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AQcast: AERMOD User's Guide

Revision 3.0

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1. Introduction

AQcast: AERMOD's user interface (UI) allows novice and experienced users to more easily set parameters for an AERMOD model run. Behind the scenes, it utilizes all the EPA approved pre-processors with the most up-to-date regulatory approved options. Using the UI, the user inputs necessary project information then hits the "*Submit*" button at the bottom of the UI. Then all programs shown in Figure 1 are sent to an Amazon Web Services (AWS) queue for processing. The *Results* tab of the UI shows what parameters were submitted to the model run as well as the status of the run (i.e. SUCCESSFUL, FAILED, or RUNNING). An email is sent to the user once the run is completed and successful and a short summary and some vital plots are shown on the *Results* tab. A link will appear on the *Results* tab to download a compressed file of all essential modeling input, intermediate, and output files.

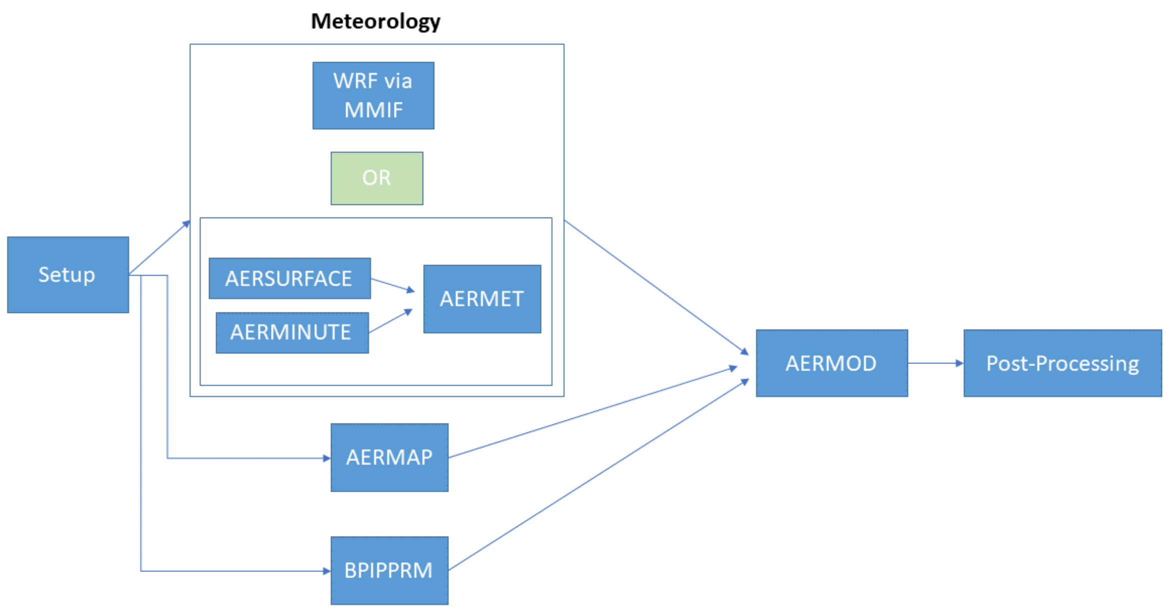

Figure 1. AQcast: AERMOD system flow chart

2. Maps

Contained in the UI are two maps where the user can input model parameters. The first map (example shown in Figure 2) in the UI is where the user can draw or upload files of their fence line and another for their building locations. A fence line (or property line) can be added and AQcast: AERMOD will remove all nested receptors within it. It will also create receptor points along the fence line at 25-meter intervals and include those receptor points in running AERMAP. (See Section 3b: Pre-Processors – AERMAP). Buildings can also be drawn or uploaded as compressed shapefiles. A default height of 3 meters is given to each building but can be edited by the user by clicking on each building. Clicking *Submit* also saves these inputs for later use in a future run via a drop-down-menu on the UI shown in Figure 2. These respective files are saved with the project description in their name. (See Section 7 for upload limitations).

