Review of CAMx HMAX Configuration in Cross State Air Pollution Rule Air Quality Modeling

Prepared by:

Alpine Geophysics, LLC

387 Pollard Mine Road

Burnsville, NC 28714

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When the Cross State Air Pollution Rule (CSAPR) Notice of Data Availability (NODA) modeling platform was transferred from EPA to Alpine Geophysics, LLC (Alpine), the first activity was to confirm that the Comprehensive Air Quality Model with Extensions (CAMx) model was giving approximately the same computational results on the Alpine computer system as on the EPA system. CAMx has very complex model code and the model very often gives small concentration differences based on the computer, compiler and parallelization options chosen by the user. These differences were expected to be small (sub part per trillion) for ozone.

When the model results on the Alpine computer system were compared to the simulation run on the EPA computer system the differences were much larger than expected. Figure 1 presented the Daily Maximum 8-hour Average (MDA8) ozone concentration for the EPA simulation for July 1, 2011 meteorological episode day using the 2017 future year emissions. Figure 2 presents the analogous results for the simulation on the Alpine computer system.

Figure 3 presents the difference between the two simulations. Blue regions denote regions where the EPA simulation predicts higher ozone concentrations than the Alpine simulation and green through red denote regions where the EPA simulation predicts lower ozone concentrations than the Alpine simulation. On this selected day, the EPA simulation predicted higher ozone concentrations than the Alpine simulation over much the western domain with noted lower predictions modeled around the Big Bend area of Texas, in and around Phoenix, and Santa Fe. Lower concentrations are seen in portions of the Midwest and eastern U.S. with concentrated higher predictions in Chicago, Louisville (KY), the New York City metro area, and other metro areas in the southeast. Peak differences demonstrated on this particular day are up to 2.8 ppb.

Since the noted differences in daily ozone concentrations were larger than expected, Alpine contacted EPA and requested a copy of the source code that EPA used to perform the simulations. The code was promptly delivered and upon inspection it was discovered that EPA had altered a parameter in the code. CAMx includes a feature called “Super Stepping”. Super stepping is a technique to relax certain numeric limits in the horizontal advection scheme to maximize model computation speed at the expense of a certain degree of numeric accuracy and can reduce the accuracy of the vertical transport solution, especially in high wind conditions over complex terrain.

As distributed, the CAMx model sets a default super stepping parameter (HMAX) to 2000 m. This defines the altitude below which peak winds are used in the calculation of the timestep. Lowering HMAX results in using winds at lower altitudes to define the timestep, and since these winds are usually much slower than winds aloft, timestep increases and computation time decreases. When super stepping is not invoked, the peak winds over the entire domain depth are used to calculate timestep. EPA had modified the code to set HMAX to 20 m, potentially reducing the accuracy of the vertical transport solution over the entire modeling domain. The CAMx model developers put in the 2000 m parameter as an appropriate balance between numeric accuracy and computational efficiency.

EPA staff was contacted about this issue and it was confirmed that the code modification was made to make the model run faster and no analysis had been performed to determine the impact of the change on the numeric accuracy of the model.

The model performance evaluation presented in the air quality modeling TSD[1] used the modified (HMAX = 20 m) version of CAMx, so this version of the model was evaluated against the observations when EPA made the conclusion that it was appropriate to use the modeling platform for air quality planning purposes. It is unknown what the impact of the change would have on the relative response to emission changes, or if the model concentration difference could change the conclusions about which monitors may be violating the NAAQS, or be in danger of violating the NAAQS.

As a result of our communication with EPA and findings in our limited comparison of the original and modified versions of CAMx, we believe that the ozone concentration data generated using the modified version of the source code may have had impact on the conclusions of CSAPR modeling, including the associated attainment and significant contribution calculations.

[1] http://www3.epa.gov/crossstaterule/pdfs/AQModeling.pdf

Figure 1. Daily maximum 8-hour average ozone concentration (ppb) on July 1, 2011 for the EPA simulation with the 2017 future year emissions.

