What is the Best Conceptualization of Ozone Production in the Houston Area?

TCEQ’s High Priority Science Questions to be addressed:

Aa) Which local emissions are responsible for the production of high ozone in Houston, Dallas, and eastern Texas?

Fa) How do mesoscale chemical environments (NOx-sensitive ozone formation vs. radical-sensitive ozone formation) vary spatially and temporally in Houston, Dallas, and eastern Texas?

Fb) Which mesoscale chemical environments are most closely associated with high ozone and aerosol?

K How can observation and modeling approaches be used for the determining
(i) the sensitivities of high ozone in the HGB non-attainment area to the precursor VOC and NOx emissions, and
(ii) the spatial/temporal variation of these sensitivities?

Ozone Formation in the Oxidation of Hydrocarbons in the Presence of Nitrogen Oxides

Ozone Production Efficiency: OH reacts with CO, VOCs $\leftrightarrow$ OH reacts with NO2

Secondary Products like CH2O and PAN reflect on hydrocarbon chemistry
1) What does it take to make Ozone?

==> NOx and VOCs! Ship Channel vs. Parish power plant.

Examine the result of the large NOx emission reductions from Parish power plant between 2000 and 2006.

Large Difference in Ozone Yield observed and modeled

Electra 08/28/00 flight data and Plume model

Transects nearly equally oxidized
(NOx / NOy) ~ 0.5

Plume Model: emit at 10 CST, Plume age 5.5 hrs

WA Parish Power Plant
ENOx = 84 kmole / hr

Ship Channel Plume
ENOx = 84 kmole / hr
EC2H4 = ENOx
EC3H6 = ENOx

E(isoprene) = 5E15 molec m-2 s-1
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2) What does it take to reach high levels of Ozone?

a) Accumulation over multi day episodes.

==> b) Rapid ozone formation in intense plumes before dilution occurs, Example Oct. 6, 2006
3) How is rapid Ozone formation maintained in Houston?

Emissions of reactive VOCs and NOx.

a) Collocated emissions of NOx and highly reactive VOCs (primarily ethene and propene).

or

b) Interaction of emissions of highly reactive alkenes from petrochemical industries with urban area sources.

Oct. 6, 2006
4) Which factors contribute to intense plumes?

a) Point Source emissions: Strong Power Plant and industrial emissions.

b) Low wind speed, low boundary layer height.

c) Emission from sources over prolonged time (hours): stagnation events or alignment of sources.
Aug 25
Stagnation followed by on-shore Flow

Sep 6
Steady Easterly Flow

Aug 30
Sea Breeze Reversal

Sep 1
Steady Westerly Flow

Electra Flights TexAQS 2000
O3 Max > 150 ppbv

Transport from Ship Channel Region Determines Location of O3 Maxima

Windspeed and PBL height Determine intensity
5) What are the sources of NOx and VOCs in the Houston area?

a) Industrial Ship Channel complex

b) Urban traffic

c) Power plants

Talks by Joost de Gouw, Thomas Ryerson, and Greg Frost.

Examine the results from the change in the emission sources between 2000 and 2006.
6) Are the sources of NOx and VOCs consistent with emission inventories and can we observe the effect of emission reductions on ozone?

a) NOx sources: Emission inventories reflect the significant reduction of point source emissions.

==> b) VOC: industrial VOC emissions are still strongly underestimated.

Similar windspeed, similar PBL height, 3 deg C in 2006 and much drier (Complicating Factor: Biomass burning in 2000)
Oct. 6, 2000 and Oct. 20, 2006
7) Is the photochemistry consistent with observations?

a) To first order yes.

b) High alkene emissions inferred from observations lead to rapid and efficient ozone formation.

c) Secondary products like CH2O, CH3CHO, PAN, PPN, APAN are to first order consistent with photochemistry.

Based primarily on 2000 data and preliminary look at 2006 data.

Use measurements of secondary species to examine understanding of photochemistry and photochemical model performance.

Compare models with observations:
Influence of VOCs on O3 formation and NOy partitioning as reflected by CH2O.
Influence of VOCs on O3 formation and NOy partitioning as reflected by CH2O

Influence of VOCs on O3 formation and NOy partitioning as reflected by CH2O