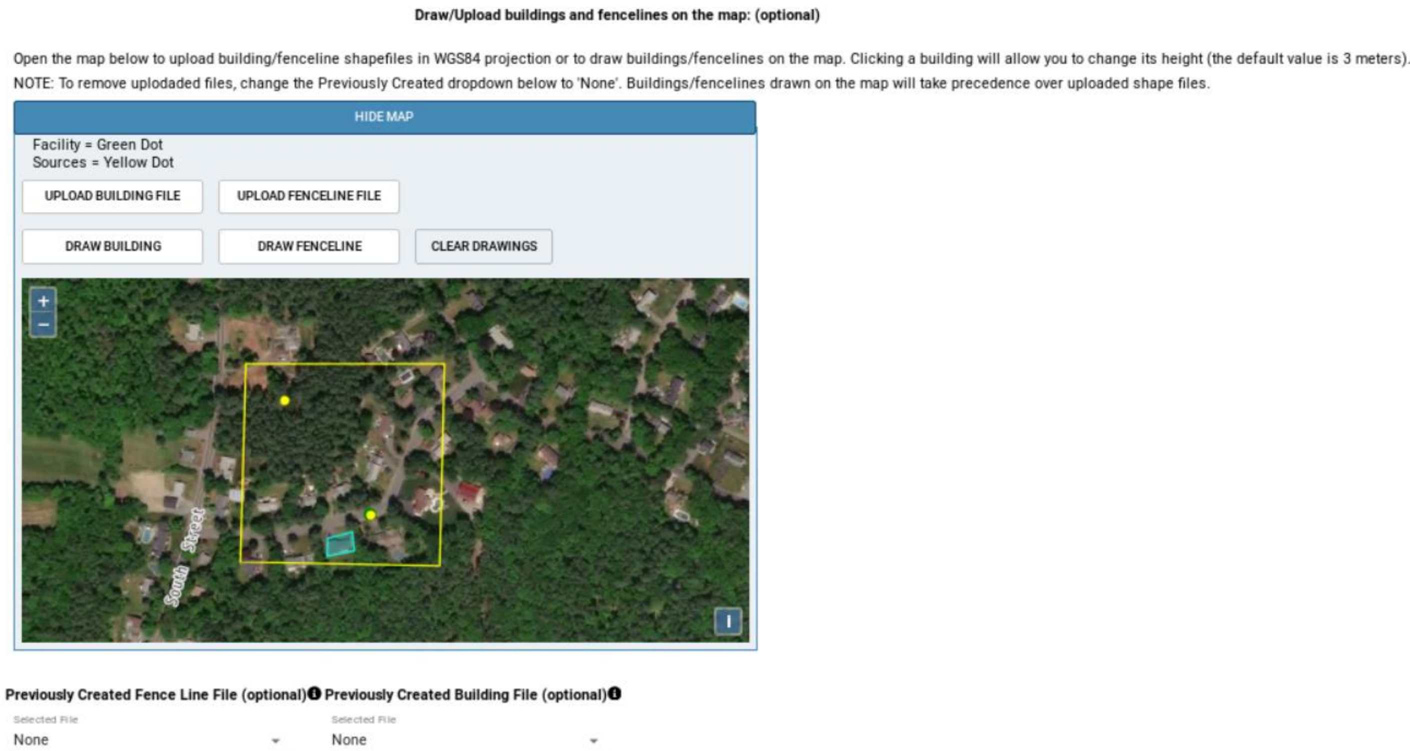

Figure 2. AQcast: AERMOD UI screenshot of fence line and building location interface.

The second map (example shown in Figure 3) in the UI is used for selecting the surface and upper air stations for processing in AERMET. Clicking the *Find Closest Meteorological Sites* button will search the NOAA station list for the five closest surface sites to the facility, with recent data including Automated Surface Observing System (ASOS) one-minute data and the five closest upper air sounding stations. See Section 3c: Pre-Processors - AERMET for more information on meteorology processing. The sites found will be shown on the map and are selectable by the user. When a previous project has been selected to load, click the “Find Closest Meteorological Sites” button and the NWS stations used in the previous project will be selected if MMIF or onsite options were not chosen. (Note: This option (NWS Meteorology) is not required. Alternatively, stored Weather, Research and Forecasting model (WRF) output, processed using the Mesoscale Model Interface (MMIF), can be used when it is available as well as state provided AERMET files. See Section 7: Meteorology Options for more information.)

