Environmental
Programs

Technical Highlights of EPA's 7th Conference on Air Quality Modeling

Workshop Guide

APTI Workshop T-029

DAY 1

Developed by Environmental Programs - North Carolina State University
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Industrial Extension Service College of Engineering North Carolina State University

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Fax Question Sheet

APTI Workshop T-029

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August 1, 2000

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APTI Workshop T-029

Technical Highlights of EPA's 7th Conference on Air Quality Modeling

Presented by OAQPS

Broadcast Agenda
August 1, 2000 1:00pm ET DAY 1

SECTION		TOPIC
1		Introduction *Jim Dicke* and *Joe Tikvart*
2		**AERMOD** Introduction, Background and History *Jeffrey Weil* Model Overview *Alan Cimorelli* Consequence Analysis *Warren Peters* Regulatory Niche *Robert Wilson*
	10 MIN.	**BREAK**
3		**ISC-PRIME** Intro & Motivation for PRIME Development *Chuck Hakkarinen* Technical Description of PRIME *Joseph Scire* Independent Evaluation of PRIME vs ISC3 *Robert Paine*
	10 MIN.	**BREAK**
4		**CALPUFF** Introduction *John Vimont* Technical Overview *Joseph Scire* Regulatory Niche *John Irwin*
	10 MIN.	**BREAK**
5		**Emissions & Dispersion Modeling Systems (EDMS)** *Julie Draper* *Theodore Thrasher* *Roger Wayson, Ph.D.*
		Wrap up

Technical Highlights of EPA's 7th Conference on Air Quality Modeling Presenters

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Introduction

Jim Dicke

Objectives

- Technical Presentations on June 28, 2000
- Summary of Statements/ Presentations on June 29, 2000
- Q/A Session - Panel Discussion on the 7th Conference

EPA's Regulatory Docket: A-99-05

- Transcript
- Public Comments
- Federal Register - May 19, 2000 pp. 31858 - 31859

The AERMOD System AMS/EPA Regulatory Model Improvement Committee (AERMIC)

Jeff Weil
University of Colorado CIRES

Outline

1. Introduction - Jeff Weil
2. Overview and Model Evaluation
   Al Cimorelli
3. Consequence Analysis
   Warren Peters
4. Regulatory Implementation
   Rob Wilson

History and Motivation

- 1970s & 80s - Significant advances in understanding turbulence and dispersion in the Planetary Boundary Layer (PBL)
- 1984 - AMS/EPA Clearwater Workshop on Updating Applied Diffusion Models

History and Motivation

- 1980s to early 90s - Development of new applied dispersion models: PPSP (1984), OML (1986), HPDM (1989), CTDMPLUS (1989), ADMS (1992)
  - But no new regulatory model

History and Motivation

- 1991 - AMS/EPA workshop for state and EPA meteorologists on PBL parameterization
- 1991 - Formation of AERMIC

AERMIC Members

- J. Weil (Chairman), R. Paine, A. Venkatram (AMS)
- A. Cimorelli, R. Lee, S. Perry, W. Peters, R. Wilson (EPA)

AERMIC Objective

- Introduce state-of-the-art modeling concepts into an EPA air quality model for regulatory applications

Focus: Replacement for the ISC Model

- ISC widely used in regulatory applications
- ISC contains several outdated concepts and practices such as:
  - Dispersion based on the Pasquill-Gifford-Turner scheme for surface sources; stability classes

Focus: Replacement for the ISC Model

  - Plume penetration of inversions - all or none
  - Complex terrain - no intermediate terrain treatment

AERMOD: A New Design for Regulatory Plume Modeling

- Dispersion based on planetary boundary layer turbulence structure, scaling, and concepts
- Surface and elevated sources
- All terrain heights relative to stack height included

AERMOD Design Criteria

- Includes state-of-the-art science
- Captures the essential physical processes
- Provides robust concentration estimates over a wide range of meteorological conditions

AERMOD Design Criteria

- Is easily implemented - simple inputs and resources,user friendly
- Can evolve - accommodates modifications with ease

AERMOD Development Process

- Model formulation
- Extensive model evaluation (10 data bases)
- Model to model comparisons (AERMOD, ISC, HPDM,CTDMPLUS, COMPLEX 1, RTDM)

AERMOD Development Process

- Review and public participation
  - Internal peer review (EPA)
  - External peer review
  - Beta testing (Two stages)
  - Model formulation available (Internet 1995, 1998, 2000)

AERMOD Development Process

  - Conference papers (1992, 1994, 1996, etc)
  - Presentation at EPA's 6th Modeling Conference (1995)
- Submission to EPA-OAQPS (This conference)

AERMOD Overview And Evaluation Results

Alan J. Cimorelli
EPA Region III

Outline

- Context
- Considerations
- AERMIC approach
- Evidence
- Conclusions

Context

Should AERMOD be adopted as a replacement regulatory model for ISC3?

Considerations

- Design value comparisons
- User community
  - Publicly available with adequate documentation
  - Easy to use & reasonable inputs

Considerations

- Improved confidence
  - Theoretical basis with peer review
  - Compare across the full distribution
  - Amount and diversity of observed comparisons

AERMIC Approach

- Up-to-date science with extensive peer review
- Comparison statistics: Robust High Concentration (RHC) and Q-Q plots

AERMIC Approach

- Evaluated using 10 databases
- Reasonable input demands
- Publicly available on SCRAM with extensive documentation

Improved Science

- Meteorology
  - Profiles of wind, temperature and turbulence
  - Treats vertical inhomogeniety

Improved Science

- Dispersion
  - Plume spread from turbulence
  - Special treatment for surface releases
  - SBL meander
- Terrain: dividing streamline concept applied at each receptor

Improved Science

- Convective Boundary Layer
  - Bi-Gaussian vertical concentration distribution
  - Improved treatment of highly buoyant plumes

Improved Science

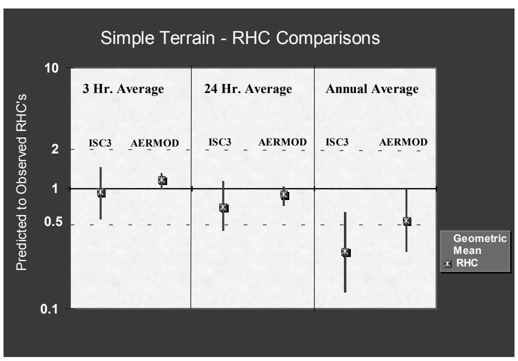
- Urban
  - Turbulence is enhanced by urban induced heat flux
  - Source specific urban/rural option

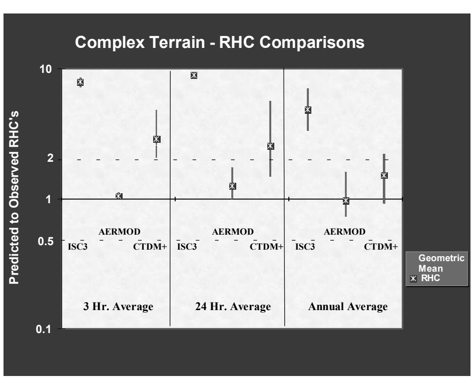
Model Evaluation

- Developmental and Performance
  - 10 databases - 5 for each phase
  - Both intensive & full year studies
  - Release heights: near-surface to > 200m
  - Downwind distances: 50m to 50km
  - Simple terrain, complex terrain and urban

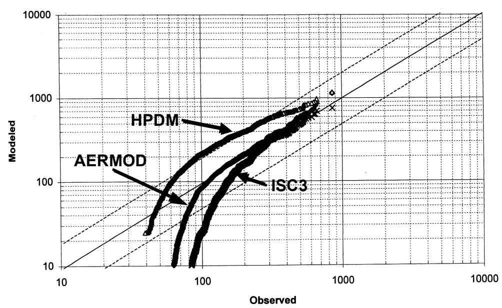
Model Evaluation

- Evaluation Statistics:
  - RHC
  - Q-Q Plots
- Model to Model Comparisons:
  - Existing regulatory: ISC3, CTDMPLUS & RTDM
  - Other submitted: HPDM

