Development of an Evaluation Framework for Long Range Transport Models

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Outline

• Review of USEPA and Federal Land Manager model evaluation efforts and lessons learned
• Review of relevant USEPA model evaluation guidance
• Examine regulatory use of LRT models and translate these into performance evaluation objectives
• Outline the components of the evaluation process
• Outline data organizational strategies, metrics for evaluation
HISTORICAL USEPA LRT MODEL EVALUATION EFFORTS
Evaluation Efforts at a Glance

- 1986 8-model study
- 1990 Rocky Mountain Acid Deposition Model Assessment Program
- 1993 Interagency Workgroup on Air Quality Modeling Phase I Evaluation
- 1998 Interagency Workgroup on Air Quality Modeling Phase II Evaluation
1986 USEPA Short-Term Long Range Transport Model Evaluation Project

- Eight long range transport models evaluated in the project for consideration as Appendix A LRT model:
  - MESOPUFF (Environmental Research and Technology, Inc.)
  - MESOPLUME (Environmental Research and Technology, Inc.)
  - MSPUFF (ND Dept. of Health)
  - MESOPUFF II (Environmental Research and Technology, Inc.)
  - MTDDIS (Rockwell International, Inc.)
  - ARRPA (Tennessee Valley Authority)
  - RADM (Dames and Moore, Inc.)
  - RTM-II (Systems Applications, Inc.)
- Evaluated against two mesoscale tracer experiments:
  - Oklahoma (1980)
  - Savannah River Laboratory Kr^{85}(1976)
- Evaluated using graphical and statistical methods recommended by American Meteorological Society (Fox, 1981)
1986 USEPA Short-Term Long Range Transport Model Evaluation Project (2)

- Models Evaluated Across Multiple Data Organization Strategies (Space/Time Paired; Paired in Space, Unpaired in Time; Unpaired in Space/Time, etc.).
Rocky Mountain Acid Deposition Model Assessment Project

- Acid Rain Mountain Mesoscale Model (ARM3) (SAI) developed for Western Acid Deposition Task Force.
- Compared against 7 other models from 1986 LRT study
  - Evaluated using same approach as 1986
    - Oklahoma and SRL data sets
    - AMS statistics for various data pairing strategies
    - Model scoring system weighted each tracer experiment and data pairing combination equally. Best performing model in each tracer/data combination awarded four points, three points for second, two for third, etc.
      - MESOPUFF-II performed best for unpaired data combination for each tracer experiment
      - ARM3 performed best for both tracer experiments for space/time data pairing.
      - Final overall scoring: ARM3 – 21, MESOPUFF II - 20
  - Model evaluation approach exposes fundamental issue – need for defining performance objectives according to nature of regulatory applications and defining an objective scoring scheme reflecting these performance objectives.
Interagency Workgroup on Air Quality Modeling (IWAQQM)

- Phase I Evaluation – “off-the-shelf” models, ARM3 and MESOPUFF-II evaluated, coding errors discovered in ARM3, leaving MESOPUFF II only model available

- Phase II Evaluation – CALPUFF/CALMET and CITPUFF/NUATMOS evaluated.
  - Trajectory evaluation using CALMET and NUATMOS using observations and “hybrid” fields based upon observation blending with 80-km MM4 data.
  - Statistical evaluation using ASTM/Irwin methods for evaluation (Oklahoma and SRL datasets).
    - CALMET/MM4 combination produced more accurate trajectory statistics than NUATMOS/MM4 combination
Lessons Learned from Prior Evaluation Efforts

• No USEPA recommended methodology for evaluation of air quality models. No consistent approach between efforts in 1980’s and 1990’s.

• Evaluation methodology used all published AMS metrics and data organizational strategies. This did not take into consideration regulatory use of LRT models, weighting schemes not most appropriate for particular methods LRT models are used for.

• High sensitivity of LRT models to meteorological inputs. Need for more objective meteorological performance evaluation measures.

