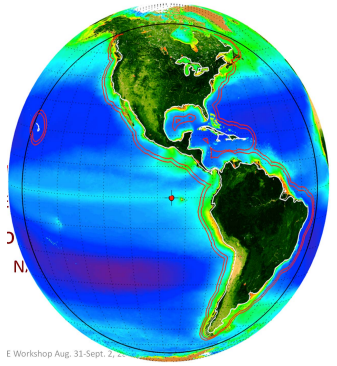
Recommendations on future science and engineering studies for Ocean Color

Antonio Mannino

NASA GSFC



FY15 Ocean Science Priorities

Priority	Notes	Suggested GEO-CAPE Ocean Tasks
High		Plan for Korean Field Campaign
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

Priority	Notes	Suggested GEO-CAPE Ocean Tasks
High	focus on imaging time.	**High spatial resolution analysis of cloud cover (sub-km)** to aid in the intelligent scheduling of imaging to maximize data and science content.
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

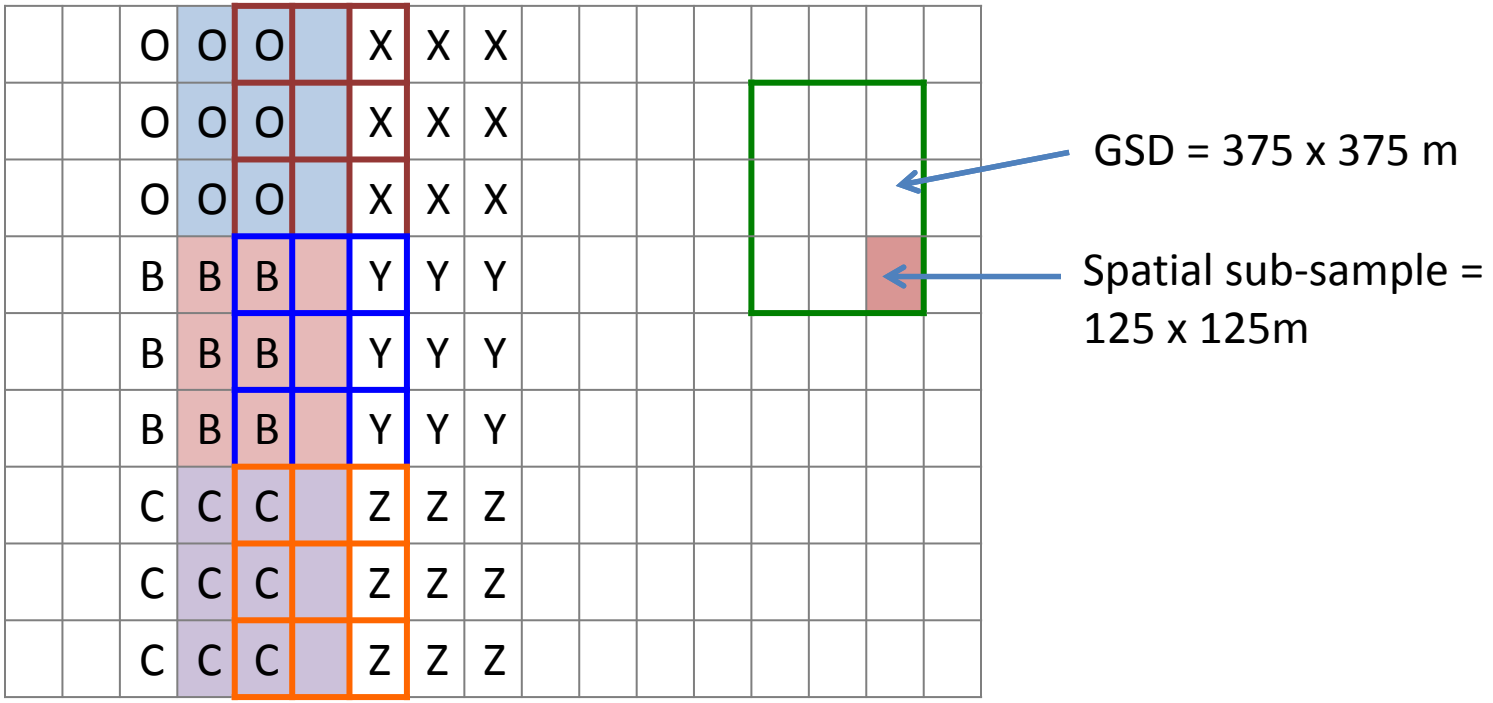
- **Science studies per prioritization in previous slides**
- **GEO-CAPE "suborbital simulated datasets" - such as Aerostate or Airplane observations (hyperspectral, diurnal, appropriate GSD)**

