June 1, 2006

Round 4 Modeling: Effect of Grid Spacing

Regional air quality modeling is being performed to support SIP development for ozone, $PM_{2.5}$, and regional haze. The modeling includes annual $PM_{2.5}$ analyses with 36 km grid spacing and summer ozone analyses with 12 km grid spacing. Recently, a stakeholder group sponsored 4 km ozone modeling, which indicated differences in control strategy results in portions of the domain. In response to this modeling, LADCO performed limited 4 km ozone modeling analyses. The results of the stakeholder and LADCO modeling are summarized below.

Stakeholder Modeling

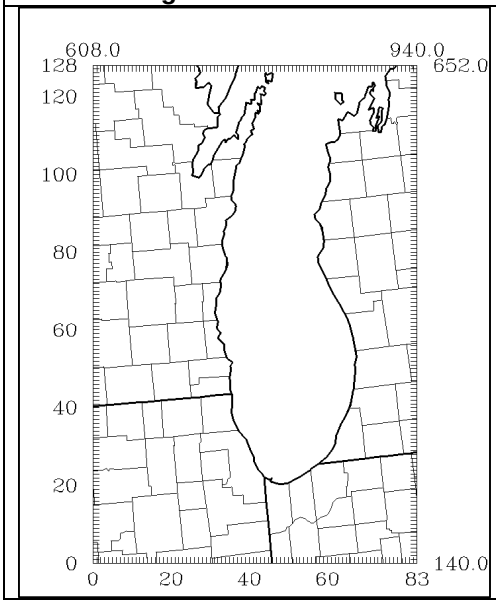
A stakeholder group (including the Midwest Ozone Group [MOG]) sponsored modeling to address several issues, including finer grid spacing and control strategies. The modeling study was performed by Alpine Geophysics and Environ and is documented in two presentations: "Five States Modeling Study: 8-hr Ozone/PM2.5 Residual Nonattainment and Emissions Strategy Effectiveness", April 4, 2006 and "Five States Modeling Study: Updated 8-hr Ozone Nonattainment and Emissions Strategy Effectiveness", May 10, 2006.

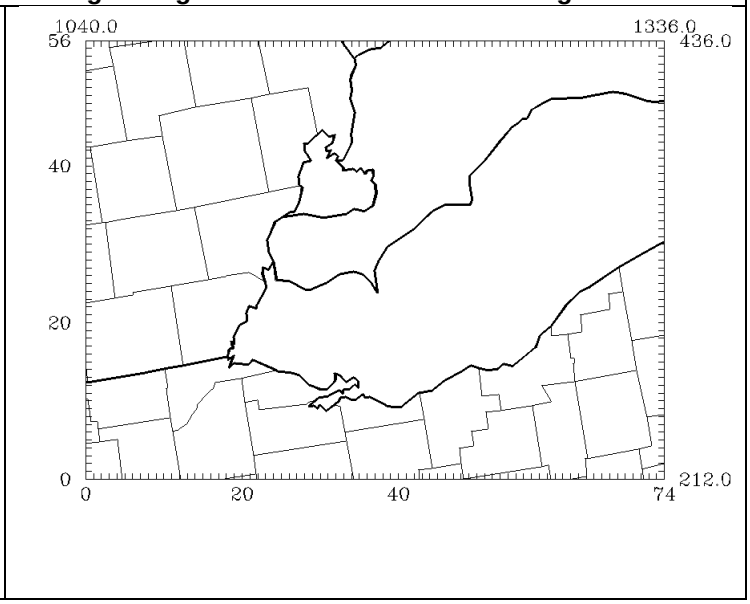
The stakeholder modeling consisted of:

- LADCO's Base J/Round 3 emissions inventory for 2002 and 2009 for all sectors, except on-road sources. On-road emissions were developed using SMOKE at 36/12/4 km grid spacing.
- Meteorological fields developed using MM5 at 36/12/4 km grid spacing.
- Attainment tests applied consistent with LADCO modeling.
- Four future year control scenarios: (1) 2009 run with existing controls, (2) 2009 run with 2018 EGU emissions, (3) 2009 run with 2018 on-road emissions, and (4) 2009 run with 2018 EGU and on-road emissions. Note: the purpose of these runs was to demonstrate the effect of allowing greater time penetration of on-the-books federal control measures.

