Studies of Emissions and Composition, Clouds and Climate Coupling by Regional Surveys (SEAC\textsuperscript{4}RS):

Aerosol and Radiation (A&R) Remote Sensing Planning Slides

April 2013

http://espo.nasa.gov/missions/seac4rs/

SeaWiFS, Aug 16, 2000. Norm Kuring
A&R Mission Goals
Bottom Line Up Front

• An operative word in SEAC^4RS is in the “RS” (Regional Surveys). Even with ~150 flight hours, the parsing structure of the mission will require focus and efficacious use of time. With all the other CONUS airborne activity in 2012/2013 what will maximize the scientific benefit of the mission?

• **Remote sensing, radiation, and upper troposphere** capabilities makes SEAC^4RS distinct from all of the other missions.

• Time devoted to polarimeter, lidar, and radar applications should not be seen as “engineering” or mundane. These are the future of science and science adds focus to development. Again, this is what makes us distinct from other missions.

• Chemistry and microphysics should thus see the remote sensing community as customers. Conversely, remote sensing will provide much needed context to *in situ* measurements.

• There are no shortage of good science questions, but there is limited flight time. We need to carefully bundle science needs and flight plans.
SEAC4RS A&R: What has changed?

- **Science:** we are going from one of the last great unknown regions to an area with significant amounts of previous and ongoing research. The bar is much higher to go from “good productive research” to “outstanding game changing findings”.

- **Aircraft:** No G-V but DC-8 and ER-2 payloads are the same. SPEC Lear might be able to cover some lost ground on the cirrus front. But taken as a whole loss of the G-V is a major loss to the coordinated flights science demands. Bottom line, this is going to cost us a lot of DC-8 time.

- **Ground Network:** Gone from very sparse trustworthy ground based data to “swimming in it.” But quality ground based lidar data is less available.

- **Meteorology & Environment:** Going from complex with poor observability and predictability but with strong regional signals, to good observability and predictability but a situation where we have to pay closer attention to detail.

- **Other Missions:** The SOAS, SENEX and BBOP mission are well conceived and can spend the required time focusing on complex chemistry. We have a wider range, scope and the advantage of the world’s best radiation and remote sensing packages measurements coupled with comprehensive chemistry. I think this answers the question “How do we go about making ‘outstanding game changing findings?’”.

- **Clouds and Aerosol particles:** Like SE Asia, the science leads us to the conclusion that cloud and aerosol components of the same problem, and should be treated that way.
The “Perfect SEAC4RS Day”

It would be nice if it happened to us, but don’t count on it.

SeaWiFS, Aug 16, 2000. Norm Kuring
Something More Recent
Aerosol Tools in a Nutshell
Complete Instrument slide set to be posted online

- **ER2:**
  - Remote sensing: AirMSPI, CPL, eMAS, RSP
  - Radiation hyperspectral, Solar, IR

- **DC8**
  - Chemistry: Inorganic ion w/some organic filters, Aerosol mass spectrometers
  - Microphysics: Fine and quasi-coarse size, multi wavelength and refractive scattering/absorption, phase function extinction hygroscopicity, CCN, Black carbon characterization, cloud droplet size, polar imaging neph.
  - Radiation: SSFR, Solar, IR
  - Remote Sensing: 4STAR, HSRL Dial, RPI
  - Radar: 13.4 & 35.6 GHz
IMPROVE Maps:
Where to find what

Sulfate

Nitrate

LOC

POM

μg/m³

μg/m³

μg/m³

μg/m³
Consider the Vertical
(Campbell CALIOP 2006-2011 ASO Climatology, operational data)

- 532 nm Extinction (km⁻¹)

Levels:
- 500 m
- 1500 m
- 2500 m
- 3500 m
Fire: How to apply tools to significant and unpredictable variability at fine scales

Aug 17, 2012

Aug 18, 2012
Southeast US (SEUS): Good days to wrap your brains around

Aug 24, 2012

Small but persistent burning

Aug 29, 2012

Sep 2, 2012
Fine mode AOT Odds in the SEUS: Walker Branch TN AERONET as an example
Engineering Requirements & Questions: Getting Down to Basics of what remote sensing is seeing

What is the information content of the multi-angle, multi-spectral polarimetric reflectances and how does it vary as the data acquired move away from the principal plane? Read: ACE

How can lidar be synergistically combined with polarimetry and other sensors to completely describe the atmospheric aerosol and radiation column from space?

- Requirement: Generate a benchmark radiation, polarimeter and lidar development data set (Dust, smoke(s), hazes, AOT>0.4; varying land surface). Colocation of sensors and in situ is key.

- Satellites: Provide key data to push current capabilities and inspire further development.

- Flights: Requires several ~3 hr area flight components that can be bundled with other radiation science topics. Plus, well constructed survey flights for chemistry can be applied.

- Collateral Support: New Soumi-NPP product development and verification.
Development & Interpretive Questions: “Does it work?”, "What does it mean?” and "How can we?"

