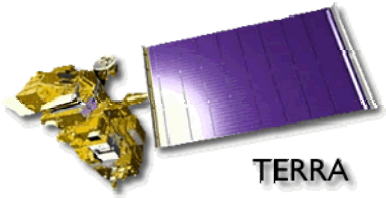
Assimilation of MODIS aerosol optical depth measurements: Impacts of regional aerosol events on Houston air quality during TexAQS II



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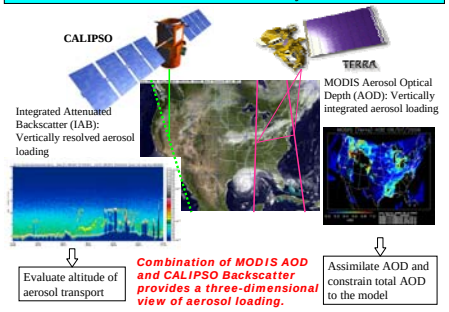
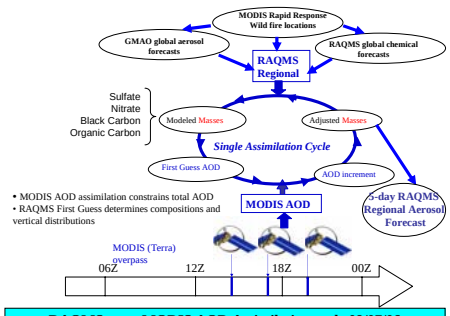
Abstract:
The field experiments TexAQS II/GoMACCS coincided with intensive fire activities over the Pacific Northwest, persistent sulfate pollution in the eastern US and transport of Saharan dust. This study assesses the influence of these regional and hemispheric-scale aerosol events on local air quality in Houston during the field experiments using the Real-Time Air Quality Modeling System (RAQMS) and satellite observations. The model used for this study is the regional component of RAQMS with a MODIS aerosol optical depth (AOD) assimilation. The model performance over the Houston area is evaluated with respect to aircraft and ground-based measurements obtained during TexAQS II/GoMACCS. The regional aerosol distributions are compared with the AOD retrieval obtained from MODIS on the Terra satellite and EPA surface measurements. The observations from the CALIPSO satellite, which depict vertical aerosol distributions, allow us to evaluate the altitudes of aerosol layers simulated by the model for the first time. The implication of these model evaluations is discussed. Finally aerosol distributions at a synoptic scale during the field experiments are summarized and the consequent influence on Houston air quality is discussed.

Satellite data used in Analysis

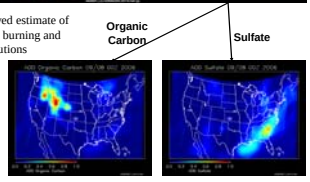


$RAQMS_{regional}$ (80km) AOD Assimilation/Forecast Procedure



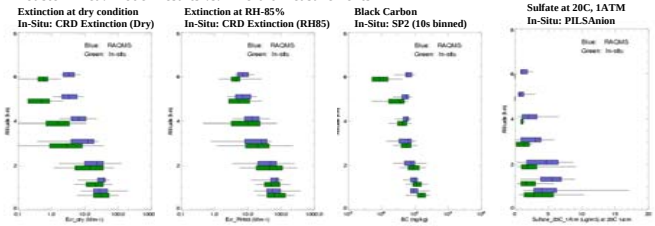
$RAQMS_{regional}$ MODIS AOD Assimilation cycle 09/07/06

AOD assimilation improved estimate of smoke from NW biomass burning and SE sulfate aerosol distributions

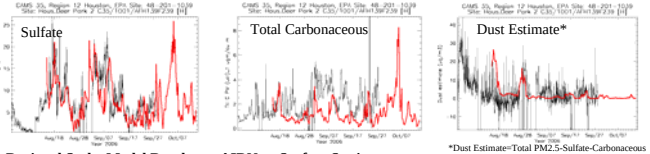


Model Verification

Houston Area: Model Results vs. Aircraft Measurements

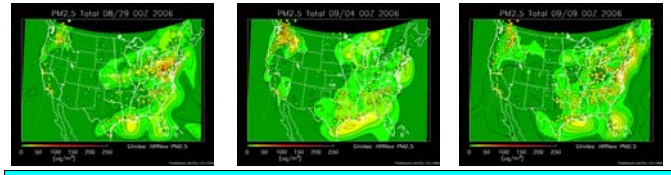


Houston Area: Model Results vs. Surface Station @ Deer Park



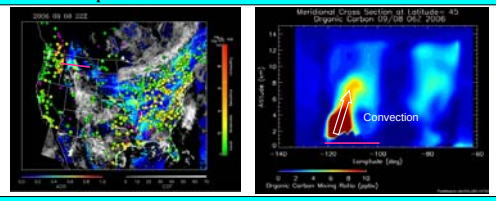
*Dust Estimate=Total PM2.5-Sulfate-Carbonaceous