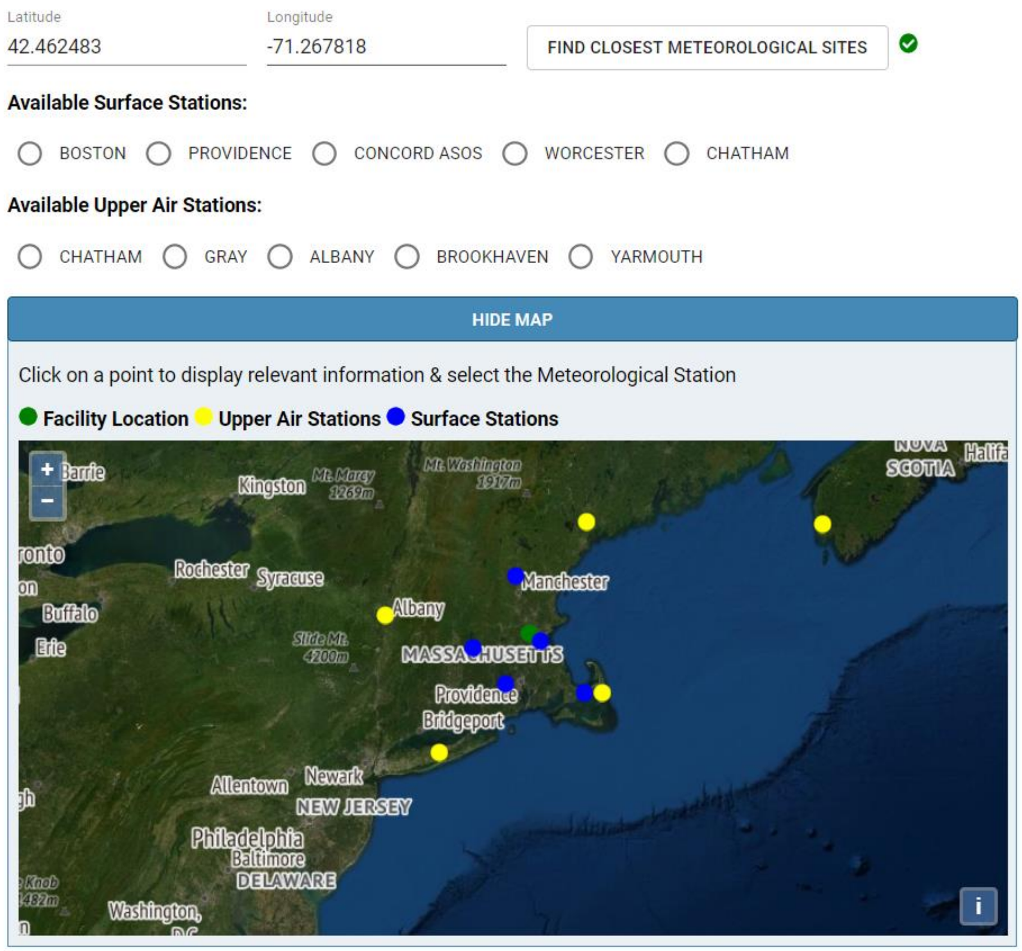

Figure 3. AQcast: AERMOD UI screen shot of five closest surface and upper air stations to the facility.

3. Pre-processors

a. AERMINUTE

AERMINUTE is used to provide more frequent wind observations to the surface data. Stations with ASOS one-minute data are used and processed by AERMINUTE. The Ice Free Winds (IFW) group installation date is updated as well. (See Appendix B for data source.)

b. AERMAP

AERMAP is used to include a list of surface receptor locations for which to calculate concentrations over the modeling period. The UI provides the option for three separate nested grids surrounding the facility. The first gridded nest has 50 meter horizontal grid spacing, the second has 100 meter spacing and the optional third grid has 1000 meter spacing. (Note: most regulatory agencies require the maximum overall concentration to be in 100 meter grid spacing.) To only use grid 1 and grid 2, change the grid 3 spacing to 0 meters. AQcast has been designed to process many receptors in parallel, so for typical applications there is no computational need to create many gridded nests. However, if the user is modeling a domain out to 50 kilometers, it is recommended to use a third gridded nested.

If a fence line shapefile is provided or drawn in the UI, receptors will be placed by default at 25m horizontal spacing along the line and all receptors within the fence line will be removed. Along with the receptor nested grids, fence line points and sensitive receptor points can also be included. For more information on sensitive receptors, see Section 7.

c. AERMET

When the user selects NOAA station data for meteorology, AQcast will download and process all files needed for input into AERMOD including AERMINUTE, AERSURFACE and all three stages of AERMET. The user also has the option to use ADJ_U*, which adjusts the surface friction velocity (u* or ustar) for low wind speed stable conditions. See the corresponding pre-processor sub-sections for more information.

d. BPIPPRM

This pre-processor takes the user-provided facility building and stack information and derives directional wind components for use in AERMOD's PRIME downwash algorithms. BPIPPRM is optional for an AERMOD run. The user may provide a zipped shapefile or draw the buildings in the UI, AQcast will get the coordinates and shapes from the files and run BPIPPRM accordingly creating AERMOD ready data in the form of *downwash.txt*.

e. AERSURFACE

AERSURFACE uses 2016 National Land Cover Data, Impervious Surface data, and Tree Canopy data to determine surface characteristics. Monthly sectors and 12 spatial sectors are used. If the station is an airport then all sectors are assumed to be an airport.

