Analysis of URM Performance for 24 June 1992

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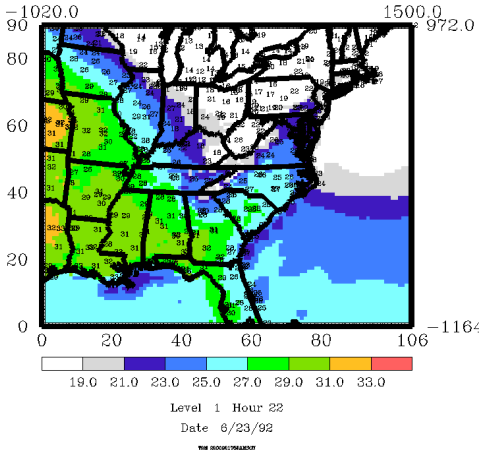
Problem:

URM underestimated ozone at both the Look Rock and Big Meadows sites on 24 June 1992. This date was a Class 4 day for both sites. At Look Rock, the maximum hourly ozone concentration occurred at 0100 EST. URM underestimated the daily maximum by about 36 ppb. At Big Meadows, the maximum hourly ozone concentration occurred around 1800 EST, and URM computed a peak to occur within a couple hours of that time. However, URM underestimated the peak by about 12 ppb. Time series plots for these and other monitoring sites are posted elsewhere on this web site.

Findings:

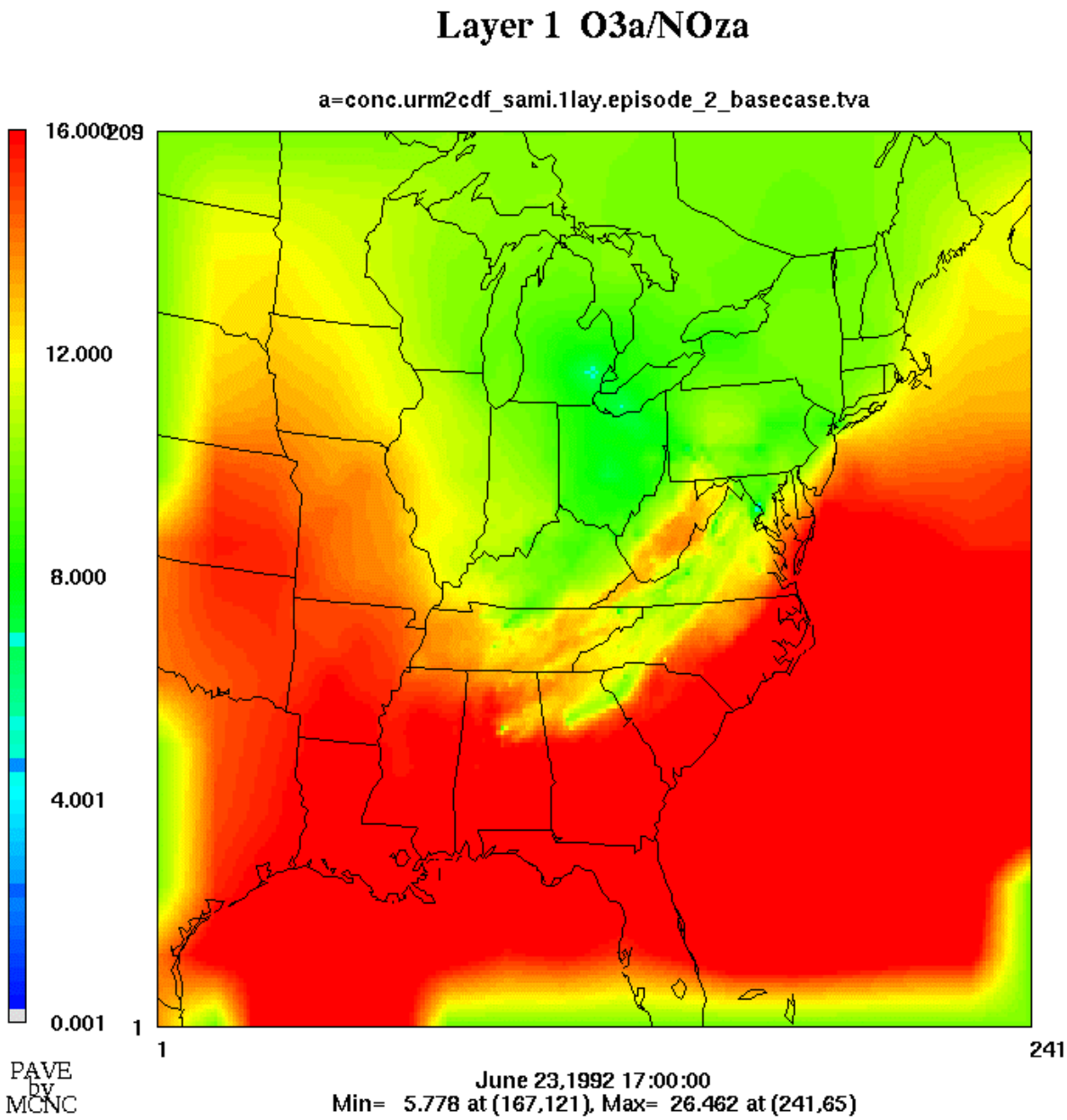
Both meteorology and URM modeling issues were examined in detail to better understand these biases. Grid-wide (12 km) errors in meteorological parameters were examined.

