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For Discussion Purposes
Regional Meteorological Data Processing Protocol
EPA Region 5 and States
May 6, 2011

Purpose: The purpose of this protocol is to recommend a methodology that can be used by Region 5 States to process National Weather Service meteorological data for use in AERMOD regulatory modeling applications. This document highlights several aspects of meteorological data processing including: choice of surface met data, choice of upper air met data, approach for processing surface characteristics, and thoughts on representativeness.

This protocol is the result of numerous discussions held between EPA and the States. It is based on guidance available in the "Guideline on Air Quality Models", 40 CFR Part 51, Appendix W (Guideline). It also relies on the information in the AERMOD Implementation Guide, dated March 19, 2009 and User Guides for AERSURFACE, AERMET, and AERMINUTE. Other references are highlighted in the text of the document.

Contents:

I. Background

Over the past 20 years, meteorological (met) data processing has changed significantly. For most of the 1990's and early 2000's, Region 5 States used ISCST3 and the processed met data available from the Support Center for Regulatory Modeling, typically using a 5-year period from 1984-1992. This data was acquired from the National Climatic Data Center (NCDC) and, for the most part, filled by EPA and ready to use in ISCST3.

As AERMOD replaced ISCST3 as the recommended regulatory modeling tool, new met processing procedures were implemented[1]. Namely, surface characteristics (i.e., surface roughness, Bowen ratio, and albedo) are used in the AERMOD preprocessor, AERMET. This information is used in AERMOD to determine the profiles of winds, temperature, and turbulence. The release of AERSURFACE (ASF) and the ASF methodology has provided a consistent, technically sound approach for determining appropriate surface characteristic values.

For many years, States have provided processed met data to applicants for use in regulatory applications. The approaches used to process the met data through AERMET have often varied from state to state. This document lays out a methodology that allows Region 5 states to develop processed met data in a consistent manner.

II. Surface Data

A. Time Period and Format:

It is getting harder to justify the use of 20-25 year old met data. Issues such as urban sprawl, and even climate change, can impact the representativeness of older data. Additionally, the general public is increasingly questioning why old meteorological data are driving our air quality decisions. Very recent Integrated Surface Database (ISD) data data is available from NCDC in standard hourly format and in 1-minute average format.

Recommendation: SCRAM data should be replaced. As the Guideline states, at least 5 consecutive years of recent, readily available, adequately representative data should be utilized (e.g., 2000 or later) Free full-archive standard ASOS data is available for those with a .gov, .edu, .mil, .us, or k12 domain extension at ftp://ftp3.ncdc.noaa.gov/pub/data/noaa/ . One-minute ASOS data (DSI-6405) is available for free at ftp://ftp.ncdc.noaa.gov/pub/data/asos-onemin/ . The purpose of the 1-minute met data is discussed in the next section.

B. Missing data and calms

The SCRAM met was provided with missing data filled in for the vast majority of stations. This was necessary because ISCST3 required a 100% complete met data set when run in the regulatory default mode. While valid data retrieval requirements must

[1] Federal Register, Volume 70, Page 68216

still be met,[2] AERMOD does not require missing data to be filled. The EPA guidance document, Missing Data Procedures for Substituting Values for Missing NWS Meteorological Data for Use in Regulatory Air Quality Models, Dated July 7, 1992, provides a technique for filling in missing data. This approach uses either interpolation for short time frames (a few hours) or substitution from another met data set determined to be reasonably representative, through examination of information such as wind roses, terrain, and surface characteristics. The substitution procedure was primarily applicable to National Weather Service (NWS) data sets.

Beginning in the 1990's NWS surface data has been collected using the Automated Surface Observation System (ASOS) method combined with the Meteorological Terminal Aviation Routine (METAR) reporting system. The new reporting system has resulted in an increased number of calm and missing hours.

Met data consisting of 2-minute averaged wind information, rolled every minute, is available on the NCDC website at http://www.ncdc.noaa.gov/oa/climate/climatedata.html#asosminutedata. This data is available for most NWS stations and can be used to generate 5-year met data sets that contain significantly fewer calm and missing hours compared to standard ASOS data. A methodology for processing the 1-minute data has been developed by the Office of Air Quality Planning and Standards (OAQPS). A new tool called AERMINUTE can be applied to the 1-minute data to generate hourly averaged wind data. A new version of AERMET has been released that can incorporate the AERMINUTE output file. In addition to addressing the calm and missing hour issue, the met data files generated using the 1-minute wind data can improve the representativeness of airport data by providing hourly averages.

