# Overview of Model Evaluation Plans for CMAQ FY04 Release

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# Model Evaluation Team

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## Comprehensive evaluation approach to consider…

- How well does the model perform overall?
- What does the evaluation tell us about specific model processes and inputs (meteorology, emissions)?
- How will the model behave in regulatory emission control scenarios?
- How sensitive are the responses to different model specifications (e.g., chemical mechanisms, vertical grid structure)?
- What information can be fed back to model development?

# Evaluation Plan Summary Outline

- Current Status:
  - Annual 2001 36km national simulation to be completed by April, 2004
  - CB4 chemical mechanism will be used (in collaboration with OAQPS)
  - MM5 version 3 meteorology completed, emissions underway
  - Additional simulations planned for winter and summer 2002

- Evaluation Plan for CMAQ Inputs:
  - Meteorology
  - Emissions

- CMAQ Evaluation:
  - Performance Evaluation (Eder presentation)
  - Diagnostic Evaluation (Dennis presentation)
  - Spatial and Temporal Analyses
  - Sensitivity Studies
    - Chemical mechanisms
    - Vertical Layer testing
    - Emission control strategies

# Evaluation of CMAQ Inputs: Meteorology

Surface-Based

- 2-m Temperature
- 2-m Specific humidity
- 10 m wind (speed, direction)
- Hourly precipitation

Upper-Air

- Boundary layer wind profiles
- Boundary layer temperature profiles
- Specific humidity profiles

Evaluation will consider ...

- Full-domain summary
- Regional, local, and geographic-based summary
- Diurnal, synoptic, monthly and seasonal performance

# Evaluation of CMAQ Inputs: Emissions

- Emission processing errors
  - gridding, chemical speciation, temporal allocation
  - diurnal and daily average emissions for key species
- Non-reactive particulate matter
  - Augment existing inventory by speciating primary PM2.5 emissions based on peer-reviewed literature *(elemental carbon, aluminum, barium, cadmium, calcium, chromium, copper, iron, lead, manganese, nickel, rubidium, silicon, sodium, strontium, tin, titanium, vanadium, zinc)*
  - Comparison with STN network observations
- Inverse modeling for seasonal $NH_3$ emissions

# Performance Evaluation for CMAQ

- Compares model predictions at all observational network locations
- Summary statistics include $R^2$, RMSE, Mean Bias, Normalized Mean Bias, and more...
- Comparisons made for $O_3$, $HNO_3$, $SO_4$, $NO_3$, $NH_4$, EC, OC, ...
- Brian Eder's presentation summarizing performance evaluation for FY03 release will follow
- Summary comparison of model performance at all monitors can identify major problems to troubleshoot

# Diagnostic Model Evaluation for CMAQ

- Comparison of model predictions to observations at intensive field sites (e.g., SOS, PM supersite campaigns) for July 2001
  - Chemical ratios and indicators considered: ozone production efficiency and response curve
  - Analyses designed to identify processes and/or inputs responsible for model predictions
  - High temporal resolution (hourly)
  - Low spatial density of data
  - 12 km CMAQ runs for this period
  - Special configuration of CMAQ
- Sensitivity analyses
  - Model responses to individual processes or inputs
  - Model against model comparisons for control strategy responses
- Box-model comparisons (photochemical, PM)
- Robin Dennis' presentation on diagnostic evaluation plans will follow

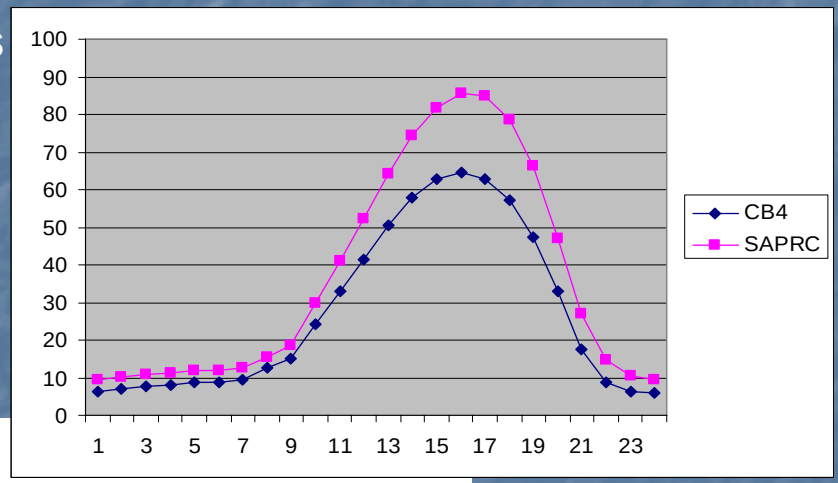
# Spatial and Temporal Analysis for CMAQ