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

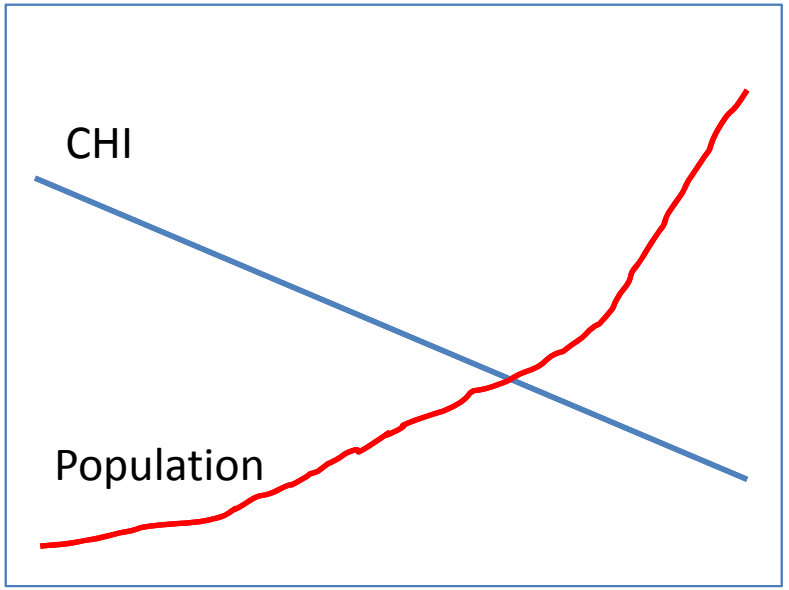


FY16 Oceans SWG Activities

- 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,



Ocean Health Index

- 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.

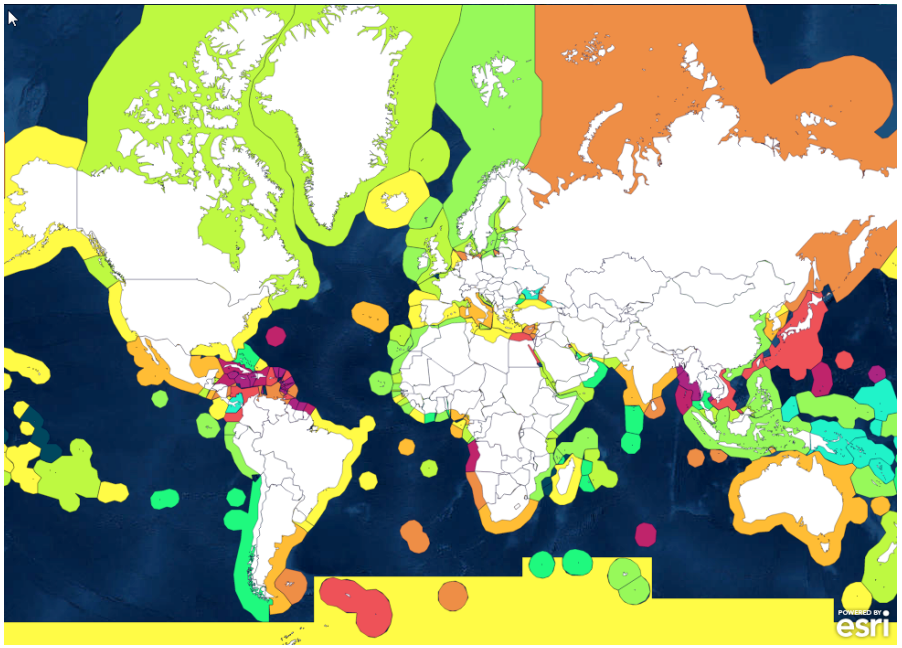
Ecological Integrity refers to the ability of an ecosystem to support and maintain ecological processes and a diverse community of organisms; is a Resilience measure used in calculating scores for five of the Goals. The Goals that it influences are Food Provision (Fishing), Artisanal Fishing Opportunity,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

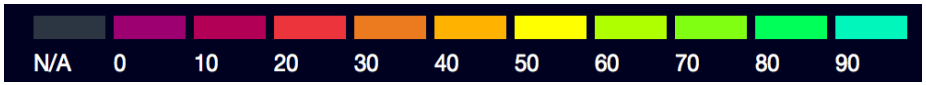
http://www.oceanhealthindex.org/Components/Ecological_Integrity/

Andreasen, J. 2001. Considerations for the development of a terrestrial index of ecological integrity. Ecological Indicators 1, 21–35.

