South Carolina Department of Environmental Services
2015 – 2019 Meteorological Data Processing Using AERMET v21112
September 2021

OVERVIEW

The AERMOD dispersion modeling system is the United States Environmental Protection Agency's (EPA) preferred modeling system for State Implementation Plan (SIP) revisions for existing sources and the New Source Review (NSR) and Prevention of Significant Deterioration (PSD) programs. AERMET is a program that processes meteorological data for use in the AERMOD dispersion model (EPA, 2019). AERMET accepts upper air sounding and surface station meteorological data along with surface characteristics and merges them into a format AERMOD can read. All meteorological surface data is derived from 1-hour Integrated Surface Hourly Data (ISHD) and one-minute (DSI-6405) and five-minute (DSI-6401) Automated Surface Observing System (ASOS) data from the National Weather Service (NWS) for years 2015-2019. The meteorological data was processed in September 2021 using version 21112 of AERMET, version 15272 of AERMINUTE, and version 20060 of AERSURFACE. As EPA releases new versions of AERMOD and AERMET, the Bureau of Air Quality (BAQ) will update the pre-processed meteorological data (as needed) to help streamline the modeling process.

BAQ provides AERMOD-ready meteorological data by county (or partial county). The data can be downloaded at https://des.sc.gov/programs/bureau-air-quality/air-dispersion-modeling-overview/air-dispersion-modeling-data (SCDES, n.d.) via an interactive GIS map or clickable list of county names. Each AERMET meteorological zip file has six pairs of PFL and SFC files for each ADJ_U* and non-ADJ_U* AERMET option. The zip file contains five one-year files and one five-year concatenated file of processed meteorological data. Below is a brief description of how the BAQ processed the AERMET data found on the DES website. A similar procedure should be followed to process project-specific AERMET data, should that be necessary.

1. Surface Data Preparation

Six years of ISHD surface met data were downloaded from the National Centers for Environmental Information (NCEI) Integrated Surface Database (ISD) website (NCEI, n.d.). Please note that at least the first 5 hours of the succeeding year were needed to properly handle the last 5 hours of each AERMET year due to time zone differences between ISHD input data in GMT (Greenwich Mean Time) and AERMET in local time, which is EST for all South Carolina ASOS locations. The single-year ISHD files were downloaded and unzipped for each met site, and all 5 years (plus a partial 6th year) of ISHD met data were concatenated for use in AERMET. Data from the following ASOS sites were chosen (due to acceptable completeness requirements) to represent South Carolina AERMOD air dispersion modeling:

- KAGS – Augusta, GA (Bush Field)
- KAND – Anderson
- KCAE – Columbia
- KCHS – Charleston
- KCRE – North Myrtle Beach
- KFLO – Florence

- KGRD – Greenwood
- KGSP – Greenville-Spartanburg
- KMEB – Laurinburg-Maxton, NC
- KOGB – Orangeburg
- KSAV – Savannah, GA
- KUZA – Rock Hill

2. Upper Air Data Preparation

Five individual years of upper air radiosonde met data in FSL format were downloaded from the Earth System Research Laboratory (ESRL, n.d.). Charleston, SC (CHS), Greensboro, NC (GSO), Peachtree City, GA (FFC), Jacksonville, FL (JAX), and Morehead City, NC (MHX) upper air data were used, but JAX and MHX upper air data were only used as alternate upper air data to fill missing CHS upper air data. Completeness of the 12Z (morning) sounding was evaluated by preliminarily running AERMET for each upper air site for each year of data (using any "dummy" surface data and any set of surface characteristics). Note that only 12Z soundings are used in AERMET for daily convective parameter computations, and all other soundings in the station file are ignored. The AERMET output diagnostics files inform the modeler which 12Z soundings are missing from the input data. All missing 12Z upper air data from the FSL file were identified and filled with an alternate upper air dataset using one of the two methods briefly described below:

- If 12Z upper air FSL data were missing but were available in the University of Wyoming upper air data archive (UWYO, n.d.), the University of Wyoming sounding data was reformatted to FSL format (and placed in correct chronological order) within the FSL file so that it could be processed by AERMET.