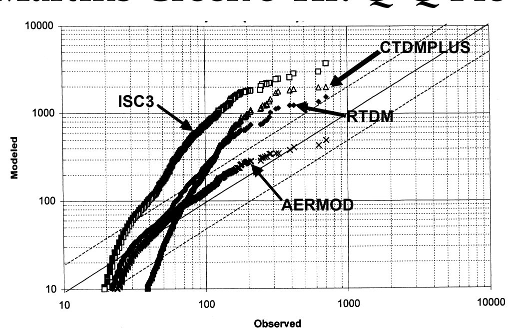




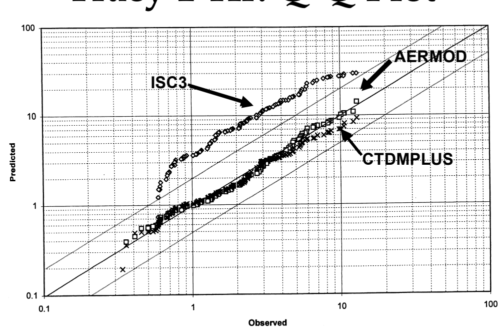
Clifty Creek 3-Hr. Q-Q Plot



Martins Creek 3-Hr. Q-Q Plot



Tracy 1-Hr. Q-Q Plot



Conclusions

- AERMOD estimates design values better then ISC3 & CTDMPLUS
- AERMOD contains more current science then does ISC3

Conclusions

- AERMOD out performs both ISC3 and CTDMPLUS over the entire concentration distribution
- AERMOD's implementation burden is similar to ISC3 - easy to use and readily available

Therefore

There is adequate evidence to support the proposed action of replacing both ISC3 and CTDMPLUS with AERMOD

Consequence Analysis for the AERMOD Modeling System

Warren Peters
US EPA

Background

- Provides comparison of between existing and proposed guideline air dispersion models
- Is not a regulatory requirement

Background

- Includes 76 combinations of:
  - source types
  - stack heights
  - environments
  - meteorological settings
  - terrain scenarios

Background

- Adds computer timings
- Provides experience with AERMOD
- Find report on website:
  - http://www.epa.gov/scram001/
  - look for the 7th Modeling Conference

Ratio of Regulatory Design Concentrations

(AERMOD/ISCST3)-Flat And Simple Terrain

	-------- High 2nd High ----------------			
	1 hour	3 hour	24 hour	Annual
Average ratio over all runs	1.03	1.10	1.22	1.33
Highest ratio	3.15	2.67	3.41	3.89
Lowest ratio	0.28	0.26	0.22	0.30
Total run number	48	48	48	48

Ratio of Regulatory Design Concentrations

(AERMOD / ISCST3)-Complex Terrain

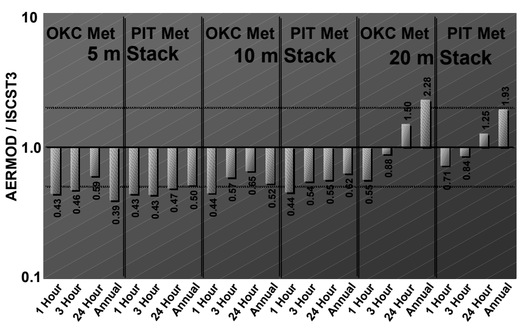
	-------- High 2nd High ----------------			
	1 hour	3 hour	24 hour	Annual
Average ratio over all runs	0.310	0.209	0.188	0.191
Highest ratio	0.732	0.388	0.393	0.504
Lowest ratio	0.085	0.077	0.076	0.092
Total run number	28	28	28	28

Ratio of Regulatory Design Concentrations

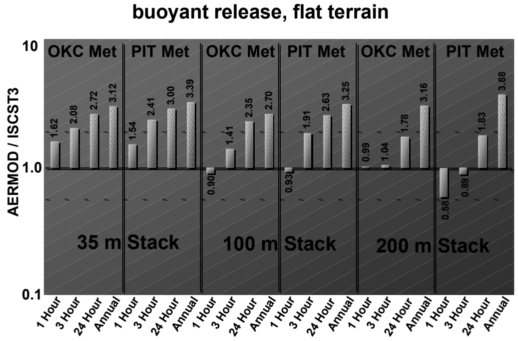
(AERMOD / CTDMPLUS)-Complex Terrain

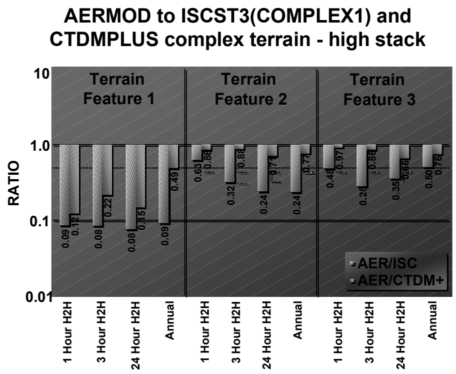
	-------- High 2nd High ----------------			
	1 hour	3 hour	24 hour	Annual
Average ratio over all runs	0.760	0.790	0.743	0.721
Highest ratio	2.133	1.765	1.537	1.24
Lowest ratio	0.123	0.186	0.147	0.373
Total run number	28	28	28	28

High-second high concentration
non-buoyant release, flat terrain



High-second high concentration
buoyant release, flat terrain





General Conclusions

- AERMOD provides different, sometimes significantly different results
- The results from the consequence analysis are generally consistent with the model evaluation results

General Conclusions

- AERMOD was quickly learned - very similar to ISC
- The computer run times -
  - 5-6 times slower - point, volume source
  - 2-3 times slower - area source

AERMOD
Regulatory Implementation

Robert Wilson
U.S. EPA Region 10

Outline

- General Applicability
- Screening for AERMOD
- AERMOD or ISC-PRIME or both
- AERMOD or CTDMPLUS
- AERMAP
- AERMET
- AERMOD

General Applicability

- Replace ISC with one year transition
- Industrial sources - point, volume, area
- Simple and complex terrain
- Steady-state conditions - up to 50 km
- No deposition

Screening for AERMOD

- SCREEN3
  - Point, Area, Volume, and Flare sources in simple terrain
  - Stable plume impact for point sources in complex terrain (Valley Model)
- CTSCREEN
  - Terrain above stack top

AERMOD, ISC-PRIME or Both?

- AERMOD - general application, all terrain
- ISC-PRIME - "if dry deposition or … downwash is important…"

AERMOD, ISC-PRIME or Both?

- Implementation Issues
  - How does one determine whether or not downwash is important?
  - If downwash is important, should one use ISC-PRIME in place of AERMOD, or both models?

AERMOD, ISC-PRIME or Both?

- If one uses both models, for what sources and receptors, and during what meteorological conditions should each model be applied?
- Use of two models could be obviated if PRIME algorithms are implemented in AERMOD

AERMOD, ISC-PRIME or Both?

- In general, apply AERMOD for industrial sources
- If downwash is important, apply ISC-PRIME for downwash sources in downwash impact area
- For analyses involving deposition, apply ISC-PRIME

AERMOD or CTDMPLUS?

