Inside the Black Box: Recent Updates and Proposed Changes in Air Dispersion Modeling

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Overview

- Introduction
- The purpose of air dispersion modeling
- Implications on permitting
- Review: 2017 Appendix W Update
- 2018 and beyond: modeling updates and planned developments
- Summary; Q&A
Why Air Dispersion Modeling?

The Clean Air Act (CAA) is the most complex US Environmental Regulation

- Requires EPA to continuously update National Ambient Air Quality Standards (NAAQS)
- Impacts every industrial sector
- The Air Permit is the Permit to construct and/or operate most large capital projects
- NGO’s focus on using the CAA to block new development and shut down existing plants
- Air Dispersion Modeling is the cornerstone for demonstrations showing compliance with the CAA

Local Scale (< 50 km): AERMOD

- Major Source Permitting
- Federal Designation Programs
- State-Specific initiatives and programs

Regional Scale (> 50 km): CALPUFF, CAMx/CMAQ, SCICHEM

- Class I Analyses
- Regional Haze / BART
- Single Source Ozone and Secondary PM2.5 Impacts

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Air Permits

Construction Permits

- Minor Source
  - State or Local Permit

- Major NSR
  - PSD Permit (attainment) BACT Modeling
  - NNSR Permit (nonattainment) LAER Offsets

Operating Permits

- State Operating Permit
- Title V - Facility-wide - Federally Enforceable

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Construction Permits (Minor)

- Minor source permitting:
  - Purpose: attainment and maintenance of NAAQS
  - Must meet regulatory emissions limits
  - May require ambient assessment (NAAQS, toxics)
  - Can avoid being major by taking limitations (through pollution control devices, limits on hours of operation, limits on fuel usage)
Construction Permits (Major)

- Major new sources & major modifications
  - Prevention of Significant Deterioration (PSD)

- Applies to attainment area pollutants
- Goal: protect clean air
  - Nonattainment NSR (NA-NSR or NNSR)

- Applies to nonattainment area pollutants
- Goal: make progress toward attainment of NAAQS
Construction Permits (Major)

- Best Available Control Technology (BACT)
- No significant deterioration in existing air quality (PSD Increment)
- Does not cause or contribute significantly to NAAQS exceedance
- Other adverse impacts
  - Soils, vegetation, visibility
  - Class I Areas
Construction Permits (Major)

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- No significant deterioration in existing air quality (PSD Increment)
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- Other adverse impacts
  - Soils, vegetation, visibility
  - Class I Areas

*How do we demonstrate compliance with the NAAQS, PSD Increments and/or State Toxic Guidelines?*
Air Dispersion Modeling

Emissions
 Atmospheric Impacts

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Modeling Guidance: Appendix W

The Guideline on Air Quality Models, (40 CFR Part 51, Appendix W) establishes approved models and modeling techniques that may be used for regulatory modeling

- Originally published in April, 1978
- After long delays at OMB, rule finalized on January 17, 2017
- First update since 2005
- All related supporting files are located at: https://www3.epa.gov/ttn/scram/appendix_w/2016/AppendixW_2017.pdf
Key Updates in the 2017 Appendix W

1. Removal of CALPUFF as a preferred model
2. Established Model Clearinghouse (MCH) Procedure
3. Revisions to the AERMOD Modeling System
   - 16216r version of AERMET & AERMOD including revised options for NO$_x$-to-NO$_2$ conversion and
   - Enhancements for low wind speed events.
   - A new option for generating meteorological data using model-generated (versus observed) meteorology (MMIF).
   - Incorporation of the BLP model to include modeling buoyant line sources (e.g. aluminum pot lines, long rooftop monovents).
   - Screening: Replacement of obsolete SCREEN3 with AERSCREEN.
4. Requirement to account for secondary pollutant (Ozone and PM$_{2.5}$) formation for single sources.
Conversion of $\text{NO}_X$ to $\text{NO}_2$