• No data sets available to evaluation chemical transformation mechanisms of LRT models
EXISTING USEPA MODEL EVALUATION GUIDANCE
Relevant Model Evaluation Guidance

- Interim Procedures for Evaluating Air Quality Models (Revised) (EPA-450/4-84-023)
- Protocol for Determining the Best Performing Model (EPA-454/R-92-025)
- Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze (EPA-454/B-07-002)
Paradigm Question

• Carhart et al. (1989) noted that there was no recommended USEPA modeling guidance specific LRT models. 1986 EPA study applied all model metrics across all data organization strategies in the evaluation of the 8 models included in that study.
  – Are LRT models dispersion models or chemistry models?
    • Concerned about peak values
    • Concerned about accuracy of transport
    • Concerned about transformation and removal mechanisms

• Should they be evaluated in the same manner as near-field dispersion models, photochemical grid models, or some other way?
1984 USEPA Interim Evaluation Procedures Document

• The USEPA interim procedures document suggests:
  – definition of performance objectives relative to the nature of the regulatory applications of the model;
  – compilation of data sets and performance measures that will be used for each performance objective;
  – objective scheme for assigning weights to each performance measure and data set combination; and
  – an objective scheme for scoring the performance of any models relative to one another.
Defining Performance Objectives – Start with Regulatory Use of Model

• Current Regulatory Uses:
  – PSD Class I NAAQS and increment analyses
  – Visibility and deposition for Air Quality Related Values analysis for PSD

• Potential Future Uses:
  – Single source $\text{O}_3$ NAAQS analyses
  – Single source $\text{PM}_{2.5}$ NAAQS analyses
Class I Increment

1. Increments are deterministic standards. Short-term averaging periods, not to be exceeded more than once per year. Annual averaging period never to be exceeded.

2. Concerned with air quality impacts within boundaries of Class I areas.

3. Concerned with a model’s ability to predict peak concentrations, paired in space, not in time.
CHEMICAL TRANSFORMATION - AIR QUALITY RELATED VALUES (VISIBILITY), $O_3$, AND $PM_{2.5}$
Air Quality Related Values

- Visibility and deposition are the two primary air quality related values (AQRV’s).
- Visibility (light extinction) is a function of the treatment of extinction efficiency of secondary PM components such as sulfate, nitrate, and organic carbon.
  - Sulfate and nitrate are hygroscopic, meaning that particles readily absorb water.
  - Particle radiative properties are significantly affected by atmospheric moisture (relative humidity).
Visibility Affecting Pollutant Species

Model Sensitivity to Relative Humidity

From Karamchandani et al., 2008: “CALPUFF Chemistry Upgrade”, AER Final Report CP277-07-01 prepared for the American Petroleum Institute, Washington, D.C.
Model Sensitivity to Temperature

From Karamchandani et al., 2008: “CALPUFF Chemistry Upgrade”, AER Final Report CP277-07-01 prepared for the American Petroleum Institute, Washington, D.C.
Growth of Sulfate

Hygroscopic Growth Curves

Water Growth Curves

Relative Humidity (%) vs. \( f(RH) \)

- \( fS(RH) \)
- \( fL(RH) \)
- Original
- \( fSS(RH) \)
Performance Objectives - Visibility

• Concerned with model’s ability to predict secondary aerosols over the entire concentration distribution, not just peak values.

• Secondary aerosol formation directly tied to photolysis rates and background fields of temperature, moisture, and precursor compounds.

• Performance objectives:
  – Advection and diffusion: Assess performance across entire concentration distribution, not only unpaired peak values. Higher emphasis upon concentrations paired in space and time, due to sensitivity to temporal and spatial coupling to background meteorological and precursor fields.
  – Chemistry: Operational evaluation of model chemical transformation mechanism
DEVELOPING AN OBJECTIVE EVALUATION FRAMEWORK
Evaluation Framework

• Evaluation of LRT models within their defined regulatory niche requires an evaluation of three independent components of the AQ model system
  – Meteorological component
  – Advection and diffusion component
  – Chemical transformation
Meteorology and Model Intercomparisons

• LRT model performance are inherently linked to the suitability of the meteorological fields coupled to the AQ model.

