Community Input on Coastal and Inland Water HyspIRI Data Products

K.Turpie, UMBC
on behalf of the HyspIRI Aquatic Studies Group (HASG)

HyspIRI Science Workshop
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HyspIRI ASG Current Roster

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Bachmann, Charles*	Naval Research Laboratory
Bell, Thomas*	University of California at Santa Barbara
Bissett, Paul	Florida Environmental Research Institute
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Member	Affiliation
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Moisan, Tiffany*	NASA Wallops
Moses, Wesley*	Navy Research Laboratory
Muller-Karger, Frank	University of South Florida
Palacios, Sherry	NASA Ames Research Center
Park, Youngje	Korea Ocean Satellite Center (KOSC)
Perovich, Donald*	Army Corp of Engineers
Philpot, Bill*	Cornell University
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Torres Perez, Juan	Oak Ridge Associated Universities (ORAU), NASA Ames
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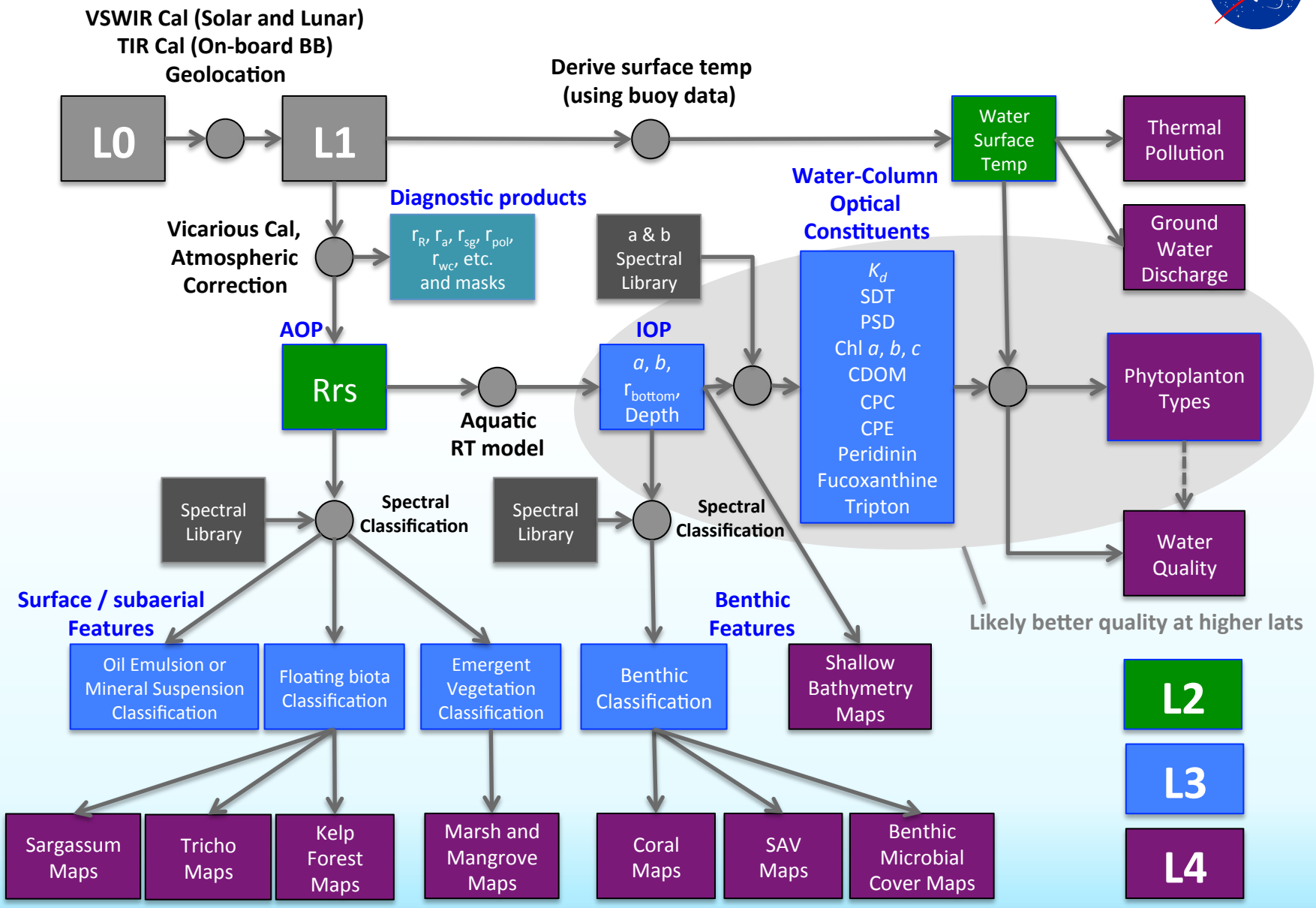
* - HASG White Paper Authors

☆ - Chair

- Initial committee was established Aug 2012 by invitation.
- Group tripled by Oct 2012 after the Science Workshop.
- If you are interested in participating in the HASG, please contact Kevin Turpie

Charter: to identify and develop potential aquatic data products or applications for coastal and inland waters for the HyspIRI mission.