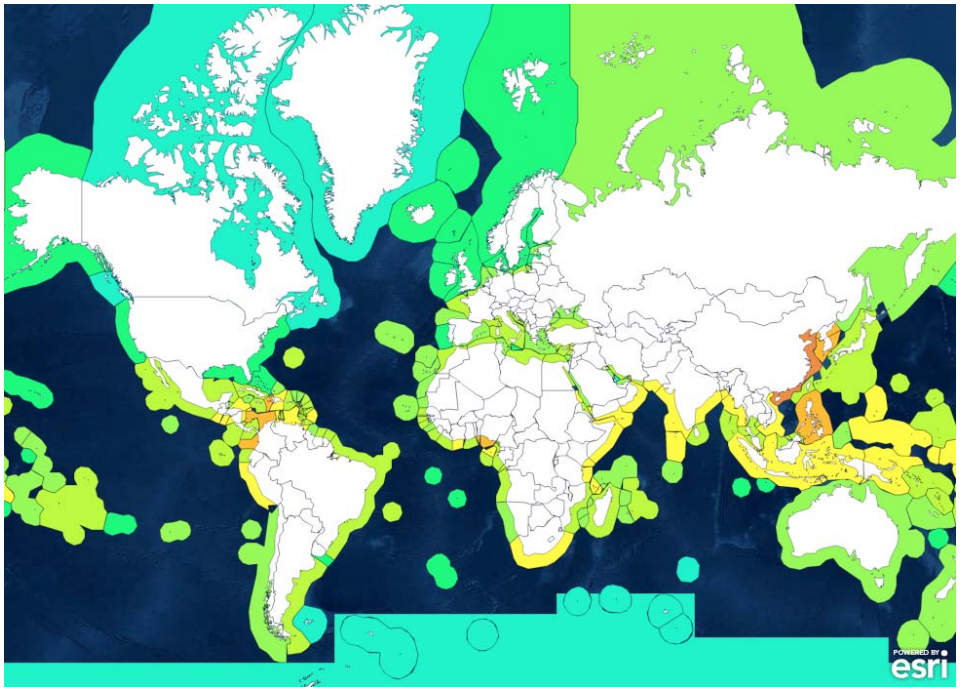
FY16 GEO-CAPE Ocean SWG Activities

Food Provision





Clean Waters



http://www.oceanhealthindex.org/

Coastal Bays Ecosystem Health Index

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.

GOOD ESTUARINE HEALTH → POOR ESTUARINE HEALTH

	Sinepuxent Bay	Chincoteague Bay	Assawoman Bay	Isle of Wight Bay	Newport Bay	St. Martin River
Water quality						
Water quality index[1]	0.85	0.74	0.33	0.53	0.35	0.33
Chlorophyll *a* (µg L^{-1})[2]	5	5	15	11	15	16
Total nitrogen (mg L^{-1})[2]	0.35	0.54	1.19	0.84	2.08	1.93
Total phosphorus (mg L^{-1})[2]	0.04	0.04	0.05	0.05	0.07	0.09
Dissolved oxygen (mg L^{-1})[2]	6.1	6.1	6.1	5.6	6.0	5.5
Brown tide (max. cells µL^{-1})[3]	35-200	>200	35-200	35-200	>200	35-200
Macroalgal biomass (max. g m^{-2})[4]	50	320	100	250	10	390
Living resources						
Benthic index[5]	3.5	3.6	3.4	3.1	3.4	2.2
Hard clam density (clams m^{-2})[6]	0.32	0.27	0.16	0.28	0.14	0.04
Sediment toxicity[7]	10	8	12	11	13	19
Habitat						
Seagrass area (% of bay)[8]	36	32	8	5	4	<1
Wetland area (% of watershed)[9]	61	45	45	16	23	16
Natural shoreline (% of total)[10]	81	98	72	35	96	52

