

Uncertainty Analyses and Relative Reduction Factors in Application to 8-hr Ozone Modeling

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Overview

- Draft guidance suggests the development and use of relative reduction factors (RRF) in the estimation of the future design value (DVF) based upon the current design value (DVC)
- What is the impact of the number of days on the stability of the calculated RRF?
- What are the differences in estimated RRF due to
 - Emissions processing
 - Meteorological episodes
 - Chemical mechanisms
 - Photochemical models

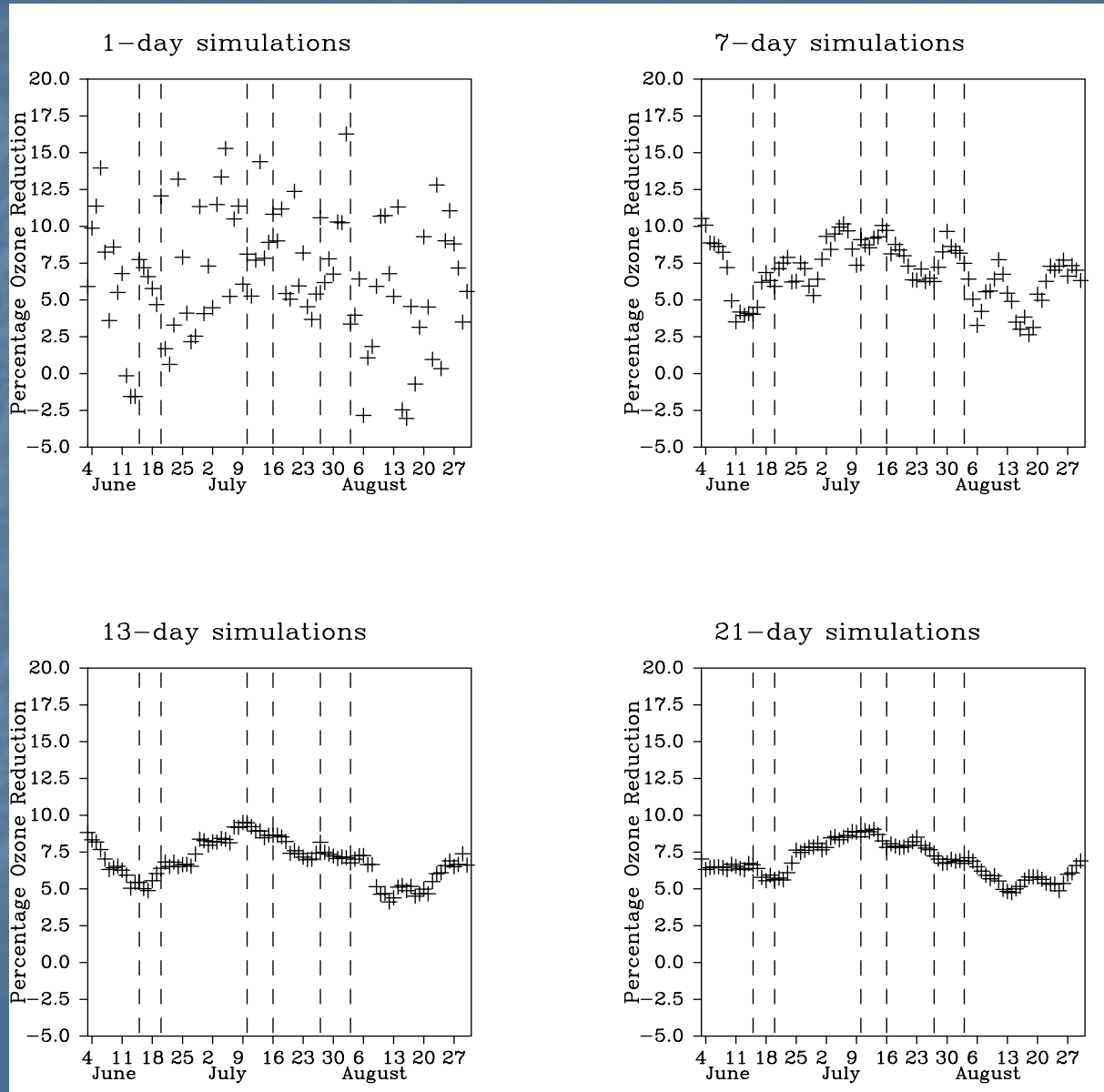
Summary of Model Simulations

| Met. Episode | Met. Model | Emissions Processing | Emission Scenarios | AQ Model |
|--------------------------|-------------|----------------------|--------------------------------|-----------------------|
| June 1 – August 31, 1995 | RAMS | EMS-95 | 2007 Base 2007 NOx SIP Call | UAM-V |