Since version 1626r all Tiers are default

- Tier 1: 100% conversion of $\text{NO}_X$ to $\text{NO}_2$
- Tier 2: New Ambient Ratio Method (ARM2);
- Tier 3: Ozone Limiting Method (OLM) or Plume Volume Molar Ratio Method (PVMRM)
  - Requires project specific information such as the in-stack ratio of $\text{NO}_2$ to $\text{NO}_X$ and ambient ozone data
Ambient Ratio Method 2 (ARM2)

- Revised NO$_X$-NO$_2$ transformation based on both better science than the original ARM and hourly ambient monitor data
- The ARM2 scaling is based on a curve fit of NO$_2$/NO$_X$ ratios against ambient NO$_X$ concentrations
- ARM2 minimum default NO$_2$/NO$_X$ ratio of 0.5; MHC approval required for lower minimum
- ARM2 increases the “compliance range” up to 376 μg/m$^3$
- At NO$_X$ concentrations below 149 μg/m$^3$, ARM2 provides LESS refinement than ARM did. Could cause challenges in SIL demonstrations
Low Wind Options

Prior to 2017 AERMOD consistently over-predicted in low-wind conditions.

The “adjusted u-star” (ADJ_U*) option
- provides improved model performance
- reduce time + costs in mitigating compliance issues

- ADJ_U* default as of v16216r
  - Alters the calculation plume dispersion under stable (i.e. night-time) conditions.

- LOWWIND3 will remain BETA (i.e. requires MCH justification).

- Both low-wind options diminish building downwash-related impacts
Default vs. Low Wind Meteorology
Meteorological Data for Dispersion Modeling

- Meteorological data representativeness is key to any regulatory air quality modeling analysis
  - A lack of available representative meteorological data is often seen as a fatal flaw when selecting a site for development

- Onsite meteorological data collection can be costly, and technically impractical in certain situations
  - One full year of data is required
  - Must be subject to a quality assurance and quality control program, established with an approved meteorological monitoring protocol
  - Time to acquire and configure equipment and construction of site

The 2017 update to Appendix W introduced another option…

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Prognostic Meteorological Data

- Data from three dimensional atmospheric models are now able to be used in a regulatory setting with AERMOD

8.4.5.1 (a) of Appendix W: “For some modeling applications, there may not be a representative NWS or comparable meteorological station available (e.g., complex terrain), and it may be cost prohibitive or infeasible to collect adequately representative site-specific data. For these cases, it may be appropriate to use prognostic meteorological data, if deemed adequately representative, in a regulatory modeling application.”

- The prognostic meteorological model is executed for the model area to produce wind speeds & directions that reflect the effects of local topography and land cover

- Data from prognostic meteorological models like WRF can be processed through EPA’s Mesoscale Meteorological InterFace (MMIF) program to develop AERMET and AERMOD friendly data
Resolution – Key to Capturing Influence of Terrain

Terrain as seen by WRF-4km Domain with 4km Terrain Resolution
Source: WRF/WPS

Terrain as seen by WRF-1km Domain with 900m Terrain Resolution
Source: WRF/WPS

Terrain as seen by WRF-450m Domain with 30m Terrain Resolution.
Source: ASTER Global DEM
### Prognostic Meteorological Data – Final Thoughts

- In the future, EPA and/or States may make standardized prognostic meteorological data available
  - Time savings in use of the prognostic meteorological modeling
  - Most applicable to situations where representative data are not available due to distance, land cover discrepancies
- Complex terrain situations would likely require customized, case-specific application of prognostic meteorological models
- Either way, this approach represents a considerable potential for time + cost savings
  - The availability of representative meteorological data may not be the fatal flaw it once was for project site selection
Inside the Modeling Black Box

Air Dispersion Modeling

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2018 (and Beyond): State of the Modeling

The Regional-State-Local (RSL) Modeling Conference is an annual technical conference hosted by the EPA Office of Air Quality Planning and Standards (OAQPS) for both regulatory agencies and stakeholders.

