The Ministry of the Environment, Conservation and Parks

Modelling Updates

Winter 2023 Air Practitioner's Meeting

February 2, 2023

Ontario

Discussion Topics

- AERMOD/AERMET Model Version Updates
- Use of the AERMOD Urban Option and associated settings
- Situational Use of the CALPUFF Model
  - Shoreline fumigation
  - Complex terrain/meteorology
  - Wet plumes
- Expectations for Use of CALPUFF or SDM
  - Ministry review process

AERMOD/AERMET Version Updates

- In April 2022, the US Environmental Protection Agency (USEPA) released a new version (v22112) of the AERMOD/AERMET modelling system
- This version includes technical updates that are not included in the ministry's current specified version of July 2019 (v19191).
- Some of the important technical updates and bug fixes in v22112 include:
  - Bug fixes to the Urban Option calculations
  - Bug fixes to BOUYLINE source
  - Bug fixes to RLINE and RLINEXT
  - Updated plume meander calculations in RLINE
  - Added 'debug' files for BOUYLINE, RLINE and URBANOPT
  - Added a 'FAST' option for RLINE
  - Removed 'ALPHA' designation from RLINE and BOUYLINE with Urban Option
  - Added various 'ALPHA' options

AERMOD/AERMET Version Updates – Cont'd

- The ministry does not necessarily adopt each new version of the AERMOD/AERMET modelling system
  - to reduce unnecessary burden on the regulated community, we perform a consequence analysis (in addition to the USEPA's assessment) to determine the potential impacts of the updates, and decide whether to adopt
- Our consequence analysis assessed AERMOD (22112) / AERMET (22112) against AERMOD(19191) / AERMET(19191) with various common source types / configurations.
  - same configuration is used each time
- **Based on our review of the USEPA's technical updates and our resulting consequence analysis, the ministry is adopting the updated versions of the AERMOD/AERMET models in April 2023.**
  - ensures that the ministry's prescribed regulatory air dispersion models continue to be based on the best available science and remain consistent with other jurisdictions.
  - this is the 4th official model version update since 2015

AERMOD/AERMET Version Updates – Reminders

- Use of newer AERMOD versions (i.e. v22112) before official adoption requires:
  - approval under s7(1) – submission must include rationale
  - met data must be processed with corresponding version of AERMET
- Adoption of a new model version doesn't necessarily trigger an Emission Summary Dispersion Modelling (ESDM) report update for all facilities.
  - Schedule 4 and 5 facilities and those with Environmental Compliance Approvals (ECA) Limited Operating Flexibility (LOF) are required to update by March 31st of the following year, or by the timeline outlined in the LOF approval
  - all other facilities are not required to update their ESDMs until required to submit (e.g. ECA amendment, Notice, etc.)

Meteorological Data - Reminders

Regional meteorological data sets

- Pre-processed regional met data sets posted on ontario.ca are to be used only when the surface characteristics within 3 km from your site are relatively uniform and reasonably represented by one of the data sets
  - CROPS, FOREST, URBAN*, SUBURBAN
- If the land use, and resulting surface characteristics, vary significantly within the 3 km, local meteorological data sets should be used that have been refined to reflect the local land use conditions
  - particularly important to use local or site-specific data sets if a facility is located near a water body or if concentrations/frequency of exceedance are being determined **at specific/sensitive receptor locations** (e.g. when assessing odour).
  - EMRB provides refined site-specific meteorological data sets upon request for free
  - s13(1) approval is required to use local or site-specific meteorological data sets

* Use of URBAN met data is different than the URBAN OPTION in AERMOD

AERMOD Urban Dispersion Option

- AERMOD allows the user to specify 'Urban' dispersion conditions for the site/sources being modelled, if the facility is located in an area that is deemed to be 'urban' in nature.
- Factors that affect the selection of the urban option:
  - surrounding land use;
  - location of a facility relative to the urban core (e.g. downtown Toronto);
  - population/urban intensity.
- 'Urban' option is designed to alter nighttime dispersion parameters due to the urban heat island effect (higher temperatures in the urban core than the outlying areas which results in local nighttime convective circulation),
  - use of inappropriate parameters under the "Urban" option can have a significant impact on modelled concentrations, more than would be attributed to the *urban heat island* effect itself

