CEOS Systems Engineering Office (SEO)

NASA LaRC was asked to lead the systems engineering effort in early 2007. The SEO was established in April 2007 to support the CEOS SIT, CEOS Constellation Teams and CEOS Working Groups.

**SEO Charter**
- systems engineering framework
- requirements definition
- mission assessment and studies
- constellation architecture planning
- foster communication within CEOS

**CEOS Constellations**
Support four constellation created in 2006 to bring about technical and scientific cooperation and collaboration among space agencies.
Completed a 14-minute narrated video for CEOS in November 2007. The video illustrates how current and future international satellite constellations can collectively observe the land, oceans, precipitation, and atmosphere of the Earth, for the benefit of society. It presents results from remote sensing of volcanic eruptions, tropical deforestation, biomass burning, smoke dispersion, greenhouse gases, floods, hurricanes, and rising sea levels. DVD’s were distributed at the CEOS Plenary and GEO (Group on Earth Observation) Plenary meetings.
A systematic approach to space-based implementation of GEOSS for societal benefit
Atmospheric Composition Constellation

SBA Impact Assessment and Mission Architecture Assessment

System Requirements Document using the SEO framework

Fire/Smoke Aerosol Project led by Jack Fishman (NASA LaRC) utilizing CALIPSO data
• Assess the ECV parameters and identify missing parameters or inconsistencies between GEOSS, GCOS and CEOS documentation.
  - Example: ECV’s relate to 33 of the 36 (92%) GEOSS 10-yr Plan Climate SBA Observational Requirements.
  - Example: Missing “Terrestrial Reanalysis”

• Using the “systems framework” determine relevant informational products and science models.

• Perform assessments and gap analyses of measurements and missions for each ECV.

• Engage CEOS Working Groups, GEO Climate SBA lead, GCOS in developing requirements and reviewing assessments.
**Essential Climate Variables (ECV)**

- **28 total ECVs** - space-based measurable atmospheric, ocean and terrestrial parameters including TWO “Reanalysis” ECV’s (A.8 and O.6) for Oceans and Atmosphere.

<table>
<thead>
<tr>
<th>A. Atmosphere</th>
<th>O. Oceans</th>
<th>T. Terrestrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.1 Surface Wind Speed and Direction</td>
<td>O.1 Sea Ice</td>
<td>T.1 Lakes</td>
</tr>
<tr>
<td>A.2 Upper-air Temperature</td>
<td>O.2 Sea Level</td>
<td>T.2 Glaciers and Ice Caps, and Ice Sheets</td>
</tr>
<tr>
<td>A.3 Water Vapor</td>
<td>O.3 Sea Surface Temperature</td>
<td>T.3 Snow Cover</td>
</tr>
<tr>
<td>A.4 Cloud properties</td>
<td>O.4 Ocean Color</td>
<td>T.4 Albedo</td>
</tr>
<tr>
<td>A.5 Precipitation</td>
<td>O.5 Sea State</td>
<td>T.5 Land Cover</td>
</tr>
<tr>
<td>A.6 Earth Radiation Budget</td>
<td>O.6 Ocean Reanalysis (Multiple ECVs)</td>
<td>T.6 fAPAR (Fraction of Absorbed Photosynthetically Active Radiation)</td>
</tr>
<tr>
<td>A.7 Ozone</td>
<td>O.7 Ocean Salinity</td>
<td>T.7 LAI (Leaf Area Index)</td>
</tr>
<tr>
<td>A.8 Atmospheric Reanalysis (multiple ECVs)</td>
<td></td>
<td>T.8 Biomass</td>
</tr>
<tr>
<td>A.9 Aerosols</td>
<td></td>
<td>T.9 Fire Disturbance</td>
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<tr>
<td>A.10 CO\textsubscript{2}, CH\textsubscript{4} and other Greenhouse Gases</td>
<td></td>
<td>T.10 Soil moisture</td>
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<tr>
<td>A.11 Upper-air Wind</td>
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</tbody>
</table>
Example Requirements: Climate (Ocean Domain)

### Decision Makers
- Policies for coastal population growth
- Disaster plans for hurricane flooding
- Water usage restrictions
- Initiatives impacting global warming

### Information products & services
- Forecasts (mean sea level, storm surge level)
- Warnings (hurricane, flood, drought)
- Maps (hurricane storm surge, stream flow, water storage)

### Knowledge & Models
- Sea Level Rise Models
- Climate Models (Global Warming, El Nino and La Nina)
- Hurricane, Flood, Drought Models
- Stream Flow and Water Storage Models

### Measurements
- **Sea Level** (Sea Surface Height – SSH)
- **Sea Surface Temperature** (SST)
- **Sea State** (surface winds, wave information)

### Instruments and Missions
- **Instruments**
  - Radar Altimeter (Sea Level)
  - Synthetic Aperture Radar (Sea State)
  - Wind Scatterometer (Sea State)
  - Imager (Sea Surface Temperature)

- **Missions**
  - TOPEX/Poseidon, Jason 1,2,3 (high precision)
  - ERS-2, ENVISAT (in orbit, complementary)
  - Cryosat-2, HY-2A, SARAL, Sentinel-3A, SWOT (future)
Significance of Top Down Requirements

- Established traceability from instruments to products and services would allow for benefit evaluation of instruments and measurements
  - Would provide CEOS organizations a tool that could define gaps and overlaps in instruments and measurements
  - With weightings at each level, this tool would provide decision makers with a way to evaluate the societal benefit of their investments

- Traceable Climate requirements would provide a better understanding of global climate models
  - Would allow a broader community the insight to global climate models, their inputs and data outputs
  - With this knowledge, contributions to these models could come from unlikely sources
GISS Inputs to the CEOS SEO Climate Analysis

**Users Table Required Fields**
- User name
- Information Products required
- Other information required

**Products Table Required Fields**
- Product name
- Model Output required
- Other information required

**Models Table Required Fields**
- Model name
- Input measurements required
- Measurement accuracy required
- Measurement coverage required
- Model Outputs

**Measurements Table Required Fields**
- Measurement
- Horizontal resolution
- Vertical Resolution
- Accuracy

**Missions & Instruments Table Required Fields**
- Mission
- Instrument
- Measurements
  - Horizontal resolution
  - Vertical Resolution
  - Accuracy
  - Frequency

Who uses your model output data to develop products?

Can we get all the specifics of your GCM model?
What are the inputs? Where do they come from?
What inputs are lacking or could be improved?
Brian Killough, SEO Director – NASA LaRC
Phone: 757-864-7047  Email: Brian.D.Killough@nasa.gov

Shelley Stover, SEO Systems Engineer – NASA LaRC / SSAI
Phone: 757-593-4962  Email: Shelley.K.Stover@nasa.gov