOD, 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 ONSITE station identifier in the surface file generated by AERMET.

The measurement site or prognostic grid cell's latitude (*lat*) and longitude (*long*) can be entered in either order because AERMET distinguishes between the two by the suffix on each: N or S with the latitude and W or E with the longitude. For example, "38.4N 81.9W" will 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. Therefore, the latitude and longitude should always be specified as positive numbers.

The parameter, *tadjust*, is an optional adjustment factor that is subtracted from the reported hour to convert the time to local standard time. The default value is zero if omitted from the LOCATION keyword on the ONSITE or PROG pathway. Though optional, it should be included when the offset to local standard time is non-zero or when the last parameter,

*elevation*, is specified, which is also optional. If elevation is entered and the data is already in local standard time, a zero should be entered for *tadjust*. For stations west of Greenwich, England, i.e., the Prime Meridian (0° longitude), *tadjust* should be specified as a positive number when the data is in GMT. 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, users should verify if the data are reported in local Daylight Savings Time. If this is the case, then *tadjust* should be specified as 1 to return the data to local standard time, assuming that Daylight Savings Time was used throughout the entire data period. If the data period covers times when Daylight Savings Time is not used, then all hours should be set to Local Standard Time prior to AERMET processing.

The final parameter, *elevation*, refers to the station elevation above mean sea-level (MSL), in meters, and is optional with a default value of zero meters. Station elevation should be included, however, when the actual station elevation is non-zero since it will be used in the substitution hierarchy for missing station pressure data (see Section 5.5).

### 3.5.6 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 control file. This keyword is also used to specify the input file name to Stage 2. The syntax and type for the QAOUT keyword are:

<b>Syntax:</b>	QAOUT <i>extracted_data_filename</i>
<b>Type:</b>	Optional (Stage 1 only; Stage 1 and 2 combined), Nonrepeatable Mandatory (Stage 2 only) if reading ONSITE or PROG data, Nonrepeatable

The *qa\_output\_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 300 characters. Note that when running AERMET for Stage 1 only or a combined Stage 1 and 2 run, the QAOUT keyword is

optional. For a combined Stage 1 and 2 run, Stage 2 will use the internal AERMET arrays to read extracted data from Stage 1. However, if running AERMET for Stage 2 only, the QAOUT keyword is mandatory for Stage 2 to read the QA'd output. Unlike the SURFACE and UPPERAIR QAOUT files which contain variables needed for Stage 2, plus additional variables for quality assurance, all input variables for ONSITE or PROG data are output to the QAOUT file.

Quality assessment is an optional process, and the user does not have to perform a QA prior to merging the site-specific 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 are not checked.

Site-specific data may be reported more frequently than once per hour (see the OBS/HOUR keyword discussed below in Section 3.5.13). For observations more frequent than once per hour, the QA procedures operate on the sub hourly data and the hourly averaged data.

When 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 date and time of violation. The number of times the variable is missing, exceeds the upper bound or 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. Thus, it is up to

the user to review the QA summary information and, using sound meteorological principles and any regulatory guidance, either replace, modify, or keep the value in question.

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 using the RANGE keyword, as described below (Section 3.5.8). The user can QA additional variables by using the AUDIT keyword.

### 3.5.7 AUDIT

As mentioned in the previous section, there are only three weather elements that are tracked by default during 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:

<b>Syntax:</b>	AUDIT <i>osname1</i> ... <i>osnamen</i> or AUDIT ALL
<b>Type:</b>	Optional (Stage 1 or Stage 1 and 2 combined), Repeatable

where *osname1*, ..., *osnamen* are the internal AERMET names of the weather elements as defined in Table B-3 and Table B-4 in Appendix B. For the multi-level variables (e.g., temperature) only the two leading alphabetic characters can be specified (e.g., TT) or with a level such as TT01, TT02, etc., otherwise AERMET will terminate with an error, i.e., TTNN will result in an error. Every level where the variable appears will be QA'd. As many names can be specified on a single keyword that will fit within the 500-character limitation of a line. Since this keyword is repeatable, more than one AUDIT keyword can be used to define all the additional elements to track. Beginning with version 21DRF, if the user wishes to audit all variables, the user enters the word ALL after the keyword AUDIT. The case of the word ALL is case insensitive.

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.

### 3.5.8 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 by using the RANGE keyword. The syntax and type for the RANGE keyword are:

<b>Syntax:</b>	RANGE <i>osname lower_bound</i> <[=] <i>upper_bound missing_indicator</i>
<b>Type:</b>	Optional (Stage 1 or Stage 1 and 2 combined), Repeatable, Reprocessed

where *osname* is the internal AERMET name of the weather element as defined in Table B-3 and Table B-4 in 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 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. For the multi-level variables (e.g., wind speed and temperature), only the first two characters should be specified (e.g., WS and TT).

The default upper and lower bounds are multiplied by the multipliers in the units columns of Table B-3 and Table B-4 in Appendix B, therefore, the user must multiply any new upper and lower bounds by the same multiplier when entering the data on the RANGE keyword. For example, for precipitation PRCP, if the new upper bound is 120 mm, then the new upper bound entered with the RANGE keyword is 12000. However, the multiplier is not applied to the *missing\_indicator*.

### 3.5.9 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 several times throughout the model run (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:

<b>Syntax:</b>	NO_MISSING <i>osname1</i> ... <i>osnamen</i> Or NO_MISSING ALL
<b>Type:</b>	Optional (Stage 1 or Stage 1 and 2 combined), Repeatable

where *osname1*, ..., *osnamen* are the internal AERMET names of the weather elements to omit from the message file. Beginning with version 21DRF, if the user wishes to suppress messaging for all variables, then the word ALL can follow the keyword NO\_MISSING. 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.

### 3.5.10 OSHEIGHTS

AERMET provides two options to specify the measurement heights for 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 will 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 the 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 OSHEIGHTS 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:

<b>Syntax:</b>	OSHEIGHTS <i>height1 height2 ... heightn</i>
<b>Type:</b>	Optional if height information is provided in the data; otherwise, mandatory (Stage 1 or Stage 1 and 2 combined), 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 resolve the inconsistency so the data will process correctly.

### 3.5.11 DELTA\_TEMP

In addition to measuring ambient temperature directly, a site-specific data program may measure differences in temperature. These measurements can be between the levels where the ambient temperature is measured or independent 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:

<b>Syntax:</b>	DELTA_TEMP <i>index lower_height upper_height</i>
<b>Type:</b>	Optional (Stage 1 or Stage 1 and 2 Combined), Repeatable, Reprocessed

Each statement includes an index that corresponds to the temperature difference represented by the *lower\_heights* and *upper\_heights*. The *index* can range from one to three. At present, only DT01 is utilized in Stage 2.

### 3.5.12 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:

<b>Syntax:</b>	THRESHOLD <i>threshold_wind_speed</i>
<b>Type:</b>	Mandatory (Stage 1 or Stage 1 and 2 combined), 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. For applications involving prognostic data, the

recommended threshold is 0 m/s (EPA, 2023a) and AERMET will issue a warning if the threshold is not equal to the recommended value.

AERMET also imposes a minimum allowable wind speed for 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.

### 3.5.13 OBS/HOUR

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:

<b>Syntax:</b>	OBS/HOUR <i>n_obs</i> [ <i>average method</i> ]
<b>Type:</b>	Mandatory for data with more than 1 observation per hour (Stage 1 or Stage 1 and 2 combined), 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.

Beginning with version 21DRF, there is an optional parameter that can be specified for wind speed and wind direction averaging, scalar averaging or vector averaging. The default when no averaging method is specified is scalar averaging. Another way to specify scalar averaging, is for the user to enter SCALAR after the number of observations per hour. To specify vector averaging, the user can enter VECTOR after the number of observations per hour. The vector averaging approach is based on that discussed in Section 6.2.2 in EPA (2000). If vector averaging is used, the VECTORWS modeling option should be used in AERMOD.

### **3.6 MERGE**

Prior to version 21DRF, the MERGE pathway merged the upper air, surface, and any site-specific data prior to the final METPREP stage. Beginning with version 21DRF, this pathway is now obsolete. While executing, if AERMET encounters the MERGE pathway and associated keywords, AERMET will alert the user and ignore them. The warning messages are meant to allow easier transition for AERMET inputs that were formatted for AERMET versions prior to 21DRF.

### **3.7 METPREP**

This pathway is where the boundary layer parameters, used by the AERMOD dispersion model, are estimated. This pathway is also referred to as Stage 2. This is the second and final step following the previous data extraction pathways. Several of the keywords described previously are also used on this pathway in a nearly identical manner. Prior to version 21DRF, this was called Stage 3.

#### **3.7.1 DATA**

Prior to version 21DRF, this keyword was a reference to the output of the MERGE pathway. This keyword is now obsolete, and AERMET will ignore the keyword and associated datafile if present in the AERMET control file.

### 3.7.2 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:

<b>Syntax:</b>	MODEL <i>model_name</i>
<b>Type:</b>	Optional (Stage 2 or Stage 1 and 2 combined), Nonrepeatable

where *model\_name* identifies the dispersion model. The AERMOD model is the default model, making this keyword optional.

### 3.7.3 THRESH\_1MIN

In 2003, the 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).

The THRESH\_1MIN keyword specifies 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), users 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 THRESH\_1MIN keyword uses the following syntax:

<b>Syntax:</b>	THRESH_1MIN <i>threshold_speed</i>
<b>Type:</b>	Optional (Stage 2 or Stage 1 and 2 combined), 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 2. The Stage 2 report file documents whether the THRESH\_1MIN option has been used.

#### 3.7.4 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 (Greenwich Mean Time) to LST (Local Standard Time), since the time zone specified on the ONSITE pathway is likely referenced to local time. Beginning with version 23132, if the GMT to LST conversion is zero, AERMET will use the longitude from the LOCATION keyword to approximate the GMT to LST conversion for the sunrise/sunset times. If the approximated conversion is greater than 1, AERMET will issue a message that the approximate conversion will be used for sunrise and sunset times. Therefore, care should be taken when

using a GMT to LST conversion of zero as the approximated conversion may not be the actual conversion at that location.

For 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:

<b>Syntax:</b>	LOCATION <i>site_id</i> <i>source_lat/long</i> <i>source_long/lat</i> [ <i>tadjust</i> ]
<b>Type:</b>	Conditional (Stage 2 or combined Stage 1 and 2), Nonrepeatable
<b>Order:</b>	Latitude ( <i>lat</i> ) and longitude ( <i>long</i> ) 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 since AERMET distinguishes between the two by the suffix on each: N or S with the latitude and W or E with the longitude. For example, "38.4N 81.9W" will 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 the Greenwich England, i.e., the Prime Meridian (0° longitude), such as in the U.S.

### 3.7.5 NWS\_HGT

Several parameters computed for the dispersion model require the instrument height at which the measurement was taken. 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 control file. If there are no site-specific data input to AERMET, or for isolated hours when there are no site-specific data, then NWS data

may be substituted for the computations. However, instrument height is not one of the reported NWS parameters. The NWS\_HGT keyword is used to provide this information. The syntax and type are:

<b>Syntax:</b>	NWS_HGT <i>variable_name instrument_height</i>
<b>Type:</b>	Mandatory, Repeatable

The *variable\_name* specifies which meteorological instrument is being referenced and is followed by the *instrument\_height* in meters. Currently, there is only one variable name: WIND. Prior to the conversion to ASOS, the height of the wind instrument (anemometer) was about 6.7 meters or 9.1 meters. The height of wind instrumentation at ASOS sites is typically 10.1 meters or 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 the annual summaries prior to running Stage 2 to obtain the correct height to use with this keyword.

### 3.7.6 XDATES

Like 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. As noted previously in Sections 3.3.3, 3.4.3, and 3.5.4, the METPREP XDATES can be the controlling date window if a combined Stage 1 and 2 run is executed without the EXTRACT and QAOUT files in one or more of the SURFACE, UPPERAIR, or ONSITE/PROG pathways. The syntax and type are:

<b>Syntax:</b>	XDATES <i>YB/MB/DB [TO] YE/ME/DE</i> Or XDATES <i>YB/MB/DB [-] YE/ME/DE</i>
<b>Type:</b>	Optional (Stage 2 or Stage 1 and 2 combined), Nonrepeatable



*YB*, *MB* and *DB* are the beginning year, month, and day, respectively, of the data to merge and *YE*, *ME*, and *DE* are the ending year month and day, respectively. Beginning with version 21DRF, the year must be entered as a four-digit integer (e.g., 1992). 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 individual components of the start date or end date can be separated by spaces or the '/' character or no separator at all. However, the start date cannot be separated by spaces and the end date separated by '/' or vice-versa. Both dates must use the same delimiter. The complete start date and end date can be separated by a space, '- ', or the word "TO". The case of the word "TO" can be upper, lower, or a mix of cases. The following are valid methods to enter the dates, using January 1, 2020 and December 31, 2020 as the dates:

- 2020/01/01 2020/12/31
- 2020/01/01 TO 2020/12/31
- 2020/01/01 – 2020/12/31
- 2020 01 01 TO 2020 12 31
- 2020 01 01 – 2020 12 31
- 2020 01 01 2020 12 31
- 20200101 20201231

The following are invalid methods to enter dates, again using January 1, 2020 and December 31, 2020 as the dates:

- 2020/01/01 2020 12 31
- 2020 01 01 2020/12/31
- 2020/01/01 - 2020 12 31
- 2020 01 01 - 2020/12/31
- 2020/01/01 TO 2020 12 31
- 2020 01 01 TO 2020/12/31

The XDATES keyword is optional and if omitted, AERMET will determine the period of extraction based on the dates present in the input data (upper air, surface, site-specific, or prognostic).

### 3.7.7 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 meteorological variables that are affected and the option (*parameter*) to use. The syntax and type are:

<b>Syntax:</b>	METHOD <i>process parameter</i>
<b>Type:</b>	Optional (Stage 2 only Stage 1 and 2 combined), Repeatable

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, TEMP, and COARE.

#### 3.7.7.1 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. Prior to version 16216, randomization was disabled by default if the secondary keyword WIND\_DIR was not specified. Beginning with version 16216, AERMET's default behavior is to randomize NWS wind directions when the WIND\_DIR keyword is not specified. However, if the user wants a reminder as to how the data were processed, the RANDOM

parameter can be specified. WIND\_DIR is included in the METPREP pathway using the following format:

<b>Syntax:</b>	METHOD WIND_DIR RANDOM or NORAND
<b>Type:</b>	Optional (Stage 2 or Stage 1 and 2 combined), 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 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.

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.

### 3.7.7.2 REFLEVEL

The secondary keyword RELEVEL 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 RELEVEL 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.

Additionally, 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:

<b>Syntax:</b>	METHOD REFLEVEL SUBNWS
<b>Type:</b>	Optional (Stage 2 or combined Stage 1 and 2), Non-repeatable

### 3.7.7.3 ASOS\_ADJ

Beginning with version 11059, AERMET has been modified to add ½ knot (0.26 m/s) to all ASOS-based wind speeds to compensate for the bias introduced by truncation of wind speeds to whole knots, rather than rounding (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 1-minute ASOS wind data files generated with AERMINUTE (EPA, 2010).

The ½ knot ASOS wind speed adjustment is applied, by default, during Stage 2 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 2 METPREP pathway using the following format:

<b>Syntax:</b>	METHOD ASOS_ADJ NO_ADJ
<b>Type:</b>	Optional (Stage 2 or combined Stage 1 and 2), Non-repeatable

To document the source of the wind data in the Stage 2 OUTPUT file, 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, PROG, 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.

#### 3.7.7.4 STABLEBL

AERMET includes two options for stable boundary layer conditions, a Bulk Richardson Number approach to calculate surface friction velocity,  $u^*$  and temperature scale,  $\theta^*$  and an approach to adjust  $u^*$  under low wind stable conditions. Each method is detailed in the following sections.

#### BULKRN

AERMET includes an option to calculate  $u^*$  and  $\theta^*$  using a Bulk Richardson Number approach. This approach uses temperature differences between two heights for site-specific data using the METHOD STABLEBL BULKRN keyword on the METPREP pathway. To use the BULKRN approach, the temperature differences between the two heights must be included in the site-specific data using the DT01 variable in the Stage 1 inputs for ONSITE or PROG pathway. Additionally, the two heights for the temperature differences must be listed with the DELTA\_TEMP keyword in the Stage 1 input file with the ONSITE or PROG pathway. See Section 3.5.11 for more information about the temperature differences input to AERMET. The syntax for the BULKRN option is:

<b>Syntax:</b>	METHOD STABLEBL BULKRN
<b>Type:</b>	Optional (Stage 2 or combined Stage 1 and 2), Non-repeatable

## ADJ\_U\*

AERMET includes an option in Stage 2 processing to adjust the surface friction velocity ( $u^*$  or  $u_{star}$ ) for low wind speed stable conditions, based on Qian and Venkatram (2011) for most applications, such as NWS data. The option is selected by including the METHOD STABLEBL ADJ\_U\* keyword on the METPREP pathway. In addition, AERMET incorporated a different 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\* option is as follows:

<b>Syntax:</b>	METHOD STABLEBL ADJ_U*
<b>Type:</b>	Optional (Stage 2 or combined Stage 1 and 2), Non-repeatable

There are caveats with the use of ADJ\_U\* option in AERMET. AERMET will perform the adjust  $u^*$  calculations regardless of the presence of turbulence variables in the input data. However, as outlined in Appendix W (40 CFR Part 51), the use of adjusted  $u^*$  is prohibited when site-specific turbulence is input to AERMOD and AERMOD is run in DFAULT mode. AERMOD will issue an error and abort. The ADJ\_U\* option is considered a non-default option in AERMOD when site-specific data that include turbulence are included. There are options in AERMOD (added with version 21112) to allow the user to use meteorological data that uses the ADJ\_U\* option even if turbulence data are included in the AERMOD inputs. These options essentially ignore the input turbulence parameters. See the AERMOD User's Guide Section 3.5.9 for details (EPA, 2023c). The use of ADJ\_U\* and turbulence is 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 using ADJ\_U\* with turbulence data for regulatory modeling applications.

### 3.7.7.5 CCVR and TEMP

Beginning with version 13350, the AERMET program includes substitutions for missing cloud cover and temperature data based on linear interpolation across gaps of one or two 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. Additionally, 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 one or two 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 since key parameters needed for the convective height processing are not calculated. Substitution of temperature and cloud cover may allow for the needed parameters to be calculated and subsequently, the convective parameters to be calculated.

The cloud cover and temperature substitutions are applied by default unless the application involves both NWS and ONSITE surface data. 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 2. Options have also been incorporated in AERMET during Stage 2 that allow users to disable cloud cover and/or temperature substitutions, irrespective of the type(s) of data being processed. These Stage 2 options also allow users to activate these substitutions for cases with both NWS and ONSITE data. However, this could result in substitutions of an hour 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 one to two hours. Interpolations are only made based on non-interpolated values on both sides of the

data gap. In addition, substitutions for missing ONSITE temperature data are only applied for values from the same measurement level, if multi-level temperature data are available.

The options for users to disable or activate the cloud cover (CCVR) and temperature (TEMP) substitutions are included under the METHOD keyword in Stage 2. Unlike previous versions of AERMET, versions 21DRF and later can interpolate temperatures for hours 23 and 24 as these versions use internal arrays so AERMET can “read ahead” for substitution. For this reason, persistence is not used and the NOPERS option (no persistence) in previous versions of AERMET is obsolete and ignored by AERMET.

<b>Syntax:</b>	METHOD CCVR SUB_CC	(activates CCVR substitutions)
	or	
	METHOD CCVR NO_SUB	(disables CCVR substitutions)
	-----	
	METHOD TEMP SUB_TT	(activates TEMP substitutions)
	or	
	METHOD TEMP NOTSUB	(disables TEMP substitutions)
<b>Type:</b>	Optional (Stage 2 only or Stage 1 and 2 combined), Non-repeatable (for a given option of CCVR of TEMP)	

### 3.7.7.6 COARE

Beginning with version 23132, AERMET uses the COARE algorithms (Fairall et al., 2003) for processing observed or prognostic overwater data and replaces the need for the standalone AERCOARE processor (EPA, 2012). Evaluation of the implementation of COARE in AERMET can be found in EPA (2023d) and evaluation of prognostic data with COARE can be found in EPA (2023e). Guidance on the use of COARE with prognostic data can be found in U.S. EPA (2023a). The user can invoke COARE processing in Stage 2 of AERMET by invoking COARE with the METHOD keyword and can invoke additional options with COARE. The



syntax to invoke COARE or not to invoke COARE is listed below with more details about each parameter following. The default action when COARE is not listed in the input control file is to not invoke the COARE processing. If RUN\_COARE and NO\_COARE are both listed in the AERMET control file, AERMET will issue an error and abort processing. If AERMET encounters NO\_COARE with one of the options described below, those options are ignored and no COARE processing occurs. For COARE processing to be invoked, the following variables are also needed by AERMET: air temperature, wind speed and direction, relative humidity, and sea surface temperature. If relative humidity is not available, then the dewpoint temperature is needed in order to calculate relative humidity. If both relative humidity and dewpoint temperature are not available, COARE will not be invoked.

<b>Syntax:</b>	METHOD COARE RUN_COARE (activates COARE) or METHOD COARE NO_COARE (disables COARE)
<b>Type:</b>	Optional (Stage 2 only or Stage 1 and 2 combined), Non-repeatable (for a given activation status of COARE)

To invoke the options described below, METHOD COARE RUN\_COARE must be listed in the AERMET control file.

WARM or NO\_WARM

When invoked with METHOD COARE, the WARM option allows for the use of the COARE algorithms' warm layer options. The NO\_WARM option explicitly tells AERMET not to invoke the warm layer options. The default action when invoking COARE is to not use the warm layer options. The syntax of the warm layer options are:

<b>Syntax:</b>	METHOD COARE WARM (activates COARE warm layer processing) or METHOD COARE NO_WARM (disables COARE warm layer processing)
<b>Type:</b>	Optional (Stage 2 only or Stage 1 and 2 combined), Non-repeatable (for a given warm layer status of COARE; Repeatable with other COARE options)

If both COARE WARM and COARE NO\_WARM are encountered in the AERMET control file, AERMET will issue an error and abort processing.

For the warm layer option, the following variables are also needed in addition to the core variables (temperature, wind, and relative humidity): solar insolation, downward longwave radiation, and in the absence of downward longwave radiation, ceiling height and cloud cover are needed.

**At this time, the recommendation for COARE processing is not to invoke the warm layer option for regulatory applications with either observed or prognostic data as it has not been fully evaluated.**

#### COOL or NO\_COOL

When invoked with METHOD COARE, the COOL option allows for the use of the COARE algorithms' cool skin options. The NO\_COOL option explicitly tells AERMET not to invoke the cool skin options. The default action when invoking COARE is to not use the cool skin options. The syntax of the cool skin options are:

<b>Syntax:</b>	METHOD COARE COOL (activates COARE cool skin processing)  or  METHOD COARE NO_COOL (disables COARE cool skin processing)
<b>Type:</b>	Optional (Stage 2 only or Stage 1 and 2 combined), Non-repeatable (for a given cool skin status of COARE; Repeatable with other COARE options)

If both COARE COOL and COARE NO\_COOL are encountered in the AERMET control file, AERMET will issue an error and abort processing.

For the cool skin option, the following variables are also needed in addition to the core variables (temperature, wind, and relative humidity): solar insolation, downward longwave radiation, and in the absence of downward longwave radiation, ceiling height and cloud cover are needed.

**At this time, the recommendations for COARE processing is not to invoke the cool skin option for regulatory applications with either observed or prognostic data as it has not been fully evaluated.**

#### Surface roughness options

With the COARE processing, there are three options for calculating surface roughness,  $z_o$ :

- Calculate  $z_o$  based on surface friction velocity  $u^*$
- Calculate  $z_o$  based on surface friction velocity  $u^*$  and wave period based on Oost et. al, (2002)
- Calculate  $z_o$  based on significant wave height and period based on Taylor and Yelland (2001)

The syntax for the surface roughness options are:

<b>Syntax:</b>	<p>METHOD COARE ZO_U* (z<sub>0</sub> as a function of u*)</p> <p>or</p> <p>METHOD COARE ZO_U*_PER (z<sub>0</sub> as a function of u* and significant wave period)</p> <p>or</p> <p>METHOD COARE ZO_PER_HT (z<sub>0</sub> as a function of wave measurements)</p>
<b>Type:</b>	Optional (Stage 2 only or Stage 1 and 2 combined), Non-repeatable (for a given surface roughness option of COARE; Repeatable with other COARE options)

If more than one of the surface roughness options is chosen, AERMET will issue an error and abort. If no surface roughness option is chosen, the default method is to use the surface friction velocity to calculate z<sub>0</sub>. Also, if ZO\_U\*\_PER or ZO\_PER\_HT is selected and wave measurements are not available, the wave height and period are calculated based on relationships for a well developed sea state (Taylor and Yelland, 2001).

### Mixing height options

With COARE processing, there are six options to calculate mixing heights (listed with AERCOARE options for reference):

1. AERMET default; use site-specific mixing heights using AERMET's default methodology where for convective hours, site-specific mixing heights are used for convective mixing heights and mechanical mixing heights are calculated. For stable hours, the site-specific mixing height is used for the mechanical mixing height. For all hours, the mechanical mixing height is smoothed. This option is not available in AERCOARE.
2. Use the site-specific mixing heights for both convective and mechanical mixing heights for each hour (convective height equals mechanical height each hour with no smoothing of mechanical mixing heights). This option is the default mixing height option in AERCOARE, AERCOARE option mixopt=0.



For options MIX\_DEFAULT, MIX\_OBS, ZIC\_OBS\_NS, and ZIC\_OBS\_SM, site-specific mixing heights are required and AERMET will issue an error if no site-specific mixing heights are input. Options CALC\_ZI\_NS, and CALC\_ZI\_SM do not require site-specific heights. As with the other COARE options, if more than one mixing height option is selected, AERMET will issue an error and abort.

In addition to the options described above, there are other options available for COARE processing: SSTDEPTH (Section 3.8), ZI\_GUST (Section 3.9), ZI\_MIN (Section 3.10), MIN\_MOL (Section 3.11), and DEF\_VPTG (Section 3.12). At this time, there is no recommended guidance on specific values for ZI\_GUST, ZI\_MIN, MIN\_MOL, and DEF\_VPTG, but default values can be routinely used for regulatory applications using COARE.

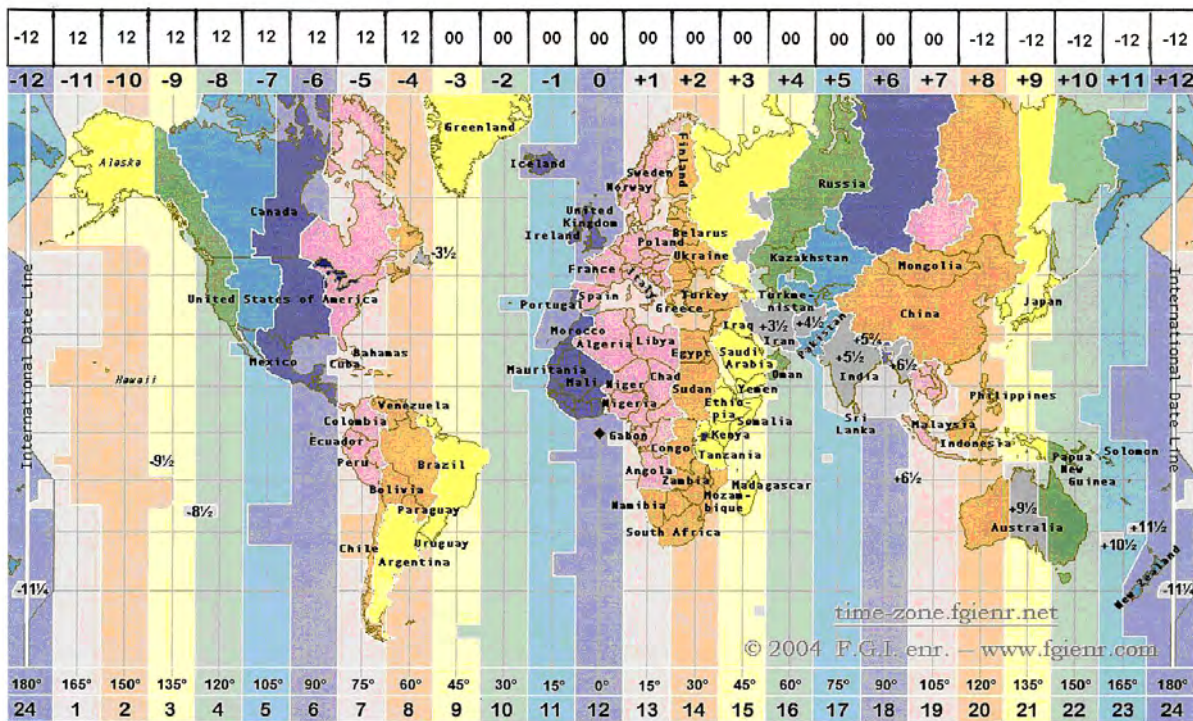
#### 3.7.7.7 SUNRISE

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 of 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  $\pm 1$  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 3-1). 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. This approach computes a ‘pseudo’ time zone based on the LOCATION 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 spans pseudo-zones -9, -10, and -11 based on longitude. This is not an uncommon occurrence.

Figure 3-2 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 3-1. 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 3-1. Time Zone Boundaries (with preferred sounding time across top).**

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	--

**Figure 3-2. Preferred sounding time by time zone.**

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 3.7.8. When searching 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 2 has been defined: UASELECT. The syntax of the new UASELECT option is as follows:

<b>Syntax:</b>	METHOD UASELECT SUNRIS(E)
<b>Type:</b>	Optional (Stage 2 only or Stage 1 and 2 combined), Non-repeatable

Note that the 'E' on 'SUNRISE' is optional and can be omitted.

### 3.7.8 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 2. The syntax of the UAWINDOW keyword is as follows:

<b>Syntax:</b>	UAWINDOW <i>window_begin</i> <i>window_end</i>
<b>Type:</b>	Optional (Stage 2 only or Stage 1 and 2 combined), Non-repeatable

where *window\_begin* represents the beginning of the sounding window and *window\_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 is 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 can 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 will select the 12Z sounding. However, if soundings were available for 9Z and 13Z, AERMET will 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 UAWINDOW is used in conjunction with the SUNRISE method, *window\_begin* and *window\_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.

### 3.7.9 Surface characteristics

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 effective surface roughness length ( $z_0$ ). Beginning with version 21DRF, AERMET allows for the input of hourly surface characteristics for overwater applications for the PROG pathway. For all other applications, the surface characteristics are input via the methods described below. For overwater applications with the PROG pathway, the surface characteristics input methods described below are used to fill in missing values for the hourly surface characteristics.