| July 6 – 19, 1997 | MM5 | EMS-2001 SMOKE | 1997 Base -50%NOx/25%VOC | CAMx CMAQ |
| July 10 – 18, 1995 | RAMS MM5 | EMS-95 | 1995 Base -50%NOx/25%VOC | UAM-V SAQM |
| July 2 – 31, 1999 | MM5 | SMOKE | 1996 Base 2010 Clear Skies | CMAQ/CB4 CMAQ/RADM |
| 3 episodes in 1995 | RAMS | SMOKE | 1996 Base 2010 Clear Skies | CAMx |

Question 1: What is the impact of the number of days on the stability of the calculated RRF?

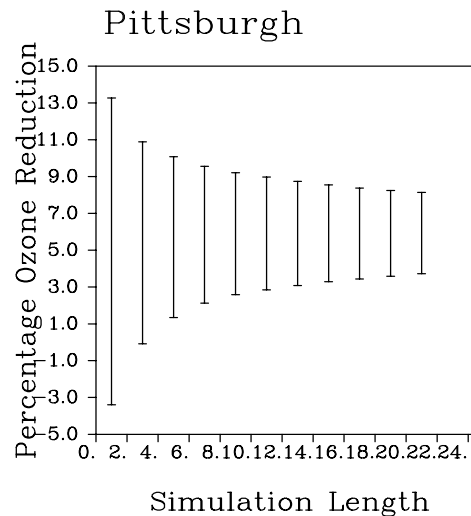
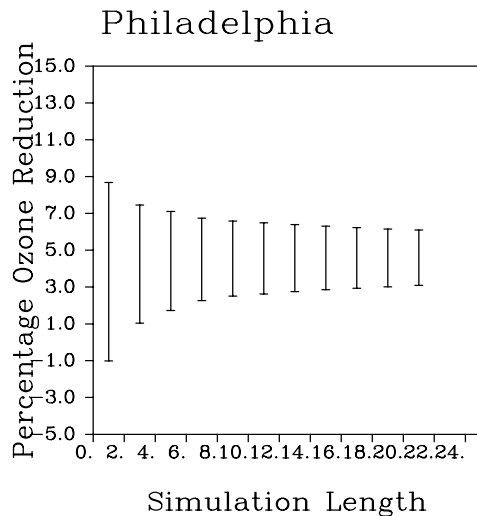
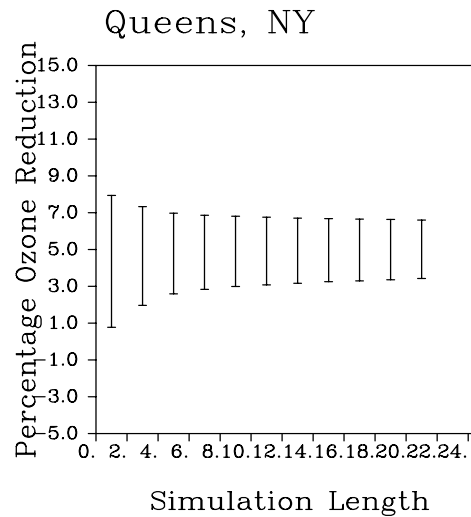
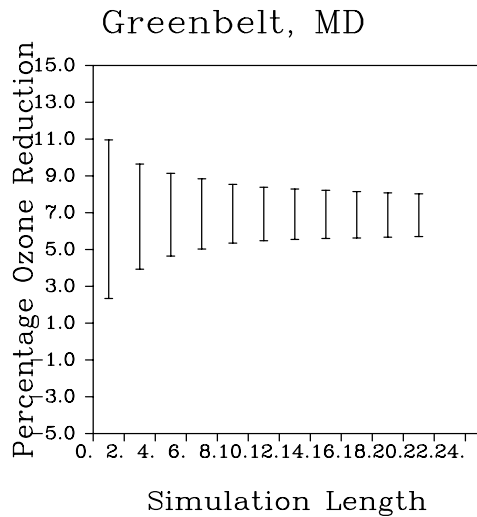
- Used 1995 90-day RAMS/UAM-V simulation with 2007 base and 2007 NO_x SIP-call control emissions
- Calculated RRF over sliding centered 1-day, 3-day, 5-day, etc. "Simulation Lengths"
- Calculated the mean and standard deviation of the 90 1-day RRF, 88 3-day RRF, etc.
- Did not apply base-case threshold concentration or "neighboring grid cell" criteria