Aquatic Product Hierarchy



Potential Coastal and Inland Aquatic Products for the Hyperspectral Infrared Imager (HyspIRI)

1. Introduction

2.1 Wetland Classification and Mapping	Klemas
2.2 Land/Water/Ice Geomorphology	Jo
2.3 Water Surface Features Classification	Hu
2.4 Water-Column Retrievals	Devred
2.5 Bathymetry	Lee
2.6 Benthic Cover Classification and Mapping	Hochberg

3. Discussion

4. Conclusions and Recommendations

HyspIRI Characteristics

Spatial Resolution

- 60 m resolution can observe better to observe estuaries, lakes, and littoral regions than traditional 750-1000m resolution ocean color (OC) instruments.
- Spatially resolves fine-scaled dynamics on water surface, bulk features of wetlands and reefs.
- Provides opportunity to understand intra-pixel variability for OC instruments.
- 60 m reverts to 1000 m for depths > 50 m – could exclude important waters.

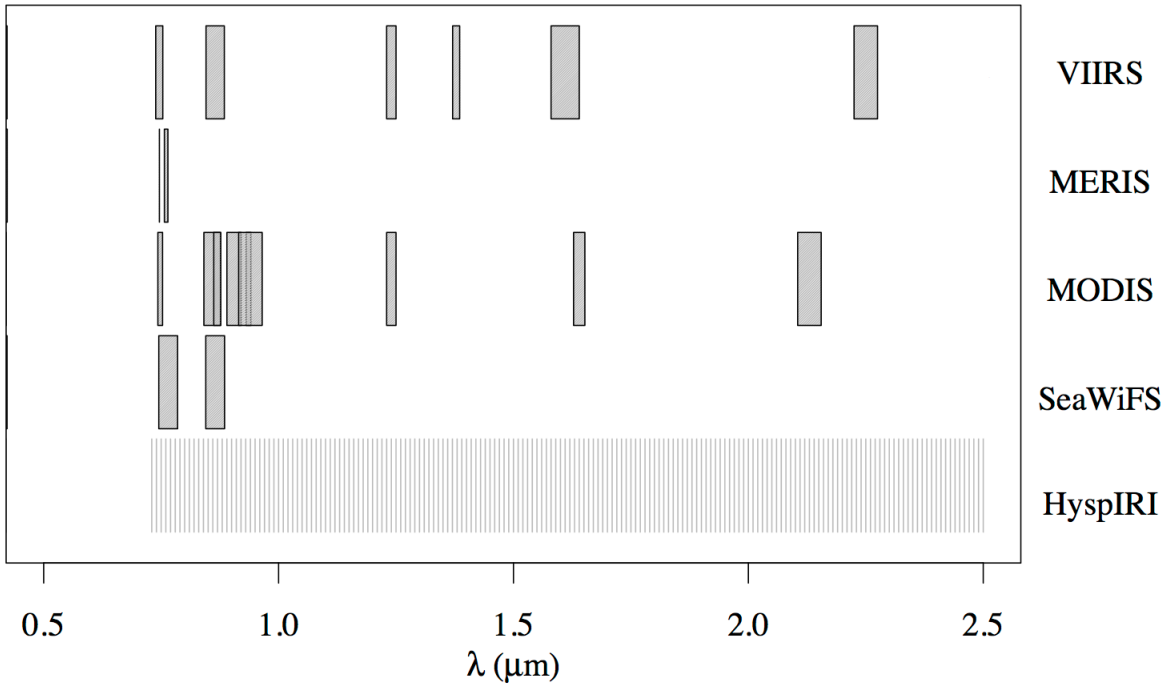
Spectral Resolution and Range

- Spectral resolution necessary in complex coastal and inland aquatic regions.
- Range to 2.5 microns greater than OC instrument (~1 micron), which useful for wetland vegetation, atmospheric correction near coasts, and may be useful for glint.