- For typical situations, apply AERMOD
- If details of plume interaction with elevated terrain is important, and adequate meteorological data are available, CTDMPLUS may be applied

AERMAP

- Terrain data required for all applications
- U.S. Geological Survey Digital Elevation Model (DEM) data available at http://edcwww.cr.usgs.gov/doc/edchome/ndcdb/ndcdb.html
- Generally, use 7.5-minute (1:24,000) DEM data

AERMAP

- Use regular grids and discrete receptors to identify maximum impacts in complex terrain - coarse to fine receptor spacing
- Source elevations - AERMAP or user specified; use caution close to source

AERMAP

- Domain extent can effect concentration estimates
  - Use caution with disparate terrain features
  - May require multiple runs with different domains

AERMET
Minimum Meteorological Data Required

- wind speed ($7z_o$ to 100 m)
- wind direction
- ambient temperature (z_o to 100 m)
- cloud cover
- morning radiosonde observation
- surface characteristics (user specified)
  - surface roughness, Bowen ratio, albedo

AERMET

- Representativeness of Met Data
  - adequate to construct realistic and reasonably representative boundary layer profiles
  - proximate to source; similar surface characteristics
  - wind and temperature profiles up through plume height

AERMET

- Representativeness
  - laterally and vertically representative of transport and dispersion within the domain
  - different representativeness criteria for each variable
  - case-by-case subjective judgements required

AERMET

- Representativeness
  - NWS surface (airport) data may be used if adequately representative
  - "Meteorological Monitoring Guidance for Reg. Modeling Applications," EPA-454/R-99-005, Feb. 2000, http://www.epa.gov/scram001/
- Missing Data - use appropriate missing value code

AERMOD

- Operation similar to ISCST3
- Regulatory default control option
- Urban option

The ISC-PRIME Model

Introduction and Motivation for its Development

Chuck Hakkarinen
EPRI

PRIME History

- Development of Plume Rise Model Enhancements (PRIME) began in 1993 to address existing model limitations
  - Limited comparisons with field data

PRIME History

- Based on wind tunnel observations for:
  - winds perpendicular to building face
  - neutral stability, moderate to high wind speed
- Location of stack not considered

More Limitations with Existing Models

- Plume buoyancy not considered in determining interaction with building wake
- Vertical wind speed shear not considered

More Limitations with Existing Models

- No descent of mean streamlines in lee of building
- No linkage between cavity and far wake models

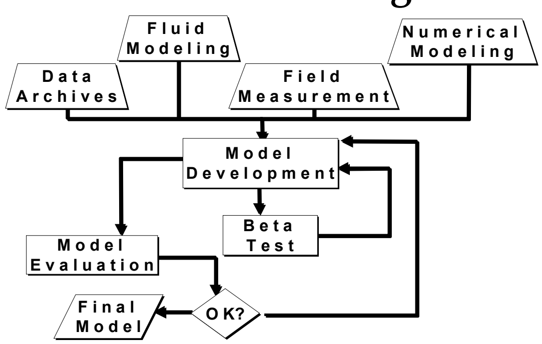
Key Features of PRIME

- Modular - can plug into various air quality models
- Empirical streamlined deflection (based primarily on EPA wind tunnel data)

Key Features of PRIME

- Wake dimensions dependent on wind angle to building (based on EPA tunnel data & concepts from Fackrell, Wilson)
- Numerical plume rise model that includes streamline deflection, vertical wind speed shear, location of stack

PRIME Paradigm



PRIME Players

- Funds provided by 10 utilities
- In-kind contributions from:
  - Electricity Supply Association of Australia
  - National Center for Atmospheric Research
  - Jersey Central Power & Light
- Project managed by EPRI

PRIME Players

- Earth Tech (model development & evaluation)
- ENSR (field and archival data collection, independent model evaluation)
- Monash University (wind tunnel simulations)

PRIME Players

- NCAR (field data collection)
- Washington State University (numerical modeling)
- STMI (project coordination, beta testing)

PRIME Presentations

- This Introduction (Chuck Hakkarinen, EPRI)
- Model Description (Joe Scire, Earth Tech)
- Model Evaluation (Robert Paine, ENSR)

CALPUFF - Overview of Capabilities

Joseph S. Scire
Earth Tech, Inc.

Overview

- Integrated Modeling System
  - Diagnostic Meteorological Model (CALMET)
  - Non-steady-state Puff Model (CALPUFF)

Overview

- Postprocessors (CALPOST, PRTMET)
- Graphical User Interfaces (GUIs)
- Terrain, Landuse, and Meteorological Processors

Design Specifications

- Suitable for:
  - Fence-line impacts (~ meters) to long-range transport (hundreds of km)
  - Averaging times from one hour to one year
  - Wet and dry deposition calculations
  - Simple chemical transformation (SO_x, NO_x, SOA)

Design Specifications

- Plume extinction/visibility effects
- Complex terrain
- Coastal areas, over-water transport
- Calm, stagnation, recirculation, reversing flows
- Point, area, line, and volume sources
- Cumulative impact assessments

Why Use a PUFF Model?

- Non-steady-state conditions
  - Causality effects
  - Curved, recirculating, stagnating flows

Why Use a PUFF Model?

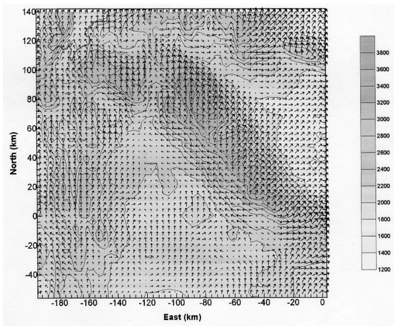
- Spatial variability in met. fields
  - Coastal effects, terrain-induced flow effects
  - Non-homogeneous land use and surface characteristics

Why Use a PUFF Model?

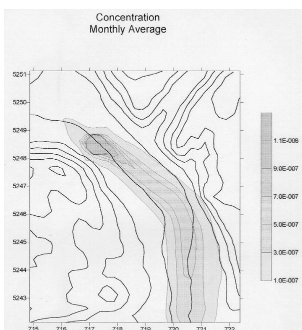
- Cumulative impact analyses
  - Many sources within a spatially-varying flow field
- Calm/light wind speed conditions
  - Multiple hours of emissions contributing
  - Pollutant buildup and fumigation

ANIMATION

Complex Winds



Terrain Channeling



Major Features

- Source types (buoyant or non-buoyant)
  - Point, area, volume, or line sources
  - Constant, cyclical, or arbitrarily-varying emissions and source parameters

Major Features

- Dispersion
  - Direct turbulence measurements
  - Similarity-theory (turbulence-based dispersion)
  - PDF for convective conditions
  - Pasquill-Gifford(rural)/ McElroy-Pooler(urban)
    - Time-averaging and roughness adjustments to PG curves

Major Features

- Dry deposition
  - Resistance model for gases and particulate matter
  - Predicts pollutant removal and deposition fluxes

Major Features

- Wet deposition
  - Scavenging coefficient approach
  - Function of precipitation type and intensity
  - Predicts pollutant removal and deposition fluxes

Major Features

- Chemistry
  - SO_2 to SO_4, NO_x to HNO_3/NO_3, SOA
  - Aqueous phase chemistry (SO_2 to SO_4)

Major Features

- Building Downwash
  - Huber-Synder, Schulman-Scire Downwash
  - PRIME (version out by Fall, 2000)

Major Features

- Subgrid-scale complex terrain module
  - Dividing streamline formulation (CTDM-like)
  - Lift and wrap components

Major Features

- Over-water/Coastal Interaction
  - Over-water PBL parameters
  - Plume fumigation
  - Subgrid scale coastal module (TIBL, coastline definition)

Major Features

- Wind shear effects
  - Puff splitting
    - Vertical splitting
    - Horizontal splitting (new)
  - Differential advection and dispersion
- Plume rise
  - Buoyant and momentum rise (pt, area, line, volume)

Major Features

- Partial penetration into elevation inversions
- Stack tip effects
- Building downwash effects
- Vertical wind shear effects
- Rain hat effects

Major Features

- Visibility
  - Light extinction coefficients
    - New FLAG Methodology (Method 6)
    - Deci-views and percent change in extinction
    - Sulfate, nitrate, coarse & fine PM, SOA, EC
- Interfaces to external programs/models

Major Features

  - MM5 - prognostic meteorological model
  - EPM - emissions production model
- Graphical User Interfaces (GUIs)

Recent Developments

- Horizontal puff splitting
- Boundary condition module
- Mass/flux tracking options
- Subgrid-scale coastal/TIBL module
- Flagpole receptors
- Rain hat option on stacks