1. Ranges from 0 (no reference criteria met) to 1 (all criteria met). Calculated from chlorophyll *a*, total nitrogen & phosphorus and dissolved oxygen (see page 16). **2.** Medians of monthly measurements from 2001 through 2003, from 57 sites (see page 16). **3.** Maximum values, monitored since 1999 at 15 sites (see page 26). **4.** Survey of 388 sites throughout the Coastal Bays in 2001 and 2003 (see page 23). **5.** Combines a range of benthic fauna measurements from 54 sites between 2000 and 2001. Range is from 1 (poor) to 5 (good) (see page 32). **6.** Averages from 1994-2000 from a total of 1499 sites (see page 33). **7.** Apparent Effect Threshold-combines critical levels of a range of toxicants, measured between 1991-1996 from > 900 sites (see page 36). **8.** 2002 aerial photographic survey (see page 21). **9.** Survey carried out in 1988 and 1989 (see page 28).**10.** Aerial photographic survey carried out in 1989 (see page 27).

Maryland DNR

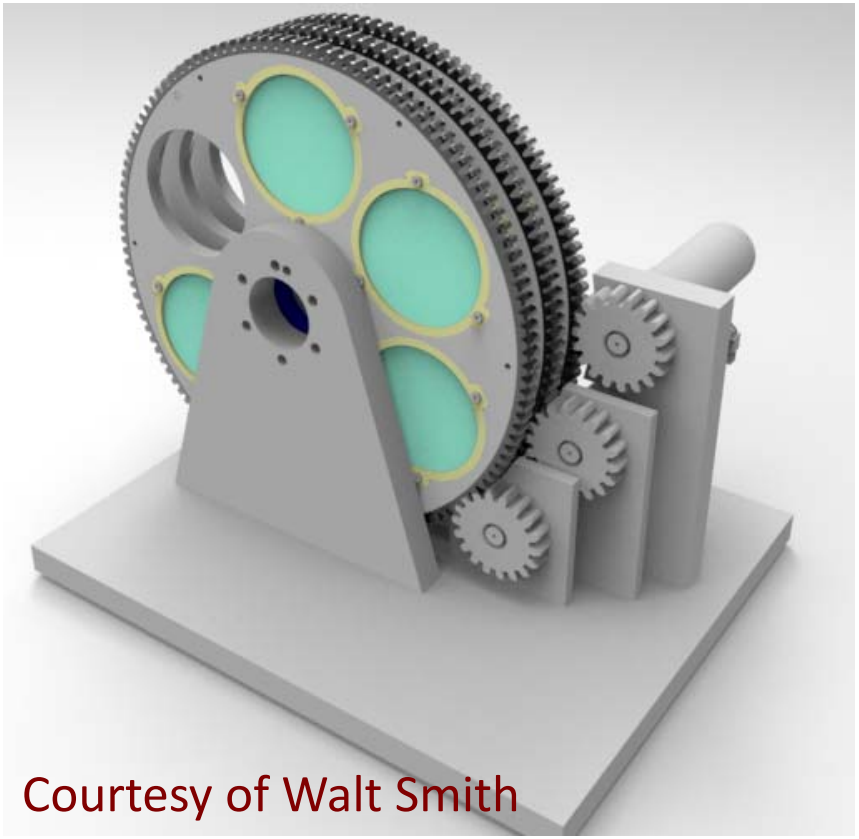
Carruthers, Dennison, Wazniack and Hall. Coastal Bays Ecosystem Health Index: Bringing it all together.