• This year’s conference was held in Boston, MA on June 5 – 6
• RSL conferences cover recent updates in air dispersion modeling and related regulatory guidance.
• The conference also previews upcoming revisions and anticipated release dates to the modeling and guidance.
• These updates and revisions can have significant impacts on future projects and even projects currently under agency review.
Overview of 2018 Updates & Ongoing Research

- AERMOD
  - Updates: ALPHA/BETA
  - Upcoming: New Building downwash
- Anticipated meteorological refinements (AERSURFACE) that should improve the AERMOD’s modeling of plume rise
- Improvements in Cumulative Modeling
- Challenges introduced in assessing secondary PM$_{2.5}$ and Ozone formation
- First refinement on the definition of “ambient air” since the CAA
- Demystifying the Model Clearinghouse process
Updates

- Review of latest version of AERMOD (version 18081)
  - Introduction of ALPHA vs. BETA modeling options
  - Tier 2 (ARM2) NO\textsubscript{x}-to-NO\textsubscript{2} conversion for buoyant line sources

Future Refinements

- Next version anticipated in 2019
  - Will include RLINE transportation model as a BETA option.
  - Will also incorporate Tier 3 NO\textsubscript{x}-to-NO\textsubscript{2} conversion for buoyant line sources (currently not performed)
  - Finalize new building downwash (PRIME2) program

- Future versions (post-2019) will include other alternate models including the Offshore Coastal Dispersion model
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Conversion of NO\textsubscript{X} to NO\textsubscript{2}

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- Tier 1: 100% conversion of NO\textsubscript{X} to NO\textsubscript{2}
- Tier 2: New Ambient Ratio Method (ARM2); fixed for buoyant line sources in version 18081
- Tier 3: Ozone Limiting Method (OLM) or Plume Volume Molar Ratio Method (PVMRM)
  - Requires project specific information such as the in-stack ratio of NO\textsubscript{2} to NO\textsubscript{X} and ambient ozone data
  - Still not available for buoyant line sources but the OLM option is being developed
Meteorological Processing: AERSURFACE

- Significant update to the meteorological pre-processor AERSURFACE that quantifies local surface characteristics
- These surface characteristics are used in determining the daily mixing height which drives how “high” a buoyant plume will rise or be trapped under. Lower mixing heights are often associated with higher predicted impacts.
- Current version of AERSURFACE uses land cover data from 1992 while the new version will be able to accept data from 2001, 2006 and 2011.
- Additionally, the new version will account for changing seasonal leaf canopy cover
- In June, EPA mentioned that a test BETA version would be released “soon”
Cumulative Impact Modeling

- Cumulative (project plus unaffected facility and inventory sources) modeling against the NAAQS and PSD Increments is the most common problem in modeling demonstrations in terms of additional cost, complexity, and time to complete. The 2017 Appendix W update allows for:
  - Modeling domain to be defined as the farthest distance between a modeled SIL exceedance or 50 km, **whichever is less**. EPA emphasizes that the number of inventory sources to be included in cumulative modeling should typically be small.
  - Selecting and excluding ambient background monitors to prevent “double counting” impacts.

- One potential relief has been the 2017 Appendix W option to develop “actuals” for nearby inventory sources
  - Not actually “actuals”; rather this is a single value developed from the weighted average of the last two years of available actuals.
2017 Changes to Ozone and PM$_{2.5}$ Assessments

- The 2017 Appendix W places more emphasis on using chemical transport models (CTMs) to quantify secondary impacts on ozone and PM2.5; two tier approach is recommended.

<table>
<thead>
<tr>
<th>Tier 1</th>
<th>Rely on technically credible, existing relationships between precursor pollutants and secondary impacts</th>
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<tbody>
<tr>
<td>Tier 2</td>
<td>Use a Chemical Transport Model to quantify secondary impacts</td>
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- December 2016 guidance: Addresses both Tier 1 and Tier 2 approaches for Ozone and PM$_{2.5}$. Not a draft; replaces May 2014 PM$_{2.5}$ guidance for some aspects; less prescriptive.