Recent Developments

- Visibility
  - Flag methodology implemented
- Chemistry
  - Secondary organic aerosols
  - Aqueous phase chemistry
  - Non-linear repartitioning of NO_3

Recent Developments

- Processors
  - Appending files (APPEND)
  - Summing files (CALSUM)
  - Scaling files (CALSUM, POSTUTIL)
  - Repartitioning of HNO_3/NO_3 (POSTUTIL)
    - Source contribution analysis
    - Non-linear chemistry effects (NO_3)

Recent Developments

- Computation of total S and N deposition
  - Wet + dry deposition
  - S from SO_2, SO_4
  - N from NO_x, HNO_3, NH_3NO_3, $(NH_3)2SO_4$
- Addition of global terrain and land-use datasets, Canadian terrain data format

Recent Developments

- Fogging and icing (cooling towers)
  - Visible plume lengths
  - Frequency of plume-induced fogging and icing
  - Emissions processor (wet and hybrid (abated) cooling towers)
  - Postprocessors
    - Plume mode
    - Receptor mode

Data Requirements

- Routinely-available geophysical datasets
  - Terrain (USGS formats, Canadian formats, Global datasets)
  - Landuse (USGS CTG format, Global datasets)
- Meteorological data

Data Requirements

- Routine surface observations (CD144, SAMSON, HUSWO formats, generic (site-specific) data)
- Upper air data (NCDC or generic formats)
- Precipitation data
- Overwater (buoy) data (NOAA data)
- Optional prognostic meteorological data (MM5)

Data Requirements

- Ambient ozone monitoring data
  - AIRS dataset, CASTNET dataset
- Ambient ammonia data
  - CASTNET datasets
- Background plume extinction
  - FLAG report (lists values for each Class I area)
- Source and emissions data

Computer Needs

- Significant CPU requirements
  - Runtimes from few minutes (screening runs) to 1-2+ days (full 3-D simulations)
- Significant disk requirements
  - Meteorological fields (few MB to 10-20 GB)

Computer Needs

- But, current PCs adequate for virtually all regulatory applications
  - Modest cost ($3,500) for 1 GHz PC, 40 GB disk, 128 MB RAM

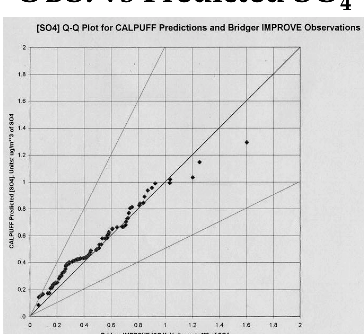
Model Evaluation

- SW Wyoming Air Quality Study
- MM5 meteorological modeling
  - 1995 simulation
  - 60 km, 20 km nest
- CALMET diagnostic modeling
  - MM5 as initial guess field

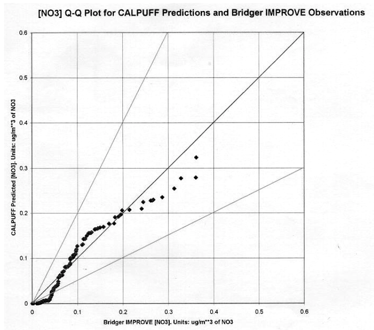
Model Evaluation

  - 4 km resolution (116 x 100 cells)
  - Terrain-enhanced precipitation
- CALPUFF modeling
  - Boundary condition module
  - Secondary Organic Aerosol (SOA) module
  - Visibility, acid deposition, ambient pollutant concentrations

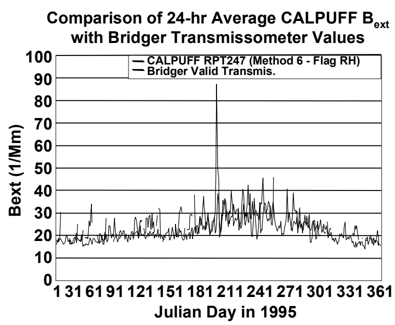
OBS. vs Predicted SO_4



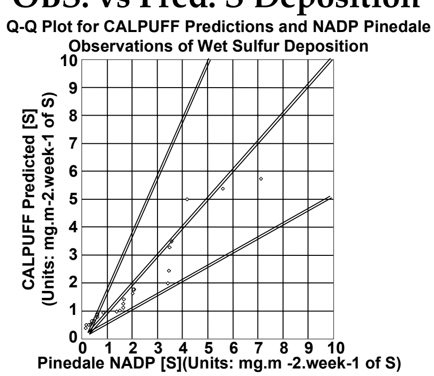
OBS. vs Predicted NO_3



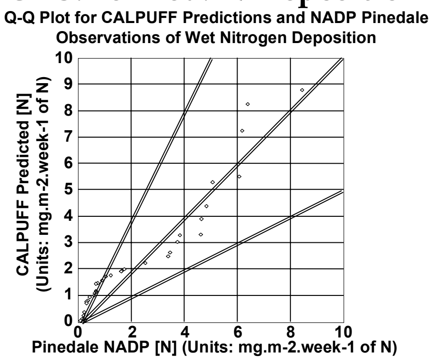
OBS. vs Predicted B_{ext}



OBS. vs Pred. S Deposition



OBS. vs Pred. N Deposition



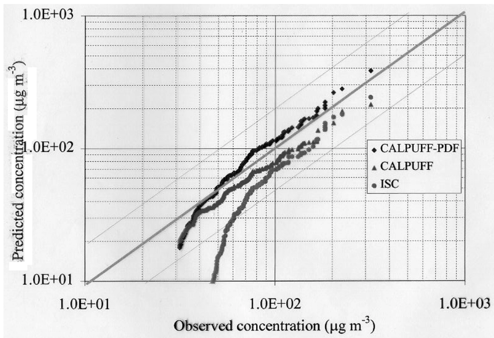
Near-field Evaluations

- Kincaid SF6 tracer study
  - Tracer releases from 187 m stack in flat terrain
  - 200 samplers in rings from 0.5 km - 50 km
  - 30 experiments of 6-9 hours duration
- Lovett SO_2 evaluation dataset

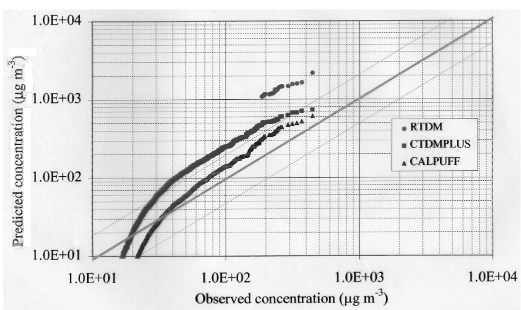
Near-field Evaluations

- Complex terrain in Hudson River Valley, NY
- Ambient monitoring along ridge near 145 m stack
- Samplers on ridge 2 km - 3.5 km from stack
- Peak terrain height ~ 340 m

Kincaid Evaluation



Lovett Evaluation



Project PRIME: Evaluation of Building Downwash Models Using Field and Wind Tunnel Data

Robert J. Paine
ENSR Corporation

Overview of Presentation

- Description of evaluation data bases
- ISCST3 and ISC-PRIME evaluation results
- Summary of overall model performance

Evaluation Database Search

- 8 tracer experiments
- 3 full-year monitoring networks
- 3 wind tunnel studies

Model Development Databases

- 1 full-year network (50% of days chosen at random)
- 4 tracer studies
- EPRI field study at Sayreville, NJ
- Wind tunnel data

