WRAP 2002 Visibility Modeling:
Summary of 2005 Modeling Results

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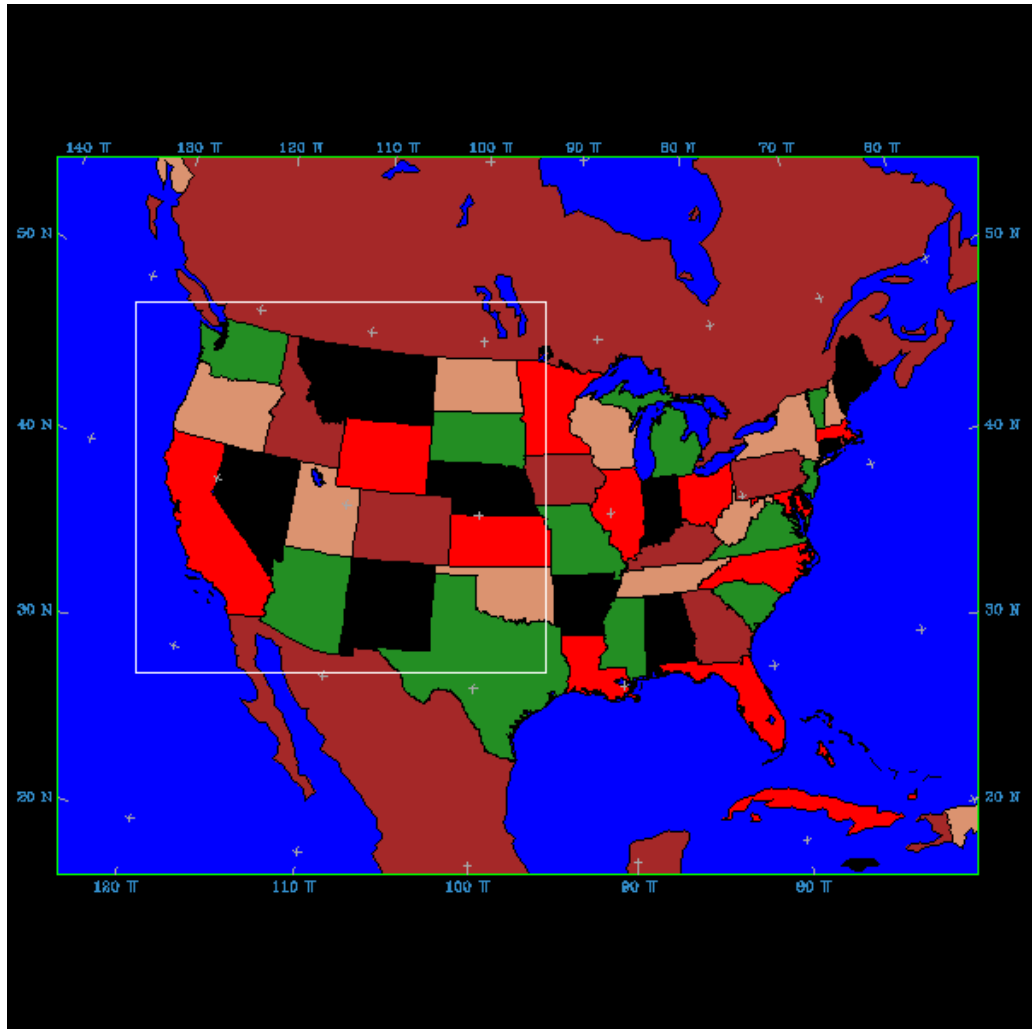
Topics

- 2002 CMAQ Model Performance Evaluation
- Comparison of 36km versus 12km CMAQ
- Comparison of CMAQ and CAMx
- Fire Sensitivity Modeling
- Source Apportionment Modeling
- CMAQ Clean Conditions Visibility modeling

CMAQ 2002 Visibility Modeling

- National RPO grid
- RMC MM5 modeling
  - 36 km: (165, 129, 34)
  - 12 km: (220, 199, 34)
- Final 2002 Emissions Base version A
- Model performance evaluation (MPE) compares model results to ambient monitoring data (IMPROVE, NADP, CASTNet, STN, AQS)



Air Quality Model Versions

- Started with CMAQ version 4.4
- Switched to CMAQ version 4.5 in October:
  - includes new options for vertical advections with improved mass conservation.
  - Has options for landuse dependent vertical mixing and sea salt emissions, not used here.
- Using pre-release version of CAMx 4.3

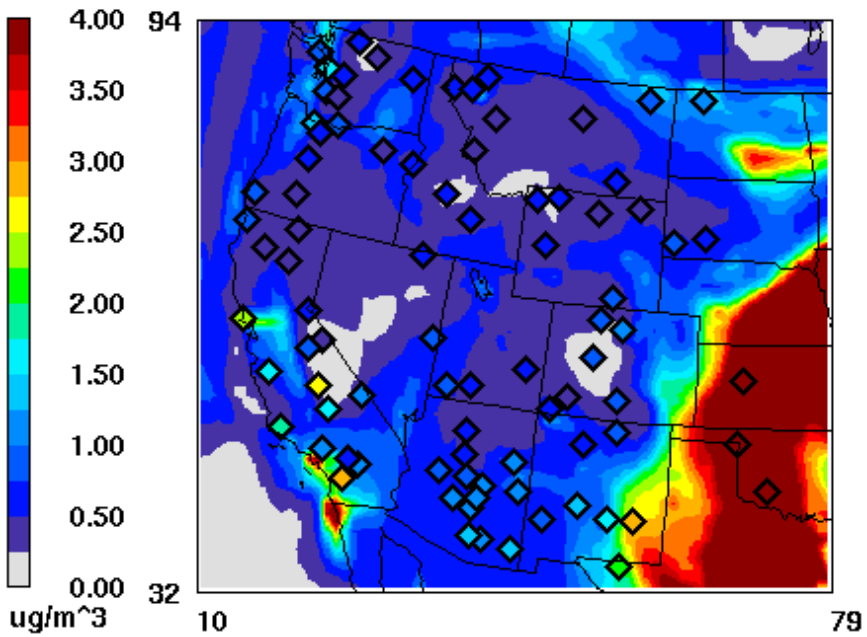
Model Performance Evaluation

- We compute routine statistical metrics: mean fractional bias and error, etc.
- Spatial plots showing model and data.
- Bar plots showing monthly average error and bias.
- Bugle plots of performance benchmarks and performance goals.
- Stacked-bar time series plots for each IMPROVE Site.
- Stacked bar plots of model and data for the best 20% and worst 20% visibility days.

Spatial plots of model and data

Sulfate

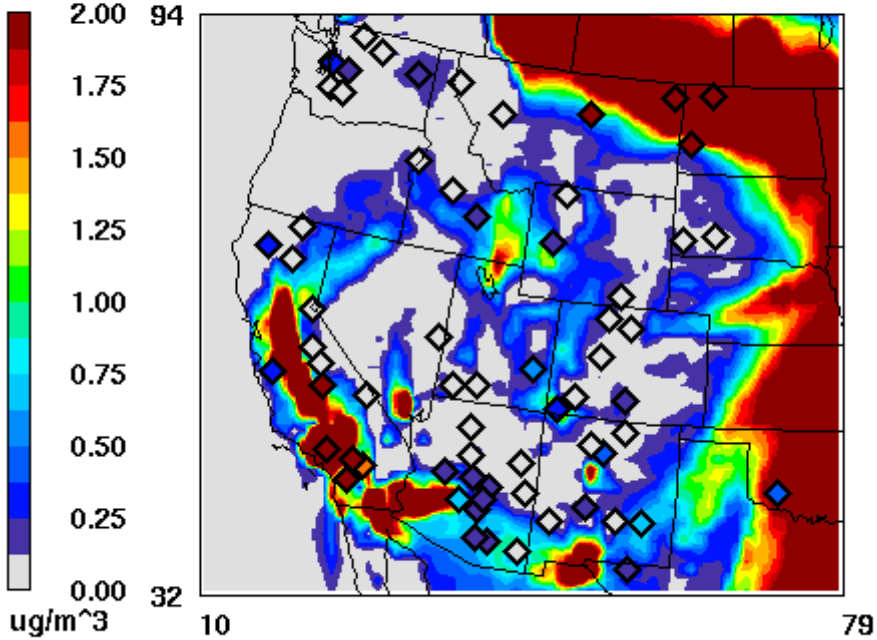
CMAQv45.Base02a36km vs. IMPROVE overlay



June 25,2002 0:00:00
Min= 0.04 at (10,33), Max= 11.23 at (75,32)