90-Day Time Series of Ozone Reductions $[(1-RRF)*100\%]$ at Greenbelt, MD for 1-day, 7-day, 13-day, and 21-day simulations



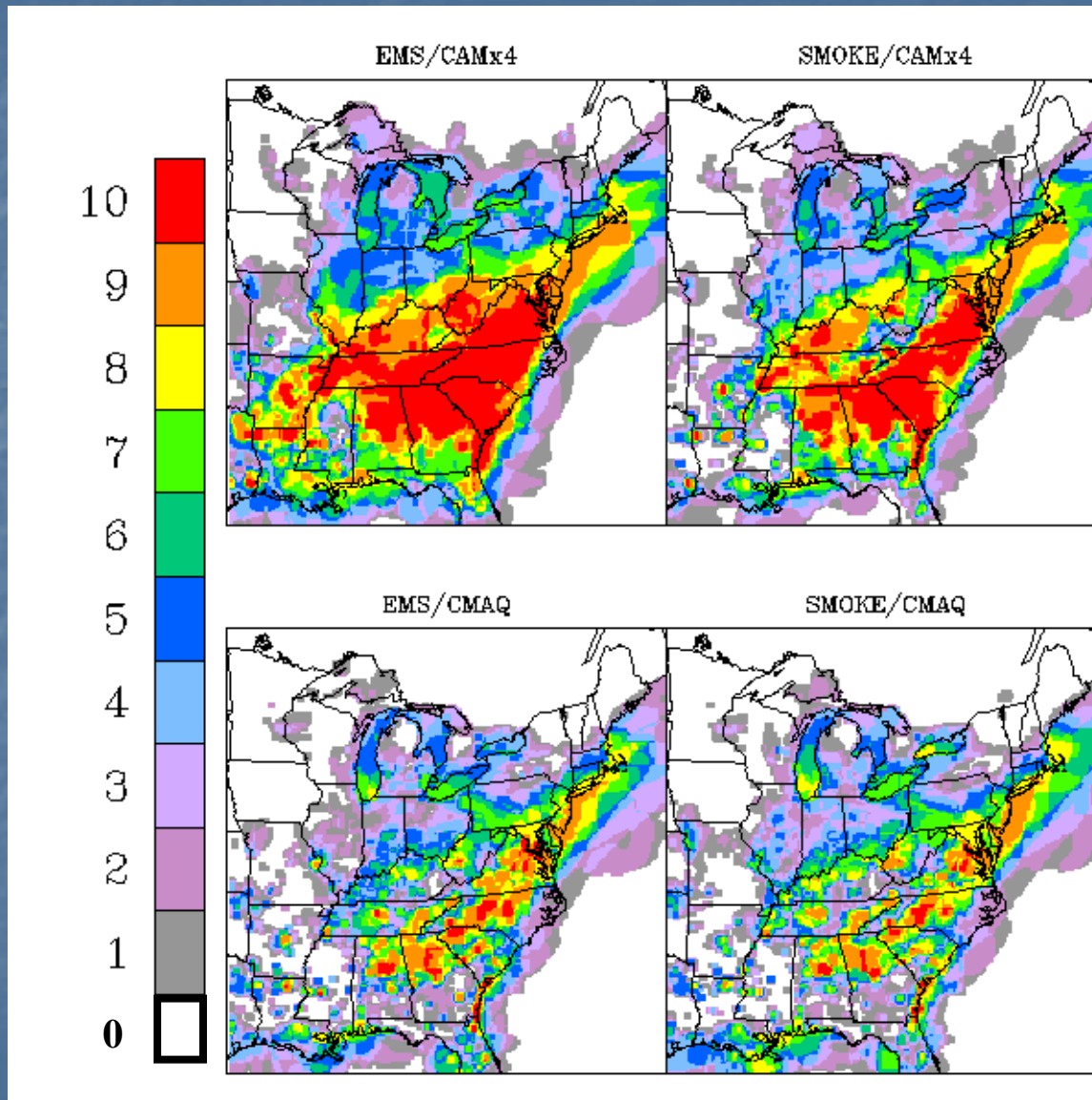
- Vertical lines mark the three high-ozone episodes of 1995
- For 1-day RRF, ozone reductions range from -3% (disbenefit) to 16%
- Variability around the mean ozone reduction of $\sim 6\%$ is greatly reduced for the 13-day and 21 day simulations
- In other words, when calculating RRF over 21 days, the choice of days has little impact on this calculation (no threshold considered)