AERMET requires two sets of surface characteristics (primary and secondary) in the METPREP pathway when the SUBNWS option is specified and both ONSITE and SURFACE data are provided (including 1-minute ASOS wind data). If either ONSITE (PROG) 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`. These keywords specify the temporal frequency, number of sectors, and the site characteristics (albedo, Bowen ratio, and 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 of characteristics should be added to the METPREP pathway immediately after the primary set when defining both a primary and secondary set of surface characteristics. For the primary set of characteristics, the `FREQ_SECT` keyword must appear before `SECTOR` and `SITE_CHAR` keywords. The same is true for the secondary set of characteristics; `FREQ_SECT2` must appear before the `SECTOR2` and `SITE_CHAR2` keywords. The keywords for the primary characteristics should be grouped together and the secondary characteristics should be grouped together. Each keyword is detailed below.

3.7.9.1 Frequency and number of sectors: FREQ\_SECT or FREQ\_SECT2

The FREQ\_SECT and FREQ\_SECT2 keywords define how often the surface characteristics change (the *frequency*), or alternatively, the period over which these characteristics remain constant, and the number of non-overlapping sectors into which the 360°-compass is divided (*number\_of\_sectors*).

The syntax and type for the FREQ\_SECT and FREQ\_SECT2 keywords are as follows:

<b>Syntax:</b>	FREQ_SECT <i>frequency number_of_sectors</i> [ <i>year_list</i> ] or FREQ_SECT2 <i>frequency number_of_sectors</i> [ <i>year_list</i> ]
<b>Type:</b>	Mandatory (Stage 2 or Stage 1 and 2 combined), Nonrepeatable (if no years listed), Repeatable (if years listed), Reprocessed
<b>Order:</b>	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 for the Northern Hemisphere:

<u>Season #</u>	<u>Season</u>	<u>Months</u>
1	Winter	December, January, February
2	Spring	March, April, May
3	Summer	June, July, August
4	Autumn	September, October, November

For the Southern Hemisphere the site characteristics are distributed by month as follows:

<u>Season #</u>	<u>Season</u>	<u>Months</u>
1	Winter	June, July, August
2	Spring	September, October, November
3	Summer	December, January, February
4	Autumn	March, April, May

When entering the surface characteristics by season, beginning with version 21DRF, AERMET will use the location of the primary and secondary site to determine the hemisphere of the site and assign the seasonal characteristics to the correct months. For example, for a location in the Southern Hemisphere, the user does not have to assign summer surface characteristics to winter in AERMET to account for the fact that AERMET previously used Northern Hemisphere months for season assignments (i.e., June-August as spring). The user now enters summer surface characteristics to summer and AERMET will assign the correct months, June-August for the Northern Hemisphere, and January, February, and December, for the Southern Hemisphere.

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*. Beginning with version 21DRF, the user has the option to list which year or years go with a specific set of surface characteristics if performing a multi-year run of AERMET with the optional *year\_list*. This is to allow the user to calculate boundary layer parameters for multiple years without running AERMET separately for each year if surface characteristics change year by year. For a more detailed description and example, see Section 3.7.9.5. The year list can be a single year, a list of years separated by commas or spaces, or a range of years, i.e., 2010-2015.

### 3.7.9.2 Defining sectors: SECTOR or SECTOR2

A SECTOR statement defines the beginning and ending wind direction sector for which the surface characteristics are applied. The syntax and type of this keyword are:

<b>Syntax:</b>	SECTOR <i>sector_index beginning_direction ending_direction</i> or SECTOR2 <i>sector_index beginning_direction ending_direction</i>
<b>Type:</b>	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, must cover the full circle (360°), and must be defined so that the end of one sector corresponds to the beginning of the next sector. 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 5.6.3.1 for additional discussion about sectors.

### 3.7.9.3 Specification of surface characteristics: SITE\_CHAR or SITE\_CHAR2

The site characteristics are specified on the SITE\_CHAR and SITE\_CHAR2 keywords, with one statement for each combination of period and wind sector. The syntax and type for these keywords are:

<b>Syntax:</b>	SITE_CHAR <i>frequency_index sector_index albedo Bowen roughness</i> or SITE_CHAR2 <i>frequency_index sector_index albedo Bowen roughness</i>
<b>Type:</b>	Mandatory (Stage 2), 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 will 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 0.9 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 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 in 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 3-1 through Table 3-5, 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 3-1. Albedo of Ground Covers by Land Use and Season**

Land-Use	Spring	Summer	Autumn	Winter
Water (fresh & salt)	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 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 applicable. For bodies of water, it is assumed that the surface is frozen.

**Table 3-2. 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 3-3. Daytime Bowen Ratio 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



**Table 3-4. 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 3-5. 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

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, 2020).

#### 3.7.9.4 Optional keywords AERSURF and AERSURF2

AERMET includes optional keywords, AERSURF and AERSURF2 under the METPREP pathway, which can be used to specify separate external files which contain the 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, 2020), without requiring the user to copy-and-paste the results into the AERMET input file. The syntax of the AERSURF and AERSURF2 keywords is as follows:

<b>Syntax:</b>	AERSURF <i>primary_surfchar_filename</i> [ <i>year_list</i> ] AERSURF2 <i>secondary_surfchar_filename</i> [ <i>year_list</i> ]
<b>Type:</b>	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, and *year\_list* refers to the list of years as described in Section 3.7.9.1.

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.

#### 3.7.9.5 Optional yearly assignment of surface characteristics

As discussed in Section 3.7.9.1, the user can assign specific surface characteristics to each year in a multi-year AERMET run. The year assignment can also be done for an AERMET

run that is for a single run. The addition of this assignment in AERMET is to allow the user to execute one AERMET run for a multi-year AERMET dataset versus running each year separately in Stage 2 (old Stage 3). For example, prior to version 21DRF, if processing AERMET for a 5-year dataset and year 1 was a dry year and year 2 was wet, or year 3 had a change in number of sectors than other years, then Stage 2 would have to be processed separately for each year and then the resulting outputs had to be concatenated together to create a single meteorological dataset for input to AERMOD. Beginning with version 21DRF, the user can enter a set of surface characteristics and assign them to one or more years of the processing period. To invoke the multi-year capability in AERMET, the user enters the years assigned to the specific set of surface characteristics after the number of sectors associated with the site with the `FREQ_SECT` or `FREQ_SECT2` keyword. The use of a year list is independent for `FREQ_SECT` and `FREQ_SECT2` if both are specified. That is to say, the user can specify multiple surface characteristics for the primary site but use constant set of surface characteristics for all years for the secondary site. A caveat to using a year list is that all years in the AERMET run must be accounted for in the lists. If multiple surface characteristics are used for a site, then each year must be accounted for in the list(s).

The following shows the format for defining both a primary and a secondary set of surface characteristics in the METPREP pathway for the period 2016 to 2020. All years have the same number of sectors but 2016, 2018, and 2019 are dry years for the primary site, and 2017 and 2020 are average moisture conditions for the primary site. For the secondary site, 2016, 2017, and 2020 are wet years, 2018 is a dry year, and 2019 is an average year. The input format would be:

\*\* Primary Surface Characteristics, 2016, 2018, 2019

FREQ_SECT	frequency	number_of_sectors	2016	2018	2019
SECTOR	sector_index	beginning_direction	ending_direction		
SITE_CHAR	frequency_index	sector_index	albedo	Bowen	roughness

\*\* Primary Surface Characteristics, 2017 and 2020

FREQ_SECT	frequency	number_of_sectors	2017	2020	
SECTOR	sector_index	beginning_direction	ending_direction		
SITE_CHAR	frequency_index	sector_index	albedo	Bowen	roughness

\*\* Secondary Surface Characteristics, 2016, 2017, and 2020

FREQ_SECT2	frequency	number_of_sectors	2016	2017	2020
SECTOR2	sector_index	beginning_direction	ending_direction		
SITE_CHAR2	frequency_index	sector_index	albedo	Bowen	roughness

\*\* Secondary Surface Characteristics, 2018

FREQ_SECT2	frequency	number_of_sectors	2018		
SECTOR2	sector_index	beginning_direction	ending_direction		
SITE_CHAR2	frequency_index	sector_index	albedo	Bowen	roughness

\*\* Secondary Surface Characteristics, 2019

FREQ_SECT2	frequency	number_of_sectors	2019		
SECTOR2	sector_index	beginning_direction	ending_direction		
SITE_CHAR2	frequency_index	sector_index	albedo	Bowen	roughness

Using the AERSURF and AERSURF2 keywords the format would be:

```
** Primary Surface Characteristics, 2016, 2018, 2019
   AERSURF    filename1 2016 2018 2019

** Primary Surface Characteristics, 2017 and 2020
   AERSURF    filename1 2017 2020

** Secondary Surface Characteristics, 2016, 2017, and 2020
   AERSURF2   filename2 2016 2017 2020

** Secondary Surface Characteristics, 2018
   AERSURF2   filename2 2018

** Secondary Surface Characteristics, 2019
   AERSURF2   filename2 2019
```

The primary set of characteristics will be applied for those hours in which the data are used when the site-specific data are provided. Likewise, the primary characteristics will be applied to the NWS surface data if site-specific data are omitted from the application and only one set of surface characteristics is required. If both site-specific 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 site-specific data for those hours in which site-specific 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.**

### 3.8 SSTDEPTH

Beginning with version 23132 and the addition of the COARE algorithms in AERMET, AERMET allows for two options to specify a measurement depth of sea surface temperature (ONSITE variable TSEA) for COARE calculations. One option is to explicitly specify the measurement depths with the input data file using the ‘ZDEP’ variable on the READ keyword. With this option, the ‘ZDEP’ variable will need to be included for each observation period within the data file. This method allows for the measurement depth to vary hour by hour.

The SSTDEPTH keyword on the METPREP pathway provides an alternative approach for specifying TSEA depths. The syntax and type for the SSTDEPTH keyword are as follows:

<b>Syntax:</b>	SSTDEPTH <i>SST measurement depth</i>
<b>Type:</b>	Optional

If the SSTDEPTH keyword is specified and the ‘ZDEP’ variable is also defined on the READ keyword, AERMET will use the depth based on the SSTDEPTH keyword to override the depth variable that may be present in the data file. This is analogous behavior to the OSHEIGHTS keyword and ‘HTnn’ variables as discussed in Section 3.5.10. If TSEA measurements are listed in the data file but no measurement depths are included via the ‘ZDEP’ variable or SSTDEPTH keyword, a default SST depth of 0.5 m will be used.

### 3.9 ZI\_GUST

Beginning with version 23132 and the addition of the COARE algorithms in AERMET, AERMET uses a mixing height for COARE gust calculations. The default height is 600 m. AERMET allows the user to override the default mixing height to use for gust calculations in COARE using the ZI\_GUST keyword. The syntax and type for the ZI\_GUST keyword are as follows:

<b>Syntax:</b>	<i>ZI_GUST mixing height for COARE gust calculations</i>
<b>Type:</b>	Optional

If the ZI\_GUST keyword is not included, the default value of 600 m is used in COARE calculations.

### 3.10 ZI\_MIN

Beginning with version 23132 and the addition of the COARE algorithms in AERMET, there is a minimum convective and mechanical mixing height allowed by AERMET to output to AERMOD. The default minimum mixing height is 25 m. AERMET allows the user to override the default minimum mixing height from COARE using the ZI\_MIN keyword. This option only affects mixing heights calculated as part of the COARE processing and not for other applications. The syntax and type for the ZI\_MIN keyword are as follows:

<b>Syntax:</b>	<i>ZI_MIN minimum mixing height output by AERMET</i>
<b>Type:</b>	Optional

If the ZI\_MIN keyword is not included, the default value of 25 m is used in COARE calculations.

### 3.11 MIN\_MOL

Beginning with version 23132 and the addition of the COARE algorithms in AERMET, there is a minimum absolute value of Monin-Obukov length allowed by AERMET to output to AERMOD. The default value is 5 m. AERMET allows the user to override the default minimum Monin-Obukhov length output by COARE using the MIN\_MOL keyword. This option only affects Monin-Obukhov lengths calculated as part of the COARE processing and not for other applications. The syntax and type for the MIN\_MOL keyword are as follows:

<b>Syntax:</b>	MIN_MOL <i>absolute value of minimum Monin-Obukhov length output by AERMET</i>
<b>Type:</b>	Optional

If the MIN\_MOL keyword is not included, the default value of 5 m is used in COARE calculations.

### 3.12 DEF\_VPTG

Beginning with version 23132 and the addition of the COARE algorithms in AERMET, there is a default value of potential temperature gradient output by COARE in AERMET. This value is used when hourly values of the gradient are not available. The default value is 0.01 (C/m) and is only applicable to applications using COARE. The syntax and type for the DEF\_VPTG keyword are as follows:

<b>Syntax:</b>	DEF_VPTG <i>default potential temperature lapse rate</i>
<b>Type:</b>	Optional

If the DEF\_VPTG keyword is not included, the default value of 0.01 (C/m) is used in COARE calculations.



### 3.13 Output from Stage 2: OUTPUT and PROFILE

AERMET Stage 2 processing creates two output files to be input into 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:

<b>Syntax:</b>	OUTPUT <i>parameter_filename</i>
<b>Type:</b>	Mandatory (Stage 2 only or Stage 1 and 2 combined), 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 described in Appendix C, Section C. 2. The contents of this file are:

- Year
- Month (1 - 12)
- Julian Day (1 - 366)
- Hour (1 - 24)
- Sensible heat flux, H (Watts/meter<sup>2</sup>)
- 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,  $z_0$  (meters)
- Bowen ratio,  $B_0$
- Albedo,  $r(\phi)$
- 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)
- 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, PROG=prognostic data)
- Wind data source flag (OS = ONSITE pathway input file, SFC = SURFACE pathway input file)
- Substitution flag (NoSubs = No substitution, Sub\_CC = substituted cloud cover, Sub\_TT = substituted temperature, Sub\_CC-TT = substituted cloud cover and temperature)

The second file to be written during Stage 2 contains profile (multilevel) data as identified on the PROFILE keyword. The syntax and type are:

<b>Syntax:</b>	PROFILE <i>profile_filename</i>
<b>Type:</b>	Mandatory (Stage 2 only or Stage 1 and 2 combined), 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.

If 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 described in Appendix C Section C. 2 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
- 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,  $\sigma_{\theta}$  (degrees)
- Standard deviation of the vertical wind speed fluctuations,  $\sigma_w$  (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 if 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 3.7.7.2.

### **3.14 Recommendations for running overwater applications in AERMET**

With the inclusion of COARE in AERMET version 23132, the following options are recommended for COARE processing, for both observed and prognostic data. Note, for version 23132 of AERMET and version 23132 of AERMOD, the use of COARE is considered a beta option in AERMOD and the BETA option must be used with the AERMOD MODELOPT keyword (EPA, 2023c). Deviations from the recommended guidance should be done in consultation with the appropriate reviewing authority and Regional Office. Recommendations are as follows:

- For prognostic data, the user has the option to use the pass-through option or use COARE. At this time, based on evaluations (EPA, 2023e), the recommended approach is to use COARE with prognostic data.
- The use of the warm layer and cool skin options should not be used as they have not been fully evaluated.
- The surface roughness values should be based on the methodology of the ZO\_U\* option with COARE. The methods based on wave data have not been fully evaluated.

- When using data with input mixing heights, the recommended mixing height option is MIX\_OBS (use observed mixing heights for convective mixing heights for convective hours and mechanical mixing heights for all hours with no smoothing of mechanical mixing heights).
- When using data with no input mixing heights, the recommended mixing height option is CALC\_ZI\_SM (calculate mixing heights with smoothing).
- The use of the default value of 600 m for the mixing height used for gust calculations (ZI\_GUST, Section 3.9) is recommended. The user does not need to use the ZI\_GUST keyword to use the default 600 m.
- The use of the default value of 25 m for the minimum value of mixing height (ZI\_MIN, Section 3.10) is recommended. The user does not need to use the ZI\_MIN keyword to use the default 25 m.
- The use of the default value of 5 m for the minimum absolute value of Monin-Obukhov length (MIN\_MOL, Section 3.11) is recommended. The user does not need to use the MIN\_MOL keyword to use the default 5 m.
- The use of the default value of 0.05 K/m for potential temperature lapse rate (DEF\_VPTG, Section 3.12) is recommended when no user input potential temperature lapse rate is used. The user does not need to use the DEF\_VPTG keyword to use the default potential temperature lapse rate

## **4.0 Example AERMET runs**

The following are two examples of an AERMET run from start to finish. The first example is a case that is most often used for AERMET and AERMOD applications, which utilize National Weather Service data for the surface and upper air data. The second example builds upon the first in that the NWS example is used in conjunction with site-specific data. Each example will show each stage's input and output along with the message and report files. For the purposes of showing how AERMET functions, each data source will be its own AERMET Stage 1 run.

### **4.1 National Weather Service data**

#### **4.1.1 Surface data extraction**

The first example extracts and QAs National Weather Service surface data for Albany, NY, for a ten-day period of March 1 through March 10, 1988. Figure 4-1 shows the Stage 1 control file, EX01\_SURFACE.INP. The raw surface data are CD-144 format and extracted QA data will be written to SURFACE\_EXTRACT.TXT and SURFACE\_QAOUT.TXT, respectively. Note that for QA, no additional variables are requested for auditing so auditing will be limited to winds and temperature. The report file and message files are EX01\_S1\_SURFACE\_REPORT.TXT and EX01\_S1\_SURFACE\_MESSAGE.TXT, respectively. Note that filenames do not have to have “.txt” extension, but for the purposes of the example, “.txt” extensions are used for easier opening in a text editor.

```

JOB
  REPORT   EX01_S1_SURFACE_REPORT.TXT
  MESSAGES EX01_S1_SURFACE_MESSAGE.TXT

SURFACE

  DATA    S1473588.144  CD144  1
  EXTRACT  SURFACE_EXTRACT.TXT
  QAOUT    SURFACE_QAOUT.TXT

  XDATES   1988/3/1  TO  1988/3/10

  LOCATION 14735  42.75N  73.8W  0  83.8

** 725180 14735 ALBANY COUNTY AP                US US NY KALB +42750 -073800 +00838

```

**Figure 4-1. Control file to extract and QA NWS surface data.**

To execute AERMET Stage 1 for this example, the user will type the following at the command prompt:

```
aermet.exe EX01_SURFACE.INP
```

assuming the control file and AERMET executable are in the same folder. Processing information will be written to the screen. If the user wishes to have that information written to a text file, the user will type the following at the command prompt:

```
aermet.exe EX01_SURFACE.INP > example_run.txt
```

The contents of example\_run.txt are shown in Figure 4-2 and show the AERMET processing. The first line lists the start date and time of the AERMET processing. The next ten lines notify the user of the extraction dates followed by ten lines denoting each day's data are being QA'd. The final messages are that AERMET completed successfully followed by the AERMET processing end date and time.

```

START PROCESSING DATE/TIME: MAY 19, 2022 14:57:05 PM
Stage 1: Extracting surface data for month/day/year 03/01/1988 LST
Stage 1: Extracting surface data for month/day/year 03/02/1988 LST
Stage 1: Extracting surface data for month/day/year 03/03/1988 LST
Stage 1: Extracting surface data for month/day/year 03/04/1988 LST
Stage 1: Extracting surface data for month/day/year 03/05/1988 LST
Stage 1: Extracting surface data for month/day/year 03/06/1988 LST
Stage 1: Extracting surface data for month/day/year 03/07/1988 LST
Stage 1: Extracting surface data for month/day/year 03/08/1988 LST
Stage 1: Extracting surface data for month/day/year 03/09/1988 LST
Stage 1: Extracting surface data for month/day/year 03/10/1988 LST
Stage 1: QA'ing surface data for month/day/year 03/01/1988 LST
Stage 1: QA'ing surface data for month/day/year 03/02/1988 LST
Stage 1: QA'ing surface data for month/day/year 03/03/1988 LST
Stage 1: QA'ing surface data for month/day/year 03/04/1988 LST
Stage 1: QA'ing surface data for month/day/year 03/05/1988 LST
Stage 1: QA'ing surface data for month/day/year 03/06/1988 LST
Stage 1: QA'ing surface data for month/day/year 03/07/1988 LST
Stage 1: QA'ing surface data for month/day/year 03/08/1988 LST
Stage 1: QA'ing surface data for month/day/year 03/09/1988 LST
Stage 1: QA'ing surface data for month/day/year 03/10/1988 LST

AERMET FINISHED SUCCESSFULLY

END PROCESSING DATE/TIME: MAY 19, 2022 14:57:05 PM

```

**Figure 4-2. Processing steps for NWS surface data extraction.**

Figure 4-3 shows the processing messages contained in EX01\_S1\_SURFACE\_MESSAGE.TXT. Messages that start with ‘W’ are warning messages, ‘I’ are informational messages, ‘E’ are error messages, and ‘Q’ are quality assurance messages. Refer to Appendix D for message definitions. The very first message is a warning message indicating that too many fields were found with the DATA keyword and that the blocking factor or type was not needed. This is in reference to the number 1 found after the CD144 format keyword with the SURFACE DATA keyword. The next message, I01, indicates that Stage 1 processing is being performed. Message I59 indicates the ASOS commission date of the station. The first occurrence of message I40 indicates that SURFACE extraction has begun with the processing start date and time. Messages I46 through I56 indicate the number of observations that are extracted, retained or valid, duplicate observations, overwritten observations, and calms. The second I40 message indicates the date and time that SURFACE extraction ended. The remaining messages are quality assurance messages and give the date and times, in Local



Standard Time, of the observations that were flagged as calm. Note that there are twenty Q43 messages, corresponding to the number of observations flagged as calm with the I56 message.

Figure 4-4 through Figure 4-6 show the contents of the report file, EX01\_S1\_SURFACE\_REPORT.TXT.

**Figure 4-4** shows the file summary of Stage 1. Shown are the AERMET version number, start processing time, and the name of the AERMET control file. Following is the input summary of the stage (Stage 1) and the filenames of input and output files for each path. If a path is not being processed, AERMET will denote by listing the path along with “NO PROCESSING REQUESTED.” For paths being processed, the file status along with the filename is listed. For optional operations, such as debugging, if the DEBUG option is not chosen, AERMET will list “NO FILE” for the filename. Station information (site identifier, coordinates, time adjustment, elevation) for upper air, surface, site-specific, or prognostic is also summarized along with the requested dates for the station.

Figure 4-5 shows the QA summary of the surface extraction. Since no specific variables were requested for auditing via the AUDIT keyword, only temperature, wind direction, and wind speed were audited by default. The report file shows the audited variables with their missing value indicators and lower and upper bounds. Note that the missing value indicators are not subject to the conversion factor for the surface variables while the bounds have the conversion factor applied (See Table B-1 in Appendix B). Next, follows the number of observations read in for each variable, the number of missing observations, number of observations that exceed the lower and upper bounds, and percent of observations that were accepted. In this example, no data are missing so all data are accepted. The final summary lists the following:

- number of calm wind observations,
- number of observations with zero wind direction and non-zero wind speed,

- number of observations with non-zero wind direction and zero wind speed,
- number of observations flagged as variable winds,
- number of observations where the temperature is less than the dewpoint,
- number of observations with precipitation but no weather code and,
- number of observations with a weather code but no precipitation.

Figure 4-6 shows the message summary portion of the report file. The message file summarizes the number of each type of message: error, warning, information, and quality assurance messages. If the number of messages for a specific message type is greater than zero, then AERMET also issues the number of each message code associated with the message type. For this example, there are no error messages and there is one warning message, W01. There are nine information messages distributed among I01, I40, I46, I47, I50, I53, I56, and I59. There is one QA message, Q43. After the message summary, AERMET notifies the user that AERMET completed successfully, along with the end date and time of AERMET processing.

Finally, Figure 4-7 shows the format of the EXTRACT file, SURFACE\_EXTRACT. The QAOUT file has a similar format. The header information gives the AERMET version, location information (station identifier, coordinates, time conversion and elevation). Next, follows the file type (EXTRACT or QAOUT), processing dates and the header for the data columns. If audited variables used different defaults for missing or bound values, those will be indicated as well in the header. Following the data headers are the actual data that are formatted as described in Section C. 1. Of Appendix C. For variable names, see Table B-1 in Appendix B.

SURFACE	W01	SURF_PATH	TOO MANY FIELDS 4 FOR DATA KEYWORD; BLOCKING FACTOR AND/OR TYPE NOT NEEDED
	I01	READINP	PROCESSING STAGE 1
SURFACE	I59	SF_TEST	STATION 14735 ASOS COMMISSION DATE: 19950801
SURFACE	I40	SF_PROC	SURFACE EXTRACTION BEGIN: 20220519 14:57:05
SURFACE	I46	SF_PROC	NUMBER OF EXTRACTED SURFACE OBSERVATIONS: 240
SURFACE	I47	SF_PROC	NUMBER OF RETAINED OBSERVATIONS: 240
SURFACE	I50	SF_PROC	NUMER OF DUPLICATE OBSERVATIONS NOT USED: 0
SURFACE	I53	SF_PROC	NUMBER OF OVERWRITTEN OBSERVATIONS: 0
SURFACE	I56	SF_PROC	NUMBER OF OBSERVATIONS FLAGGED AS CALM 20
SURFACE	I40	SF_PROC	SURFACE EXTRACTION END: 20220519 14:57:05
SURFACE	Q43	SF_AUDIT	19880302 HR 02 CALM WIND
SURFACE	Q43	SF_AUDIT	19880302 HR 03 CALM WIND
SURFACE	Q43	SF_AUDIT	19880302 HR 04 CALM WIND
SURFACE	Q43	SF_AUDIT	19880302 HR 05 CALM WIND
SURFACE	Q43	SF_AUDIT	19880302 HR 06 CALM WIND
SURFACE	Q43	SF_AUDIT	19880302 HR 07 CALM WIND
SURFACE	Q43	SF_AUDIT	19880303 HR 19 CALM WIND
SURFACE	Q43	SF_AUDIT	19880303 HR 21 CALM WIND
SURFACE	Q43	SF_AUDIT	19880305 HR 24 CALM WIND
SURFACE	Q43	SF_AUDIT	19880306 HR 01 CALM WIND
SURFACE	Q43	SF_AUDIT	19880306 HR 02 CALM WIND
SURFACE	Q43	SF_AUDIT	19880306 HR 03 CALM WIND
SURFACE	Q43	SF_AUDIT	19880306 HR 04 CALM WIND
SURFACE	Q43	SF_AUDIT	19880306 HR 05 CALM WIND
SURFACE	Q43	SF_AUDIT	19880306 HR 06 CALM WIND
SURFACE	Q43	SF_AUDIT	19880306 HR 07 CALM WIND
SURFACE	Q43	SF_AUDIT	19880308 HR 21 CALM WIND
SURFACE	Q43	SF_AUDIT	19880308 HR 22 CALM WIND
SURFACE	Q43	SF_AUDIT	19880308 HR 24 CALM WIND
SURFACE	Q43	SF_AUDIT	19880309 HR 01 CALM WIND

**Figure 4-3. Contents of the SURFACE extraction message file.**

```

AERMET_SETUP
SUCCESSFUL

AERMET VERSION  22112

START PROCESSING DATE/TIME: MAY 19, 2022  14:57:05 PM

RUNSTREAM CONTROL FILE: EX01_SURFACE.INP

***** INPUT SUMMARY *****

PROCESSING STAGES 1

1.  JOB FILE NAMES

MESSAGES  OPEN      EX01_S1_SURFACE_MESSAGE.TXT
REPORT    OPEN      EX01_S1_SURFACE_REPORT.TXT
DEBUG     NO FILE

2.  UPPERAIR DATA

NO PROCESSING REQUESTED

3.  SURFACE DATA

PROCESSING DATES: 03/01/1988 - 03/10/1988

      SITE ID      LATITUDE      LONGITUDE      TIME ADJUSTMENT      ELEVATION
-----
LOCATION:           14735           42.75           -73.80              0              83.80

DATA FILE:        OPEN      S1473588.144
EXTRACT FILE:    OPEN      SURFACE_EXTRACT.TXT
QAOUT FILE:      OPEN      SURFACE_QAOUT.TXT

4.  ONSITE DATA

NO PROCESSING REQUESTED

5.  PROG DATA

NO PROCESSING REQUESTED

6.  METPREP DATA

NO PROCESSING REQUESTED

```

**Figure 4-4. Input summary contents of the SURFACE extraction report file.**

```

***** QA SUMMARY *****

SURFACE DATA

VARIABLE      MISSING VALUE      LOWER BOUND      UPPER BOUND
TMPD          999.00              <= -30.00       >= 40.00
WDIR          999.00              < 0.00          > 360.00
WSPD          999.00              < 0.00          > 50.00

VARIABLE      #          #          LOWER      UPPER      %
              OBS          MISSING    BOUND      BOUND      ACCEPTED
TMPD          240          0          0          0          100.00
WDIR          240          0          0          0          100.00
WSPD          240          0          0          0          100.00

WIND, TEMPERATURE, AND PRECIPITATION CHECKS
NUMBER OF HOURS:
  20 CALM WINDS (WDIR = 0, WSPD = 0)
  0 WDIR = 0, WSPD > 0
  0 WDIR > 0, WSPD = 0
  0 WINDS FLAGGED AS VARIABLE
  0 TEMPERATURE < DEWPOINT
  0 PRECIP WITHOUT WEATHER CODE
  0 WEATHER CODE WITHOUT PRECIP

```

**Figure 4-5. QA summary contents of the SURFACE extraction report file.**

```
***** MESSAGE SUMMARY *****  
  
ERROR MESSAGES          0 MESSAGES  
  
WARNING MESSAGES       1 MESSAGES  
W01:                   1  
  
INFORMATION MESSAGES   9 MESSAGES  
I01:                   1  
I40:                   2  
I46:                   1  
I47:                   1  
I50:                   1  
I53:                   1  
I56:                   1  
I59:                   1  
  
QA MESSAGES            20 MESSAGES  
Q43:                   20  
  
AERMET FINISHED SUCCESSFULLY  
END PROCESSING DATE/TIME: MAY 19, 2022  14:57:05 PM
```

