

Dispersion Modeling -- A Myriad of Options, An Array of Uses



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Items to be Addressed

- ✍ Purpose of Dispersion Modeling
- ✍ Brief History of Dispersion Modeling
- ✍ Screening vs. Refined Dispersion Modeling
- ✍ How to Select the Proper Dispersion Model
 - Which one works best for my needs
- ✍ Next Generation of Dispersion Modeling
- ✍ A Comparison of ISCST versus AERMOD Predictions
- ✍ Summary/Recommendations

Why Is Dispersion Modeling Necessary

Audience Participation Required

1. Dispersion Modeling is frequently a required part of the permit review process;
2. Dispersion Modeling is a tool used primarily to assure protection of ambient air quality standards;
3. Dispersion Modeling is an effective surrogate for on-site ambient monitoring;
4. It provides an opportunity for clients and consultants to work together on permitting projects; and
5. It provides for interesting discussions at CAPCA meetings.

History of Dispersion Modeling

- ✍ Let's start with focusing on the primary purpose of dispersion modeling – to assess ambient air quality impacts from new or modified sources
 - Early attempts at dispersion modeling used simplistic approaches to atmospheric motion
- ✍ Examples include:



History of Dispersion Modeling

- ✍ The Clean Air Act (CAA) established a greater purpose for dispersion modeling
- ✍ It became an important tool for quantifying impacts from new stationary sources relative to the “new” ambient air quality standards
- ✍ And, therefore part of the permit approval process
- ✍ Thus began the computer age of dispersion modeling

How Dispersion Modeling Has Changed Since 1970

✍ Early Days

- No Personal Computers; thus centralized processing of dispersion modeling runs
- Lengthy process; difficult to optimize through iterations
- Remember the computer punch cards?

✍ PCs eventually become primary mode of dispersion modeling

✍ Revolutionized both the procedural and strategic value of dispersion modeling

Dispersion Modeling Today

A Wide Variety of Choices to Meet Specific Needs

- ✍ Screening Models
- ✍ Refined Models
- ✍ Simple Terrain
- ✍ Complex Terrain
- ✍ Continuous Release
- ✍ Intermittent (Puff)
- ✍ Long Range Transport Models
- ✍ Dense Gas Models
- ✍ Visibility Models
- ✍ Fogging and Icing Models

? See 40 CFR 51 Appendix W for list of EPA-approved models

Proper Selection of Dispersion Models

Screening Models

✍ Advantages

- Quick run time
- Valuable as an initial tool to determine project feasibility
- Minimal input required
- Conservative

✍ Disadvantages

- Limited versatility (single source modeling)
- Quicker computers ? Less reasons not to use refined techniques
- Conservative

Screening Dispersion Models

SCREEN3

- ✍ Relatively easy to run
- ✍ Interactive format for input parameters
- ✍ Built-in meteorology
- ✍ Computes concentrations in both simple and complex terrain (utilizing VALLEY model algorithms)
- ✍ Includes algorithm for consideration of building downwash
- ✍ Calculates impacts within building cavity
- ✍ Single source model
- ✍ Results are expressed as 1-hour averages in simple terrain and 1 and 24-hour averages in complex terrain

Screening Dispersion Models

ISCST3

- ✍ ISCST3 can be run in either screening or refined mode
- ✍ Screening computations based on same basic algorithm as used in SCREEN3
- ✍ Can be used in both simple and complex terrain
 - though ISC only has EPA-preferred status for receptor elevations between ground level and final plume rise
- ✍ As a screening model it offers advantages to SCREEN3
 - Multiple sources
 - Greater model output options
 - Multiple averaging periods
- ✍ But, it does not calculate impacts within building cavity area

Screening Dispersion Models

CTSCREEN

- ✍ Screening version of CTDMPLUS model
- ✍ CTSCREEN provides impact calculations in complex terrain
- ✍ Commonly used in PSD applications where there is a lack of representative meteorology
- ✍ Model does not include downwash calculations
- ✍ Model provides impact calculations for 1, 3, 24 hour and annual averaging periods
- ✍ Compared to other screening models, CTSCREEN is difficult to set-up – terrain is the main reason