Urban / Rural Dispersion Option (Continued)

- When the 'Urban' option is selected in AERMOD with default settings under this option :
  - site-specific wind-sector dependent surface roughness lengths contained in AERMET meteorological file are **not used** during evening, nighttime and some morning hours – they are overridden and an urban surface roughness of 1 m is applied
    - this results in the site being modelled as if it were located in a dense urban area like downtown Toronto;
    - use of a constant roughness length value of 1 m is **not** appropriate particularly in cases where the upwind land use has a significantly lower surface roughness (e.g., water has a surface roughness of 0.001 m vs. 1 m for high intensity residential).

Urban / Rural Dispersion Option (Continued)

- **URBANROUGHNESS**
  - The user can override the 1 m roughness with a different, more appropriate value, such that it varies hourly.
    - If this value is not selected correctly, an inappropriate roughness value is still used, regardless of the value specified.
  - Sensitivity tests confirmed that in many instances, it is the change in roughness length (and other associated surface characteristics) that results in much more significant impacts on modelled concentrations than the urban heat island effect itself.
    - This is an unintended outcome of the use and purpose of the urban option.

Urban vs. Rural classification

- Appropriate settings must be used when undertaking the modelling to ensure that model-predicted concentrations are reasonably representative.
  - **URBAN land use, in the context of dispersion modelling, does not simply mean the presence of any built-up area.**
  - **Users must demonstrate that their facility is located in an area that is deemed to be urban in order to use the Urban option.**
    - **this is done using land use classification data <u>not visual approaches</u>**
- Section 5.4.5 of The Air Dispersion Modelling Guideline for Ontario (ADMGO) outlines the procedure to be followed:
  - The **US EPA document *Guideline on Air Quality Models (40 CFR Part 51, Appendix W)*** describes procedures for classifying sites as urban or rural, and requires that either a land use classification procedure or a population based procedure be used in this determination. **The land use procedure is considered a more definitive criterion, and should be used by modellers for the purposes of the Regulation** unless the ministry has indicated in writing that another procedure (e.g. the population density procedure) is acceptable.

Land Use Classification Procedure

- US EPA document *Guideline on Air Quality Models (40 CFR Part 51, Appendix W)*. Section 7.2.1.1 outlines the land use procedure to be used for determining 'urban' or 'rural' classification:
- It is based on the method outlined in:

Auer, A. H. 1978. Correlation of Land Use and Cover with Meteorological Anomalies, Journal of Applied Meteorology.

Land Use Procedure:

1) classify the land use within the total area, A_o, circumscribed by a 3 km radius circle about the source using the meteorological land use typing scheme proposed by Auer [1];
2) if land use types I1, I2, C1, R2, and R3 account for 50 percent or more of A_o, urban dispersion coefficients may be considered if there are no other limiting conditions (e.g. proximity to water, etc); otherwise, use appropriate rural dispersion coefficients.

- Land use classifications should be based on most recent (or proposed) land uses around the facility
  - Examples of appropriate data sources include:
    - City zoning maps
    - consolidated zoning data from the Municipal Property Assessment Corporation (MPAC)

Land Use Classification Procedure (Cont'd)

- Regardless of resulting classification, facilities near major waterbodies (e.g. within the 3 km radius) generally should NOT use the Urban Option as the "urban heat island" is a **regional phenomenon**.
- The presence of the water broadly affects the meteorology and limits the formation of the nighttime convective conditions
- Hence the "urban heat island" effect is unlikely to occur (e.g. cooler closer to the lake).