**Figure 4-6. Message summary contents of the SURFACE extraction report file.**

```

AERMET 22112
LOCATION 14735      42.750N      73.800W  0 83.800
FILE TYPE: EXTRACT
DATES 1988 03 01 1988 03 10
DATE  HR  ASOS  PRCP    SLVP    PRES    TSKC    PWTH    ASKY    TMPD    DPTP    RHUM    WDIR    WSPD
19880301  01   N   -9.00  99999.0  1003.0  404.0    0.0    99.0    -2.8    999.0  999.0  270.0    3.1
19880301  02   N   -9.00  99999.0  1003.0  101.0    0.0    99.0    -2.8    999.0  999.0  280.0    4.1
19880301  03   N   -9.00  99999.0  1003.0  101.0    0.0    99.0    -3.9    999.0  999.0  280.0    4.1
19880301  04   N   -9.00  99999.0  1003.0  101.0    0.0    99.0    -5.0    999.0  999.0  290.0    5.1
19880301  05   N   -9.00  99999.0  1003.0    0.0    0.0    99.0    -5.6    999.0  999.0  290.0    5.7
19880301  06   N   -9.00  99999.0  1004.1    0.0    0.0    99.0    -5.6    999.0  999.0  290.0    2.6
19880301  07   N   -9.00  99999.0  1004.1    0.0    0.0    99.0    -6.1    999.0  999.0  290.0    5.1
19880301  08   N   -9.00  99999.0  1005.1  606.0    0.0    99.0    -5.6    999.0  999.0  310.0    4.1
19880301  09   N   -9.00  99999.0  1005.1  707.0    0.0    99.0    -5.0    999.0  999.0  270.0    7.2
19880301  10   N   -9.00  99999.0  1005.1  606.0    0.0    99.0    -5.0    999.0  999.0  300.0    8.2
19880301  11   N   -9.00  99999.0  1005.1  202.0    0.0    99.0    -4.4    999.0  999.0  300.0    7.7
19880301  12   N   -9.00  99999.0  1004.1    0.0    0.0    99.0    -4.4    999.0  999.0  270.0    8.8
19880301  13   N   -9.00  99999.0  1003.0    0.0    0.0    99.0    -3.9    999.0  999.0  270.0    9.3
19880301  14   N   -9.00  99999.0  1002.0    0.0    0.0    99.0    -3.9    999.0  999.0  310.0    7.2
19880301  15   N   -9.00  99999.0  1002.0    0.0    0.0    99.0    -4.4    999.0  999.0  260.0    9.3
19880301  16   N   -9.00  99999.0  1001.0    0.0    0.0    99.0    -4.4    999.0  999.0  270.0    7.2

```

**Figure 4-7. Format of the SURFACE EXTRACT and QAOUT files.**

#### 4.1.2 Upper air data

The next example uses upper air data from Albany, NY for the same ten-day period as the previous surface data example. Figure 4-8 shows the Stage 1 control file, EX01\_UPPER.INP. The raw upper air data are in 6201 format, and extracted and QA data will be written to UPPER\_EXTRACT.TXT and UPPER\_QAOUT.TXT, respectively. Note that temperature, wind speed, and lapse rate are requested for QA.

```
JOB
  REPORT    EX01_S1_UPPER_REPORT.TXT
  MESSAGES  EX01_S1_UPPER_MESSAGE.TXT

UPPERAIR

  DATA     14735-88.UA  6201FB  1
  EXTRACT   UPPER_EXTRACT.TXT
  QAOUT     UPPER_QAOUT.TXT

  XDATES    1988/3/1 TO 1988/3/10

  LOCATION  14735  73.80W  42.75N  5  83.8
  AUDIT     UATT  UAWS  UALR

**  725180 14735 ALBANY COUNTY AP                US US NY KALB  +42750 -073800 +00838
```

**Figure 4-8. Control file to extract and QA NWS upper air data.**

To execute AERMET Stage 1 for this example, the user will type the following at the command prompt:

```
aermet.exe EX01_UPPER.INP
```

assuming the control file and AERMET executable are in the same folder. Processing information will be written to the screen. If the user wishes to have that information written to a text file, the user will type the following at the command prompt:

```
aermet.exe EX01_UPPER.INP > example_upper.txt
```



The contents of example\_upper.txt are shown in Figure 4-9 and show the AERMET processing. The first line gives the start date and time of the AERMET processing. The next ten lines notify the user of the extraction dates followed by ten lines denoting each day's data are being QA'd. The final messages are that AERMET completed successfully followed by the AERMET processing end date and time.

```
START PROCESSING DATE/TIME: MAY 19, 2022 14:57:32 PM
Stage 1: Extracting upper air data for month/day/year 03/01/1988 LST
Stage 1: Extracting upper air data for month/day/year 03/02/1988 LST
Stage 1: Extracting upper air data for month/day/year 03/03/1988 LST
Stage 1: Extracting upper air data for month/day/year 03/04/1988 LST
Stage 1: Extracting upper air data for month/day/year 03/05/1988 LST
Stage 1: Extracting upper air data for month/day/year 03/06/1988 LST
Stage 1: Extracting upper air data for month/day/year 03/07/1988 LST
Stage 1: Extracting upper air data for month/day/year 03/08/1988 LST
Stage 1: Extracting upper air data for month/day/year 03/09/1988 LST
Stage 1: Extracting upper air data for month/day/year 03/10/1988 LST
Stage 1: QA'ing upper air data for month/day/year 03/01/1988 LST
Stage 1: QA'ing upper air data for month/day/year 03/02/1988 LST
Stage 1: QA'ing upper air data for month/day/year 03/03/1988 LST
Stage 1: QA'ing upper air data for month/day/year 03/04/1988 LST
Stage 1: QA'ing upper air data for month/day/year 03/05/1988 LST
Stage 1: QA'ing upper air data for month/day/year 03/06/1988 LST
Stage 1: QA'ing upper air data for month/day/year 03/07/1988 LST
Stage 1: QA'ing upper air data for month/day/year 03/08/1988 LST
Stage 1: QA'ing upper air data for month/day/year 03/09/1988 LST
Stage 1: QA'ing upper air data for month/day/year 03/10/1988 LST

AERMET FINISHED SUCCESSFULLY

END PROCESSING DATE/TIME: MAY 19, 2022 14:57:32 PM
```

**Figure 4-9. Processing steps for NWS upper air data extraction.**

Figure 4-10 shows the processing messages contained in EX01\_S1\_UPPER\_MESSAGE.TXT. As with the surface example, messages that start with 'W' are warning messages, 'I' are informational messages, 'E' are error messages and 'Q' are quality assurance messages. The very first message is a warning message indicating that too many fields were found with the DATA keyword and that the blocking factor or type was not needed. This is in reference to the number 1 found after the 6201 format with the UPPERAIR DATA keyword. The second W01 message indicates elevation is not needed for upper air data. The third message, I01, indicates that Stage 1 processing is being performed. The first occurrence of message I20 indicates that UPPERAIR extraction has begun with the processing

state date and time. Messages I22 through I26 indicate the number of extracted soundings, number of unique valid soundings, number of duplicate soundings, and number of skipped soundings. The second I20 message indicates the date and time that the UPPERAIR extraction ended. The remaining messages are related to QA. Message Q28 alerts the user that the sounding for March 1, 1988, hour 19 has a sounding top of 0 m and is less than 5 km. The Q23 messages indicate missing data for a particular level, and Q24 and Q25 refer to violations of the lower and upper bounds, respectively.

Figure 4-11 through Figure 4-15 show the content of EX01\_UPPER\_REPORT.TXT. Figure 4-11 shows the file summary of Stage 1. The first lines list the AERMET version number, start processing time, and the name of the AERMET control file. Following is the input summary of Stage 1 and the filenames of input and output files for each path. If a path is not being processed, AERMET will denote by listing the path along with “NO PROCESSING REQUESTED.” For paths being processed, the file status along with the filename are listed. For optional operations, such as debugging, if the DEBUG option is not chosen, AERMET will list “NO FILE” for the filename. Station information (site identifier, coordinates, time adjustment, elevation) for upper air, surface, site-specific, or prognostic is also summarized along with the requested dates for the station.

Figure 4-12 through Figure 4-14 show the QA summary of the upper air extraction. Figure 4-12 shows the missing value indicators and bounds for the audited variables (temperature, wind speed, and lapse rate). Note that the missing value indicators are not subject to the conversion factor for the surface variables while the bounds have the conversion factor applied (See Table B-2 in Appendix B). Next in Figure 4-13, follows the number of observations read in for each variable, the number of missing observations, number of observations that exceed the lower and upper bounds, and percent of observations that were accepted by level. The individual sounding levels are grouped into layers. For temperature and wind speed, 100% of the data are accepted but lapse rate acceptance is less than 100% for some layers. Finally, Figure 4-14 summarizes the following:

- number of calm wind observations,

- number of observations with non-zero wind direction and zero wind speed,
- number of observations where the temperature is less than the dewpoint,
- number of soundings that do not extend to 5,000 m,
- number of days with no soundings, and
- number of days with soundings but no AM soundings.

Figure 4-15 shows the message summary portion of the report file. The message file summarizes the number of each type of message: error, warning, information, and quality assurance messages. If the number of messages for a specific message type is greater than zero, then AERMET will issue the number of each message code associated with the message type. For this example, there are no error messages and there are two warning messages, W01. There are eight information messages distributed among I01, I20, I22, I23, I24, I25, and I26. There are nine QA messages distributed among Q23 through Q28. After the message summary, AERMET notifies the user that AERMET completed successfully, along with the end date and time of AERMET processing.

Figure 4-16 shows the format of the EXTRACT file, UPPERAIR\_EXTRACT.TXT . The header information is much like the EXTRACT file for SURFACE data and shows the AERMET version, location information (station identifier, coordinates, time conversion and elevation). Next follows the file type (EXTRACT or QAOUT), processing dates and the header for the data columns. If audited variables used different defaults for missing or bound values, those will be indicated as well in the header. Following the data header are the actual data that is formatted as described in Table C-2 of Appendix C. For variable names see Table B-2 in Appendix B. The QAOUT file, shown in Figure 4-17, has a similar format with the exception of the listed values for the audited variable, UALR (lapse rate). For both SURFACE and UPPERAIR EXTRACT and QAOUT files, the EXTRACT files contain variables needed by METPREP. The QAOUT files contain those same variables plus any additional audited variables, such as UALR, that are not needed by METPREP.

```

UPPERAIR W01 UPPER_PATH TOO MANY FIELDS 4 FOR DATA KEYWORD; BLOCKING FACTOR AND/OR TYPE NOT NEEDED
UPPERAIR W01 GETLOC STATION ELEVATION NOT NEEDED
UPPERAIR I01 READINP PROCESSING STAGE 1
UPPERAIR I20 UP_PROC UPPER AIR EXTRACTION BEGIN 20220519 14:57:32
UPPERAIR I22 READ_6201 END OF DATA WINDOW ENCOUNTERED
UPPERAIR I23 UP_PROC NUMBER OF EXTRACTED SOUNDINGS: 20
UPPERAIR I24 UP_PROC NUMBER OF UNIQUE VALID SOUNDINGS: 20
UPPERAIR I25 UP_PROC NUMBER OF DUPLICATE SOUNDINGS: 0
UPPERAIR I26 UP_PROC NUMBER OF SKIPPED SOUNDINGS: 0
UPPERAIR I20 UP_PROC UPPER AIR EXTRACTION END 20220519 14:57:32
UPPERAIR Q28 UP_AUDIT 19880301 HR 19 TOP OF SOUNDING 0.0 M < 5000 M
UPPERAIR Q23 UP_AUDIT 19880302 HR 07 UAWS MISSING FOR LEVEL 8
UPPERAIR Q23 UP_AUDIT 19880302 HR 07 UAWS MISSING FOR LEVEL 9
UPPERAIR Q23 UP_AUDIT 19880302 HR 07 UAWS MISSING FOR LEVEL 10
UPPERAIR Q24 UP_AUDIT 19880304 HR 19 UALR LB -4.4 < -2.0 LEVEL 8
UPPERAIR Q25 UP_AUDIT 19880306 HR 07 UALR UB 5.7 > 5.0 LEVEL 2
UPPERAIR Q25 UP_AUDIT 19880306 HR 07 UALR UB 5.1 > 5.0 LEVEL 3
UPPERAIR Q24 UP_AUDIT 19880309 HR 19 UALR LB -3.0 < -2.0 LEVEL 2
UPPERAIR Q25 UP_AUDIT 19880310 HR 07 UALR UB 5.9 > 5.0 LEVEL 9

```

**Figure 4-10. Contents of the UPPERAIR extraction message file.**

```
AERMET_SETUP
SUCCESSFUL

AERMET VERSION  22112

START PROCESSING DATE/TIME: MAY 19, 2022  14:57:32 PM

RUNSTREAM CONTROL FILE: EX01_UPPER.INP

***** INPUT SUMMARY *****

PROCESSING STAGES 1

1.  JOB FILE NAMES

MESSAGES  OPEN   EX01_S1_UPPER_MESSAGE.TXT
REPORT    OPEN   EX01_S1_UPPER_REPORT.TXT
DEBUG     NO FILE

2.  UPPERAIR DATA

PROCESSING DATES: 03/01/1988 - 03/10/1988

      SITE ID      LATITUDE      LONGITUDE      TIME ADJUSTMENT
      -----      -
LOCATION:    00014735      42.75      -73.80      5

DATA FILE:    OPEN      14735-88.UA
EXTRACT FILE: OPEN      UPPER_EXTRACT.TXT
QAOUT FILE:   OPEN      UPPER_QAOUT.TXT

UPPER AIR DATA ABOVE 5000 NOT EXTRACTED

UPPER AIR AUTOMATIC DATA CHECKS ARE: OFF

3.  SURFACE DATA

NO PROCESSING REQUESTED

4.  ONSITE DATA

NO PROCESSING REQUESTED

5.  PROG DATA

NO PROCESSING REQUESTED

6.  METPREP DATA

NO PROCESSING REQUESTED
```

**Figure 4-11. Input summary contents of the UPPERAIR extraction report file.**

***** QA SUMMARY *****			
UPPERAIR DATA			
VARIABLE	MISSING VALUE	LOWER BOUND	UPPER BOUND
UATT	-9990.00	<= -35.00	>= 35.00
UAWS	9990.00	< 0.00	> 50.00
UALR	-9999.00	<= -2.00	>= 5.00

**Figure 4-12. Initial QA summary contents of the UPPERAIR extraction report file.**

LEVEL	VARIABLE	# OBS	# MISSING	LOWER BOUND	UPPER BOUND	% ACCEPTED
SURFACE	UATT	20	0	0	0	100.00
	UAWS	20	0	0	0	100.00
0 - 500 M	UATT	65	0	0	0	100.00
	UAWS	65	0	0	0	100.00
	UALR	65	0	1	2	95.38
500 - 1000 M	UATT	46	0	0	0	100.00
	UAWS	46	3	0	0	93.48
	UALR	46	0	0	0	100.00
1000 - 1500 M	UATT	43	0	0	0	100.00
	UAWS	43	0	0	0	100.00
	UALR	43	0	1	0	97.67
1500 - 2000 M	UATT	49	0	0	0	100.00
	UAWS	49	0	0	0	100.00
	UALR	49	0	0	1	97.96
2000 - 2500 M	UATT	50	0	0	0	100.00
	UAWS	50	0	0	0	100.00
	UALR	50	0	0	0	100.00
2500 - 3000 M	UATT	31	0	0	0	100.00
	UAWS	31	0	0	0	100.00
	UALR	31	0	0	0	100.00
3000 - 3500 M	UATT	29	0	0	0	100.00
	UAWS	29	0	0	0	100.00
	UALR	29	0	0	0	100.00
3500 - 4000 M	UATT	20	0	0	0	100.00
	UAWS	20	0	0	0	100.00
	UALR	20	0	0	0	100.00
> 4000 M	UATT	76	0	0	0	100.00
	UAWS	76	0	0	0	100.00
	UALR	76	0	0	0	100.00

**Figure 4-13. QA summary contents of the UPPERAIR extraction report file.**

```

NON-QA SUMMARY CHECKS

CALM WIND CONDITIONS (WS=0, WD=0):          0
ZERO WIND SPEED; NON-ZERO WIND DIRECTION:    0
DEW POINT GREATER THAN DRY BULB TEMPERATURE: 0
NUMBER OF SOUNDINGS THAT DO NOT EXTEND TO 5000 M: 1

NUMBER OF DAYS WITH NO SOUNDINGS:          0

NUMBER OF DAYS WITH SOUNDINGS BUT NO AM SOUNDINGS: 0

```

**Figure 4-14. Final QA summary contents of the UPPERAIR extraction report file.**

```

***** MESSAGE SUMMARY *****

ERROR MESSAGES          0 MESSAGES

WARNING MESSAGES       2 MESSAGES

W01:                   2

INFORMATION MESSAGES   8 MESSAGES

I01:                   1
I20:                   2
I22:                   1
I23:                   1
I24:                   1
I25:                   1
I26:                   1

QA MESSAGES            9 MESSAGES

Q23:                   3
Q24:                   2
Q25:                   3
Q28:                   1

AERMET FINISHED SUCCESSFULLY

END PROCESSING DATE/TIME: MAY 19, 2022 14:57:32 PM

```

**Figure 4-15. Message summary contents of the UPPERAIR extraction report file.**



```

AERMET 22112
LOCATION 00014735 42.750N 73.800W 5 83.800
FILE TYPE: EXTRACT
DATES 1988 03 01 1988 03 10
DATE      SND  HR  LEV  UAPR  UAHT  UATT  UATD  UAWD  UAWS
19880301  1  07  1  1011.3  0.0  -5.9  -10.5  280.0  2.0
19880301  1  07  2  1008.0  26.0  -6.0  -14.5  285.0  3.0
19880301  1  07  3  1000.0  88.0  -6.1  -13.2  290.0  4.0
19880301  1  07  4  950.0  487.0  -9.0  -13.6  294.0  11.0
19880301  1  07  5  930.0  652.0  -10.3  -14.0  294.0  12.0
19880301  1  07  6  913.0  794.0  -9.7  -25.5  293.0  12.0
19880301  1  07  7  900.0  905.0  -10.1  -25.1  292.0  12.0
19880301  1  07  8  884.0  1043.0  -10.6  -24.4  291.0  12.0
19880301  1  07  9  870.0  1166.0  -10.9  -14.3  290.0  13.0
19880301  1  07  10  850.0  1345.0  -11.5  -15.9  287.0  13.0
19880301  1  07  11  821.0  1611.0  -12.9  -20.2  282.0  13.0
19880301  1  07  12  804.0  1770.0  -14.2  -21.0  280.0  13.0
19880301  1  07  13  800.0  1808.0  -14.4  -20.2  279.0  13.0
19880301  1  07  14  785.0  1951.0  -15.6  -17.7  279.0  14.0
19880301  1  07  15  750.0  2294.0  -17.6  -22.1  279.0  15.0
19880301  1  07  16  744.0  2354.0  -18.0  -22.9  279.0  16.0
19880301  1  07  17  700.0  2806.0  -22.1  -24.9  275.0  19.0
19880301  1  07  18  650.0  3347.0  -25.5  -28.2  268.0  23.0
19880301  1  07  19  636.0  3505.0  -26.6  -29.3  265.0  22.0
19880301  1  07  20  626.0  3619.0  -26.9  -35.2  262.0  21.0
19880301  1  07  21  617.0  3724.0  -26.5  -41.3  258.0  21.0
19880301  1  07  22  600.0  3926.0  -26.2  -41.9  251.0  21.0
19880301  1  07  23  594.0  3999.0  -26.0  -42.7  249.0  22.0
19880301  1  07  24  550.0  4553.0  -28.9  -45.1  237.0  24.0
19880301  1  07  25  500.0  5230.0  -32.6  -48.3  232.0  29.0

```

**Figure 4-16. Format of the UPPERAIR EXTRACT file.**

```

AERMET 22112
LOCATION 00014735 42.750N 73.800W 5 83.800
FILE TYPE: QAOUT
DATES 1988 03 01 1988 03 10
DATE      SND  HR  LEV  UAPR  UAHT  UATT  UATD  UAWD  UAWS  UALR
19880301  1  07  1  1011.3  0.0  -5.9  -10.5  280.0  2.0  -9999.0
19880301  1  07  2  1008.0  26.0  -6.0  -14.5  285.0  3.0   -0.4
19880301  1  07  3  1000.0  88.0  -6.1  -13.2  290.0  4.0   -0.2
19880301  1  07  4   950.0  487.0  -9.0  -13.6  294.0  11.0  -0.7
19880301  1  07  5   930.0  652.0 -10.3  -14.0  294.0  12.0  -0.8
19880301  1  07  6   913.0  794.0  -9.7  -25.5  293.0  12.0   0.4
19880301  1  07  7   900.0  905.0 -10.1  -25.1  292.0  12.0  -0.4
19880301  1  07  8   884.0  1043.0 -10.6  -24.4  291.0  12.0  -0.4
19880301  1  07  9   870.0  1166.0 -10.9  -14.3  290.0  13.0  -0.2
19880301  1  07  10  850.0  1345.0 -11.5  -15.9  287.0  13.0  -0.3
19880301  1  07  11  821.0  1611.0 -12.9  -20.2  282.0  13.0  -0.5
19880301  1  07  12  804.0  1770.0 -14.2  -21.0  280.0  13.0  -0.8
19880301  1  07  13  800.0  1808.0 -14.4  -20.2  279.0  13.0  -0.5
19880301  1  07  14  785.0  1951.0 -15.6  -17.7  279.0  14.0  -0.8
19880301  1  07  15  750.0  2294.0 -17.6  -22.1  279.0  15.0  -0.6
19880301  1  07  16  744.0  2354.0 -18.0  -22.9  279.0  16.0  -0.7
19880301  1  07  17  700.0  2806.0 -22.1  -24.9  275.0  19.0  -0.9
19880301  1  07  18  650.0  3347.0 -25.5  -28.2  268.0  23.0  -0.6
19880301  1  07  19  636.0  3505.0 -26.6  -29.3  265.0  22.0  -0.7
19880301  1  07  20  626.0  3619.0 -26.9  -35.2  262.0  21.0  -0.3
19880301  1  07  21  617.0  3724.0 -26.5  -41.3  258.0  21.0   0.4
19880301  1  07  22  600.0  3926.0 -26.2  -41.9  251.0  21.0   0.1
19880301  1  07  23  594.0  3999.0 -26.0  -42.7  249.0  22.0   0.3
19880301  1  07  24  550.0  4553.0 -28.9  -45.1  237.0  24.0  -0.5
19880301  1  07  25  500.0  5230.0 -32.6  -48.3  232.0  29.0  -0.5

```

**Figure 4-17. Format of the UPPERAIR QAOUT file.**

### 4.1.3 Data merger and boundary layer calculations

After extracting the surface and upper air data, the next step is to merge the two datasets and calculate boundary layer parameters in Stage 2. The AERMET Stage 2 control file, EX01\_NWS\_S2.INP, is shown in Figure 4-18. The QAOUT files from Stage 1 upper air and surface extraction are shown in the UPPERAIR and SURFACE pathways. The METPREP pathway lists the two output files, EX01\_NWS.SFC and EX01\_NWS.PFL. Method options include NWS substitution and randomization of the wind directions. The NWS anemometer height is listed as 6.1 m. Surface characteristics are annual for one 360° sector. The location coordinates are those of the source, not the meteorological station as described in Section 3.7.4.

```
JOB
  REPORT      EX01_NWS_S2_REPORT.TXT
  MESSAGES    EX01_NWS_S2_MESSAGE.TXT

UPPERAIR
  QAOUT       UPPER_QAOUT.TXT

SURFACE
  QAOUT       SURFACE_QAOUT.TXT

METPREP

  OUTPUT      EX01_NWS.SFC
  PROFILE     EX01_NWS.PFL

  LOCATION    MYSITE 74.00W 41.3N 5

  METHOD       REFLEVEL  SUBNWS
  METHOD       WIND_DIR  RANDOM
  NWS_HGT     WIND      6.1
  FREQ_SECT   ANNUAL  1
  SECTOR      1      0      360
  SITE_CHAR   1  1    0.15  2.0  0.12

** 725180 14735 ALBANY COUNTY AP                US US NY KALB +42750 -073800 +00838
```

**Figure 4-18. Control file for boundary layer calculations in METPREP.**

To execute AERMET Stage 2 for this example, the user will type the following at the command prompt:

```
aermet.exe EX01_NWS_S2.INP
```

assuming the control file and AERMET executable are in the same folder. Processing information will be written to the screen. If the user wishes to have that information written to a text file, the user will type the following at the command prompt:

```
aermet.exe EX01_NWS_S2.INP > example_stage2.txt
```

The contents of `example_stage2.txt` are shown in Figure 4-19 and show the AERMET processing. The first line lists the start date and time of the AERMET processing. The next ten lines notify the user of the upper air extraction dates followed by ten lines denoting surface extraction dates. The next ten lines denote the initial data assignments for variables such as wind and temperature were performed, and the next ten lines denote PBL calculations were performed. The final messages are that AERMET completed successfully followed by the AERMET processing end date and time.

The contents of the message file, `EX01_NWS_S2_MESSAGE.TXT` are shown in Figure 4-20 and Figure 4-21. Figure 4-20 shows the initial message that Stage 2 is being processed along with warning messages that the upper air elevation is not needed, and that the `LOCATION` keyword is not needed for `METPREP`. Next follow messages regarding upper air and surface data extraction, including that the NWS station is an ASOS station, but the extracted data are before the commission date. The PBL calculations begin with message `I70` which includes the date and time the processing started. Next follows the message that the solar angle approach will be used to determine stability. Remaining messages in Figure 4-20 and messages in Figure 4-21 refer to PBL calculations such as which sounding is used for each day (`I77`), whether the sounding is extended or not (`W76`), and messages about skipping calculations due to missing data (`I72`).

```
START PROCESSING DATE/TIME: MAY 20, 2022 9:58:29 AM
Stage 2: Extracting upper air data for month/day/year 03/01/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/02/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/03/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/04/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/05/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/06/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/07/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/08/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/09/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/10/1988 LST
Stage 2: Extracting surface data for month/day/year 03/01/1988 LST
Stage 2: Extracting surface data for month/day/year 03/02/1988 LST
Stage 2: Extracting surface data for month/day/year 03/03/1988 LST
Stage 2: Extracting surface data for month/day/year 03/04/1988 LST
Stage 2: Extracting surface data for month/day/year 03/05/1988 LST
Stage 2: Extracting surface data for month/day/year 03/06/1988 LST
Stage 2: Extracting surface data for month/day/year 03/07/1988 LST
Stage 2: Extracting surface data for month/day/year 03/08/1988 LST
Stage 2: Extracting surface data for month/day/year 03/09/1988 LST
Stage 2: Extracting surface data for month/day/year 03/10/1988 LST
Stage 2: Initial data assignments for month/day/year 03/01/1988 LST
Stage 2: Initial data assignments for month/day/year 03/02/1988 LST
Stage 2: Initial data assignments for month/day/year 03/03/1988 LST
Stage 2: Initial data assignments for month/day/year 03/04/1988 LST
Stage 2: Initial data assignments for month/day/year 03/05/1988 LST
Stage 2: Initial data assignments for month/day/year 03/06/1988 LST
Stage 2: Initial data assignments for month/day/year 03/07/1988 LST
Stage 2: Initial data assignments for month/day/year 03/08/1988 LST
Stage 2: Initial data assignments for month/day/year 03/09/1988 LST
Stage 2: Initial data assignments for month/day/year 03/10/1988 LST
Stage 2: PBL calculations for month/day/year 03/01/1988 LST
Stage 2: PBL calculations for month/day/year 03/02/1988 LST
Stage 2: PBL calculations for month/day/year 03/03/1988 LST
Stage 2: PBL calculations for month/day/year 03/04/1988 LST
Stage 2: PBL calculations for month/day/year 03/05/1988 LST
Stage 2: PBL calculations for month/day/year 03/06/1988 LST
Stage 2: PBL calculations for month/day/year 03/07/1988 LST
Stage 2: PBL calculations for month/day/year 03/08/1988 LST
Stage 2: PBL calculations for month/day/year 03/09/1988 LST
Stage 2: PBL calculations for month/day/year 03/10/1988 LST
```

AERMET FINISHED SUCCESSFULLY

```
END PROCESSING DATE/TIME: MAY 19, 2022 9:58:29 AM
```

**Figure 4-19. Processing steps for boundary layer calculations**

	I01	READINP	PROCESSING STAGE 2		
UPPERAIR	W01	GETLOC	STATION ELEVATION NOT NEEDED		
METPREP	W70	PBL_TEST	LOCATION KEYWORD NOT NEEDED		
UPPERAIR	I20	UP_PROC	UPPER AIR EXTRACTION BEGIN 20220520 09:58:29		
UPPERAIR	I23	UP_PROC	NUMBER OF EXTRACTED SOUNDINGS: 20		
UPPERAIR	I24	UP_PROC	NUMBER OF UNIQUE VALID SOUNDINGS: 20		
UPPERAIR	I25	UP_PROC	NUMBER OF DUPLICATE SOUNDINGS: 0		
UPPERAIR	I26	UP_PROC	NUMBER OF SKIPPED SOUNDINGS: 0		
UPPERAIR	I20	UP_PROC	UPPER AIR EXTRACTION END 20220520 09:58:29		
SURFACE	I40	SF_PROC	SURFACE EXTRACTION BEGIN: 20220520 09:58:29		
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880301		
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880302		
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880303		
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880304		
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880305		
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880306		
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880307		
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880308		
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880309		
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880310		
SURFACE	I46	SF_PROC	NUMBER OF EXTRACTED SURFACE OBSERVATIONS: 240		
SURFACE	I47	SF_PROC	NUMBER OF RETAINED OBSERVATIONS: 240		
SURFACE	I40	SF_PROC	SURFACE EXTRACTION END: 20220520 09:58:29		
METPREP	I70	PBL_PROC	PBL CALCULATIONS BEGIN: 20220520 09:58:29		
METPREP	I84	PBL_PROC	SOLAR ANGLE APPROACH WILL BE USED FOR STABILITY DETERMINATION		
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880301 IS 19880301 HR 07 SOUNDING # 1		
METPREP	W76	READ_SOUND	DATE 19880301 TOP OF SOUNDING 5.2 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED		
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880302 IS 19880302 HR 07 SOUNDING # 1		
METPREP	W76	READ_SOUND	DATE 19880302 TOP OF SOUNDING 5.4 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED		
METPREP	I72	PBL_PROC	DATE: 19880302 HR 02 WINDS CALM OR MISSING, SKIP CALCULATIONS		
METPREP	I72	PBL_PROC	DATE: 19880302 HR 03 WINDS CALM OR MISSING, SKIP CALCULATIONS		
METPREP	I72	PBL_PROC	DATE: 19880302 HR 04 WINDS CALM OR MISSING, SKIP CALCULATIONS		
METPREP	I72	PBL_PROC	DATE: 19880302 HR 05 WINDS CALM OR MISSING, SKIP CALCULATIONS		
METPREP	I72	PBL_PROC	DATE: 19880302 HR 06 WINDS CALM OR MISSING, SKIP CALCULATIONS		
METPREP	I72	PBL_PROC	DATE: 19880302 HR 07 WINDS CALM OR MISSING, SKIP CALCULATIONS		

**Figure 4-20. Initial contents of the Stage 2 message file.**

METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880303 IS 19880303 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880303 TOP OF SOUNDING 5.4 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED
METPREP	I72	PBL_PROC	DATE: 19880303 HR 19 WINDS CALM OR MISSING, SKIP CALCULATIONS
METPREP	I72	PBL_PROC	DATE: 19880303 HR 21 WINDS CALM OR MISSING, SKIP CALCULATIONS
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880304 IS 19880304 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880304 TOP OF SOUNDING 5.4 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880305 IS 19880305 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880305 TOP OF SOUNDING 5.4 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED
METPREP	I72	PBL_PROC	DATE: 19880305 HR 24 WINDS CALM OR MISSING, SKIP CALCULATIONS
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880306 IS 19880306 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880306 TOP OF SOUNDING 5.4 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED
METPREP	I72	PBL_PROC	DATE: 19880306 HR 01 WINDS CALM OR MISSING, SKIP CALCULATIONS
METPREP	I72	PBL_PROC	DATE: 19880306 HR 02 WINDS CALM OR MISSING, SKIP CALCULATIONS
METPREP	I72	PBL_PROC	DATE: 19880306 HR 03 WINDS CALM OR MISSING, SKIP CALCULATIONS
METPREP	I72	PBL_PROC	DATE: 19880306 HR 04 WINDS CALM OR MISSING, SKIP CALCULATIONS
METPREP	I72	PBL_PROC	DATE: 19880306 HR 05 WINDS CALM OR MISSING, SKIP CALCULATIONS
METPREP	I72	PBL_PROC	DATE: 19880306 HR 06 WINDS CALM OR MISSING, SKIP CALCULATIONS
METPREP	I72	PBL_PROC	DATE: 19880306 HR 07 WINDS CALM OR MISSING, SKIP CALCULATIONS
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880307 IS 19880307 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880307 TOP OF SOUNDING 5.4 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880308 IS 19880308 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880308 TOP OF SOUNDING 5.5 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED
METPREP	I72	PBL_PROC	DATE: 19880308 HR 21 WINDS CALM OR MISSING, SKIP CALCULATIONS
METPREP	I72	PBL_PROC	DATE: 19880308 HR 22 WINDS CALM OR MISSING, SKIP CALCULATIONS
METPREP	I72	PBL_PROC	DATE: 19880308 HR 24 WINDS CALM OR MISSING, SKIP CALCULATIONS
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880309 IS 19880309 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880309 TOP OF SOUNDING 5.5 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED
METPREP	I72	PBL_PROC	DATE: 19880309 HR 01 WINDS CALM OR MISSING, SKIP CALCULATIONS
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880310 IS 19880310 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880310 TOP OF SOUNDING 5.0 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED

**Figure 4-21. Final contents of the Stage 2 message file.**

Figure 4-22 through Figure 4-25 show the contents of the report file, EX01\_NWS\_S2\_REPORT.TXT. Figure 4-22, like

Figure 4-4 and Figure 4-11, presents the summary files and locations of the upper air and surface stations. Figure 4-23 shows the summary for the METPREP pathway, including processing dates, site location (even though this input is optional), the output filenames and processing options. For this example, wind directions are randomized, and cloud and temperature substitutions are performed. Following the METPREP summary is the surface characteristics summary where the surface characteristics for each processed year are shown. For this example, only one year is processed and it is for one sector. Updated from 21DRF to 22112 and shown in Figure 4-24, is a summary of the number of total observations and observations per day for each data type (upper air, NWS surface, site-specific or prognostic, and ASOS 1-minute observations). This update is like the summary of observations found in AERMET versions prior to 21DRF. Also shown in Figure 4-24 is a summary of the PBL processing. This summary gives the number of days with no convective conditions, number of calms and variable winds, and number of substituted (interpolated) cloud cover and temperature hours. Finally, in Figure 4-25 is the message file summary, similar to Figure 4-6 and Figure 4-15. For boundary layer calculations there are no error messages. There are 22 warning messages distributed among W01, W45, W70, and W76, and 43 information messages distributed among several message types, and no quality assurance messages. Finally, the report file notifies the user that AERMET finished successfully with the date and time the program finished processing.