- If the primary sounding data were missing from both the ESRL FSL file and the University of Wyoming archive, the Iowa Method was used to fill in missing morning sounding data using an alternate site as described below:
    - For background, see "A method for filling AERMET upper air data" (Ashton, 2006)
    - An alternate sounding was chosen to represent the missing sounding.
        - FFC was used to fill in missing soundings at GSO
        - GSO was used to fill in missing soundings at FFC
        - JAX was used to fill missing soundings at CHS that were paired with KOGB and KSAV surface data
        - MHX was used to fill missing sounding at CHS that were paired with KCHS and KCRE
    - The hypsometric equation was applied to elevation and pressure data in the alternate sounding data to correct pressure and height information in the sounding to reflect the primary sounding site surface elevation.
    - Since there is only a minor difference (no more than 100 ft) between the primary and alternate sounding elevations, there was no need to change any other variable data within the alternate sounding.

- Newly filled soundings using alternate data were placed in chronological order within the newly revised FSL format file.

After all missing 12Z soundings were filled, follow-up AERMET "dummy" tests were completed using all station-years of filled soundings to ensure AERMET would accept each of the filled soundings. AERMET stage 3 output message files were checked for each run to ensure that AERMET would accept the filled soundings. After filling in missing soundings, the final dataset used in AERMET is 100% complete for all three primary upper air sites paired with surface ASOS data.

3. One-minute and Five-minute Data Preparation

The AERMINUTE processor (version 15272) was used to calculate hourly average winds from one-minute and five-minute ASOS winds. A few AERMINUTE processing notes are as follows:

- See EPA's AERMINUTE User Guide, Section 3, for more information (EPA, 2015).
- BAQ created AERMINUTE input files according to the proper format for AERMINUTE.
- One-minute ASOS wind files (NCDC, n.d.a) were downloaded (one file for each month) for each station-year of interest (6405-YYYY data, where YYYY is the 4-digit year).
- Five-minute ASOS wind files (NCDC, n.d.b) were downloaded (one file for each month) were downloaded for each station-year of interest ("6401-YYYY" data, where YYYY is the 4-digit year).
- Each AERMINUTE run was for one station-year (i.e., 12 monthly files of 1-minute wind data and 5-minute substitute wind for a station).
- Station-year output files were used as minute wind input to AERMET.

4. Determination of Paired Surface and Upper Air Data

BAQ meteorologists chose the best fit upper air data site for each surface data site based on 1) the distance from the ASOS site to nearby upper air sites and 2) whether or not the ASOS site was more inland with higher ASOS elevations (coupled with GSO or FFC) versus coastal with lower ASOS elevations (coupled with CHS). The following surface and upper air pairings were determined:

- KAGS surface data were paired with Peachtree City (FFC) upper air data
- KAND, KCAE, KFLO, GRD, GSP, MEB, and UZA were paired with Greensboro (GSO) upper air data
- KCHS, KCRE, KOGB, and KSAV were paired with Charleston (CHS) upper air data.

5. Monthly Surface Characteristics Preparation Using AERSURFACE

Surface characteristics (Bowen ratio, albedo, and surface roughness length) are necessary inputs to run EPA's AERMET program. SCDES developed surface characteristics by running EPA's AERSURFACE program (version 20060) using 2016 National Land Cover Data (NLCD) and supplemented with 2016 NLCD impervious and tree canopy data (EPA, 2020). Surface characteristics were developed on a monthly basis and broken up into sectors that were chosen to have similar land use and resulting surface characteristics. More specific notes about the procedures used for developing the surface characteristics by month and sector are as follows:

- For each ASOS wind measurement site location listed in Section 1, BAQ meteorologists chose starting and ending sector boundaries (in degrees), where similar land use was contained within the chosen boundaries of each sector around the met site. (Please be aware that the EPA AERSURFACE program will reorder the sectors if the first AERSURFACE input sector does not begin with the smallest degree. The AERSURFACE output sector order will always begin with the smallest degree.)
- A maximum of 12 sectors (with 30-degree width) were chosen for each site, except Greenwood met site best fit 11 sectors (where a couple of sectors exceeded 30 degrees).
- All sectors were assigned as airport or non-airport sectors consistent with recommendations as described EPA's AERMINUTE User Guide.
- For each met site, AERSURFACE was **run three times (for AVG, DRY, and WET scenarios)** with the following settings:
    - OPTIONS keyword: ZORAD
    - DEBUGOPT keywords: GRID and TIFF
    - CENTERLL keyword: latitude and longitude of the ASOS site
    - DATAFILE keyword: land cover, canopy, and impervious file names
    - ZORADIUS keyword: default 1.0 km radius
    - CLIMATE keyword: **AVG, DRY and WET scenarios** with "NOSNOW" and "NONARID"
    - FREQ_SECT keyword: MONTHLY for 12 sectors (except 11 for Greenwood) and VARYAP is set here
    - SECTOR keyword: sector number, sector starting and ending degrees, and AP or NONAP are specified
    - SEASON keyword: WINTERNS, SPRING, SUMMER, and AUTUMN are specified for all sites (dependent on location and local climatology)
- AERSURFACE output files and calculated surface characteristics were quality-assured to ensure that outputs were reasonable for the met site for use in AERMET.
- County-level precipitation data (NCDC, n.d.c) is used to define 30-year monthly precipitation averages as well as 30th and 70th percentiles within the climatological period (1981-2010) for determining monthly surface moisture (for Bowen ratio) for each month and met site to be processed through AERMET.
- The same county-level precipitation data from the 5 AERMET years were compared to climatological 30th and 70th percentiles to determine whether a month was average, dry, or wet.
- Precipitation data and AERSURFACE outputs were combined in an Excel spreadsheet that defined unique surface characteristics for each met site and each month, dependent on precipitation data.
- Monthly surface characteristic information for an entire year were used as input to AERMET.

6. AERMET Processing

BAQ configured AERMET to a single pairing of surface & upper air stations using the notes as provided below. Please refer to EPA's AERMET users guide for additional information about specific AERMET processing and settings (EPA, 2019). **Please note that BAQ processed the met files twice. One run used "Adj_UStar" (adjustment for calm wind hours) by setting the METHOD keyword**

"STABLEBL ADJ_U*" in AERMET stage 3. The other run did NOT include the ADJ_U* ("No_Adj_UStar") option in AERMET stage 3.

- Prepare input data (as described above).
    - A 5-year concatenated "ISHD" surface data file with at least day 1 of year 6 appended to the file (OR 5 individual years with day 1 of the following year appended to each file)
    - 5 individual year upper air sounding data files ("FSL" formatted data)
    - AERMINUTE data files (5 individual years)
    - Final monthly surface characteristics file (a set of albedo, Bowen ratio, and surface roughness for each month in the five-year period)
    - AERMET stage 1, 2, and 3 input files
- Prepare Stage 1 SURFACE Pathway Options.
    - DATA keyword: surface file name with file format "ISHD"
    - EXTRACT keyword: output file name with extracted data
    - XDATES keyword: "YY-1-1 to [YY+1]-1-1" (These are the days to extract. YY is the 2-digit AERMET processing year. Note that day 1 of the succeeding year is needed as input to handle NWS data in GMT that occurs on the last 5 EST hours of December 31st of the AERMET processing year. Thus, data is extracted from January 1, YY to January 1, [YY+1])
    - LOCATION keyword: Site ID, location, and elevation specifications for the specific ASOS location
        - Enter Site ID (5-digit WBAN number)
        - Enter Latitude (N) (in decimal degrees, rounded to the nearest thousandth place)
        - Enter Longitude (W) (in POSITIVE decimal degrees, rounded to the nearest thousandth place)
        - Conversion Time Adjustment (tadjust): 5 (for local standard time conversion)
        - Enter Elevation (m)
    - QAOUT keyword: output file name for data after Quality Assessment (QA)
    - AUDIT keyword: dry bulb temperature (TMPD), wind speed (WDIR), and wind direction (WSPD) variables are audited for QA
- Prepare Stage 1 input file UPPERAIR pathway options.
    - DATA keyword: upper air file name with file format "FSL"
    - EXTRACT keyword: output file name for extracted data
    - XDATES keyword: "YY-1-1 to [YY+1]-1-1" (same as SURFACE pathway, days to extract)
    - LOCATION keyword: enter site ID, location, and elevation specifications.
        - Enter upper air site ID: 5-digit WBAN number
        - Enter latitude (N) (in decimal degrees, round to the nearest hundredth place)
        - Enter longitude (W) (in POSITIVE decimal degrees, round to the nearest hundredths place)
    - Conversion time adjustment (tadjust): 5
    - QAOUT keyword: output file name for data after QA
- Prepare Stage 2 input file pathway options.