<u>Seasonal Determination</u>: The user can choose to input their own seasonal monthly categories or have them calculated in the system. If the user does not select to use their own AERSURFACE categories, AQcast will process and calculate the categories based on the surface meteorology. (Note: this selection is required if you are using an Onsite Meteorology file, see Section 7 for more information). Monthly seasonal determination is calculated using the ish-lite data (a reduced and formatted version of the NWS surface station data) and how many days during the month are below 32°F, using the default categories as a starting point. Table 1 shows the logic for changing a particular month from default values.

Table 1: Monthly Category Determination Criteria:

Month	Adjustment Criteria	New Category
March, April	Month > 16 days below freezing	3
May	March < 5 days below freezing	1
June	April > 10 days below freezing	5
August	September > 5 days below freezing	2
October, November	> 16 days below freezing	3

Climate Precipitation: The user has the option to input their own climate precipitation category for each modeled year. If not chosen, AQcast will calculate observed annual rainfall for each modeled year and compare it to the climate average to determine wet/dry/average precipitation for the year. AQcast will then find the nearest station with daily snow depth data and consider a month to be category 4 (winter with snow cover) if that month has a majority of days with snow depth greater than 1 inch. For a list of data sources, See Appendix B.

4. Ozone Background Data

If the user selects to model NO_2 and does NOT provide a background ozone value, then AQcast will calculate one. It finds and downloads the hourly ozone monitor data for that year, and then finds the hourly average ozone concentration of the monitors within 50 kilometers that have at least 90% data capture. A list of the monitors used can be found in *Monitors.txt* in the project tar files downloadable from the UI *Results* tab.

5. WRF and MMIF

(Currently not Available but ***COMING SOON***). Once this option is active, it will process and use WRF output as the meteorology option. AQcast includes archived 12 km WRF output for North America from 2014 through 2018. Using this, MMIF will be run for the modeling time selected (assuming it is within the years of available archived data) to create inputs into AERMET. AERMET will then be processed as normal.

6. Pollutants

As seen in Figure 4, AQcast: AERMOD includes the option to model all recognized pollutants by the AERMOD model including NO_2, SO_2, $PM_{2.5}$, PM_{10}, Lead, CO, and Other. Each checked pollutant in the UI will have its own AERMOD run for short-term (i.e. NO_2 1-hr covering the entire five modeling years) and long-term (i.e. separate NO_2 annual average runs for each year of the five modeling years) resulting in six total AERMOD runs for NO_2 in this case. Note: if you check NO_2 at least one (but not necessarily all) sources must have emissions of NO_2 or it will not be modeled. This is true for all pollutants. This freedom in the UI allows sources to have emissions of single pollutants while still being able to model multiple pollutants in one project. For instance, let us say we wanted to model NO_2 and $PM_{2.5}$ but the sources for those pollutants are not the same. In this case we could list two sources, where "stack1" can emit NO_2 only and "stack2" can emit $PM_{2.5}$ only. Thus, in this case, we are modeling each pollutant with a single but different source. For more information on model results (See Section 8: Output).

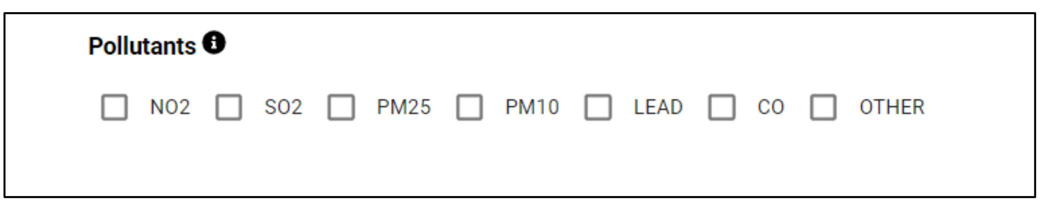

Figure 4. UI screen shot of Pollutant options

7. UI Options

Load Previous Project – This option will provide a list of all previously run AERMOD projects. A user can load a previous project selecting one from the list and all input options from that project will be loaded into the rest of the UI. After loading, the various parameters can be modified. Note that to load properly, the previous project must have completed. When rerunning a project, it is suggested that a user edit the "Project Description" as it will create a set of new project files instead of overwriting the previous ones.

