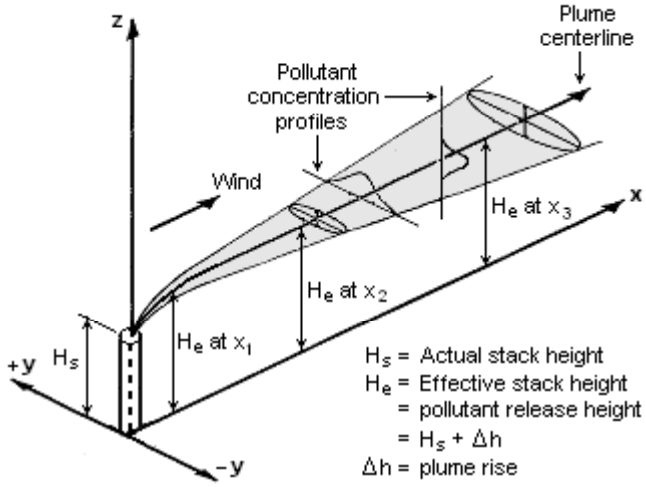
Modeling Concerns for Fugitive Sources in the Iron, Steel and Mining Industries

Chatten Cowherd, Ph.D.
MRIGlobal

For presentation at Modeling Conference in Research Triangle Park, NC
March 13, 2012

Overview

1. Modeling Concerns for the Iron, Steel and Mining Sector—Fugitive Sources
   - Emission factors
   - Particle size distributions
   - Source representation
   - PM_{10} and $PM_{2.5}$ depletion issues



2. Recommendations to Improve Accuracy

Modeling Challenges: Non-Stack Sources and Batch Processes

- AERMOD is best suited to model steady state emissions from unobstructed stacks, which do not represent many types of sources at iron, steel and mining facilities
- Conversely, fugitive sources in the iron, steel and mining industry pose challenges for accurate air modeling—for example
  - Roadways (paved and unpaved)
  - Handling and storage of many different raw materials and products
  - Emissions from roof vents
  - Slag pits – high temperature, water cooled, material handling operations at or below grade
- Characteristics of fugitive sources
  - Diffuse with spatial and temporal variations
  - Low-level releases with strong effects of obstructions to air flow

•AISI asks that EPA consider development of modeling refinements to address these types of problem sources before requiring modeling for NAAQS compliance

Roadways and Other Fugitive $PM_{10}/PM_{2.5}$ Emission Sources

- Emission Factors (AP-42)
  - Based on data mostly from the 1970s and 1980s
  - Intended to bracket “worst case” conditions
  - Not representative of current work practices that have achieved improvements in air quality (the Title V era)
- Particle Size Distributions (AP-42)
  - Test methods directed to TSP (total suspended particulate matter)
  - Particle size data supplementary with future expectation of size-specific air quality standards
- Test Methods for Open (Fugitive) Sources
  - Advanced on interim basis, without full standardization
  - Little data on cross-comparison (only one EPA-funded collaborative test)

Roadways and Other Fugitive PM_{10}/$PM_{2.5}$ Emission Sources

- It is well known and widely documented that atmospheric dispersion models used for predicting impacts from non-Gaussian fugitive sources lead to over-prediction of transportability and the resultant air quality impacts of fugitive dust emissions
- AERMOD does not account for:
  - Observed dust plume depletion (for both PM_{10} and $PM_{2.5}$) due to particle electrostatic agglomeration, enhanced gravitational settling and deposition near the point of release, all enhanced under low winds
  - Proper representation of source configuration (e.g., moving point source vs. continuously emitting line or elongated volume source)
  - Pit trapping of emissions released below grade
- AERMOD accuracy for fugitive dust during low wind speed conditions is suspect

Roadways and Other Fugitive $PM_{10}/PM_{2.5}$ Emission Sources

- Over-prediction (in the range of a factor-of-4) first became clear from receptor analysis of fugitive dust impacts at monitoring sites, in comparison with the predictions of mainstream dispersion models.
- Modeling deficiencies leading to over-prediction of fugitive dust impacts are summarized in the table below.

