EFFECTS OF REVISED BIOGENIC EMISSIONS ESTIMATES ON OZONE IN THE HOUSTON/GALVESTON REGION

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1. INTRODUCTION

This report summarizes the results from incorporating improved emissions input data into a photochemical modeling application for the Houston/Galveston (H/G) airshed. This exercise is part of a larger modeling study intended to evaluate the effectiveness of candidate control strategies in demonstrating attainment of the one-hour ozone National Ambient Air Quality Standard (NAAQS) for the eight-county H/G ozone nonattainment area. The photochemical modeling performed as part of this exercise used the Comprehensive Air Quality Model (CAMx, Version 1.13) (Environ, 1998) for the Coastal Oxidant Assessment for Southeast Texas (COAST) 6 - 11 September 1993 episode.

Before one can use the model to evaluate future year scenarios, one must confirm that the model can capably replicate a historic ozone episode. It is fairly common for the model inputs, especially the emissions inventory estimates, to be revised one or more times during this process to reflect better a understanding of the conditions that lead to the high ambient ozone. This report will discuss the effects of improving base year biogenic emission estimates as well as the effects of a revision to the 2007 mobile source inventory. In both cases, the inventory changes are believed to provide a more accurate characterization of the base- and projected-year emissions.

2. REVISIONS TO BIOGENIC EMISSION ESTIMATES

The emissions inventories that are input into the CAMx model are originally developed in four separate categories, only later to be merged into low-level and elevated CAMx input files. The four inventory sectors are biogenic, mobile, area, and point source emissions. The Texas Natural Resource Conservation Commission (TNRCC) developed and maintains the emissions database used in the COAST modeling studies.

The COAST 1993 base year emissions data set was revised by TNRCC to reflect a change in the composition of the biogenic estimates. The COAST attainment-year (2007) emissions inventory was also changed to reflect an updated mobile source inventory as well as to reflect the new biogenic estimates. Both changes are discussed in more detail below.

The biogenic component of the inventory was revised to incorporate results of an extensive evaluation of biogenic emissions in the urban areas. While the total biogenic volatile organic compounds (VOCs) may be low compared to other areas of the domain, the amount of urban biogenic emissions is potentially a governing factor in the amount of ozone that is generated within a NOx-laden urban area.

In the original quantification of biogenic emissions, urban areas were not sufficiently surveyed to properly determine the density of leaf biomass in the urban residential areas. Due to this limited surveying, urban residential areas were assigned a very high leaf biomass density in
both Houston and Beaumont. This resulted in an overestimation of biogenic emissions within these areas. The main purpose of the new work was to improve the characterization of vegetation in the urban residential areas.

A secondary consideration was that the old biogenic inventory had been created with an outdated set of emission factors. The emission factors used in the original data set had been assembled from a literature review and did not match the BEIS2 emission factors. Subsequently, TNRCC decided that the inventory should be recalculated using BEIS2 factors, because these factors had been determined using methods consistent from plant species to plant species.

A summary of differences between original and the current biogenic inventory is listed below. Only biogenic emissions within Texas were changed.

- Urban land use: The original data base assigned same species distribution and leaf biomass density to all urban residential areas. The new database reclassified “urban residential” into 6 separate zones in Houston and 3 separate zones in Beaumont.

- Agricultural land use: The original database assumed that only crops were grown in crop lands. The new data base used additional data from satellite imagery, interviews with county agricultural extension agents, and field surveys to assign the proper mixture of crop lands, grass lands, range lands, forest, and wetlands within the crop categories.

- Forest land use: The original forest land use was based on older United States Geological Survey data. The new land use fields were based on Texas Parks and Wildlife Department vegetation databases, which not only document the distribution of land use but also the plant species present within the categories. Field observations also were incorporated into these categories.

- Emission factors: The old inventory used a database assembled from a literature review. The new database uses the BEIS2 emission factors.

- Salt marshes: Salt marsh biogenic emissions were set to zero. This can be important in Brazoria County.

- NOx Emissions factors: These were not changed.

Figure 1 shows the isoprene differences over the 4-km COAST domain for a representative hour between the original and revised low-level emissions input file. A couple of features can be observed: 1) large increases of emitted isoprene along the Trinity, Neches, and Sabine rivers, 2) most of the counties north of a Houston-Beaumont line experience biogenic VOC increases, 3) grid cells containing the Brazos river tend to see VOC decreases, and 4) urban areas like Harris Co. and especially Beaumont/Port Arthur have much less biogenic loading in the new base case. Plots of the change in total emitted VOC are available on the TNRCC web page and show similar patterns as Figure 1. Figure 2 shows the domainwide average isoprene emissions in the 4-km grid as a time series for the original and revised base cases.
Figure 1. Isoprene emissions changes between the original and current base year biogenic inventories. The left side of the plot displays those areas in which emissions have increased. The right side of the plot shows decreases in biogenic isoprene from the original estimate set.

