

## Geo-CAPE Working Meeting

St. Petersburg, FL      Wednesday – Friday, March 24-26, 2010

The meeting focused on preparing to begin mission design studies. Goals included: endorsing two draft STMs (one for Ocean Color Science and one for Atmospheric Science) as appropriate starting points for mission design studies; identifying any additional needed instrument design studies; and specifying initial mission design studies and preparations needed.

The first day of the workshop provided breakout sessions for the Ocean Color and Atmospheric Science Working Groups (SWGs) to review what has been accomplished during the past year, and to discuss areas of current work. On the Atmospheric side, four sub-teams reported out.

The Variability Sub-Team has been driven by the fact that spatial and temporal variability of trace gases and aerosols have never been studied with models designed to characterize the behavior of these species on scales this small. Overall, the team determined that new information on trace gases and aerosols can be found on all spatial scales. The Sensitivity/Simulation Sub-Team has performed an initial analysis of the ability of different spectral band combinations to resolve near-surface and free tropospheric O<sub>3</sub>. The wavelength combinations considered were UV, VIS, TIR, and MIR. With the exception of the MIR, additional information about PBL amounts was obtained using the additional information provided by each of the wavelength inputs. Next steps will focus on quantifying the sensitivity of the most promising combinations (UV+VIS, UV+TIR, UV+VIS+TIR) with clouds included in the radiative transfer calculations. The Aerosol Sub-Team was formed after the other sub-teams, as the Science Working Group felt that measurement of aerosols required different considerations than the issues that faced the groups measuring trace gases. Aerosol Extinction Optical Depth (AOD) is the single threshold product, and the subteam suggested that additional baseline products include Aerosol Absorption Optical Depth (AAOD), UV Aerosol Index (UVAI) and Aerosol Optical Centroid Height (AOCH). The STM sub-group worked to incorporate aerosol requirements which emerged since the last workshop (September 2009) to produce an STM that could be agreed upon by all. The Atmospheric Science Questions that GEO-CAPE will address are:

1. What are the temporal and spatial variations of emissions of gases and aerosols that are important for air quality and climate?
2. How do physical, chemical, and dynamical processes determine tropospheric compositions and air quality over scales ranging from urban to continental, diurnally to seasonally?
3. How does air pollution drive climate forcing and how does climate change affect air quality on a continental scale?
4. How do we improve air quality forecasts and assessments for societal benefit?
5. How do regional and intercontinental transport affect local and regional air quality?
6. How do episodic events, such as wild fires, dust outbreaks, and volcanic eruptions, affect atmospheric composition and air quality?

The group concurred that the mission should be defined in terms of two sets of measurements: Baseline and threshold. GEO-CAPE *baseline* measurements will include O<sub>3</sub>, NO<sub>2</sub>, CO, SO<sub>2</sub>, HCHO, CH<sub>4</sub>, NH<sub>3</sub>, CHOCHO (4-km product at nadir); AOD, AAOD, AI, AOCH and a cloud-detection capability (4-km product at nadir). GEO-CAPE *threshold* measurements will include O<sub>3</sub>, NO<sub>2</sub>, CO, SO<sub>2</sub> (8-km product at nadir); and AOD (8-km product at nadir). In both baseline and threshold, CO and ozone are to be measured with two pieces of information in the troposphere, with sensitivity to the lowest 2 km.

There was an extensive discussion of whether the measurement requirements set forth in the STM should reflect the resolution of the final scientific product or the measurement pixel size of the instrument. Currently the STM contains a mixture of product resolution and pixel size requirements, and there is not yet a consensus on how best to communicate both the engineering and science requirements for each product in the STM without eliminating viable instrument options.

In their breakout session, the Ocean Color SWG reviewed the results of the Instrument Design Study for "CEDI" held in January 2010. The primary objective of that study was an instrument design that meets and exceeds the oceans threshold requirements. Secondary goals were to reduce the volume and mass of GEO-MDI (a predecessor concept), determine how frequently we can image US coastal waters and regions of special interest, and identify what technological innovations are most critical to meet threshold/goal requirements. Assuming a spatial resolution of 375m per pixel at nadir, major findings of the study were: baseline requirements can be met with 0.5m aperture; 7.5 m<sup>3</sup> volume, 621 kg, 392 W; pointing of ~0.5 arc-sec. At the March working meeting, the SWG discussed several areas for future consideration: 15 min scans are not ideal (<10 min would be better); pointing stability and image stabilization vs. spacecraft stabilization; need for a more capable processor (they do exist but haven't been certified); are S-class electronics necessary and available?; prism vs. grating design; is solar diffuser needed if lunar calibration is performed? Additional discussion topics included: cloud avoidance algorithms using near-real-time information as a means to preserve scan time, perhaps using other onboard sensors or GOES; and NO<sub>2</sub> and O<sub>3</sub> measurement requirements (O<sub>3</sub>: 0.5 -3% error when using climatology, and only 0.3% error with real-time data, can be coarse resolution; NO<sub>2</sub>: 3-5% error when using climatology, better to use real-time, 2 km should suffice, 4 km is too coarse due to cloud contamination. Can use any satellite to get ozone for the same day; GEO-CAPE will measure NO<sub>2</sub>.)

The March 25 Morning Plenary session included a presentation (R. Volkamer) on glyoxal and IO in the remote marine boundary layer that highlighted one example of common research problems of the the atmospheric composition and the ocean biology scientific communities. After a review of the first day's activities, the discussion evolved from gas variability to cloud avoidance, using a presentation by D. Edwards as a guide. Cloud fraction is important for aerosol retrieval; 1-2 km or finer is desired. Gas retrievals can tolerate some fraction (TBD) of cloud contamination to some extent, and both need to be quantitatively studied separately. It was also mentioned that the aerosol baseline requirements might be met with the fine spatial resolution instrument (i.e., CEDI). Capturing diurnal variation motivates GEO-CAPE, thus measurements are required every 1-2 hr. Clouds pose a potential limitation, as coarser spatial resolution leads to more chance of cloud contamination, reducing the temporal resolution.