Mean and Standard Deviation of RRF for Different “Simulation Lengths” at Four Monitors, Calculated from the June – August, 1995 UAM-V simulations



- At all monitors, the RRF standard deviations decrease significantly as the simulation length increases from 1 day to ~14 days
- At most monitors, there is no substantial reduction in variability as the simulation length is further increased
- Did not apply base-case threshold concentration or “neighboring grid cell” criteria

Number of Days with Base Case > 70 ppb for a 12-Day Simulation in 1997 with Four Modeling System Combinations

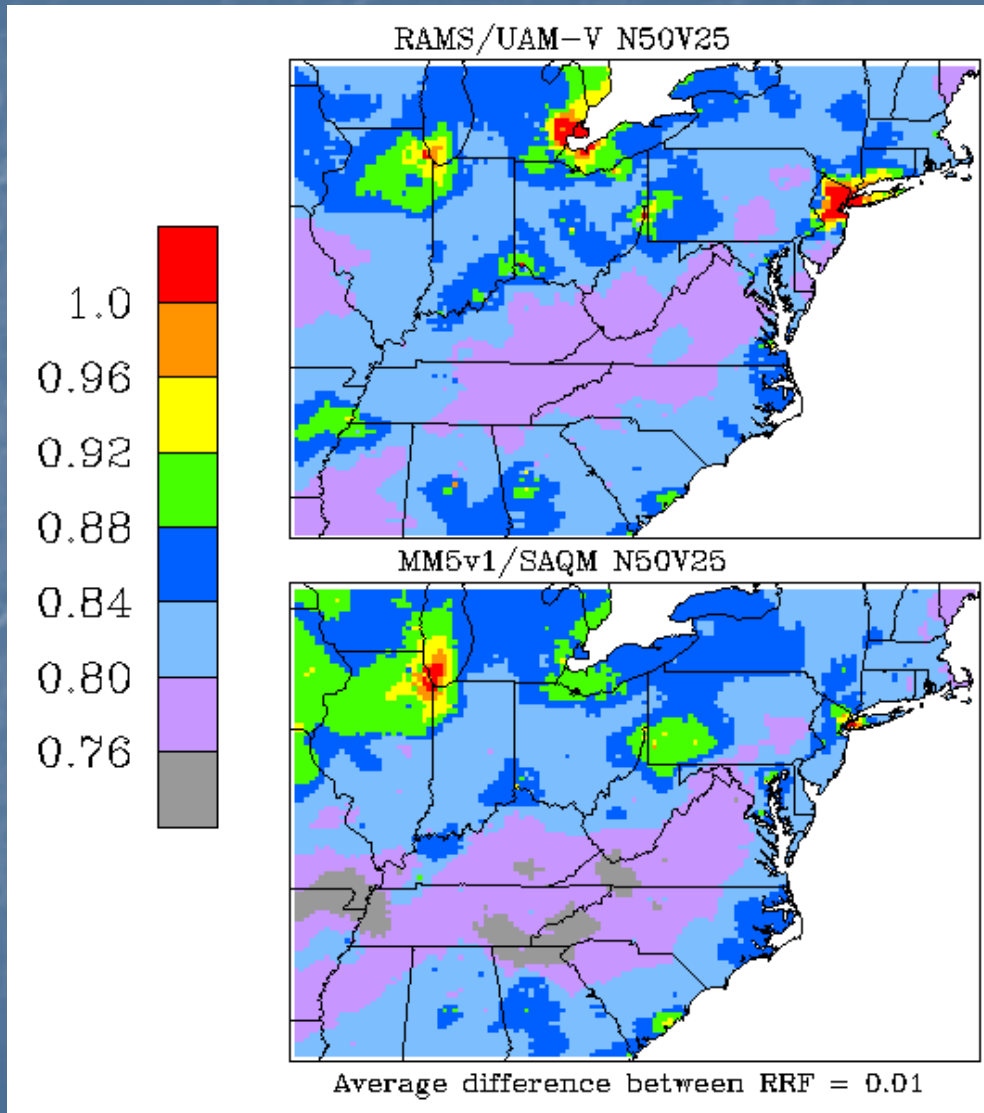


- Although this 12-day simulation encompasses a regional-scale high ozone episode, there are four or fewer days >70 ppb at a number of grid cells, especially for the CMAQ simulations