Figure 2. Isoprene emissions time series plot. The line with plus sign markers is the revised base. The darker line is the original base case emissions. Units are gram-moles per hour.
3. CAMX SIMULATION RESULTS

Most of the model domain experiences ozone changes of less than plus or minus five parts per billion in response to the revised biogenic inventory. As discussed in Section 2.1, the primary cause for concern with the old biogenic inventory was that VOC emissions were possibly overestimated in the urban areas of Houston and Beaumont/Port Arthur. Ozone is reduced over southern Harris County by approximately 5-10 ppb with the corrected emissions input data. A second noticeable change is that more ozone (5-10 ppb) is produced over Brazoria County in the revised base case run. As would be expected from a run in which solely biogenic VOC emissions were varied, ozone changes occurred only during the day.

The model predicts large modeled isoprene increases in response to the revised biogenic inventory along the Trinity River. The single largest isoprene increase is in Liberty County, where about 20 ppb more isoprene is seen in the new base case. There is a smaller area of increase in Brazoria and Fort Bend counties, as well. Interestingly, there is little change in the ozone pattern in the Trinity River valley, suggesting that most of this area is already sufficiently VOC-laden.

The next section will focus on the differences between the simulations on a day-by-day basis. On 6 September, note the extension of the Houston ozone plume to the Southwest as shown in Figure 4. The additional VOC from the increased biogenic emissions in Fort Bend Co. reacts with the NOx-laden urban plume to produce 5-10 ppb more ozone.

Figure 4. Model ozone at 4 p.m. CST in the original base case (left) and the revised biogenic inventory base case (right) on 6 September 1993.
For afternoon ozone on 7 September 1993, the model ozone patterns before and after the biogenic emissions revisions are similar to those shown in Figure 5, but the ozone plume extending from Houston is a little wider in downwind Matagorda County. Also the ozone formation downwind of the urban plume appears to start around two hours earlier over areas in which biogenic emissions were increased.

![Layer 1 Ozone](image)

Figure 5. Model ozone at 4 p.m. CST in the original base case (left) and the revised biogenic inventory base case (right) on 7 September 1993.

The ozone fields are very similar on the 8th (see Figure 6), 9th and 10th. This is likely the result of westerly winds which advect NOx from Houston over areas in which biogenic VOC is unchanged (i.e., Gulf of Mexico). Interestingly, on this and other days there are only small ozone differences in Beaumont-Port Arthur (where base case concentrations can exceed 125 ppb). This indicates that the B/PA area is primarily NOx-limited during this episode.
Figure 6. Model ozone at 4 p.m. CST in the original base case (left) and the revised biogenic inventory base case (right) on 8 September 1993.

On the last day of the simulation (9/11/93), peak ozone is as much as 15 ppb higher along the Waller/Harris County line. This is due to the transport of excess ozone from Brazoria County where VOC emissions are now higher. There is a separate area of depleted ozone which is emanating again from Houston.

Table 1 compares some of the common evaluation statistics generated from the two runs. As can be seen from the table, the regional evaluation statistics are largely unchanged.

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<th>Date</th>
<th>Max Model Ozone Domainwide</th>
<th>Max Model Ozone Stationwide</th>
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<th>Normalized Gross Error</th>
<th>Normalized Mean Simulated</th>
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Table 1. Model performance statistics. Plain text values are original base case. Values in bold are for the simulation with the revised biogenic inventory.
4. CONCLUSIONS

This report summarizes the results from a sensitivity simulation involving changes to the COAST emissions data. In this case, the emissions database was improved to reflect the best current understanding of the base year emissions loading in the Houston/Galveston airshed. The enhanced biogenic emissions did not result in deviations in model ozone predictions that would cause one to reconsider past findings from the COAST modeling. Although the change to future on-road mobile source emissions was not tested directly, it is seen in other reports in this series that the future VOC/NO\textsubscript{x} directional guidance is not affected by this change, nor was the conclusion that very significant NO\textsubscript{x} reductions are required to model attainment.

The net effect of revising the base year biogenic emissions estimates was to increase VOC, principally isoprene, in rural areas while decreasing the amount of biogenic VOC in the urban areas. In general, the model ozone response was relatively small (less than plus or minus 5 ppb). Model performance quality did not vary as a function of old vs. new biogenic inventory data sets. The most significant change in model ozone upon incorporating the new emissions was that more ozone was generated within the Houston plume over rural counties where emitted isoprene was increased (Fort Bend, Brazoria, etc.). The area with the largest increase in biogenic, the Trinity River valley, did not experience much of a change in model ozone in this episode. This region is clearly NO\textsubscript{x}-limited throughout the 6-11 September 1993 episode. Ozone in Houston was lowered by 5-10 ppb when the urban biogenics were reduced.
5. REFERENCES


Texas Natural Resource Conservation Commission, 1998: Protocol for Ozone Modeling of the Houston-Galveston area with the Comprehensive Air Quality Model with Extensions (CAMx) and COAST Data. Austin, TX.