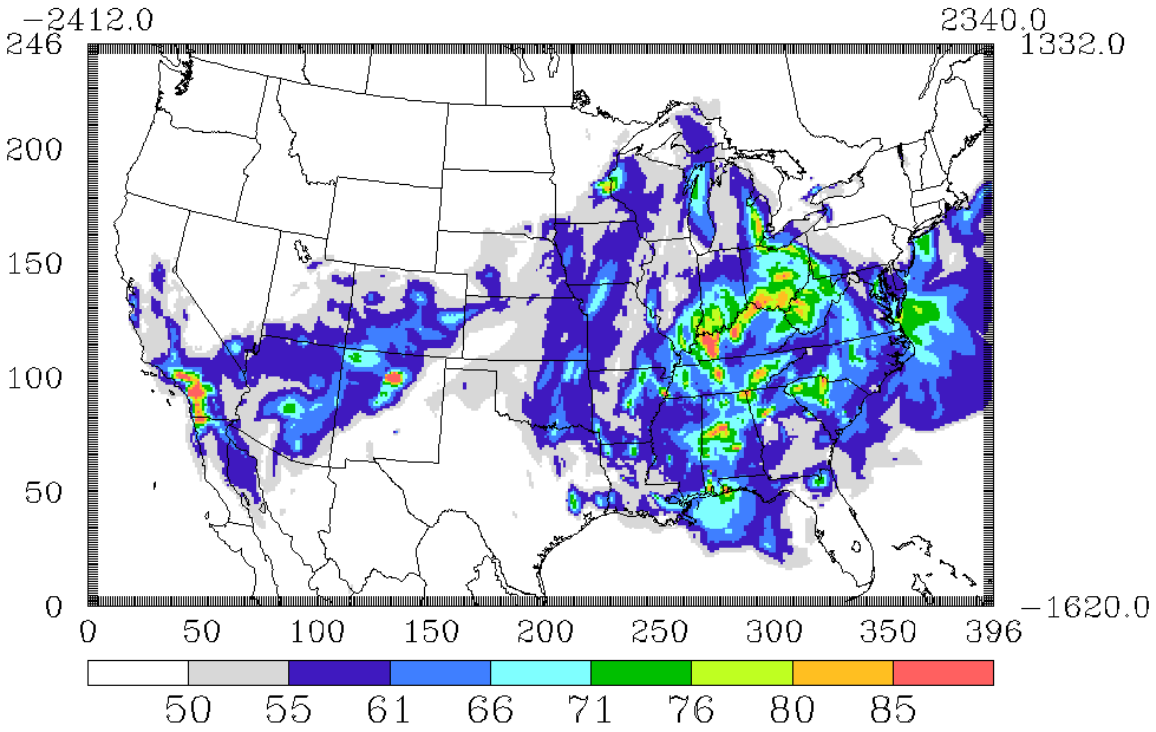

Figure 2. Daily maximum 8-hour average ozone concentration (ppb) on July 1, 2011 for the Alpine simulation with the 2017 future year emissions.

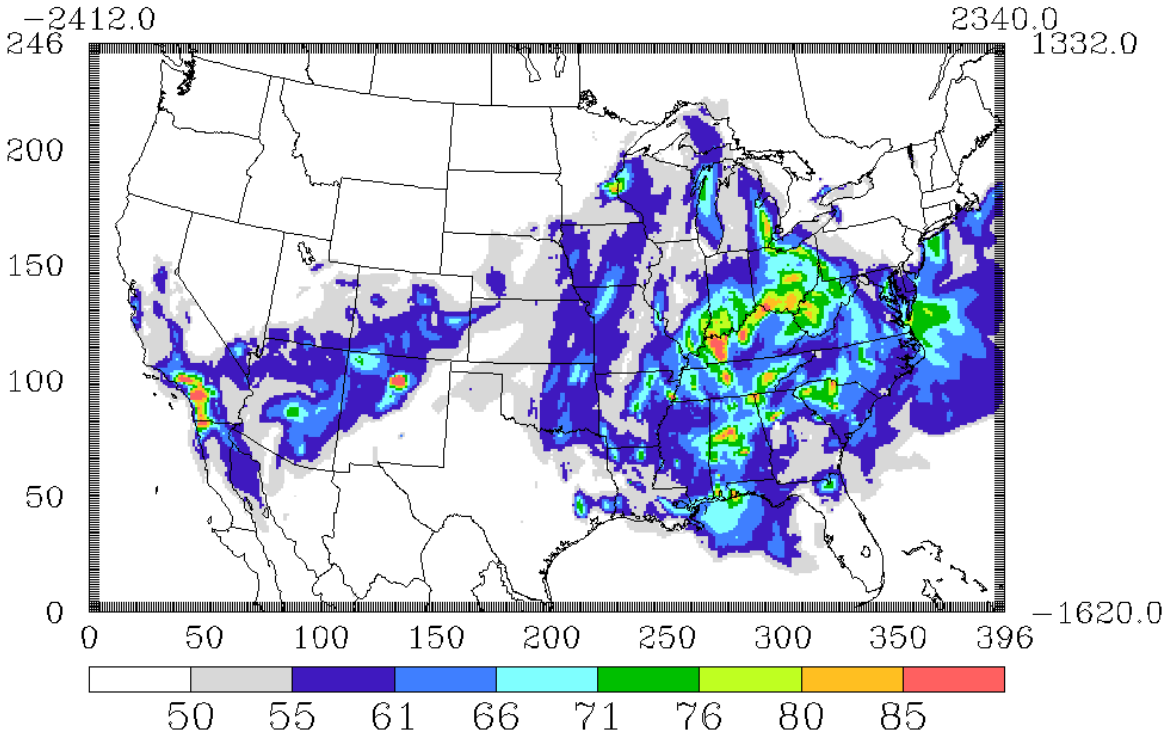

Figure 3. Difference in daily maximum 8-hour average ozone concentrations (ppb) between the EPA and Alpine simulation on July 1, 2011 with the 2017 future year emissions.