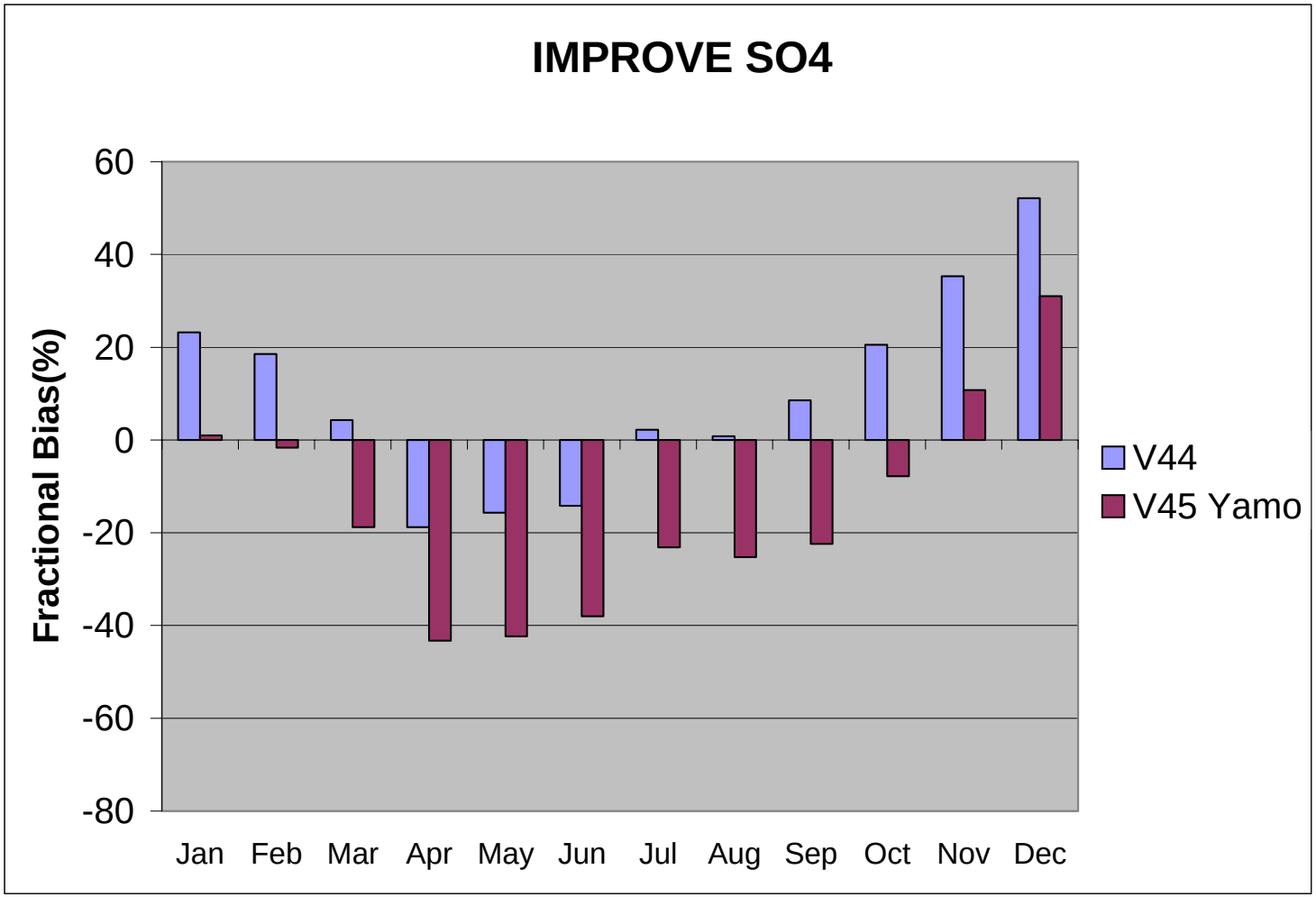
Nitrate

CMAQv45.Base02a36km vs. IMPROVE overlay

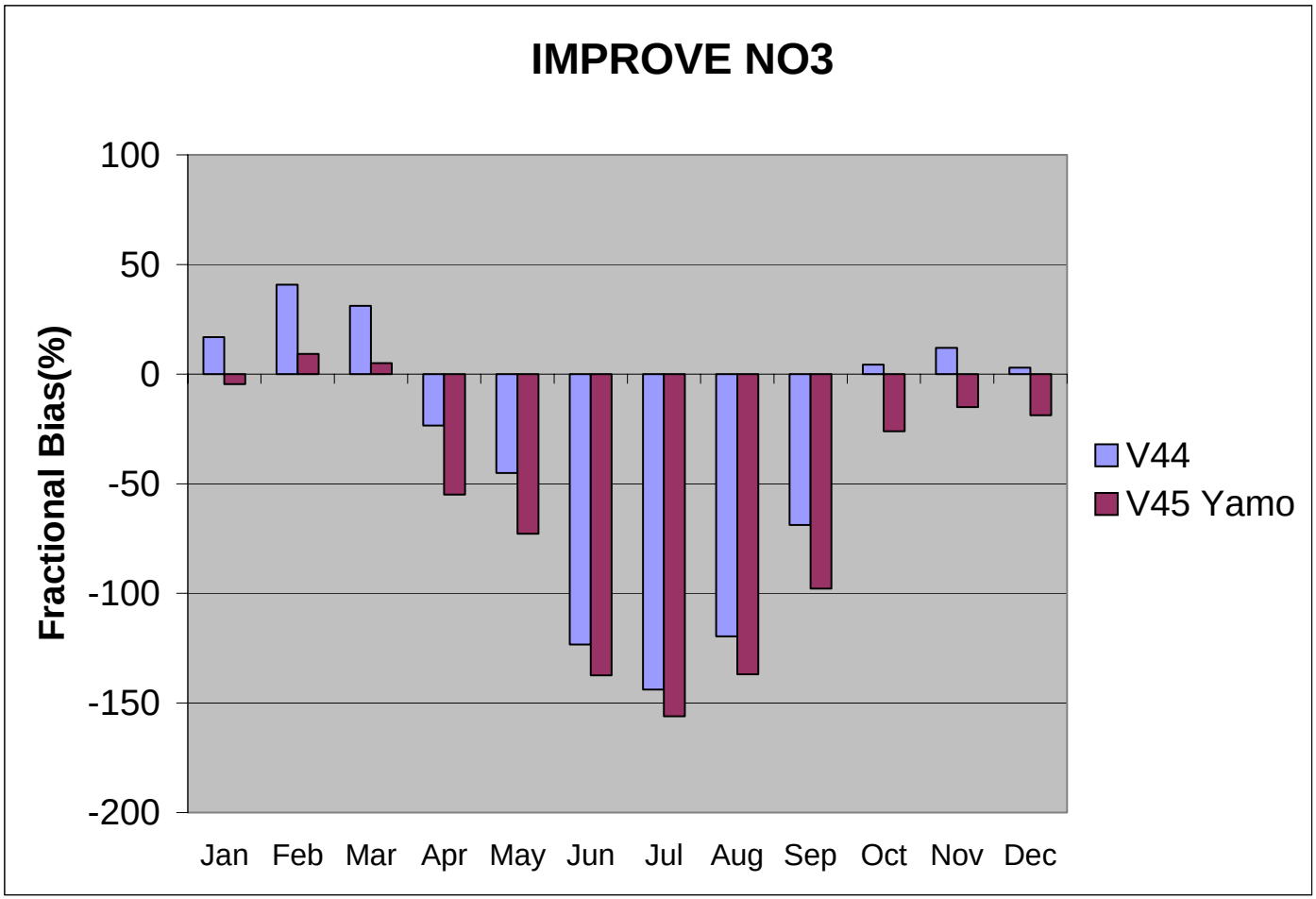


January 26,2002 0:00:00
Min= 0.00 at (17,91), Max= 6.42 at (23,46)