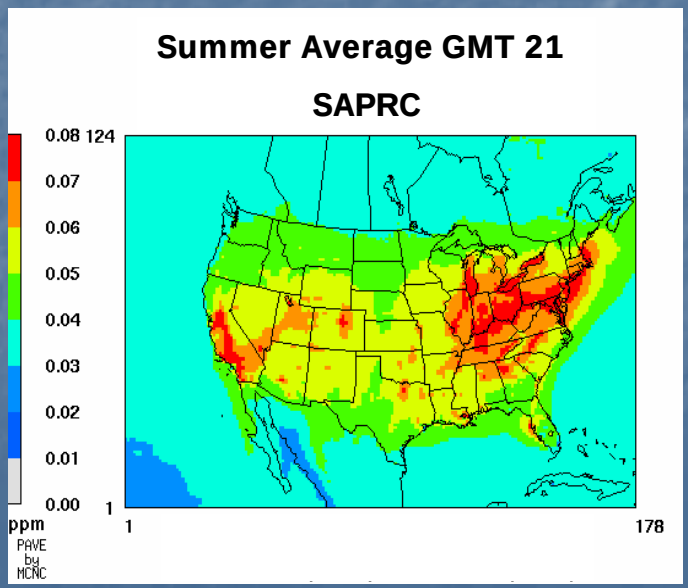
- Spatial comparison
  - Observational data spatially interpolated (e.g., kriging)
  - Geographical areas identified where model performance better/worse
  - Consider 1-hr and 8-hr max for $O_3$ and 24-hr average for aerosols, monthly assessment
- Temporal comparison
  - Apply standard time-series analysis techiques such as the Kolmogorov-Zurbenko (KZ) filter
  - Consider model performance at separate time-scales (seasonal/monthly, syntopic, and diurnal)
  - Comparison against observations at individual locations, regions

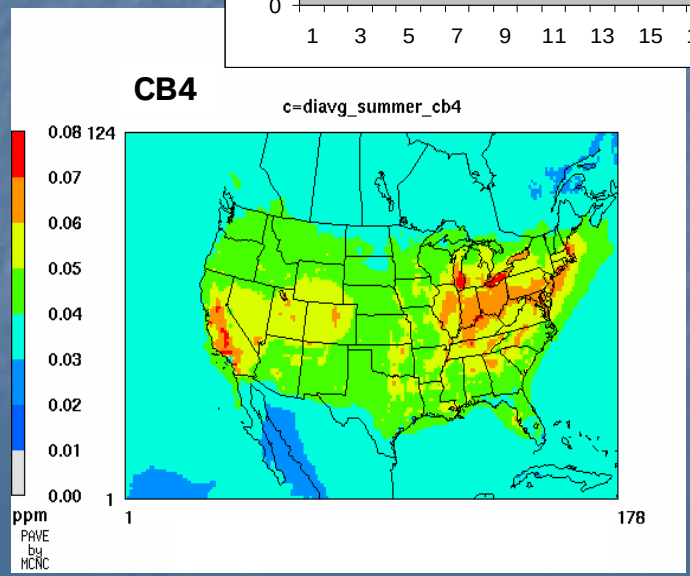
# CMAQ Evaluation: Sensitivity Tests
## Comparison of Chemical Mechanisms

SAPRC vs CB4 during summer and winter cases

- Simulations performed with FY03 CMAQ
- Performance evaluation statistics
- Diurnal average differences
- Currently looking at summer $O_3$



# CMAQ Evaluation: Sensitivity Tests Vertical Layer Testing

- Comparison of model predictions with 14, 15, 18, 23, and 34 layers
- Simulations underway for Summer 1999 case
- Client needs require computational efficiency
  - Vertical layering an option
  - But, at what cost?
- Emission control tests included

# CMAQ Evaluation: Sensitivity Tests Emission Control Strategies

- Tests using 2001 36km CMAQ domain
  - Clear Skies, Transport Rule reductions (collaboration with OAQPS)
  - 6 week simulations for different seasons
  - Chemical mechanism comparisons
- Domain-wide analyses
  - Major spatial changes
  - Relative reduction factors (RRFs)
- Diagnostic emission control strategy tests
  - Higher resolution CMAQ simulations needed
  - Identify model processes involved in response to strategy
  - Special model configurations to be used or new, development versions needed
- How will CMAQ respond to control strategies applications for States, RPOs, OAQPS?

# Working schedule

- June 2004:
  - Performance evaluation for meteorology and CMAQ
  - Spatial and temporal CMAQ analyses
  - Sensitivity studies
    - chemical mechanism comparison
    - emission control strategy tests (RRFs)
    - vertical layer tests
    - nitrate prediction uncertainty characterization
- December 2004:
  - Supersite in-depth analyses
  - Sensitivity studies
    - nitrate replacement of sulfate testing
    - grid size effect on sulfate prediction (coordination with VISTA)
    - inverse modeling for $NH_3$
    - source apportionment tests for non-reactive $PM_{2.5}$ emissions

# In Summary

- New evaluation plan constructed to support FY04 CMAQ Release for client needs and applications
- More comprehensive, fuller understanding of model performance
  - Performance evaluation, including meteorology
  - Diagnostic evaluation tests
    - Includes emission studies (source apportionment for primary PM2.5, inverse modeling for $NH_3$)
  - Spatial and temporal analyses
- Sensitivity tests
  - Chemical mechanism sensitivity
  - Emission control strategy responses
  - Vertical layer specification
- Schedule based on June 2004 (CMAQ release) and follow-on tests December 2004