Figure 4-26 and Figure 4-27 show the contents of the two output files, EX01\_NWS.SFC and EX01\_NWS.PFL, respectively. The user can refer to Table C-4 and Table C-5 in Appendix C, Section C. 2 for the format of these output files.



```

AERMET_SETUP
SUCCESSFUL

AERMET VERSION  22112

START PROCESSING DATE/TIME: MAY 20, 2022   9:58:29 AM

RUNSTREAM CONTROL FILE: EX01_NWS_S2.INP

***** INPUT SUMMARY *****

PROCESSING STAGES 2

1.  JOB FILE NAMES

MESSAGES  OPEN    EX01_NWS_S2_MESSAGE.TXT
REPORT    OPEN    EX01_NWS_S2_REPORT.TXT
DEBUG     NO FILE

2.  UPPERAIR DATA

PROCESSING DATES: 03/01/1988 - 03/10/1988

      SITE ID      LATITUDE    LONGITUDE    TIME ADJUSTMENT
      -----      -
LOCATION:    00014735      42.75      -73.80      5

DATA FILE: NO FILENAME INPUT
EXTRACT FILE: NO FILENAME INPUT
QAOUT FILE:   OPEN    UPPER_QAOUT.TXT

UPPER AIR DATA ABOVE 5000 NOT EXTRACTED

UPPER AIR AUTOMATIC DATA CHECKS ARE: OFF

3.  SURFACE DATA

PROCESSING DATES: 03/01/1988 - 03/10/1988

      SITE ID      LATITUDE    LONGITUDE    TIME ADJUSTMENT    ELEVATION
      -----      -
LOCATION:    14735      42.75      -73.80      0      83.80

ASOS COMMISSION DATE: 19950801
DATA FILE: NO FILENAME INPUT
ASOS1MIN FILE: NO FILENAME INPUT
EXTRACT FILE: NO FILENAME INPUT
QAOUT FILE:   OPEN    SURFACE_QAOUT.TXT

4.  ONSITE DATA

NO PROCESSING REQUESTED

5.  PROG DATA

NO PROCESSING REQUESTED

```

**Figure 4-22. Input summary contents of the Stage 2 report file.**

```

6. METPREP DATA

PROCESSING DATES: 03/01/1988 - 03/10/1988

          SITE ID      LATITUDE      LONGITUDE      TIME ADJUSTMENT
          -----      -
LOCATION:          -9          42.75          -73.80          5

OUTPUT FILE:    OPEN      EX01_NWS.SFC
PROFILE FILE:   OPEN      EX01_NWS.PFL

METPREP PROCESSING OPTIONS
PROCESS          OPTION  DESCRIPTION

WIND DIRECTION      RANDOM  WIND DIRECTIONS ARE RAMDOMNIZED
REFLEVEL            SUBNWS  NWS WINDS AND TEMPS SUBSTITUED FOR MISSING ONSITE DATA
CLOUD COVER         SUB_CC  CLOUD COVER SUBSTITUTED
TEMPERATURE         SUB_TT  TEMPERATURE SUBSTITUTED

***** SFC CHARACTERISTICS SUMMARY *****

PRIMARY SITE CHARACTERISTICS

YEAR: 1988 FREQUENCY ANNUAL
          NUMBER OF SECTORS: 1

YEAR          BEGIN SECTOR  END SECTOR  ALBEDO  BOWEN RATIO  ROUGHNESS LENGTH (M)
1988          0.          360.       0.15    2.00         0.1200

```

**Figure 4-23. METPREP summary contents of the Stage 2 report file.**

```

***** OBSERVATIONS PER DAY SUMMARY *****

STARTING: 01-MAR-1988
ENDING: 10-MAR-1988

***** TOTAL OBSERVATION COUNTS *****

NWS UPPER AIR  OBS    20
NWS SURFACE    OBS   240
ONSITE/PROG    OBS    0
1-MIN ASOS HR  OBS    0

***** DAILY OUTPUT STATISTICS *****

      1988 MO/DY:  03/01  03/02  03/03  03/04  03/05  03/06  03/07  03/08  03/09  03/10
NWS UPPER AIR  OBS    2    2    2    2    2    2    2    2    2    2
NWS SURFACE    OBS   24   24   24   24   24   24   24   24   24   24
ONSITE/PROG    OBS    0    0    0    0    0    0    0    0    0    0
1-MIN ASOS HR  OBS    0    0    0    0    0    0    0    0    0    0

***** PBL PROCESSING SUMMARY *****

NUMBER OF DAYS WITH NO CONVECTIVE CONDITIONS:      0

NUMBER OF TOTAL CALMS:      20
NUMBER OF VARIABLE WINDS:    0

NUMBER OF SUBSTITUTIONS (INTERPOLATION) FOR MISSING CLOUD COVER:      0
NUMBER OF SUBSTITUTIONS (INTERPOLATION) FOR MISSING TEMPERATURE:      0

```

**Figure 4-24. Observations summary and PBL processing summary contents of the Stage 2 report file.**

```
***** MESSAGE SUMMARY *****

ERROR MESSAGES          0 MESSAGES

WARNING MESSAGES       22 MESSAGES

W01:          1
W45:         10
W70:          1
W76:         10

INFORMATION MESSAGES   43 MESSAGES

I01:          1
I20:          2
I23:          1
I24:          1
I25:          1
I26:          1
I40:          2
I46:          1
I47:          1
I70:          1
I72:         20
I77:         10
I83:          1

QA MESSAGES            0 MESSAGES

AERMET FINISHED SUCCESSFULLY

END PROCESSING DATE/TIME: MAY 20, 2022  9:58:29 AM
```

**Figure 4-25. Message summary contents of the Stage 2 report file.**

42.750N		73.800		UA_ID: 00014735				SF_ID: 14735				OS_ID:				VERSION: 22112				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	270.3	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	270.3	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.	979.7	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.	979.7	0.1200	2.00	1.00	8.80	273.0	6.1	265.3	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

Figure 4-26. Partial contents of the EX01\_NWS.SFC file.

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

**Figure 4-27. Partial contents of the EX01\_NWS.PFL file.**

## 4.2 Site-specific example

Building on the NWS example in Section 4.1, this section will detail the extraction of site-specific data as well as the merging with NWS surface and upper air data and subsequent boundary layer calculations.

### 4.2.1 Site-specific data extraction

The site-specific data for this example are a dataset composed of three levels, 10, 50, and 100 m, with the following variables at each level:  $\sigma_{\theta}$  (standard deviation of horizontal wind direction),  $\sigma_w$  (standard deviation of the w-component of the wind speed), temperature, wind direction and wind speed. A sample of the site-specific data file, ONSITE.MET, is shown in Figure 4-28. The AERMET control file, ONSITE\_S1.INP, is shown in Figure 4-29. Based on the control file READ statements, the order of variables in the site-specific data are day (OSDY), month (OSMO), year (OSYR), hour (OSHR), height (HTNN),  $\sigma_{\theta}$  (SANN),  $\sigma_w$  (SWNN), temperature (TTNN), wind direction (WDNN), and wind speed (WSNN). NN refers to the height level 01, 02, and 03. Note that in the data file (Figure 4-28) there is a 0 between the year and height. This column is skipped using the FORMAT statements. The report and message files are denoted by the keywords REPORT and MESSAGE and the input data, ONSITE.MET, is denoted by the DATA keyword. The QAOUT keyword denotes the output file, and the location is given with the LOCATION keyword. The READ and FORMAT statements control the reading of the file as described in Section 3.5.3. Non-default missing values and bounds are given for several variables and the wind speed threshold is 0.3 m/s. No variables are listed for auditing so the default audits of temperature and winds will occur.

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
1	3	88	4	0	10.0	74.4	0.040	-1.66	199.70	0.60
1	3	88	4	0	50.0	58.9	-99.000	-0.76	99.50	0.90
1	3	88	4	0	100.0	55.1	0.450	-0.76	321.60	1.30
1	3	88	5	0	10.0	25.3	0.130	-1.36	289.30	1.20
1	3	88	5	0	50.0	29.4	-99.000	-0.86	339.30	1.50
1	3	88	5	0	100.0	29.8	0.470	-1.26	333.20	2.10
1	3	88	6	0	10.0	50.0	0.100	-2.16	254.00	0.80
1	3	88	6	0	50.0	44.0	-99.000	-1.46	293.00	1.10
1	3	88	6	0	100.0	18.6	0.460	-1.86	301.80	2.20
1	3	88	7	0	10.0	43.3	0.170	-2.26	264.30	0.90
1	3	88	7	0	50.0	28.3	-99.000	-1.76	305.20	1.80
1	3	88	7	0	100.0	15.0	0.470	-2.06	307.70	2.90

**Figure 4-28. Partial contents of the site-specific data file ONSITE.MET.**

```

JOB
  REPORT   ONSITE_S1_REPORT.TXT
  MESSAGES ONSITE_S1_MESSAGE.TXT

ONSITE
  DATA    ONSITE.MET
  QAOUT    ONSITE_QAOUT.TXT

XDATES     1988/3/1 TO 1988/3/10
LOCATION    99999 74.0W 41.3N 0

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 4-29. Control file to extract and QA site-specific data.**



To execute AERMET Stage 1 for this example, the user will type the following at the command prompt:

```
aermet.exe ONSITE_S1.INP
```

assuming the control file and AERMET executable are in the same folder. Processing information will be written to the screen. If the user wishes to have that information written to a text file, the user will type the following at the command prompt:

```
aermet.exe ONSITE_S1.INP > onsite_s1.txt
```

The contents of example\_run.txt are shown in Figure 4-30 and show the AERMET processing. The first line lists the start date and time of the AERMET processing. The next ten lines notify the user of the extraction dates followed by ten lines denoting each day's data are being QA'd. The final messages are that AERMET completed successfully followed by the AERMET processing end date and time.

```

START PROCESSING DATE/TIME: MAY 20, 2022 10:51:02 AM
Stage 1: Extracting onsite data for month/day/year 03/01/1988 LST
Stage 1: Extracting onsite data for month/day/year 03/02/1988 LST
Stage 1: Extracting onsite data for month/day/year 03/03/1988 LST
Stage 1: Extracting onsite data for month/day/year 03/04/1988 LST
Stage 1: Extracting onsite data for month/day/year 03/05/1988 LST
Stage 1: Extracting onsite data for month/day/year 03/06/1988 LST
Stage 1: Extracting onsite data for month/day/year 03/07/1988 LST
Stage 1: Extracting onsite data for month/day/year 03/08/1988 LST
Stage 1: Extracting onsite data for month/day/year 03/09/1988 LST
Stage 1: Extracting onsite data for month/day/year 03/10/1988 LST
Stage 1: QA'ing onsite data for month/day/year 03/01/1988 LST
Stage 1: QA'ing onsite data for month/day/year 03/02/1988 LST
Stage 1: QA'ing onsite data for month/day/year 03/03/1988 LST
Stage 1: QA'ing onsite data for month/day/year 03/04/1988 LST
Stage 1: QA'ing onsite data for month/day/year 03/05/1988 LST
Stage 1: QA'ing onsite data for month/day/year 03/06/1988 LST
Stage 1: QA'ing onsite data for month/day/year 03/07/1988 LST
Stage 1: QA'ing onsite data for month/day/year 03/08/1988 LST
Stage 1: QA'ing onsite data for month/day/year 03/09/1988 LST
Stage 1: QA'ing onsite data for month/day/year 03/10/1988 LST

AERMET FINISHED SUCCESSFULLY

END PROCESSING DATE/TIME: MAY 20, 2022 10:51:02 AM

```

**Figure 4-30. Control file to extract and QA site-specific data.**

Figure 4-31 shows the processing messages contained in ONSITE\_S1\_MESSAGE.TXT. Messages that start with 'W' are warning messages, 'I' are informational messages, 'E' are error messages and 'Q' are quality assurance messages. The I01 message indicates that Stage 1 is being processed. The first I60 message indicates the start time of site-specific data extraction and message I63 and I64 indicate the number of extracted and duplicate observations, respectively. The second I60 message indicates the end of the extraction process. Message Q64 indicates a wind speed less than the threshold and the remaining Q61 messages indicate missing variables with the indicated times and levels.

```

I01      READINP      PROCESSING STAGE 1
ONSITE   I60      OS_PROC      BEGIN: ONSITE EXTRACTION 20220520 10:51:02
ONSITE   I63      OS_PROC      NUMBER OF EXTRACTED OBSERVATIONS:      240
ONSITE   I64      OS_PROC      NUMBER OF DUPLICATE OBSERVATIONS:      0
ONSITE   I66      OS_PROC      NUMBER OF BAD HEIGHT LEVELS:      0
ONSITE   I60      OS_PROC      END: ONSITE EXTRACTION 20220520 10:51:02
ONSITE   Q64      CHECK_WIND 19880307 HR 02 WIND SPEED < 0.30 LEVEL 2
ONSITE   Q61      AUDIT      19880301 HR 11 TT01 MISSING LEVEL 1
ONSITE   Q61      AUDIT      19880301 HR 11 WD01 MISSING LEVEL 1
ONSITE   Q61      AUDIT      19880301 HR 11 WS01 MISSING LEVEL 1
ONSITE   Q61      AUDIT      19880301 HR 11 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880301 HR 11 WD02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880301 HR 11 WS02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880301 HR 11 TT03 MISSING LEVEL 3
ONSITE   Q61      AUDIT      19880301 HR 11 WD03 MISSING LEVEL 3
ONSITE   Q61      AUDIT      19880301 HR 11 WS03 MISSING LEVEL 3
ONSITE   Q61      AUDIT      19880303 HR 18 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880303 HR 19 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880303 HR 20 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880303 HR 21 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880303 HR 22 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880303 HR 23 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880303 HR 24 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 1 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 2 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 3 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 4 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 5 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 6 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 7 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 8 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 9 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 10 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 11 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 12 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 13 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 14 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 15 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 16 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 17 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 18 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 19 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 20 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 21 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 22 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 23 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880304 HR 24 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880305 HR 1 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880305 HR 2 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880305 HR 3 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880305 HR 4 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880305 HR 5 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880305 HR 6 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880305 HR 7 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880305 HR 8 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880307 HR 2 WD02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880307 HR 16 WD01 MISSING LEVEL 1
ONSITE   Q61      AUDIT      19880307 HR 16 WS01 MISSING LEVEL 1
ONSITE   Q61      AUDIT      19880307 HR 17 WD01 MISSING LEVEL 1
ONSITE   Q61      AUDIT      19880307 HR 17 WS01 MISSING LEVEL 1
ONSITE   Q61      AUDIT      19880308 HR 10 TT01 MISSING LEVEL 1
ONSITE   Q61      AUDIT      19880308 HR 10 WD01 MISSING LEVEL 1
ONSITE   Q61      AUDIT      19880308 HR 10 WS01 MISSING LEVEL 1
ONSITE   Q61      AUDIT      19880308 HR 10 TT02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880308 HR 10 WD02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880308 HR 10 WS02 MISSING LEVEL 2
ONSITE   Q61      AUDIT      19880308 HR 10 TT03 MISSING LEVEL 3
ONSITE   Q61      AUDIT      19880308 HR 10 WD03 MISSING LEVEL 3
ONSITE   Q61      AUDIT      19880308 HR 10 WS03 MISSING LEVEL 3

```

Figure 4-31. Contents of the ONSITE\_S1\_MESSAGE.TXT message file.

Figure 4-32 through Figure 4-34 show the contents of the report file, ONSITE\_S1\_REPORT.TXT. Figure 4-32 is analogous to

Figure 4-4 and Figure 4-11, showing the input information. Figure 4-33 shows the QA summary of the site-specific data and has a missing value and bounds summary like Figure 4-5 and Figure 4-13. Since there is more than one level of data, the QA summary is by level. Most of the data are accepted and there was only one wind speed less than the threshold. Finally, Figure 4-34 shows the message summary for the site-specific data extraction. There are no error or warning messages and five information messages distributed among I01, I60, I63, and I64. There are 63 QA messages with 62 of those associated with Q61 and one for Q64.

```

AERMET_SETUP
SUCCESSFUL

AERMET VERSION 22112

START PROCESSING DATE/TIME: MAY 20, 2022 10:51:02 AM

RUNSTREAM CONTROL FILE: ONSITE_S1.INP

***** INPUT SUMMARY *****

PROCESSING STAGES 1

1. JOB FILE NAMES

MESSAGES OPEN ONSITE_S1_MESSAGE.TXT
REPORT OPEN ONSITE_S1_REPORT.TXT
DEBUG NO FILE

2. UPPERAIR DATA

NO PROCESSING REQUESTED

3. SURFACE DATA

NO PROCESSING REQUESTED

4. ONSITE DATA

PROCESSING DATES: 03/01/1988 - 03/10/1988

      SITE ID      LATITUDE      LONGITUDE      TIME ADJUSTMENT      ELEVATION
      -----      -
LOCATION:          99999          41.30          -74.00              0              0.00

DATA FILE: OPEN ONSITE.MET
QAOUT FILE: OPEN ONSITE_QAOUT.TXT

NUMBER OF OBSERVATIONS/HOUR: 1

THRESHOLD WIND SPEED (M/S): 0.30

5. PROG DATA

NO PROCESSING REQUESTED

6. METPREP DATA

NO PROCESSING REQUESTED

```

**Figure 4-32. Input summary contents of the ONSITE extraction report file.**

```

***** QA SUMMARY *****

```

ONSITE DATA

VARIABLE	MISSING VALUE	LOWER BOUND	UPPER BOUND
TT	-99.00	<= -30.00	>= 40.00
WD	-999.00	< 0.00	> 360.00
WS	-999.00	<= 0.00	>= 50.00

HOURLY VALUES

LEVEL	VARIABLE	# OBS	# MISSING	LOWER BOUND	UPPER BOUND	% ACCEPTED
10.000 M	TT	240	2	0	0	99.17
	WD	240	4	0	0	98.33
	WS	240	4	0	0	98.33
50.000 M	TT	240	41	0	0	82.92
	WD	240	3	0	0	98.75
	WS	240	2	0	0	99.17
100.000 M	TT	240	2	0	0	99.17
	WD	240	2	0	0	99.17
	WS	240	2	0	0	99.17

WIND AND TEMPERATURE CHECKS (IF APPLICABLE)  
NUMBER OF OBS:

- 1 CALM WINDS (< THRESHOLD)
- 0 NO INPUT WD WITH WS
- 0 NO INPUT WD WITH WS

**Figure 4-33. QA summary contents of the ONSITE extraction report file.**

```

***** MESSAGE SUMMARY *****

ERROR MESSAGES          0 MESSAGES

WARNING MESSAGES       0 MESSAGES

INFORMATION MESSAGES   5 MESSAGES

I01:          1
I60:          2
I63:          1
I64:          1

QA MESSAGES           63 MESSAGES

Q61:          62
Q64:          1

AERMET FINISHED SUCCESSFULLY

END PROCESSING DATE/TIME: MAY 20, 2022  10:51:02 AM

```

**Figure 4-34. Message summary contents of the ONSITE extraction report file.**

Figure 4-35 shows the QAOUT file, ONSITE\_QA.OUT. The header has similar information as the SURFACE and UPPERAIR QAOUT files shown in Figure 4-7 and Figure 4-17, respectively. Additionally, the ONSITE QAOUT file will include the threshold wind speed, an over land or over water identifier, and modified missing values or bounds for the variables. Also included are the first and last levels for multi-level variables. In this example, all variables occur on all three levels. For descriptions of the variable names see Table B-3 and Table B-4 in Appendix B.

```

AERMET VERSION 22112
LOCATION 99999      41.300N      74.000W  0
FILE TYPE: QAOUT
THRESHOLD  0.300
OVERLAND
DATES 1988 03 01 1988 03 10
RANGE SANN      0 <=      95      -99
RANGE TTNN     -30 <      40      -99
RANGE WDNN      0 <=     360     -999
RANGE WSNN      0 <      50     -999
HTNN FIRST-LAST LEVELS  1  3
SANN FIRST-LAST LEVELS  1  3
SWNN FIRST-LAST LEVELS  1  3
TTNN FIRST-LAST LEVELS  1  3
WDNN FIRST-LAST LEVELS  1  3
WSNN FIRST-LAST LEVELS  1  3
DATE      HR      LEV      HTNN      SANN      SWNN      TTNN      WDNN      WSNN
19880301  01      1      10.0000   48.7000   0.1100   0.6400   317.5000   0.8000
19880301  01      2      50.0000   14.7000  -99.0000   1.8400   323.3000   2.0000
19880301  01      3     100.0000    9.1000   0.4100   1.6400   320.5000   3.7000
19880301  02      1      10.0000   22.5000   0.0800   0.3400   273.1000   0.9000
19880301  02      2      50.0000   15.6000  -99.0000   1.0400   304.0000   1.5000
19880301  02      3     100.0000   13.4000   0.3400   0.7400   308.5000   2.5000
19880301  03      1      10.0000   63.3000   0.0800  -0.7600   276.5000   0.6000
19880301  03      2      50.0000   32.9000  -99.0000   0.0400   331.7000   1.3000
19880301  03      3     100.0000   27.0000   0.3900  -0.1600   319.1000   2.3000
19880301  04      1      10.0000   74.4000   0.0400  -1.6600   199.7000   0.6000
19880301  04      2      50.0000   58.9000  -99.0000  -0.7600    99.5000   0.9000
19880301  04      3     100.0000   55.1000   0.4500  -0.7600   321.6000   1.3000
19880301  05      1      10.0000   25.3000   0.1300  -1.3600   289.3000   1.2000
19880301  05      2      50.0000   29.4000  -99.0000  -0.8600   339.3000   1.5000
19880301  05      3     100.0000   29.8000   0.4700  -1.2600   333.2000   2.1000

```

**Figure 4-35. Partial contents of the ONSITE QAOUT file.**



#### 4.2.2 Data merge and boundary layer calculations

After extracting the site-specific data, the next step is to merge the site-specific data with the surface data and upper air data extracted in Stage 1 as part of the example discussed in Section 4.1. The AERMET Stage 2 control file, ONSITE\_S2.INP, is shown in Figure 4-36. The QAOUT files from the upper air and surface extractions discussed in 4.1 are shown in the UPPERAIR and SURFACE pathways. The site-specific QAOUT data are shown in the ONSITE pathway. The METPREP pathway lists the two output files, ONSITE\_NWS.SFC and ONSITE\_NWS.PFL. The LOCATION keyword gives the location of the modeled source and method options include NWS substitution and randomization of the wind directions. The NWS anemometer height is listed as 6.1 m. Since surface data are from two sources, the site-specific location, and the NWS station, two sets of surface characteristics are listed. The site-specific characteristics are denoted by `FREQ_SECT`, `SECTOR`, and `SITE_CHAR` and are monthly for two sectors. The NWS station surface characteristics are denoted by `FREQ_SECT2`, `SECTOR2`, and `SITE_CHAR2` and are the same as shown in the example discussed in Section 4.1.3.

To execute AERMET Stage 2 for this example, the user will type the following at the command prompt:

```
aermet.exe ONSITE_S2.INP
```

assuming the control file and AERMET executable are in the same folder. Processing information will be written to the screen. If the user wishes to have that information written to a text file, the user will type the following at the command prompt:

```
aermet.exe ONSITE_S2.INP > onsite_s2.txt
```

The contents of ONSITE\_S2.TXT are shown in Figure 4-37 and show the AERMET processing. The first line lists the start date and time of the AERMET processing. The next ten lines notify the user of the upper air extraction dates followed by ten lines denoting surface extraction dates. The next ten lines denote that the initial data assignments for variables such as wind and temperature are being performed, and the following ten lines denote PBL calculations

are being performed. The final messages indicate that AERMET completed successfully followed by the AERMET processing end date and time.

Figure 4-38 through Figure 4-40 show partial contents of the ONSITE\_2\_MESSAGE.TXT file. Figure 4-38 shows extraction messages for the upper air, surface, and site-specific data. The messages for the upper air and surface extraction are the same as shown in Figure 4-20 in Section 4.1.3. Messages I60 through I64 and the second I60 message denote the site-specific extraction. Message I70 indicates the beginning of PBL calculations and I82 indicates that the solar angle method will be used to determine stability. In Figure 4-39, message I73 occurs throughout the PBL calculations, indicating that the measurement height of 10 m from the site-specific data is less than 20 times the surface roughness of 0.75. This is pointed out to indicate that AERMET is using the site-specific characteristics when site-specific data are available. Figure 4-40 shows messages about sounding information and note that message I90 indicates that NWS data are substituted for March 3, 1988, hour 10.