• In model intercomparison studies, using a common source of meteorological data between all air quality modeling systems reduces the potential contribution of differences in meteorological data on dispersion model performance.

• Meteorological model performance by necessity is an integral part of any LRT model evaluation framework.
Single Source Chemistry Evaluations

• Application of LRT models for chemistry usually only involve an individual or small group of sources.

• Traditional photochemical grid model (PGM) evaluation techniques (chemistry evaluation) combined with inert tracer evaluation (advection and diffusion) are combined to examine the suitability of a model for use in single source chemistry applications.
  – The best performing chemistry model will only be as good as its ability to treat advection and diffusion appropriately.
Example: Aircraft Traverses and Model Receptors

Source: Vijayaraghavan, et al., 2010; “Evaluation of an Advanced Reactive Puff Model using Aircraft-based Plume Measurements”
DATA ORGANIZATIONAL STRATEGIES
Data Organizational Issues

• The 1984 Interim Evaluation Procedures document identified a key concept in developing an evaluation protocol – data organization.

• Compilation of data sets and performance measures that will be used for each performance objective; each performance objective is tied to regulatory use of a model.

•
## Data Organization

<table>
<thead>
<tr>
<th>A. Peak Concentration Comparisons</th>
<th>B. All-Concentration Comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A-1)</td>
<td>(B-1)</td>
</tr>
<tr>
<td>Compare highest observed value for each event with highest prediction for same event (paired in time, not space)</td>
<td>Compare observed and predicted values at a given station, paired in time (A data set for each station).</td>
</tr>
<tr>
<td>(A-2)</td>
<td>(B-2)</td>
</tr>
<tr>
<td>Compare highest observed value for each event at each monitoring station with the highest prediction at the same station (paired in space, not time).</td>
<td>Compare observed and predicted values for a given time period paired in space (not appropriate for data sets with few monitoring sites).</td>
</tr>
<tr>
<td>(A-3a)</td>
<td>(B-3)</td>
</tr>
<tr>
<td>Compare maximum observed value over all periods with highest predicted values representing different time or space pairing (fully unpaired, paired in location, paired in time, paired in space and time)</td>
<td>Compare observed and predicted values at all stations, paired in time and location (one data set) and by time of day</td>
</tr>
<tr>
<td>(A-3b)</td>
<td>(B-4)</td>
</tr>
<tr>
<td>Compare maximum predicted value over all periods with highest observed values for various pairings (as in A-3a).</td>
<td>Same as (B-3), but for subsets of meteorological conditions (stability and wind speed) and by time of day</td>
</tr>
<tr>
<td>(A-4a)</td>
<td></td>
</tr>
<tr>
<td>Comparison of highest $N = 25$ observed and highest $N$ predicted values, regardless of time or location</td>
<td></td>
</tr>
<tr>
<td>(A-4b)</td>
<td></td>
</tr>
<tr>
<td>Compare highest $N = 25$ observed and highest $N$ predicted values, regardless of time, for a given monitor location (a data set for each station).</td>
<td></td>
</tr>
<tr>
<td>(A-5)</td>
<td></td>
</tr>
<tr>
<td>Same as (A-4a), but for subsets of events by meteorological conditions (stability and wind speed) and by time of day.</td>
<td></td>
</tr>
</tbody>
</table>
AIR QUALITY MODEL STATISTICAL MEASURES
**AMS Statistics**

<table>
<thead>
<tr>
<th>Statistical Measure</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Difference</td>
<td>( \bar{d} = \frac{1}{N} \sum_{i=1}^{N} d_i = \bar{M} - \bar{P} )</td>
</tr>
<tr>
<td>Standard Deviation of Residuals</td>
<td>( \sigma_d^2 = \frac{1}{N-1} \sum_{i=1}^{N} (d_i - \bar{d})^2 )</td>
</tr>
<tr>
<td>Average Absolute Residuals</td>
<td>(</td>
</tr>
</tbody>
</table>
AMS Statistics