The finer grid spacing modeling consisted of 4 km grids in both the Lake Michigan region and Detroit-Cleveland region (see Figure 1).

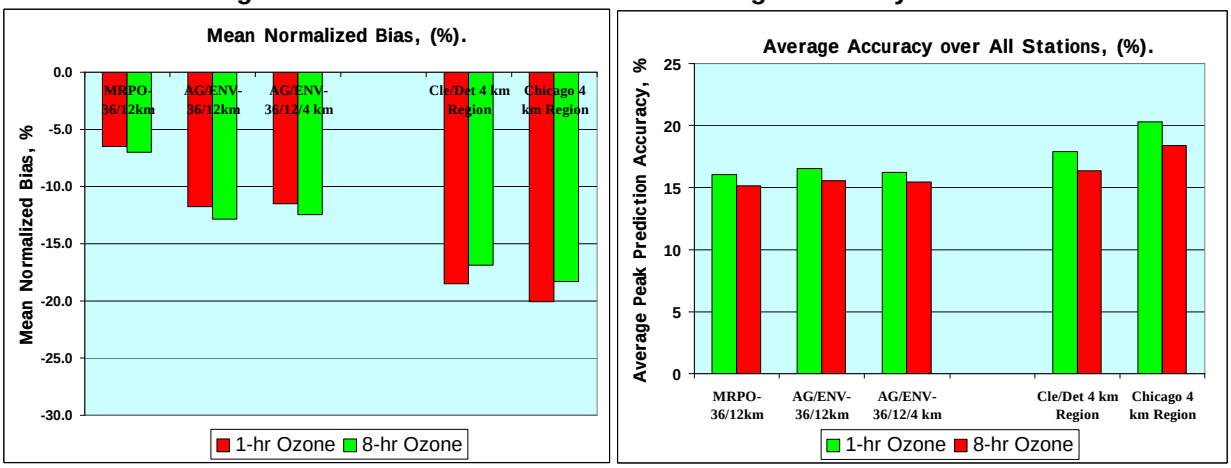
Figure 1. 4 km Grids for Lake Michigan Region and Detroit-Cleveland Region





Model Performance: Average accuracy, mean normalized bias, mean normalized gross error (not shown), and peak unpaired accuracy (not shown) statistics were calculated for 1-hour and 8-hour ozone (see Figure 2). (Note, average accuracy is considered to be the most relevant statistic in terms of the attainment test.)

Figure 2. Mean Normalized Bias and Average Accuracy Statistics



On the 12 km grid, the statistics meet EPA model performance goals (for 1-hour ozone). Compared to the LADCO (Base J) modeling, the stakeholder modeling appears to produce equivalent average peak accuracy over all stations, nearly equivalent gross error in hourly estimation, and somewhat larger underestimation bias in hourly concentration predictions. On the 4 km grid, the stakeholder modeling yields (compared with 12 km grid) slightly poorer average peak prediction accuracy, slightly higher hourly gross error, and poorer hourly bias.