    - ASOS1MIN keyword (SURFACE pathway option): 1-minute wind file name for station and year being processed
    - QAOUT keywords: Extracted surface and upper air files from the EXTRACT files in stage 1 are input in SURFACE and UPPERAIR pathways
    - OUTPUT keyword: an output file name for the merged met data
    - XDATES keyword (Days to Merge): "YY-1-1 to [YY+1]-1-1" (same range as Stage 1 dates)
- Prepare Stage 3 METPREP input file pathway options.
    - DATA keyword: Stage 2 OUTPUT file (with final merged met data after QA)
    - METHOD keywords:
        - Randomize NWS wind directions (REFLEVEL SUBNWS)
        - Adjust ASOS wind speeds (WIND_DIR RANDOM)
        - Adjust Surface Friction Velocity: **BAQ processed this both ways 1) by setting "STABLEBL ADJ_U*" (Adj_UStar) and 2) not setting Adj_U* (no_Adj_UStar)**
        - Set option to substitute for missing cloud cover (SUB_CC)
        - Set option to substitute for missing temperature (SUB_TT)
    - NWS_HGT keyword: the anemometer height (AGL) for the met station
    - THRESH_1min keyword: set to 0.5 m/s (velocity is considered calm below this value)
    - OUTPUT keyword: output .SFC file
    - PROFILE keyword: output .PFL file
    - Default sounding selection used (AERMET defaults to using a 1-hour window before and after 12Z to locate a sounding to use.)
    - FREQ_SECT keyword: "Monthly" and the number of sectors (typically 12) for the unique set of surface characteristics (Note that 11 sectors were used for Greenwood, SC.)
    - SECTOR keyword: The start and end direction from AERSURFACE output is specified for each sector for the ASOS site (Sectors must match AERSURFACE output sectors.)
    - SITE_CHAR keyword: Albedo, Bowen ratio, and surface roughness for all 12 months and all 12 sectors (11 sectors for Greenwood) are entered. (Surface characteristics must match final output surface characteristics as described in the AERSURFACE section above.)
    - XDATES keyword (Days to Merge): "YY-1-1 to [YY+1]-1-1" (same range as Stage 1 dates)
- Run AERMET executable in three stages.
    - Run Stage 1 and check stage 1 output report file for the following:
        - Check for "AERMET Data Processing Finished Successfully"
        - Confirm settings are correct as described in stage input files
        - Check "VIOLATION SUMMARY" - % Accepted for TMPD, WDIR and WSPD were greater than 90%
        - Check for NO ERROR MESSAGES
        - Investigate warning messages and provide proper justification for proceeding
    - Run Stage 2 and check stage 2 output report file for the following:

        - Check for "AERMET Data Processing Finished Successfully "
        - Confirm settings are correct as described in stage input files
        - Check for NO ERROR MESSAGES
        - Investigate warning messages and provide proper justification for proceeding
    - Run Stage 3 and check stage 3 output report file for the following:
        - Check for "AERMET Data Processing Finished Successfully"
        - Confirm settings are correct as described in stage input files
        - Check for NO ERROR MESSAGES
        - Investigate warning messages and provide proper justification for proceeding
- Remove January 1 of YEAR+1 from the .SFC and .PFL files. (For example, January 1, 2016 data should be removed from the 2015 .SFC and .PFL files).
- After following the above procedure for 5 years of met data, concatenate the 5 separate years of met data into a single 5-year dataset.
- Ensure that AERMOD will run with the generated .SFC and .PFL files, and check the AERMOD output file to ensure that the met data meets 90% completion requirements (EPA, 2000).

7. AERMET Representative Analysis Per County

It is important that the meteorological data are representative of the project location being modeled. BAQ meteorologists examined all 46 counties in South Carolina to determine which of the 12 meteorological datasets compiled by AERMET would be most representative for South Carolina AERMOD modeling purposes. The state has been divided into 12 areas such that the meteorological station data assigned to each area is deemed by BAQ to be the most representative, in general, for AERMOD modeling purposes for that area and should be used as the default data for a given area. Please note that PSD applications (and facilities with local terrain that deviates significantly from terrain near the ASOS site) must address the suitability of the chosen meteorological data for the project site. For rare occasions where meteorological data from ASOS stations do not represent the project site, applicants should consult BAQ staff for further guidance.

The following criteria were considered for pairing all counties (or partial counties) in South Carolina with the most appropriate meteorological data:

- Proximity of surface meteorological site to the county
- Geographic features and elevation data
- Land use
- Soil type
- Wind roses (much of South Carolina exhibited similar wind regimes)
- Placement of facilities within the county (used to determine whether or not a county should be split into two parts, north and south)

8. References

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