```

JOB
  REPORT      ONSITE_S2_REPORT.RPT
  MESSAGES    ONSITE_S2_MESSAGE.TXT

UPPERAIR
  QAOUT       UPPER_QAOUT.TXT

SURFACE
  QAOUT       SURFACE_QAOUT.TXT

ONSITE
  QAOUT       ONSITE_QAOUT.TXT

METPREP

  OUTPUT      ONSITE_NWS.SFC
  PROFILE     ONSITE_NWS.PFL

  LOCATION    MYSITE 74.00W 41.3N 5
  METHOD       REFLEVEL  SUBNWS
  METHOD       WIND_DIR  RANDOM
  NWS_HGT     WIND      6.1

  FREQ_SECT   MONTHLY 2
  SECTOR 1    35      225
  SECTOR 2    225     35

  SITE_CHAR   1  1  0.350  0.800  0.300
  SITE_CHAR   2  1  0.350  0.800  0.300
  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
  SITE_CHAR  12  1  0.350  0.800  0.300
  SITE_CHAR   1  2  0.500  1.500  0.750
  SITE_CHAR   2  2  0.500  1.500  0.750
  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
  SITE_CHAR  12  2  0.500  1.500  0.750

  FREQ_SECT2  ANNUAL 1
  SECTOR2     1      0      360
  SITE_CHAR2  1  1  0.15  2.0  0.12

```

**Figure 4-36. Control file for boundary layer calculations in METPREP.**

```
START PROCESSING DATE/TIME: MAY 20, 2022 10:51:04 AM
Stage 2: Extracting upper air data for month/day/year 03/01/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/02/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/03/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/04/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/05/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/06/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/07/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/08/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/09/1988 LST
Stage 2: Extracting upper air data for month/day/year 03/10/1988 LST
Stage 2: Extracting surface data for month/day/year 03/01/1988 LST
Stage 2: Extracting surface data for month/day/year 03/02/1988 LST
Stage 2: Extracting surface data for month/day/year 03/03/1988 LST
Stage 2: Extracting surface data for month/day/year 03/04/1988 LST
Stage 2: Extracting surface data for month/day/year 03/05/1988 LST
Stage 2: Extracting surface data for month/day/year 03/06/1988 LST
Stage 2: Extracting surface data for month/day/year 03/07/1988 LST
Stage 2: Extracting surface data for month/day/year 03/08/1988 LST
Stage 2: Extracting surface data for month/day/year 03/09/1988 LST
Stage 2: Extracting surface data for month/day/year 03/10/1988 LST
Stage 2: Extracting onsite data for month/day/year 03/01/1988 LST
Stage 2: Extracting onsite data for month/day/year 03/02/1988 LST
Stage 2: Extracting onsite data for month/day/year 03/03/1988 LST
Stage 2: Extracting onsite data for month/day/year 03/04/1988 LST
Stage 2: Extracting onsite data for month/day/year 03/05/1988 LST
Stage 2: Extracting onsite data for month/day/year 03/06/1988 LST
Stage 2: Extracting onsite data for month/day/year 03/07/1988 LST
Stage 2: Extracting onsite data for month/day/year 03/08/1988 LST
Stage 2: Extracting onsite data for month/day/year 03/09/1988 LST
Stage 2: Extracting onsite data for month/day/year 03/10/1988 LST
Stage 2: Initial data assignments for month/day/year 03/01/1988 LST
Stage 2: Initial data assignments for month/day/year 03/02/1988 LST
Stage 2: Initial data assignments for month/day/year 03/03/1988 LST
Stage 2: Initial data assignments for month/day/year 03/04/1988 LST
Stage 2: Initial data assignments for month/day/year 03/05/1988 LST
Stage 2: Initial data assignments for month/day/year 03/06/1988 LST
Stage 2: Initial data assignments for month/day/year 03/07/1988 LST
Stage 2: Initial data assignments for month/day/year 03/08/1988 LST
Stage 2: Initial data assignments for month/day/year 03/09/1988 LST
Stage 2: Initial data assignments for month/day/year 03/10/1988 LST
Stage 2: PBL calculations for month/day/year 03/01/1988 LST
Stage 2: PBL calculations for month/day/year 03/02/1988 LST
Stage 2: PBL calculations for month/day/year 03/03/1988 LST
Stage 2: PBL calculations for month/day/year 03/04/1988 LST
Stage 2: PBL calculations for month/day/year 03/05/1988 LST
Stage 2: PBL calculations for month/day/year 03/06/1988 LST
Stage 2: PBL calculations for month/day/year 03/07/1988 LST
Stage 2: PBL calculations for month/day/year 03/08/1988 LST
Stage 2: PBL calculations for month/day/year 03/09/1988 LST
Stage 2: PBL calculations for month/day/year 03/10/1988 LST

AERMET FINISHED SUCCESSFULLY

END PROCESSING DATE/TIME: MAY 20, 2022 10:51:04 AM
```

**Figure 4-37. Processing steps for the boundary layer calculations**

	I01	READINP	PROCESSING STAGE 2
UPPERAIR	W01	GETLOC	STATION ELEVATION NOT NEEDED
METPREP	W70	PBL_TEST	LOCATION KEYWORD NOT NEEDED
UPPERAIR	I20	UP_PROC	UPPER AIR EXTRACTION BEGIN 20220520 10:51:04
UPPERAIR	I23	UP_PROC	NUMBER OF EXTRACTED SOUNDINGS: 20
UPPERAIR	I24	UP_PROC	NUMBER OF UNIQUE VALID SOUNDINGS: 20
UPPERAIR	I25	UP_PROC	NUMBER OF DUPLICATE SOUNDINGS: 0
UPPERAIR	I26	UP_PROC	NUMBER OF SKIPPED SOUNDINGS: 0
UPPERAIR	I20	UP_PROC	UPPER AIR EXTRACTION END 20220520 10:51:04
SURFACE	I40	SF_PROC	SURFACE EXTRACTION BEGIN: 20220520 10:51:04
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880301
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880302
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880303
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880304
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880305
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880306
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880307
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880308
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880309
SURFACE	W45	CHECK_ASOS	STATION IS ASOS, BUT BEFORE COMMISSION DATE 19950801 FOR DATE: 19880310
SURFACE	I46	SF_PROC	NUMBER OF EXTRACTED SURFACE OBSERVATIONS: 240
SURFACE	I47	SF_PROC	NUMBER OF RETAINED OBSERVATIONS: 240
SURFACE	I40	SF_PROC	SURFACE EXTRACTION END: 20220520 10:51:04
ONSITE	I60	OS_PROC	BEGIN: ONSITE EXTRACTION 20220520 10:51:04
ONSITE	I63	OS_PROC	NUMBER OF EXTRACTED OBSERVATIONS: 240
ONSITE	I64	OS_PROC	NUMBER OF DUPLICATE OBSERVATIONS: 0
ONSITE	I66	OS_PROC	NUMBER OF BAD HEIGHT LEVELS: 0
ONSITE	I60	OS_PROC	END: ONSITE EXTRACTION 20220520 10:51:04
METPREP	I70	PBL_PROC	PBL CALCULATIONS BEGIN: 20220520 10:51:04
METPREP	I84	PBL_PROC	SOLAR ANGLE APPROACH WILL BE USED FOR STABILITY DETERMINATION

**Figure 4-38. Initial contents of the Stage 2 message file ONSITE\_S2\_MESSAGE.TXT**

METPREP	I73	WINDS	DATE: 19880301	HR 01	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 02	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 03	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 05	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 06	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 07	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 08	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 09	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 10	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 12	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 13	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 14	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 15	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 16	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 17	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 18	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 19	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 20	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 21	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 22	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 23	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880301	HR 24	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880302	HR 01	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880302	HR 02	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880302	HR 03	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880302	HR 04	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880302	HR 05	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880302	HR 06	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880302	HR 07	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880302	HR 08	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880302	HR 18	WIND HEIGHT	10.00	<	20X	Z0	0.75
METPREP	I73	WINDS	DATE: 19880302	HR 19	WIND HEIGHT	10.00	<	20X	Z0	0.75

**Figure 4-39. Partial contents of the Stage 2 message file ONSITE\_S2\_MESSAGE.TXT**

METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880301 IS 19880301 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880301 TOP OF SOUNDING 5.2 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED
ONSITE	I90	PROFILE	NWS DATA SUBSTITUTED FOR ONSITE DATA FOR DATE: 19880301 HR 11
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880302 IS 19880302 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880302 TOP OF SOUNDING 5.4 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880303 IS 19880303 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880303 TOP OF SOUNDING 5.4 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880304 IS 19880304 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880304 TOP OF SOUNDING 5.4 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880305 IS 19880305 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880305 TOP OF SOUNDING 5.4 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880306 IS 19880306 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880306 TOP OF SOUNDING 5.4 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880307 IS 19880307 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880307 TOP OF SOUNDING 5.4 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880308 IS 19880308 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880308 TOP OF SOUNDING 5.5 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED
ONSITE	I90	PROFILE	NWS DATA SUBSTITUTED FOR ONSITE DATA FOR DATE: 19880308 HR 10
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880309 IS 19880309 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880309 TOP OF SOUNDING 5.5 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED
METPREP	I77	READ_SOUND	SOUNDING FOR DATE: 19880310 IS 19880310 HR 07 SOUNDING # 1
METPREP	W76	READ_SOUND	DATE 19880310 TOP OF SOUNDING 5.0 KM EXTENDS BEYOND 5.0 KM; SOUNDING NOT EXTENDED

**Figure 4-40. Final contents of the Stage 2 message file ONSITE\_S2\_MESSAGE.TXT**

Figure 4-41 through Figure 4-45 show the contents of the report file, ONSITE\_S2\_REPORT.TXT. Figure 4-41 is similar to

Figure 4-4, Figure 4-11, and Figure 4-32 in that it shows the summary files and locations of the upper air and surface stations and site-specific tower location. Figure 4-42 shows the summary for the METPREP pathway, including processing dates, site location (even though not needed), the output filenames and processing options. For this example, wind directions are randomized, and cloud substitution is performed. However, temperature substitution is not performed. Following the METPREP summary is the surface characteristics summary in Figure 4-43 where the surface characteristics for each processed year are shown for both the primary (site-specific tower) and secondary (NWS station) locations. For this example, only one year is processed. Figure 4-44 shows the observations and PBL calculation summaries and is analogous to Figure 4-24. Finally, in Figure 4-45 is the message file summary, like Figure 4-25. For the boundary layer calculations there are no error messages, 22 warning messages distributed among W01, W45, W70, and W76, and 211 information messages distributed among several message types and no quality assurance messages. Finally, the report file notifies the user AERMET finished successfully with the date and time the program finished processing.

Figure 4-46 and Figure 4-47 show the contents of the two output files, ONSITE\_NWS.SFC and ONSITE\_NWS.PFL, respectively. The user is referred to Table C-4 and Table C-5 in Appendix C, and Section C. 2 for the formats. Note that the data in the surface file shown in Figure 4-46 is a mix of site-specific (NAD-OS) and NWS (NAD-SFC) data. For the profile data shown in Figure 4-47 the three levels of temperature, wind, and turbulence data from the site-specific data are evident.



```

AERMET_SETUP
SUCCESSFUL

AERMET VERSION 22112

START PROCESSING DATE/TIME: MAY 20, 2022 10:51:04 AM

RUNSTREAM CONTROL FILE: ONSITE_S2.INP

***** INPUT SUMMARY *****

AERMET_SETUP SUCCESSFUL

PROCESSING STAGES 2

1. JOB FILE NAMES

MESSAGES OPEN ONSITE_S2_MESSAGE.TXT
REPORT OPEN ONSITE_S2_REPORT.RPT
DEBUG NO FILE

2. UPPERAIR DATA

PROCESSING DATES: 03/01/1988 - 03/10/1988

      SITE ID   LATITUDE   LONGITUDE   TIME ADJUSTMENT
-----
LOCATION: 00014735      42.75      -73.80           5

DATA FILE: NO FILENAME INPUT
EXTRACT FILE: NO FILENAME INPUT
QAOUT FILE: OPEN UPPER_QAOUT.TXT

UPPER AIR DATA ABOVE 5000 NOT EXTRACTED

UPPER AIR AUTOMATIC DATA CHECKS ARE: OFF

3. SURFACE DATA

PROCESSING DATES: 03/01/1988 - 03/10/1988

      SITE ID   LATITUDE   LONGITUDE   TIME ADJUSTMENT   ELEVATION
-----
LOCATION: 14735      42.75      -73.80           0           83.80

ASOS COMMISSION DATE: 19950801
DATA FILE: NO FILENAME INPUT
ASOSIMIN FILE: NO FILENAME INPUT
EXTRACT FILE: NO FILENAME INPUT
QAOUT FILE: OPEN SURFACE_QAOUT.TXT

4. ONSITE DATA

PROCESSING DATES: 03/01/1988 - 03/10/1988

      SITE ID   LATITUDE   LONGITUDE   TIME ADJUSTMENT   ELEVATION
-----
LOCATION: 99999      41.30      -74.00           0           0.00

DATA FILE: NO FILENAME INPUT
QAOUT FILE: OPEN ONSITE_QAOUT.TXT

NUMBER OF OBSERVATIONS/HOUR: 1

5. PROG DATA

NO PROCESSING REQUESTED

```

**Figure 4-41. Input summary contents of ONSITE\_S2\_REPORT.TXT**

```

6. METPREP DATA

PROCESSING DATES: 03/01/1988 - 03/10/1988

          SITE ID      LATITUDE    LONGITUDE    TIME ADJUSTMENT
          -----      -
LOCATION:          -9          41.30        -74.00         5

OUTPUT FILE:    OPEN      ONSITE_NWS.SFC
PROFILE FILE:   OPEN      ONSITE_NWS.PFL

METPREP PROCESSING OPTIONS
PROCESS                OPTION  DESCRIPTION
WIND DIRECTION         RANDOM  WIND DIRECTIONS ARE RAMDOMNIZED
REFLEVEL               SUBNWS  NWS WINDS AND TEMPS SUBSTITUED FOR MISSING ONSITE DATA
CLOUD COVER           SUB_CC  CLOUD COVER SUBSTITUTED
TEMPERATURE           NOTSUB  TEMPERATURE NOT SUBSTITUTED

```

**Figure 4-42. METPREP summary contents of ONSITE\_S2\_REPORT.TXT**

***** SFC CHARACTERISTICS SUMMARY *****						
PRIMARY SITE CHARACTERISTICS						
YEAR: 1988 FREQUENCY MONTHLY						
NUMBER OF SECTORS: 2						
YEAR	MONTH	BEGIN SECTOR	END SECTOR	ALBEDO	BOWEN RATIO	ROUGHNESS LENGTH (M)
1988	JANUARY	35.	225.	0.35	0.80	0.3000
1988	JANUARY	225.	35.	0.50	1.50	0.7500
1988	FEBRUARY	35.	225.	0.35	0.80	0.3000
1988	FEBRUARY	225.	35.	0.50	1.50	0.7500
1988	MARCH	35.	225.	0.35	0.80	0.3000
1988	MARCH	225.	35.	0.50	1.50	0.7500
1988	APRIL	35.	225.	0.25	0.40	0.5000
1988	APRIL	225.	35.	0.25	0.70	1.0000
1988	MAY	35.	225.	0.25	0.40	0.5000
1988	MAY	225.	35.	0.25	0.70	1.0000
1988	JUNE	35.	225.	0.12	0.20	0.7000
1988	JUNE	225.	35.	0.15	0.30	1.5000
1988	JULY	35.	225.	0.12	0.20	0.7000
1988	JULY	225.	35.	0.15	0.30	1.5000
1988	AUGUST	35.	225.	0.12	0.20	0.7000
1988	AUGUST	225.	35.	0.15	0.30	1.5000
1988	SEPTEMBER	35.	225.	0.20	0.60	0.5000
1988	SEPTEMBER	225.	35.	0.20	1.00	1.2500
1988	OCTOBER	35.	225.	0.20	0.60	0.5000
1988	OCTOBER	225.	35.	0.20	1.00	1.2500
1988	NOVEMBER	35.	225.	0.20	0.60	0.5000
1988	NOVEMBER	225.	35.	0.20	1.00	1.2500
1988	DECEMBER	35.	225.	0.35	0.80	0.3000
1988	DECEMBER	225.	35.	0.50	1.50	0.7500
SECONDARY SITE CHARACTERISTICS						
YEAR: 1988 FREQUENCY: ANNUAL						
NUMBER OF SECTORS: 1						
YEAR		BEGIN SECTOR	END SECTOR	ALBEDO	BOWEN RATIO	ROUGHNESS LENGTH (M)
1988		0.	360.	0.15	2.00	0.1200

**Figure 4-43. Surface characteristics summary contents of ONSITE\_S2\_REPORT.TXT**

```

***** OBSERVATIONS PER DAY SUMMARY *****

STARTING: 01-MAR-1988
ENDING: 10-MAR-1988

***** TOTAL OBSERVATION COUNTS *****

NWS UPPER AIR  OBS    20
NWS SURFACE    OBS   240
ONSITE         OBS   240
1-MIN ASOS HR  OBS    0

***** DAILY OUTPUT STATISTICS *****

      1988 MO/DY:  03/01  03/02  03/03  03/04  03/05  03/06  03/07  03/08  03/09  03/10
NWS UPPER AIR  OBS    2     2     2     2     2     2     2     2     2     2
NWS SURFACE    OBS   24    24    24    24    24    24    24    24    24    24
ONSITE         OBS   24    24    24    24    24    24    24    24    24    24
1-MIN ASOS HR  OBS    0     0     0     0     0     0     0     0     0     0

***** PBL PROCESSING SUMMARY *****

NUMBER OF DAYS WITH NO CONVECTIVE CONDITIONS:      0

NUMBER OF TOTAL CALMS:          0
NUMBER OF VARIABLE WINDS:       0

NUMBER OF SUBSTITUTIONS (INTERPOLATION) FOR MISSING CLOUD COVER:      0

```

**Figure 4-44. Observations summary and PBL processing summary contents of the Stage 2 report file.**

```
***** MESSAGE SUMMARY *****  
  
ERROR MESSAGES          0 MESSAGES  
  
WARNING MESSAGES       22 MESSAGES  
W01:          1  
W45:         10  
W70:          1  
W76:         10  
  
INFORMATION MESSAGES   211 MESSAGES  
I01:          1  
I20:          2  
I23:          1  
I24:          1  
I25:          1  
I26:          1  
I40:          2  
I46:          1  
I47:          1  
I60:          2  
I63:          1  
I64:          1  
I66:          1  
I70:          1  
I73:         182  
I77:          10  
I83:          1  
I90:          2  
  