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

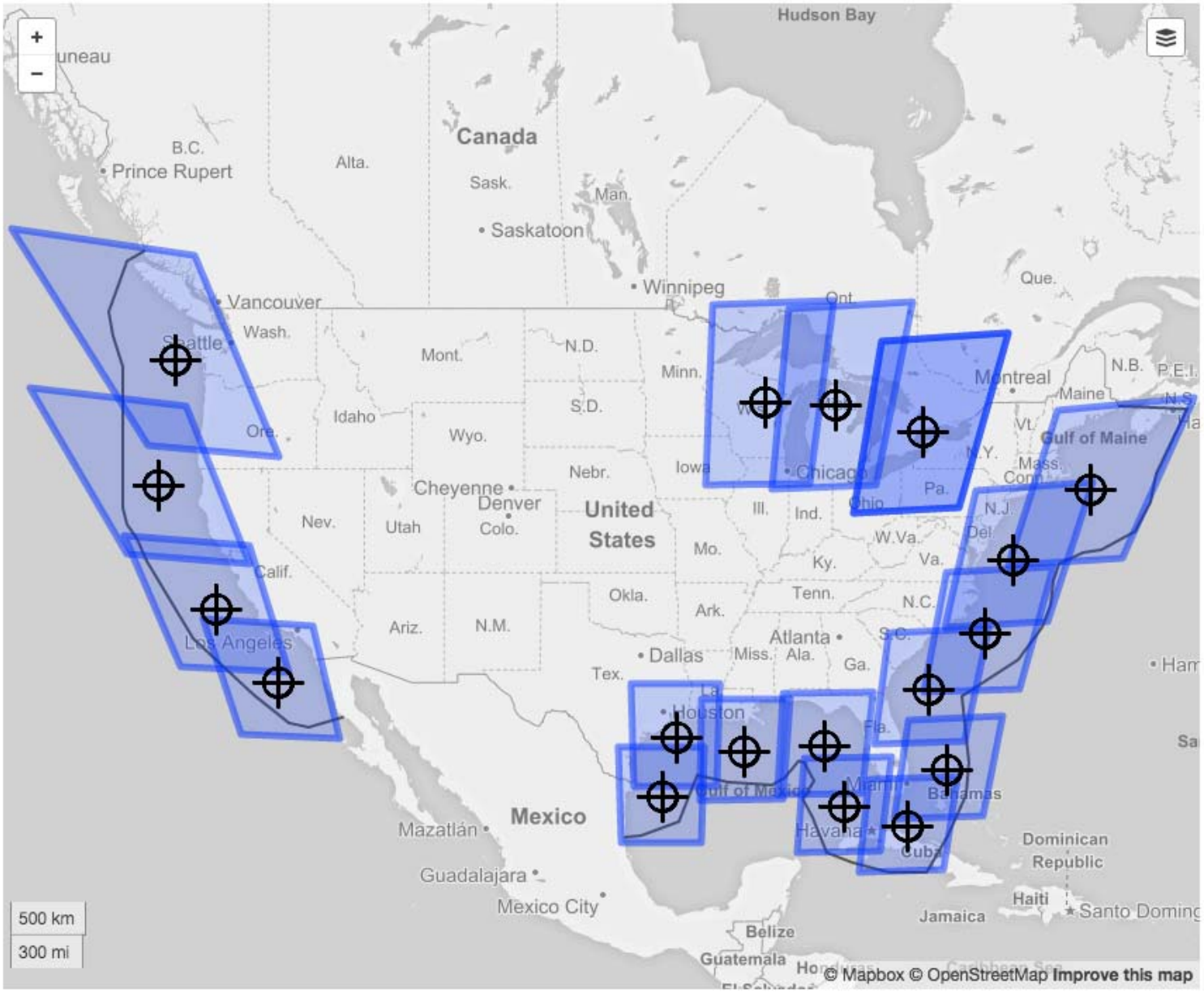
- 50 filters into 10 wheels with 5 filters each. Each wheel has an open spot
- Each wheel is independently actuated but their positions are coordinated via computer
- Design should be modular, expandable and use commercial solutions if practical
- Not considered a high precision optical mechanism however 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