<table>
<thead>
<tr>
<th>Statistical Measure</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variance</strong></td>
<td>( V = \frac{1}{N} \sum_{i=1}^{N} \left( \frac{M_i}{P_i} \right) )</td>
</tr>
<tr>
<td><strong>Fraction of Positive Residuals</strong></td>
<td>( f_p = \frac{1}{2N} \sum_{i=1}^{N} \left( 1 + d_i/</td>
</tr>
<tr>
<td><strong>Pearson’s Correlation Coefficient</strong></td>
<td>( R = \frac{\sum_{i=1}^{N} (P_i - \bar{P})(M_i - \bar{M})}{\left[ \sum_{i=1}^{N} (P_i - \bar{P})^2 \left[ \sum_{i=1}^{N} (M_i - \bar{M})^2 \right] \right]^{1/2}} )</td>
</tr>
</tbody>
</table>
# Global Statistics

<table>
<thead>
<tr>
<th>Statistical Measure</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Fractional Bias</td>
<td>[ FB = \frac{2}{N} \sum_{i=1}^{N} \left( \frac{P_i - M_i}{P_i + M_i} \right) ]</td>
</tr>
<tr>
<td>Normalized Mean Square Error</td>
<td>[ NMSE = \frac{1}{NPM} \sum (P_i - M_i)^2 ]</td>
</tr>
<tr>
<td>Factor of 2/5</td>
<td>[ FA2/5 = \left[ \frac{N(\bar{y} - y_0 = [x - x_0] \alpha)}{N} \right] \times 100 ]</td>
</tr>
<tr>
<td>Factor of Exceedance</td>
<td>[ FOEX = \left[ \frac{N_{(P_i &gt; N_i)}}{N} - 0.5 \right] \times 100% ]</td>
</tr>
</tbody>
</table>
## Spatial Statistics

<table>
<thead>
<tr>
<th>Statistical Measure</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure of Merit in Space</td>
<td>$FMS = \frac{A_M \cap A_P}{A_M \cup A_P} \times 100%$</td>
</tr>
<tr>
<td>False Alarm Rate</td>
<td>$FAR = \left( \frac{a}{a+b} \right) \times 100%$</td>
</tr>
<tr>
<td>Threat Score</td>
<td>$TS = \left( \frac{b}{a+b+d} \right) \times 100%$</td>
</tr>
<tr>
<td>Probability of Detection</td>
<td>$POD = \left( \frac{b}{b+d} \right) \times 100%$</td>
</tr>
</tbody>
</table>
Temporal Statistics

<table>
<thead>
<tr>
<th>Statistical Measure</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure of Merit in Time</td>
<td>$FMT(\bar{x}) = \frac{\sum \min{M(\bar{x},t_j), P(\bar{x},t_j)}}{\sum \max{M(\bar{x},t_j), P(\bar{x},t_j)}} \times 100%$</td>
</tr>
</tbody>
</table>
## Operational Evaluation - Chemical Transformation

<table>
<thead>
<tr>
<th>Statistical Measure</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Normalized Bias</td>
<td>[ MNB = \frac{1}{N} \sum_{i=1}^{N} \left( \frac{P_i - M_i}{M_i} \right) \times 100% ]</td>
</tr>
<tr>
<td>Mean Normalized Gross Error</td>
<td>[ MNGE = \frac{1}{N} \sum_{i=1}^{N} \left( \frac{</td>
</tr>
<tr>
<td>Mean Fractional Error</td>
<td>[ FERROR = \frac{2}{N} \sum_{i=1}^{N} \left( \frac{</td>
</tr>
</tbody>
</table>
METEOROLOGICAL MODEL
STATISTICAL MEASURES
Prognostic Meteorological Parameters Routinely Used in Air Quality Models