Project Description – This string is used for reference only and is how the user will select the results from this specific run on the UI *Results* Tab. This name will also be used when referencing this run to use previous meteorology, stack parameters, fence line, or building files. We suggest including the location or facility name, date of run, and MMIF/NOAA to make clear the source of the meteorological data.

Run Option – "Default" simply runs the model with the parameters chosen and creates figures and summaries comparable to the Significant Impact Level (SIL) and the NAAQS. This is currently the only option available. Additional model options will be available in the future.

Start Year – Start year of your model project

End Year – End year of your model project

Project Coordinates (CONUS) – Input the coordinates for the facility to be modeled. This is used to find the nearest meteorological station as well as where to plot results. Note: the coordinates must be in the contiguous United States.

State Project is Located – input the abbreviation for the state in which the project is located in. This is used to determine which state-provided meteorology to use.

Use State Provided Meteorology – If the state your project is in has state-provided meteorology, you can choose to have the system download the necessary files and use this data instead of processing data from NWS. If your state has data, but it's not listed as an option, you can email aqcast@aer.com.

Pollutants – At least one pollutant must be selected even if using a previous stack parameter file. See Section 6 for more information.

Source Parameters and Emissions – For each source to be modeled, the user needs to fill out the section under "Create New Source". The "Source Type" denotes the option to choose if it is a point source "P" or an area source "A". Not all parameters are needed for each source type. Parameters are noted with "(a)" area or "(p)" point if they are required only one source type. Proceed to fill out the corresponding parameters and emissions in the stated units provided on the UI. More than one source is possible, and to add another simply click the button "Add Another Source". Make sure that source is in the user-provided modeling domain and that the appropriate pollutant is checked. There is an option to use a previously created source file named by the project description. An hourly emissions file is optional (See below for more information).

Previously Created Source Parameter File – A previously created source file (named by the project description) can be used by selecting from a dropdown menu below the source inputs. The selected file will be loaded into the UI and plotted on the map.

Hourly Emissions File – The user may upload and use an hourly emissions file. The sources listed above must match the ones in the file as well as the hourly file must be formatted correctly, for a successful run. See the AERMODv19191 User Guide for more information. The file must end with ".emi". An example of the format is here:

```
            #     Year Mon Day Hr Name Cmass Temp (K) Velocity(m/s) emission(g/s)
   SO HOUREMIS 2017  1  1  0     STACK01   1.0  333.14999   12.72000  3.360
```

Building Locations – The user can upload a zipped file of all files pertaining to a GIS shapefile. This includes *.shp, *.dbf, *.sbn, *.shx among others. (NOTE: the projection of this shapefile **must** be WGS84. To check, open the *.prj file in a text editor and "WGS_1984" should be present a few times. The shapefile must be type POLYGON and not POLYGON ZM.) The user can also draw the buildings individually on the map in the UI. After buildings are either drawn or uploaded the user must click on each building to verify the height in meters. The default is 3 meters, which is an average one-story building. After the map, there is an option where the user can specify a previously drawn or uploaded building file named by project description and whether it was drawn or uploaded. Any previously selected file will be loaded into the map and at this time the user can add a building to it to be used in the current run. To clear uploaded files, choose the "Previously Created Building File" to be "None", and to clear drawn files click the "Clear Drawings" button near the map (Note: this will clear previously drawn fence lines). If a building was uploaded and drawn the resulting filename will contain "UploadAll" and contain all buildings for the run.

Fence line Location – Similar to building locations, the user can either draw the fence line or upload a zipped file of the GIS shapefiles. (See "Building Locations" above for information on shapefiles.) After the fence line is either drawn or uploaded to the map the user can specify a previously drawn or uploaded fence line file named by project description and whether it was drawn or uploaded. AQcast: AERMOD creates receptor points at 25-meter intervals along the fence line (See Receptors below). Any previously selected file will be loaded into the map and at this time the user can add a fence line to it to be used in the current run. To clear uploaded files, choose the "Previously Created Fence Line File" to be "None", and to clear drawn files click the "Clear Drawings" button near the map (Note: this will clear previously drawn buildings).

