Impacts of background ozone production on Houston and Dallas, TX Air Quality during the NOAA 2006 TEXAQS field mission

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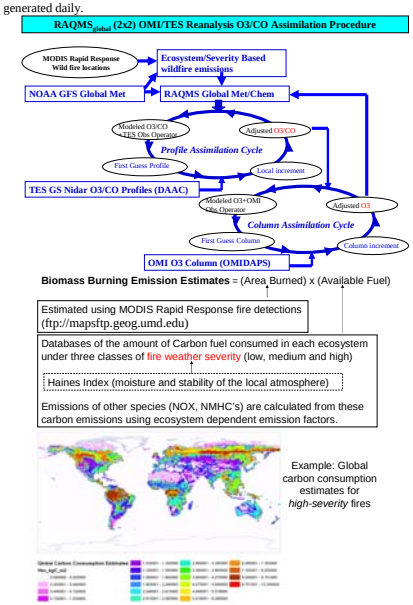
1. Background

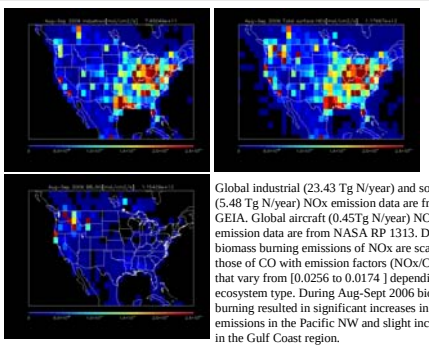
In this poster we synthesize remote and in-situ measurements from multiple observational platforms to assess contributions of remote influences on local air quality in the Houston and Dallas metropoliton areas during summer 2006. The 2006 NOAA/TCEQ Texas Air Quality Study (TexAQS). The global component of the Real-time Air Quality Modeling System (RAQMS) is used to investigate the impact of continental scale ozone production on Houston and Dallas air quality from July 15 through October 15, 2006. Lagrangian trajectory analysis provides the link between RAQMS chemical analyses, continental scale satellite observations, and surface networks during the study period. A unique aspect of the RAQMS chemical analyses is the incorporation of satellite data to improve the chemical analysis, including assimilation of column ozone observations from OMI and ozone and carbon monoxide profile observations from TES onboard the NASA Aura satellite and the use of fire counts from the MODIS instrument onboard the NASA Terra and Aqua satellites to generate biomass burning emissions.

2. RAQMS Global 2006 (January 30–October 16) Ozone Assimilation/Forecast Procedure

The following diagram illustrates the RAQMS assimilation procedure used during 2006. 6 hourly chemical analyses were conducted at 2x2 degree horizontal resolution with 35 vertical layers spanning the troposphere and stratosphere. OMI cloud-cleared column assimilation was conducted every 6 hours. TES O3/CO profile assimilation was conducted every 1 hour. Global biomass burning emission estimates were generated daily.



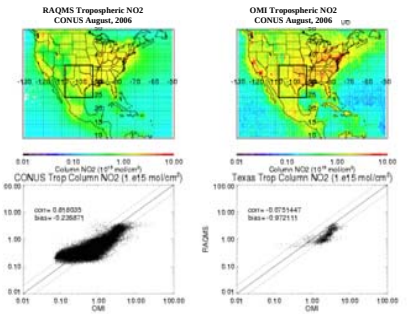
3. RAQMS NOx emissions during TEXAQS: Aug-Sep 2006



Global industrial (23.43 Tg N/year) and soil (5.48 Tg N/year) NOx emission data are from GEIA. Global aircraft (0.45Tg N/year) NOx emission data are from NASA RP 1313. Daily biomass burning emissions of NOx are scaled to those of CO with emission factors (NOx/CO) that vary from [0.0256 to 0.0174] depending on ecosystem type. During Aug-Sept 2006 biomass burning resulted in significant increases in NOx emissions in the Pacific NW and slight increases in the Gulf Coast region.

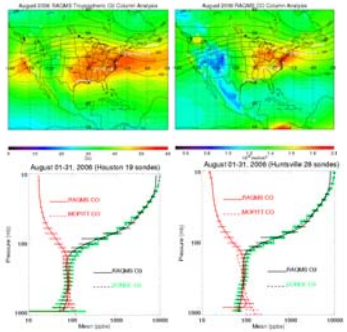
4. RAQMS Tropospheric NO2 vs OMI

We evaluate the fidelity of the RAQMS NO2 predictions by comparison with tropospheric NO2 column retrievals from OMI during August, 2006. RAQMS overestimates NO2 contributions from equatorial biomass burning sources over Africa and South America relative to OMI. RAQMS underestimates NO2 contributions from Northern Hemisphere Mid-latitude anthropogenic sources over S.E. Asia and the Continental US (CONUS) relative to OMI. Over CONUS, RAQMS NO2 columns are generally within a factor of 2 of the observed Tropospheric NO2 column.