QA MESSAGES            0 MESSAGES  
  
AERMET FINISHED SUCCESSFULLY  
END PROCESSING DATE/TIME: MAY 20, 2022 10:51:04 AM
```

**Figure 4-45. Message summary contents of ONSITE\_S2\_REPORT.TXT**

41.300N	74.000	UA_ID: 00014735			SF_ID: 14735			OS_ID: 99999			VERSION: 22112			CCVR_Sub												
88	3	1	61	1	-2.7	0.062	-9.000	-9.000	-999.	37.	7.9	0.7500	1.50	1.00	0.80	317.5	10.0	273.8	10.0	0	-9.00	999.	1003.	4	NAD-OS	NoSubs
88	3	1	61	2	-3.5	0.069	-9.000	-9.000	-999.	44.	8.5	0.7500	1.50	1.00	0.90	273.1	10.0	273.5	10.0	0	-9.00	999.	1003.	1	NAD-OS	NoSubs
88	3	1	61	3	-1.6	0.046	-9.000	-9.000	-999.	24.	5.7	0.7500	1.50	1.00	0.60	276.5	10.0	272.4	10.0	0	-9.00	999.	1003.	1	NAD-OS	NoSubs
88	3	1	61	4	-1.0	0.034	-9.000	-9.000	-999.	15.	3.6	0.3000	0.80	1.00	0.60	199.7	10.0	271.5	10.0	0	-9.00	999.	1003.	1	NAD-OS	NoSubs
88	3	1	61	5	-6.3	0.093	-9.000	-9.000	-999.	68.	11.3	0.7500	1.50	1.00	1.20	289.3	10.0	271.8	10.0	0	-9.00	999.	1003.	0	NAD-OS	NoSubs
88	3	1	61	6	-2.8	0.062	-9.000	-9.000	-999.	37.	7.5	0.7500	1.50	1.00	0.80	254.0	10.0	271.0	10.0	0	-9.00	999.	1004.	0	NAD-OS	NoSubs
88	3	1	61	7	-3.6	0.069	-9.000	-9.000	-999.	44.	8.5	0.7500	1.50	1.00	0.90	264.3	10.0	270.9	10.0	0	-9.00	999.	1004.	0	NAD-OS	NoSubs
88	3	1	61	8	-5.4	0.148	-9.000	-9.000	-999.	137.	54.2	0.7500	1.50	0.67	1.30	314.7	10.0	271.8	10.0	0	-9.00	999.	1005.	6	NAD-OS	NoSubs
88	3	1	61	9	25.1	0.321	0.558	0.007	248.	437.	-118.3	0.7500	1.50	0.56	1.90	310.1	10.0	272.3	10.0	0	-9.00	999.	1005.	7	NAD-OS	NoSubs
88	3	1	61	10	60.6	0.396	0.949	0.008	506.	599.	-92.0	0.7500	1.50	0.52	2.30	314.8	10.0	273.0	10.0	0	-9.00	999.	1005.	6	NAD-OS	NoSubs
88	3	1	61	11	88.3	0.793	1.182	0.005	671.	1695.	-505.9	0.1200	1.50	0.51	7.70	297.0	6.1	268.8	2.0	0	-9.00	999.	1005.	2	NAD-SFC	NoSubs
88	3	1	61	12	97.8	0.438	1.247	0.007	711.	851.	-76.9	0.7500	1.50	0.51	2.50	308.9	10.0	274.7	10.0	0	-9.00	999.	1004.	0	NAD-OS	NoSubs
88	3	1	61	13	99.6	0.535	1.277	0.006	749.	939.	-137.9	0.7500	1.50	0.51	3.20	315.9	10.0	274.9	10.0	0	-9.00	999.	1003.	0	NAD-OS	NoSubs
88	3	1	61	14	88.9	0.533	1.248	0.006	781.	933.	-151.8	0.7500	1.50	0.51	3.20	290.1	10.0	275.3	10.0	0	-9.00	999.	1002.	0	NAD-OS	NoSubs
88	3	1	61	15	65.9	0.483	1.147	0.007	818.	808.	-152.3	0.7500	1.50	0.52	2.90	299.8	10.0	275.5	10.0	0	-9.00	999.	1002.	0	NAD-OS	NoSubs
88	3	1	61	16	31.5	0.453	0.905	0.007	841.	733.	-263.9	0.7500	1.50	0.55	2.80	315.2	10.0	275.0	10.0	0	-9.00	999.	1001.	0	NAD-OS	NoSubs
88	3	1	61	17	-15.1	0.430	-9.000	-9.000	-999.	678.	469.5	0.7500	1.50	0.62	2.90	308.4	10.0	274.3	10.0	0	-9.00	999.	1001.	0	NAD-OS	NoSubs
88	3	1	61	18	-15.6	0.147	-9.000	-9.000	-999.	249.	18.1	0.7500	1.50	0.86	1.90	310.8	10.0	273.3	10.0	0	-9.00	999.	1001.	0	NAD-OS	NoSubs
88	3	1	61	19	-11.2	0.124	-9.000	-9.000	-999.	108.	15.1	0.7500	1.50	1.00	1.60	313.3	10.0	272.2	10.0	0	-9.00	999.	1001.	0	NAD-OS	NoSubs
88	3	1	61	20	-7.4	0.100	-9.000	-9.000	-999.	76.	12.2	0.7500	1.50	1.00	1.30	326.2	10.0	271.3	10.0	0	-9.00	999.	1002.	0	NAD-OS	NoSubs
88	3	1	61	21	-17.5	0.154	-9.000	-9.000	-999.	146.	18.8	0.7500	1.50	1.00	2.00	327.3	10.0	270.5	10.0	0	-9.00	999.	1001.	0	NAD-OS	NoSubs
88	3	1	61	22	-15.8	0.147	-9.000	-9.000	-999.	135.	17.8	0.7500	1.50	1.00	1.90	319.5	10.0	269.8	10.0	0	-9.00	999.	1001.	0	NAD-OS	NoSubs
88	3	1	61	23	-2.8	0.062	-9.000	-9.000	-999.	40.	7.5	0.7500	1.50	1.00	0.80	283.6	10.0	268.7	10.0	0	-9.00	999.	1001.	0	NAD-OS	NoSubs
88	3	1	61	24	-11.2	0.124	-9.000	-9.000	-999.	104.	15.0	0.7500	1.50	1.00	1.60	297.5	10.0	268.3	10.0	0	-9.00	999.	1001.	0	NAD-OS	NoSubs

Figure 4-46. Partial contents of ONSITE\_NWS.SFC

88	3	1	1	10.0	0	317.5	0.80	0.64	48.70	0.11
88	3	1	1	50.0	0	323.3	2.00	1.84	14.70	99.00
88	3	1	1	100.0	1	320.5	3.70	1.64	9.10	0.41
88	3	1	2	10.0	0	273.1	0.90	0.34	22.50	0.08
88	3	1	2	50.0	0	304.0	1.50	1.04	15.60	99.00
88	3	1	2	100.0	1	308.5	2.50	0.74	13.40	0.34
88	3	1	3	10.0	0	276.5	0.60	-0.76	63.30	0.08
88	3	1	3	50.0	0	331.7	1.30	0.04	32.90	99.00
88	3	1	3	100.0	1	319.1	2.30	-0.16	27.00	0.39
88	3	1	4	10.0	0	199.7	0.60	-1.66	74.40	0.04
88	3	1	4	50.0	0	99.5	0.90	-0.76	58.90	99.00
88	3	1	4	100.0	1	321.6	1.30	-0.76	55.10	0.45
88	3	1	5	10.0	0	289.3	1.20	-1.36	25.30	0.13
88	3	1	5	50.0	0	339.3	1.50	-0.86	29.40	99.00
88	3	1	5	100.0	1	333.2	2.10	-1.26	29.80	0.47

**Figure 4-47. Partial contents of ONSITE\_NWS.PFL**

## 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. More information about the methodology used to calculate the boundary layer parameters can be found in the AERMOD Model Formulation Document (EPA, 2023f).

### 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 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 reported.

AERMET estimates the heights reported in the sounding using the hypsometric equation,

$$z_2 = z_1 + [(R_d * T_v / g)] * \ln(p_1 / p_2)$$

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 gas constant for dry air,  $T_v$  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.

**Table 5-1. UPPERAIR Gradient calculation variables with default lower and upper bounds.**

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, wind *shear*, is a vector quantity. In AERMET, the shear is computed separately from 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 three 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 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. Since 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 UP\_INC. This is specified in the module UPPERAIR 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**

To implement the ASOS wind speed adjustment described in Section 3.7.7.3, AERMET must determine whether surface wind observations are from an ASOS site. 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 NWS surface file during Stage 1 processing, the observation date and time in LST 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 a "Y" in the ASOS column of the SURFACE EXTRACT and QAOUT files. If a commission date is not found, or the observation occurred before the commission date, the record is flagged with an "N" in the ASOS column to indicate it

is not an ASOS observation. See Appendix C for the format of the SURFACE EXTRACT and QAOUT files.

For those NWS surface formats that include a data field to indicate that measurements were made with ASOS instrumentation (HUSWO, 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 flagged 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-4 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. Since 1-minute ASOS wind data are presumed to be ASOS, all data from the hourly averaged 1-minute data are assumed to be an ASOS observation.

### **5.3 Validation of NWS surface format by active data range**

Validations are incorporated in AERMET, 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 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 5-2 lists the active dates for each of the NWS surface formats read by AERMET as currently implemented in AERMET. Note that ISHD is currently an active format, and the validation is not performed for the ISHD format.

**Table 5-2. Format Active Dates**

<b>NWS Surface Format</b>	<b>Start Date</b>	<b>End Date</b>
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

### 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 keyword 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 apart from

the ISHD format since ISHD includes many stations located within the U.S. and internationally for which a WBAN number has not been 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 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 sub-hourly values**

By default, AERMET assumes that there is one observation period per hour. However, the site-specific 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 sub-hourly observations to an hourly average. The user must tell AERMET the number of observation periods per hour that are in the site-specific data using the OBS/HOUR keyword. See Section 3.5.13 for a discussion on how to use this keyword. The site-specific meteorological guidance document (EPA, 1987) suggests at least 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 sub-hourly 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 directions are set to missing. When using the scalar averaging approach, 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, 2000) to properly account for the 0°-to-360° crossover. When using the vector averaging method, the east-west and north-south components of the wind are calculated based on equations 6.2.13 and 6.2.14 outlined in Section 6.2.2 of the meteorological monitoring guidance for regulatory modeling applications (EPA, 2000). The hourly average wind speed is then calculated using equation 6.2.15 in (EPA, 2000) and the hourly average wind direction is calculated using equation 6 and correction methodology listed in Section 4.6 of the AERMINUTE user's guide (EPA, 2023b).

To obtain a one-hour average of the standard deviation variables, the hourly average of the standard deviation is the square root of sum of variances (square of standard deviation) for each sub-hourly interval divided by the number of valid observations.

## **5.5 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 old Stage 3 (prior to version 21DRF) or new Stage 2 (21DRF and later) 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 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:

- 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 2) pathway, but the inputs will be ignored, and processing will continue.
- The station elevation is allowed as an optional argument on the LOCATION keyword for the SURFACE and ONSITE pathways in Stage 1.
- 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.
- 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.
- 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 2 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:

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;
  - 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.

## **5.6 Boundary layer parameter estimates**

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 characteristics are required. The surface characteristics are discussed in detail in Section 3.7.9, 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.

### **5.6.1 Reference wind and temperature**

If there are site-specific data in the meteorological input to Stage 2, 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 control file (see Section 3.7.7 for the keyword METHOD, and Section 3.7.7.2 for 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 3.7.5) 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 control file, 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 secondary keyword must be specified for AERMET to utilize NWS wind and temperature data for the reference level data. NWS data currently are not subject to the criteria above for either wind or temperature.

#### 5.6.2 Surface friction velocity and Monin-Obukhov length for prognostic overwater locations

For applications involving prognostic data and overwater applications, AERMET 22112 was modified to reset input surface friction velocity,  $u^*$ , and Monin-Obukhov length,  $L$ , when the reference wind speed (see discussion in the previous section) is reset when the reference wind speed is below the minimum value based on  $2^{1/2} * \sigma_{vmin}$ , where  $\sigma_{vmin} = 0.2$  m/s. For applications involving observed data (NWS or site-specific) or prognostic data for a land-based application, this wind speed reset occurs before any of the boundary layer calculations, such as surface friction velocity or Monin-Obukhov length, are calculated. However, for prognostic overwater applications, surface friction velocity and Monin-Obukhov length are input variables

(Section 3.5.1). When the reference wind speed input from the prognostic data is below the minimum value ( $2^{1/2} * \sigma_{vmin}$ ) and reset to the minimum value, the following steps are performed to reset the input surface friction velocity and Monin-Obukhov length:

1. Calculate  $u^*$  within AERMET based on the original input wind speed.  $U^*$  is calculated based on the user input option of adjusting  $u^*$  (ADJ\_U\*) or not adjusting  $u^*$ .
2. Calculate  $u^*$  within AERMET based on the reset wind speed ( $2^{1/2} * \sigma_{vmin}$ ).  $U^*$  is calculated based on the user input option of adjusting  $u^*$  (ADJ\_U\*) or not adjusting  $u^*$ .
3. Calculate a  $u^*$  ratio as the ratio of the  $u^*$  from step 2 to the  $u^*$  from step 1.
4. Apply the ratio from step 3 to the original input  $u^*$  from the prognostic data to calculate a reset value of  $u^*$
5. Apply the cube of the ratio from step 3 to the original L from the prognostic data to calculate a reset value of L.

The reset of  $u^*$  and L are attempts to consider the reset of the wind speed while retaining the original formulation of  $u^*$  and L.

### 5.6.3 Surface characteristics

The atmospheric boundary layer is the 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 latent heat flux  $\lambda E$ ; 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 3-1 through Table 3-5) and wind direction.

The user specifies these values on SITE\_CHAR keyword statements for one, four or 12 (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 3.7.9 for detailed discussions on these parameters.

#### 5.6.3.1 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<sup>3</sup> of characteristics by surface area within a

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<sup>3</sup> Weighting should be based on wind direction frequency, such as determined from a wind rose

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 (1978) 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 (1978) 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.

For a surface with a large roughness, however, the rate of the boundary layer growth as defined by Högström and Högström (1978) would be sufficiently rapid 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, Högström and Högström (1978) 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.

## 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 control 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:

<b>JOB</b> -	for specifying overall <b>JOB</b> control options (all stages);
<b>SURFACE</b> -	for processing NWS hourly <b>SURFACE</b> data (Stages 1 and 2);
<b>UPPERAIR</b> -	for processing NWS <b>UPPER AIR</b> data (Stages 1 and 2);
<b>ONSITE/PROG</b> -	for processing <b>ONSITE or PROGnostic</b> meteorological data (Stages 1 and 2);
<b>METPREP</b> -	for <b>MET</b> eological data <b>PREP</b> aration for use in a dispersion Model (Stage 2).

Two types of tables are provided for each pathway. The first table lists all 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 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 21DRF, the maximum record length for the AERMET control file input file has been increased from 132 to 500 characters. Another important enhancement introduced with version 21DRF of AERMET, which applies across all pathways, is that the maximum field length for filenames has been increased from 96 to 300 and the use of double quotes (“) as field delimiters for filenames is allowed to support filenames with embedded spaces.

- 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);
  
- PROG-** for processing **PROG**nostic 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);<sup>4</sup>
  
- METPREP** - for **MET**eorological data **PREP**aration for use in a dispersion Model (Stage 2).

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<sup>4</sup> MERGE pathway is obsolete with version 21DRF and later

**Table A-1. Description of Job Pathway Keywords**

<b>Keyword</b>	<b>Type</b>	<b>Description</b>
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.
DEBUG	Optional, Non-repeatable	Flag indicating to output debug information for calculations in Stage 1 and 2.
MESSAGES	Mandatory, Non-repeatable	Identifies the warning/error messages file.
NOPRINT	Optional, Non-repeatable	Flag indicating to suppress printing of information to the screen.
REPORT	Optional, Non-repeatable	Identifies the general report file.

**Table A-2. Description of Keyword Parameters for the JOB Pathway**

<b>Keyword</b>	<b>Parameters</b>	
CHK_SYNTAX	<none>	
DEBUG	[debug_filename]	
where:	debug_filename	Optional name of the file where all debug information is written; If no file is named the default filename is aermet_debug.txt
MESSAGES	message_filename	
where:	message_filename	The name of the file where all source-code-generated messages are written
NOPRINT	<none>	
REPORT	summary_filename	
where:	summary_filename	The name of the file where AERMET writes a summary of all preprocessor activity for the current run

**Table A-3. Description of SURFACE Pathway Keywords**

<b>Keyword</b>	<b>Type</b>	<b>Description</b>
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.

**Table A-4. Description of Keyword Parameters for the SURFACE Pathway**

<b>Keyword</b>	<b>Parameter(s)</b>	
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 or ALL	
where:	sfname1 ... ... sfnameN Or ALL	Name(s) of variables that are to be tracked and reported during quality assessment (as defined in Table B-2 of Appendix B). If “ALL” (case insensitive) is included, all variables will be audited.
DATA	archive_filename file_format [ASOS]	



<b>Keyword</b>	<b>Parameter(s)</b>	
EXTRACT	extracted_data_filename	
where:	extracted_data_filename	Name of the output file for data extracted from an archive data file
LOCATION <sup>5</sup>	site_id lat long [tadjust] [elevation]	
where:	site_id lat(long)  long(lat)  [tadjust]  [elevation]	<p>Site identifier for which data are to be processed.</p> <p>Station latitude in decimal degrees with the suffix N for sites north of the equator, S for sites south of the equator.</p> <p>Station longitude in decimal degrees with the suffix W for sites west of Greenwich, E for sites east of Greenwich.</p> <p>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).</p> <p>Station elevation (m above sea-level); default of 0m if omitted.</p>
NO_MISSING	sfname1 ... sfnameN or ALL	
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 tallied. If "ALL" (case insensitive) is included, suppression will take place for all variables.
QAOUT	qa_output_filename	
where	qa_output_filename	Name of the output file from the QA/input to merge data.

<sup>5</sup> Coordinates can be entered as latitude and longitude or longitude and latitude as long as the correct suffixes are used.



Keyword	Parameter(s)	
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 4-digit year, month and day to extract; Elements can be separated by slashes, dashes, or blanks; Optional; used to make this record more readable Ending 4-digit year, month and day to extract; Elements can be separated by slashes, dashes, or blanks;

**Table A-5. Description of UPPERAIR Keywords**

<b>Keyword</b>	<b>Type</b>	<b>Description</b>
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-6. Description of Keyword Parameters for the UPPERAIR Pathway**

<b>Keyword</b>	<b>Parameter(s)</b>	
AUDIT	uaname1 ... uanameN or ALL	
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). If “ALL” (case insensitive) is included, all variables will be audited.
DATA	archive_filename file_format	

Keyword	Parameter(s)	
where:	archive_filename  file_format	<p>The name of the file containing the archive of upper air data</p> <p>Archive file format; valid parameters are:  <b>6201FB</b> (TD-6201 fixed-length blocks)  or  <b>6201VB</b> (TD-6201 variable-length blocks)  or  <b>FSL</b> 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) <a href="https://ruc.noaa.gov/raobs/">Earth System Research Laboratory (ESRL) Radiosonde Database</a> at <a href="https://ruc.noaa.gov/raobs/">https://ruc.noaa.gov/raobs/</a>.</p> <p>or  <b>IGRA</b>  IGRA data retrieved from National Centers for Environmental Information (NCEI) web site.</p> <p><b>NOTE:</b> 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.</p>
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 <sup>6</sup>	site_id latlong [tadjust]	

<sup>6</sup> Coordinates can be entered as latitude and longitude or longitude and latitude as long as the correct suffixes are used.

Keyword	Parameter(s)	
where:	site_id  lat(long)  long(lat)  [tadjust]	Site identifier for which data are to be processed.  Station latitude in decimal degrees with the suffix N for sites north of the equator, S for sites south of the equator.  Station longitude in decimal degrees with the suffix W for sites west of Greenwich, E for sites east of Greenwich.  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> Or ALL Or DELMAND CALMDIR SUB_TTTD	
Where:	<none> or ALL  DELMAND CALMDIR SUB_TTTD	Delete mandatory levels, set wind direction to 0 for calm wind, interpolate missing temperature and dewpoint  Delete mandatory levels  set wind direction to 0 for calm wind  interpolate missing temperature and dewpoint  Note; each modification can be listed separately; Listing all 3 is the same as <none> or ALL
NO_MISSING	uaname1 ... uanameN	

Keyword	Parameter(s)	
where:	uaname1 . . . . . . uanameN Or All	Suppresses missing data messages for the upper air variables specified, as defined in Appendix B; the number of times the variable is missing is tallied. If “ALL” (case insensitive) is included, suppression will take place for all variables.
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  lower_bound  <[=]  upper_bound  missing_indicator	Variable name, as defined in Table B-1  Minimum value of the valid range of values for uaname  Exclude (<) or include (<=) the lower and upper bounds (the endpoints) in the QA  Maximum value of the valid range of values for uaname  Value to indicate the value is missing
XDATES	YB/MB/DB [TO] YE/ME/DE	
	YB/MB/DB  [TO]  YE/ME/DE	Beginning 4-digit year, month and day to extract; Elements can be separated by slashes, dashes, or blanks;  Optional; used to make this record more readable  Ending 4-digit year, month and day to extract; Elements can be separated by slashes, dashes, or blanks;

**Table A-7. Description of ONSITE/PROG Pathway Keywords**

<b>Keyword</b>	<b>Type</b>	<b>Description</b>
ONSITE PROG	Mandatory, Non-repeatable	Start of ONSITE pathway. Start of PROG 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	FORTTRAN 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 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.

<b>Keyword</b>	<b>Type</b>	<b>Description</b>
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.



**Table A-8. Description of Keyword Parameters for the ONSITE/PROG Pathway**

Keyword	Parameter(s)	
AUDIT	osname1 ... osnameN or ALL	
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. If “ALL” (case insensitive) is included, all variables will be audited.
DATA	Filename [land water flag]	
where:	Filename	The name of the file containing the ONSITE data. The optional land water flag denotes if the data are over land (OL) or overwater (OW). Both flags are applicable for both ONSITE and PROG pathways.
DELTA_TEMP	index lower_height upper_height	
where:	index  lower_height  upper_height	Index for the i <sup>th</sup> temperature difference measurement  Lower measurement height for the i <sup>th</sup> temperature difference  Upper measurement height for the i <sup>th</sup> 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 control file 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 <sup>7</sup>	site_id latlong [tadjust] [elevation]	
where:	site_id	Site identifier for which data are to be processed.
	lat(long)	Station latitude in decimal degrees with the suffix N for sites north of the equator, S for sites south of the equator.
	long(lat)	Station longitude in decimal degrees with the suffix W for sites west of Greenwich, E for sites east of Greenwich.
	[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 or ALL	
where:	osname1 . . . osnameN	Suppresses missing data messages for the ONSITE variables specified, as defined in Appendix B; the number of times the variable is missing is tallied. If “ALL” (case insensitive) is included, suppression will take place for all variables.
OBS/HOUR	n_obs [average method]	
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.

<sup>7</sup> Coordinates can be entered as latitude and longitude or longitude and latitude as long as the correct suffixes are used.

		If OBS/HOUR is not specified, AERMET will assume 1 observation per hour. The optional average method will apply to averaging of winds. If blank or SCALAR, the current averaging method discussed in Section 5.4 will be used. If VECTOR is included, vector averaging will be done as discussed in Section 5.4.
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.

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.
	<p><b>NOTE:</b> Beginning with version 11059, AERMET allows the use of REAL values for lower_bound, upper_bound, and missing_indicator.</p>	
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 control 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.

Keyword	Parameter(s)	
THRESHOLD	threshold_wind_speed	
where:	threshold_wind_speed	Minimum valid wind speed for the ONSITE/PROG measurements; cannot exceed 1.0 m/s.
XDATES	YB/MB/DB [TO] YE/ME/DE	
where:	YB/MB/DB  [TO]  YE/ME/DE	Beginning 4-digit year, month and day to extract; Elements can be separated by slashes, dashes, or blanks;  Optional; used to make this record more readable  Ending 4-digit year, month and day to extract; Elements can be separated by slashes, dashes, or blanks.

**Table A-9. Description of METPREP Pathway Keywords**

<b>Keyword</b>	<b>Type</b>	<b>Description and Usage</b>
METPREP	Mandatory, Non-repeatable	Start of METPREP pathway.
AERSURF	Optional, Repeatable	Specify file name for <i>primary</i> surface characteristics, such as output file from AERSURFACE; contains <code>FREQ_SECT</code> , <code>SECTOR</code> , and <code>SITE_CHAR</code> keyword inputs.
AERSURF2	Optional, Repeatable	Specify file name for <i>secondary</i> surface characteristics, such as output file from AERSURFACE; inputs in the AERSURF2 file are interpreted as secondary site characteristics, and may contain <code>FREQ_SECT2</code> , <code>SECTOR2</code> , and <code>SITE_CHAR2</code> keyword inputs, or <code>FREQ_SECT</code> , <code>SECTOR</code> , and <code>SITE_CHAR</code> 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	Obsolete; ignored	
DEF_VPTG	Conditional*, Non-repeatable	Specifies the default value of potential temperature lapse rate for COARE processing. <code>DEF_VPTG</code> can be used to override the default value of 0.01 C/m.  *Only applicable with COARE processing; ignored otherwise.
FREQ_SECT	Mandatory, Repeatable, Reprocessed	Number of surface characteristics by wind direction sector and time period for the <i>primary</i> location. Must precede <code>SECTOR</code> and <code>SITE_CHAR</code> statements, and 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 <i>secondary</i> location.  *Must be specified if both ONSITE and NWS winds are included, and must precede <code>SECTOR2</code> and <code>SITE_CHAR2</code> statements.

Keyword	Type	Description and Usage
LOCATION	<p>Conditional*, Non-repeatable</p> <p>If UPPERAIR data are available (with or without ONSITE mixing heights): OBSOLETE</p> <p>Beginning with AERMET version 13350, if ONSITE mixing heights are used without UPPERAIR data: Mandatory</p>	<p>The LOCATION keyword under the METPREP pathway in Stage 2 (old Stage 3) is no longer used by AERMET, <u>unless</u> ONSITE mixing heights are used without any UPPERAIR data.</p> <p>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.</p> <p>For applications with <u>only</u> ONSITE mixing heights, without UPPERAIR data, the LOCATION keyword under the METPREP should be used to specify the conversion from GMT to LST.</p>
METHOD	Conditional*, Repeatable	<p>Specify processing methodology used for a particular variable.</p> <p>* whether or not this keyword is mandatory depends on the processing to be performed and the types of data included in the merged database.</p>
MIN_MOL	Conditional*, Non-repeatable	<p>Specifies the minimum absolute value of Monin-Obukhov length output by COARE processing. Use of MIN_MOL can be used to override the default value of 5 m.</p> <p>*Only applicable with COARE processing; ignored otherwise.</p>
MODEL	Optional, Non-repeatable	<p>Name of model for which data are processed. Default: AERMOD.</p>
NWS_HGT	Conditional*, Non-repeatable	<p>NWS instrument height, in meters, for the specified variable.</p> <p>* Mandatory if METHOD REFLEVEL SUBNWS is specified.</p>
SECTOR	Mandatory, Repeatable, Reprocessed	<p>Defines a wind direction sector in degrees for the <i>primary</i> location. See also FREQ_SECT and SITE_CHAR.</p>

<b>Keyword</b>	<b>Type</b>	<b>Description and Usage</b>
SECTOR2	Conditional**, Repeatable, Reprocessed	Defines a wind direction sector in degrees for the <i>secondary</i> location. See also <code>FREQ_SECT2</code> and <code>SITE_CHAR2</code> .
SITE_CHAR	Mandatory, Repeatable, Reprocessed	Define the direction-dependent surface characteristics of albedo, Bowen ratio, and surface roughness length (meters) for the <i>primary</i> location. See also <code>FREQ_SECT</code> and <code>SECTOR</code> .
SITE_CHAR2	Conditional**, Repeatable, Reprocessed	Define the direction-dependent surface characteristics of albedo, Bowen ratio, and surface roughness length (meters) for the <i>secondary</i> location. See also <code>FREQ_SECT2</code> and <code>SECTOR2</code> .
SSTDEPTH	Conditional*, Non-repeatable	Specifies the depth of sea surface temperature measurements for COARE processing. If the <code>SSTDEPTH</code> keyword is specified and depths are also defined in the data file, the <code>SSTDEPTH</code> input will be used and values in the data file ( <code>ZDEP</code> ) will be ignored. *Only applicable with COARE processing; ignored otherwise.
THRESH_1MIN	Optional, Non-repeatable	Option to specify a wind speed threshold for winds derived from 1-minute ASOS wind data processed through <code>AERMINUTE</code> .
UAWINDOW	Optional, Non-repeatable	Specifies the time window to use for selecting upper air sounding.
XDATES	Optional, Non-repeatable	Inclusive dates for data processing.
ZI_GUST	Conditional*, Non-repeatable	Specifies the mixing height used for gustiness calculations with COARE processing. Use of <code>ZI_GUST</code> can be used to override the default value of 600 m. *Only applicable with COARE processing; ignored otherwise.



Keyword	Type	Description and Usage
ZI_MIN	Conditional*, Non-repeatable	Specifies the minimum mixing height output by COARE processing. Use of ZI_MIN can be used to override the default value of 25 m. *Only applicable with COARE processing; ignored otherwise.

\*\* 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.

**Table A-10. Description of Keyword Parameters for the METPREP Pathway**

Keyword	Parameter(s)	
AERSURF  AERSURF2	primary_surfchar_filenam [year list1]  secondary_surfchar_filenam [year list2]	<i>(for primary surface data location)</i>  <i>(for optional secondary surface data location)</i>
where:	primary_surfchar_filenam  [year list1] secondary_surfchar_filenam  [year list2]	The name of the file containing the surface characteristic inputs for the <b>primary</b> surface data location (FREQ_SECT, SECTOR, and SITE_CHAR keywords) Optional list of years associated with AERSURF The name of the file containing the surface characteristic inputs for the <b>secondary</b> surface data location (FREQ_SECT2, SECTOR2, and SITE_CHAR2 keywords) Optional list of years associated with AERSURF2
DATA	ignored	

FREQ_SECT	frequency number_of_sectors [year list1]	<i>(for primary surface data location)</i>
FREQ_SECT2	frequency number_of_sectors [year list2]	<i>(for optional secondary surface data location)</i>
where:	frequency	Specifies how often the surface characteristics change; valid parameters are: <b>MONTHLY</b> - every calendar month <b>SEASONAL</b> - where the seasons are defined as: Spring = March, April, May Summer = June, July, August Autumn = September, October, November Winter = December, January, February <b>ANNUAL</b> - constant for the entire year
Year list1, year_list2	number_of_sectors	Specifies the number of wind direction sectors by which the surface characteristics vary Optional list of years associated with FREQ_SECT or FREQ_SECT2

Keyword	Parameter(s)	
LOCATION	site_id lat(long) long(lat) [tadjust] [elevation]	
where:	site_id  lat(long)  long(lat)  [tadjust]  [elevation]	<p>Site identifier for which data are to be processed.</p> <p>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).</p> <p>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).</p> <p>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).</p> <p>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.</p> <p><u>NOTE:</u> The LOCATION keyword under the METPREP pathway is obsolete for applications that include UPPERAIR data, and inputs will be ignored; however, applications that use <b>only</b> ONSITE mixing heights, without UPPERAIR data, should still use the LOCATION keyword under the METPREP pathway to specify the conversion from GMT to LST.</p>
METHOD	atmos_variable option	
where:	atmos_variable	<p>Identifies the variable that will be processed:</p> <p><b>UASELECT</b> – selecting upper air sounding.</p> <p><b>WIND_DIR</b> – processing of NWS wind directions.</p> <p><b>REFLEVEL</b> – substitution of NWS data</p> <p><b>STABLEBL</b> – specify option for SBL processing</p> <p><b>ASOS_ADJ</b> – adjustment of ASOS wind speeds for truncation</p> <p><b>COARE</b> – invoke COARE processing and options</p> <p><b>CCVR</b> – option to substitute for missing cloud cover</p> <p><b>TEMP</b> – option to substitute for missing temperature</p>

Keyword	Parameter(s)