- EPA proposed new Significant Impact Levels (SILs)
  - Ozone: 1 ppb (8-hr)
  - PM$_{2.5}$: 0.2 µg/m$^3$ (annual, reduced from 0.3 µg/m$^3$), 1.2 µg/m$^3$ (24-hr)
How would one perform a Tier 1 assessment?

- The MERP represent a level of emissions of precursors that is not expected to contribute significantly to concentrations of ozone or secondarily-formed PM$_{2.5}$.

- In December, 2016, EPA proposed guidance on developing regional specific MERP’s for each averaging period of ozone and PM$_{2.5}$.

- MERPs are based on NO$_X$ and VOC precursors for ozone and NO$_X$ and SO$_2$ precursors for PM$_{2.5}$. Each precursor gets a separate MERP; however, cumulative assessment is needed.

- Tier-1 analysis vs. a Tier-2 analysis; impacts in excess of the MERP’s result in a Tier-2 analysis involving time and cost intensive CTMs (e.g. CAMx, CMAQ or SCIPUFF)
Range of MERP Values in EPA guidance

24-hr PM$_{2.5}$
- NO$_X$: 1,075 tpy to 100,000 tpy
- SO$_2$: 210 tpy to 27,000 tpy

Annual PM$_{2.5}$
- NO$_X$: 3,184 tpy to 779,000 tpy
- SO$_2$: 1,795 tpy to 75,500 tpy

8-hr Ozone
- NO$_X$: 107 tpy to 5,573 tpy
- VOC: 814 tpy to 145,000 tpy

These MERP values are based off of the full range of hypothetical sources modeled by EPA, at various locations across the US. The values are heavily dependent on what region the source is located – local atmospheric chemistry.

Lower range MERP values for SO$_2$ for 24-hr PM2.5 and NO$_X$ for ozone point toward need for Tier 2 analyses for large projects.
Qualitative approach for ozone and secondary PM$_{2.5}$ are no longer be accepted

Any PSD project that is significant for PM$_{2.5}$ will need to address secondary PM$_{2.5}$ even if the precursor emissions for NO$_X$ and SO$_2$ are below the Significant Emission Rates (SERs)

Similarly if any precursor emissions (NO$_X$ and SO$_2$ for secondary PM$_{2.5}$; NO$_X$ and VOC for ozone) is over the SER, then both precursors need to be considered

In June, EPA mentioned that draft guidance would be released “this summer”
PRIME2: Refined Downwash

- Currently an ALPHA option
- Next update: end of 2018
- Possibly BETA by end of 2019

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Ambient Air Guidance

- Effort underway to reconsider the decades-old interpretation of “ambient air” based on “first principles of the CAA.”
- Considering definitions of “general public,” “access,” and “buildings” and how to interpret these terms
  - Examples:
    - Roads through property;
    - Roads adjacent to property;
    - Railroad tracks;
    - Remote terrain;
    - Over-water locations
- In June, EPA expected that the draft revision would be released by the “end of summer”
Projects that require non-default modeling must submit justification to the EPA Model Clearinghouse (MCH)

- Applicant submits request to State
- State reviews and submits to Region
- Region reviews and submits to MCH

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Model Clearinghouse Review

- Turnaround ~ 2 weeks for actual MCH review
  - However “upfront” time with state and regions took up to 6 months on average

- EPA recommended “Formal/Informal” meetings (i.e. off-the-record, non-discoverable) with client, state, region & MCH
  - These meetings will be strongly encouraged to discuss projects with significant questions regarding modeling guidance and/or problematic results
Summary of Updates

■ 2017 Appendix W Review
■ 2018 Updates to AERMOD
■ Improvements in Cumulative Modeling
■ Challenges introduced in assessing secondary PM$_{2.5}$ and Ozone formation
■ First refinement on the definition of “ambient air”
■ Anticipated meteorological refinements (AERSURFACE) that should improve the model’s modeling of plume rise
■ Demystifying the Model Clearinghouse process
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Questions?