[Cowherd, C. Jr: “Transportability Assessment of Haul Road Dust Emissions”. Report Issued to USEPA. August 2009.]

Modeling Deficiencies for Roadways and Other Fugitive PM_{10}/ $PM_{2.5}$ Emission Sources

Table 4. Modeling Deficiencies for Dust Dispersion Analyses

Modeling deficiency	Estimated over-prediction	Principal Investigator—[Ref.]	Comments
Misrepresentation of haul roads as continuously emitting area sources	Factor of 2	Randy Reed (NIOSH)—[13]	Based on algorithm comparisons
Cumulative effects of modeling deficiencies	Factor of 4 for "average" groundcover	Pace (USEPA)—[1]	Based on comparisons of modeled with measured dust impacts for grid models.
Exclusion of near-source agglomeration and enhanced deposition	Up to a factor of 6, depending on wind and groundcover	Cowherd (MRI)—[7,8] Etyemezian (DRI)—[9]	Based on field tests of near-source impacts of unpaved road emissions with various adjacent groundcover types
Exclusion of trapping by vertical obstacles during horizontal transport	Factor of 2 to 6, depending on wind and groundcover	Yayi Dong (Idaho DEQ)—[15]	Based on modeling comparisons and field validation
Lack of treatment of pit trapping	Factor of 2	Randy Reed (NIOSH)—[13]	Extensive literature review that references model validation studies Cole (TRC)—[13]
Instant vertical mixing in grid models	Factor of 2	Yayi Dong (Idaho DEQ)—[15]	Applies to grid models only

[Cowherd, C. Jr.: "Transportability Assessment of Haul Road Dust Emissions." Report Issued to USEPA. August 2009.]

Recommendations for Over-prediction Adjustments

•Over-prediction of fugitive dust impacts has been offset by the "factor-of-four" correction (Countess[1]). EPA scientists at Research Triangle Park, NC made "divide-by-four" adjustments to CMAQ modeled concentrations to account for the significant discrepancy between predicted and observed impacts of fugitive dust sources (see Pace[2,3]).

Recommendations (see Cowherd[4])

1. Adopt an emissions pre-processing step (similar to CMAQ area-wide fugitive dust modeling)

2. Develop a set of emission reduction factors that offset AERMOD modeling deficiencies, based on the distinguishing characteristics of roadways and other source categories and the near-source dispersion environment

1) Countess, Richard. "Reconciling Fugitive Dust Emission Inventories with Ambient Measurements." Presented at Emission Inventory Conference. Available November 15, 2007, http://www.epa.gov/ttn/chief/conference/ei12/fugdust/countess.pdf

(2) Pace, Thompson G. Methodology to Estimate the Transportable Fraction (TF) of Fugitive Dust Emissions for Regional and Urban scale Air Quality Analyses. U.S. Environmental Protection Agency, Research Triangle Park, NC. August 3, 2005.

(3) Pace, T.G.; Cowherd, C. Jr.: "Estimating PM-2.5 Transport Fraction Using Acreage-Weighted Country Land Cover Characteristics—Examples of Concept," In Proceedings of the 96th Annual Meeting of the Air and Waste Management Association: San Diego, CA, June 2003.

(4) Cowherd, C. Jr: "Transportability Assessment of Haul Road Dust Emissions". Report Issued to USEPA. August 2009.

Summary

- Air dispersion models are not currently accurate enough to meet regulatory challenges – especially for fugitive, area, volume, and low-stack sources that are prevalent in the iron, steel and mining industry
- Steps to improve accuracy should include
  - Incorporate the emission deposition pre-processing step into the standard modeling protocol
  - Adjust the model to address wind speed-dependent emissions to avoid positive bias for fugitive and volume/area sources during low wind speed events
  - Re-examine the applicability of AP-42 emission factors and particle size distributions and adjust as necessary
- The number of modeling improvements needed is significant and will take time – AISI and MRIGlobal are available to assist EPA