	<p>option</p> <p><u>Processing options:</u></p> <p>For <b>UASELECT</b>, valid parameters are:</p> <p style="padding-left: 40px;"><b>SUNRIS(E)</b> – select upper air sounding based on local sunrise</p> <p>For <b>WIND_DIR</b> (<u>not</u> applicable to 1-min ASOS data), valid parameters are:</p> <p style="padding-left: 40px;"><b>NORAND</b> – leave NWS wind directions to the nearest 10°</p> <p style="padding-left: 40px;">or <b>RANDOM</b> – randomize NWS wind directions (default).</p> <p>For <b>REFLEVEL</b>, valid parameters are:</p> <p style="padding-left: 40px;"><b>SUBNWS</b> – allows substitution of NWS data for missing ONSITE wind and/or temp data (other parameters automatically substituted);</p> <p style="padding-left: 40px;"><b>NOTE:</b> this option <b>must</b> be used if no ONSITE data are provided.</p> <p>For <b>STABLEBL</b>, valid parameters are:</p> <p style="padding-left: 40px;"><b>BULKRN</b> – Bulk Richardson Number - This option requires onsite measurements of temperature difference.</p> <p style="padding-left: 40px;"><b>ADJ_U*</b> – Option to adjust U* (surface friction velocity) for low wind/stable conditions. For applications <u>without</u> the BULKRN option, the ADJ_U* option is based on Qian and Venkatram (2011). For applications <u>with</u> the BULKRN option, the ADJ_U* option is based on Luhar and Rayner (2009).</p> <p>For <b>ASOS_ADJ</b>, valid parameters are:</p> <p style="padding-left: 40px;"><b>NO_ADJ</b> – do not adjust ASOS wind speeds for truncation.</p> <p>For <b>COARE</b>, valid parameters are:</p> <p style="padding-left: 40px;"><b>NO_COARE</b> – Do not invoke COARE processing</p> <p style="padding-left: 40px;"><b>RUN_COARE</b> – Invoke COARE processing</p> <p style="padding-left: 40px;"><b>WARM</b> – Invoke COARE warm layer processing</p> <p style="padding-left: 40px;"><b>NO_WARM</b> – Do not invoke COARE warm layer processing</p> <p style="padding-left: 40px;"><b>COOL</b> – Invoke COARE cool skin processing</p> <p style="padding-left: 40px;"><b>NO_COOL</b> – Do not invoke COARE cool skin processing</p> <p style="padding-left: 40px;"><b>ZO_U*</b> - Calculate surface roughness based on u*</p> <p style="padding-left: 40px;"><b>ZO_U*_PER</b> – Calculate surface roughness based on u* and wave period</p> <p style="padding-left: 40px;"><b>ZO_PER_HT</b> – Calculate surface roughness based wave height and period</p> <p style="padding-left: 40px;"><b>MIX_DFAULT</b> – Calculate mixing heights using AERMET default method</p>

Keyword	Parameter(s)
	<p><b>MIX_OBS</b> – Use observed mixing heights both convective and mechanical mixing heights</p> <p><b>ZIC_OBS_NS</b> – Use observed mixing heights for convective heights and calculate mechanical heights with no smoothing</p> <p><b>CALC_ZI_NS</b> - Calculate mechanical heights with no smoothing and set convective heights equal to mechanical heights for convective hours</p> <p><b>ZIC_OBS_SM</b>– Use observed mixing heights for convective heights and calculate mechanical heights with smoothing</p> <p><b>CALC_ZI_SM</b> - Calculate mechanical heights with smoothing and set convective heights equal to mechanical heights for convective hours</p> <p>For <b>CCVR</b>, valid parameters are:</p> <p><b>SUB_CC</b> – select option to substitute for missing cloud cover</p> <p><b>NO_SUB</b> – disable option to substitute for missing cloud cover</p> <p><b>NOPERS</b> – disable subs for hrs 23 and 24 based on persistence</p> <p>For <b>TEMP</b>, valid parameters are:</p> <p><b>SUB_TT</b> – select option to substitute for missing temperature</p> <p><b>NOTSUB</b> – disable option to substitute for missing temperature (<b>NO_SUB</b> can also be used for <b>TEMP</b>)</p> <p><b>NOPERS</b> – disable subs for hrs 23 and 24 based on persistence</p> <p><u>NOTE:</u> 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. 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. Also, NOPERS is ignored for both substitution methods.</p>

<b>Keyword</b>	<b>Parameter(s)</b>	
MODEL	model_name	
where:	model_name	Name of the dispersion model which uses the output files generated by AERMET. Allowable names are: <b>AERMOD</b>
NWS_HGT	variable_name instrument_height	
where:	variable_name	Weather variable that requires an instrument height to be defined; valid names are: <b>WIND</b> (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 2, 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

Keyword	Parameter(s)	
SECTOR	sector_index beginning_direction ending_direction <i>(for primary data location)</i>	
SECTOR2	sector_index beginning_direction ending_direction <i>(for optional secondary data location)</i>	
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 <u>NOTE:</u> The end of one sector must be the same as the beginning of the next sector.
SITE_CHAR	frequency_index sector_index albedo Bowen roughness <i>(for primary data location)</i>	
SITE_CHAR2	frequency_index sector_index albedo Bowen roughness <i>(for secondary data location)</i>	
where:	frequency_index	Index of the time period for which the surface characteristics apply; for <b>ANNUAL</b> on <b>FREQ_SECT</b> keyword, valid values: 1 (for the entire year) for <b>MONTHLY</b> on <b>FREQ_SECT</b> keyword, valid values: 1 ... 12 (corresponding to each month of the year) for <b>SEASONAL</b> on <b>FREQ_SECT</b> 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.



Keyword	Parameter(s)	
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 2.
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	
where:	YB/MB/DB	Beginning 4-digit year, month and day to extract; Elements can be separated by slashes, dashes, or blanks;
	[TO]	
	YE/ME/DE	Optional; used to make this record more readable Ending 4-digit year, month and day to extract; Elements can be separated by slashes, dashes, or blanks;

## **Appendix B. Variable names and default QA values**

This appendix lists the variable names for each type of data and provides a short description and the units for each variable along with the default bounds and missing value codes. This information is presented in the tables that follow 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, 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 ( $\leq$ ) 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 are either included or excluded according to the Type of Check. Note that the multiplier, if present, must also be applied to these values.

**Table B-1. 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 <sup>†</sup>	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 <sup>a</sup>	Sky cond//height, level 1	code//hundredths ft	<=	09999	0	07300
ALC2 <sup>a</sup>	Sky cond//height, level 2	code//hundredths ft	<=	09999	0	07300
ALC3 <sup>a</sup>	Sky cond//height, level 3	code//hundredths ft	<=	09999	0	07300
ALC4 <sup>b</sup>	Sky cond//height, level 4	code//hundredths ft	<=	09999	0	07850
ALC5 <sup>b</sup>	Sky cond//height, level 5	code//hundredths ft	<=	09999	0	07850
ALC6 <sup>b</sup>	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 <sup>c</sup>	ASOS Sky condition	tenths	<=	99	0	10
ACHT <sup>d</sup>	ASOS Ceiling	kilometers*10	<=	999	0	888
HZVS	Horizontal visibility	kilometers*10	<=	99999	0	1640
TMPD <sup>*</sup>	Dry bulb temperature	°C*10	<	999	-300	360
TMPW	Wet bulb temperature	°C*10	<	999	-650	350
DPTP	Dew-point temperature	°C*10	<	999	-650	350
RHUM	Relative humidity	whole percent	<=	999	0	100
WDIR <sup>*</sup>	Wind direction	tens of degrees	<=	999	0	36
WSPD <sup>*</sup>	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.

**Table B-2. Variable and QA Defaults for UPPERAIR Variables**

<b>Variable Name</b>	<b>Description</b>	<b>Units</b>	<b>Type*</b>	<b>Missing Indicator</b>	<b>Lower Bound</b>	<b>Upper Bound</b>
UAPR	Atmospheric pressure	millibars*10	<	99999	5000	10999
UAHT	Height above ground	meters	<=	99999	0	5000
UATT	Dry bulb temperature	°C*10	<	9990	350	+350
UATD	Dew point temperature	°C*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	°C/(100 meters)	<=	9999	2	5
UADD	Dew point deviation	°C/(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.

**Table B-3. Variable and QA Defaults for ONSITE or PROG Single Level and Date/Time Variables**

<b>Variable Name</b>	<b>Description</b>	<b>Units</b>	<b>Type *</b>	<b>Missing Indicator</b>	<b>Lower Bound</b>	<b>Upper Bound</b>
HFLX	Surface sensible heat flux	watts/square meter	<	-999	-100	800
LFLX	<i>Surface latent heat flux</i>	<i>watts/square meter</i>	<	-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	<i>Snow amount</i>	<i>centimeters</i>	<=	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	<i>Temperature diff.(U - L)1</i>	°C	<	9	-2	5
DT03	<i>Temperature diff.(U - L)1</i>	°C	<	9	-2	5
VPTG	Potential temperature lapse rate	°C/m*1000	<=	-9	5	100
MOBL	Monin-Obukhov length	meters	<	-99999	-8888	8888
WSTR	Convective velocity scale	m/s	<=	-9	0	2
ALBD	Albedo	Dimensionless	<	999	0	1
BOWN	Bowen ratio	dimensionless	<	999	-10	10
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	<i>Ceiling height</i>	<i>kilometers*10</i>	<=	999	0	300
TSKC	Sky cover (total or opaque)	tenths	<=	99	0	10
TSEA	Sea surface temperature	°C	<=	99	-30	50
ZDEP	Depth of sea surface temperature	meters	<=	9999	-10	10
HWAV	Significant wave height	meters	<=	9999	0	60
TWAV	Significant wave period	meters	<=	9999	0	60
RDOW	Longwave downward radiation	watts/square meter		-9999	0	1000

Variable Name	Description	Units	Type *	Missing Indicator	Lower Bound	Upper Bound
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

<sup>1</sup>( 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 only used for overwater applications with the PROG pathway. The exceptions are USTR and TSKC which are used when input with the ONSITE pathway but not the PROG pathway for overland applications.

*Parameters in Italics are not used by AERMET.*



**Table B-4. Variable and QA Defaults for ONSITE or PROG 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
<i>SEnn</i>	<i>Std. dev. vertical wind</i>	<i>degrees</i>	<	<i>99</i>	<i>0</i>	<i>25</i>
<i>SVnn</i>	<i>Std. dev. v-comp. of wind</i>	<i>meters/second</i>	<	<i>99</i>	<i>0</i>	<i>3</i>
SWnn	Std. dev. w-comp. of wind	meters/second	<	99	0	3
<i>SUnn</i>	<i>Std. dev. u-comp. of wind</i>	<i>meters/second</i>	<	<i>99</i>	<i>0</i>	<i>3</i>
TTnn*	Temperature	°C	<	99	-30	40
WDnn*	Wind direction	degrees from north	<=	999	0	360
WSnn*	Wind speed	meters/second	<=	99	0	50
<i>VVnn</i>	<i>Vertical wind component</i>	<i>meters/second</i>	<	<i>999</i>	<i>0</i>	<i>5</i>
DPnn	Dew-point temperature	°C	<	99	-65	35
RHnn	Relative humidity	whole percent	<=	999	0	100
<i>V1nn</i>	<i>User's vector #1</i>	<i>user's units</i>	<	<i>999</i>	<i>0</i>	<i>100</i>
<i>V2nn</i>	<i>User's vector #2</i>	<i>user's units</i>	<	<i>999</i>	<i>0</i>	<i>100</i>
<i>V3nn</i>	<i>User's vector #3</i>	<i>user's units</i>	<	<i>999</i>	<i>0</i>	<i>100</i>

'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:** Parameters in italics are not currently used in AERMET.

## **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 QAOUT file for site-specific or prognostic data, and the OUTPUT and PROFILE files that will be input to AERMOD.

### **C. 1. EXTRACT/QAOUT files**

Table C-1 and Table C-2 list the format of the EXTRACT and QAOUT files for the SURFACE and UPPER pathways. Note that different variables are output for each of the two file types. The EXTRACT file contains the variables needed in Stage 2. The QAOUT file contains the same variables plus any additional variables that are QA'd but not needed for Stage 2. Table C-3 lists the format for the QAOUT file for the ONSITE or PROG pathway. Note for ONSITE or PROG data, if heights are read in, either with the HT variable or OSHEIGHTS, they will be the first variable listed in the QAOUT file, regardless of the order they were read in the raw data file. Remaining variables are then listed based on their order in the subroutine ONSITE\_INIT in the ONSITE module.

**Table C-1. SURFACE EXTRACT and QAOUT file header format and data format.**

<b>Header section</b>	
<b>Row Number</b>	<b>Description</b>
1	AERMET version number
2	Location information
3	File type (EXTRACT or QAOUT)
4	Date of data period
>4	Optional Range modifications <sup>1</sup>
>4	Data header
<b>Data section</b>	
<b>Column<sup>2</sup></b>	<b>Description</b>
DATE	Date (YYYYMMDD) in LST
HR	Hour of observation in LST
ASOS	ASOS status for hour (Y=ASOS observation, N=non-ASOS observation)
PRCP	Precipitation (mm)
SLVP	Sea level pressure (mb)
PRES	Station pressure (mb)
TSKC	Total/opaque cloud cover
PWITH	Precipitation type
ASKY	ASOS sky condition
TMPD	Dry bulb temperature (°C)
DPTP	Dew point temperature (°C)
RHUM	Relative humidity (percent)
WDIR	Wind direction
WSPD	Wind speed (m/s)
ALC1	Sky condition/height, level 1
ALC2	Sky condition/height, level 2
ALC3	Sky condition/height, level 3
ALC4	Sky condition/height, level 4
ALC5	Sky condition/height, level 5
ALC6	Sky condition/height, level 6
PWVC	Present weather
ACHT	ASOS ceiling
HZVS	Horizontal visibility
TMPW	Wet bulb temperature

<sup>1</sup> The RANGE values are output for variables that are changed from the default missing value or bounds.

<sup>2</sup> Shaded variables are in the QAOUT file only if audited.

**Table C-2. UPPERAIR EXTRACT and QAOUT file header format and data format.**

<b>Header section</b>	
<b>Row Number</b>	<b>Description</b>
1	AERMET version number
2	Location information
3	File type (EXTRACT or QAOUT)
4	Date of data period
>4	Optional Range modifications <sup>1</sup>
>4	Data header
<b>Data section</b>	
<b>Column<sup>2</sup></b>	<b>Description</b>
DATE	Date (YYYYMMDD) in LST
SND	Sounding number for the day
HR	Hour of sounding in LST
LEV	Level number
UAPR	Pressure of level (mb)
UAHT	Height of level (m)
UATT	Dry bulb temperature (°C)
UATD	Dew point temperature (°C)
UAWD	Wind direction of level
UAWS	Wind speed of level (m/s)
UASS	Wind speed shear (m/s)/(100 m)
UADS	Wind direction shear degrees/(100 m)
UALR	Temperature lapse rate °C/(100 m)
UADD	Dew point deviation °C/(100 m)

<sup>1</sup> The RANGE values are output for variables that are changed from the default missing value or bounds.

<sup>2</sup> Shaded variables are in the QAOUT file only if audited.

**Table C-3. ONSITE/PROG EXTRACT and QAOUT file header format and data format.**

<b>Header section</b>	
<b>Row Number</b>	<b>Description</b>
1	AERMET version number
2	Location information
3	File type (QAOUT)
>3	Threshold speed (m/s) <sup>1</sup>
>3	Temperatures used for DELTA_TEMP <sup>1</sup>
>3	Overland (OVERLAND) or overwater (OVERWATER) flag
>3	Date of data period
>3	Optional Range modifications <sup>2</sup>
>3	First and last level for multi-level variables <sup>1</sup>
>3	Data header
<b>Data section</b>	
<b>Column</b>	<b>Description</b>
DATE	Date (YYYYMMDD) in LST
HR	Hour of sounding in LST
LEV	Level number
HTNN	Height of level <sup>1</sup>
OSVAR1	Variable 1 <sup>3</sup>
.	
.	
OSVARN	Variable N <sup>3</sup>

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<sup>1</sup> If applicable

<sup>2</sup> The RANGE values are output for variables that are changed from the default missing value or bounds.

<sup>3</sup> After the height variable, variables are written in the order they are listed in subroutine onsite\_init in mod\_onsite.f90 and shown in Table B-3 and Table B-4 in Appendix B

## **C. 2. OUTPUT and PROFILE outputs**

Table C-4 and Table C-5 list the formats for the OUPUT (surface data and boundary layer parameters) and PROFILE file output from AERMET for input to AERMOD.

**Table C-4. OUTPUT file format.**

<b>Header section</b>	
<b>Variable</b>	<b>Description</b>
1	Latitude of primary surface station
2	longitude of primary surface station
3	Upper air station identifier
4	Surface station identifier
5	Onsite or prognostic station identifier
6	AERMET version
7	Various information such as the use of adjusted u*, Bulk Richardson number use, and MMIF version
<b>Data section</b>	
<b>Column</b>	<b>Description</b>
year	2-digit year
month	2-digit month
day	2-digit day of month
j_day	Julian day of year
hour	Hour of day in LST
H	Sensible heat flux (W/m <sup>2</sup> )
u*	Surface friction velocity (m/s)
w*	Convective velocity scale (m/s)
VPTG	Vertical potential temperature gradient above Zic (K/m)
Zic	Convective mixing height (m)
Zim	Mechanical mixing height (m)
L	Monin-Obukhov length (m)
z <sub>o</sub>	Surface roughness length (m)
B <sub>o</sub>	Bowen ratio
R	Albedo
W <sub>s</sub>	Reference wind speed (m/s)
W <sub>d</sub>	Reference wind direction (degrees)
Z <sub>ref</sub>	Reference heights for winds (m)
temp	Reference temperature (K)
Z <sub>temp</sub>	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)
WADJ	Wind speed adjustment and data source flag
SUBflag	Substitution 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  $7 \cdot z_0$ , 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
- the height must be less than or equal to 100 meters.



**Table C-5. PROFILE file format.**

<b>Column</b>	<b>Description</b>
year	2-digit year
month	2-digit month
day	2-digit day of month
hour	Hour of day in LST
height	Height of level (m)
top	1 if this is the last level for the hour, 0 otherwise
WDnn	Wind direction at current level (degrees)
WSnn	Wind speed at current level (m/s)
TTnn	Temperature at current level (°C)
SAnn	Standard deviation of wind direction, $\sigma_{\theta}$ (degrees)
SWnn	Standard deviation of vertical wind speed, $\sigma_w$ (m/s)

## **Appendix D. Messages**

During processing, AERMET writes messages to the file defined by the MESSAGES keyword on the JOB pathway. Each message has the form:

### **Pathway code subroutine message**

Where pathway is the pathway defined in the control file (JOB, UPPERAIR, SURFACE, ONSITE, PROG, or METPREP). The code is a three-character code with the first character being an “E” for error, “I” for informational, “Q” for quality assurance (audit) and “W” for warning. The latter two characters are a numeric string to link the code to a specific message type. The subroutine identifies the subroutine in which the event that triggered message occurred and finally the message is the actual message identifying the issue. Error messages lead AERMET to abort processing, warning messages identify potential issues that are not fatal but may require attention and informational messages relay information to the user, such as the commission date for an ASOS station. Quality assurance messages alert the user of missing or values out of bounds so they may fit the warning and informational categories.

## D. 1. Error messages

Error codes E01-E08 generally refer to control file processing, E30-39 refer to UPPERAIR processing, E40-E47 refer to SURFACE processing, E50-E61 refers to ONSITE or PROG pathway, and E70-E85 refers to the METPREP pathway.

- E01 Invalid path or keyword; syntax error in AERMET control file
- E02 Invalid filename or duplicate filename
- E03 Incorrect number of fields or invalid parameters for a keyword; duplicate entry of keyword
- E04 Invalid or obsolete file format
- E05 Invalid option for keyword or invalid variable
- E06 Missing path identifier
- E07 Invalid path pairings, i.e., SURFACE with PROG
- E08 Missing keyword
- E30 Sounding file not in specified format (IGRA, 6201, FSL)
- E31 Error reading sounding data line
- E32 Invalid date fields in upper air data file
- E33 Invalid wind speed units for FSL sounding data
- E34 Multiple surface data lines for a given sounding for FSL or IGRA sounding data
- E35 Multiple versions of FSL formats detected for FSL sounding data file; missing value indicators or pressure conversion indicate multiple versions
- E36 Number of levels read for FSL or IGRA sounding data does not match expected number of levels for a sounding
- E37 No soundings extracted but no errors
- E38 Sounding extraction not completed
- E39 No soundings extracted with errors
- E40 Error reading data line for surface observations
- E41 Error reading dates for hourly averaged 1-minute ASOS data
- E42 Invalid date fields in surface data file
- E43 Invalid elevation field in surface data file
- E44 Invalid station coordinates in surface data file

- E45 Invalid SAMSON header record in surface SAMSON data file
- E46 More than one set of header records in surface SAMSON data file
- E47 Invalid station identifier in surface data file
- E50 Number of instances of READ keyword do not match number of instances of FORMAT keywords for ONSITE or PROG pathways.
- E51 OBS/HR not present when OSMN variable read from data; OBS/HR > 1 and OSMN not read from data
- E52 Date/time variables not read with first READ statement or date/time variables not first set of variables for a READ statement.
- E53 First or last character of FORMAT statement is not a parenthesis; Number of left and right parentheses in FORMAT statement do not match
- E54 No DELTA\_TEMP heights listed for DT01
- E55 Number of READ statements exceeds maximum allowed or error reading ONSITE or PROG QAOUT file
- E56 Number of observations/hour exceeds value of OBS/HR for sub-hourly site-specific data
- E57 Number of heights specified by OSHEIGHTS not equal to number of HT levels if both OSHEIGHTS specified and height is read in from site-specific or prognostic data file
- E58 Input data heights not increasing with each READ statement for a given hour when reading site-specific or prognostic data file and height is read from data file.
- E59 Invalid date/time variable found in QAOUT data; variable is not one of the first variables on the line of data.
- E60 ONSITE or PROG wind speed and direction not processed together. If one is read in, the other should be as well.
- E60 ONSITE or PROG sea surface temperature depth read in but no sea surface temperature.
- E61 When OSHEIGHTS not used, the first level for HT is not 1 and the last level is not equal to one of the multi-level variable's last level.
- E62 OSHEIGHTS not in ascending order

- E70 No valid data available based on input dates and available data for UPPERAIR, SURFACE, ONSITE, or PROG data.
- E71 LOCATION keyword missing; needed when MIXHTS included in ONSITE or PROG data and no UPPERAIR data.
- E72 NWS\_HGT missing if processing SURFACE data and SUBNWS invoked
- E73 Surface characteristics keyword(s) missing
- E74 Invalid year for multi-year specified surface characteristics or year has not been assigned or assigned more than once. Applies to both primary and secondary sites.
- E75 Invalid surface characteristics parameter (invalid frequency, sector number). Applies to both primary and secondary sites.
- E76 Duplicate listing of SITE\_CHAR, SITE\_CHAR2, SECTOR, or SECTOR2. This is not triggered when multiple years are associated with surface characteristics
- E77 Invalid combination of item with action, i.e., STABLEBL paired with RANDOM
- E78 UAWINDOW beginning hour after ending hour
- E79 Invalid variable for NWS\_HGT
- E80 Invalid value for NWS\_HGT height (not a number or height < 0 m)
- E81 UPPERAIR data not read in and no onsite or prognostic mixing heights
- E82 No onsite or prognostic mixing heights needed for chose COARE mixing height option
- E83 COARE NO\_COARE and RUN\_COARE selected
- E84 Multiple COARE options chosen for a particular action
- E85 Data overflow or bad data for OUTPUT (surface) file
- E86 Data overflow or bad data for PROFILE file

## D. 2. Warning messages

Warning codes W01-W03 generally refer to control file processing, W30-35 refer to UPPERAIR processing, W40-W55 refer to SURFACE processing, W60-W69 refers to ONSITE or PROG pathway, and W70-W81 refers to the METPREP pathway.

- W01 Too many fields associated with keyword (usually obsolete fields such as blocking factor) or obsolete keyword or path ignored; extra fields will be ignored.
- W02 Duplicate listing of variable for items such as AUDIT, NO\_MISSING, RANGE, etc.
  
- W03 Extraction dates will be determined by METPREP XDATES if UPPERAIR, SURFACE, ONSITE, or PROG XDATES missing in combined Stage 1 and 2 AERMET runs.
- W04 Incorrect sign of GMT to LST conversion for longitude.
- W30 Upper air station WBAN in data file does not match user entered station ID
- W31 First level of sounding not surface level, skip sounding
- W32 Surface level height missing, skip sounding
- W33 Reached limit of warning code specified in message for upper air data
- W34 No upper air data extracted as specified by dates with XDATES keyword. Check XDATES
- W35 Sounding data not in temporal order
- W40 Station WBAN in data file does not match user entered WBAN or previous record's WBAN. Also issued when AERMINUTE WBAN does not match user entered WBAN.
- W41 User may have entered WMO number instead of WBAN; consider entering WBAN in control file
- W42 Limit reached on number of warning messages
- W43 Station elevation missing in SURFACE data file or does not match user entered elevation.
- W44 Station coordinates not provided in SURFACE data file
- W45 Station is flagged as ASOS station but no commission date or before ASOS commission date; also issued when the ASOS flag switches after commission date

- W46 No surface data extracted as specified by dates with XDATES keyword. Check XDATES
- W47 Invalid entry for CD-144 variables or HUSWO cloud cover
- W48 AERMINUTE output does not overlap with surface data XDATES.
- W49 Surface data not in temporal order
- W50 Observation is outside accepted dates for processed SURFACE data format.
- W51 Variable exceeds a specified threshold. Currently this is applicable to threshold wind speed specified by the THRESHOLD keyword or ASOS wind speed exceeds a specified threshold for SURFACE data.
- W52 ASOS flag set for non-ISHD data with DATA keyword for SURFACE data; reset to non-ASOS
- W53 ASOS flag set for SURFACE station in ASOS list based on WBAN number
- W54 ASOS flag set for SURFACE station not in ASOS list based on WBAN number
- W55 SURFACE station found in ASOS list for non-ISHD data file
- W56 Number of observations (missing + non-missing) for an hour are less than NOBS/HR for sub-hourly site-specific data
- W60 ONSITE or PROG DATA keyword indicates data is overland but presence of variables for COARE processing indicate data is overwater
- W61 First level for wind speed and direction not equal or unequal number of levels for wind speed and wind direction for ONSITE or PROG data.
- W62 Site-specific or prognostic data not in temporal order
- W63 Data line in raw site-specific or prognostic data does not match FORMAT statement associated with READ statement for line.
- W64 Variable read from ONSITE or PROG data file but is not used by AERMET and will be ignored.
- W65 Variable exceeds a specified threshold. Currently this is applicable to threshold wind speed specified by the THRESHOLD keyword, ASOS wind speed exceeds a specified threshold for SURFACE data or the sea surface temperature depth specified by SSTDEPTH exceeds the depth threshold.
- W66 OBS/HR=1 with OSMN being read in; OSMN will be ignored in data.

- W67 OSHEIGHTS specified and HT read in ONSITE or PROG data; HT will be ignored and OSHEIGHTS will be used.
- W68 ONSITE or PROG variable being audited but not read in from data; Ignore audit
- W69 DELTA\_TEMP listed but not DT01, warn user that temperatures may be used.
- W70 LOCATION keyword not needed for METPREP or extra field with LOCATION keyword
- W71 NWS\_HGT not equal to ASOS anemometer height in internal ASOS list
- W72 NWS\_HGT height > 30 m
- W73 Not enough variables for stable boundary layer calculations; cloud cover and net radiation not read in and or no insolation and BULKRN calculations not performed.
- W74 Secondary site surface characteristics listed but not needed.
- W75 Variable exceeds bounds (this is not the same as upper and lower bound checks when auditing) or may be suspect
- W76 Upper air sounding not extended.
- W77 Convective mixing height exceeds original sounding top
- W78  $W^* < 0.001$ , reset to 0.001
- W79 MMIF version found for data while using ONSITE pathway
- W80 Multiple MMIF versions detected
- W81 Obsolete parameter detected and will be ignored
- W82 COARE requested with overland data; COARE will be ignored
- W83 COARE option, with the exception of RUN\_COARE, selected with NO\_COARE; COARE will not be invoked
- W84 SST\_DEPTH will be used instead of hourly sea surface temperature depth
- W85 Not enough variables for COARE; COARE will not be invoked
- W86 Not enough variables for COARE cool skin or warm layer; COARE will be invoked without options
- W87 Reach limit of error messages
- W88 Longitude and GMT to LST conversion don't match



### D. 3. Informational messages

Information code I01 refers to control file processing, I20-29 refer to UPPERAIR processing, I40-I59 refer to SURFACE processing, I60-I68 refers to ONSITE or PROG pathway, and I70-I86 refers to the METPREP pathway.

I01	Alert user of processing stage or stages
I20	Upper air extraction process begin or end date/time.
I21	Duplicate sounding found for hour
I22	End of data window (set by XDATES) reached; no further data extraction
I23	Mandatory level deleted or sounding has no levels after deleting mandatory levels.
I24	Wind direction set to 0 for calm wind in sounding
I25	Reset missing temperature
I26	Reset missing dewpoint
I27	Could not compute layer index for auditing
I28	No sounding for the day
I29	No morning sounding for the day
I40	Surface data extraction process begin or end date/time.
I41	ISHD data observation not within accepted number of minutes of the hour
I42	ISHD record type not processed
I43	Potential duplicate observation found for the hour
I44	Special report used for hour from ISHD data
I45	Observation for the hour replaced with new observation from ISHD data
I46	Number of extracted surface observations
I47	Number of retained surface observations
I48	Number of special surface ISHD observations used
I49	Number of regular surface ISHD observations used
I50	Number of duplicate surface observations not used
I51	Number of special surface ISHD observations not used
I52	Number of regular surface ISHD observations not used
I53	Number of overwritten surface observations
I54	Number of non-supported ISHD observations read

- I55 Number of observations outside acceptable number of minutes within the hour
- I56 Number of calm observations
- I57 Number of variable wind observations
- I58 SAMSON observation may be modeled
- I59 ASOS commission date
- I60 Site-specific or prognostic data extraction process begin or end date/time.
- I61 List of DELTA\_TEMP heights
- I62 Potential duplicate site-specific or prognostic sub-hourly or hourly observation
- I63 Number of extracted site-specific or prognostic observations
- I64 Number of duplicate site-specific or prognostic observations
- I65 Number of sub-hourly site-specific or prognostic observations not used
- I66 Number of bad height levels
- I67 Location is overland and certain variables will be read but not used
- I68 Reset input SST depth to absolute value of depth is input depth is negative
- I69 Reset input minimum Monin-Obukhov length for COARE calculations to absolute value of minimum Monin-Obukhov length if minimum Monin-Obukhov length is negative
- I70 PBL processing begin or end date/time.
- I71 Missing insolation and cloud cover
- I72 Temperature and/or pressure missing, or winds calm or missing, skip calculations for the hour.
- I73 Wind measurement height  $< 20$  times  $z_0$
- I74 Wind speed  $<$  square root of 2 times minimum  $\sigma_v$ ; reset wind to square root of 2 times minimum  $\sigma_v$
- I75 Cloud cover missing, skip calculations
- I76 Net radiation  $> 0$  for stable hour
- I77 Sounding date/time for the processed date
- I78 No convective parameters calculated for the day depending on sounding issues
- I79 Convective mixing height set to maximum allowed convective height or mechanical mixing height set to maximum allowed mechanical mixing height
- I80 Location is overland and certain variables will not be used from Stage 1 output

- I81 Heat flux  $\leq 0$  for convective hour, reset to 0.1
- I82 Bulk Richardson number approach not used
- I83 MMIF version found
- I84 Alert user how stability determined for each hour, Monin-Obukhov length or solar angle.
- I85 If site-specific  $u^*$  for the hour and adjust  $u^*$  requested, alert user that  $u^*$  will not be adjusted.
- I86 If wind reset to square root of 2 times minimum  $\sigma_v$ , recalculate site-specific  $u^*$ ,  $L$ , or  $w^*$
- I87 Mixing height calculated for hour with missing PROG or ONSITE mixing height when mixing height is an input variable.
- I90 TSEA specified but not SSTD or SSTDEPTH; use default depth
- I91 Sunrise/sunset time based on longitude, not GMT to LST conversion factor when GMT to LST conversion factor is 0
- I92 COARE mixing height set to minimum value when mixing height is below minimum allowed value

#### D. 4. Quality assurance messages

Quality assurance messages Q20-Q28 refer to UPPERAIR processing, Q40-Q47 refer to SURFACE processing and Q60-Q70 refer to ONSITE/PROG processing.

- Q20 Cannot recompute heights of sounding
- Q21 Difference between observed height and recomputed height > 50 m
- Q22 Height is missing for a level, cannot compute UASS, UADS, UALR, or UADD
- Q23 Variable missing for level
- Q24 Variable violates lower bound for level
- Q25 Variable violates upper bound for level
- Q26 Wind speed is zero for non-zero wind direction or calm for level
- Q27 Temperature < dewpoint for level
- Q28 Top of sounding < 5 km
- Q40 Variable missing
- Q41 Variable violates lower bound
- Q42 Variable violates upper bound
- Q43 Calm wind
- Q44 Wind speed = 0 and wind direction > 0
- Q45 Wind speed > 0 and wind direction = 0
- Q46 Non-zero precipitation without weather
- Q47 Weather without non-zero precipitation
- Q60 Report first level for variable
- Q61 Missing value for variable (specific level for multi-level variable)
- Q62 Variable violates lower bound (specific level for multi-level variable)
- Q63 Variable violates upper bound (specific level for multi-level variable)
- Q64 Wind speed < threshold for level
- Q65 Reset averaged wind speed to calm for level due to insufficient sub-hourly values > threshold
- Q66 Reset averaged wind speed to missing for level due to insufficient sub-hourly values
- Q67 Temperature < dewpoint for level

- Q68 Set hourly average for variable to missing due to insufficient sub-hourly values;  
exception is precipitation
- Q70 Keep total precipitation for hour but not enough values for average

## Appendix E. AERMET modules and subroutines

The following tables list the AERMET modules and subroutines with descriptions and a list of subroutines or programs that call the subroutine. Note that the module FILE\_UNITS has no subroutines, only file unit numbers and names.

**Table E-1. List of subroutines and functions in module MAIN1**

Subroutine or Function	Description	Calling subroutines
CHECKDATES	Checks the year, month, and day of a date to ensure the date is a valid date.	Module MAIN1: GETDATES
CHECKFILE	Processes the MESSAGE, REPORT, DEBUG, DATA, EXTRACT, QAOUT, SURFACE, PROFILE, AERSURF, and AERSURF2 filenames from the AERMET control file.	Module READ_INPUT: JOB_PATH Module UPPERAIR: UPPER_PATH Module SURFACE: SURF_PATH Module ONSITE: OS_PATH Module PBL: PBL_PATH
COORD	Function to read latitude or longitude text string and convert to a number	Module MAIN1: GETLOC
DATA_DATES	Checks the year, month, day, and date of data from upper air, surface, or site-specific/prognostic data to ensure a valid date and within the window specified by XDATES for appropriate data path.	Module MAIN1: READ_6201, READ_FSL, READ_IGRA Module SURFACE: NEW_OBS, READ_ISHD Module ONSITE: AUDIT, READ_EXT, READ_OS Module PBL: CHECK_OBS, COARE1
DATALINE	Processes the DATA, AERSURF, or AERSURF2 keyword lines for AERMET control file	Module UPPERAIR: UPPER_PATH Module SURFACE: SURF_PATH Module ONSITE: OS_PATH Module PBL: PBL_PATH
