Panel Session on Uncertainty in Atmospheric Transport and Dispersion Models

Moderator

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Panel Plan

- Moderator – Steve Hanna
- Rapporteurs – Pat Hayes (DTRA) and Katherine Snead (EPA OAR)
- Panelists (12 min each) - Dave Stauffer (Penn State), John Wyngaard (Penn State), Ian Sykes (Titan), Mike Brown (LANL), Joe Chang (HSI)
- Discussion (50 min)
- Wrap Up – Bruce Hicks (NOAA) and Mark Miller (NOAA)

Sources of Model Uncertainty

- Natural stochastic (turbulent) variations
- Input data (e.g., wind speed observations by anemometers and by radiosondes) have errors or are unrepresentative
- Physics assumptions in the model technical document are incorrect or inadequate or are inappropriate for the intended application
- Model parameters (e.g., scaling constants) are uncertain
- Coding/software errors
- The users guide is unclear about which input data to use and what switches to set, causing different users to get different results
- The model is best suited (tuned) for certain simple scenarios where field data are available. Uncertainties increase for source scenarios and met conditions that have not been so well studied.

Relation to uncertainty studies by other disciplines

- NRC, EPA, and others have a 20 year history of accounting for uncertainty in modeling – but not usually air quality modeling
- Books by experts (Hoffman, Cullen and Frey) usually focus on health risk models and other empirical models
- Many approaches exist and have been tested and published
- BUT – Some of the approaches are less useful for atmospheric models, since our models are deterministic and not empirical

Two approaches to predicting uncertainty

- **Direct -** The uncertainty (i.e., the pdf of C) is directly predicted by the model (e.g., HPAC/SCIPUFF), which includes formulas for internal plume fluctuations and meandering.

- **External -** The model does not directly predict the uncertainty. Instead the uncertainty is assumed to be caused by variations in inputs and model parameters and is estimated separately, through multiple model runs (ensembles), sensitivity studies, etc.

Overview of available external methods for estimating uncertainty, ordered by complexity

- Full Monte Carlo probabilistic (allows all inputs and model parameters to be simultaneously varied and correlations determined, but takes a lot of time, and may produce too much uncertainty)
- Ensemble method (a subset of the MC method with a few model runs sufficient to capture “spread”)
- Jackknife method (another subset of MC also called the “leave-out-one” method)
- Response surface methods (fits orthogonal functions to MC outputs – can be precalculated)
- One-at-a-time (OAT) sensitivity studies (not good for nonlinear systems)

Rules of Thumb Based on Experience

- Experts' experiences suggest "factor of two" uncertainty in dispersion model predictions in best scenarios
- Uncertainty increases to "factor of 5 or 10" for poorly defined scenarios or complex terrain and/or met conditions
- In- plume σ_C/C is about unity on the plume centerline for one-hour sampling times and is larger (factor of 5 to 10) on plume edges.
- Etc.