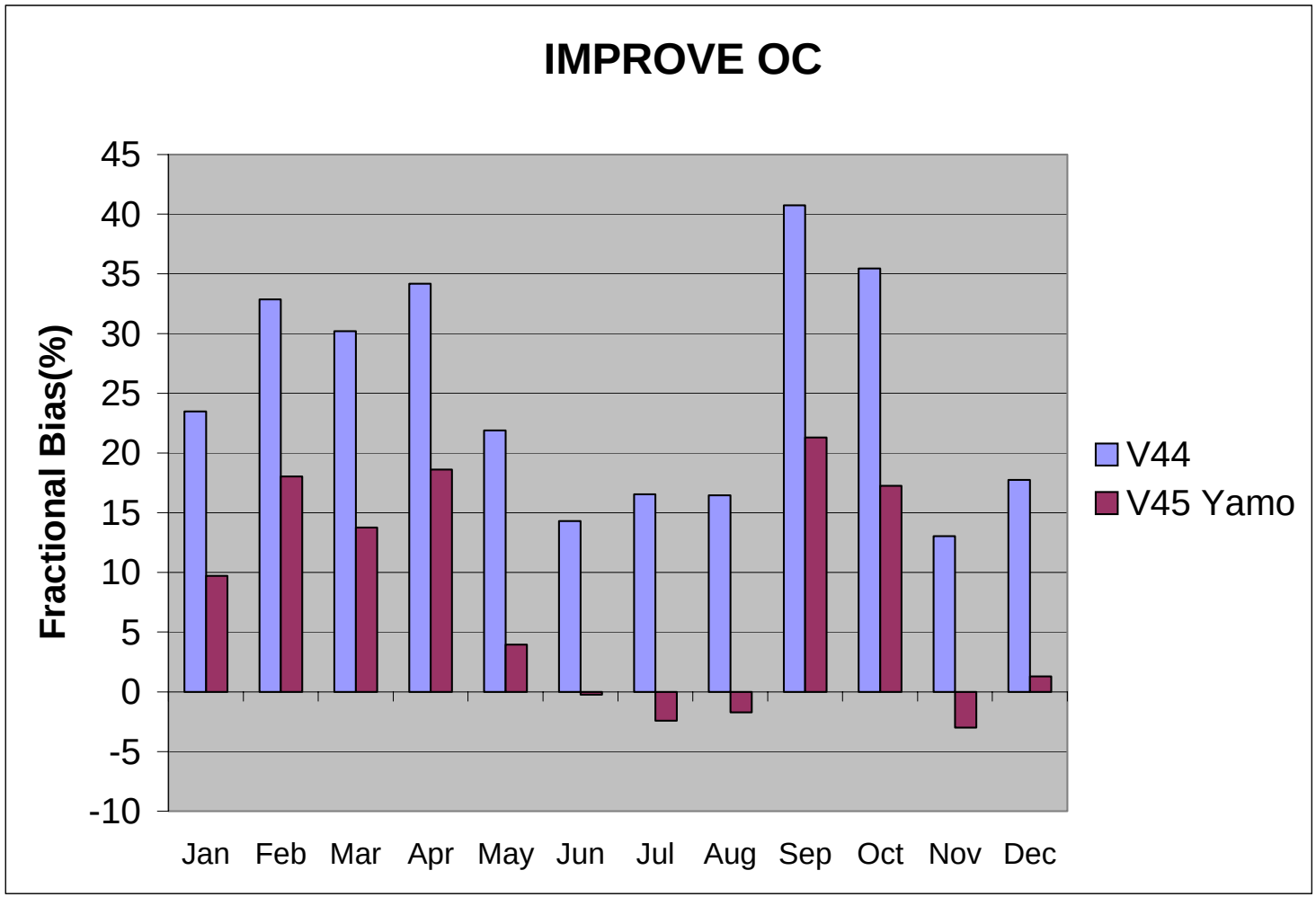
Bar plots of monthly error and bias: SO4



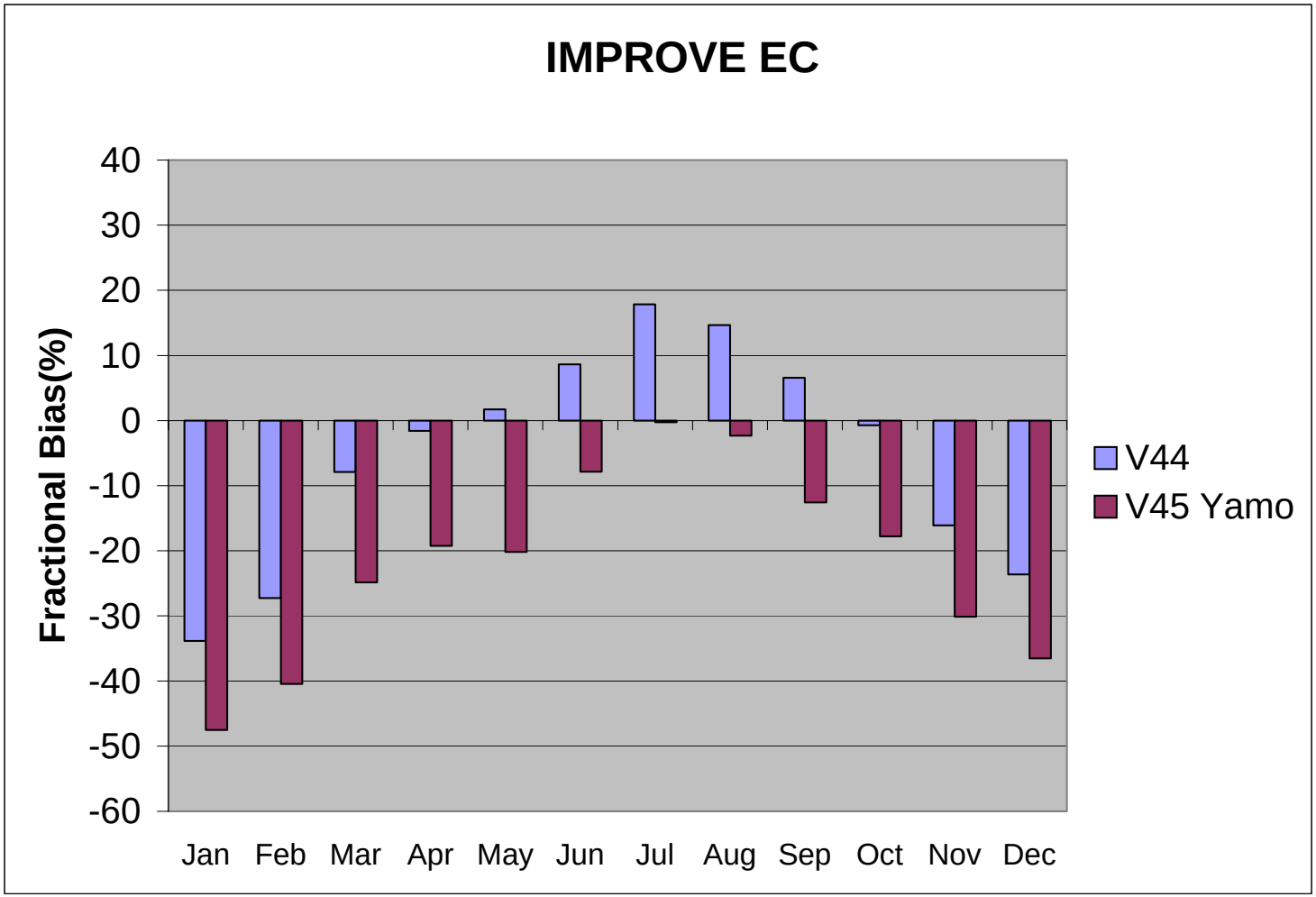
Bar plots of monthly error and bias: NO3