Additional Screening Models

Other EPA “Preferred” Models – Not Commonly Used

- ✎ COMPLEX1 – Complex terrain model – replaced by SCREEN3 and CTSCREEN
- ✎ VALLEY – Algorithm incorporated in SCREEN3
- ✎ CAL3QHC – Used for traffic modeling
- ✎ LONGZ – Used to calculate long-term impacts (seasonal/annual)
- ✎ SHORTZ – Similar to LONGZ but for short-term averaging periods
- ✎ RTDM – Rough (complex) terrain model
- ✎ VISCREEN – Used to assess the visual impacts of a plume (not to be confused with regional haze)

Refined Dispersion Modeling

Current List of EPA-Preferred Refined Models

- ✍ BLP – Buoyant Line Plume – Early refined model developed to address aluminum reduction plants – and similar facilities.
- ✍ CALINE3 – Designed to assess impacts from highway-related air pollution sources.
- ✍ CALPUFF – Sophisticated model becoming widely used for far-field predictions
- ✍ CTDMPLUS – Complex Terrain Dispersion Model plus Algorithms for Unstable Situations
- ✍ ISCST3 – Industrial Source Complex Model – Current workhorse of refined models.
- ✍ OCD – Offshore and Coastal Dispersion Model – Developed to predict impacts of offshore emissions on coastal areas.
- ✍ Where's AERMOD???

Refined Dispersion Modeling

- ✍ AERMOD not yet an EPA-preferred model (more on that later)
- ✍ ISC is currently the most widely used refined dispersion model (and has been for about 20 years)
- ✍ Provides impact computations for:
 - Single or multiple sources;
 - In simple or complex terrain (remember preferred status limitation);
 - For point, area or volume sources;
 - In rural or urban dispersion environments;
 - Uses hourly, on-site or sequential National Weather Service (NWS) meteorological observations.
- ✍ Currently accepted for *almost* any permit application.

Refined Dispersion Modeling

More About ISC

- ✍ Model comes in Short-term (ST) and Long-term (LT) versions
- ✍ A good decision-making tool/model of choice for air quality analyses supporting the permitting of new or modified sources
- ✍ Very valuable for source/impact optimization and strategic decision-making
 - Stack height optimization
 - Emission point location
 - Determining allowable emission limits
 - Determination of allowable permit flexibility
- ✍ Just remember that the model does not calculate impacts within cavity regions

Refined Dispersion Modeling

More About ISC

- ✍ The model is thought to be quite conservative in downwashing situations, especially for hot, buoyant plumes
- ✍ This led EPRI to sponsor the development of the **Plume Rise Model Enhancements (PRIME)** algorithms
- ✍ PRIME has been incorporated into the overall ISC code (called ISC-PRIME)
- ✍ PRIME does reduce predicted impacts for certain downwashing scenarios
- ✍ ISC-PRIME includes cavity calculations
- ✍ ISC-PRIME is not EPA approved, consult your permitting authority prior to use

Refined Dispersion Modeling

- ✍ ISC does have it's limits of usefulness
- ✍ Especially where receptors are at distances greater than 50 kilometers from the source
 - Example would be PSD permitting where Class I area is greater than 50 km from source or
 - Modeling domain (cumulative impact analysis) extends beyond 50 km (such as due to large SIA)
- ✍ Steady-state nature of plume and atmospheric dispersion parameters breaks down
- ✍ Enter.....CALPUFF

Refined Dispersion Modeling

CALPUFF

- ✍ CALPUFF is an EPA-preferred model for distances greater than 50 km
- ✍ CALPUFF is a non steady-state “puff” dispersion model
- ✍ Unlike ISC, CALPUFF allows for a non-straight line plume trajectory
- ✍ CALPUFF can be run in its diagnostic mode using the CALMET processor, or
- ✍ It can be run in its screening mode (CALPUFF-Lite) using input directly from the ISC model.