Courtesy of Walt Smith

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

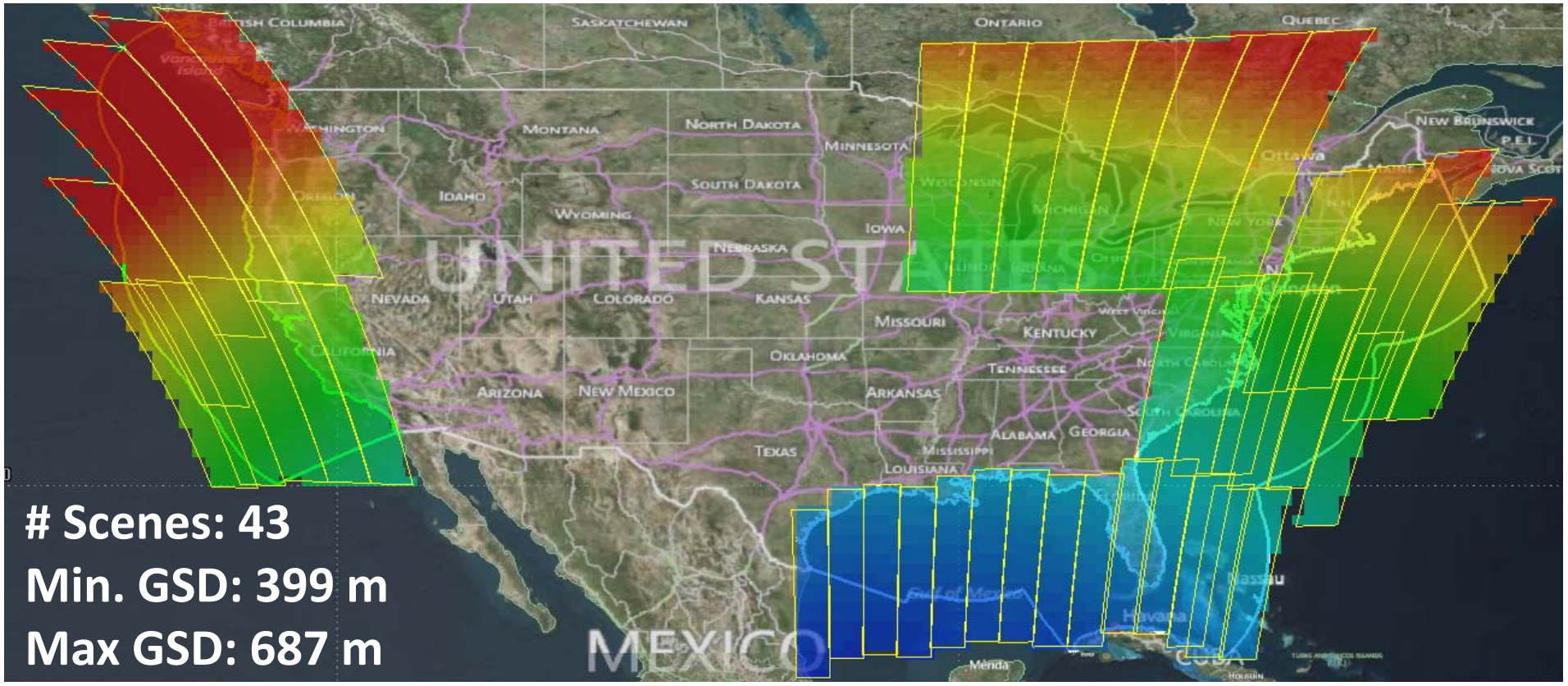
Strawman 18 Coastal/Lakes Survey Scenes Using FR

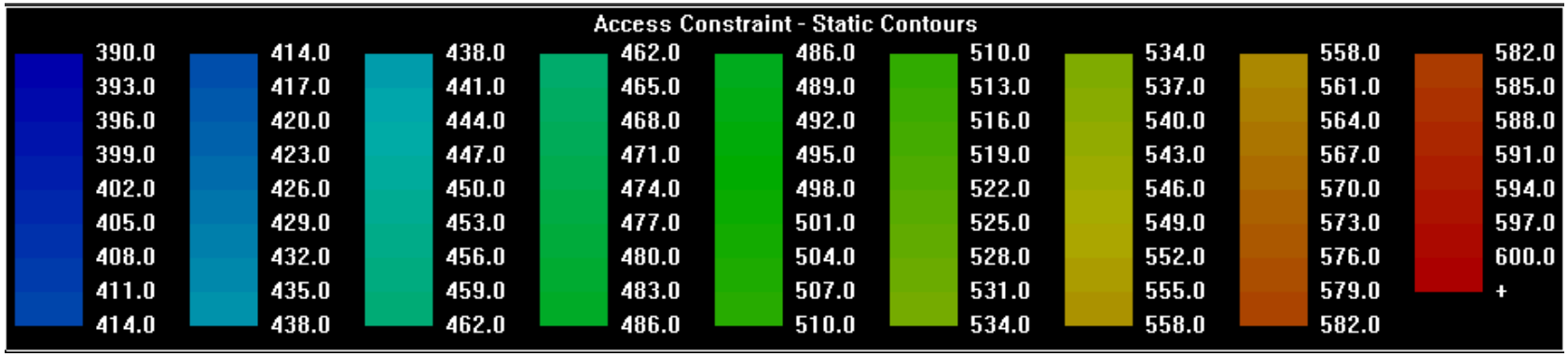


~45min to scan CONUS coastal waters

Source: GSFC analysis via GUI Editor, assuming spherical Earth – Satellite at 95W

COEDI - 375m GSD, 500km coverage





Courtesy of Jeremy Frank et al.