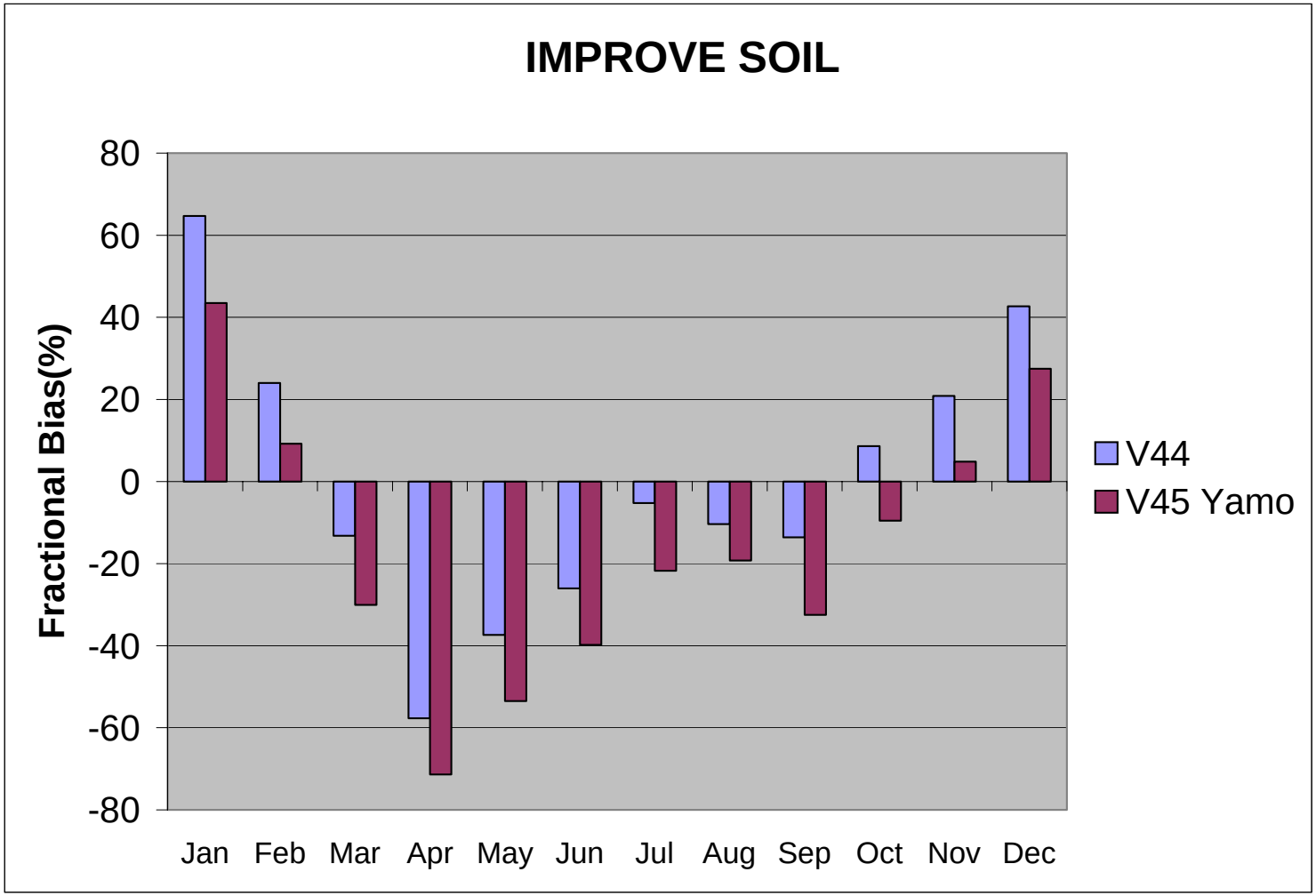
Bar plots of monthly error and bias: OC



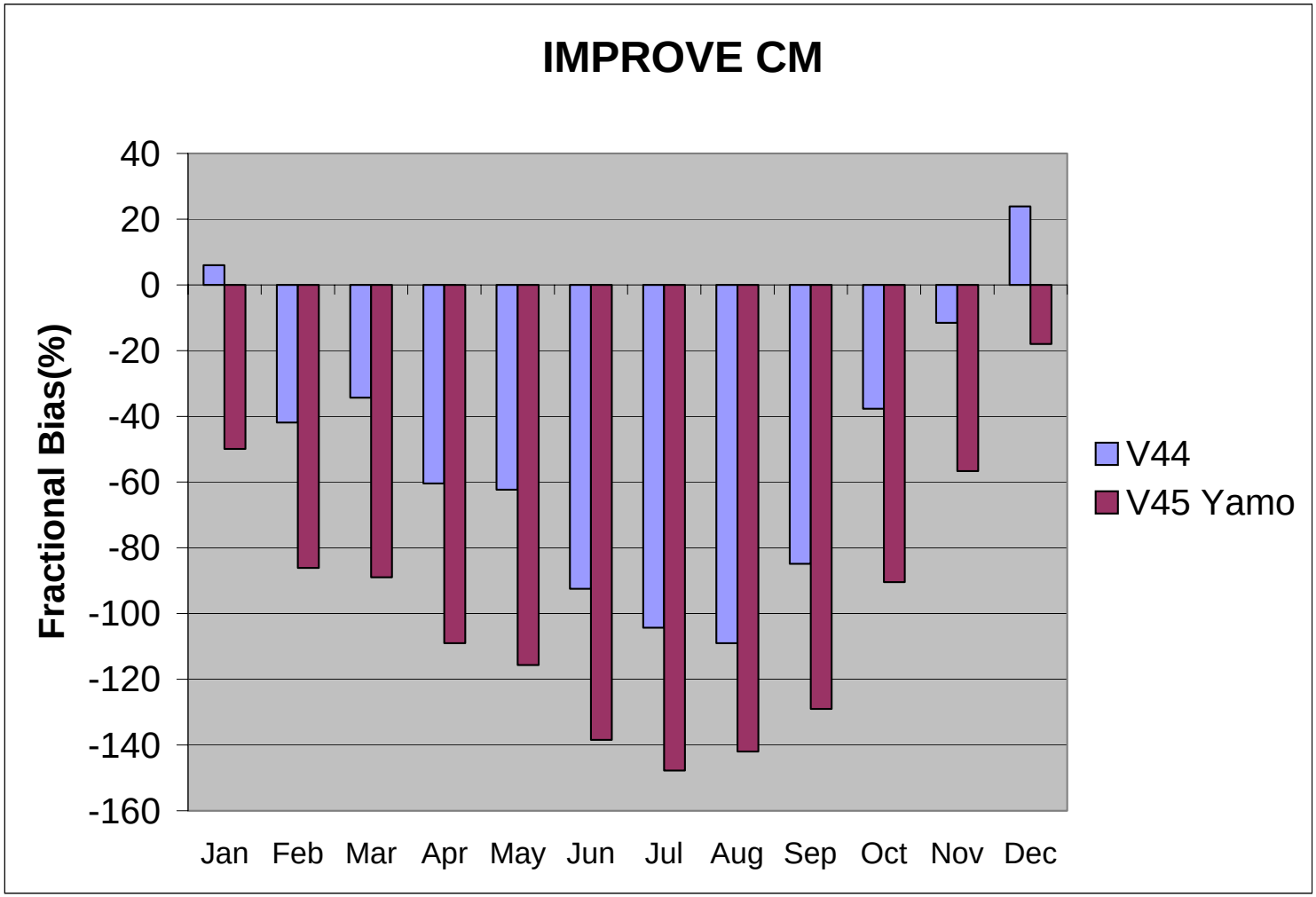
Bar plots of monthly error and bias: EC



Bar plots of monthly error and bias: Soil

