Deposition in AERMOD: overview

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Background

- Recent interest in AERMOD deposition
  - Polyfluoroalkyl sulfonate (PFAS), perfluorooctanoic acid (PFOA), Perfluorooctanesulfonic acid (PFOS)
  - Hg deposition
  - Ammonia deposition
- AERMOD incorporates dry and wet deposition for particles and gases
  - Generally not used for regulatory applications but can be incorporated if important (Section 7.2.1.3 of *The Guideline*)

AERMOD Gas Deposition

- **19191 – ALPHA option; previously non-DEFAULT**
- Added early 2000's (Wesely et al., 2002)
- Inputs include:
  - Land use around source (GDLANUSE)
  - Seasonal/month assignments (GDSEASON)
  - Gas properties
    - Diffusivity in air (cm^2/s)
    - Diffusivity in water (cm^2/s)
    - Cuticular resistance to uptake by lipids (s/cm)
    - Henry's Law constant (Pa m^3/mol)
  - Optional user supplied deposition velocity
    - Cannot calculate deposition outputs or use GDLANUSE and GDSEASON
    - Use with caution
- See AERMOD User's Guide Sections 3.2.2.12 – 3.2.2.14; 3.3.3

AERMOD Particle Deposition

- Method 1
  - Default
    - From ISCST3
    - Based on Pleim et al. (1984); Acid Deposition and Oxidant Model (ADOM)
  - Inputs by size bin
    - Diameter (microns)
    - Mass fraction (0-1)
    - Density (g/cm^3)
- Method 2
  - Added early 2000's (Wesely et al., 2002)
  - Simplified approach when particle size distribution not well known
  - **19191 – ALPHA option; previously non-DEFAULT**
  - Inputs
    - Fine mass fraction (0-1)
    - Mean particle diameter (microns) of fine mass fraction

When do I use…?

- Method 1
  - A significant fraction (> 10%) of total particulate mass has a diameter of 10 microns or larger or,
  - The particle size distribution is known
- Method 2
  - Particle size distribution is not well known and,
  - When a small fraction (< 10%) of total particular mass has a diameter of 10 microns or larger
- See Section 3.3.4 of AERMOD User's Guide

Key Differences Between Dry Deposition Methods

- Gravitational settling velocity (V_g)
  - Method 2
    - Fine mode: 0 m/s
    - Coarse mode: 0.002 m/s
      - Reasonable compared to Method 1 Vg for coarse particles
- No V_{dphor} (phoretic effect) for Method 2 in deposition velocity

$$V_{g,i} = \frac{g\left(\rho_i - \rho_{air}\right)\left(10^{-4} Diam_i\right)^2 S_{CF,i}}{18\mu}$$

Method 1 (diameter dependent)

Key Differences Between Dry Deposition Methods (continued)

Method 1 (diameter dependent)

$$V_{d,i} = \frac{1}{R_a + R_{p,i} + R_a R_{p,i} V_{g,i}} + V_{g,i} + V_{dphor}$$

V_{dphor}: 0.0001 m/s

Method 2

$$V_{d1} = \frac{1}{R_a + R_p}$$

fine

$$V_{d2} = 0.002 + \left(\frac{1}{R_a + R_p + 0.002 R_a R_p} \right)$$

coarse

$V_d = F_{fine} V_{d1} + (1 - F_{fine}) V_{d2}$

Key Differences Between Dry Deposition Methods (continued)

- R_p calculation
  - Resistance (s/m) to particle deposition in the quasilaminar sublayer enveloping surface elements

$$R_{p,i} = \frac{1}{G_{adj} u_* \left(Schmidt_i^{2/3} + x_{inert} \right)}$$

Method 1 (diameter dependent)

$$R_p = \frac{500}{u_*}$$

Method 2 stable (L > 0)

$$R_p = \frac{500}{u_* \left(1 - \left(-300/L\right)\right)}$$

Method 2 unstable (L < 0)

Deposition – AERMOD 19191 update

- Method 2 and gas deposition converted to ALPHA options
  - Previously non-DEFAULT
  - Evaluation of both methods needed in AERMOD
  - Compare to other AQ models such as CMAQ
- Method 1 unchanged; can use DEFAULT keyword
- Always consult with appropriate reviewing authority on deposition use

Useful Links

- ISCST3 user's guide volume 2 (METHOD 1)
  - https://www3.epa.gov/ttn/scram/userg/regmod/isc3v2.pdf
- AERMOD user's guide
  - https://www3.epa.gov/ttn/scram/models/aermod/aermod_userguide.pdf
- AERMOD deposition algorithms document (draft)
  - https://www3.epa.gov/ttn/scram/7thconf/aermod/aer_scid.pdf
- Deposition report
  - https://www3.epa.gov/ttn/scram/7thconf/aermod/driscdep.zip
- Deposition presentation at 2018 Regional, State, and Local Modelers Workshop
  - Details and examples
  - http://www.cleanairinfo.com/regionalstatelocalmodelingworkshop/archive/2018/Presentations/2-5_2018_RSL-Particle_Deposition.pdf