Previously Created Fenceline File – A previously created fenceline file (named by the project description) can be used by selecting from a dropdown menu below the map. The selected file will be loaded into the UI and plotted on the map. A drawn fenceline can be added to any loaded shapes.

Previously Created Building File – A previously created building file (named by the project description) can be used by selecting from a dropdown menu below the map. The selected file will be loaded into the UI and plotted on the map. Drawn buildings can be added to any loaded shapes.

Receptors – A gridded field of receptors will be created based on user-selected receptor grid bounds and spacing. See Section 3.b AERMAP for more information.

Sensitive Receptors – This option will search a predefined national list of churches, schools, parks, and hospitals and include those located in the modeling domain to the gridded receptors.

AERSURFACE Seasonal Categories – This option allows the user to select the AERSURFACE categories used in running the pre-processor AERSURFACE for meteorology stations. If selected, the categories provided will be used for all years of the modeling. The category defaults and descriptions are provided in Figure 5. For more information on how these categories are selected, should the user not provide values, see Section 3.e.

Category	Description	Default
1	Midsummer with lush vegetation	Jun, Jul, Aug
2	Autumn with unharvested cropland	Sep, Oct, Nov
3	Late autumn after frost and harvest, or winter with no snow	Dec, Jan, Feb
4	Winter with continuous snow on ground	
5	Transitional spring with partial green coverage or short annuals	Mar, Apr, May

Figure 5. AERSURFACE category descriptions and defaults

AERSURFACE Climate Precipitation – This option allows the user to select the AERSURFACE climate precipitation used in running the pre-processor AERSURFACE for meteorology stations. If selected, the user must select the appropriate category for each modeled year (i.e., WET, AVERAGE, DRY). See Figure 6 below.

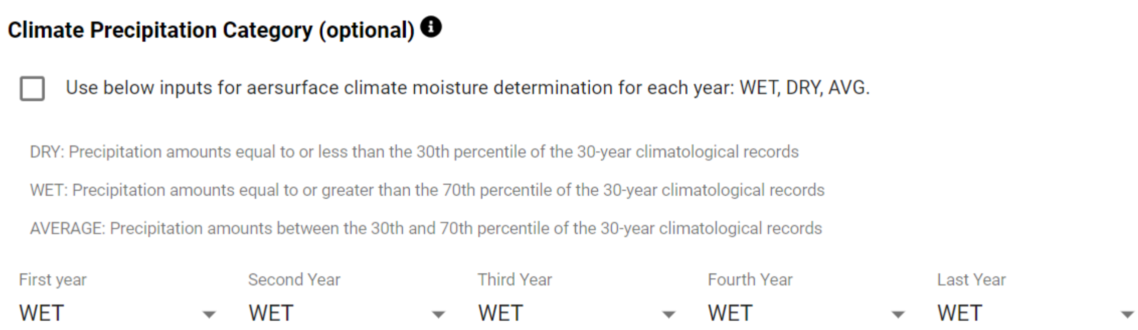

Figure 6 AERSURFACE Climate Precipitation

Meteorology Options – One of the below options must be selected. These are listed by priority. For example, if 'Previous Met.' was selected, any selected stations in the map would be ignored. When loading a previous project, click the "Find Closest Meteorological Sites" button and the NWS stations used will be selected when the list loads.

1. <u>WRF and MMIF</u> – If selected, AQcast: AERMOD will run MMIF on AQcast's archived WRF data for the run period selected, which must be in the range of available archived data (currently 2014-2018). MMIF will be run to provide AERMET input data.

2. Meteorology from previous job – The user has the option to use previously processed meteorology, such as MMIF or AERMET data from a previously submitted project, by selecting the project description in the dropdown menu.
3. Onsite Meteorology – An onsite meteorology file is optional to include via the UI and should contain the latitude, longitude, and base elevation option in meters. This data will be supplemented by NOAA FSL upper air data. The format must be correct, or the job will fail. You also **MUST** provide the AERSURFACE categories. For more information on the onsite format, refer to AERMET v19191 User Guide. The format is as follows for hourly onsite observations:

   OSYR OSMO OSDY OSHR PRES SLVP PAMT TT01 WS01 WD01 SA01 RH01

4. State Provided Meteorology Data – Some EPA state agencies provide pre-processed AERMET data. If the user's facility is located in one of these states the user has the option to use the state pre-processed meteorological data. Sometimes this data is old so the user has the option to process current meteorology. If chosen to use the state data, AQcast will download the necessary state-provided pre-processed AERMET files and use them in AERMOD for the following states [TX]. Other states can be included upon request. Email aqcast@aer.com.
5. Default meteorology stations – AQcast: AERMOD will select the nearest NOAA surface (with ASOS one-minute data) and upper air stations to the user provided coordinates for processing in AERMET. (*CHOOSE THIS* if using state-provided meteorology above.)
6. Selected Meteorology stations – The user can choose to search for the five closest surface and upper air stations to their provided coordinates. From that list the user can select which station to use.

Split AERMOD runs – By checking this box, AQcast: AERMOD will split the receptors used in each simulation, resulting in a series of smaller runs. This uses the exact code from the EPA but the separation can significantly decrease run time. For example, splitting a single simulation of 10K receptors can result in smaller groups, each covering 500 receptors. The results are merged, then summaries and plots are created. *Note: this splitting method is usually not accepted by regulatory agencies but can be used to review initial results quicker.*

8. Output

After successful completion of AQcast: AERMOD an email will be sent to the user notifying them the project is complete. The UI: *Results* tab will provide a final summary of the maximum concentrations and design value for the selected pollutant along with some plots. A link to download a tar ball of the outputs and model setup files will also be provided in the *Results* tab. A list of example files is provided in Appendix A. Additional plots will be provided in the tar ball that are not shown on the UI.

9. References

- AERMOD v19191:
  - Scram Site: https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models#aermod
  - User Guide: https://www3.epa.gov/ttn/scram/models/aermod/aermod_userguide.pdf

- AERMET v19191 User Guide: https://www3.epa.gov/ttn/scram/7thconf/aermod/aermet_userguide.pdf
- EPA's MMIF Model:
  - https://www.epa.gov/scram/air-quality-dispersion-modeling-related-model-support-programs#mmif

Appendix A

Sample File List for User Download

AERMET

- ####.OUT – AERSURFACE out files for AERMET stage 3
- *.ISH – surface station data from NOAA
- *.FSL – upper air radiosonde data
- *_S#.inp (.MSG, .RPT) – stage # (1,2,3) input files for AERMET along with message and report files for each
- *.PFL and *.SFC – profile and surface files (final output of AERMET), used in AERMOD

AERMINUTE

- 6405*.dat – Downloaded one-minute-asos data from the same surface station used in AERMET
- .inp – AERMINUTE input file

AERSURFACE

- AERSURFACE*.DAT – AERSURFACE input files
- *.tif – Land Cover, Impervious Surface, Tree Canopy for 2016
- *.OUT – output used in AERMET stage 3
- *.INP, *.out, *.log – input, output and log for each year

AERMOD

- *.PLT and *.SUM – Output files for each pollutant and period modeled
- *.PFL and *.SFC – profile and surface files, final output of AERMET stage 3
- *aermod.inp – input files for each pollutant and period modeled
- *aermod.out – output files for each pollutant and period modeled
- ozone*.dat – ozone background files created and used only for NO_2 modeling if user did not specify background concentration option in UI
- downwash.txt (if buildings are included)
- aer_all.rec – receptor file from AERMAP

BPIP

- BPIP.INP – input file used to run the building downwash program
- BPIP.OUT – output file including data needed for AERMOD input file
- BPIP.SUM – summary of bpipprm run

Output

- fenceline* – a GIS shapefile that represents the border between private and public land for your modeling case
- bldg* – a GIS shapefile that represents the buildings in your project area
- SenRecDets.csv – list of sensitive receptor locations and names (if option chosen)

- ConcSummary.txt – summary of the maximum and design values and locations from your facility.
- Protocol_Summary.txt – Receptors spacing information, GEP stack height information
- Monitors.txt – If modeling NO_2 and background concentrations were calculated, this lists the monitoring stations used
- MetSummary.txt – Provides a summary of the surface and upper air NOAA stations assuming the corresponding UI option was chosen. This also lists basic quality capture rates for met data.
- facility.kml – Google Earth file to display 3D view of facility with sources and buildings

<u>Other</u>

- n##w###.tif – USGS elevation data downloaded for use in aermap
- StackParams.csv – All stack data for this project including location, parameters, and emissions.
- aermap.inp – input file for AERMAP. (*.out files cannot be provided. The *.rec is in the aermod folder.)