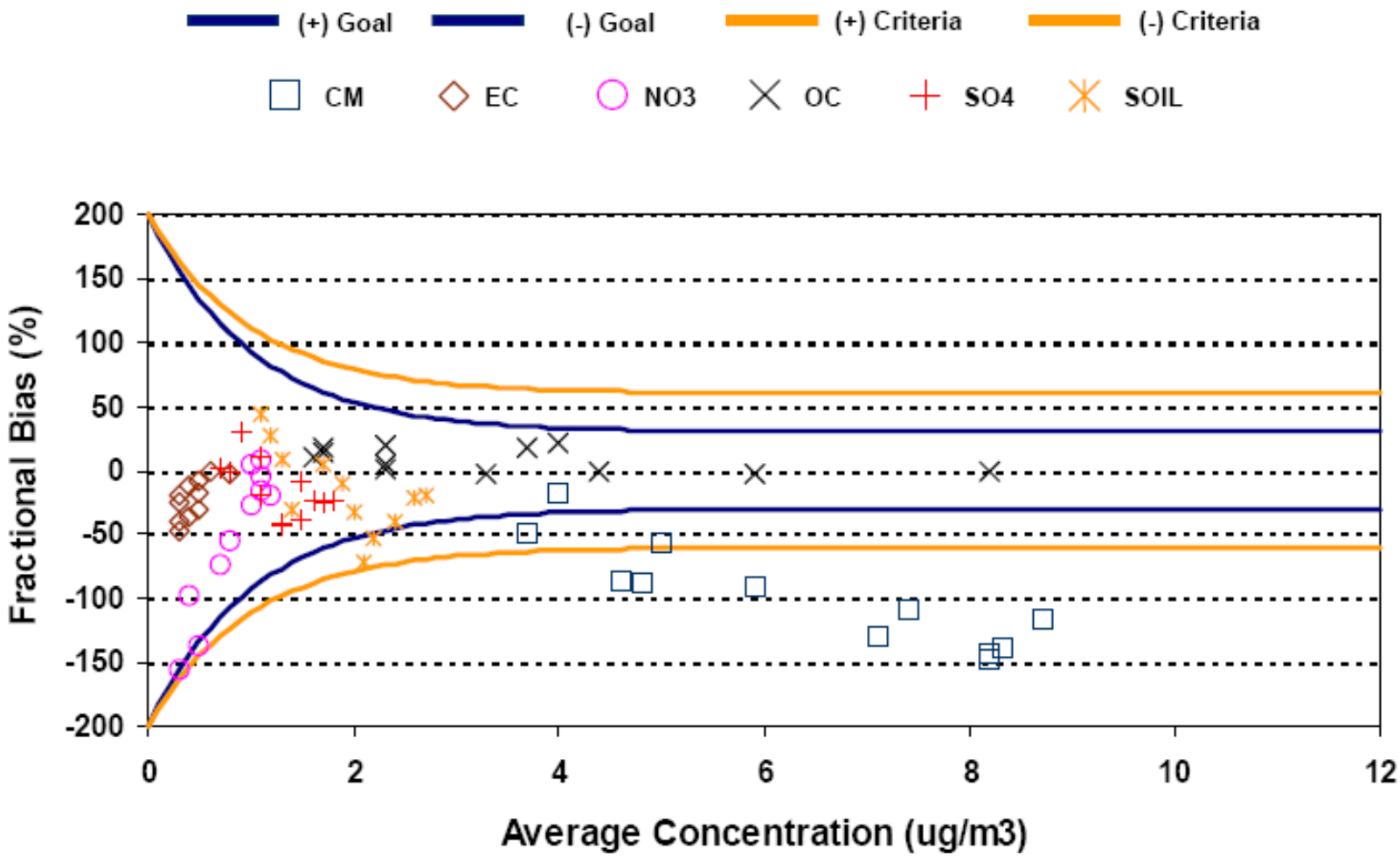


Bar plots of monthly error and bias: CM



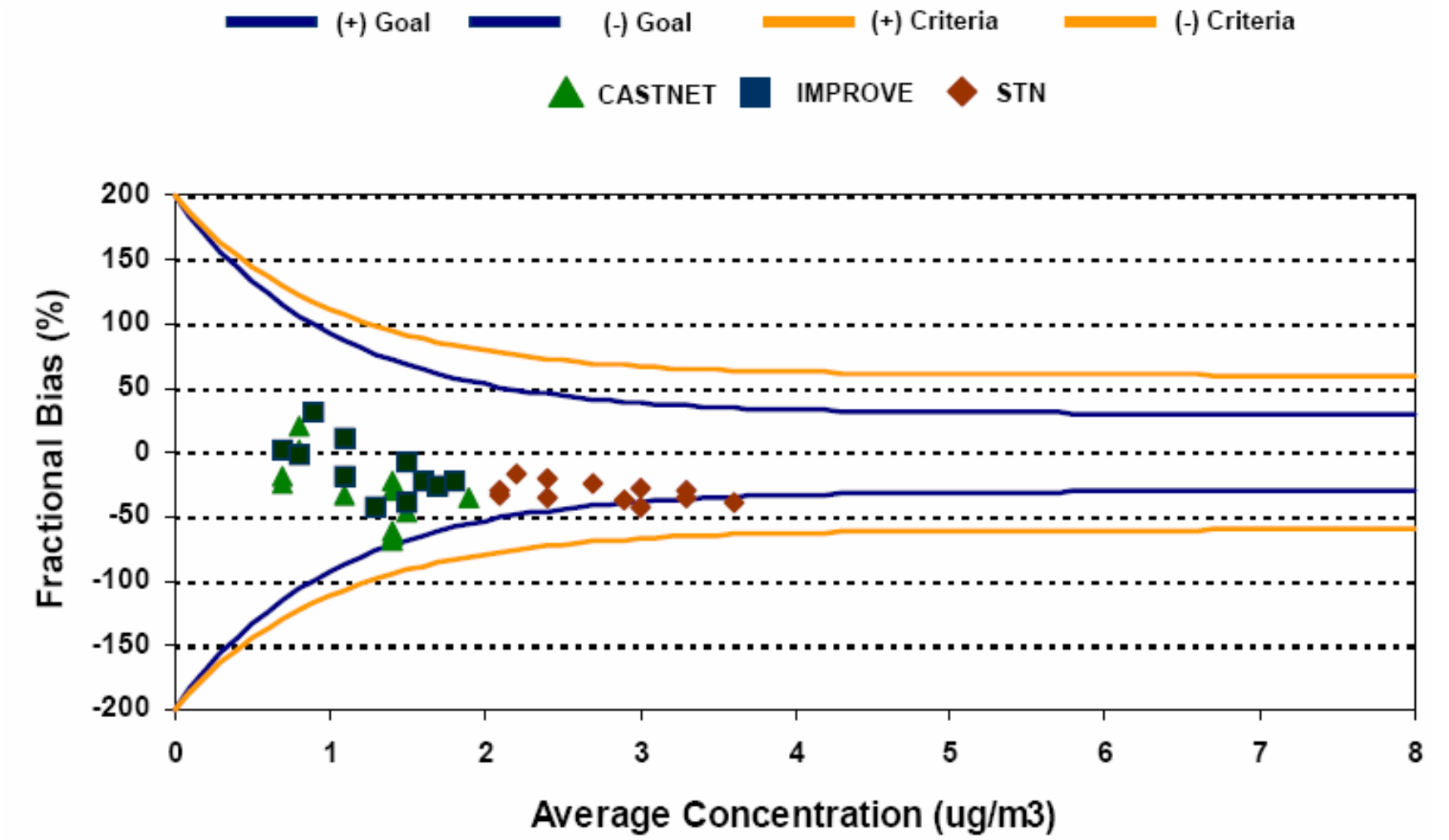
Bugle plots of performance benchmarks & goals