Land Use Classification Procedure (cont'd)

Type	Description: Use and structures	Description: Vegetation
I1	Heavy industrial Major chemical, steel and fabrication industries; generally 3–5 story buildings, flat roofs	Grass and tree growth extremely rare; <5% vegetation
I2	Light-moderate industrial Rail yards, truck depots, warehouses, industrial parks, minor fabrications; generally 1–3 story buildings, flat roofs	Very limited grass, trees almost total absent; <5% vegetation
C1	Commercial Office and apartment buildings, hotels; >10 story heights, flat roofs	Limited grass and trees; <15% vegetation
R1	Common residential Single family dwelling with normal easements; generally one story, pitched roof structures; frequent driveways	Abundant grass lawns and light-moderately wooded; >70% vegetation
R2	Compact residential Single, some multiple, family dwelling with close spacing; generally <2 story, pitched roof structures; garages (via alley), no driveways	Limited lawn sizes and shade trees; <30% vegetation
R3	Compact residential Old multi-family dwellings with close (<2 m) lateral separation; generally 2 story, flat roof structures; garages (via alley) and ashpits, no driveways	Limited lawn sizes, old established shade trees; <35% vegetation
R4	Estate residential Expansive family dwelling on multi-acre tracts	Abundant grass lawns and lightly wooded; >80% vegetation
A1	Metropolitan natural Major municipal, state, or federal parks, golf courses, cemeteries, campuses; occasional single story structures	Nearly total grass and lightly wooded; >95% vegetation
A2	Agricultural rural	Local crops (e.g., corn, soybean); >95% vegetation
A3	Undeveloped Uncultivated; wasteland	Mostly wild grasses and weeds, lightly wooded; >90% vegetation
A4	Undeveloped rural	Heavily wooded; >95% vegetation
A5	Water surfaces Rivers, lakes	

- Auer Jr., August H. "Correlation of Land Use and Cover with Meteorological Anomalies." *Journal of Applied Meteorology* May 1978: 636 – 643.

Use of the Urban Option

- Once a Proponent has demonstrated, that based on the land use classification, the facility in question is located in an area that is considered Urban, the Urban Option and Urban Sources may be used for that site.
  - Users should include details of their analysis and supporting materials in their submissions (e.g. a table showing the area and percentage for each land use category, and whether they're considered Urban or Rural)
  - Ensures that the option is being used appropriately
- In order to make use of the site-specific surface characteristics, the user must set the URBANROUGHNESS parameter as the **minimum** surface roughness value in the corresponding meteorological data set. (Note, this is a non-default option).
  - the surface roughness is located in column 13 of the surface met data file (*.sfc) and varies for each hour based on wind direction
  - selection of the minimum surface roughness allows the model to use the actual hourly surface roughness lengths in the data, which is the desired outcome

Use of the Urban Option (Cont'd)

- The minimum URBANROUGHNESS should be specified for any met data set being used (e.g. both regional and local met data sets)
  - note, the "CROPS" or "FOREST" Regional met data sets **should not be used** with the AERMOD Urban Option.
  - URBAN or SUBURBAN data sets are reasonable for use with Urban Option
  - note when using an URBAN regional met data set (e.g. when appropriate given the surrounding land uses), proponents do not need to modify the URBANROUGHNESS as these data sets already contain a uniform surface roughness of 1 m.

Effect of Population

- The URBAN option in AERMOD requires the user to specify the "population" in the area (e.g. URBANPOP keyword).
  - the population is used to calculate the potential intensity of the urban heat island effect, based on historical temperature differentials between urban and rural areas.
  - the larger the population, the stronger the theoretical effect
- There have been inconsistent approaches for assessing the population to be specified in the Urban Source (part of the Urban Option)

  Based on US EPA guidance:
  - for relatively isolated urban areas (e.g. non-contiguous urban corridors), users should use the published census data for that urban area (e.g. Milton, Guelph).
  - for urban areas adjacent to or near other urban areas or part of urban corridors (e.g. Mississauga, Toronto, Ottawa), the total population of these entire urban areas should not be used.
    - EMRB recommends that the population of the nearest urban sub-center (e.g. East York, Clarkson, etc) or the total population based on the census data within a maximum 10 km x 10 km area around the facility be used (e.g. not the population of the entire urban area/corridor such as Toronto or Mississauga).
  - this is done to avoid overstating the potential urban heat island effect.

