Preparation for SEAC^{4}RS Aircraft Campaign

Studies of Emissions and Atmospheric Composition, Clouds, and Climate Coupling by Regional Surveys

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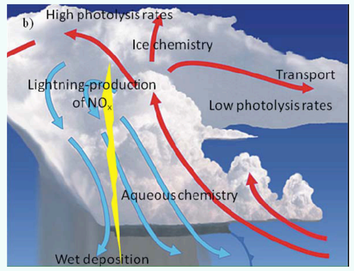
Mission objectives

1. To determine how pollutant emissions are redistributed via deep convection throughout the troposphere.
2. To determine the evolution of gases and aerosols in deep convective outflow and the implications for UT/LS chemistry.
3. To identify the influences and feedbacks of aerosol particles from anthropogenic pollution and biomass burning on meteorology and climate through changes in the atmospheric heat budget (i.e., semi-direct effect) or through microphysical changes in clouds (i.e., indirect effects).
4. To serve as a calibration/validation test bed for future satellite instruments and missions.

Deep convection over the SE US

Figure 1: processes associated with deep convection (from NCAR DC-3 homepage). Deep convection in the SE US is able to quickly pump up the mix of natural and anthropogenic emissions from the boundary layer to the free troposphere and possibly even deliver some species to the stratosphere. SEAC4RS seeks to better understand these processes and the associated chemistry.



Aircraft/Instrumentation

DC-8 (low altitude):

Aerosol properties (extinction, absorption, backscatter, depolarization, mass spectra, optical depth, chemical composition), CO, CO2, CH4, hydro and halocarbons, solar irradiance, IR, miro met, NO, NO2, NOy, nitrates, H2Ov, N2O, CH2O, black carbon, O3, actinic flux, PAN, SO2, precipitation, peroxides, HCN, organic acids, OVOC

Figure 2: 1, 2 , and 3 hour rings from Houston, Texas

ER-2 (high altitude):

Broadband IR, polarimetry, aerosol and cloud height, multi-spectral imagery, hyperspectral flux, radiometry, H2Ov, trace gases, state variables, turbulence, CO, O3, temperature and pressure, CO2, CO

Spec Learjet:

4 cloud particle probes to cover size range rom 1um to several cm (2D-S optical array cloud imaging probe, fast cloud droplet probe, high volume precipitation spectrometer, cloud particle imager)

References:

Randel et al. 2012. 'Global variations of HDO and HDO/H2O rations in the upper troposphere and lower stratosphere derived from ACE-FTS satellite measurements.' *JGR*.

SEAC4RS Draft Plan, September 2013

Diagram: https://www2.acd.ucar.edu/dc3

Modeling in the field

We will be performing quick-look data analysis and near-real-time (NRT) modeling. By comparing model results to field data, we will be able to

1) guide flight planning
2) provide feedback to instrument PIs on data anomalies that may indicate instrument problems
3) monitor progress of mission towards meetings its objectives
4) contribute to internal and external reporting of emerging results while in the field, including providing an archive of model field data.

Model details:

- GEOS-Chem nested North American domain (10-60N, 130-60W)
- 0.25° x 0.3125° horizontal resolution (native horizontal resolution of GEOS5.7 assimilated meteorology)
- NRT: ~1.5 day lag
- Include detailed oxidant-aerosol chemistry, long-lived greenhouse gases, and tracers
- NEI 2010 at ¼ degree resolution
- Most other inventories at 1x1 degree resolution
- FLAMBE or FINN for fire emissions

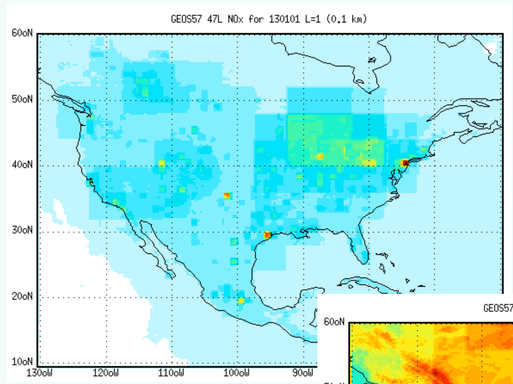


Figure 3: GEOS-Chem model output for nested N.A. domain at ¼ degree resolution.
Only run for 1 day starting with a 4x5 deg restart file (which is why it still looks boxy).
Still in development/testing, run with some emissions off.