Recommendation: One-minute met data should be used for regulatory modeling applications. The recently released met processing tools, AERMINUTE and AERMET, are available to process the raw met data. (See AERMET User's Guide Addendum for information on input changes). AERMET will process 1-minute data to produce the surface met data file for use in AERMOD. Standard ASOS data should be included using the SURFDATA keyword in the AERMINUTE control file. The Quality Control tools available in AERMINUTE should be used to examine the usefulness of flagged data and to validate against quality controlled data from the standard observations.

[2] Meteorological Monitoring Guidance for Regulatory Modeling Applications. 2000, EPA-454-/R-99-005.

III. Upper Air Data

A. Time Period Recommendation: Use time period concurrent with surface data.

B. Format Recommendation: Upper Air data is available for free from http://esrl.noaa.gov/raobs/. Users should select: Hours of access -- All times; Data levels – All levels; Wind units – tenths of meters/second.

C. Missing data recommendation: As with surface data, filling upper air missing data is not required. If upper air data is to be filled, consult the Regional Office before developing an approach.

IV. Surface Characteristics

A. AERSURFACE (ASF)

1. Methodology

As mentioned above, ASF is an EPA tool which implements a recommended methodology for processing surface characteristics. The ASF User's Guide, combined with the AERMOD Implementation Guide, provides substantial information on how to implement AERSURFACE. This protocol will address some decision points not explicitly outlined in the Guides. The information in this document will apply to those using ASF as well as those using other spatial tools such as Geographic Information Systems (GIS).

a. Land cover data

National Land Cover Database (NLCD) data is available from the USGS Land Cover Institute website: http://seamless.usgs.gov, select Seamless Viewer. ASF is currently designed to read the 1992 Land Cover categories. A draft version of ASF which can read 2001 land cover data has been developed but has not yet been released for general use. Additionally, some concerns about the 2001 data categories have emerged, so use of 2001 land cover data is not generally recommended.

Recommendation: For the state supplied met data, examine the temporal representativeness of the 1992 land cover data for use in ASF. If land use has not changed significantly at the met tower site, and/or the source site, between 1992 and 2001, 1992 data should be used. If 1992 NLCD is not representative for a particular application, contact the EPA Region 5 Office to discuss possible processing using the draft ASF tool for 2001 NLCD. Any alternative approach to determining surface roughness, Bowen ratio and albedo values should be discussed, justified, and documented prior to use.

NLCD can be downloaded in two formats: complete state files at http://landcover.usgs.gov/natllandcover.php **or seamless data at** http://seamless.usgs.gov **which covers a user defined geographic area. Either format is acceptable. Seamless data is preferable for sites near state boundaries because it will provide complete coverage on both sides of the state line.**

For most areas, 1/3rd arc-second (about 10m) should be adequate resolution for areas in Region 5. In areas with flat terrain, 1 arc-second (about 30m) data may be adequate. In other, areas with severe terrain influences, 1/9th arc-second data may also be used.

b. Met Tower Location

The ASF program asks the user "Is this site at an airport?" The answer impacts how ASF will apply the Commercial/Industrial/Transportation category. If the site is at an airport, 95% of the land cover is considered to be "transportation" and 5% "commercial/industrial". For sites not considered to be at an airport, 20% of the land cover is "transportation" and 80% is "commercial/industrial". The answer to this question may not be obvious for some tower locations.

Recommendation: While there may be some cases where the tower location would not be correctly represented by the "airport" land use described above, in general, if the tower is located on airport property, the answer to the question above should be "yes". Tower location can be reported either as UTM or LAT/LON coordinates. If using LAT/LON, the data should be reported to at least the ten-thousandth digit (e.g., 39.8453, -89.9675). The reported met tower location should always be verified.

c. Seasonal Definitions

Snow Cover: ASF defines seasons by asking whether the area experiences continuous snow cover, either for at least one month or for most of the winter. Because snow cover inhibits the amount of convection in the atmosphere, ASF users should caution not to overestimate the amount of snow cover assumed in the model.

Recommendation: Local climatological data (LCD) reports can help determine an answer to this question for specific seasons and months. They are available free for .gov, .edu, .mil, .k12 domains online at http://cdo.ncdc.noaa.gov/qclcd/QCLCD. Daily snow/ice cover totals are reported. For months with days with snow cover (trace or more), ASF should be run twice; once with continuous snowcover and once without snowcover. The values are then weighted based on the snow cover days / no snow cover days ratio. The application can be processed on a seasonal or monthly basis. An example below shows the calculation for an albedo monthly application, which may be the most common approach. The following approach should be used for Bowen ratio and surface roughness also. The five-year period of meteorological data should be examined when answering this question.

