Air Dispersion Modeling Team Initiative to Update Meteorological Data

Update – October 2013

In 2012, the Texas Commission on Environmental Quality (TCEQ) Air Dispersion Modeling Team (ADMT) completed the update of pre-processed meteorological data for the state of Texas in response to revisions made to the Environmental Protection Agency's (EPA) AERMET program. In 2011, the EPA revised AERMET to include the AERMINUTE processor in the second stage of AERMET processing (EPA, 2011). The AERMINUTE processor is used to calculate hourly average winds from one-minute Automated Surface Observing Systems (ASOS) winds. The inclusion of AERMINUTE had the desired effect of significantly increasing the data retrieval rate for ASOS wind data. However, this led to an increase in the frequency of lower wind speeds when compared to standard observations only. As EPA notes (EPA, 2013), concerns have arisen about the use of National Weather Service (NWS) data, specifically the use of low wind speeds (< 1 m/s) in AERMOD associated with application of the AERMINUTE tool (EPA, 2011). EPA addressed the concerns in December 2012 by including a wind speed threshold option to treat winds below the threshold as calms. The recommended value for the threshold is 0.5 m/s, which is based on the upper bound of the recommended starting speed for anemometers as listed in Table 5-2 of Section 5.2 of the meteorological monitoring guidance [EPA, 2000] (EPA, 2013). As a result of the wind speed threshold option, the ADMT updated the current pre-processed meteorological data for the state of Texas to include the 0.5 m/s wind speed threshold. The methodology and rationale for selecting and processing the meteorological data is the same as the 2012 update, except the years of meteorological data processed represent 20o7-2012, instead of 2005-2010. The methodology and rationale for the pre-processed meteorological data files are described below.

Introduction

The AERMOD System is the United States EPA preferred modeling system for the New Source Review (NSR) Prevention of Significant Deterioration (PSD) and Minor Source permitting programs. AERMET is a program that processes meteorological data for AERMOD (EPA, 2004). AERMET accepts upper air sounding and surface station meteorological raw input data along with generalized surface characteristics and merges them into a format that AERMOD can read. The TCEQ ADMT previously developed meteorological datasets using data obtained in the 1980s and 1990s from a limited number of locations in Texas. With the release of new versions of AERMOD and AERMET, the ADMT began an initiative to streamline the modeling process by updating and expanding the number of meteorological datasets used in the NSR permitting process.

Recently, EPA revised AERMET to take one-minute ASOS wind data processed through the AERMINUTE processor and use it in the second stage of AERMET processing (EPA, 2011). As a result of this change to the program, the ADMT began updating the pre-processed meteorological data for the state to provide a consistent set of meteorological data and to streamline the modeling audit review process. The goal was to select weather station data and surface characteristics that would be representative for each of Texas' 254 counties. The ADMT process used to update and expand the meteorological data sets is described in this paper. The process involved meteorological station selection, determination of surface characteristics (annual average Bowen ratio, noon-time albedo, and surface roughness length), incorporation of station information to generate and run an AERMET input file, and running AERMOD to determine completeness of each year and dataset.

Meteorological Station Selection

AERMET is a meteorological data preprocessor for AERMOD. AERMET processes commercially available or custom on-site meteorological data. Since custom on-site meteorological data is not common, the ADMT uses NWS meteorological data from weather stations, typically located at airports. The two types of weather data required for the AERMET program are surface and upper air data. It is important that the NWS data are representative of a location being modeled. Representative in this case means similar meteorological conditions, topography, and surface characteristics. Because of the lack of surface and upper air stations in each county, a surface and upper air station was chosen to represent each county. The following criteria were used to determine which stations' characteristics best represent a county's characteristics:

- Proximity
- Average temperature range
- Average elevation range
- Average precipitation
- Number of days in a growing season
- Type of terrain
- Climatology Classification Maps

After all the surface and upper air stations were selected, staff determined basic station information, such as elevation, latitude, longitude, and Coordinated Universal Time (UTC) time conversion. Then, staff downloaded the relevant raw upper air and surface meteorological data for the years 2007-2012. The meteorological data used for regulatory modeling analyses must be 90 percent complete (EPA, 2000). An additional year of meteorological data was downloaded to account for possible missing data in case any of the other years did not meet the 90 percent completeness criteria requirement. One item of note regarding this analysis: several surface stations were relocated in 2008 to a different latitude and/or longitude. The greatest distance that one moved was approximately 1630 meters. These moves would not affect how these stations were used to develop the meteorological datasets. Staff marked these stations and combined the two 2008 surface files to avoid runtime errors in future processing. All of this information was stored in a Microsoft Office Access database to use as a reference in order to generate AERMET input files.