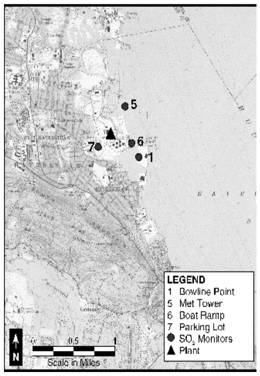
Independent Evaluation Databases

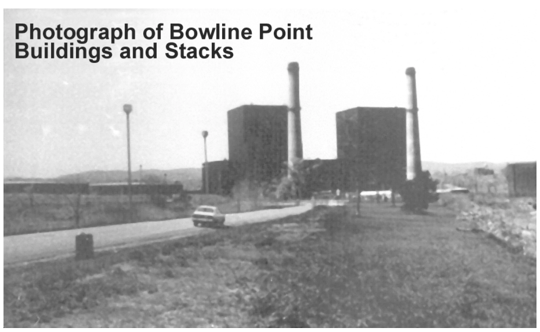
- 1 full-year network (Hudson River Valley)
- 2 tracer studies (AGA, EOCR)
- 1 wind tunnel study (Lee power plant)

Conventional Monitoring Network: Bowline Point

- Source type: electric utility
- Two 600 MW units
- 87-m stacks; buoyant release
- Number of hours: 8,760
- Location: Hudson River Valley
- Monitor Distances: 250-850 meters

Map of Bowline Point Monitoring Network





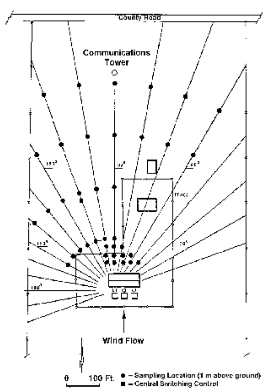
Tracer Site: American Gas Association (AGA) Study

- Source type: gas compressor station stacks
- Stack heights: 10-25 m high
- Release type: buoyant

Tracer Site: American Gas Association (AGA) Study

- Number of tracer hours: 63
- Locations: Texas and Kansas, summer period
- Tracer sampler coverage: 50-200 m

Layout of AGA Network



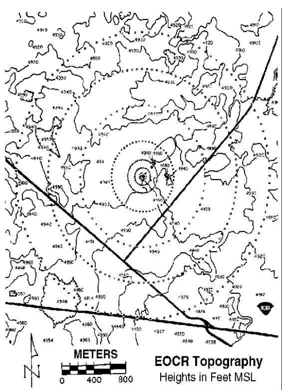
Tracer Site: EOCR Test Reactor

- Source type: non-buoyant releases from ground and rooftops
- Source height: 0, 25, and 30 meters
- Release type: non-buoyant

Tracer Site: EOCR Test Reactor

- Number of tracer hours: 22 (multiple tracers)
- Tracer sampler coverage: 7 rings at about 40, 80, 200, 400, 800, 1200, and 1600 meters

Layout of EOCR Network



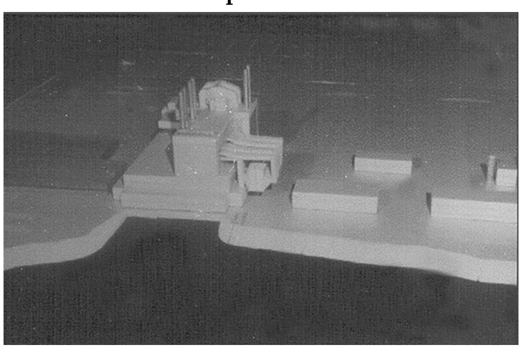
Wind Tunnel Study: Lee Power Plant

- Source type: steam boiler stacks
- Source height: 64.8 m high
- Release type: buoyant
- Number of hours: 1,062 runs with combinations of units, loads, and neutral versus stable conditions

Wind Tunnel Study: Lee Power Plant

- Location: Monash University wind tunnel, Australia (neutral and stable conditions simulated)
- Real-World Distance Coverage: 150-900 meters

Wind Tunnel Setup for the Lee Power Plant



Model Evaluation Procedures

- Fractional Bias Statistic:
- FB = 2 * [(Co - Cp) / (Co + Cp)],
- Co = avg. observed conc.; Cp = avg. predicted conc.
- FB = 0 for perfect model, +/- 2 for model with no skill
  - Procedures use Absolute FB (AFB)

Model Evaluation Procedures

- Composite Performance Measure (CPM): weighted average of AFB values over various 'regimes'
- Regimes consist of predetermined stability and wind speed categories

Model Evaluation Procedures

- Model Comparison Measure (MCM): difference of CPMs for two separate models
- If MCM with 95% confidence interval does not intersect zero, model performance is significantly different

Model Evaluation Procedures

- Bowline Point: Model Evaluation Methodology software from EPA, two monitors tested over full year
- AGA and EOCR: arc maxima used; resampling used to determine 95% confidence interval for CPM

Model Evaluation Procedures

- Lee Power Plant: centerline concentration used; resampling used to determine 95% confidence interval for CPM

Top Observed and Modeled Concentrations:

Bowline Point Monitor (μg/m³)

Rank #	Obs. Conc.	ISCST3 Conc.	ISC-PRIME Conc.
1	823.5	922.9	692.8
2	652.7	802.9	643.0
5	538.7	648.5	545.7
10	409.6	563.5	513.0
25	304.7	447.7	411.8
50	234.2	370.9	352.1
# Stable Cases	4	21	5

Top Observed and Modeled Concentrations:

Boat Ramp Monitor (μg/m³)

Rank #	Obs. Conc.	ISCST3 Conc.	ISC-PRIME Conc.
1	513.9	560.9	579.3
2	504.8	546.6	554.6
5	429.5	465.1	492.4
10	365.7	454.3	410.5
25	288.2	433.0	363.4
50	211.4	412.9	329.9
# Stable Cases	2	7	0

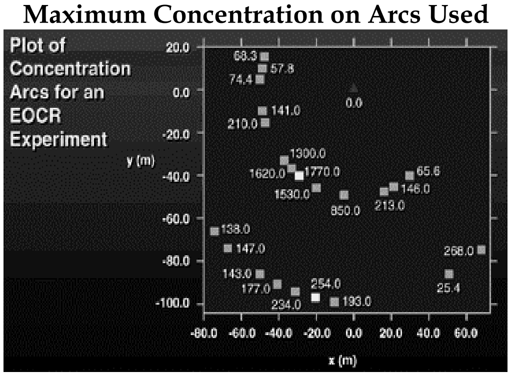
Results for Bowline Point

- For ISCST3, the Composite Performance Measure is 0.271 +/- 0.099
- For ISC-PRIME, the CPM is 0.134 +/- 0.095

Results for Bowline Point

- Model Comparison Measure, or difference of the CPMs, is 0.136, +/- 0.118 (does not intersect zero)
- Better performance of ISC-PRIME over ISCST3 is statistically significant

Maximum Concentration on Arcs Used



Results of Statistical Tests for AGA Data Base
(Upper Quartile Statistic Used)

- 95% limits on FB for ISCST3: -0.96 to -0.62
  - (pre/obs ratios): 1.90 to 2.85
- 95% limits on FB for PRIME: -0.47 to -0.015
  - (pre/obs ratios): 1.02 to 1.61

Results of Statistical Tests for AGA Data Base

- 95% confidence limits on differences in FB for the two models: -0.70 to -0.41
- ISC-PRIME overpredicts, but not as much as ISCST3
  - The difference in performance is statistically significant

Results of Statistical Tests for EOCR Data Base
(Upper Quartile Statistic Used)

- 95% limits on FB for ISCST3: -1.50 to -1.10
  - (pre/obs ratios): 3.44 to 7.0
- 95% limits on FB for PRIME: -0.92 to -0.036
  - (pre/obs ratios): 1.04 to 2.67

Results of Statistical Tests for EOCR Data Base

- 95% confidence limits on differences in FB for the two models: -1.10 to -0.52
- ISC-PRIME over-predicts, but not as much as ISCST3
  - The difference in performance is statistically significant

Results of Statistical Tests for Lee Data Base

(High Wind, Neutral Conditions)

- 95% limits on FB for ISCST3: 0.65 to 0.79
  - (pre/obs ratios): 0.43 to 0.51
- 95% limits on FB for PRIME: 0.16 to 0.32
  - (pre/obs ratios): 0.72 to 0.85

