

Final Report

**DALLAS/FORT WORTH CAM<sub>x</sub> MODELING:  
IMPROVED MODEL PERFORMANCE  
AND TRANSPORT ASSESSMENT**

**HARC Project H35, Phase 2**

Prepared for

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## EXECUTIVE SUMMARY

The Texas Commission on Environmental Quality (TCEQ) is developing an 8-hour ozone State Implementation Plan (SIP) for the Dallas/Fort Worth (DFW) region using the Comprehensive Air Quality model with extensions. The Texas Environmental Research Consortium (TERC) sponsored Phase 1 of Project H35 to examine the role of ozone transport in causing high 8-hour ozone in eastern Texas, including the DFW region.

Phase 2 of Project H35 improved ozone model performance for the August 13-22, 1999 DFW SIP episode and investigated how updated modeling assumptions impact ozone transport assessments. There were three components to the work:

- CAMx sensitivity runs were completed to investigate how changes in modeling inputs and assumptions affect ozone model performance. Two MM5 runs were completed to support the CAMx sensitivity analysis.
- Chemical Process Analysis was used to investigate the revised 1999 base case and two related model scenarios.
- APCA ozone source apportionment was used to investigate the impact of several modeling assumptions on ozone transport for 2010 future year scenarios.

### Improved 1999 Model Performance: Run 34

Sensitivity tests showed the expansion of the modeling domain eastward, northward, and higher produced slightly improved model performance with less reliance on boundary conditions. Using the larger domain, additional sensitivity tests evaluated ozone sensitivity to changes in the emissions, meteorology, and chemistry to show that reducing NO<sub>x</sub> in the DFW core counties, adding more biogenic emissions, and implementing the NO<sub>x</sub> recycling reactions in CB4 consistently produced higher ozone. These runs generally improved the normalized bias and average paired peak accuracy, but hurt the unpaired peak accuracy. The use of the CMAQ-based vertical diffusivity profiles and the CB2002 chemical mechanism lowered ozone. All other tests either led to mixed results or very little change.

A new 1999 base case for the DFW SIP modeling called “Run 34” was developed in Phase 2 of Project H35. Changes in Run 34 from the previous Run 17b base case are:

- Expanded modeling domain extending to the Atlantic Ocean and Canada.
- Higher model top at about 14-km.
- Meteorology from MM5 “Run 6” using the Noah/Eta PBL scheme.
- Enhanced near surface mixing from the “Kv100” adjustment.
- Extended inorganic chemistry (CB4xi) with “NO<sub>x</sub> recycling” reactions.

Run 34 shows improved ozone model performance compared to Run 17b. A tendency toward ozone under-prediction (negative bias) was improved by the updated meteorology “MM5 Run 6” and the chemistry updates (NO<sub>x</sub> recycling). The “Kv100” vertical mixing adjustment, which sets the largest diffusivity in the lowest 100m of each column to all layers in the first 100m, improved ozone predictions in areas with intense surface NO emissions in the DFW core area. Expanding the modeling domain, both vertically and horizontally, reduced uncertainties in

specifying boundary conditions at some cost of increased computer resources to model a larger domain.

### **Process Analysis of 1999 Model Results**

Chemical Process Analysis (CPA) was used to investigate several aspects of atmospheric chemistry that are important to understanding DFW model performance and control strategy development. New modeling tools were developed to analyze CPA results through the entire boundary layer rather than just near the surface. CPA analysis of results for the DFW area from “Run 34” and two related scenarios revealed many common features across modeled days and scenarios:

- Ozone production showed hot spots over urban areas and major NO<sub>x</sub> point sources in rural areas consistently across days.
- The areas of most intense oxidant production tend to be VOC-limited on all days but there are differences in the extent of VOC and NO<sub>x</sub>-limited areas between days
- August 17<sup>th</sup> is the most extensively VOC-limited day during the episode: Other days examined were less strongly VOC-limited than August 17<sup>th</sup>.
- When NO<sub>x</sub> emissions were reduced in the DFW core as a sensitivity test, the VOC-limited area almost completely disappeared on days other than August 17<sup>th</sup>.
- The regions that tend to be VOC-limited are the Dallas and Fort Worth urban cores.
- The fraction of OH radicals reacting with isoprene (relative to all hydrocarbons) revealed areas outside of the DFW urban/suburban area where biogenic emissions have high importance.
- An area of low fraction of OH reacting with isoprene runs from south to north (Waco to DFW) near IH-35. The relatively low importance of isoprene in these areas is due to differences in land cover (i.e., agricultural and urban areas) leading to low biogenic emission levels. This land cover difference likely contributes to the DFW urban area tending to be VOC-limited.