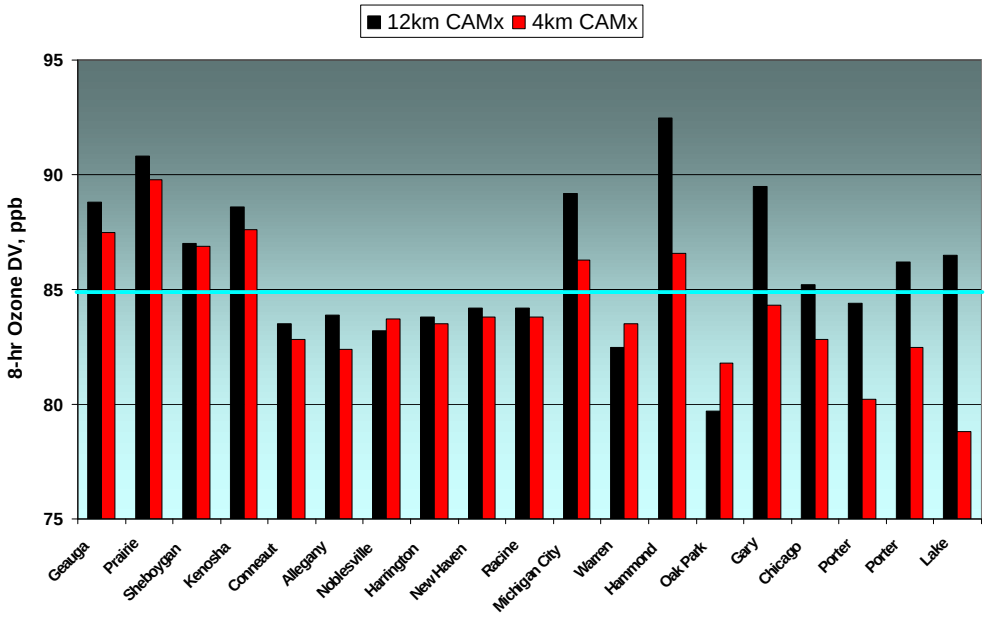
Examination of the meteorological fields shows acceptable performance at both the 12 km and 4 km scales, although the results tend to be slightly better at the 12 km scale (see Table 1).

Table 1. Meteorological Model Performance (Lake Michigan Region and Detroit-Cleveland Region)

	Detroit-Cleveland		Lake Michigan	
Mean RMSE	**4km**	**12km**	**4km**	**12km**
Wind Speed	1.66	1.50	1.54	1.33
Temperature	2.48	1.96	2.54	1.87
Humidity	1.78	1.69	1.76	1.69

Strategy Modeling: The four future year scenarios provide information on the effect of existing ("on the books") controls. The results of the 2009 base run (with existing controls) are shown in Figure 3. As can be seen, the most significant difference at 4 km occurs in the southern portion of the Lake Michigan region (i.e., Chicago and northwestern Indiana sites). Except for this subregion, the stakeholder modeling shows similar residual nonattainment problems in eastern Wisconsin and northeastern Ohio.

Figure 3. Future Year (2009) Modeled Ozone Design Values



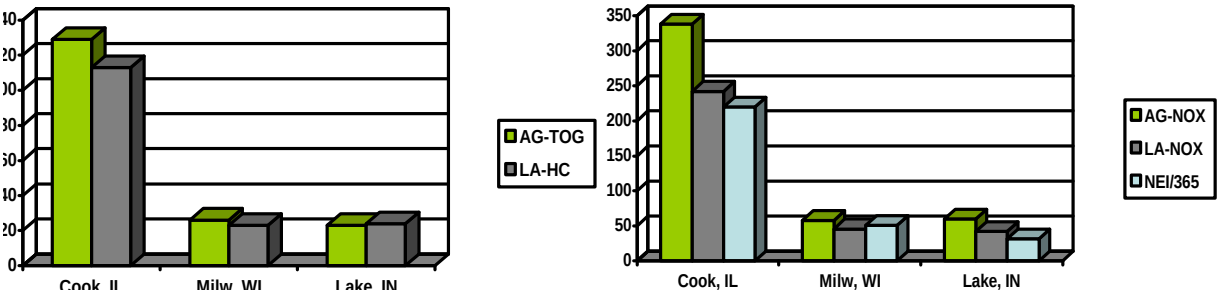
The 2018 EGU emissions reflect full implementation of the Clean Air Interstate Rule, and the 2018 on-road emissions reflect a number of federal control programs (e.g., Tier II and low S fuel). The results of these runs show all sites in attainment.