Example: For calendar year 2006 at station XY, the following information is gathered from LCD reports;

January - 10 days with trace or more of snow cover

Number of days in January - 31

Two separate ASF runs provide the following albedo information

Run without continuous snow cover - 0.15
Run with continuous snow cover - 0.33

To determine the value to be included in AERMET Stage 3 for January albedo values use:

$$\frac{(21 * (0.15) + 10 * (0.33))}{31} = 0.21$$

Where 21 is the number of days without snow cover, 10 is the number of days with snow cover,.

d. Arid Region/Surface Moisture

ASF will prompt the user to answer the question "Is this site in an arid region?" If continuous snow cover is assumed for the area, this question will not be asked. Region 5 does not have arid regions so ASF will ask the user to characterize the surface moisture conditions at the site relative to climatological normals. The moisture conditions impact the Bowen ratio value generated by ASF. Bowen ratio, which is the ratio of sensible heat to latent heat, can enhance or inhibit convective conditions in the atmosphere. Wet conditions will result in a lower Bowen ratio, which will dampen the convective conditions in AERMOD. Similar to the snow cover recommendation discussed on page 5, users should caution not to overestimate wet conditions for use in ASF.

Recommendation: Start with the default assumption that moisture conditions are average. If the precipitation information and/or soil moisture data indicate an exceptionally "dry" or "wet" year, that year should be processed as wet or dry in ASF. There is considerable discretion in categorizing the moisture conditions for an area.

Useful information can be found in the ASF User's Guide, which recommends surface moisture condition can be determined by comparing precipitation for the period of data to be processed to the 30-year climate record, selecting "wet" conditions if precipitation is in the upper 30th-percentile, "dry" conditions if precipitation is in the lower 30th-percentile, and "average" conditions if precipitation is in the middle 40th-percentile. The 5-year period precipitation,

judged on a year-to-year annual basis, should be examined and compared to the area climate record. The LCD reports can help answer this question.

Additionally, thirty-year monthly and yearly climate data on soil moisture can also provide useful information. For example, the website http://www.cpc.ncep.noaa.gov/soilmst/w.shtml is a National Weather Service product which contains climatological soil moisture normals on a monthly basis that can be compared to specific monthly values. Drought index archive maps are available from http://www.cpc.ncep.noaa.gov/products/monitoring_and_data/drought.shtml

e. Domain Issues

The ASF methodology uses a 1 km default domain for determining surface roughness values around the tower location. (A beta version of ASF has been developed that bases the radius for determining surface roughness on internal boundary layer considerations. This tool has not yet been released.) As the ASF User's Guide notes, significant discrepancies have been identified between station coordinates reported by NCDC and the actual location of the met tower for NWS sites. It is important to verify coordinates of the met towers. The default domain for Bowen ratio and albedo used in the ASF methodology is a 10km by 10km box centered on the tower site.

The surface roughness domain can be subdivided into at most 12 sectors (i.e., 30 degrees each). For many areas, fewer sectors may suffice depending on the homogeneity of the 1km area surrounding the tower. Other factors such as nearby water bodies, can influence the number and orientation of the sectors.

Recommendation: A site specific evaluation should be conducted to determine the most appropriate number of sectors and their orientation. As a default, the 1 km domain with twelve 30 degree sectors may often be adequate for the surface roughness domain. Twelve sectors may be more than needed for many NWS tower sites but it should ensure that any variation that does exist with land cover data will be accounted for. If the site encompasses a distinct land use variation, such as a coastline, additional guidance on buffer zone recommendations is available in the AERMET User's Guide.

The 10km by 10km albedo and Bowen ratio domain should be centered on the tower location for most applications. If an application site is used as the center of the 10km by 10km domain, the rationale should be documented and justified.

AERSURFACE output should be examined and compared to aerial photos, or other information, to determine if the results are reasonable representative.

V. Representativeness

Many Region 5 states have opted to provide pre-processed met data for use in regulatory AERMOD modeling. While this provides a useful service to applicants, and to a large degree, simplifies the review process for the reviewing authority, it is important to emphasize the need to ensure representativeness of the pre-processed data when being used in AERMOD. For most areas in the Midwest, terrain influences are minor and historically, the nearest NWS site has been determined to be the best representative station available. Because surface characteristics can vary significantly even within areas of similar terrain, it's important to examine whether the surface characteristics of the source are reasonably consistent with the surface characteristics of the met site. Surface stations located further away from a source, or even in a neighboring state, may be more representative than the nearest NWS station. This can also be true for upper air data sites. The AERMET stage 3 input files could be reviewed along with the processed met data to provide a way to compare sites. The ASF tool, along with publicly available data viewers, as described in the ASF Users Guide, will be useful as checks against how representative the met site is for various source applications.

Recommendation: Recommendations on met data to be used for specific geographic areas need to include caveats explaining that the nearest met station, both surface and upper air, may not always be the most representative met station site.