Regional Scale: Model Results vs. AIRNow Surface Station



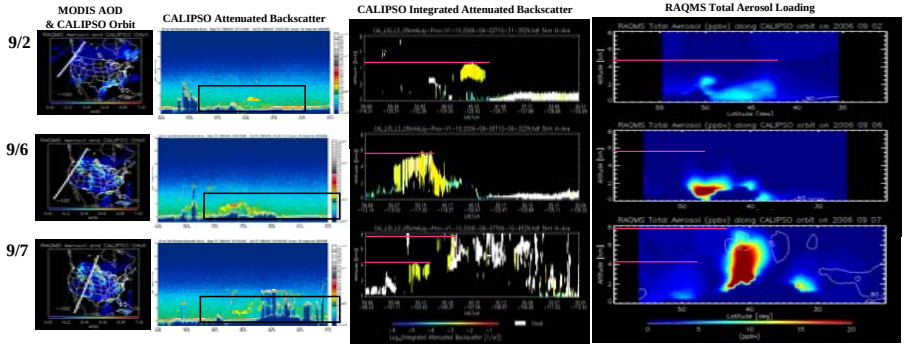
Convective Transport of Smoke

Heat released from fire locally creates convective environment. When the convection is strong enough, smoke is transported upward and redistributed into vertical levels, which determine the subsequent transport pathway. Thus, the representation of smoke injection height is one of the most critical elements to simulate smoke transport. In RAQMS, convective transport due to fires is represented based on total carbon burned with the conversion factor of 8000 BTU/lb. The heat flux is partitioned into two components, sensible heat flux and radiative heat flux, and added to the soil layer of fire locations. Relative humidity is assumed to be 100 % where a fire location is.

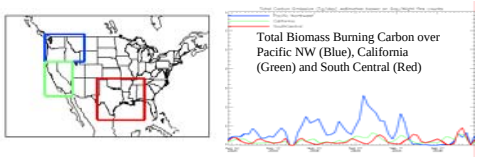


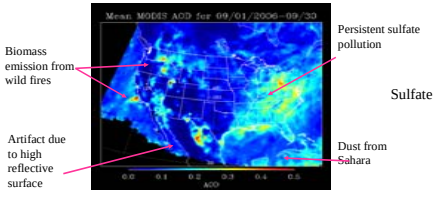
Altitudes of Aerosol Layers: Model Results vs. CALIPSO

The altitudes of aerosol layers near fire locations from RAQMS are compared with the CALIPSO attenuated backscatter. The RAQMS altitudes generally show lower than those CALIPSO observed.

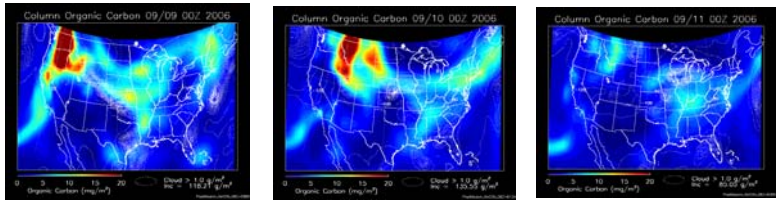


Summary of Regional Aerosol Distributions During TexAQS 2006

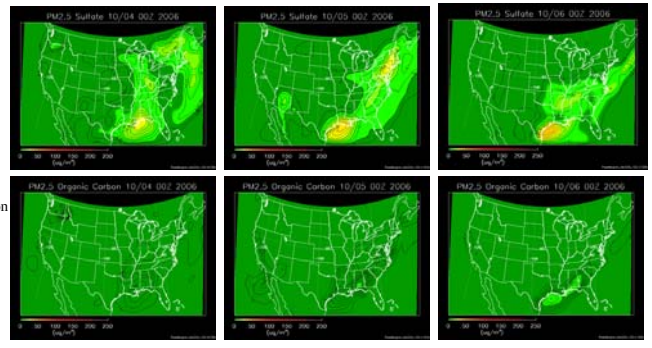




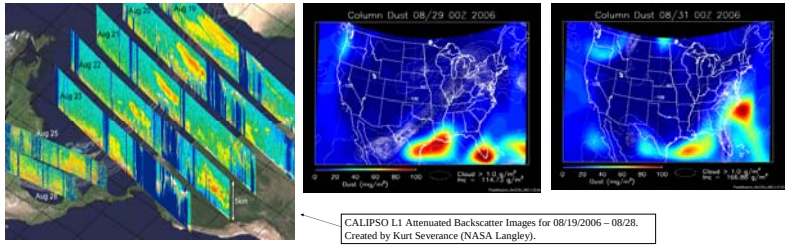
Smoke Transport from Pacific Northwest: Intensive Fire Activities over the Pacific Northwest Between 09/01 and 09/08. Southeastward Transport of smoke is seen on 09/09 and 09/10.



Sulfate and Organic Carbon from the Eastern US: The highest Sulfate concentrations were observed on the P3 flight of 10/6 during TexAQS 2006. The RAQMS simulation shows an area of high concentrations of sulfate and organic carbon being elongated from the Gulf of Mexico to the Northeast. as they are transported southeastward on 10/4 – 10/6.



Saharan Dust Transport: Influenced Houston Air Quality Between 08/26 – 08/31



CALIPSO L1 Attenuated Backscatter Images for 08/19/2006 – 08/28. Created by Kurt Severance (NASA Langley).

Conclusions

- **The comparisons of aerosol species between the RAQMS analysis and in-situ/ground-based measurements generally show a good agreement near the surface. However, a discrepancy gets larger with height.**
- **The evaluation of the altitude of smoke layer close to an intensive fire source is made using the CALIPSO aerosol integrated attenuated backscatter for the first time. This reveals that the altitudes of smoke layers are generally lower by 30% than those CALIPSO observed. This, combined with an analysis of assimilation increments (not shown in this poster), suggests a need for the improvement of an estimate of injection height of smoke over fire.**
- **This study illustrates regional aerosol distributions during TexAQS 2006. The aerosol events during this time period include 1) Saharan dust transport to the Western gulf of Mexico between 8/26 – 8/31, 2) smoke transport from the Pacific Northwest toward the southeast in early September, 3) the strongest smoke transport from the NW to the Houston area on 9/9 and 4) an outflow of a mixture of sulfate and carbonaceous aerosol from the eastern US to the western Gulf of Mexico between 10/4 and 10/6.**

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