LADCO Modeling

For this modeling, 4 km grids were placed over Lake Michigan and the Detroit-Cleveland area, similar to the stakeholder modeling. The first phase of the 4 km modeling was to apply the 4 km inputs developed by stakeholder group as a benchmarking exercise. Two runs were performed: 2002 basecase (base J) and 2009 base (Round 3) scenarios. The application was consistent with the stakeholder ozone application (i.e., CAMx v4.20, no plume in grid, no land-lake adjusted vertical diffusivity estimates). The results were consistent with the stakeholder modeling.

The second phase of the 4 km modeling was to apply the 4 km emissions developed by LADCO (consistent with Base K/Round 4) and the 4 km meteorology developed by Alpine Geophysics. In general, LADCO's 4 km on-road emissions are similar to those developed by Alpine for VOC, but were lower for NOx (see Figure 4).

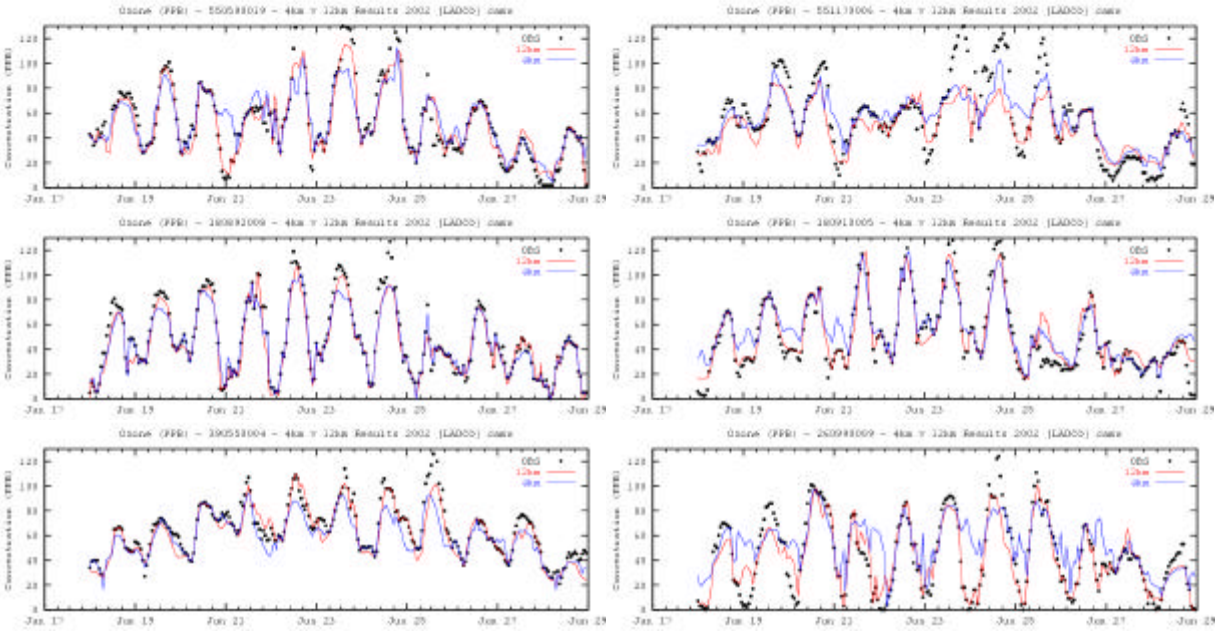
Figure 4. LADCO v. Alpine VOC (left) and NOx (right) On-Road Emissions



Two runs were performed: 2002 basecase (base K) and 2009 base (Round 4) scenarios. These runs included plume-in-grid treatment, use of CAMx v4.30, and use of land-lake adjusted vertical diffusivity estimates.