Results of Statistical Tests for Lee Data Base

(High Wind, Neutral Conditions)

- 95% confidence limits on differences in FB for the two models: 0.39 to 0.53

Results of Statistical Tests for Lee Data Base
(High Wind, Neutral Conditions)

- ISC-PRIME slightly under-predicts, and ISCST3 under-predicts somewhat more
  - The difference in performance is statistically significant

Results of Statistical Tests for Lee Data Base
(All Stable Conditions)

- 95% limits on FB for ISCST3: -1.80 to -1.70
  - (pre/obs ratios): 12 to 19
- 95% limits on FB for PRIME: -0.50 to -0.012
  - (pre/obs ratios): 1.01 to 1.67

Results of Statistical Tests for Lee Data Base
(All Stable Conditions)

- 95% confidence limits on differences in FB for the two models: -1.70 to -1.30
- ISC-PRIME slightly over-predicts, and ISCST3 grossly over-predicts
  - The difference in performance is statistically significant

Overall Conclusions on Independent Evaluation

- **ISC-PRIME is unbiased or over-predicts for each data base, so its use is protective of air quality**
- **ISCST3 is especially conservative for stable conditions; ISC-PRIME performs much better**

Conclusions

- **Under neutral conditions, the performance of the two models is more comparable, but ISC-PRIME is somewhat better**
- **ISC-PRIME has a statistically better performance result for each database**

CALPUFF and IWAQM Introduction

John Vimont
National Park Service

IWAQM History

- Need for LRT model to evaluate Class I area impacts
- IWAQM formed
- Phase 1 recommendation
  - ISCST (screen)
  - MESOPUFF II (refined)

IWAQM History

- 6th Modeling Conference
- Phase 2 Developed
  - CALPUFF Recommended
    - Screening Technique
    - Refined Analysis

CALPUFF Evaluations

- Tracer comparisons
  - Savannah River
  - Idaho Falls
  - Great Plains
  - Project Mohave
- Trajectory Comparisons
- Comparison with ISC3

Evaluation Conclusions

- Tracer
  - Magnitude and spread - Ok
  - Direction sensitive to observations
  - Generally "factor of 2"
  - Data availability affects results
  - Met data in complex terrain must be input cautiously
  - Need terrain treatment

Evaluation Conclusions

- Trajectories
  - Improved with use of FDDA "data"
- ISC3 Comparison
  - Steady State Meteorology
    - CALPUFF can emulate ISC3
  - With varying meteorology
    - CALPUFF similar with "simple flows"
    - Can be significantly higher if "complex"

LRT Screening Technique

- CALPUFF with single station met (5 years)
- Applicable to single source or closely grouped sources
- Receptor rings - use highest concentration anywhere on the ring
- Generally conservative, but not necessarily

LRT Refined Technique

- CALMET / CALPUFF
- 5 years NWS or minimum 1 year FDDA
- Receptors cover Class I area
- Applicable for multi-source impacts
- Use combined LRT & near-field

Phase 2 Recommendation

- Use Screen or Refined
- Include chemical transformation and removal
- PSD increment and NAAQS
- Visibility analyses
- Deposition of Sulfur & Nitrogen

Phase 2 & FLAG

- Analysis procedures for AQRVs
  - Phase 2 outlined procedures which were current, but changing
  - FLM responsibility
  - FLAG report represents FLM's unified guidance
  - Procedures in FLAG or provided by FLM should be followed

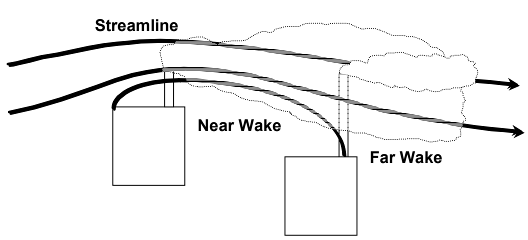
The PRIME Plume Rise and Building Downwash Model

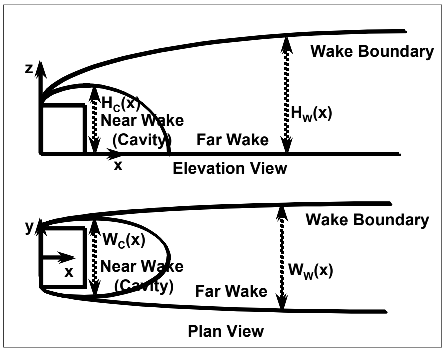
Joseph S. Scire
Earth Tech, Inc.

The EPRI Downwash Modeling Project

- Field measurements and wind-tunnel simulations
- Numerical model experiments
- PRIME model development
- Beta-testing and evaluation

Downwash Schematic for Two Stack Locations





Problems with ISC

- No consideration of:
  - stack location
  - streamline deflection
  - velocity deficit in wake
  - wind direction effects
  - linkage between near/far wakes

Problems with ISC

- Over-prediction during light wind speed, stable conditions
- Not valid in cavity
- Dispersion coefficients distorted to compensate for lack of streamline deflection

Key Features of PRIME

- Explicit treatment of plume path
  - numerical plume rise
  - streamline deflection
  - velocity deficit in wake
- Enhanced dispersion in wake
  - calculates turbulence intensity
  - P.D.F. for initial dispersion

Key Features of PRIME

  - eddy diffusivity beyond P.D.F.
  - turbulence decays to ambient
- Near/Far wake interaction
  - fractional capture by cavity
  - uniform mixing in cavity
  - captured mass re-emitted to far wake as volume source

Plume Rise

- Numerical solution of the mass, energy and momentum conservation laws
- Allows for increased plume growth due to building induced turbulence
- Includes wind shear effects

Plume Rise

- Applies in arbitrarily-varying temperature and wind stratification
- Accounts for initial plume size
- Non-Boussinesq (includes density effects)

Plume Rise

- Wind speed profile adjusted for wake velocity deficit
- Streamline ascent/descent added to rise
- Approximates Briggs' rise for uniform wind profile

Wake Dimensions

- Scale length $R=B_S^{2/3} B_L^{1/3}$
- Vertical Wake Boundary $H_W=1.2R(x/R+(H/1.2R)^3)^{1/3}$
- Horizontal Wake Boundary $W_W=W/2+R/3(x/R)^{1/3}$
- Downwind Cavity Length $L_R=1.8W/((L/H)(1+0.24W/H))$

Comparison of PRIME and ISC with Observations

- Alaska North Slope tracer study
  - combustion turbine (H_s/H_B=1.15)
  - 38 hours data with high winds
- Bowline Point Station
  - two 600 MW units (H_s/H_B=1.33)
  - half-year met, hourly emissions

Comparison of PRIME and ISC with Observations

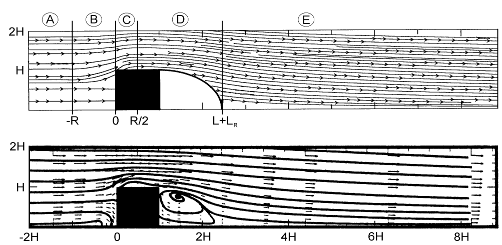
- EPA-Snyder wind-tunnel data
  - combustion turbines
  - steam boiler
- EPA-Thompson tunnel data
  - cavity observations
  - no buoyancy or momentum

EPA Wind-Tunnel Data

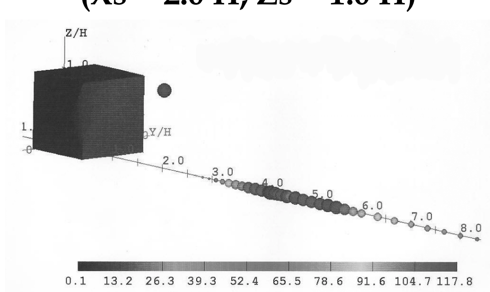
- About 300 concentration profiles for three plant types with variations of:
  - stack height
  - exhaust speed
  - wind angle
  - Froude number
  - stack location

