UNITED STATE ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27111

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MEMORANDUM

SUBJECT: Release of AERMOD & AERMET Version 22112 and MMIF Version 4.0

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TO: EPA Regional Modeling Contacts

The United States Environmental Protection Agency (EPA), Office of Air Quality Planning and Standards (OAQPS) is releasing new versions (22112) of the AERMOD dispersion model and the AERMET preprocessor AERMOD, replacing AERMOD version 21112 and AERMET version 21112 as the regulatory versions of AERMOD and AERMET. Released concurrently with AERMOD and AERMET is MMIF 4.0 that replaces the draft version of MMIF 4.0 and MMIF 3.4.2.

This memorandum provides information on these updated programs, including the nature of the updates and the status of the releases regarding regulatory applications. A series of release presentations on AERMOD, AERMET, and MMIF will be provided during the first day of the upcoming Regional, State, and Local Dispersion Modelers' Workshop (https://www.epa.gov/scram/2022-regional-state-and-local-dispersion-modelers-workshop). If there are any questions about this new release of the AERMOD Modeling System or issue found with the updated model components, please send an email to Tillerson.Clint@epa.gov.

Background

In 2005, the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) was promulgated as the EPA's preferred near-field dispersion model for regulatory applications, replacing the Industrial Source Complex (ISC) model. There were a variety of regulatory formulation and related implementation updates to the AERMOD Modeling System in 2017. AERMOD was designed to accept more robust meteorological data, including multi-level profiles of wind, temperature, and turbulence to simulate the atmospheric boundary layer more accurately.

AERMET is the regulatory meteorological preprocessor for AERMOD and can process National Weather Service (NWS) surface data, NWS upper air data, site-specific data, i.e., data collected a at local representative meteorological station, and pre-processed prognostic meteorological data. AERMET processes the input meteorological data to calculate boundary layer parameters for input to the AERMOD model.

For more information regarding the regulatory application of the AERMOD Modeling System, please consult the *Guideline on Air Quality Models* (40 CFR Part 51, Appendix W).

AERMOD

Updates Included in AERMOD 22112

AERMOD 22112 is a routine release that does not include any scientific updates to the regulatory formulation of AERMOD as described in Appendix W. AERMOD 22112 replaces the regulatory version 21112. In summary, updates in AERMOD 22112 include bug fixes to the BUOYLINE and RLINE/RLINEXT source types and the urban option for all source types; new ALPHA and BETA options including new research grade options to further research in the areas of land-based building downwash, offshore platform downwash, NO2 conversion, and low wind conditions; and enhancements to RLINE/RLINEXT source types and NO2 conversion methods. Refer to the AERMOD user's guide for information on using the new options. A new Appendix B titled "Description of ALPHA and BETA Options in AERMOD 22112" has been added to the AERMOD formulation document with descriptions of the ALPHA and BETA options in AERMOD. Refer to the AERMOD Model Change Bulletin #16 for a complete list of changes in AERMOD 22112. The more substantial updates and new options of interest include the following:

- Correction to calculation of plume penetration factor for tall stacks in an urban environment.
- Correction to double counting the NO2 background concentrations when the PVMRM NOX-to-NO2 Tier 3 method is applied when modeling NO2.
- Correction to number of BUOYLINE sources. Originally limited to 10, corrected to have no limit.
- Correction to urban option for all source types and source-specific corrections BUOYLINE and RLINE/RLINEXT source types.
- Debug files added for BUOYLINE and RLINE/RLINEXT source types and urban option.
- Added meander to RLINE/RLINEXT source types.
- General speed improvements for RLINE/RLINEXT source types.
- Added RLINE/RLINEXT to FASTALL option.
- Removed ALPHA requirement for using the urban option with RLINE/RLINEXT and BUOYLINE source types. Note the use of the RLINE source type requires the BETA keyword and RLINEXT requires the ALPHA keyword.
- NOMINO3 option has been added that removes the nighttime, stable, minimum ozone restriction of 40 ppb (78 ug/m3) for NO2 conversion.
- The GRSM NO2 conversion method has been changed from ALPHA to BETA status.
- The TTRM2 NO2 conversion method has been added as a new ALPHA NO2 conversion technique. TTRM2 applies the existing TTRM method with one of ARM2, OLM, or PVMRM and will select the lowest NO2 concentration from TTRM and the other selected NO2 technique.
- Added platform downwash algorithm from the OCD model for offshore platforms as an ALPHA option. Platform downwash is enabled using the new keyword PLATFORM on SO pathway to input overwater platform dimensions. Platform downwash has been implemented for POINT, POINTHOR, and POINTCAP source types. Platform downwash does not utilize the PRIME downwash algorithm.
- Added experimental source type SWPOINT as an ALPHA option to facilitate further research of "sidewash" phenomena caused by building downwash. Sidewash occurs when wind is at an oblique angle to the long side of an elongated building. In this circumstance, there is a lateral shift of the cavity that forms on the lee side of the building. This a point type source with limited input and no buoyancy and does not utilize the PRIME building downwash algorithm.

- Added two ALPHA low wind options (FRANmin and PBAL) to the LOW_WIND keyword in the CO pathway. FRANmin is a user-specified minimum value for the meander factor within a range of 0.0 – 1.0 which overrides the default value of 0.0. PBAL is a secondary keyword to replace the default energy balance approach to determining plume meander with a momentum balance approach.

