Recommendations on future science and engineering studies for Ocean Color

Antonio Mannino

NASA GSFC
<table>
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<tr>
<th>Priority</th>
<th>Notes</th>
<th>Suggested GEO-CAPE Ocean Tasks</th>
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<tr>
<td>High</td>
<td>Plan for Korean Field Campaign</td>
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</table>
| High     | Apply existing/new observations of high temporal, high spatial or high spectral resolution data sets that have a rich set of associated obs.  
1. **Short-term dynamics** of physical, biogeochemical and bio-optical processes. Definition of spatial scales of features for GEO-CAPE time-space domain.  
2. **Algorithm development** for coastal ocean products including non-standard products that are mission critical/highly desirable. e.g. diurnal PAR and NPP  
3. **Interdisciplinary** atmosphere/ocean studies  
4. Exchange across land-sea interface  
5. Linkages with DISCOVER AQ, GOCI cruises, etc.  
6. Define the BRDF of coastal particles with varying solar angles  
7. Exchange processes between coastal and offshore waters, through mixing, advection, transport and diffusion along fronts and plumes. |
| High     | **Retrieval and viewing enhancements for GEO-CAPE OC science**  
1. Development of atmospheric correction methodology/code, LUTs, etc. for geo  
a. to account for combination of geo sensor viewing angles & variability in diurnal & seasonal solar geometry (solar zenith angle and earth’s orbit),  
b. for retrieval of ocean Rrs in the UV as well as VIS-NIR.  
2. BRDF – studies leading to BRDF correction of Rrs at relevant solar angles  
3. Refinement of sea-state and surface reflectance models for use at varying solar zenith angles and geostationary view angles. |
## FY15 Ocean Science Priorities

<table>
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<tbody>
<tr>
<td>High</td>
<td>focus on imaging time.</td>
<td><strong>High spatial resolution analysis of cloud cover (sub-km)</strong> to aid in the intelligent scheduling of imaging to maximize data and science content.</td>
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</tbody>
</table>
| High     | Changed from medium high to high. Note the addition of #4, deemed highly relevant by the SWG | **GOCI, high latitude polar orbiters** (SeaWiFS, MODIS, MERIS, VIIRS; including same-day orbital overlap), SEVIRI, and HICO data analysis as well as simulated GEO-CAPE data  
1. Short-term dynamics  
2. Analysis of spatial resolution requirements  
3. Algorithm development for coastal ocean products  
4. Investigate temporal variability at the northern limits of the GEO-CAPE domain using PO satellite data |
| High/Med | 2 day data synthesis meeting | |
| Low      | FY 16 likely be a high priority for field campaign | **Atmospheric Property Requirements for Atmospheric Corrections:**  
Aerosol, NO2, O3, water vapor detection and retrieval requirements. What spatial and temporal resolution is needed for NO2 and ozone? How can we detect and correct for absorbing aerosols? |
| Low      | Revisit this topic after results FY12-14 are completed. | **Impacts of remote sensing reflectance (Rrs) errors on inherent optical properties (IOP) retrievals:** How much reflectance error can we tolerate to discern diurnal changes in IOPs? |
FY16 Ocean Science Priorities

- **KORUS-OC Field Campaign**
  - See white paper for science objectives and priorities

- **Other studies if funding permits**
  - Compute expected SNR for high solar zenith angles and sensor view angles conditions.
    - Determine adequacy of this SNR for detection of diurnal variability beyond a certain level (5%)?

FY17 and beyond

- **Science studies per prioritization in previous slides**
- **GEO-CAPE “suborbital simulated datasets” - such as Aerostate or Airplane observations** (hyperspectral, diurnal, appropriate GSD)
FY16 Ocean Color Engineering Priorities

- **Complete filter wheel breadboard assembly and functional testing**
  - Note - funding to complete this approved in FY15

- **Cost estimation of GEO-CAPE coastal ecosystem mission**
  - host fees for GEO-CAPE OC sensor (FR and spectrometer)
  - project mngmt, SE, SMA, ground sys., & mission ops for hosted payload