- Episode selection becomes crucial to ensure sufficient # of days for stable RRF calculation
- Is there a benefit of having a “hotter” base case run/model? I.e., a model with a base case bias of +5% will probably yield a larger number of days for RRF calculations than a model with a base case bias of -5%

Question2: How Large Are Model-to-Model Differences in RRF?

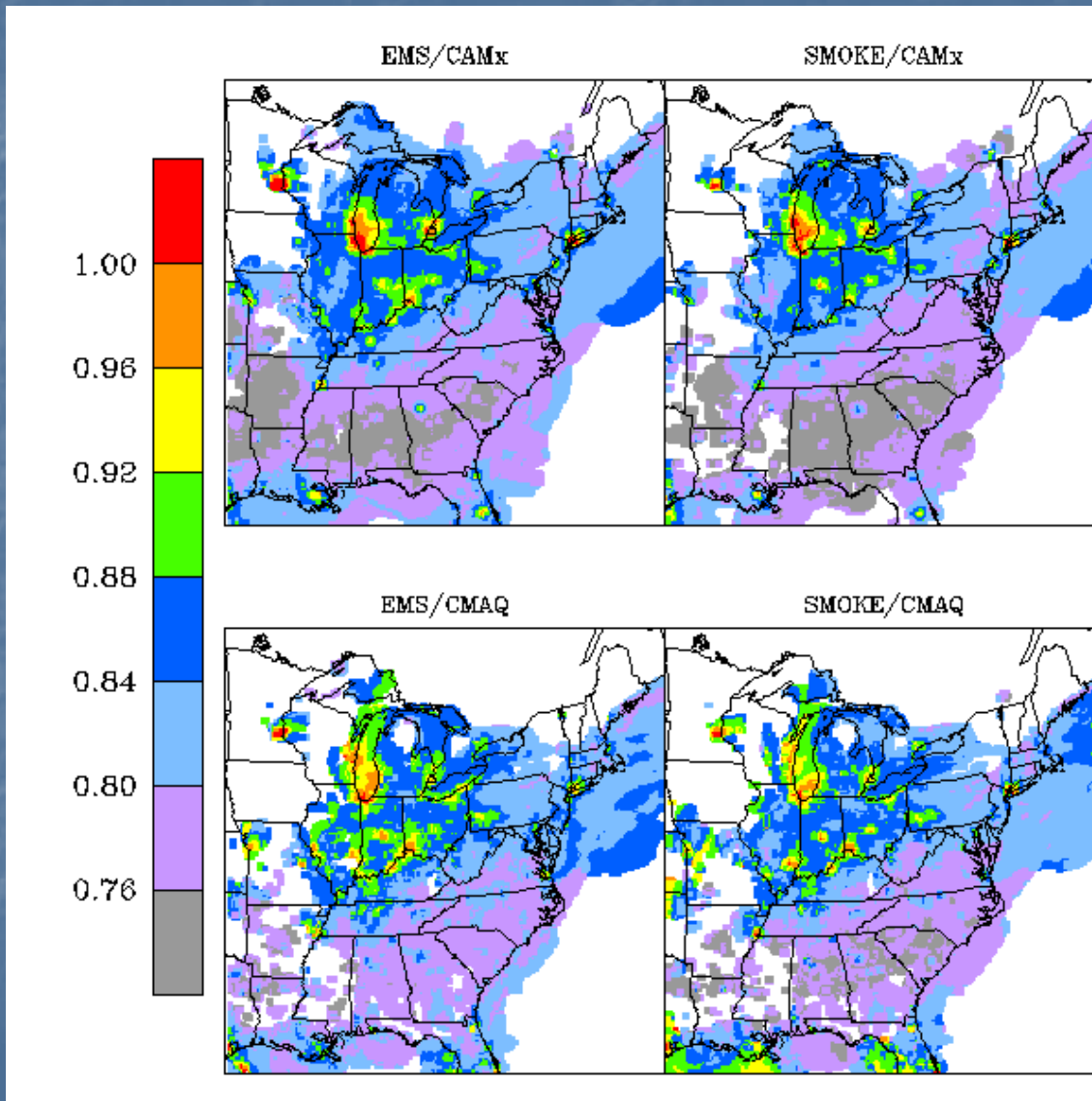
- Determine the differences in estimated RRF caused by differences in
 - Emissions processing
 - Meteorological episodes
 - Chemical mechanisms
 - Photochemical models
- Assess the potential impact of these differences on the modeled attainment test