Determination of Surface Characteristics

Bowen ratio, albedo, and surface roughness length are the surface characteristics used by AERMET for site-specific information. The Bowen ratio is the ratio of the sensible heat flux to the latent heat flux. It is an indicator of surface moisture and, together with the albedo and other meteorological observations, is used to determine the planetary boundary layer parameters for convective conditions driven by the surface sensible heat flux. The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. The surface roughness length is related to the height of obstacles to the wind flow. It influences the surface shear stress and is an important factor in determining the magnitude of mechanical turbulence and the stability of the boundary layer.

Bowen Ratio

The ADMT obtained a map of mean annual Bowen ratio values from Spatial Water Balance of Texas, a publication from the University of Texas at Austin Center for Research in Water Resources. The map was imported into Geographic Information System (GIS) software as a *raster* dataset. A raster consists of a matrix of cells (or pixels) organized into a grid where each cell contains a value representing information, such as heat flux ratios.

Bowen ratio values are depicted on the map via shading, which ranges from white (low Bowen ratio values) to black (high Bowen ratio values). Each shade represents a different range of Bowen ratio values. The midpoint of the Bowen ratio value range for each shade was selected as the Bowen ratio value for all rasters that consisted of that shade. For example, the white shade on the map represents Bowen ratio values ranging from 0.24 to 0.5. The midpoint of the range, 0.37, was assigned as the Bowen ratio value for all white raster pixels. Staff overlaid the raster dataset with a Texas county map, and calculated average Bowen ratio values for each county using raster tools within the GIS software.

Albedo

Vegetation classifications from the Vegetation/Cover Types of Texas map, dated 2000, were used to determine albedo values for processing with AERMET. The Bureau of Economic Geology of The University of Texas at Austin developed the map. There are 11 regions and 53 vegetation/cover types in Texas depicted on this map. As discussed below, the 53 vegetation types were generalized to fit into the 8 categories outlined in Table 4-1 *Albedo of Ground Covers by Land-Use and Season* in the User's Guide for the AERMOD Meteorological Preprocessor (AERMET) (EPA, 2004).

Staff researched each region description and picture of the 53 vegetation types were researched on the Texas Parks and Wildlife website (http://www.tpwd.state.tx.us/publications/pwdpubs/pwd_bn_w7000_0120/). Then staff generalized the vegetation classifications based on Vegetation/Cover Types of Texas map as follows:

- The vegetation type labeled *grassland* was usually generalized as grassland. The vegetation type labeled *Tobosa - Black Grama Grassland* was generalized as desert shrub. This generalization is more appropriate given that the vegetation type is located in far west Texas, an area best characterized as an arid region.
- The vegetation type labeled *brush* was usually generalized as grassland if it was described as densely packed and green in color. The vegetation types labeled *Ceniza - Blackbrush - Creosotebush Brush* and *Mesquite - Blackbrush Brush* were generalized as desert shrub. These generalizations are appropriate given that Creosotebush Brush is located on the slopes of the Rio Grande River Basin (from Val Verde to Zapata Counties) and Blackbrush Brush is located on the South Texas Plains; these areas are best characterized as arid regions.
- The vegetation type labeled *shrub* was generalized as desert shrub, if located in hot, arid regions.
- Vegetation types labeled *woods*, *forest*, or *parks* were generalized as either deciduous forest or coniferous forest.
  - The main tree in each vegetation/cover type was researched to determine if it was coniferous or deciduous. Live Oak and Gray Oak are deciduous trees, but are evergreen. They were generalized as coniferous because they maintain leaves throughout year.
- The vegetation type labeled *crops* was generalized into cultivated land.
- Vegetation types labeled *barrier island* and *swamp* were generalized into swamp.
- The vegetation type labeled *urban* was generalized into urban.