The timing of the Look Rock maximum dictated that conditions most associated with the ozone maximum were those on the previous day (23 June). This was the second "spin-up" day of the episode. However, RAMS performance was exceptionally good on this day. Wind direction bias (grid-wide) was <10 degrees. RAMS correctly simulated the up-valley (from the southwest within the Tennessee Valley) airflow near the surface that was observed on 23 June. Near Big Meadows the model also simulated daytime near-surface airflow from the southwest quadrant. Most nearby observations agreed with this. Gird-averaged wind speed bias was only +1.2 m/s. Surface temperature bias was only -0.7 C (second best day of the episode). No precipitation or significant cloud cover occurred nor did the RAMS results indicate such. An unseasonably cool airmass from Canada covered the region on 23 June with the axis of the temperature minimum lying along the Appalachians. The cool air extended south into extreme northern Georgia (see Plot A for 1700 EST). **Conclusion: There is no evidence that meteorological modeling errors were a major factor in the ozone bias found over the Appalachians.**



Plot A

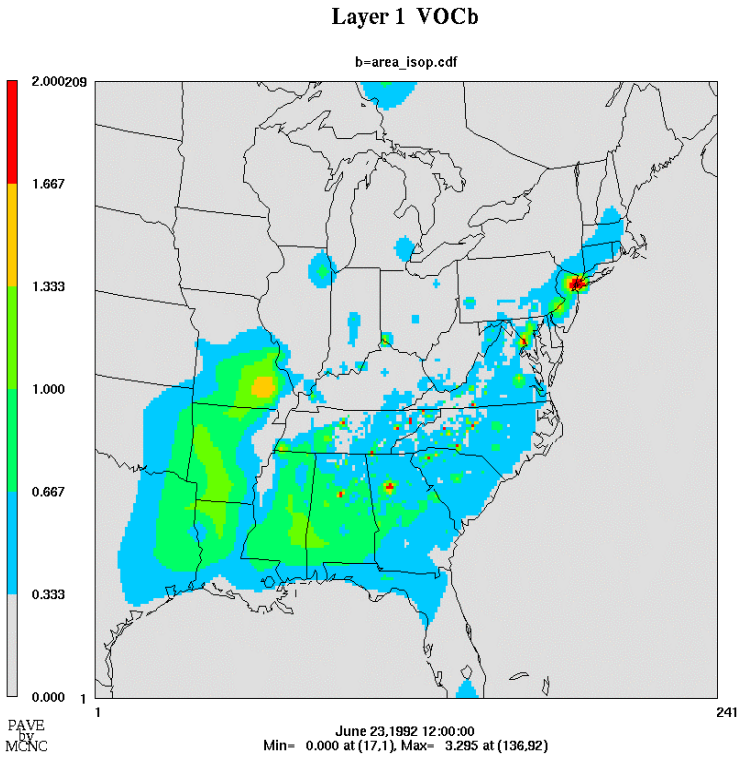
The URM ozone underestimation bias was centered over the southern Appalachians and appeared to generally decrease to the west, south and east of the mountains. For example, comparisons with data from Nashville, Sipsey Wilderness, Atlanta, and Washington, DC, showed URM results agreeing well in those areas. The low bias was found nearer the mountains, especially at Knoxville, Chattanooga, Look Rock (Cove Mountain data were not available), Charlotte, Roanoke, Big Meadows, and Greenbrier (WV). Smaller biases occurred for Charleston (WV) and Lexington. In general, the bias was greater at high elevation sites. A plot of computed O_3/NO_z (plot B, for 1700 EST on 23 June), an indication of the ozone productivity of the atmosphere, shows a region of minimum values centered over the southern Appalachians and is geographically similar to the temperature pattern for this