EPA Wind Tunnel Streamlines for Steam Boiler Building

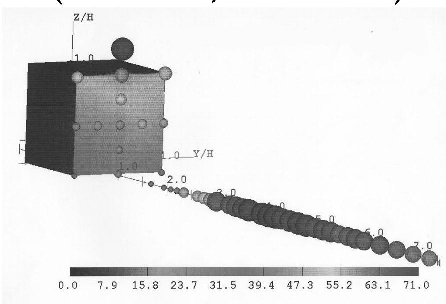
PRIME Calculates Mean Streamline Slopes



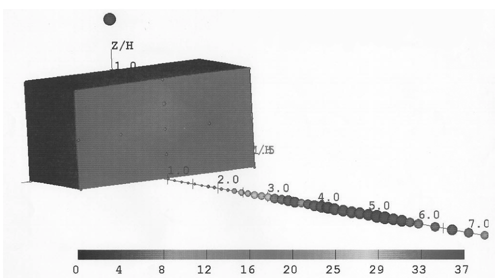
Building 1
(Xs = 2.0 H, Zs = 1.0 H)

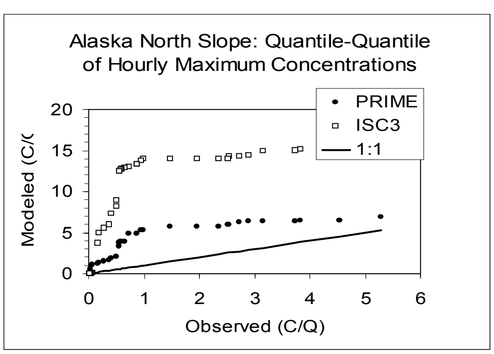


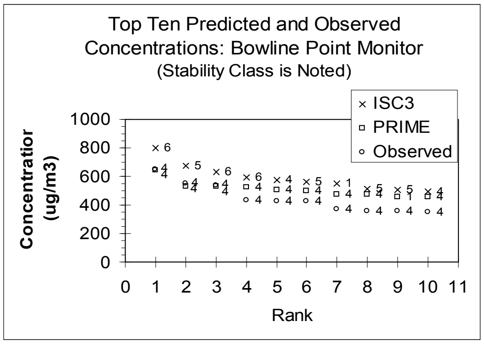
Building 1
(Xs = 1.0 H, Zs = 1.25 H)

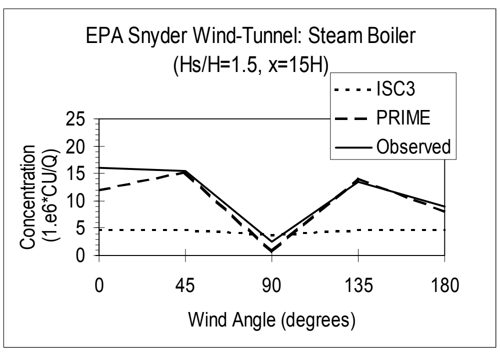


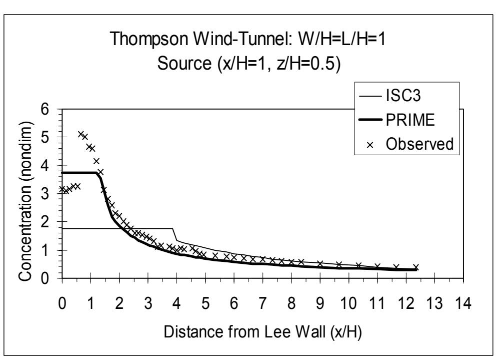
Building 2
(Xs = 0. H, Zs = 1.5 H)






Top Ten Predicted and Observed
Concentrations: Bowline Point Monitor
(Stability Class is Noted)
ISC3
PRIME
Observed
Concentratior (ug/m3)
Rank


EPA Snyder Wind-Tunnel: Steam Boiler
(Hs/H=1.5, x=15H)
ISC3
PRIME
Observed
Concentration (1.e6*CU/Q)
Wind Angle (degrees)


Thompson Wind-Tunnel: W/H=L/H=1
Source (x/H=1, z/H=0.5)
ISC3
PRIME
Observed
Concentration (nondim)
Distance from Lee Wall (x/H)

Summary

- PRIME incorporates observed plume behaviors:
  - enhanced dispersion in wake
  - plume trajectory affected by mean streamline deflections
  - location of source relative to building affects downwash

Summary

- PRIME considers both near and far wakes
- PRIME eliminates ISC discontinuities
- PRIME compared as well or better than ISC with field and wind-tunnel data

CALPUFF'S Regulatory Niche

John S. Irwin
Meteorologist
AQMG/OAQPS/EPA

Outline

- Where is CALPUFF discussed in 40 CFR Part 51?
- What are the meteorological requirements?
- What is long range transport?

Outline

- What are "complex winds"?
- What is a "case-by-case" analysis?
- Regulatory concerns and conclusions

40 CFR Part 51 CALPUFF

1 Section 3.2.2(e) - "case-by-case"

2 Section 6.2.1(e) - regional haze

3 Section 6.2.3 - long range transport

4 Section 7.2.8 - "complex winds" (note typo)

5 Section 8.3(d) - meteorology data

40 CFR Part 51 CALPUFF

6 Section 8.3.1.2(d) - length of meteorological record

7 Section 8.3.3.2(h) - turbulence

8 Section 8.3.3.2(k) - CALMET processor

9 Appendix A.4 - CALPUFF Summary (note typo)

Meteorological Requirements:

Sections 8.3(d), 8.3.1.2(d), 8.3.3.2(h), 8.3.3.2(k)

- Length of analysis varies:
  - 5 years with NWS data
  - less than 5 years with mesoscale meteorological fields
- Is site-specific data required? No
- Is use of CALMET required? Yes

Long Range Transport: Section 6.2.3

- What is it?
  - Impacts of concern involve transport that is greater than 50 km (Note, 'large domain application')
- Is there a recommended screening approach?
  - Perhaps, for an isolated source group

Long Range Transport: Section 6.2.3

- Is a protocol required? No
- What is role of FLM's?
  - To provide procedures for AQRV analyses

Complex Winds Section 7.2.8

- What are they ?
  - There are cases when the transport of interest is less than 50 km, when steady-state straight-line transport is inappropriate
    - "Case-by-case" analysis

Complex Winds Section 7.2.8

- Is there a recommended screening approach? No
- Is a protocol required? Yes

Case-by-Case Section 3.2.2(e)

1 Scientific peer review (new)
2 Model is applicable to the problem
3 Data necessary are available and adequate

Case-by-Case Section 3.2.2(e)

4 Appropriate evaluations show model is not biased towards under-predictions (edited)
5 Protocol has been established (new)

Regulatory Considerations

- EPA defines the regulatory version of the code
  - EarthTech Inc will provide the code and documentation
- The defaults provided are the suggested regulatory settings (But you still must use judgement - Do you need puff splitting?)

Regulatory Considerations

- Model switches not defaulted require expert judgment
  - May want to conduct 'side-analyses' to help in these decisions
- AERMOD and PRIME improvements

"We Are Not In ISC-Land Any More ..."

- This is a modeling system that demands experience and judgment
- If all you know is ISC3, and you think ISC3 is 'complex', you need not apply for the job

EDMS
The Emissions and Dispersion Modeling System

Julie Ann Draper, FAA
Theodore G. Thrasher, CSSI Inc.
Roger L. Wayson, Ph.D., P.E.