The Sensitivity Sub-Team (J. Neu reporting) found three spectral band combinations that show promise for achieving sensitivity in the lower troposphere, and will be investigated further. There is a need to review the science drivers for separating the free troposphere from the lower troposphere, and to better define what capabilities are needed to meet the science objectives. For example, is sensitivity below 800 hPa sufficient, or do we need to get below 900 hPa?

Highlights of the Atmospheric Observing Strategy discussion (A. Eldering) included data rates (much higher than previous missions, but we think technology should be available to handle this); longitude (Atmospheric STM has 100°W, Decadal Survey said 80°W); emphasis on regular, repeated viewing patterns.

The Ocean breakout discussions were summarized by J. Campbell. The CEDI study found that 11 scan boxes are needed to cover coastal US; 3 more to cover Great Lakes and 5 for Caribbean. If each scan could be extended E-W to cover more per box, then 5 boxes could cover coastal US, saving some scan time.

Additional points which were addressed in this session included: the fact that the CEDI instrument has capability to measure key aerosol parameters; co-measurements of O<sub>3</sub> and NO<sub>2</sub> are needed to avoid large

errors in water-leaving radiance over the oceans; and a reminder not to lose sight of the multidisciplinary potential of combined instruments – interdisciplinary vs. multidisciplinary.

The March 25 Afternoon Plenary opened with a presentation on cloud avoidance algorithm development (D. Mandl), describing work in progress for HypIRI. The possibility of the high spatial resolution (ocean color) instrument being used for aerosol measurements over land was briefly discussed.

**The draft Geo-CAPE Atmospheric and Ocean Color Science Traceability Matrices (STMs) were endorsed by voice consensus as a sufficient, although not immutable, starting point for preliminary mission planning work.**

In the Afternoon Atmosphere Breakout session, J. Fishman volunteered to lead the formulation of a white paper and a journal article on GEO-CAPE atmospheres. One other highlight from this session was the reminder that the focus of GEO-CAPE is temporal sampling, indicating that if we can measure what is currently measured from LEO, and do it multiple times daily, we will advance the state of science with this mission.

In the Afternoon Ocean Color Breakout session, the question was raised of how far offshore the atmospheric community is planning to observe. This is related to the interest in interdisciplinary science that would be possible from a combination of ocean color and trace gas measurements. Image stability (jitter) was again acknowledged as a big issue. It was suggested that this task be given to JPL and GSFC engineers to make recommendations based on their experience with existing spacecraft. Contacting Korea as a source of information on jitter was suggested. Another topic for near-term attention is a review of the current design for 2 km-resolution measurements for NO<sub>2</sub> (and potentially glyoxal) retrieval. On the subject of cloud avoidance, it was suggested that the technology is there; we just need to decide how we want to go about it. An outline for a white paper will be developed in the next 4-6 weeks, full paper development in the next 3-6 months.

Friday, March 26 (Plenary) morning began with a presentation on mission preformulation and formulation activities, as well as possible implementation pathways (M. DiJoseph). This was followed by an interactive discussion (R. Key) of a strawman schedule for a 2020 launch. The majority of subsequent discussion time was spent identifying trade studies and other near-term needs for both the atmospheric and ocean SWGs.

The studies, activities, reviews, and other milestones for a standard spacecraft mission were presented in the context of a presumed 2020 launch of a complete Baseline Geo-CAPE mission. There was much discussion regarding the level of specificity for atmospheric sensors that was appropriate and how the solicitation and award process would proceed. After much discussion, there was agreement to pursue the following three goals.

- GOAL #1 : Accelerated Threshold (minimum science) mission study
  - instrument brush-up of UV-vis
  - instrument brush-up of NIR Gas Correlation Filter Radiometer (GCFR)
  - gather information about hosted payload options (one host to carry all, and also host each instrument on different platform)
  - mission studies (hosted and dedicated; would probably not have detailed implementation plan, but should know technical interface info)
- GOAL #2: First Baseline (complete) mission study
  - evaluate TIR only FTS (instrument study)
  - instrument brush-up NIR Tropospheric Infrared Mapping Spectrometer (TIMS)
  - baseline mission with 3 atmospheric instruments (all spectral regions) + ocean color imager
- GOAL #3: Second Baseline mission study

instrument study of PanFTS to meet all atmospheric needs  
baseline mission study with PanFTS + ocean color imager

Because the incremental steps needed for Goal #1 also contribute to later Goals, the above list should be implemented in the order as presented, if possible. Rough estimates suggest that the available ~\$300 k might allow 2 brush-ups and the accelerated mission studies (both hosted & dedicated) in FY10. The group also identified other high-priority supporting studies that are summarized below.

Ocean FY10 priorities for future Engineering Studies: 1) Pointing stability, 2) Spectral sampling for coastal ocean sensor, 3) Calibration / flat fielding, 4) Alternatives: other spectrometer designs; reorient optics to reduce mass (remove strongback) for CEDI, 5) Solar diffuser

Atmospheric Priority Topics: 1) Document scientific basis for the current requirements for product and pixel resolution, 2) Transition our small sensitivity studies into something that combines regional and global models, 3) Annotate the STM, 4) Publish variability and sensitivity studies, 5) Explore engineering possibilities for higher spatial resolution after #1 is done, 6) Explore possibility of doing aerosol science from high-resolution events imager.