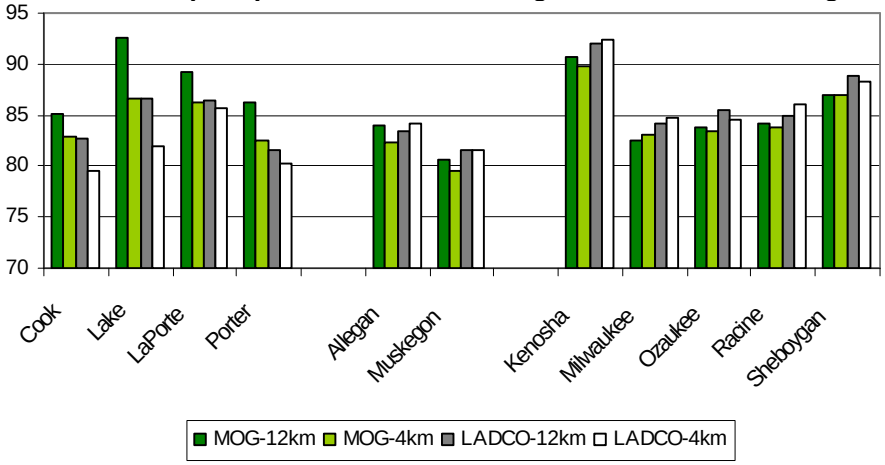
Model Performance: Hourly time series plots were prepared for several monitors (see Figure 5). The results are similar at 12 km and 4 km, with some site-by-site and day-by-day differences.

Figure 5. Ozone Time Series Plots for 12 km and 4 km Modeling (June 17-29, 2002)



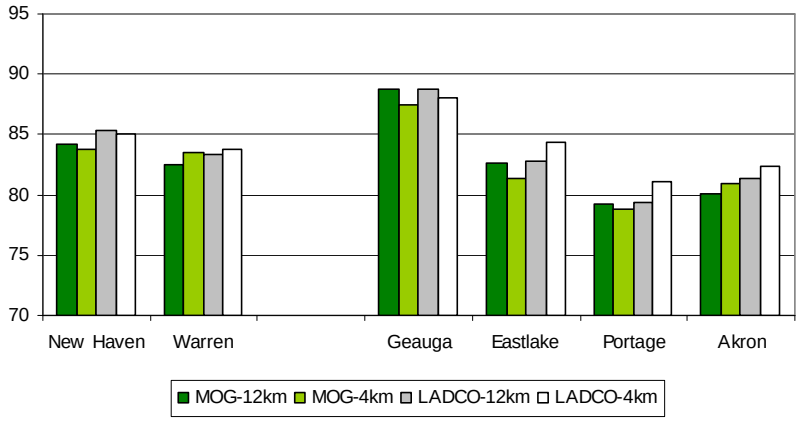
Strategy Modeling: The figures below show the future year (2009) design values for existing controls with 12 km and 4 km grid spacing for the stakeholder (MOG) and LADCO modeling[1].

Figure 6. Future Year (2009) Ozone Modeled Design Values – Lake Michigan Region



[1] It should be noted that for several sites, less than 10 days were used to calculate future year design values. Given the relatively small number of days, the model result for these sites is less reliable. Only sites with about 10 days (or more) are included in Figures 6 and 7.

Figure 7. Future Year (2009) Ozone Modeled Design Values – Detroit-Cleveland Region



Based on these results, the following findings should be noted:

- The 12 km and 4 km design values are similar, with the most notable changes in northwestern Indiana and northeastern Illinois (e.g., 4 km values are as much as 4 ppb lower than 12 km values).

- The differences in the southern part of the Lake Michigan area are plausible, given the tight emissions gradient there (i.e., finer grid resolution appears to provide more appropriate representation).

In light of these findings, 12 km grid spacing can continue to be used for ozone modeling, but any results for northeastern Illinois/northwestern Indiana should be viewed with caution (i.e., probably 1 – 4 ppb too high). Strategy runs should be performed periodically with 4 km grid spacing to check the model response and, in particular, provide a more refined answer for northeastern Illinois/northwestern Indiana.