Introduction

Julie Draper
EDMS Program Manager
Office of Environment & Energy
Federal Aviation Administration

FAA Review Of Proposed Appendix W

FAA Proposal:

Enhancement of EDMS Description in Appendix W to Include AERMOD Dispersion Algorithms

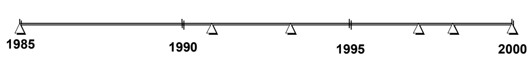
Topics of Discussion

- Introduction to EDMS and proposal
  - Julie Draper
- Changes to EDMS for AERMOD incorporation
  - Theodore Thrasher

Topics of Discussion

- EDMS evaluation plan for using AERMOD
  - Roger Wayson
- Concluding remarks
  - Julie Draper

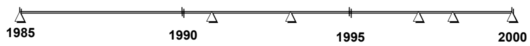
EDMS History



Developed by the FAA in cooperation with the USAF

- 1985 - Complex Source Microcomputer Model
- 1991 - EDMS
- 1993 - EPA Preferred Guideline Model

EDMS History



Developed by the FAA in cooperation with the USAF

- 1997 - Re-Engineered as EDMS 3.0
- 1998 - FAA Required Model for Aviation Sources
- 2000 - Current Version: EDMS 3.2
- 2001 - EDMS 4.0

EDMS Capability

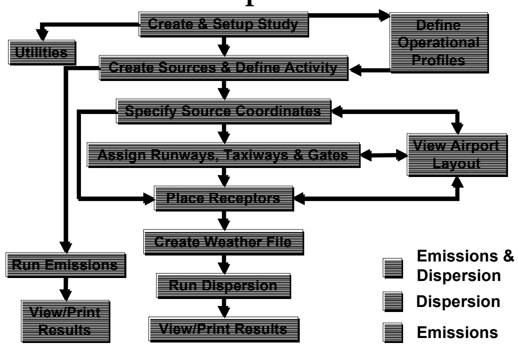
- Emission inventory & dispersion modeling
- All airport sources with focus on aviation sources (aircraft, APUs1, GSE2)
- Compilation of EPA methodologies & publicly available data

EDMS Capability

- Automation, user interface, & guidance
  - 1 APU: Auxiliary Power Unit
  - 2 GSE: Ground Support Equipment

Julie Ann Draper,
Theodore G. Thrasher,
Roger L. Wayson

Emission & Dispersion Data Flow



Proposed Enhancement of Appendix W

Enhance EDMS Description to Include AERMOD Dispersion Algorithms

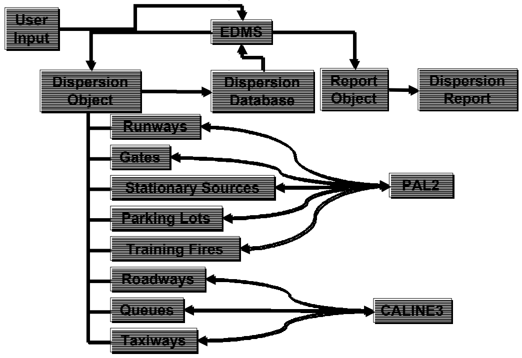
- **Existing Appendix W: GIMM**
- **EPA Proposed Appendix W: PAL2 & CALINE3**
- **FAA Proposed Enhancement: AERMOD**

Changes to EDMS for AERMOD Incorporation

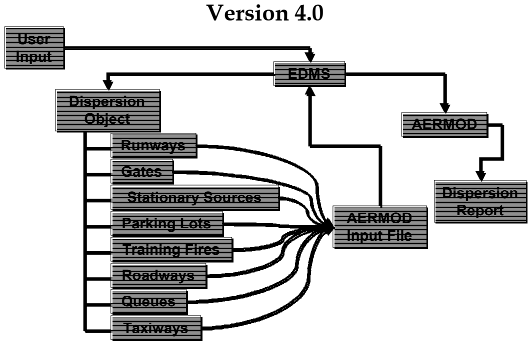
Theodore Thrasher
Senior Systems Analyst
CSSI, Inc.

Julie Ann Draper,
Theodore G. Thrasher,
Roger L. Wayson

How EDMS Currently Calculates Concentrations



How EDMS Will Calculate Concentrations in Version 4.0



Input File Object

- Dispersion calculations will now be handled by AERMOD
- AERMOD uses an input file to receive data into the model

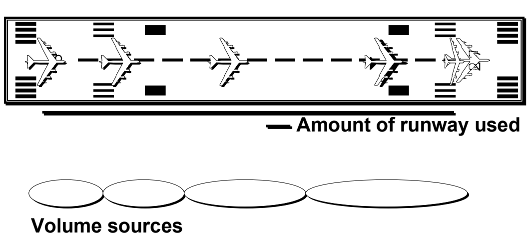
Input File Object

- EDMS will generate the input file, based on user-provided data from the interface
- Users may also create their own input files

Runway Dispersion

- AERMOD has no accelerated line source like PAL2
- Multiple volume sources will be used to simulate an aircraft on takeoff

Runway Dispersion



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Taxiway Dispersion

- AERMOD's volume source will be used to simulate dispersion along a line
- AERMOD User's Guide provides guidance for doing this
- Initial dispersion coefficient sy for the volume source is set to length/2.15

Gate Dispersion (GSE)

- Currently, ground support equipment are modeled using the PAL2 point source
- AERMOD's point source will be used in EDMS 4.0

Parking Lot Dispersion

- The area source from PAL2 is currently used in EDMS to model parking lot dispersion
- AERMOD's area source will now be used

Parking Lot Dispersion

- This adds the ability to design parking lots as polygons
- Parking lots no longer need to be aligned with the cardinal axes

Averaging

- EDMS currently provides limited averaging of the concentrations to compute NAAQS
- Many states have other averaging requirements
- AERMOD has a more flexible averaging tool that will now be used

Interface Changes

- AERMOD requires that weather data be run through a pre-processor (AERMET)
  - An interface to AERMET will be developed

Interface Changes

- Since parking lots are no longer required to be rectangular and aligned with the cardinal axes a change to the user interface is necessary

Interface Changes

- AERMOD allows much more flexibility with the placement of receptors
  - The user interface will be changed to reflect this

Interface Changes

- AERMOD's report generation capability is replacing the reports currently generated by EDMS
- The EDMS interface will allow the reports created from AERMOD to be displayed on the screen and printed

EDMS Evaluation Plan for Using AERMOD

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Work to be Done

- A stepped evaluation process
  - Sensitivity testing
  - Comparison, EDMSPAL2 to EDMSAERMOD
  - Comparison to other models (ADMS)

Work to be Done

- Validation by comparison to measured concentrations
- Improvement implementation shown by validation
- User friendly interface adaptation

Sensitivity Testing

- Purpose
  - To determine discontinuities and problems with implementation
- Method
  - Holding all but one variable constant while exercising single variable over valid range

Sensitivity Testing

- Analysis procedure
  - Plotting and tabulation of model results
  - Recognition of discrepancies
- Expected results
  - Correct implementation of AERMOD into EDMS

Comparison of Models

- Purpose
  - To compare results of other modeling efforts
    - PAL2 / CALINE to AERMOD versions of EDMS
    - ADMS vs. AERMOD at airports

Comparison of Models

- Method
  - Running of similar cases at airports
    - US and European airports
    - Airports where measurement data used to validate modeling preferred

Comparison of Models

- Analysis procedure
  - Plotting and tabulation of model results
  - Statistical testing of results
- Expected results
  - Verification of EDMSAERMOD results

Validation

- Purpose
  - To determine overall accuracy of EDMSAERMOD
- Method
  - Measurement plan at airports
    - Aircraft / motor vehicle specific
    - Overall

Validation

- Analysis procedure
  - Plotting and tabulation of results
  - Statistical comparison
- Expected Results
  - Determination of accuracy of predictions

Iterative Adaptation

- Each testing will result in feedback
- Feedback loop will result in further analysis and program alterations

Iterative Adaptation

- Alterations in:
  - Aircraft specific implementation of algorithms
  - Processing
  - User interface
    - Input data
    - Input requirements

Concluding Remarks

- The FAA supports EPA's AERMOD proposal
- The FAA proposes the enhancement of EDMS Description in Appendix W to include AERMOD Dispersion Algorithms

Concluding Remarks

- The end product will be a team effort
- Continued coordination with EPA, FAA, and the aviation community

For more information visit:
www.aee.faa.gov/aee-100/
aee-120/edms/banner.htm