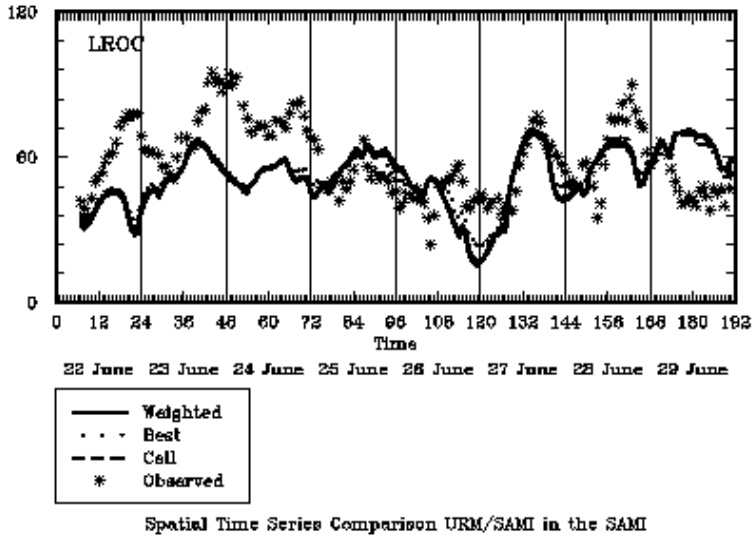
Plot B

same time. A plot (C) of total VOC emissions for noon on 23 June shows higher values to the south and east of the mountains. Relatively low VOC emissions over west Tennessee and Kentucky are due to vegetation type. However, the low VOC emissions over the mountains and areas east and north are most likely due to the presence of the unseasonably cool airmass that coincides with the VOC emission minimum. High ozone that formed downwind of Birmingham and Atlanta (124 ppb) on 23 June are consistent with the higher levels of VOCs simulated for that area. Thus, URM seemed to produce high ozone in those areas where the cool airmass had the least effect on VOC emissions. Of course, not all ozone performance problems can be blamed on levels of VOCs, but the similarity in the ozone bias pattern to those for VOC emissions, temperature and ozone productivity suggest that low VOC emissions probably played a significant role in influencing the problem. **Conclusion: A low bias in URM-simulated ozone at sites on 23 June 1992 in the southern Appalachian appears associated with the presence of an unseasonably cool airmass over the region.**

Discussion:
The biogenic emissions model relates vegetation VOC emissions to temperature using a least squares fit to observed data. Emissions are so sensitive to temperature that they tend to increase logarithmically as temperature increases. Thus, VOC emissions and the ozone productivity of the atmosphere are very sensitive to temperature. The unseasonably cool outbreak of Canadian air over the region on 23-24 June suggests a condition that would stress the assumed biogenic response to temperature because it occurred at a time of year when such cool temperatures normally do not occur. The biogenic emissions data are not perfectly correlated with temperature, so it is not unreasonable to expect that significant departures form seasonal conditions could lead to significant biases in modeled biogenic emissions. It is also important to note that evaporative anthropogenic VOC emissions are also strongly influenced by temperature, so it is possible that some of the low ozone productivity may also be due to low anthropogenic VOC emissions in the cool areas. Given the state of knowledge of modeling (emissions, meteorology and chemical), it is not likely that significant improvements in model performance can be realized at this time for 24 June. Computed and observed Look Rock ozone are illustrated in plot D. It is also important to realize that, because of disparities in the timing of ozone maxima, the computed ozone maximum for Look Rock on 23 June (the second spin-up day) was nearer in magnitude and in timing to the observed maximum than was that computed for 24 June. Given when the high Look Rock ozone occurred, it would appear that the computed ozone maximum on 23 June may better represent the late night Look Rock ozone maximum than that which was computed for the afternoon of 24 June.

