# IMPACT OF HIGH RESOLUTION MODELING ON OZONE PREDICTIONS IN THE CASCADIA REGION

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## 1. INTRODUCTION

Air quality in the Pacific Northwest is strongly influenced by complex terrain and unique meteorological conditions within and near the Columbia River Gorge and the Cascade Mountain range. Topographical features interact closely with the regional flow, and therefore have an important impact on the dispersion of pollutants. In addition, unresolved subgrid variability in precursor emissions within the metropolitan areas also suggests the need for high resolution in photochemical modeling.

Despite the need for high resolution modeling, weather forecasting and air quality simulations in the region have been and are routinely applied with grid sizes of 36, 12 and/or 4 km (Mass et al., 2002; O'Neill et al., 2005). There have been only a few meteorological modeling studies conducted with horizontal grid sizes near or less than 1 km (Colle and Mass, 1998a and 2000a; Sharp and Mass, 2002); the effect of high model resolution on air quality simulations and ozone predictions remains unknown. It is also not clear whether high resolution meteorological input or emissions will have a larger impact on air quality simulations if not applied simultaneously.

In this study, the MM5/SMOKE/CMAQ modeling system was used for nested 4 km and 1 km domains encompassing the Portland metropolitan area and the Columbia River Gorge for an ozone episode that occurred at July, 1998 to investigate the impact of high resolution meteorological and photochemical modeling on ozone predictions for the region. The effects of high resolution meteorological input were compared with those of high resolution emissions by running CMAQ at 1 km with two scenarios: one with 1 km MM5 but 4 km emissions and the other with both MM5 and emissions at 1 km.

For emissions sources, spatial surrogates at 4 km resolution were used to allocate the emissions for the 4 km domain and some source categories in the 1 km domain when surrogates at finer resolution weren't available. Surrogate available at 1 km resolution included population, mileage on roadways, major airport, livestock, and Oregon drycleaners.

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## 2. HIGH RESOLUTION MM5 RUN

The run with 1 km MM5 but 4 km emissions was compared with the 4 km run first to investigate the impact of high resolution meteorological input. Ozone surface contour plots at 15 LST on July 27 are shown in 1a and 1b for the 4 km run and 1 km run, respectively, with the difference plot (1b-1a) shown in 1c. Here the 1 km run ozone contours (1b) are the gridded means aggregated from 1 km to 4 km grid cells, so that they can be compared with the 4 km results.

Similar ozone peaks were predicted by the two runs on that ozone episode day. When using high resolution MM5, the areas with elevated ozone are reduced in size and shifted slightly further downwind. The maximum ozone increases occur along the Columbia River Gorge and the foothills of Cascades where the terrain effects are substantial. For example, transport of ozone along the Gorge can be clearly identified, with ozone increases around 20 ppb compared to the 4 km run. On the other hand, ozone decreases, mostly around 10-20 ppb, were predicted closer to the source region when high resolution MM5 was used.

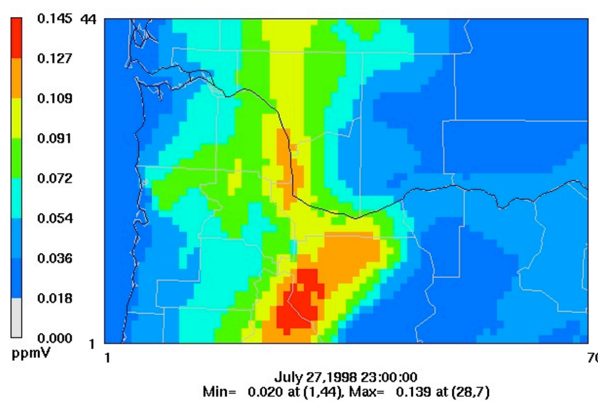


Fig. 1a. Surface ozone contours from CMAQ at 15 LST on July 27, 1998 from the 4 km run.

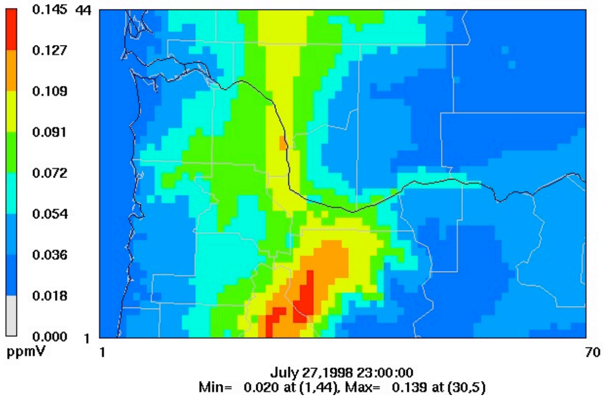


Fig. 1b. Surface ozone contours from CMAQ at 15 LST on July 27, 1998 from the 1 km run using 1 km MM5 but 4 km emissions.

