Effects of temporal variability in industrial emissions on ozone formation in southeast Texas

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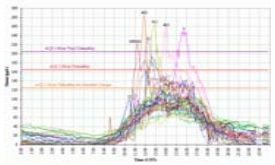
Summary

- Temporal variability in industrial emissions of hydrocarbons is significant.
- Temporal variability in industrial emissions can have significant impacts on ozone formation and accumulation in the southeast Texas.
- The variability in industrial emissions has the potential to cause increases and decreases of **10-52 ppb (13-316%)**, or more, in ozone concentration.
- The variability also has the potential to increase region wide maxima in ozone concentrations by up to **12 ppb**.

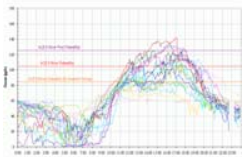
Introduction

- Ozone formation in the Houston/Galveston region is frequently **Faster** and **More Efficient** in terms of moles of NOx consumed per mole of ozone formed.
- Faster formation of ozone often leads to **Extremely High ozone concentration** in spatially isolated areas.
- These unique features of ozone formation in the HG area are associated w/ plumes of **Reactive hydrocarbons** from industrial facilities (Kleinman, 2003).
- Industrial emissions of hydrocarbons have **significant temporal variability**, but they have been assumed to be constant for current air quality regulation and modeling studies.
- So the impacts of variability in industrial hydrocarbon emissions on ozone formation will be investigated.

Houston 10-23-2003



Dallas 8-7-2003



Source : TCEQ (2006)

Development of sub-domain model

- Thousands of variable emission scenarios are possible, and all of these instances may lead to different patterns of ozone formation and accumulation due to emission variability.
- To consider the full range of possible emission scenarios or emission snapshots, it is necessary to construct **computationally efficient** photochemical models.
- The main difference from a typical full domain model is the **size of the domain**.
- Ideally, the **computationally efficient** models would **approximate**, as closely as possible, the simulation that would be performed by a **full 3-D regional air quality model**, but do so with a small fraction of the computational efforts of the full model.

Development and use of sub-domain model described in Nam et al., 2006.

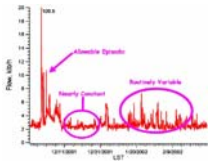
Modeling domain for the **full** 3-D CAMx simulation

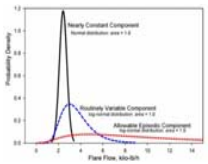
- HG domain has 1km resolution. This level of spatial resolution is necessary to accurately model concentration gradients observed in the **industrial source region** (Allen et al., 2004).
- From the simulation results using the full domain
  - Sub-domains to be modeled
  - BC and IC for sub-domain modeling

Preparation of input data

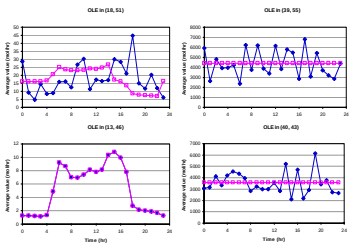
- BNDEXTR : BC, IC from full model output
- MM5CAMx : Height/Pressure, Wind, Temperature, Water vapor, Cloud/Rain, Vertical diffusivity
- WINDOW : Extracting ground level emission
- LOMASK : Adding ground level emission events
- Programming : Albedo/Haze/Ozone column, Land Use
- Reused : Photolysis rate, Top Condition, Elevated point source emission

Development of stochastic inventory





- Stochastic emission inventory generator (Webster, 2007)
  - Based on observations from various emission sources (10 FL and 2 CT)
  - Identified multiple PDFs, each accounting for one of the components of the emission variability.
  - Randomly generate emissions based on the model
- Individual point sources in the HG area were randomly assigned one of the unit operation models according to their source types → stochastic EI

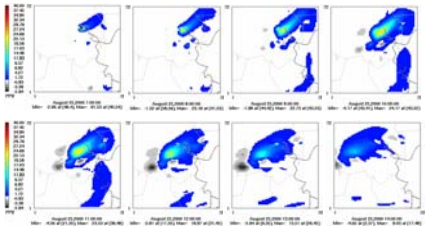


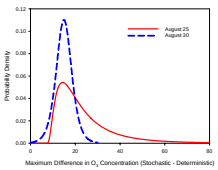
Stochastic EI

Deterministic EI = EI before varying industrial emissions

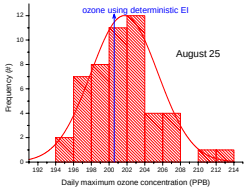
Impacts of variable industrial emissions of hydrocarbons on ozone formation

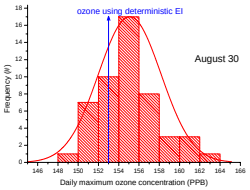
Changes in O_3 due to variable industrial emission





Daily maximum O_3 using variable industrial emissions





Policy Implications

- Large emission events can, by themselves, cause ozone exceedances (TCEQ has placed limits, 1,200 lbs/hr, on emission events – fines may be imposed for large events)
- Emission variability increase area-wide maximum ozone concentration by several ppb, on average; therefore decreasing variability can reduce ozone concentration by several ppb.
- Strategies exist for reducing variability, especially in flares; policies may be considered like those adopted in BAAQMD.

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