<u>Figures</u>

- Elevation.png – image with the modeling domain and elevation with the facility location in the middle.
- metSites.png – (non MMIF only) image with the surface and upper air stations relative to the facility location.
- Windrose*.png - (non MMIF only) image of the surface winds for the surface station and modeling period selected.
- *MaxDailyConcPlot*.png – images of the maximum concentrations for the pollutant over the modeling period
- SensitiveReceptor.png – (if selected) image of the sensitive receptor locations
- Windrose_*.png – (non MMIF only) image showing winds for the modeling period.
- Design plots - images of the design concentrations for the pollutant over the modeling period

Appendix B

Data Sources Used by AQcast: AERMOD

- Land Cover
  - Use: National Land Cover Data, Impervious, and Canopy Data (2016) used in AERSURFACE
  - Source: ftp://newftp.epa.gov/Air/aqmg/nlcd/2016/
- Elevation Data
  - Use: 30 m elevation data used by aermap
  - Source: https://prd-tnm.s3.amazonaws.com/StagedProducts/Elevation/1/IMG/n34w107.zip
- ASOS one-min data
  - Use: AERMINUTE for better wind data, by surface station call sign and month
  - Source: ftp://ftp.ncdc.noaa.gov/pub/data/asos-onemin/
- ASOS Anemometer height
  - https://www.weather.gov/media/asos/ASOS%20Implementation/windtower.xls
- FSL Data
  - Use: AERMET, radiosonde data for nearby station, twice daily vertical profiles.
  - Source: https://ruc.noaa.gov/raobs/
- Ish Data
  - Use: AERMET, surface temperature, wind speed, wind direction, cloud cover, by wban and wmo IDs
  - Source: ftp://ftp.ncdc.noaa.gov/pub/data/noaa/
- Ish- lite Data
  - Use: AERSURFACE, seasonal determination, simple format of ish data listed above
  - Source: ftp://ftp.ncdc.noaa.gov/pub/data/noaa/isd-lite/
- Snow Cover Data
  - Use: AERSURFACE, seasonal determination, winter with snow cover or not
  - Source: https://www.nohrsc.noaa.gov/nsa/discussions_text/National/snowdepth/201301/snowdepth_2013011406_e.txt (example date)
- FSL_List.txt
  - Use: MetStatoinSearch.py to find the nearby upper air stations
  - Source: https://ruc.noaa.gov/raobs/GetRaobs.cgi?shour=All+Times&ltype=All+Levels&wunits=Knots&bdate=2018061812&edate=2018061817&access=All+Sites&view=YES&osort=Station+Series+Sort&oformat=FSL+format+%28ASCII+text%29
- Good_snow.txt
  - Use: AERSURFACE, search through possible sites for snow cover data.
  - Source: list created based on data availability for recent years of snow cover data.
- Mshr_standard.txt
  - Use: MetStatoinSearch.py to find the nearby surface stations
  - Source: https://www.ncdc.noaa.gov/homr/reports/mshr
- Nrmpcp.txt

- Use: AERSURFACE, climate average annual precipitation totals by station
  - Source: https://www1.ncdc.noaa.gov/pub/data/ccd-data/nrmpcp.txt
- Background Ozone
  - Use: AERMOD, if NO_2 is modeled
  - Source: https://aqs.epa.gov/aqsweb/airdata/hourly_44201_2018.zip (example year)
- IFW Group installation date
  - https://www.weather.gov/media/asos/ASOS%20Implementation/IFW_stat.pdf
- Sensitive Receptor List - National_Sensitive_Features.csv
  - Use: aermap, finds nearby sensitive locations to include as receptors.
  - Source *(note: data was further filtered and doesn't include all points in the below datasets.)*
    - Schools http://www2.census.gov/geo/docs/maps-data/data/gazetteer/2017_Gazetteer/2017_Gaz_unsd_national.zip
    - Hospitals https://www.arcgis.com/home/item.html?id=f114757725a24d8d9ce203f61eaf8f75
    - Churches, schools, hospitals https://www.arcgis.com/home/item.html?id=007ff07891e34e339a6da82a5c44fd31
    - Parks https://www.arcgis.com/home/item.html?id=578968f975774d3fab79fe56c8c90941
- National Emissions Inventory ***COMING SOON***
  - Use: AERMOD, cumulative impact study needs other nearby sources of same pollutant
  - Source: https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data