AERMOD Modeling Issues with Buoyant Volume Sources and Downwash in Low Winds

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Presented at the 10th EPA Modeling Conference, March 15, 2012

Outline of Presentation

- Need for Buoyant Volume Source approach in AERMOD
- Recommendations for modeling approaches
- Evaluation of the modeling approach
- Problem with downwash concentrations in low-wind stable conditions
- How these issues might be affecting routine modeling assessments for 1-hour SO_2 NAAQS compliance

Modeling Buoyant Volume Sources

- Only approved approach is Buoyant Line and Point (BLP) model
- EPA intends to augment AERMOD to add buoyant line/volume source feature, but we need a working solution now
- BLP only applies to buoyant sources with rooftop releases in long lines; e.g., potlines at aluminum smelter
- BLP constraints: all buildings must be equally long, equally separated, and with identical buoyancies
- Traditional stack releases within this “heat island” (not on the buildings) are not adequately addressed by BLP
- BLP dispersion uses old P-G procedure

BLP-AERMOD Alternative Approach

- Would use BLP to predict hourly plume height
- Use AERMOD's hourly volume source approach to set hourly release heights
- This will work, however, only for buildings and rooftop emissions that are equally long, equally separated, and with identical buoyancies
- Does not address point sources within the buoyant source area, nor any other type of buoyant volume
- A non-BLP approach, described below, does not have this limitation

Non-BLP Calculation of Hourly Plume Rise from Buoyant Volume Sources

- Uses recommendations communicated to Mark Neyman of IDEM and Mary Portanova of EPA Region 5 by John Irwin of EPA, Sept. 2003
- Details have been communicated to EPA for a pending modeling application
- Approved for Indiana Lake County SIP
- Uses stable, neutral, and convective plume rise equations for buoyant fire plumes
- Buoyancy and emissions can be grouped into separate areas with consistent characteristics

Calculation of Hourly Plume Rise from the Buoyant Volume Sources, cont.

- Initial horizontal and vertical size of volume source is computed using Irwin (2003) recommendations
  - Initial sigma-y = equivalent source diameter/4.3
  - Initial sigma-z = plume rise/4.3
- Plume rise uses internal met variables calculated by AERMOD, imported into Excel, and used for hourly plume height calculations
- Release height is the sum of the physical height of the volume source plus the hourly plume rise

Proposed Application for Non-uniform Aluminum Reduction Facility

- Distribution of buoyancy throughout the heat island is not uniform, nor are emissions uniform
- However, the whole area acts as an integrated large heat island
- We divided the area into four parts to define the separate emission areas
- Model evaluation results for a monitor within 1 km indicate that this approach works well

Monitor vs. Modeling Results

- Observed design concentrations:
  - 2009: 99.6 $\mu g/m^3$
  - 2010: 47.2 $\mu g/m^3$
- AERMOD predictions without enhanced buoyancy rise (including potline roof vents)
  - 2009: 3111.8 $\mu g/m^3$
  - 2010: 3472.0 $\mu g/m^3$
- AERMOD predictions with proposed modeling approach
  - 2009: 99.4 $\mu g/m^3$
  - 2010: 99.5 $\mu g/m^3$

Conclusions for Non-BLP Alternative for Buoyant Volume Sources

- AERMOD needs procedure to accommodate buoyant volume sources
- BLP approach has many source limitations
- Proposed approach avoids these limitations and uses AERMOD meteorological profiles to characterize plume rise without change to the model except for additional debug printout

Additional Comment: Building Downwash in Light Winds

- Unexpected AERMOD results for buoyant stacks with heights close to building heights
- Many recent AERMOD runs indicate predictions of design concentrations for buoyant point sources due to building downwash in <u>stable, nearly calm conditions</u>
- This is contrary to expectations, since building wake expected to be weak, and plume rise high
- What do the AERMOD evaluations tell us?

Key AGA Stable Experiments: Stack Height Approximately Equal to Building Height

Exp.	Dist (m)	WS (m/s)	stability	OBSERVED	AERMOD
8073B	150	1.8	6	2.94	227.86
8073C	200	1.8	6	3.67	218.67
8073A	100	1.8	6	7.83	200.79

AERMOD is “seriously conservative” for these cases

These Issues Could Seriously Affect 1-Hour SO_2 Modeling Applications

- One example is a regional modeling study in NW Indiana (mentioned by AISI in a meeting with EPA in summer 2011)
- Several iron and steel facility SO_2 emissions were modeled with AERMOD
- Modeling issues likely include buoyant volume sources and downwash under low wind speeds
- Even with annual average emissions, AERMOD design SO_2 concentrations were several times higher than observations at 2 regional monitors