CMAQ 4.5 vs. IMPROVE for all species



Bugle plots of performance benchmarks & goals

CMAQ 4.5 vs. SO4 for all ambient data



Stacked-bar time series plots: IMPROVE data

AGTI1

Agua Tibia, CA

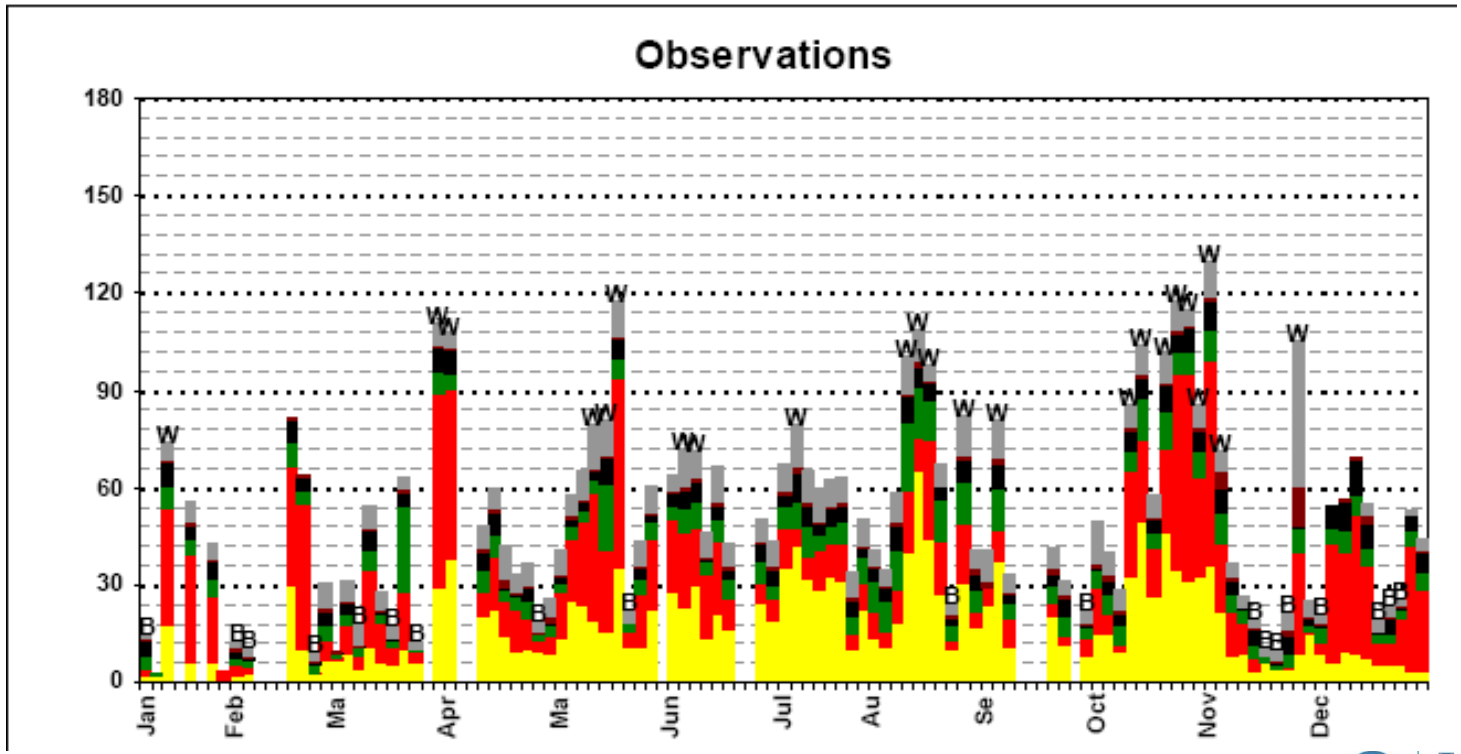
2002 Reconstructed Extinction

Observations (top) vs. CMAQv4.5 Model Results (bottom)

Model Case: 2002 Base02a 36k YAMO

- Coarse Material
- Soil
- Elemental Carbon
- Organic Material
- Ammonium Nitrate
- Ammonium Sulfate

*Excludes Rayleigh Extinction



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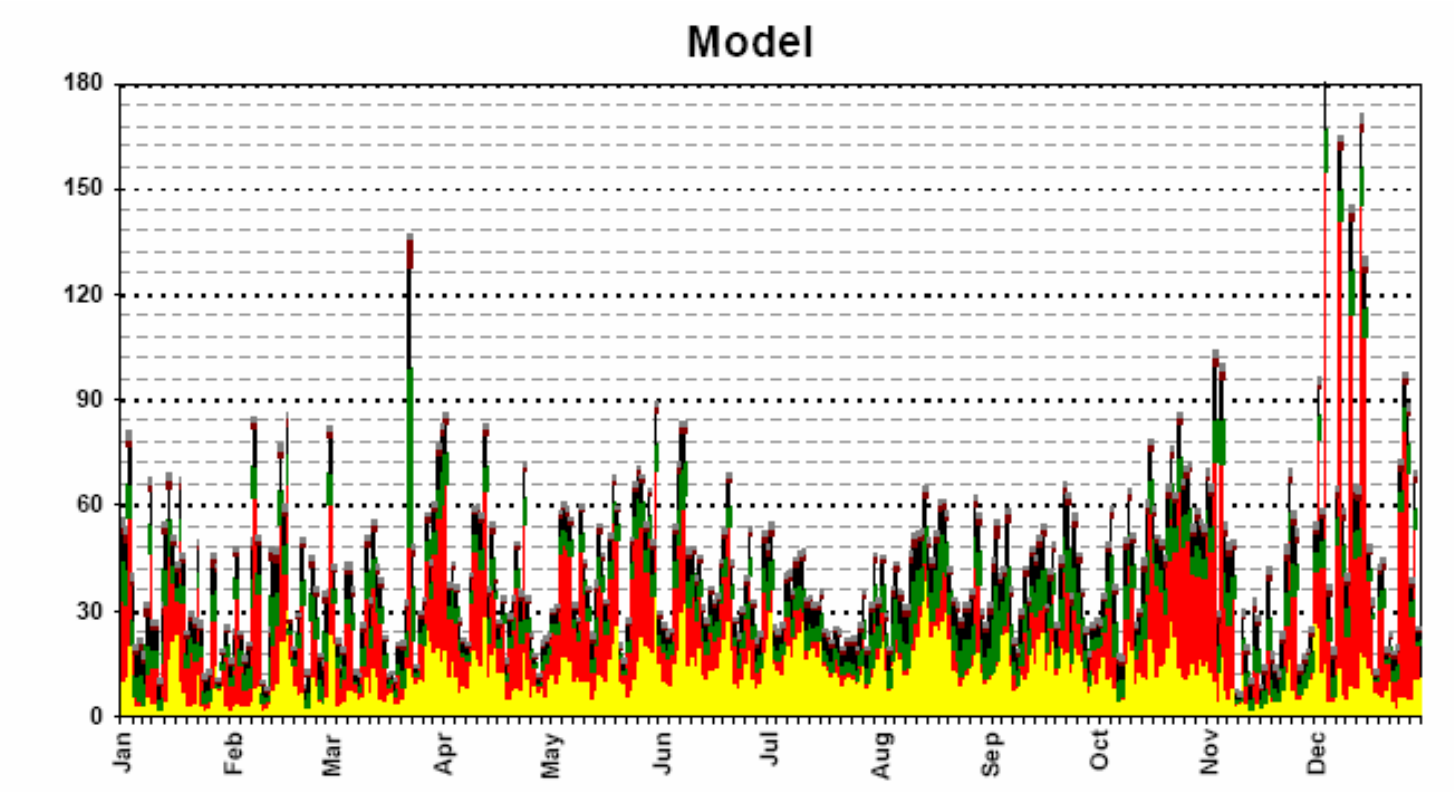
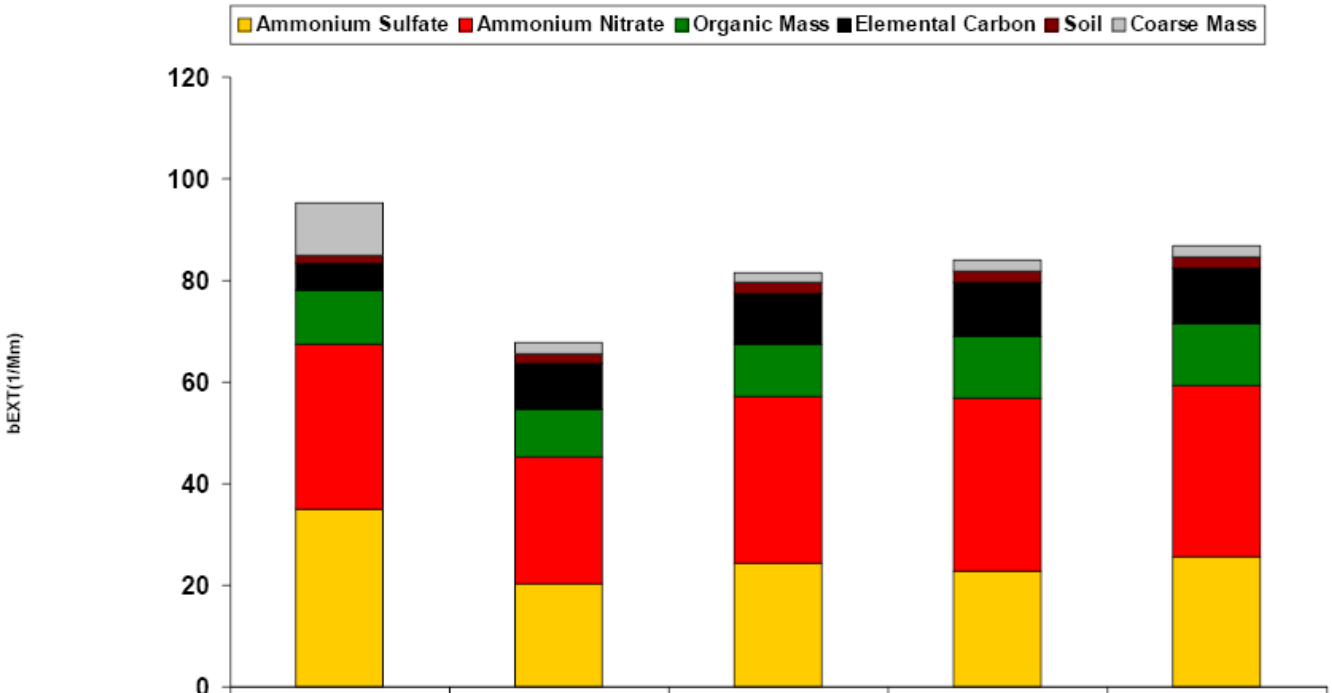
Stacked-bar time series plots: Model results