**Aerosol**

1) Can the 4star system provide new information on spatial covariance of aerosol optical properties and gases from aircraft?

2) How representative are AERONET retrievals at high and low AOTs?

3) Can we verify critical reflectance retrievals of single scattering albedo?

4) What meteorological features is it the lidars are actually seeing in the planetary and convective boundary layer and how can they be exploited?

5) How well do remote sensing systems detect/represent smoke and absorption over clouds?

6) Given the diurnal nature of air chemistry and meteorology, how representative are aerosol/radiation measurements on the Terra/Aqua constellation?

7) Compared to the surface network, what value is there in current remote sensing data in representing surface air quality? Can we monitor the urban plume and its fusion into the synoptic scale haze?

8) How can synoptic scale remote sensing data and data assimilation related forecasts be used to forecast exceedences?
Radiation

1) To what accuracy can we monitor synoptic scale radiative features by combining remote sensing and model products?

2) How do we connect “radiance-world” (cloud-aerosol-gas remote sensing) with “irradiance-world” (forcing/absorption), and remote sensing products to in-situ observations?

3) In heterogeneous aerosol and cloud scenes, how well do we actually represent the 3 d radiation fields by satellite and models (total irradiance, direct/diffuse)? Can we resolve cloud bias in remote sensing data vs 3 d radiative effect, “twilight zone” phenomenon and cloud halos?

Chemistry, Microphysics, and Polarimetry

1) How well can polarimeters and current satellites characterize the evolution of aerosol particle properties in smoke and biogenic particle plumes?

2) Are polarimeters capable of detecting Brown Carbon formation, and when coupled to models, monitor SOA formation?

3) How well can we invert out particle properties based on polar nephelometer and absorption
Basic Science: Why we care about remote sensing in the first place

Chemistry

1) What is Brown Carbon and how does it relate to particle absorption properties? Is isoprene and/or aqueous phase chemistry important?

2) In the SEUS, how do hazes physically, thermodynamically and optically evolve in clear versus cloudy conditions?

3) To what extent do convective boundary layer processing and the radiation fields above clouds decouple aerosol chemical, thermodynamic and optical properties across the inversion?

4) How do the processed aerosol particles in mid and upper level detrainment layers differ optical and thermodynamic from their boundary layer counterparts?

5) Can we identify mid-level detrainment processes and their potential for nucleation?

6) How are optical properties of smoke particles changing in the far field due to the competing effects of coagulation, SOA product and evaporation/breakdown?

Deep convective transport and clouds

1) How do cold pools and non-precipitating convective features redistribute aerosol particles?

2) Can we find a typing point in CCN concentration in warm rain formation/suppression in the Gulf and how does this relate to convective redistribution?

3) When does CCN efficiency really matter for practical purposes in the SEUS?
Remote Sensing Data Quantum.

150 km/13 min? 1 hr = 3 levels straight leg or a rosette

This is ½ a synoptic scale length and is two scale lengths at meso-A

Aug 18, 2012

Aug 24, 2012
One way to burn 5 hours in SEUS to characterize haze?

- How we want to fly BL depends on if we want to continue on (odd # legs) or end up where we started (even # of legs).
- To characterize any leg requires really a minimum of 3 levels.
- Occasional porpoise is ok, but most of the time should be spent in level flights to characterize variability. Even with a 5 hour segment.
- Even with a 5 hour flight, there is still time to work pollution or convection near Houston..... Probably every flight....
- Keep in mind the atmosphere is 3 dimensional, with at times lots of directional shear. We should expect big vertical gradients in intensive aerosol properties. This means we need to keep close eye on lidar and satellite data back at the ranch.
How Much Shear?
This is a good day.

NOAA HYSPLIT MODEL
Backward trajectories ending at 0000 UTC 24 Aug 12
NAM Meteorological Data

BL air is staying still
Speed shear
“Soup”

NOAA HYSPLIT MODEL
Backward trajectories ending at 1800 UTC 24 Aug 12
NAM Meteorological Data

Aloft MS River Basin Below over forest, but they meet up!
So, we need all of our airborne tools plus good modeling support to interpret this: But it is a good marker for chemists too...

LaRC Meridional HSRL Transect From Georgia across Florida, North to South Aug 6, 2006
Closing thoughts:

• Let’s not forget it is because of remote sensing we are here. That said, remote sensing does not exist for its own sake.
• There is no shortage of things to do, but we need to bundle requirements to satisfy the large customer base. Be prepared to compromise tomorrow.
• Some investigators (e.g., Brock and Jimenez) are also on SOAS/SENEX. Their data will give the community data for the entire summer in SEUS.
• CONUS and smoke plumes can have complicated 3 dimensional flows. Model integration is going to be required to interpret data.
• People are genuinely excited about brown carbon, which is a great link between radiation and chemistry.
• Convective processing and pumping is another great unifying thread in all of this work.