Example Facility – near a large water body

Comparison between AERMOD results using 'urban' vs. 'rural' options:

- A number of different factors were assessed to compare the differences
  - with RURAL option
  - with URBAN option (as completed by client)
    - used incorrect land use
    - used default 1 m roughness
    - used inappropriate, larger population
- The results showed:
  - differences in Point of Impingement concentrations (POIs) between Urban and Rural options for some contaminants can be significant – will vary depending on source characteristics and source-receptor orientation.
    - based on LU classification, this site should not actually be considered URBAN, i.e. URBAN option should not have been used in the first place
  - difference in results is not linear (i.e., some POIs increased while others decreased); this depends on source parameters / locations, etc.
  - use of correct dispersion parameters and population is extremely important

Example Facility – near a large water body (cont'd)

Comparison of results between 'urban' vs. 'rural' for this site:

Dispersion Coefficient		Modelled Max POI Concentration (ug/m3)
Without Urban Option (e.g. **RURAL**)		1709
With **Urban** Option (URBANOPT) and default **1 m** surface roughness	With Urban Heat Island Effect and the population of the entire town (75000)	484
With **Urban** Option (URBANOPT) and minimum surface roughness (**0.009m**)	With Urban Heat Island Effect and the population of the entire town (75000)	2797
With **Urban** Option (URBANOPT) and minimum surface roughness (**0.009m**)	With Urban Heat Island Effect and the population of a smaller area surrounding the facility (13000)	2931

Second Example Facility – typical urban location

Comparison of results between 'urban' vs. 'rural' for this site:

Dispersion Coefficient		Modelled Max POI Concentration (ug/m3)
Without Urban Option (e.g. **RURAL**)		325
With **Urban** Option (URBANOPT) and default 1 m surface roughness	With Urban Heat Island Effect and population of 115000	254*
With **Urban** Option (URBANOPT) and minimum surface roughness (0.104)	With Urban Heat Island Effect and a population of 115000	254
With **Urban** Option (URBANOPT) and minimum (0.104) surface roughness	With Urban Heat Island Effect and a population of 1000000	218+

*, + - Note that the location of the MAXGLC changed

Remember:

The upwind land use dictates the downwind concentrations.

Situational use of CALPUFF

- The ministry's Air Dispersion Modelling Guidelines for Ontario (ADMGO) outlines circumstances when facilities need to consider the use of CALPUFF in their assessments.
- In particular, these include the potential for shoreline fumigation effects in addition to local complex terrain / meteorology.
- Excerpt from ADMGO:

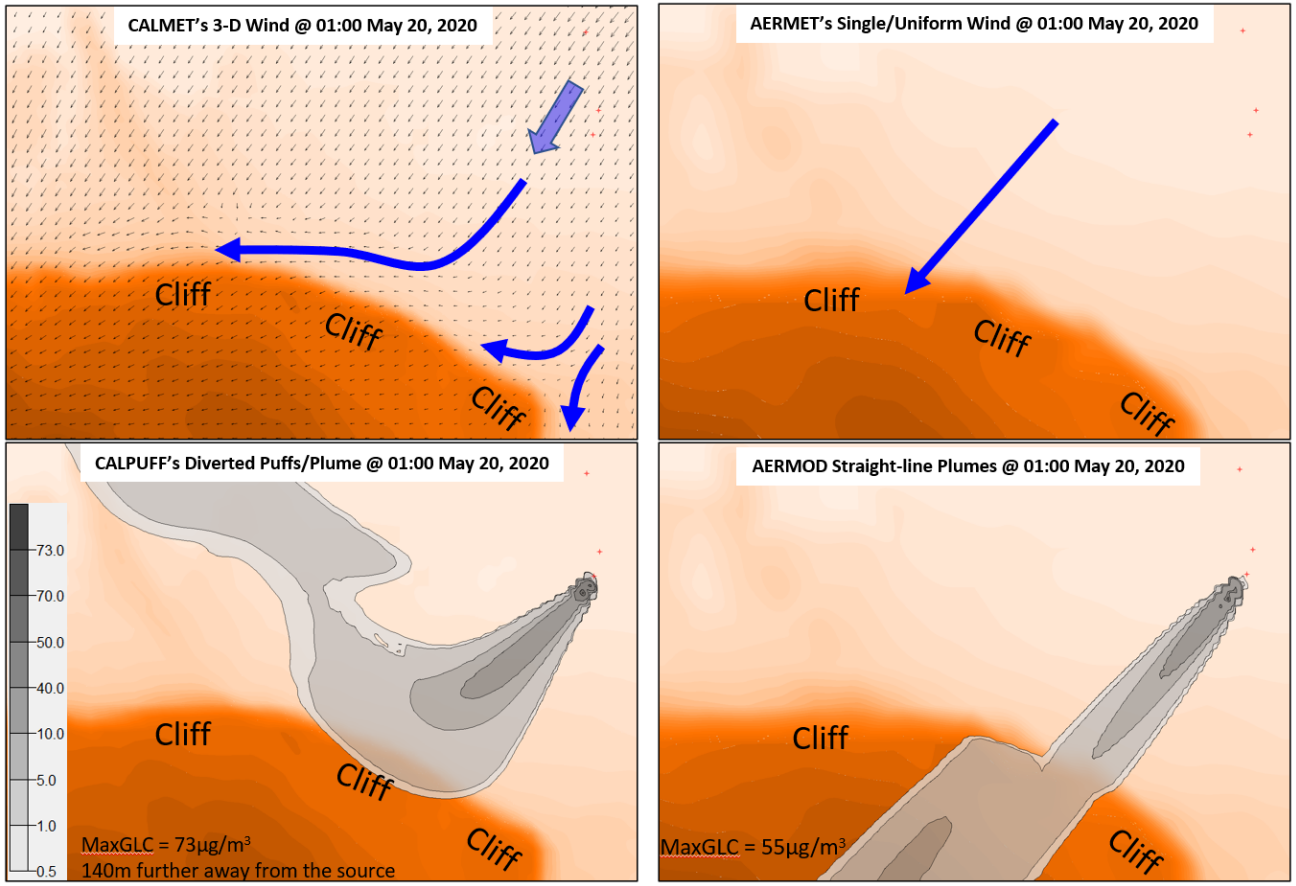
  - *Generally, facilities located within approximately 1 km of the shoreline of a larger lake or water body, that emit contaminants from taller stack sources greater than 50 metres in height, need to assess the potential for shoreline fumigation to occur using the SCREEN3 model. Should the screening assessment show that shoreline fumigation may occur, the use of an alternative model (e.g. CALPUFF, Shoreline Dispersion Model) may be required by a notice issued under section 7 of the Regulation.*

  - *The decision as to whether the use of CALPUFF is justified requires competent meteorological judgment. There are no hard and fast rules that can be applied. Situations where the use of CALPUFF could be justified include complex terrain, near large lakes and for facilities with very tall stacks.*

Situational use of CALPUFF (Cont'd)