- **Continuation of scheduling study**
  - Compute annual cycle of scene coverage statistics from automatic scheduler of FR and spectrometer to account for RSIs (and open ocean) and real cloud cover distribution for multiple cloud thresholds.
  - Optimize spectrometer iFOV “strips”observations (minimize scan time) to observe 100km inland to 400km offshore.
  - Develop demo data for end-users

- **Mature low TRL/highest risk technologies**
  - Build and test focal plane assembly (detector, filters and enclosure) that is sensor agnostic to reduce GEO-CAPE mission risk and to promote EVI/M success.
Post-FY16 Ocean Color Engineering Priorities

- **Mature high risk technologies**
  - Explore enhanced spatial resolution approaches through spatial sub-sampling and overlapping iFOVs
  - Roll camera landmark feedback software development
  - INR/Geolocation solutions: landmarks from OC sensor and/or roll camera, star camera readings, beacons on the ground
  - Fast steering mirror or scan mirror used for jitter correction

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O O O X X X
O O O X X X
B B B Y Y Y
B B B Y Y Y
B B B Y Y Y
B B B Y Y Y
C C C Z Z Z
C C C Z Z Z
C C C Z Z Z
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- GSD = 375 x 375 m
- Spatial sub-sample = 125 x 125m
FY16 Oceans SWG Activities

- Complete STM white paper / NASA Tech Memo in 2015
- Prepare EOS article (publication by summer 2016)
- White paper to DS on coastal ecosystem dynamics (diurnal)
- Translate applications info. into Applications Traceability Matrix
- Develop applications fact sheets
- Bring in other disciplines
  - Atmospheric engaged
  - Terrestrial (Schaaf joined; ask Fred Huemmrich?)
  - Phys ocean. (J. Wilkin ?)
- Expand product suite
  - Phys. Oce. (surface vector currents)
  - Continuous aerosol AOD across land-ocean
  - Fused daily land albedo; diurnal vegetation stress; LAI; wildfires
- Expand SWIR band set
  - 2.13 um (currently baseline) - continuous land-ocean aerosol properties
  - 1.38 um for cirrus cloud detection
FY16 Oceans SWG Activities

- Continue outreach to scientific communities
  - Tout diurnal measurements from space to advertise (not “GEO-CAPE”)
  - CERF 2015; Ocean Sciences 2016; Ocean Optics 2016, Fall AGU 2016
- Outreach to coastal managers and end-users
- Go to PR folks to help us hone a message
- Develop theme to sell mission
  - Coastal Health & Hazards or Coastal Health & Services
  - CHI - coastal health index is a function of (e.g.):
    - Water quality,
    - Presence/level HABs,
    - biodiversity,
    - habitat loss,
Example of ecological index

The Ocean Health Index measured **Ecological Integrity** as the relative condition of assessed species in a given location. This was calculated as the weighted sum of the International Union for Conservation of Nature’s (IUCN) assessments of species. Weights used were based on the level of extinction risk following Butchart et al. 2007: EX (extinct) = 0.0, CR (critically endangered) = 0.2, EN (endangered) = 0.5, VU (vulnerable) = 0.7, NT (not threatened) = 0.9, and LC (least concern) = 0.99. For primarily coastal goals, the spatial average of these per-pixel scores was based on a 3nmi buffer; for goals derived from all ocean waters, the spatial average was computed for the entire EEZ.

**Ecological Integrity** refers to the ability of an ecosystem to support and maintain ecological processes and a diverse community of organisms; is a Resilience measure used in calculating scores for five of the Goals. The Goals that it influences are Food Provision (Fishing), Artisanal Fishing Opportunity, Natural Products, Sense of Place (Iconic Species), and Biodiversity (all subgoals except Species).

http://www.oceanhealthindex.org/Components/Ecological_Integrity/

FY16 GEO-CAPE Ocean SWG Activities

Food Provision

Clean Waters

http://www.oceanhealthindex.org/
Table S.3: Estuarine health index results, based on raw values. Note that the four components of the water quality index are separated in this representation.