Stacked bar plots of best and worst 20% days

CMAQ 2002 Base02a 36k Agua Tibia, CA
2002 Extinction model performance
Average of Worst 20% observed days (97) Time Unpaired



	Observed Data(%)		0 Day(%)		3 Days(%)		One Week(%)		Two Weeks(%)	
Coarse Mass	10.49	(11.)	1.96	(2.9)	2.03	(2.5)	2.09	(2.5)	2.08	(2.4)
Soil	1.64	(1.7)	1.84	(2.7)	2.01	(2.5)	2.21	(2.6)	2.29	(2.6)
Elemental Carbon	5.23	(5.5)	9.09	(13.4)	9.97	(12.2)	10.77	(12.8)	10.87	(12.5)
Organic Mass	10.55	(11.1)	9.38	(13.9)	10.33	(12.7)	11.92	(14.2)	12.18	(14.)
Ammonium Nitrate	32.6	(34.2)	25.11	(37.1)	33.07	(40.5)	34.36	(40.9)	33.9	(39.1)
Ammonium Sulfate	34.94	(36.6)	20.29	(30.)	24.25	(29.7)	22.67	(27.)	25.48	(29.4)

MPE Summary

- Fairly good model performance for SO4, NO3, EC, OC and Soil:
  - large improvement compared to early modeling
- Stacked bar plots show that model has considerable skill in simulating unique conditions at diverse IMPROVE sites.
- Spatial plots and relaxed and time or space plots shows that model successfully simulates the full range of clean and polluted conditions at IMPROVE sites.

Key Finding

- The CMAQ and/or the CAMx 36-km modeling can be used, in combination with the RRF approach, to evaluate the benefits of emissions reduction strategies for all PM species other than CM, in order to project visibility changes at Class I areas for regional haze planning purposes.

CMAQ versus CAMx (1)

- Goal: Compare model performance for 2 different air quality models, CMAQ and CAMx
- Motivation: Although the model are similar in design and in many of the science processes there are important differences in the science and numerical algorithms used.
- Results include MPE for both models. See the RMC webpage has full set of plots:

CMAQ versus CAMx (2)

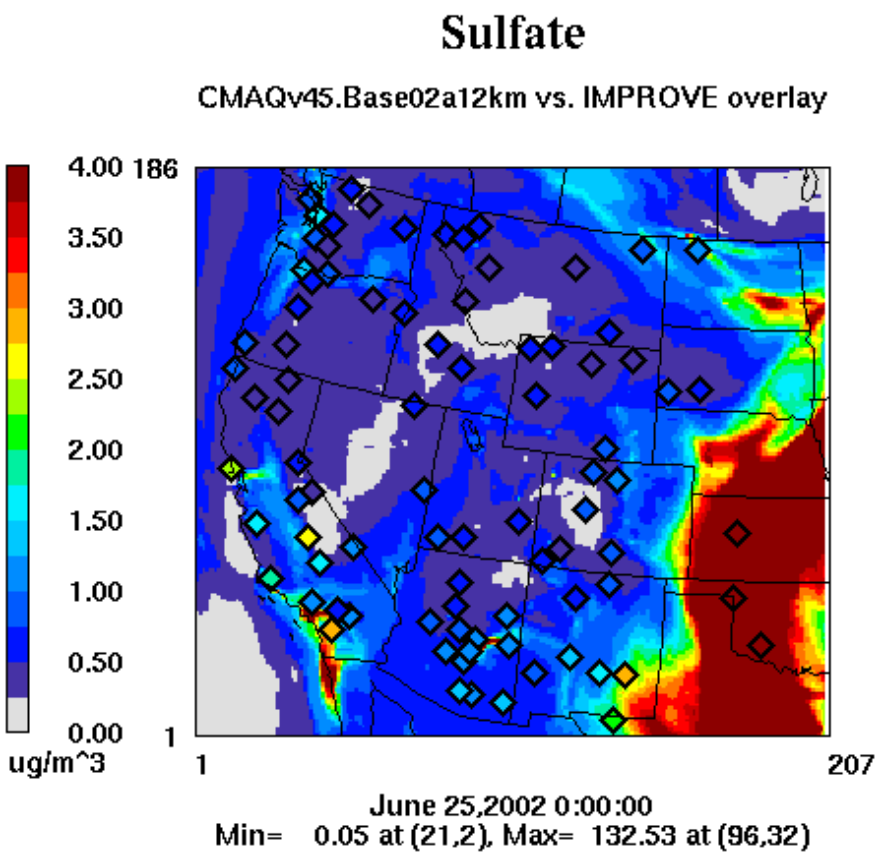
- Key Findings:
  - Both CMAQ and CAMx are acceptable for visibility modeling, and the choice of model should be based in part on factors other than model performance, such as computer run times, disk storage requirements, and source apportionment and/or sensitivity analysis needs.
  - The CMAQ and/or the CAMx 36-km modeling can be used, in combination with the RRF approach, to evaluate the benefits of emissions reduction strategies for all PM species other than CM, in order to project visibility changes at Class I areas for regional haze planning purposes.

CMAQ 12km versus 36km (1)

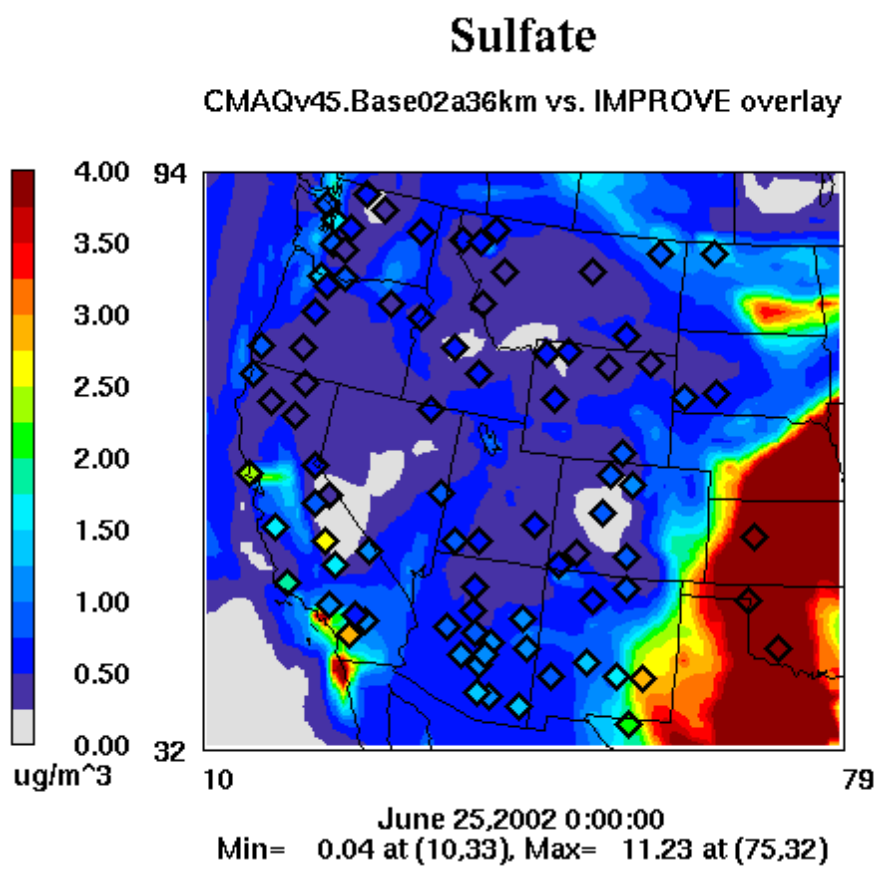
- Goal: Determine whether fine grid resolution results in better model performance.
- Motivation: finer grid resolution reduces the numerical dispersion of emissions and plumes and therefore also effects rates of chemical transformations.
- Results: Similar to previous studies there was no improvement in the MPE for IMPROVE sites in the WRAP region. It is possible that the model would have improved performance for regions with higher concentrations and areas closer to the emissions sources.