CALPUFF/ISC Comparison

ISC

- ✍ EPA-preferred for distances up to 50-km
- ✍ Steady-state plume trajectory
- ✍ Meteorology varies based on one site, only
- ✍ Plume “instantaneously” at receptor
- ✍ Single land-use classification

CALPUFF

- ✍ EPA-preferred for distances of greater than 50 km
- ✍ Non steady-state plume trajectory
- ✍ Meteorology varies temporally, spatially and 3-dimensionally
- ✍ Plume allowed to meander to receptor
- ✍ Land-use can vary over domain

Next Generation of Dispersion Modeling

- ✍ Will consist primarily of CALPUFF and AERMOD
- ✍ What is AERMOD and what does the word mean?
 - AERMOD was jointly developed by the American Meteorological Society (AMS) and EPA
 - AERMIC = **A**MS/**E**PA **R**egulatory **M**odel **I**mprovement **C**ommittee
 - AERMOD = AERMIC Dispersion Model

AERMOD Development

- ✍ 1991 -- Development of model starts
- ✍ 1998 -- Public access to model made available via EPA's SCRAM website
- ✍ 2000 – AERMOD Proposed as replacement for ISC
- ✍ 2003 – PRIME downwash algorithm proposed for incorporation into AERMOD
- ✍ SOON – AERMOD to gain EPA-preferred status formally replacing ISC as America's dispersion model workhorse

AERMOD Facts

- ✍ AERMOD has 3 components:
 - AERMOD (“the” model)
 - AERMET (AERMOD met data processor)
 - AERMAP (AERMOD terrain preprocessor)
- ✍ AERMOD represents major enhancements in the simulation of small-scale turbulent features of the atmosphere
- ✍ Improved simulation of plume interaction with elevated receptors

IS AERMOD Really An Improvement?

- ✍ Regardless of who is defining the word “improvement”, AERMOD really is an improvement over ISCST
- ✍ Physically, the model represents a definite leap in sophistication
- ✍ For the end-user the model does deliver as expected
- ✍ Most, but not all, comparisons between ISC and AERMOD show that AERMOD’s predictions are lower

ISCST/AERMOD Comparison

- ✍ Information extracted from several literature sources
- ✍ AERMOD consistently predicts lower impacts than ISC for:
 - receptors in complex terrain
 - shorter stacks in rural environments
- ✍ The AERMOD “improvement” tends to increase as averaging period time decreases
- ✍ The differences in predicted impacts tend to be less for non-downwash scenarios

ISC/AERMOD Comparison

- ✍ For downwashing plumes, AERMOD's predictions are relatively close to those predicted by ISC-PRIME, but considerably lower than impacts predicted by ISC with the standard downwash algorithms.
- ✍ Summary of snapshot example study (in Louisiana) of predicted impacts by AERMOD and ISCST:
 - Annual averaging period -- AERMOD ? ISCST = 0.676
 - 24-hour averaging period – AERMOD ? ISCST = 0.593
 - 1-hour averaging period – AERMOD ? ISCST = 0.498

ISC/AERMOD Comparison

- ✍ Lower predicted impacts come with a price
 - Full AERMOD analyses take longer (labor time) than equivalent ISCST runs by a factor of 2 to 3
- ✍ Model run time increases dramatically also
 - For previous snapshot example, average ISCST runs took 19 minutes, while average AERMOD runs took 4 hours 17 minutes
- ✍ This difference will likely decrease with time – remember how long ISCST used to take to run?

All Good Things Must Reach Closure

Summary/Model Selection Recommendations

- ✍ Dispersion modeling has taken quantum leaps forward in sophistication
- ✍ We are entering a new generation of dispersion modeling procedures – this has advantages and disadvantages
- ✍ Screening models – quick to run, minimal expertise required, conservative predictions
- ✍ Refined modeling – Best done by expert, reasonably longer model run times*, less conservative predictions
- ✍ CALPUFF – Use for distances beyond 50 km

Summary/Model Selection Recommendations (continued)

- ✍ Make sure model is approved by EPA for a specific application, otherwise discuss with local permitting authority.
 - Modeling protocols are valuable
- ✍ AERMOD will soon replace ISC as the workhorse model.
 - Will likely result in lower predicted impacts than ISCST
 - But will cost more to set-up, and will take longer to run.
 - Consider obtaining approval from local permitting authority to run ISC-PRIME
- ✍ Enjoy the remainder of the conference, and thank you for your participation.