DATETIME	Writes date and time to runtimes array to denote when AERMET starts and stops	AERMET
GETDATES	Process XDATES keyword to get start and end dates of data	Module UPPERAIR: UPPER_PATH, UP_STAGE2 Module SURFACE: SURF_PATH, SF_STAGE2 Module ONSITE: OS_PATH, OS_STAGE2 Module PBL: PBL_PATH

<b>Subroutine or Function</b>	<b>Description</b>	<b>Calling subroutines</b>
GETFIELDS	Get fields of data from input line from AERMET control file	Module MAIN1: GETDATES, GETLOC, VAR_LIST Module UPPERAIR: UP_RANGE, UP_MODKEY Module SURFACE: SURF_RANGE, SF_THRESH, NWS_HGTS Module ONSITE: DELTA_T_HT, OS_OBSNUM, OS_RANGE, OS_THRESH, OS_VARS, OSHEIGHTS Module PBL: FREQ_SEC, METHODS, MOL_MIN, SECTORS, SITE_CHAR, SSTDEPTH, UP_WINDOW, VPTG_DEF, YEAR_STR, ZI_GUST, ZIMIN
GETLOC	Process LOCATION keyword to get station ID, coordinates, GMT-LST conversion, and elevation	Module UPPERAIR: UPPER_PATH, UP_STAGE2 Module SURFACE: SURF_PATH, SF_STAGE2, READ_EXT Module ONSITE: OS_PATH, OS_STAGE2 Module PBL: PBL_PATH
GETUNIT	Determines what file unit or standard output to which to write messages	Module UPPERAIR: UPPER_PATH Module SURFACE: SURF_PATH Module ONSITE: OS_PATH Module READ_INPUT: CHECK_LINE, JOB_PATH Module PBL: PBL_PATH
GRAVITY	Calculate gravity as a function of latitude for COARE calculations	Module PBL: COARE1
HUMIDITY	Function to calculate humidity from temperature and dewpoint	Module SURFACE: READ_ISHD Module PBL: RH
LEAPYR	Determines if a year is a leap year	Module MAIN1: CHECKDATES, NUMDAYS, DATA_DATES Module SURFACE: SF_PROC Module UPPERAIR: UP_PROC Module ONSITE: OS_PROC Module PBL: PBL_PROC
NUMDAYS	Function to determine number of days in data period determined by XDATES	Module UPPERAIR: UP_PROC, NEW_SOUND Module SURFACE: SF_PROC, NEW_OBS, READ_1MIN Module ONSITE: OS_PROC, READ_EXT, READ_OS Module PBL: PBL_PROC, COARE1
PRESSURE	Function to calculate station or sea level pressure	Module SURFACE: READ_ISHD Module PBL: PRESS
RANGE_MOD	PROCESS RANGE keyword	Module UPPERAIR: UP_RANGE Module SURFACE: SURF_RANGE Module ONSITE: OS_RANGE

<b>Subroutine or Function</b>	<b>Description</b>	<b>Calling subroutines</b>
START_STOP	Writes AERMET processing dates and times to specified output file or device	AERMET Module REPORTS: INPUT_SUMM
VAR_LIST	Process NO_MISSING keyword or AUDIT keyword	Module UPPERAIR: UPPER_LIST Module SURFACE: SURF_LIST Module ONSITE: OS_LIST

**Table E-2. Subroutines and functions in module MISC**

<b>Subroutine or Function</b>	<b>Description</b>	<b>Calling subroutines</b>
CLEANUP	Closes files and deallocates arrays	AERMET



**Table E-3. Subroutines and functions in module ONSITE.**

<b>Subroutine or Function</b>	<b>Description</b>	<b>Calling subroutines</b>
AUDIT	Audits sub-hourly or hourly data	Module ONSITE: AVG_HR, OS_AUDITHR
AVG_HR	Calculates hourly averages from sub-hourly data	Module ONSITE: OS_PROC
AVG_WIND	Calculates hourly average wind direction and average vector wind speed (if requested).	Module ONSITE: AVG_HR
CALC_WIND	Calculates running totals of summed wind direction for averaging	Module ONSITE: OS_PROC
CHECK_HTS	Checks raw data to ensure heights are increasing in value with increasing levels	Module ONSITE: OS_PROC
CHECK_WIND	Checks hourly wind speeds against threshold; checks for zero wind direction and wind speed above threshold.	Module ONSITE: OS_PROC
DELTA_T_HT	Processes DELTA_TEMP keyword in AERMET control file	Module ONSITE: OS_PATH, OS_STAGE2
FINDVAR	Function to find index of a variable in array os_audit_index	Module ONSITE: AVG_HR
HEADER	Writes header information for QAOUT file	Module UPPERAIR: OS_PROC
ONSITE_INIT	Initializes osvars for Stage 1 or Stage 2	Module ONSITE: OS_PATH Module PBL: PBL_PROC
OS_AUDITHR	Audits hourly data	Module ONSITE: OS_PROC
OS_FORM	Processes FORMAT keyword in AERMET control file	Module ONSITE: OS_PATH, OS_TEST
OS_LIST	Process NO_MISSING keyword or AUDIT keyword for site-specific data; calls VAR_LIST	Module ONSITE: OS_PATH
OS_OBSNUM	Processes OBS/HOUR keyword in AERMET control file	Module ONSITE: OS_PATH
OS_PATH	Processes lines from the AERMET control file for the ONSITE or PROG path.	Module READ_INPUT: READINP
OS_PROC	Controls the reading and QA of site-specific or prognostic data for Stage 1	AERMET
OS_RANGE	Processes the RANGE keyword for site-specific or prognostic data by calling RANGE_MOD	Module ONSITE: OS_PATH, OS_STAGE2
OS_STAGE2	Reads upper air EXTRACT or QAOUT file header for Stage 2	Module READ_INPUT: READINP

<b>Subroutine or Function</b>	<b>Description</b>	<b>Calling subroutines</b>
OS_TEST	Checks that mandatory keywords have been included and valid processing requested	Module READ_INPUT: READINP
OS_THRESH	Processes THRESHOLD keyword in AERMET control file	Module ONSITE: OS_PATH, OS_STAGE2
OS_VARS	Processes READ keyword in AERMET control file	Module ONSITE: OS_PATH
OSFORMREAD	Checks that first READ statement has date/time variables and FORMAT statements do not have syntax errors	Module ONSITE: OS_TEST
OSHEIGHTS	Processes OSHEIGHTS keyword in AERMET control file	Module ONSITE: OS_PATH, OS_TEST
READ_EXT	Reads the ONSITE QAOUT file	Module ONSITE: OS_PROC
READ_OS	Reads data file named by DATA keyword	Module ONSITE: OS_PROC

**Table E-4. Subroutines and functions in module PBL**

<b>Subroutine or Function</b>	<b>Description</b>	<b>Calling subroutines</b>
AERSURF	Reads the AERSURF or AERSURF2 file to get surface characteristics	Module PBL: PBL_PROC, PBL_TEST
BULK_RICH	Calculates $u^*$ , $L$ , and $\theta^*$ based on Bulk Richardson approach	Module PBL: PBL_PROC
CALC_USTAR	Calculates $u^*$ and $L$ for stable or convective conditions	Module PBL: PBL_PROC
CHECK_FLUX	Checks that $u^*$ and $\theta^*$ won't result in unrealistic values of heat flux for stable conditions	Module PBL: PBL_PROC
CHECK_OBS	Determines if there are upperair, surface, or onsite or prognostic observations for the tested date	Module PBL: PBL_PROC
CHECK_PROF	Checks the output PROFILE file for format overflows or NaN	Module PBL: WRITEFILES
CHECK_PROF	Checks the output OUTPUT (i.e. surface) file for format overflows or NaN	Module PBL: WRITEFILES
CLOUDS	Assigns cloud cover for the hour	Module PBL: PBL_PROC
COARE1	Perform COARE calculations for overwater data	Module PBL: PBL_PROC
CONV_HT	Calculates convective mixing height for convective hours	Module PBL: PBL_PROC
FREQ_SEC	Processes FREQ_SECT or FREQ_SECT2 line from the surface characteristics file	Module PBL: AERSURF
HAVE_DATA	Assigns a logical variable denoting if a requested variable is valid for the hour	Module PBL: COARE1, LW_DOWN, PBL_PROC
LW_DOWN	Calculates or assigns longwave downward radiation for ONSITE or PROG data	Module PBL: COARE1
MECH_HT	Calculates mechanical mixing heights for the hour	Module PBL: COARE1, PBL_PROC
METHODS	Processes the METHOD line from the runstream input file	Module PBL: PBL_PATH
MOL_MIN	Reads the MIN_MOL keyword value for specifying minimum Monin-Obukhov length for COARE processing	Module PBL: PBL_PATH
NETRAD	Calculates net radiation	Module PBL: PBL_PROC
NR_ANG	Calculate critical solar angle	Module PBL: STABILITY
PBL_PATH	Processes lines from the AERMET control file for the METPREP path.	Module READ_INPUT: READINP

<b>Subroutine or Function</b>	<b>Description</b>	<b>Calling subroutines</b>
PBL_PROC	Controls the processing of PBL calculations	AERMET
PBL_TEST	Checks that mandatory keywords have been included and valid processing requested	Module READ_INPUT: READINP
PRECIP	Assign precipitation for the hour	Module PBL: PBL_PROC
PRESS	Calculates station pressure for the hour	Module PBL: PBL_PROC
PROFILE	Assigns values to pfl_data data type for the hour	Module PBL: PBL_PROC
PSIT	Stability function for COARE processing	Module PBL: COARE1
PSIU	Stability function for COARE processing	Module PBL: COARE1
READ_SOUND	Processes sounding for convective mixing height and potential temperature lapse rate calculations	Module PBL: PBL_PROC
RH	Calculates relative humidity for the hour	Module PBL: PBL_PROC
SECTORS	Processes the line SECTOR or SECTOR2 from the AERMET control file or external surface characteristics file	Module PBL: SFC_CHARS, AERSURF
SFC_CHARS	Assigns surface characteristics for the hour for primary or secondary site	Module PBL: WINDS
SFC_HEADER	Writes surface header to SURFACE file	Module PBL: PBL_PROC
SITE_CHAR	Processes the line SITE_CHAR or SITE_CHAR2 from the AERMET control file or external surface characteristics file	Module PBL: AERSURF
SSTDEPTH	Reads the SSTPDEPTH keyword value for specifying SST depth for COARE processing	Module PBL: PBL_PATH
STABILITY	Calculates critical solar elevation angle for the hour and assigns stability for the hour based on angle or Moin-Obukhov length.	Module PBL: PBL_PROC
SUBSTITUTE	Interpolates temperature and/or cloud cover for missing hours	Module PBL: PBL_PROC
SUNDAT	Calculates sunrise and sunset times and optionally calculates solar elevation angle for all hours of the day	Module PBL: PBL_PROC

<b>Subroutine or Function</b>	<b>Description</b>	<b>Calling subroutines</b>
SURF_YEARS	Checks to see what years are associated with a specific set of surface characteristics	Module PBL: AERSURF
TEMPS	Assigns temperatures for the hour for the surface data and fills in profile temperatures	Module PBL: PBL_PROC
UP_WINDOW	Processes the keyword UAWINDOW from AERMET control file	Module PBL: PBL_PATH
VAPOR_PRES	Calculate vapor pressure for COARE processing	Module PBL: COARE1
VPTG	Function to calculate the potential temperature lapse rate above the mixing height	Module PBL: PBL_PROC, CONV_HT
VPTG_DEF	Reads the DEF_VPTG keyword value for specifying default lapse rate for COARE processing	Module PBL: PBL_PATH
WINDS	Assigns winds for the hour and assigns profile values for the hour	Module PBL: PBL_PROC
WRITE_SRSS	Write local and upper air station sunrise and sunset times	Module PBL: PBL_PROC
WRITEFILES	Writes SURFACE and PROFILE files	Module PBL: PBL_PROC
WSTAR	Function to calculate convective velocity scale $w^*$	Module PBL: PBL_PROC, CONV_HT
YEAR_STR	Obtains the string of years for the FREQ_SECT or FREQ_SECT2 keyword	Module PBL: PBL_PATH
ZIGUST	Reads the ZI_GUST keyword value for specifying mixing height for gust calculations for COARE processing	Module PBL: PBL_PATH
ZIMIN	Reads the ZI_MIN keyword value for specifying minimum mixing height for COARE processing	Module PBL: PBL_PATH

**Table E-5. Subroutines and functions in module SURFACE.**

<b>Subroutine or Function</b>	<b>Description</b>	<b>Calling subroutines</b>
CHECK_ASOS	Checks the ASOS status of a station or hour	Module SURFACE: SF_TEST, READ_ISHD, READ_CD144, READ_SCRAM, READ_SAM, READ_HUSWO, READ_EXT, SF_STAGE2
CHECK_DUP	Checks to see if current observation can be overwritten with a duplicate observation	Module SURFACE: READ_ISHD, READ_CD144, READ_SCRAM, READ_SAM, READ_HUSWO, READ_EXT
DECODE144	Decodes CD-144 overpunches	Module SURFACE: READ_CD144, READ_SCRAM
HEADER	Writes header information for EXTRACT and QAOUT file	Module SURFACE: SF_PROC
NEW_OBS	Initializes/increments variables and checks for duplicates for new observation	Module SURFACE: READ_ISHD, READ_CD144, READ_SCRAM, READ_SAM, READ_HUSWO, READ_EXT
NWS_HGTS	Processes the NWS_HGT keyword in the AERMET control file	Module PBL: PBL_PATH
READ_1MIN	Processes AERMINUTE output in Stage 2	AERMET
READ_CD144	Processes CD144 format data	Module SURFACE: SF_PROC
READ_EXT	Processes the EXTRACT or QAOUT file	Module SURFACE: SF_PROC
READ_HUSWO	Processes HUSWO format data	Module SURFACE: SF_PROC
READ_ISHD	Processes ISHD format data	Module SURFACE: SF_PROC
READ_SAM	Processes SAMSON format data	Module SURFACE: SF_PROC
READ_SCRAM	Processes SCRAM format data	Module SURFACE: SF_PROC
SF_AUDIT	Audits surface data	Module SURFACE: SF_PROC
SF_PROC	Controls the reading and QA of surface data for Stage 1	AERMET
SF_STAGE2	Reads upper air EXTRACT or QAOUT file header for Stage 2	Module SURFACE: SF_PROC
SF_TEST	Checks that mandatory keywords have been included and valid processing requested	Module READ_INPUT: READINP
SF_THRESH	Processes THRESH_1MIN keyword in AERMET control file	Module PBL: PBL_PATH
SFC_INIT	Initializes the data type SFVARS, formats for certain messages, valid start/end dates for data formats, and ASOS station information	Module SURFACE: SURF_PATH
SURF_LIST	Process NO_MISSING keyword or AUDIT keyword for surface data; calls VAR_LIST	Module SURFACE: SURF_PATH
SURF_PATH	Processes lines from the AERMET control file for the SURFACE path.	Module READ_INPUT: READINP

<b>Subroutine or Function</b>	<b>Description</b>	<b>Calling subroutines</b>
SURF_RANGE	Processes the RANGE keyword for surface data by calling RANGE_MOD	Module SURFACE: SURF_PATH, SF_STAGE2

**Table E-6. Subroutines and functions in module READ\_INPUT**

<b>Subroutine or Function</b>	<b>Description</b>	<b>Calling subroutines</b>
CHECK_LINE	Reads AERMET control file and checks syntax	Module READ_INPUT: READINP
JOB_PATH	Processes lines from the AERMET control file for the JOB path.	Module READ_INPUT: READINP
READINP	Main controlling subroutine to read AERMET control file	AERMET

**Table E-7. Subroutines and functions in module REPORTS**

<b>Subroutine or Function</b>	<b>Description</b>	<b>Calling subroutines</b>
AUDIT_SUMM	Summarize audit results for upper air, surface, or site-specific/prognostic data	AERMET
DATES_LOC	Writes the processing start/end dates and location for each path (upper air, surface, site-specific, or prognostic)	Modules REPORTS: INPUT_SUMM
INPUT_SUMM	Writes names of input/output files and processing options for each path;	AERMET
OBS_SUM	Summarizes the number of observations per day for upper air soundings, surface data, 1-minute ASOS winds, and onsite or prognostic data	AERMET
PBL_SUM	Summarizes the boundary layer processing	AERMET
SFCHAR_SUM	Writes summary of surface characteristics for primary and secondary site	AERMET
SUM_FILES	Writes input/output filenames and status for each path to report file	Modules REPORTS: INPUT_SUMM
WRITE_MSG	Writes message file summary to report file	AERMET



**Table E-8. Subroutines and functions in module UPPERAIR**

<b>Subroutine or Function</b>	<b>Description</b>	<b>Calling subroutines</b>
FSL_VERSION	Determines the FSL data file format version	Module UPPERAIR: READ_FSL
HEADER	Writes header information for EXTRACT and QAOUT file	Module UPPERAIR: UP_PROC
NEW_SOUND	Initializes and increments variables for a new sounding	Module UPPERAIR: READ_EXT, READ_FSL, READ_IGRA, READ_6201
NEWTEMP	Function to calculate new temperature or dewpoint	Module UPPERAIR: UP_MODIFY
READ_6201	Process 6201 format upper air data	Module UPPERAIR: UP_PROC
READ_EXT	Read EXTRACT or QAOUT upper air file	Module UPPERAIR: UP_PROC
READ_FSL	Process FSL format upper air data	Module UPPERAIR: UP_PROC
READ_IGRA	Process IGRA format upper air data	Module UPPERAIR: UP_PROC
UP_AUDIT	Audits upper air data	Module UPPERAIR: UP_PROC
UP_MODIFY	Modifies upper air data by 1) deleting mandatory levels, 2) set wind direction to 0 if wind speed is 0 and 3) interpolate missing temperature and dewpoint	Module UPPERAIR: UP_PROC
UP_MODKEY	Processes MODIFY keyword in AERMET control file	Module UPPERAIR: UPPER_PATH
UP_PROC	Controls the reading and QA of upper air data for Stage 1	AERMET
UP_RANGE	Processes the RANGE keyword for upper air data by calling RANGE_MOD	Module UPPERAIR: UPPER_PATH, UP_STAGE2
UP_STAGE2	Reads upper air EXTRACT or QAOUT file header for Stage 2	Module READ_INPUT: READINP
UP_TEST	Checks that mandatory keywords have been included and valid processing requested	Module READ_INPUT: READINP
UPPER_INIT	Initializes the data type UPVARS and formats for certain messages	Module UPPERAIR: UPPER_PATH
UPPER_LIST	Process NO_MISSING keyword or AUDIT keyword for upper air data; calls VAR_LIST	Module UPPERAIR: UPPER_PATH
UPPER_PATH	Processes lines from the AERMET control file for the UPPERAIR path.	Module READ_INPUT: READINP
VIRT_TEMP	Function to calculate virtual temperature	Module UPPERAIR: UP_AUDIT

## **Appendix F. Comparison of 22112 AERMET to 21112 AERMET**

As part of the evaluation of 22112 AERMET, AERMET and AERMOD were run for the 17 evaluation databases used to promulgate and evaluate AERMOD for each update. AERMET version 21112 and version 22112 were run for each database and AERMOD 21112 was run for each AERMET version and model results were compared. The databases are described in Section 2 of the AERMOD evaluation document (EPA, 2023g). Table F-1 lists the databases with summaries of sources and meteorological data. Sources listed in gray are subject to the EPA's protocol for determining best performing model. Meteorological outputs were compared on an hour-by-hour basis with and without the surface friction velocity adjustment and the AERMOD results based on the AERMET versions were compared using the methodology described in Section 3.3.2 in the AERMOD model evaluation document (EPA, 2022d).

**Table F-1. AERMOD evaluation databases**

Location	Stack heights	Urban/rural	Terrain	Downwash	Turbulence parameters	Site specific AERMET inputs
Martins Creek	59, 76, 183 m	Rural	Complex	Yes	10 m $\sigma_v$ , $\sigma_w$	10m wind, temperature; 90-420 m wind (every 30 m).
Tracy	91 m	Rural	Complex	No	$\sigma_v$ , $\sigma_w$	10 and 50-400 m (every 25 m) wind, temperature
Lovett	145 m	Rural	Complex	No	$\sigma_v$ , $\sigma_w$	10, 50, and 100 m wind, temperature
Westvaco	190 m	Rural	Complex	No	$\sigma_v$ , $\sigma_w$	30, 210, 326, 366, and 416 m wind, temperature <sup>1</sup>
DAEC	1 m, 24 m, 46 m	Rural	Flat	Yes	$\sigma_v$	Insolation, 10, 23.5 and 50 m wind, temperature
EOCR	1, 25, 30 m	Rural	Flat	Yes	$\sigma_v$	4, 10, and 30 m wind, temperature
Alaska	39.2 m	Rural	Flat	Yes	$\sigma_v$ , $\sigma_w$	33 m wind, temperature
Indianapolis	84 m	Urban	Flat	No	$\sigma_v$ , $\sigma_w$	Station pressure, net radiation, 10 m wind, temperature
Kincaid	187 m	Rural	Flat	No	$\sigma_v$ , $\sigma_w$	Net radiation, insolation, 10, 30, and 50 m wind, temperature
AGA	9.8, 14.5, 24.4 m	Rural	Flat	Yes	None	10 m wind and temperature
Millston	3 stacks 29 m (freon) 48 m (SF6)	Rural	Flat	Yes	None	10 m wind speed; 43.3 m wind and temperature
Bowline	2 stacks 86.87 m	Rural	Flat	Yes	None	100 m winds and temperature
Baldwin	3 stacks 184.4 m	Rural	Flat	Yes	None <sup>2</sup>	10 and 100 m wind, temperature
Clifty Creek	3 stacks 207.9 m	Rural	Mix	No	None	10 m temperature; 60 m wind
Prairie Grass	0.46 m	Rural	Flat	No	$\sigma_v$ , $\sigma_w$	U*, mixing height, ceiling height, cloud cover; 1, 2, 4, 8, and 16 m temperature and wind; $\sigma_v$ , $\sigma_w$ at 2 m

<sup>1</sup> 30 m observations removed from AERMOD profile before running AERMOD.

## F. 1. Meteorological data differences

As previously noted, hourly comparisons were made for all surface variables and profile variables with a tolerance to account for rounding differences since AERMET 21DRF and later versions switched from real to double precision for variables. Table F-2 lists the variables with tolerances.

**Table F-2. Meteorological variables for comparison with tolerances.**

Variable	Tolerance
Sensible heat flux	0.2 W/m <sup>2</sup>
Surface friction velocity	0.002 m/s
Convective velocity scale	0.002 m/s
Θ lapse rate above mixing height	0.002 K/m
Convective mixing height	1 m
Mechanical Mixing height	1 m
Monin-Obukhov length	0.2 m
Surface roughness	0 m
Bowen ratio	0
Albedo	0
Reference wind speed	0 m/s
Reference wind direction	0°
Reference wind height	0 m
Reference temperature	0.2 K
Reference temperature height	0 m
Precipitation code	0
Precipitation	0 mm/hr
Relative humidity	1 %
Station pressure	2 mb
Cloud cover	0 tenths
Wind flag	Character: character strings compared
Profile height	0 m
Profile top indicator	Not checked
Profile wind speed	0 m/s
Profile wind direction	0°
Profile temperature	0°C
Profile $\sigma_\theta$	0°
Profile $\sigma_w$	0 m/s

Following are summaries of comparisons for each of the databases.

- **Martins Creek**

- Six hours where Monin-Obukhov length differed with a range of -411 m to 1 m for non-adjusted  $u^*$ 
  - Largest difference for 1/17/1993 hour 9
- Seven hours where Monin-Obukhov length differed with a range of -302.1 to 0.6 m for adjusted  $u^*$ 
  - Largest difference for both cases is 1/17/1993 hour 9
    - For non-adjusted and adjusted  $u^*$ , difference is due to differences in  $\theta^*$  for the hour and the  $\theta^*$  difference is due to a slight difference in the critical angle for the hour (9.782 for AERMET 21112 and 9.811 for AERMET 22112)
- All other variables and hours were within tolerances for both non-adjusted and adjusted  $u^*$

- **Tracy**

- All other variables and hours were within tolerances for both non-adjusted and adjusted  $u^*$

- **Lovett**

- Five hours where Monin-Obukhov length differed with a range of 0.2 to 16 m for both adjusted and non-adjusted  $u^*$ 
  - Max difference of 16 m for 9/12/1988 hour 7; differences due to slight differences in variables for calculating convective L, possibly due to the switch from real to double precision in AERMET 22112.
- Precipitation missing codes differed for all hours (9999 for AERMET 21112 and 99 for AERMET 21DR22112F); would make no difference in AERMOD as precipitation values matched for the two versions of AERMET.
- All other variables and hours were within tolerances for both non-adjusted and adjusted  $u^*$

- **Westvaco**

- One hour, 6/8/1981 hour 8, differed for albedo (0.15 for AERMET 21112 and 0.16 for AERMET 22112). Due to adjustment of noontime albedo for hour 8 and most likely due to switch from real to double precision in AERMET 21DRF
  - Two hours differed for the precipitation code with AERMET 21112 reporting 0 and AERMET 22112 reporting as missing. Precipitation values did not differ.
  - Seven hours differ for Monin-Obukhov length for non-adjusted  $u^*$  with a range of -0.3 to 1 m
  - Eight hours differ for Monin-Obukhov length for adjusted  $u^*$  with a range of -0.3 to 1.3 m
  - All other variables and hours were within tolerances for both non-adjusted and adjusted  $u^*$
- **DAEC**
    - One hour, 7/6/1978 hour 16 for a height of 50, differs in missing values for  $\sigma_\theta$ . This is due to the missing code in the raw data file not matching default missing code for  $\sigma_\theta$  in AERMET. AERMET interprets the missing value as valid and the AERMET control file should be updated to reset the missing code. While AERMET 22112 also does not use a reset value for the missing code, because the input  $\sigma_\theta$  is negative, AERMET 22112 interprets as missing.
    - Differences in missing codes for precipitation. Both AERMET versions report precipitation as missing and precipitation values are not different so no effect on AERMOD results.
    - All other variables and hours were within tolerances for both non-adjusted and adjusted  $u^*$
- **EOCR**
    - Three hours differ for the  $\sigma_\theta$  missing value due to missing codes (AERMET 21112 is 999 and AERMET 22112 is -99). No effect on AERMOD as both are interpreted as missing by AERMOD.
    - All other variables and hours were within tolerances for both non-adjusted and adjusted  $u^*$

- **Alaska**

- For both non-adjusted and adjusted  $u^*$ , 11/8/1987 hour 24 differs for all variables. This is because in the raw data file, hour 24 is reported as 11/9/1987 hour 0. AERMET 21112 ignores the hour because it is outside the XDATES dates. Therefore, AERMET sets hour 23 values to hour 24 for the day. AERMET 21112 converts 11/9/1987 hour 0 to 11/8/1987 hour 24 before checking against the XDATES dates. AERMET 21112 uses the reported values for the hour.
- Four hours for  $\sigma_\theta$  in the profile have different missing codes for both non-adjusted and adjusted  $u^*$
- Nine hours for  $\sigma_w$  in the profile have different missing codes for both non-adjusted and adjusted  $u^*$
- All other variables and hours were within tolerances for both non-adjusted and adjusted  $u^*$

- **Indianapolis**

- Nine hours where reference wind direction and profile wind direction differ by  $0.1^\circ$  in both non-adjusted and adjusted  $u^*$  data. Most likely due to rounding when switching from real to double precision in AERMET 22112.
- Two hours where Monin-Obukhov length differ between -0.2 and 0.2 m for both non-adjusted and adjusted  $u^*$
- Thirteen hours where  $\sigma_w$  in the profile differ between -0.04 and 0.05 m/s
- 144 hours where  $\sigma_\theta$  in the profile differs between  $-0.5$  and  $0.5^\circ$ . It appeared that AERMET 21112 was rounding the input values for  $\sigma_\theta$  in the raw met data file to the nearest integer.

- **Kincaid**

- Set A, 8/31/1980 hour 24 is missing for cloud cover and other variables that depend on cloud cover for calculations for AERMET 22112 but is not missing for AERMET 21112. This is because AERMET 21112 substitutes hour 23 for hour 24 for SURFACE data prior to PBL calculations and AERMET 22112 does not do that substitution. This is for both non-adjusted and adjusted  $u^*$ .
- One hour in Set A where AERMET 22112 cloud cover is 1 tenth and AERMET 21112 is 0 tenths. This is for both non-adjusted and adjust  $u^*$
- One hour where heat flux differs by  $1.1 \text{ W/m}^2$  for Set A for non-adjusted  $u^*$ .

- 37 hours where Monin-Obukhov length differs by 10.6 to 146.8 m for non-adjusted  $u^*$  for set A and 32 hours where Monin-Obukhov length differs by -7.2 to 84.2 m for adjusted  $u^*$  for set A.
    - Maximum differences of L due to slight difference in solar angle and  $\theta^*$  for non-adjusted  $u^*$  and 84.2 m for adjusted  $u^*$
  - Different missing values for  $\sigma_\theta$  and  $\sigma_w$  in Set A for both non-adjusted and adjusted  $u^*$ . AERMET 21112 reports -999 and AERMET 22112 reports 99. Does not affect AERMOD as AERMOD sees both values as missing.
  - Set B, 6/17/1981 hour 24 is missing for AERMET 22112 and not missing for AERMET 21112 due to the hour 23 substitution for hour 24 for SURFACE data. This is both for non-adjusted and adjusted  $u^*$ .
  - 23 hours for Set B where Monin-Obukhov length differs between -2.4 and 7.2 m for non-adjusted  $u^*$
  - 18 hours for Set B where Monin-Obukhov length differs between -2.4 and 5.6 m for adjusted  $u^*$
  - Different missing values for temperature profile for 48 hours for Set B for both non-adjusted and adjusted  $u^*$
  - Different missing values for  $\sigma_\theta$  and  $\sigma_w$  in Set B for both non-adjusted and adjusted  $u^*$  for four hours. AERMET 21112 reports -999 and AERMET 22112 reports 99. Does not affect AERMOD as AERMOD sees both values as missing.
  - All other variables and hours were within tolerances for both non-adjusted and adjusted  $u^*$
- **AGA**
    - For Houston, seven hours have Monin-Obukhov length differences between -0.2 to 0.8 m for non-adjusted  $u^*$
    - For Houston, seven hours have Monin-Obukhov length differences between -0.2 to 0.5 m for adjusted  $u^*$
    - For Wichita, five hours have Monin-Obukhov length differences between -0.2 to 3.6 m for non-adjusted  $u^*$
    - For Wichita, five hours have Monin-Obukhov length differences between -0.2 to 3.3 m for adjusted  $u^*$



- All other variables and hours were within tolerances for both non-adjusted and adjusted  $u^*$
- **Millston**
  - All hours have different missing codes for precipitation type code for both non-adjusted and adjusted  $u^*$
  - Two hours differ for Monin-Obukhov length for non-adjusted  $u^*$ , -0.2 and 0.8 m
  - Three hours differ for Monin-Obukhov length for adjusted  $u^*$ , -0.2, 0.2, and 0.9 m
  - All other variables and hours were within tolerances for both non-adjusted and adjusted  $u^*$
- **Bowline**
  - All hours have different missing codes for precipitation type code for both non-adjusted and adjusted  $u^*$
  - Eight hours differ for Monin-Obukhov length for non-adjusted  $u^*$ , -0.5 to 0.3 m
  - Six hours differ for Monin-Obukhov length for adjusted  $u^*$ , -0.5 to 0.8 m
  - All other variables and hours were within tolerances for both non-adjusted and adjusted  $u^*$
- **Baldwin**
  - 3/31/1983 hour 24 is missing for cloud cover and other variables that depend on cloud cover for calculations for AERMET 22112 but is not missing for AERMET 21112. This is because AERMET 21112 substitutes hour 23 for hour 24 for SURFACE data prior to PBL calculations and AERMET 22112 does not do that substitution. This is for both non-adjusted and adjusted  $u^*$ .
  - Monin-Obukhov length differs for 14 hours for non-adjusted  $u^*$  ranging from -0.3 to 19 m.
  - Monin-Obukhov length differs for 12 hours for adjusted  $u^*$  ranging from -1.2 m to 1.0 m
  - All other variables and hours were within tolerances for both non-adjusted and adjusted  $u^*$

- **Clifty Creek**
  - Monin-Obukhov length differs for 3 hours for non-adjusted  $u^*$  ranging from 0.3 to 1.3 m
  - Monin-Obukhov length differs for 5 hours for adjusted  $u^*$  ranging from -0.2 to 1 m.
  - All other variables and hours were within tolerances for both non-adjusted and adjusted  $u^*$
  
- **Prairie Grass**
  - Different missing codes for precipitation for all hours; also results in different precipitation codes
  - Eighteen hours differ for mechanical mixing heights for non-adjusted  $u^*$  and adjusted  $u^*$ . Differences range from -1411 to 359 m. Differences are due to a mix of site-specific mixing heights and calculated mixing heights. AERMET 21112 does not smooth the mechanical heights when there is a mix. AERMET 22112 does smooth with a mix of heights and also contains the bug fix to the assignment of mechanical mixing heights for convective hours discussed in Section 1.5
  - Two hours differ for  $\sigma_w$  with a difference of 0.01. Most likely due to rounding
  - One hour differed for L by 0.4 m.
  - All other variables and hours were within tolerances for both non-adjusted and adjusted  $u^*$

## **F. 2. AERMOD evaluations**

In addition to evaluation of meteorological data, the differences in meteorological data were evaluated based on AERMOD results. For the databases listed in gray in Table F-1, the full EPA protocol for determining best performing model was used as described in Section 3.3.2 of the AERMOD Model Evaluation document (MFED) (EPA, 2022d). The exception to the procedure outlined in the AERMOD MFED versus the AERMET evaluation presented here is that the ratio of the Model Comparison Measure (MCM) to the standard error is used as the basis of statistical significance between the two model outputs when only considering two models. If the absolute value of the ratio is less than 1.7 then the two models are not considered

statistically different. For the databases not in gray in Table F-1, the metric compared is the Robust Highest Concentration compared to observations. The RHC is defined by Equation 1 in Section 3.3.2 of the AERMOD Model Evaluation document (U.S. EPA, 2022d).

Results for the databases not subject to the EPA protocol for determining best performing model are shown in Table F-3. For most of the databases, the differences in meteorology made no difference in RHC values. This could be due to in part, that the differing hours in the meteorological data were not hours with observed concentrations. Two exceptions were DAEC and Prairie Grass. DAEC differences were very small, less than  $1 \mu\text{g}/\text{m}^3$ . The differences were due to slight differences in air temperatures in the meteorological data that were within the tolerances but given that the DAEC releases were close to ambient temperature, the modeled results were slightly different. For Prairie Grass, the differences were mostly due to the changes in mixing heights as discussed in Section F. 1.

Table F-4 lists the Composite Performance Measure (CPM) results for the databases that use the EPA protocol for determining best performing model and Table F-5 shows the Model Comparison Measure (MCM), standard error (SE), and ratio of MCM/SE for the same databases. Based on the results presented in the tables, AERMET 21112 and AERMET 22112 are not statistically different. The MCM values are close to zero and the ratio of the MCM to the standard error is within  $\pm 1.7$ .

**Table F-3. Observed and modeled robust highest concentrations for databases not subject to the EPA protocol for determining best performing model.**

Database	RHC						
	Observed	AERMET version					
		21112			22112		
		No adjust u* with turbulence	Adjust u* no turbulence	No adjust u* no turbulence	No adjust u* with turbulence	Adjust u* no turbulence	No adjust u* no turbulence
Tracy	15	13	18	25	13	18	25
DAEC (h=1 m)	346	240	188	222	240	188	222
DAEC (h=24 m)	253	84	71	75	84	71	75
DAEC (h=46 m)	140	91	59	99	91	59	99
EOCR	3763	5822	5731	8250	5822	5731	8250
Alaska	6	5	8	8	5	8	8
Indianapolis	6	4	4	5	4	4	5
AGA	296	NA	262	281	NA	262	281
Millston (Freon)	76	NA	96	101	NA	96	101
Millston (SF6)	79	NA	33	35	NA	33	35
Prairie Grass	925087	998257	885858	899076	989003	873817	887034

**Table F-4. Composite Performance Measure (CPM) for databases subject to the EPA protocol for determining best performing model.**

Scenario	Version	Database						
		Martins Creek	Lovett	Westvaco	Kincaid	Bowline	Baldwin	Clifty Creek
No adjust u*; with turbulence	21112	0.35	0.40	0.41	0.37	NA	NA	NA
	22112	0.35	0.40	0.41	0.37	NA	NA	NA
Adjust u*; no turbulence	21112	0.31	0.53	0.60	0.56	0.50	0.45	0.49
	22112	0.31	0.53	0.60	0.56	0.50	0.45	0.49
No adjust u*; no turbulence	21112	0.49	0.58	0.44	0.56	0.47	0.46	0.51
	22112	0.49	0.58	0.44	0.56	0.47	0.46	0.51

**Table F-5. Model Comparison Measure (MCM), standard error (SE) and MCM/SE ratios for databases subject to the EPA protocol for determining best performing model.**

Scenario	Metric	Database						
		Martins Creek	Lovett	Westvaco	Kincaid	Bowline	Baldwin	Clifty Creek
No adjust u*; with turbulence (22112-21112)	MCM	-1.0x10 <sup>-6</sup>	-1.0x10 <sup>-6</sup>	-1.0x10 <sup>-6</sup>	6.0x10 <sup>-5</sup>	NA	NA	NA
	SE	0.046	0.056	0.030	0.124	NA	NA	NA
	MCM/SE	-4.0x10 <sup>-5</sup>	-1.0x10 <sup>-6</sup>	-2.0x10 <sup>-5</sup>	4.8x10 <sup>-4</sup>	NA	NA	NA
Adjust u*; no turbulence (22112-21112)	MCM	-1.0x10 <sup>-6</sup>	1.0x10 <sup>-6</sup>	1.0x10 <sup>-6</sup>	2.0x10 <sup>-5</sup>	-1.0x10 <sup>-6</sup>	2.0x10 <sup>-5</sup>	3.0x10 <sup>-5</sup>
	SE	0.057	0.053	0.024	0.033	0.046	0.049	0.032
	MCM/SE	-3.0x10 <sup>-5</sup>	1.0x10 <sup>-6</sup>	2.6x10 <sup>-4</sup>	5.3x10 <sup>-4</sup>	-1.0x10 <sup>-5</sup>	3.4x10 <sup>-4</sup>	0.001
No adjust u*; no turbulence (22112-21112)	MCM	-1.0x10 <sup>-6</sup>	1.0x10 <sup>-6</sup>	1.0x10 <sup>-6</sup>	2.0x10 <sup>-5</sup>	-1.0x10 <sup>-6</sup>	2.0x10 <sup>-5</sup>	3.0x10 <sup>-5</sup>
	SE	0.065	0.047	0.033	0.037	0.047	0.048	0.024
	MCM/SE	-3.0x10 <sup>-5</sup>	1.0x10 <sup>-6</sup>	1.0x10 <sup>-6</sup>	6.3x10 <sup>-4</sup>	-1.0x10 <sup>-5</sup>	3.5x10 <sup>-4</sup>	0.001

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