Staff imported the electronic version of the Vegetation/Cover Types of Texas map into GIS software as a feature class. The features (representing the 53 vegetation/cover types) were generalized as described above. The generalized feature class was converted into a raster dataset. Then staff overlaid the raster dataset with a Texas county map and calculated average albedo values for each county using raster tools within the GIS software. Note that albedo values were rounded to four decimal places before being input into AERMET since it does not allow an albedo value with more than four decimal places.

Surface Roughness Length

Staff developed three meteorological datasets for each county representing three categories of surface roughness: low, medium, and high. The low surface roughness category represents surface roughness length values ranging from 0.001 meters to 0.1 meters. Staff input a roughness length value of 0.05 meters into AERMET to develop the low roughness meteorological dataset. The medium surface roughness category represents surface roughness length values ranging from 0.1 to 0.7 meters. Staff input a roughness length value of 0.5 meters into AERMET to develop the medium roughness meteorological dataset. The high surface roughness category represents surface roughness length values ranging from 0.7 to 1.5 meters. Staff input a roughness length value of 1.0 meters into AERMET to develop the high roughness meteorological data.

Generating and Running an AERMET Input File

Running AERMINUTE

The ADMT created AERMINUTE input files according to the proper format (EPA, 2010). For several surface stations, staff had to determine the ice-free winds (IFW) installation dates (NWS, 2007). Other necessary information that was included in the AERMINUTE input file was the year of meteorological data in question (2007 to 2012), the one-minute raw wind data input file names for the corresponding year, the raw hourly surface data input file name for that year, and output file names for the hourly averaged winds, number of minutes for each hour, and the observations. Once the information was in the AERMINUTE input file, it was run using the AERMINUTE executable program. The processed data are used in the AERMET input file.

Creating and Running AERMET Input Files

To begin, staff selected the run type, method of entering site characteristics, type of information used, and relevant year. Next, staff provided background information on the surface and upper air station used including location and type of raw data, site identification number, latitude and longitude, time adjustment, and elevation (for surface station only). Then, staff selected the output file from the AERMINUTE run containing the hourly averaged winds for the AERMET input file. Next, staff named the output files, entered the albedo and bowen ratios for the specific county dataset, and surface roughness value for the low, medium, or high category (low = .05, medium = .5, and high = 1). After all relevant information had been selected or entered, the AERMET input file was run. A surface (*.sfc) and profile (*.pfl) file is generated with each run; these files are used in AERMOD to identify meteorological data.

Running AERMOD to Determine Completeness

Staff conducted a data quality evaluation using AERMOD to assess the completeness of the processed meteorological datasets. The EPA's threshold for completeness is 90 percent. This means that meteorological datasets cannot contain more than 10 percent of missing data. For simplicity, staff used a single, generic point source, the flat terrain option, and one receptor to predict a 1-hour concentration.

The parameters for the point source follow:

- Emission Rate = 1 gram per second
- Stack Height = 10 meter
- Stack Temperature = 1273 Kelvin
- Stack Diameter = 1 meter
- Exit Velocity = 20 meters per second

Since there are only 51 surface stations and 7 upper air stations, several of the 254 counties within Texas have the same surface station and upper air station combinations. Therefore, staff chose only one county to represent a particular surface station and upper air station combination until they evaluated all combinations. Then, staff created a spreadsheet that contained the surface station (SFC) and upper air station (UA) combinations and calendar years, the completeness percentage for each combination by calendar year, and which county was used to represent each combination in the evaluation.

Summary

The ADMT began an initiative to streamline the modeling process by updating and expanding the number of meteorological datasets used in the NSR permitting process.

Staff developed 68 meteorological datasets that are representative for each of Texas' 254 counties. Since the ADMT developed pre-processed datasets, applicants only need to justify the appropriateness of the dataset and associated surface characteristics for their site.

The result of ADMT's initiative provided applicants and agency staff with a consistent set of meteorological data and streamlined the modeling and the modeling audit review process. This effort should keep permitting projects on track and help the Air Permits Division meet permit timeframe goals.

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