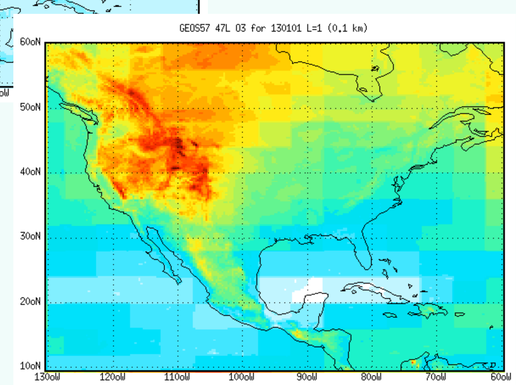


Figure 4: We can start to see finer structures that would not have been possible on the coarser global grid.
High resolution models are important for more accurate modeling of non-linear chemical species, such as ozone.

Post mission:

Use GEOS-Chem to integrate information from different aircraft, satellite, and ground platforms during SEAC4RS. Using GEOS-Chem will allow us to analyze observations taken at different times and locations. We will contribute to validation of satellite data and ground sites.

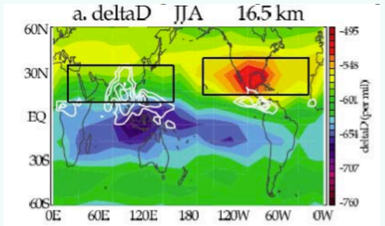
Other models:

Many other models will be used by the different groups on the SEAC4RS project. For forecasting, they include WRF-Tracers, WRF-Chem, MOZART, and NRL – NAAPS. There will also be groups running GOCART, CMAQ, and COAMPS.

Focused Studies:

North American Monsoon

Figure 4: shows the HDO/H2O ratio, which is an indicator of convection, for the Asian and NA monsoon systems. We see that the signature is much stronger for the NA monsoon, even though the monsoon strength is weaker (Figure 12 of Randel et al. 2012) .



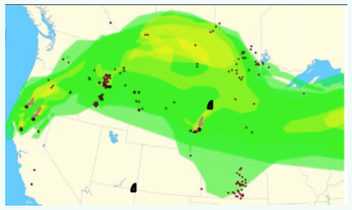
Aircraft sampling of horizontal and vertical gradients of water vapor will improve understanding of the role of water vapor in the lower stratosphere.

SE US Air Chemistry

In summer, the SE US emits extremely high levels of biogenic VOCs. The addition of anthropogenic emissions and convective activity makes for interesting chemistry. This study seeks to understand the role of biogenic VOC emissions for atmospheric chemistry and aerosol formation. How does shallow convection modify aerosol properties? What processes take place during deep convection, and what are the implications for outflow in UT/LS? In addition, declining UV radiation in September may cause the photochemical regime for ozone to switch from NOx-limited to NOx-saturated. Thunderstorms may also deliver water vapor to the lower stratosphere, which might lead to conversion of organic chlorine to chlorine radicals.

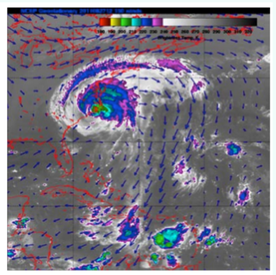
Forest Fires

Figure 5: Smoke for agricultural burning on 26 Sept. 2012. This campaign provides opportunities to study fires both in the Western US (which tend to be larger and interact with urban and fracking emissions), and in the SE US (which tend to be smaller and interact with biogenic emissions). There will be emphasis on convective processing of smoke plumes and formation of ozone and SOA.



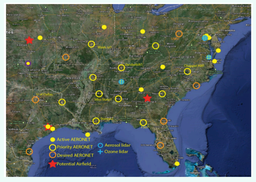
Hurricanes

Tropical cyclones may be a mechanism for transfer of trace gases to the stratosphere. Collaboration with HS3 will allow coordination with the unmanned Global Hawk aircraft, which will investigate the dynamical structure of the tropical cyclones, while the DC-8 and ER-2 investigate compositional and microphysical properties. Figure 6 shows Hurricane Ivan at 150 mb.



Validation:

TCCON and AERONET Sites



Satellites:

CloudSat
Calipso
GOES
MODIS, VIIRS
fire detection