Maps of RRF Predicted by Two Modeling System Using the Same Emissions for an Episode in 1995



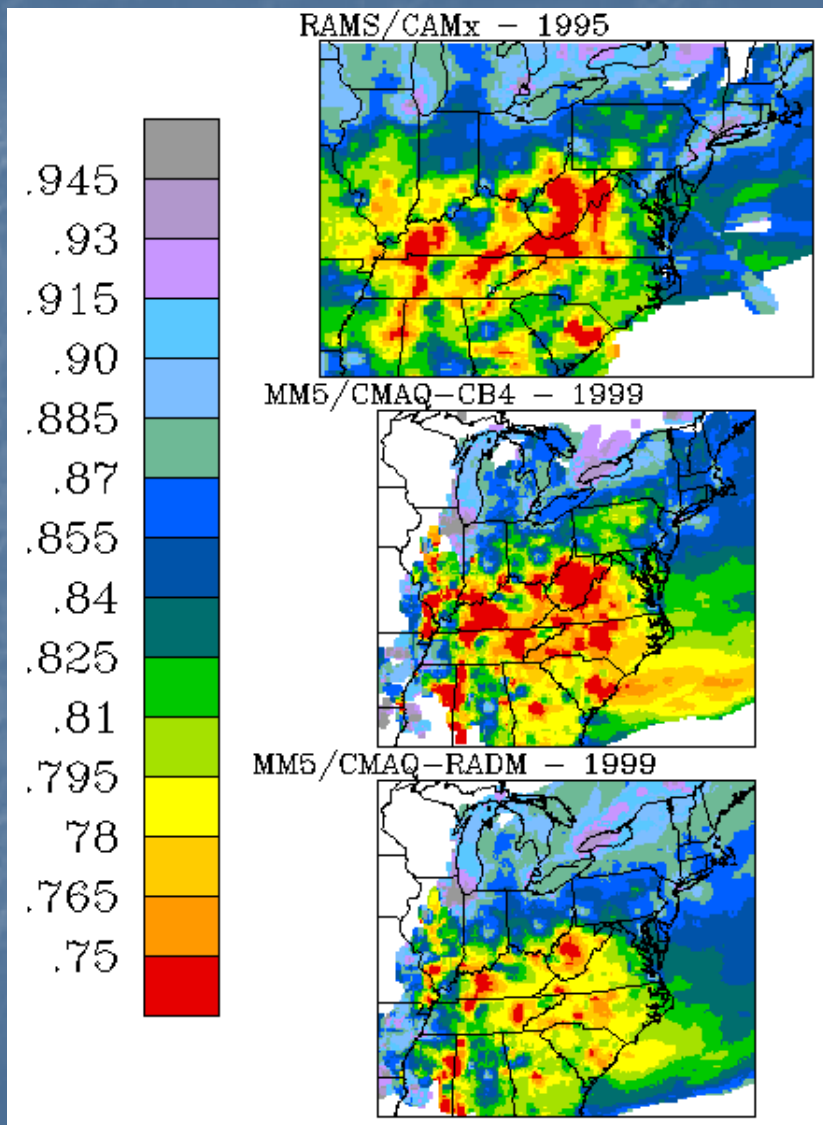
- Response of RAMS/UAM-V (top) and MM5/SAQM (bottom) to a reduction of 50%/25% in NO_x/VOC emissions
- Spatially averaged RRF differences are ~0.01 (1%)
- Larger model-to-model differences of the predicted NO_x-disbenefit in core urban areas
- No base case minimum concentration or surrounding grid cell criteria applied