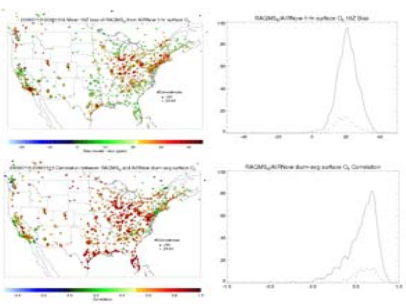
5. RAQMS CO/O3 vs MOPITT/IONS

August mean RAQMS analyzed tropospheric O3 and CO are in good agreement with IONS ozonesonde and MOPITT CO retrievals at Houston and Huntsville. The analyzed tropospheric O3 column shows a broad ozone maximum in excess of 50 DU over the South Central and Eastern US that extends out over the Western Atlantic and a localized ozone maximum off the California coast. The analyzed total column CO shows a similar CO maximum over the South Central and Eastern US but no significant CO enhancement off the California coast.

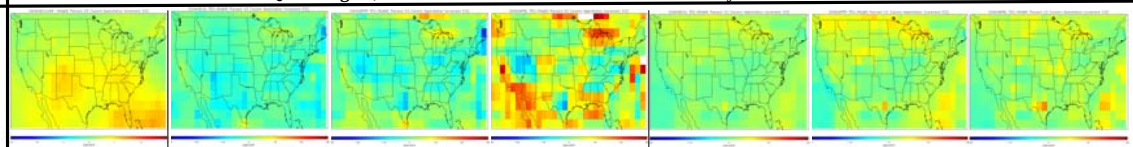


6 RAQMS Surface O3 vs EPA AIRNow

National maps of time averaged site statistics (left panels) show RAQMS 18Z surface O3 analysis is high by 10-20 ppbv through most of the SE US and by 20-30 ppbv over the Ohio River valley and Northeast but is highly correlated with measurements over most of the Eastern US. Histograms (right panels) show that most of the AIRNow sites have biases of ~20ppbv and correlations (with respect to the diurnally averaged ozone mixing ratio) of ~0.7.



7. RAQMS August, 2006 Mean OMI O3 and TES O3/CO Analysis Increments



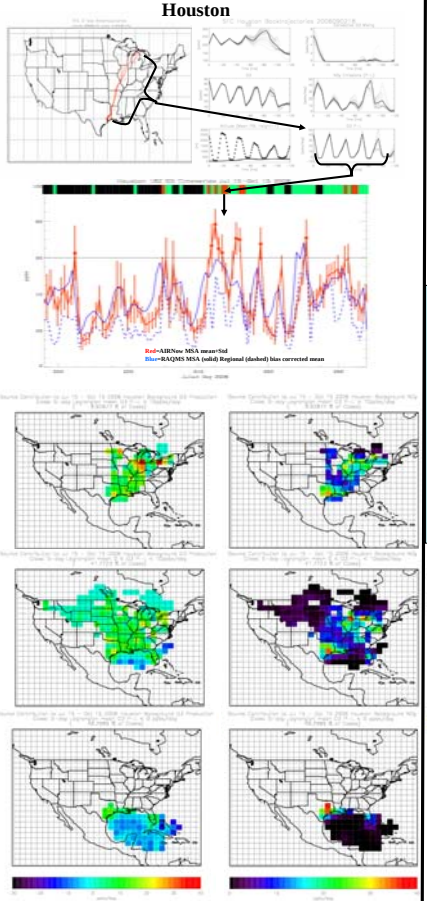
Assimilation of OMI total column O3 measurements results in small (1-1.5%) mean increases in total column O3.

Assimilation of TES O3 profiles results in moderate (+/- 10%) adjustments in total and tropospheric O3 column over CONUS. Largest (+20%) positive adjustments occur within the Southern CA, Coastal Gulf, and Great Lakes planetary boundary layer (PBL). Largest (-20%) negative adjustments occur within the Central Rockies and Central TX PBL.

Assimilation of TES CO profiles results in moderate (+/- 5%) adjustments in total and tropospheric CO column over CONUS. Largest (+10%) positive adjustments occur in the central TEXAS PBL.