CMAQ 12km versus 36km (2)

12km



36km



CMAQ 12km versus 36km (2)

- Key Finding:
  - We do not recommend the routine application of additional 12-km modeling as part of the WRAP regional haze planning effort, due to the substantially higher resources and costs associated with performing high-resolution modeling.

Fire Sensitivity Modeling

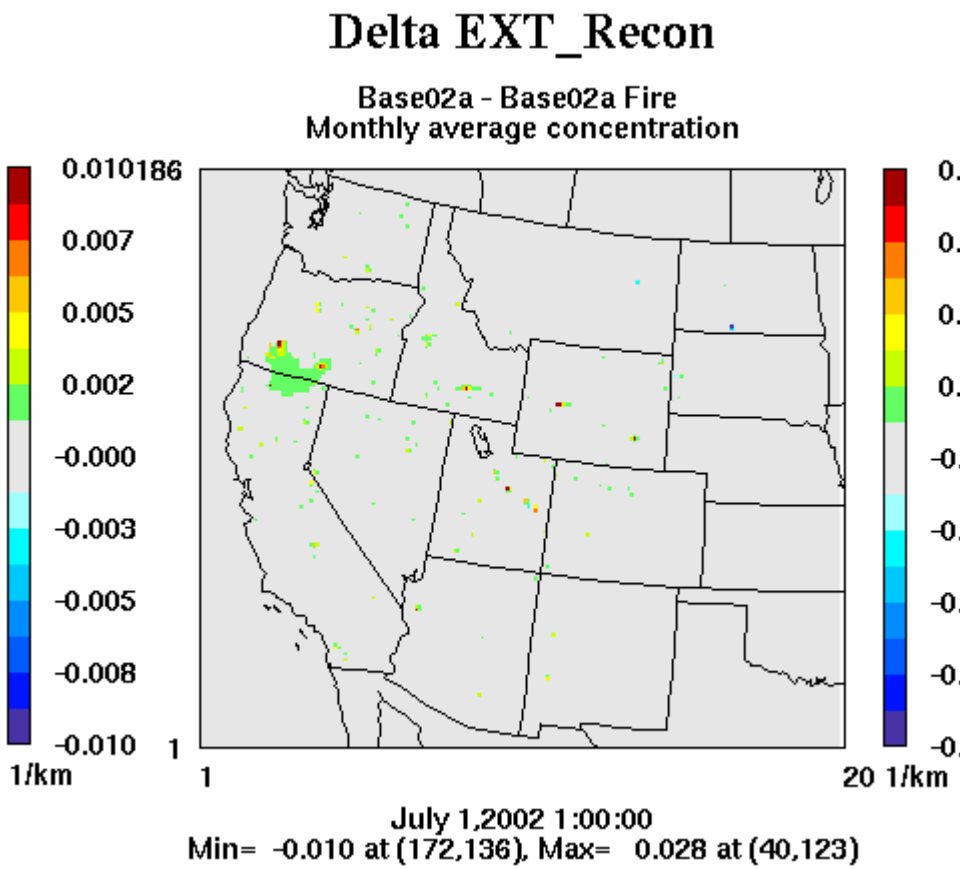
- Goals: Determine whether small fires have significant impacts on visibility at Class I areas. Determine if the model is sensitive to changes in calculation of fire plume height rise.
- Motivation: Most fires are small, and there would be a savings in cost if it is not necessary to track small fires.
- Results: Analysis of fire sensitivity results is still in progress, but preliminary results suggest that fires can affect visibility at Class I areas

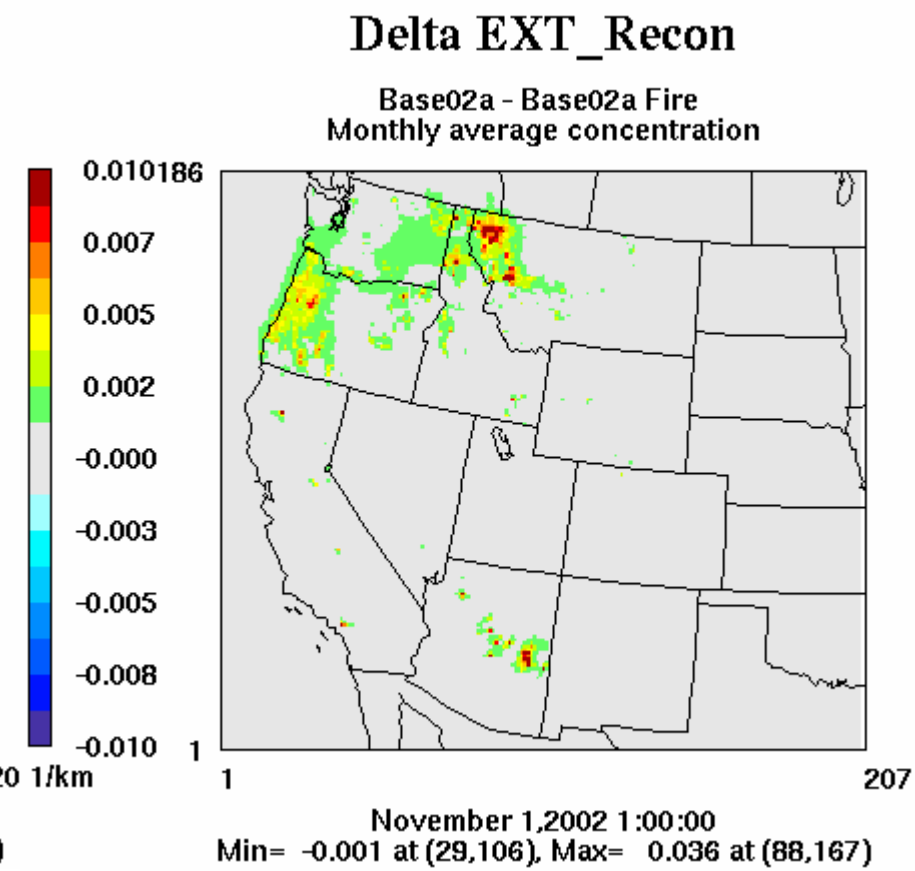
Fire Sensitivity Modeling

- Remove all fires smaller than 100 acres for woodlands and smaller than 300 acres for grass lands.
- Used 12km CMAQ for July and November
  - Concern that increased dilution and dispersion in the 36km model might make it difficult to model effects of small fires.

Fire Sensitivity Results

Monthly average for July and November





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Source Apportionment Modeling

- White paper describes issues associated with planning the CAMx PSAT modeling.

Benchmarks for CAMx PSAT computational costs for each PM species. Run time is for one day (01/02/2002) of the WRAP 36-km domain

Species	**Number of Tracers**	**RAM Memory**	**Disk Storage per day (CAMx inst filesizes that could be deleted after each day)**	**Run Time with 1 CPU no OMP**	**Run Time with 2 CPU OMP**
SO4	2	1.6 GB	1.1 GB (0.5 GB)	4.7 hr/day	4 hr/day
NO3	7	1.7 GB	2.6 GB (1.8 Gb)	13.2 hr/day	Not tested
SO4 & NO3 combined	9	1.9 GB	3.3 GB (2.4 GB)	16.8 hr/day	Not tested
SOA	14	6.8 GB	Not tested	Not tested	Not tested
Primary PM species		1.5 GB	3.0 GB (1.6 GB)	10.8 hr/day	Not tested

Source Apportionment Recommendations

- Do not include SA treatment of secondary organic aerosols:
  - CMAQ already includes 3 OC species
    - primary organic aerosols
    - biogenic secondary organic aerosols
    - biogenic secondary organic aerosols
  - Analyzing these species for the a the various existing model runs might provide enough info on OC apportionment.

Clean Conditions Modeling

- Run the model using only natural emissions.
- Goal is to establish the “model floor”, i.e., what would visibility would the model predict if all anthropgenic emissions were removed.

Next Steps

- blah blah