The CPA analysis confirmed results of earlier emission reduction sensitivity tests in showing that the DFW area has regions of both VOC and NO<sub>x</sub> sensitivity. The biogenic emission inventory plays a critical role in defining which parts of DFW are VOC vs. NO<sub>x</sub> sensitive.

### **Updates to 2010 Ozone Transport Assessment**

Ozone source apportionment modeling was completed for 2010 to evaluate how several factors influence results already developed in Phase 1 of Project H35, specifically:

- Expected reductions in 2010 EGU NO<sub>x</sub> emission levels expected to result from EPA’s Clean Air Interstate Rule (CAIR).
- Modeling uncertainties related to meteorology, as represented by the difference between alternate MM5 runs completed in this study.
- Modeling uncertainties related to improvements in the APCA source apportionment technique to better represent chemical destruction of ozone as it is transported.

## **Impacts of CAIR on 2010 Emissions**

The impacts of EPA's Clean Air Interstate Rule (CAIR) on EGU emissions were modeled based on information provided in the CAIR Technical Support Documents. Texas' NO<sub>x</sub> emissions from EGUs were to be reduced by 1%. Louisiana's EGU NO<sub>x</sub> was reduced by 26%. The EGU controls reduced NO<sub>x</sub> emissions in both Kentucky and Florida by over 300 tons/day. Georgia, Tennessee, Alabama, Mississippi, and Louisiana all reduced NO<sub>x</sub> emissions by over 100 tons per day.

## **Impacts of CAIR on 2010 Ozone Transport**

Ozone modeling for 2010 showed that ozone reductions due to CAIR were greatest in the vicinity of large reductions. Within the 12-km grid used for DFW modeling, Mississippi showed the largest decrease in episode maximum 8-hour ozone, dropping up to 15 ppb near the Mississippi River, and EGUs in this state were reduced 55%. The states that experienced the largest EGU NO<sub>x</sub> reductions due to CAIR generally had the largest corresponding reductions in ozone transport into the DFW area. The DFW area showed little decrease to the episode average and episode peak (both reduced 0.3 ppb) high 8-hour ozone due to CAIR reductions because of the strong impact of local emissions on high ozone levels in DFW. CAIR might provide greater benefit in the DFW area with greater reductions in local emissions in place.

## **Impact of Alternate Meteorology on 2010 Ozone Transport**

We evaluated the sensitivity of DFW ozone transport assessments to using alternate meteorological data from the MM5 model (MM5 Run 7 with the "Grell" convection scheme). Local sources and source regions north and east of DFW contributed more to DFW high ozone when the Grell convection scheme was used in MM5. These source regions include the 16-county DFW region, northeast Texas, Louisiana, Arkansas, and Oklahoma. Contributions from source regions south of DFW – central Texas, southern Texas, and Mexico/Gulf of Mexico – contributed less with Grell. Houston was an exception in contributing more with Grell by up to 2 ppb because the Grell scheme increased ozone levels in the Houston area by up to 30 ppb. Ozone transport contributions from States more distant than Oklahoma, Louisiana, Arkansas changed by less than 0.1 ppb due to the change in meteorological data. When Grell was used in MM5, contributions were less reliant on boundary conditions by an average of 2 ppb, as contributions from initial conditions and anthropogenic sources were higher.

## **Impact of Updated Source Apportionment Models on 2010 Ozone Transport**

We evaluated the sensitivity of DFW ozone transport assessments to changing the CAMx source apportionment methodology. The updated Anthropogenic Precursor Culpability Assessment method, called APCA2, better distinguishes between chemical processes that create and destroy ozone. The updated APCA2 methodology allocates less ozone to distant sources, more ozone to local sources, and about the same ozone to sources at intermediate distances. Ozone contributions from far distant sources, such as boundary conditions (BCs) and the Northern Plains, decrease with APCA2 because they are subject to chemical destruction during multi-day transport. The contribution of BCs to high 8-hour ozone in DFW decreased by 5.5 ppb (16%)

whereas the contribution of local DFW sources increased by 3.5 ppb (8%) using APCA2. The contributions of sources at an upwind distance of about two States were about equal between APCA and APCA2. These changes are sufficiently small that they aren't expected to alter existing conclusions from Phase 1 of Project H35. We recommend that the APCA2 method be used for future ozone transport assessment modeling.