- Winds
- Mixing Ratio (humidity)
- Temperature
- Precipitation
- Clouds
- Boundary Layer Heights
Meteorological Evaluations – The Long Road to the 10th Conference on Air Quality Modeling

• 2005 – EPA R/S/L meeting in New Orleans: USEPA R7 defined “Two Phase Paradigm” for evaluation of prognostic/diagnostic meteorological modeling systems.
• 2006 – USEPA R7/USFWS developed prototype statistical evaluation tool for diagnostic wind fields.
• 2008 – USEPA OAQPS/USEPA R7 developed prototype to couple prognostic models directly to LRT model
• 2008 – USEPA R10 introduces MMIF at 9th Conference on Air Quality Modeling
• 2009 – Prototype sent to ENVIRON for code clean up and documentation. Mesoscale Model InterFace (MMIF) 1.0 is developed.
• 2010 – MMIF updated for additional models (SCICHEM, AERMOD), multiple map projections, and COARE algorithms (pending).
• 2011 – 10th Conference on Air Quality Modeling. MMIF, MMIFStat, performance evaluation guidance, standardization of meteorological datasets for regulatory LRT applications will be introduced formally.
Basic Statistical Parameters

<table>
<thead>
<tr>
<th>Statistical Measure</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bias</td>
<td>( B = \frac{1}{IJ} \sum_{j=1}^{J} \sum_{i=1}^{I} (P_{ij} - O_{ij}) )</td>
</tr>
<tr>
<td>Gross Error</td>
<td>( E = \frac{1}{IJ} \sum_{j=1}^{J} \sum_{i=1}^{I}</td>
</tr>
<tr>
<td>Root Mean Square Error</td>
<td>( RMSE = \left[ \frac{1}{IJ} \sum_{j=1}^{J} \sum_{i=1}^{I} (P_{ij} - O_{ij})^2 \right]^{1/2} )</td>
</tr>
<tr>
<td>Index of Agreement</td>
<td>( IOA = 1 - \frac{IJ \cdot RMSE^2}{\sum_{j=1}^{J} \sum_{i=1}^{I}</td>
</tr>
</tbody>
</table>
### Target Performance Benchmarks

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Metric</th>
<th>Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Speed</td>
<td>RMSE Bias IOA</td>
<td>≤ 2 m/s ≤ ± 0.5 m/s ≥ 0.6</td>
</tr>
<tr>
<td>Wind Direction</td>
<td>Gross Error Bias</td>
<td>≤ 30 deg ≤ ± 10 deg</td>
</tr>
<tr>
<td>Temperature</td>
<td>Gross Error Bias IOA</td>
<td>≤ 2 K ≤ ± 0.5 K ≥ 0.8</td>
</tr>
<tr>
<td>Humidity</td>
<td>Gross Error Bias IOA</td>
<td>≤ 2 g/kg &lt; ±1 g/kg ≥ 0.6</td>
</tr>
</tbody>
</table>
## Example of Evaluation Protocol

<table>
<thead>
<tr>
<th>Regulatory Air Quality Objective</th>
<th>Performance Evaluation Objective</th>
<th>Data Sets</th>
<th>Performance Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSD NAAQS and Class I increments</td>
<td>Determine Model Accuracy for Peak Values</td>
<td>A-2</td>
<td>AVDIFF, STDRES, AVGABSDIFF, VAR, FPR, R</td>
</tr>
<tr>
<td>Chemical Transformation (Visibility, O₃, PM₂.₅)</td>
<td>Spatial and Temporal Correlation</td>
<td>B-1, B-3</td>
<td>R, FMS, TS, POD, FAR, FMT</td>
</tr>
<tr>
<td></td>
<td>Determine Model Accuracy Over Entire Concentration Domain</td>
<td>B-3</td>
<td>FB, FOEX, FA2/5, KS, NMSE</td>
</tr>
<tr>
<td>Chemistry</td>
<td>B-1, B-2, B-3</td>
<td>NMB, NME, MFB, FERROR,</td>
<td></td>
</tr>
</tbody>
</table>
EVALUATION DATASETS
Potential Evaluation Data Sets