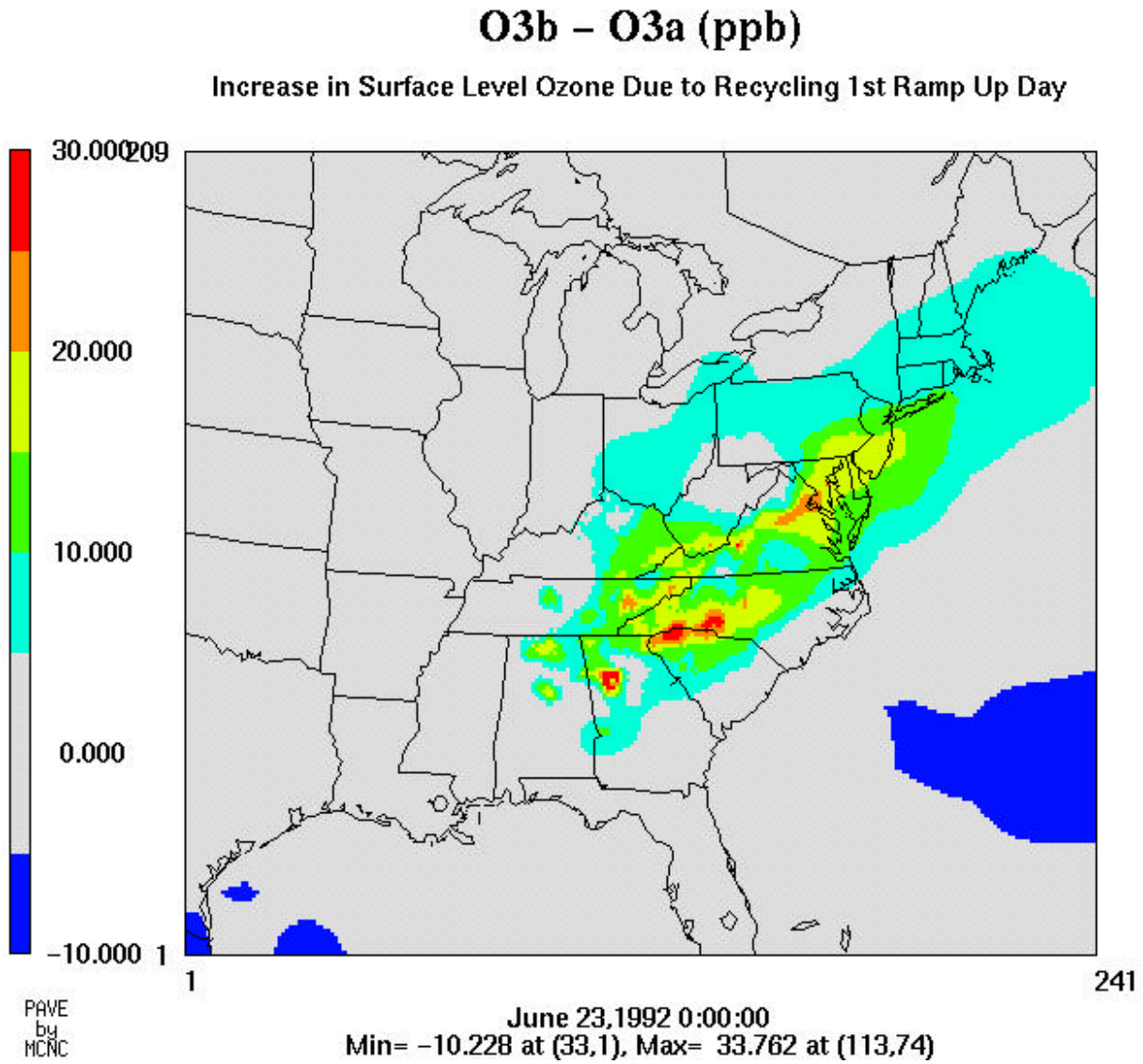


Plot C

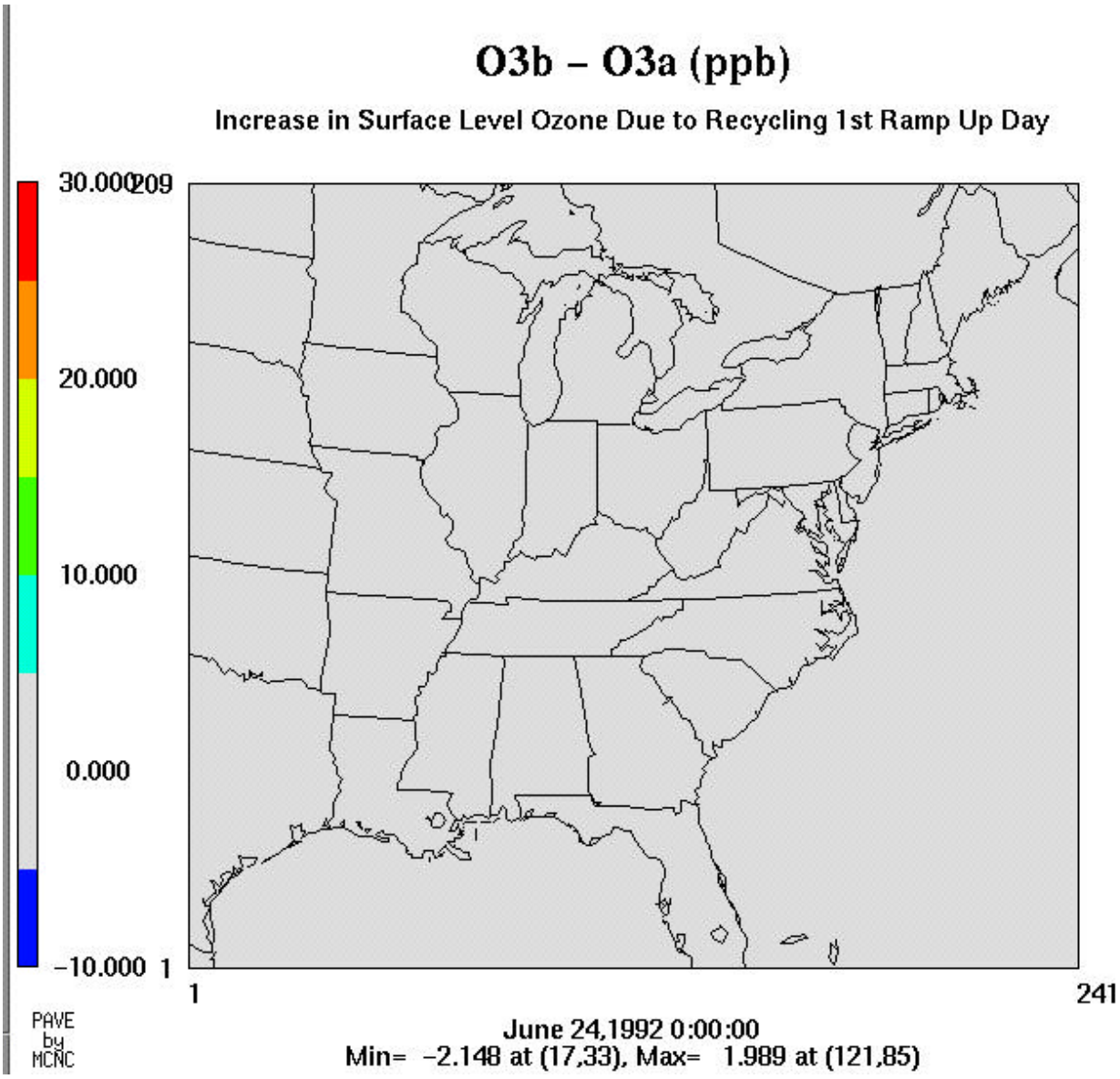


Plot D

Addition of “Extra” spin up day.
To investigate whether the underestimate at the high elevation sites could be due to an initialization problem, an “extra” spin up day was added. This was done by recycling the first spin up day. A similar test was done during the OTAG modeling process as a means of investigating the sensitivity of the modeling system to the assumed initial conditions. In the recycling for SAMI, the first spin up day June 22 was run normally, then the model was stopped. The 3-D concentration fields from the model at the end of June 22 were then used to initialize the model air quality fields (instead of the normal initial fields) and the model was run normally starting with June 22 again and through the rest of the episode. Plot E is a map plot of the increase in ozone at the beginning of June 23, the second spin up day, due to the recycling of June 22. Concentrations are as much as 30 ppb higher, especially in the area of interest in the Appalachians.



However the effect of the extra spin up day declined rapidly through the day on June 23. By the end of the day there were no cells with increase ozone above 2 ppb.


O3b – O3a (ppb)
Increase in Surface Level Ozone Due to Recycling 1st Ramp Up Day
30.000
209
20.000
10.000
0.000
-10.000
1
1
241
PAVE
by
MCNC
June 24,1992 0:00:00
Min= -2.148 at (17,33), Max= 1.989 at (121,85)