- More sophisticated air dispersion models (e.g., CALPUFF) may more accurately predict a facility's impact on local air quality depending on site-specific conditions. In such circumstances, the ministry may require facilities to use models other than AERMOD to assess compliance under O. Reg. 419/05
- The CALPUFF model is currently being used by a number of facilities in Ontario located at sites with complex terrain and/or that are potentially subject to shoreline fumigation
    - better characterize risks associated with a facility's emissions (maximum concentrations, location of maximum concentrations)
    - ensure regulatory decisions and actions by regulated facilities (i.e., abatement / control strategies) are informed by best available science
    - identify residual risk associated with abatement / control strategies currently under consideration and what additional actions may be needed in future
    - inform future investment cycles and allow industry to better plan for the future

Why is CALPUFF More Appropriate with Complex Terrain and Meteorology



- CALPUFF produces **more accurate** modelled results in complex terrain because it is better able to account for the unique meteorological conditions (e.g., wind patterns) generated by elevated terrain and varying land use, particularly for short-term events
- CALPUFF maximum modelled concentration may differ in magnitude and/or location compared to AERMOD

Orange shades are for terrain heights, and grade shades are for the modelled plumes. Arrows indicate the winds.

Ontario

Shoreline Fumigation Effects

- ADMGO has always recognized that AERMOD does not consider the potential for shoreline fumigation effects for facilities located near water bodies with stack/point emission sources
- A screening assessment should be undertaken for emissions from facilities with tall stack/point source (e.g., greater than 50 metres) located within approximately 1 km of the shoreline of a large water body
  - examples of larger lakes or water bodies that could lead to fumigation include the Great Lakes, Georgian Bay, Lake St. Clair, and others.
  - the shoreline fumigation effect is not assessed for ground level area or volume sources

Shoreline Fumigation Effects (cont'd) – Assessing Maximum POI

- If a screening assessment is required (i.e., stacks > 50m tall within 1 km of shoreline), use SCREEN3 to assess the ***potential*** for shoreline fumigation effects.
  - Facilities with multiple stacks taller than 50 metres should use a stepwise screening procedure starting with the tallest stacks and moving to shorter stacks closer to the shoreline
  - If SCREEN3 indicates a ***potential*** for shoreline fumigation effects, proponents will have to use a S7(1) approved alternate model to calculate the maximum POI concentrations resulting from possible fumigation events:
    - Shoreline Dispersion Model (SDM)
      - used to identify the hours where fumigation is likely to occur and assess POI concentrations during those hours
      - AERMOD used to model POI concentrations during all other hours
    - CALPUFF

Wet Plumes

- MECP has had an increasing number of questions related to wet plumes, particularly those from wastewater evaporators
  - The ministry has received a number of complaints about exhaust plumes coming to ground very quickly, causing impacts on neighboring properties
  - Key concern is volatiles becoming re-entrained/re-absorbed in the fine droplets
- Neither AERMOD nor SCREEN3 have the capability to handle these wet, saturated plumes
  - CALPUFF (in FULL mode, not SCREENING or FOG), although not perfect, is preferable

Expectations for use of CALPUFF or SDM

- Pre-consultation with the Environmental Monitoring and Reporting Branch (EMRB) is a **must!**
- Proponents must submit a Modelling Plan that outlines:
  - Development of the meteorological data files (e.g. prognostic "initial guess" data from the Weather Research and Forecasting (WRF) model
  - CALMET and CALPUFF model switches and settings.
  - Checklist can be provided to proponents upon request
- The process is a stepwise review of the circumstances/situation, and approval of the model settings and switches at each stage
- MECP currently has a "pilot" project in the Hamilton area
  - CALPUFF-ready meteorological data files are available to proponents upon submission of s7 and s13 requests, free of charge

* EMRB provides the pre-processed data for SDM

Files to be Submitted when Using CALPUFF

- Ministry review requires submission of:
  - Namelist (input) files for WRF (both WPS and WRF)
  - WRF validation report and review of selected output files
  - Review of CALMET input files and all related input data files such as M3D.DAT files, surf.dat and sea.dat (for buoy, if applicable)
  - Review of CALMET output data files and validation report
  - Review of CALPUFF input files, coastal line file and external emission files if applicable.

* EMRB provides the pre-processed data for SDM