**Mesoscale Tracer Experiments**
- Savannah River Laboratory SF$_6$ - 1975
- Savannah River Laboratory Kr$^{85}$ - 1976
- Atlantic Coast Unique Regional Atmospheric Tracer Experiment (ACURATE) (1982-83)
- Great Plains Tracer Experiment (1980)
- Cross Appalachian Tracer Experiment (CAPTEX) (1983)
- Across North America Tracer Experiment (ANATEX) (1987)
- European Tracer Experiment (ETEX) (1993)

**Aircraft Data Sets**
- Cumberland Power Plant (Southern Oxidant Study – 1999)
- Central California Ozone Study (CCOS) (2002)
- Northeast Texas Air Care (NETAC) Air Quality Study (2005)
- CALNEX (2010)
Single-Source Long-Range Transport Model Evaluation

Work Assignment No. 4-06

University of North Carolina at Chapel Hill
ENVIRON International Corporation
MMIF V1.0 Development

• Early 2009, ENVIRON developed the Mesoscale Model Interface (MMIF) program that converts MM5 or WRF meteorological output to CALPUFF-ready meteorological inputs without using CALMET
  – EPA Contract No. EP-D-07-102; WA No. 2-06

• MMIF Version 1.0 features:
  – Linux/Unix or Windows environment
  – Two options for defining PGT stability
  – Options to re-diagnose or pass-through PBL depth
  – Can process subset of MM5/WRF domain
  – An option to perform layer aggregation
  – Retains original MM5/WRF map projection and horizontal grid resolution
MMIFStat Development

- Statistical Analysis Software for the Mesoscale Model Interface (MMIF) output
  - Computer program able to read observed meteorological data and WRF, MM5 and MMIF output and generate set of statistics model performance measures and displays
    - Linux/Unix and Windows operating system
    - Surface meteorological evaluation (WS, WD, T, RH)
    - Single station evaluation
    - Interface with standard third-party software (e.g., Excel)
  - Developed by Alpine Geophysics, LLC under GSA contract
EPA WA 4-06: Single-Source LRT Model Evaluation

• 7 Tasks:
  – Task 1: Work Plan
  – Task 2: Update and Finalize MMIF
  – Task 3: CALPUFF Met-Input NetCDF for Visualization
  – Task 4: Document CALPUFF Tracer Test Evaluations
  – Task 5: Critical Review of Single-Source LRT Models
  – Task 6: Proof of Concept for using PGMs for Single-Source AQ/AQRV Assessments and Compare with CALPUFF
  – Task 7: Evaluate LRT Models using Tracer Test and Plume Chemistry Field Experiments
Task 2: Update MMIF

• Subtask 2a: Enhance MMIF to support AERMOD and SCIPUFF/SCICHEM
  – For AERMOD, two options to output data for user selected location (MM5/WRF grid cell):
    • Output surface and upper-air meteorological data to run through AERMET; and
    • Output meteorological data in format to directly input into AERMOD
  – SCIPUFF/SCICHEM MEDOC format for more evaluation of this modeling system
Task 2: Update MMIF

• Subtask 2b: MMIF enhancements to support CALPUFF
  – Add option to extract MM5/WRF data based on Latitude/Longitude window rather than just (i,j) offset
  – Add support for Polar Stereographic and Mercator projections
  – Add in option to use WRF/MM5 LAI, L and z0 estimates rather than lookup table approach (i.e., pass through)
  – MMIF testing and evaluation
  – Update MMIF user’s guide
    • Full documentation of MMIF critically important
Task 3: Enhance CALMET-to-NetCDF Software