8. Impacts of background ozone production

Houston



Approach:

- Bias corrected RAQMS chemical analyses are used to provide estimates of background composition along ensemble back trajectories that are initialized at 18Z from surface EPA AIRNOW ozone monitoring stations within the Houston and Dallas metropolitan statistical area (MSA).
- Lagrangian averaged O3 P-L rates along the back trajectories are used as a metric to classify back trajectories.
- The Lagrangian averages are computed during time periods where the back trajectories are outside the respective MSA, defined as more than 2° in longitude or latitude away from central Houston or Dallas.

Classifications:

RED=Class1: Enhanced back ground ozone production (ensemble mean 5-day Lagrangian averaged O3 P-L > 10 ppbv/day)

GREEN=Class 2: Moderate back ground ozone production (ensemble mean 5-day Lagrangian averaged O3 P-L > 0 ppbv/day and < 10 ppbv/day).

BLACK=Class 3: Back ground ozone destruction (ensemble mean 5-day Lagrangian averaged O3 P-L < 0 ppbv/day).

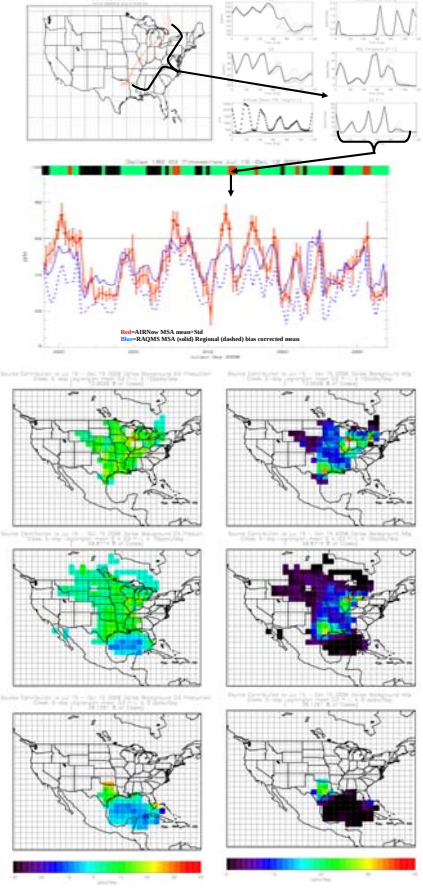
Source Attribution: Houston

- **Class 1** Midwest/Ohio River Valley source with significant O3 P-L (40ppbv/ day) due to NOx sources along the southern Great Lakes.
- **Class 2** Distributed Eastern US sources with moderate (10ppbv/day) O3 P-L due to biomass burning NOx sources in Pacific NW.
- **Class 3** Net maritime O3 loss over Gulf of Mexico with moderate (10ppbv/day) O3 P-L due to NOx sources in Florida and Louisiana.

Source Attribution: Dallas

- **Class 1** Broad Great Plains/Midwest/Ohio River Valley source with significant O3 P-L (30ppbv/ day) due to Chicago NOx sources along the southern Great Lakes.
- **Class 2** Distributed Central US sources with moderate (10-20ppbv/day) O3 P-L due to Chicago NOx sources.
- **Class 3** Net maritime O3 loss over Gulf of Mexico with moderate-significant (20-30ppbv/day) O3 P-L due to NOx sources in Florida and Texas/Oklahoma boarder.

Dallas



9. Conclusion

Continental US source contributions to daily 18Z mean Houston and Dallas ozone mixing ratios were estimated during July 15-Oct 15, 2006 using Lagrangian approaches. 5-day ensemble back-trajectories sample initialized from EPA AIRNow sites within the Houston and Dallas MSA sampled 6hr RAQMS chemical analyses that were constrained with satellite O3 and CO observations and ecosystem/severity based biomass burning emissions. Three distinct regional influence classifications are developed based on the AIRNow ensemble mean 5-day Lagrangian averaged O3 P-L: **Class 1 (Background O3 P-L > 10ppbv/day)** events account for 10% (12%), **Class 2 (Background 0<O3 P-L<10ppbv/day)** events account for 42% (60%), and **Class 3 (Background O3 P-L<0ppbv/day)** events account for 48% (28%) of the Houston (Dallas) back trajectories during the study period. Periods of enhanced regional ozone production (**Class 1**) preceed 66% (6 out of 9) and 46% (7 out of 15) of the periods with elevated (Mean >60ppbv) AIRNOW ozone within the Houston and Dallas MSAs respectively.

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