PM Model Performance & Grid Resolution

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Midwest Regional Planning Organization
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Objectives & Episodes

- **Objectives**
  - Compare model estimates to observed estimates
  - Identify issues with the emission inventory and air quality model chemistry and physical processes

- **Model**
  - CAMx Version 4.02

- **Platform**
  - RedHat v7.X Linux PCs
  - Portland Group Fortran

- **August 2 - Sept 12, 1999**
  - 8-hr ozone episode: Sept 1-5
  - March Midwest daily PM speciation data at 5 sites

- **Jan 2 - Feb 17, 2000**
  - March Midwest daily PM speciation data at 3 sites

- **June 18 - Aug 13, 2001**
  - 8-hr ozone episodes: June 25-30, July 15-24, Aug 5-9
  - PM Super-Site intensive modeling @ St. Louis and Pittsburgh
• **MM5 Domain (light yellow)**
  - 165 X, 129 Y, 35 Z
  - 36 km cells

• **CAMx Domain (dark yellow)**
  - 97 X, 90 Y, 14 Z
  - 36 km cells

• **Lambert projection**
  - Center (-97,40)
  - True latitudes (33,45)

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Model Inputs

EMISSIONS

• **Monthly: weekday, sat, sun**
  – Point source inventory based on 1999 NEI v2.0
  – Onroad based on 1999 NEI v2.0 with VMT adjustments
  – EPA NONROAD 2002 from 1999 NEI v2.0
  – CMU ammonia model March 2003 version with many adjustments
  – Area based on 1999 NEI v2.0

• **Day specific**
  – biogenics based on BIOME3/BEIS3 with BELD3 landuse, MM5 15 m temperatures and satellite PAR

• **Initial and Boundary conditions:**
  – profile (v6) released with models-3/CMAQ in June 2002
  – All 4 sides are the same
  – Concentrations vary vertically
  – Simulations spin up a week to minimize impact

• **Landuse (11 categories):**
  – 30 sec USGS landuse

• **Ozone Column:**
  – Daily TOMS ozone column data

• **Albedo:**
  – Monthly albedo based on 10 years of TOMS reflectivity data

• **Photolysis Rates:**
  – TUV4.0 processor using the discrete ordinate algorithm;
  – daily rates files based on daily O3 column and monthly albedo
Model Performance

- **March Midwest**
  - daily 24 hr samples
  - Only 3 of 6 stations in winter 2000
  - PM2.5 Speciation
  - NH3, HNO3, HNO2, SO2
- **IMPROVE and CASTnet**
  - 24 hr samples every 3 days
  - PM2.5 Speciation
- **Super Sites**
  - Hourly gases and meteorology
  - Hourly/daily PM2.5 Speciation
- **EPA Speciation**
  - 24 hr samples every 3 days
  - PM2.5 Speciation
- **AIRS -- not shown on map**
  - Hourly criteria pollutants
Summer 2001

PM2.5 (μg/m³) - ALL MONITORS - 2001 [LADCO] : camx

Model Estimates vs Observations

RCPH (μg/m³) - ALL MONITORS - 2001 [LADCO] : camx

Model Estimates vs Observations
Jan-Feb 2000

PM2.5 (ug/m3) - ALL MONITORS - 2000 [LADCO] : camx

MODEL ESTIMATES

OBSERVATIONS

SO4
NO3
OC
EC
NH4
SOIL

RCFN (ug/m3) - ALL MONITORS - 2000 [LADCO] : camx

MODEL ESTIMATES

OBSERVATIONS
PM2.5 Organic Carbon

![Graphs showing PM2.5 Organic Carbon observations and model estimates for different regions: Urban-North, Rural-North, Urban-South, Rural-South.](image)
Red dots represents hourly organic carbon measurements taken every other hour.

Stacked bars show CAMx4 model output.

POA = Primary organic carbon
ASOA = anthropogenic secondary organic aerosol
BSOA = biogenic secondary organic aerosol
Red dots represent hourly organic carbon measurements taken every other hour.
Stacked bars show CAMx4 model output.

POA = Primary organic carbon
ASOA = Anthropogenic secondary organic aerosol
BSOA = Biogenic secondary organic aerosol
PM2.5 Elemental Carbon


MODEL ESTIMATES (µg/m³) vs OBSERVATIONS (µg/m³)

Urban
Rural


MODEL ESTIMATES (µg/m³) vs OBSERVATIONS (µg/m³)
PM2.5 Total Carbon

![PM2.5 Total Carbon Scatter Plot](image-url)
PM2.5 Nitrate
Episode Average PM2.5 Nitrate

SUMMER

WINTER
Nitric Acid and Ammonia (ug/m³) 24-hr average Concentrations at March Midwest Sites

August 1999

Jan/Feb 2000
PM2.5 Sulfate
PM2.5 Soil/Crustal
Coarse Mass
Wet Deposition
Summer 2001 Episode

- AIRMoN sites used for evaluation purposes
- These sites have a temporal resolution higher than the weekly NADP monitors
July 17th, 2001

• Aircraft Ozone Measurements
• Ground level Measurements in East St. Louis
• 12km CAMx4 Simulation
Fine Grid Modeling

- CAMx4
- All grids 2-way nested
- 36 and 12 km emissions and meteorology
- 4 km flexi-nests:
  - 4 km landuse
  - Elevated point sources are coordinate-based
- ~4.5 to 5 hours runtime per episode day on a single 2.6 ghz processor for 36/12/and all 3 4km grids
- ~ 1 hour to run an episode day at 36 km (so it takes 4 and a half days to run an annual simulation on 4 processors)
Pittsburgh Super Site

PM2.5 Nitrate (µg/m³) - pitts - 2001 [IADCO] camx

Total Ammonium (µg/m³) - pitts - 2001 [IADCO] camx
Pittsburgh Super Site

PM2.5 Sulfate (µg/m³) - pitss - 2001 [LADCO] camx

SO2 (PPB) - pitss - 2001 [LADCO] camx
Prophet Field Study

PM2.5 Sulfate (ug/m3) - prophet - 2001 [LADCO] camx

PM2.5 Organic Carbon (ug/m3) - prophet - 2001
Base Year and Future Year Errors Cancel Each Other Out

• Model prediction errors are not important because we use the model in a relative sense

• Example: Predicting too much nitrate

1. Ammonia emissions too high
2. A lot of extra free ammonia to react with nitric acid to form PM2.5 nitrate
3. This PM2.5 nitrate really doesn’t exist because the ammonia emissions don’t exist
4. Cutting NOX emissions will reduce HNO3 and reduce PM2.5 nitrate
5. This will over-state NOX emission reduction benefits for PM2.5 because you are controlling PM2.5 that never existed and potentially lead to control strategies that are not as effective as advertised
Only need to look at rural/IMPROVE monitors for performance evaluation

- We only need to look at model performance for IMPROVE sites because that is where the Class I areas are located.
- Analysis of every 3 day 24-hour samples at rural locations may not reflect how well the model performs even in these areas.
- Large synoptic patterns with high PM2.5 may be missed by the 1 in 3 day sample.
- At the typical lower rural concentrations of PM2.5 it is much easier to have incorrect emissions (like wildfires for example) compensate for sectors that truly impact the monitor.
Priorities for Good PM2.5 Model Performance

**High Priority**

1. Ammonia inventory: spatial and temporal resolution
2. Primary PM emissions (ie carbon and dust)
3. Chemistry and physical processes such as deposition

**Important, but won’t save you**

1. Initial and boundary conditions
2. # of vertical layers, layer collapsing, jet stream inclusion, Kv patches
3. Fine grid resolution: 12 and 4 km