Maps of RRF Predicted by Four Modeling System for an Episode in 1997



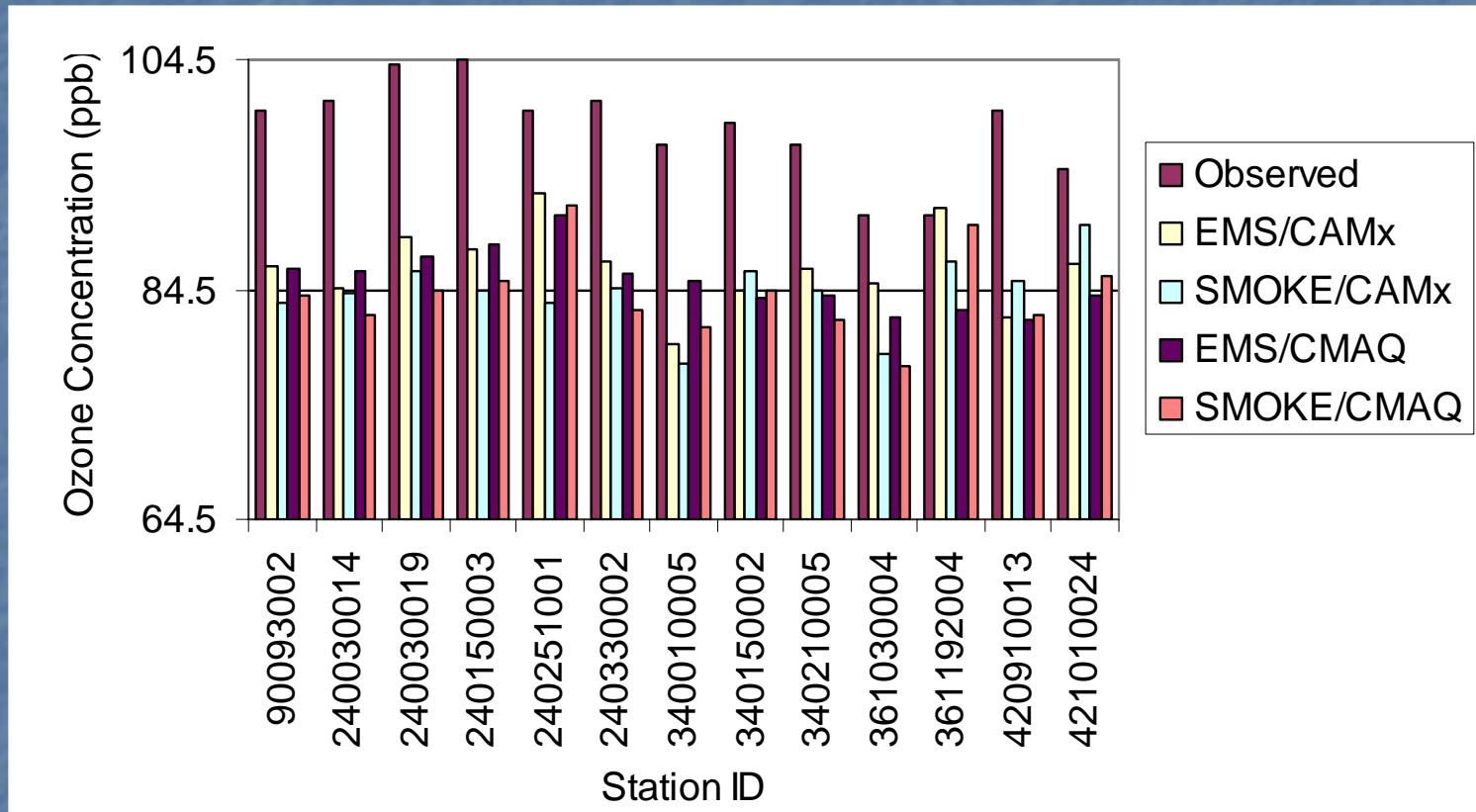
- Response of EMS/CAMx, SMOKE/CAMx, EMS/CMAQ, and SMOKE/CMAQ to a reduction of 50%/25% in NO_x/VOC emissions
- Base case minimum concentration and surrounding grid cell criteria were applied