AERMET and MMIF

Purpose of the AERMET overhaul

AERMET is based on a set of Fortran programs and was developed from the pre-processors used for the Industrial Source Complex (ISC) model, such as MPRM. Those programs were developed in the 1980's when computing power was less than it is today. AERMET used a series of interim files to process the data between the three stages (Stage 1, data ingestion and QA, Stage 2, merger of the upper-air and surface data, and Stage 3, boundary layer calculations). Because of the use of these interim files and the coding practices in the current version of AERMET, some of AERMET capabilities are limited and code updates such as including new variables or data sources is an arduous process.

In 2018, EPA decided to "overhaul" the AERMET code. This overhaul included rewriting the AERMET code using updated Fortran coding practices as much as possible, removing the dependency of intermediate files in processing, and allowing for the capability to run all stages of AERMET in one AERMET run instead of three different AERMET runs, i.e., one for each stage. A draft version of the overhauled AERMET code was released in December 2021 as version 21DRF along with an accompanying draft version of MMIF 4.0. AERMET 22112 and MMIF 4.0 are updated versions of AERMET 21DRF and Draft MMIF 4.0. Updates to the draft version based on user feedback during the December 2021-February 2022 informal public comment period.

Updates Included in AERMET 22112 relative to previous versions of AERMET

Section 1.4 of the AERMET 22112 user's guide explains many of the differences between AERMET 22112 and the latest regulatory version of AERMET 21112, including differences in control file setup and other differences users may see when comparing output from AERMET 22112 and 21112. The user is referred to Section 1.4 of the draft user's guide for more details but some of the differences are highlighted below:

- AERMET has been recoded into modules and uses internal arrays instead of temporary files to store data. For a description of the modules and subroutines in AERMET see Appendix E of the draft AERMET user's guide.
- AERMET now is composed of two stages instead of three stages. The first stage is unchanged, data ingestion and QA of NWS upper air data, NWS surface data, site-specific, or prognostic data. The merge stage, stage 2, has been eliminated. The old stage 3, the boundary layer calculations, is now stage 2. Throughout the rest of this memorandum, stage 2 refers to the boundary layer calculations stage
- AERMET 22112 can now run both stage 1 and stage 2 in a single AERMET run. Previously, users had to run each stage in a separate AERMET run. Users now have the choice to run each stage separately as before, or in a single run. See Section 1.4.1 of the draft AERMET user's guide for more details on how to setup the AERMET control files to run both stages in one AERMET run. With this change, the MERGE pathway and keywords from the old stage 2 as well as the DATA keyword with the METPREP keyword are now obsolete. AERMET will ignore the MERGE pathway and keywords as well as the DATA keyword in the METPREP pathway. The user will receive a warning that the keywords are obsolete. This allows the user to use older AERMET control files with little change.
- A new pathway, PROG for prognostic meteorological data, has been created. This pathway is analogous to the ONSITE pathway and allows AERMET to recognize the data is prognostic in nature. This pathway also allows for the special processing of overwater prognostic data (more below).
    - Prognostic data can be designated as overland or overwater with the PROG data keyword. This designation aids AERMET in determining which prognostic variables to process from the MMIF generated data file
    - In conjunction with the new PROG pathway, AERMET has additional ONSITE or PROG variables that can be used for overwater applications. See more details below.
- When inputting the processing dates via the XDATES keyword, the user must now input the years as 4-digit years.
- AERMET retains the original case of input and output filenames from the control file. This makes the code more portable across operating systems
- The EXTRACT and QAOUT files have different formats than previous versions of AERMET. The ONSITE and PROG QAOUT file now has a consistent format regardless of the input data. Previously, the ONSITE QAOUT file followed the format of the raw input data file.

- 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 due to age of the format.
- 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.
- 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-August. This feature allows the user to enter seasonal characteristics that represent the season for the hemisphere. That is, 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.
- 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 interpolation. 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.
- For applications involving site-specific or prognostic mixing heights, AERMET 22112 smooths the mixing height based on the previous hour's mixing height in similar fashion as 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, 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 output, 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.

New PROG pathway and overwater applications

As noted above, AERMET now has a new PROG pathway to process prognostic data output from the Mesoscale Model Interface (MMIF). MMIF creates AERMET ready inputs from prognostic data. A draft version of MMIF, version 4.0, was released in conjunction with AERMET 21DRF for public review and comment. MMIF, version 4.0, has been updated since December 2021 to include bug fixes reported by the public and format changes to output variables to AERMET. As with the draft 4.0 version of MMIF, MMIF 4.0 processes the prognostic data and outputs new variables that can be used for overwater applications involving AERMOD. These new variables include sensible heat flux, hourly varying surface roughness, Monin-Obukhov length, cloud cover, surface friction velocity (u*), convective velocity scale (w*), potential temperature lapse rate and others. The original variables output by MMIF (winds, insolation, mixing heights, etc.) are still output by MMIF. The new variables are output from MMIF for either overland or overwater applications. When processing an overland site, these new variables are not used from the input data and are calculated by AERMET in the same manner as when using NWS data or site-specific data. For overwater applications, these variables are used and passed through AERMET for input to AERMOD. The reasoning for this new approach is that EPA feels that calculations of variables such as Monin-Obukhov length, w*, and potential temperature lapse rate are more representative of overwater conditions, more so than what would be calculated from AERMET, which is more appropriate for land-based applications. More information about the overwater variables can be found in Section 3.5.1 of the AERMET user's guide.

Use of AERMET 22112 and MMIF 4.0

At this time, AERMET 22112 and MMIF 4.0 replace AERMET 21112 for all regulatory applications and MMIF 3.4.2 for regulatory applications involving prognostic meteorological data.