- USFS has developed prototype CALMET binary output files to NetCDF/IOAPI format that can be visualized by the public available PAVE/VERDI software
  - This task would enhance this software to operate on multiple platforms and compilers and develop documentation
  - Will extend to VERDI visualization tool since PAVE no longer supported (but still useful)
  - Will allow visualization of CALPUFF meteorological inputs without expensive third part software
    - Compliments statistical evaluation using MMIFStat
Task 4: Report on CALPUFF and Other LRT Model Tracer Experiment Evaluation

• EPA/USFS performed LRT model evaluation against tracer test data for multiple LRT models including CALPUFF (CALMET & MMIF), HYSPLIT, FLEXPART, SCIPUFF (and some CAMx)
  – 1992 European Tracer Experiment (ETEX)
  – 1983 Cross-Appalachian Tracer Experiment (CAPTEX)
  – 1980 Great Plains Tracer Experiment (GR80)

• FLMs also performed CALPUFF consequence analysis using CALMET and MMIF
  – Document and explain results
Task 5: LRT Model Review (UNC)

• Review of LRT Modeling Techniques
  – Lagrangian Puff
  – Particle
  – Chemical plume model
  – Photochemical grid/hybrid model

• Literature review and assessment
  – Capability for primary and secondary pollutants
  – Data requirements
  – Publicly availability
  – Advantages and disadvantages
  – Evaluation studies
Task 6: Single-Source PGM Demonstration

• Comparison of Single-Source Estimation Techniques for Ozone and AQ/AQRV
  – Two modeling test domains
    • 2006 12 km MM5 database covering eastern Utah and western Colorado (UT-CO)
    • 2005 Four Corners Air Quality Task Force (FCAQRF) 12/4 km domain
  – Three model configurations:
    • CAMx using APCA ozone and PSAT PM source apportionment
    • CALPUFF using MMIF
    • CALPUFF using CALMET and August 2009 application procedures
Task 6: Single-Source PGM Demonstration

- Evaluation for ozone and far-field AQ and AQRVs
  - Like one would do for a PSD or NEPA application
  - Use existing and hypothetical sources
  - PSD and other (e.g., SO4 and NO3) pollutant concentrations
  - Visibility (FLAG 2010 procedures)
  - Deposition (S and full and subsets of N species)

- Optional Tasks (not funded)
  - 6-1: SCICHEM
  - 6-2: HYSPLIT
  - 6-3: Brute Force CAMx Zero-Out
  - 6-4: Brute Force CMAQ Zero-Out
Task 6: Single-Source PGM Demonstration

New Mexico CAMx 12 km Nested Domain

- IMPROVE
- CASTNET
- NADP

CAMx 12 km: 167 x 137* (-2316, -912) to (-312, 732)
CAMx 04 km: 101 x 92* (-1192, -508) to (-788, -140)
* includes buffer cells
Task 7: Evaluate Single-Source LRT using Field Experiments

- **Subtask 7a**: Evaluate CAMx using three classic inert tracer experiments and compare with CALPUFF and other LRT models
  - ETEX, CAPTEX and GP80
  - Compare with CALPUFF/MMIF and CALPUFF/CALMET
  - Optional Task (not funded)
    - 7a-1: SCICHEM
Task 7: Evaluate Single-Source LRT using Field Experiments

- **Subtask 7b**: Evaluate Against Atmospheric Chemical Plume Observations
  - TVA Cumberland Plume 1999 SOS
  - 2002 CCOS Aircraft Measurements
  - Three models:
    - CAMx, CALPUFF/MMIF and CALPUFF/CALMET
  - Optional Tasks
    - 7b-1: SCICHEM
    - 7b-2: HYSPLIT
    - 7b-3: CALPUFF/API (CALPUFF V6.4)
References – Air Quality Model Evaluations


• USEPA, 1986b: Evaluation of Short-Term Long-Range Transport Models, Vol. II – Appendices A through E. EPA-450/4-86-016b, Research Triangle Park, NC.


References – Meteorological Evaluations