### Coastal Bays Ecosystem Health Index

![Coastal Bays Ecosystem Health Index Diagram](image)

<table>
<thead>
<tr>
<th></th>
<th>Sinepuxent Bay</th>
<th>Chincoteague Bay</th>
<th>Assawoman Bay</th>
<th>Isle of Wight Bay</th>
<th>Newport Bay</th>
<th>St. Martin River</th>
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</thead>
<tbody>
<tr>
<td><strong>Water quality</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Water quality index</td>
<td>0.85</td>
<td>0.74</td>
<td>0.33</td>
<td>0.53</td>
<td>0.35</td>
<td>0.33</td>
</tr>
<tr>
<td>Chlorophyll a (µg L⁻¹)</td>
<td>5</td>
<td>5</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>Total nitrogen (mg L⁻¹)</td>
<td>0.35</td>
<td>0.54</td>
<td>1.19</td>
<td>0.84</td>
<td>2.08</td>
<td>1.93</td>
</tr>
<tr>
<td>Total phosphorus (mg L⁻¹)</td>
<td>0.04</td>
<td>0.04</td>
<td>0.05</td>
<td>0.05</td>
<td>0.07</td>
<td>0.09</td>
</tr>
<tr>
<td>Dissolved oxygen (mg L⁻¹)</td>
<td>6.1</td>
<td>6.1</td>
<td>6.1</td>
<td>6.0</td>
<td>6.0</td>
<td>5.5</td>
</tr>
<tr>
<td>Brown tide (max. cells µL⁻¹)</td>
<td>35-200</td>
<td>&gt;200</td>
<td>35-200</td>
<td>35-200</td>
<td>&gt;200</td>
<td>35-200</td>
</tr>
<tr>
<td>Macroalgal biomass (max. g m⁻²)</td>
<td>50</td>
<td>320</td>
<td>100</td>
<td>250</td>
<td>10</td>
<td>390</td>
</tr>
<tr>
<td><strong>Living resources</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benthic index⁵</td>
<td>3.5</td>
<td>3.6</td>
<td>3.4</td>
<td>3.1</td>
<td>3.4</td>
<td>2.2</td>
</tr>
<tr>
<td>Hard clam density (clams m⁻²)</td>
<td>0.32</td>
<td>0.27</td>
<td>0.16</td>
<td>0.28</td>
<td>0.14</td>
<td>0.04</td>
</tr>
<tr>
<td>Sediment toxicity</td>
<td>10</td>
<td>8</td>
<td>12</td>
<td>11</td>
<td>13</td>
<td>19</td>
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<tr>
<td><strong>Habitat</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Seagrass area (% of bay)⁸</td>
<td>36</td>
<td>32</td>
<td>8</td>
<td>5</td>
<td>4</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Wetland area (% of watershed)⁹</td>
<td>61</td>
<td>45</td>
<td>45</td>
<td>16</td>
<td>23</td>
<td>16</td>
</tr>
<tr>
<td>Natural shoreline (% of total)¹⁰</td>
<td>81</td>
<td>98</td>
<td>72</td>
<td>35</td>
<td>96</td>
<td>52</td>
</tr>
</tbody>
</table>

Data rate costs

- 2011 Hosted Payload RFI:
  - $1.8M/yr on average for full 36MHz transponder (30 Mbps)
- IDL sensor data rates 10 to 36 Mbps (375m FR and 250m COEDI).
Filter Wheel Breadboard Mechanism

- 50 filters into 10 wheels with 5 filters each. Each wheel has an open spot
- Each wheel is independently actuated but their positions are coordinated via computer
- Design should be modular, expandable and use commercial solutions if practical
- Not considered a high precision optical mechanism however the transition speed is fast
- Filter replicas made of glass are preferred
- Prototype “proof of concept” model is intended to operate in a shirt sleeve environment at STP conditions
- Index: 60° in 0.2 seconds, still for 2.0 seconds
- Life: 3 years operating 17 hours/24 hours

Filter: 82 mm x 6 mm; 72 g; 94 mm radius
Wheel: 290 mm x 10 mm; 0.82 kg

Courtesy of Walt Smith
Strawman 18 Coastal/Lakes Survey Scenes Using FR

~45min to scan CONUS coastal waters

Source: GSFC analysis via GUI Editor, assuming spherical Earth – Satellite at 95W
COEDI - 375m GSD, 500km coverage

# Scenes: 43
Min. GSD: 399 m
Max GSD: 687 m

Courtesy of Jeremy Frank et al.