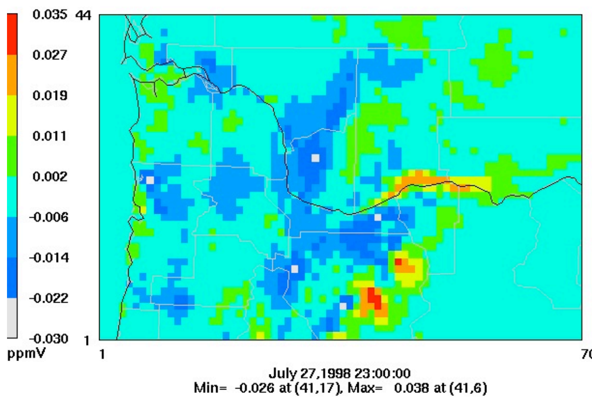


Fig. 1c. Difference plots of "1b-1a".

## 3. HIGH RESOLUTION EMISSIONS RUN

The run with 1 km MM5 but 4 km emissions was further compared with the run in which both high resolution MM5 and emissions were used. Ozone surface contour plot at 15 LST on July 27 are shown in Figure 2a for the run with high resolution MM5 only. Figure 2b shows similar contours for the run with both 1 km MM5 and emissions, with the difference plot (2b-2a) shown in 1c.

The overall pattern and ozone peaks are fairly similar between the two runs, but the run with both high resolution MM5 and emissions shows small-scale features which are missing when coarser emissions were used. Most of the differences occur close to the source region such as along the I-5 corridor and within the Portland urban area with both increases and decreases in ozone levels.

Ozone decreases (mostly less than 15 ppb) mainly occur at the grid cells with large roadway emissions, where NO titration effects are better represented with fine-scale emissions. Ozone increases (mostly less than 10 ppb) were predicted in the surrounding cells next to these roadway emissions, where NO emissions were artificially diluted when using 4 km emission surrogates. Increases in ozone were also predicted further downwind of the source region, although the changes are mostly below 5 ppb.

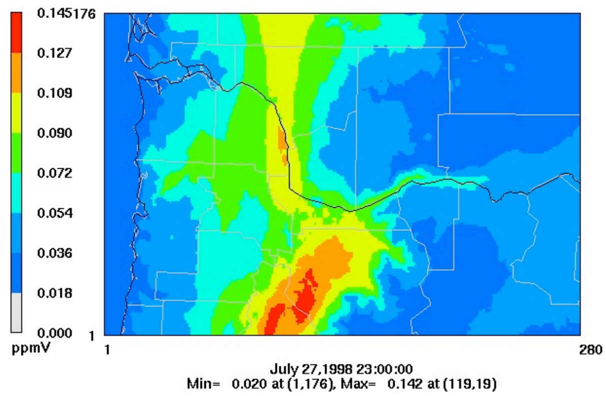


Fig. 2a. Surface ozone contours from CMAQ at 15 LST on July 27, 1998 from the 1 km run using 1 km MM5 but 4 km emissions.

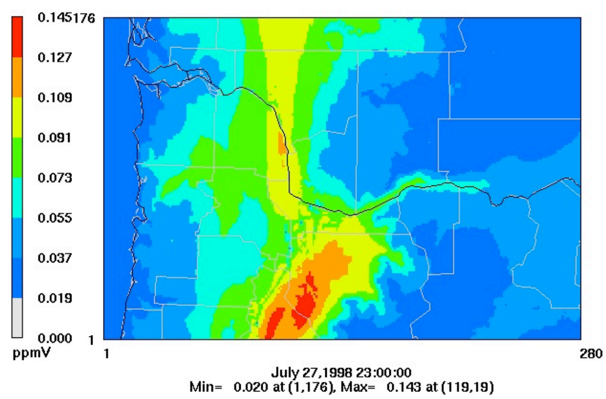


Fig. 2b. Surface ozone contours from CMAQ at 15 LST on July 27, 1998 from the 1 km run using both 1 km MM5 and emissions.

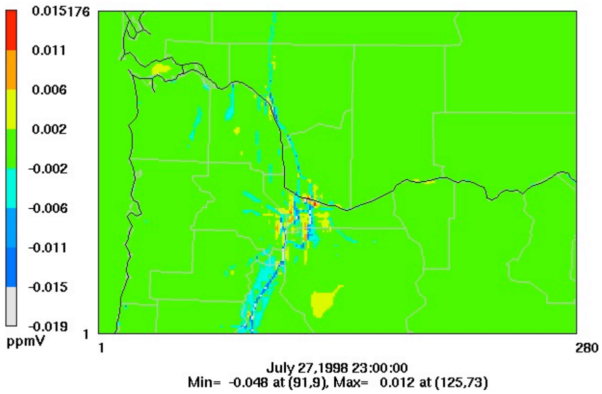


Fig. 2c. Difference plots of “2b-2a”.

## 4. CONCLUSIONS

Using high resolution meteorological input alone appeared to have a larger impact on ozone predictions in terms of the position and peak levels of the ozone plume. Ozone concentrations were higher in the 1 km case compared to the 4 km case in areas along the Columbia River Gorge and the foothills of Cascades where the terrain effects are substantial. Using high resolution emissions appeared to affect small-scale features in ozone concentration patterns mainly within the urban area. In that case both ozone increases and decreases could be identified which were missing when using coarse resolution emissions.

## 5. REFERENCES

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