Maps of RRF Predicted by Three Modeling System for two Different Episodes



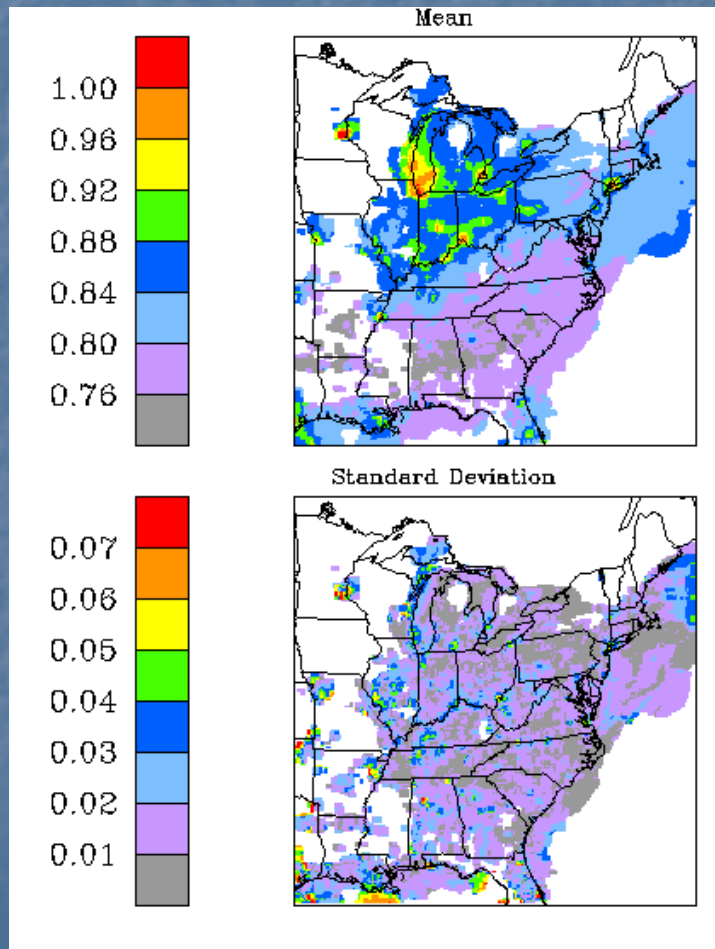
- Response of RAMS/CAMx using 1995 meteorology, MM5/CMAQ (CB4) using 1999 meteorology, and MM5/CMAQ(RADM2) using 1999 meteorology to the 2010 Clear Skies emission reductions
- Base case minimum concentration and surrounding grid cell criteria were applied
- The similarity of RRF could mask underlying flaws of the simulation of ozone-precursor relationships in all of these models → need for diagnostic base case evaluation

Example Modeled Attainment Test at OTC Monitors Exceeding the 8-hr O₃ NAAQS for Observed 1998 DVC and N50V25 DVF for Four Modeling Systems



- The use of different modeling systems can affect the outcome of the modeled attainment test
- There are no systematic differences between the modeling systems

How Can These Model-to-Model Differences Be Reconciled with the “Bright-Line” Attainment Test?



- Map of mean and standard deviation of RRF from four model simulations of 50%/25% NO_x/VOC simulations
- Standard deviations can be as high as 3-5% in some urban areas
- Using these standard deviations, one could estimate “exceedance probabilities”
- Can this be used under weight of evidence (WOE)?

Summary

- Analysis of the 1995 seasonal RAMS/UAM-V run suggests that 10 or more days are necessary to reduce the variability of calculated RRF
- Model-to-model differences of estimated RRF are generally small, but can nevertheless lead to different results of the modeled attainment test
- The similarity of RRF could mask underlying flaws of the simulation of ozone-precursor relationships in all of these models → need for diagnostic base case evaluation
- The modeled attainment test represents a 'bright-line' test and does not take into consideration the uncertainty in the estimated RRF (because of model-to-model differences, episode selection, etc.) - can this uncertainty be incorporated in addressing the DVF, since demonstration of attainment for an area requires one to provide a yes or no answer?