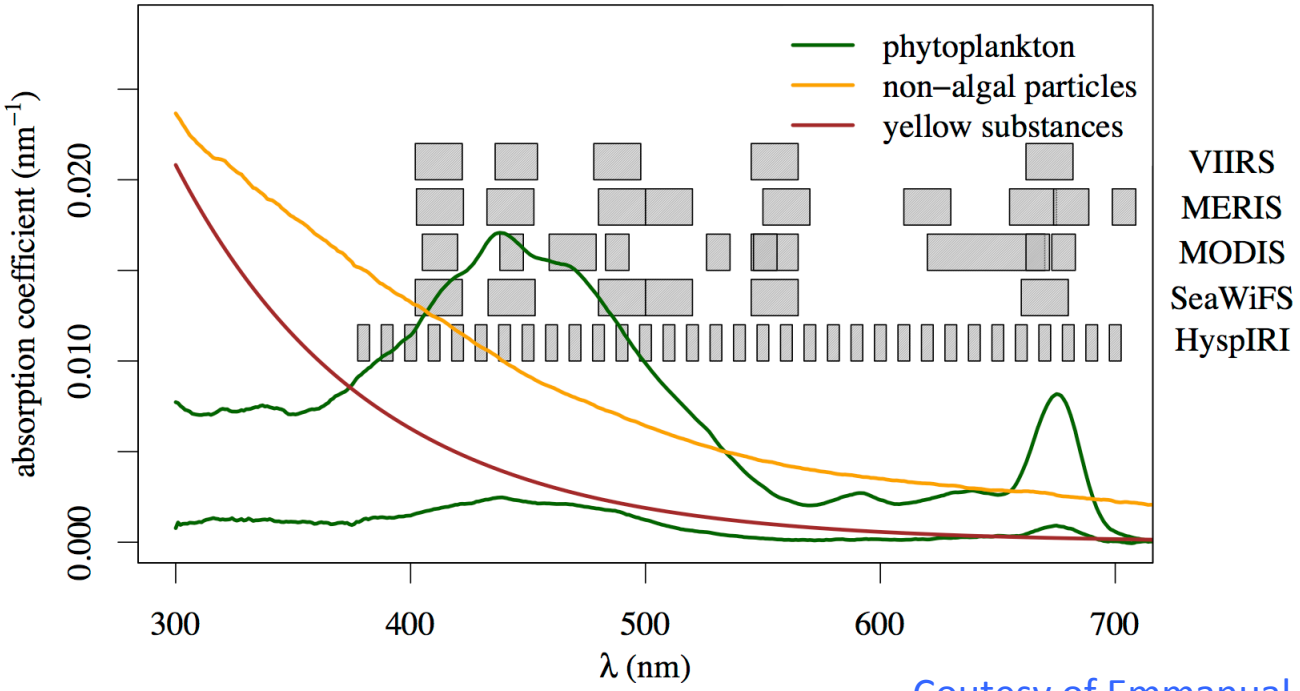
Radiometric sensitivity – Spec'ed for terrestrial targets, but has high radiometric resolution.

Polarization insensivity – Specification similar to MODIS or VIIRS, can be address if characterized.

NIR-SWIR



Visible



Coutesy of Emmanual Devred

HyspIRI Characteristics

SNR

- Lower than traditional ocean color instruments, but higher than HICO or Hyperion.
- Demand for coastal and inland targets less than open ocean.
- Spatial or spectral aggregation could boost SNR for some products.

19-day Equatorial Revisit

- Cannot monitor rapidly changing aquatic systems.
- High-lat observations less impacted (4-5 days at 60 degs).

Orbit: Sun-Synchronous, 11AM Equatorial Crossing, 4° Tilt

- Causes significant sun glint in aquatic regions.
- Dependent on surface roughness and illumination/viewing geometry.
- Greater at low lats.
- Aquatic classification algorithms tend to be more robust.
- Low reflectance targets more problematic.

Separation of TIR and VSWIR

- Could impact a few proposed products.
- Most proposed aquatic products do not use TIR.

CANDIDATE
AQUATIC L3 & L4 DATA PRODUCTS

Wetlands

Coastline*

Water Surface*

Water-Column*

Bathymetry

Benthic Environment

* EPISODIC OBSERVATIONS TO UNDERSTAND STRUCTURE AND DISTRIBUTION OF INDIVIDUAL EVENTS.

CANDIDATE
AQUATIC L3 & L4 DATA PRODUCTS

Wetlands

Coastline

Water Surface

Water-Column

Bathymetry

Benthic Environment

Ranking color coding based on :

- Uniqueness to HyspIRI,
- Relevance to Science Questions,
- Feasibility

Ranking is still under discussion.

- **Rank 1**
- Rank 2
- Rank 3
- Rank 4

CANDIDATE
AQUATIC L3 & L4 DATA PRODUCTS

Wetlands

Coastline

Water Surface

Water-Column

Bathymetry

Benthic Environment

- **Wetland Delineation**
- **Type** (e.g., Marsh, Mangrove)
- **Fraction of Vegetation Coverage**
- **Fraction of Open Water**
- Species Maps
- Veg Indices
- NDWI
- Evaporation Rates
- Soil Water Content

VSWIR + TIR

- Substrate Type
- Substrate Grain Size
- Substrate Bearing Strength

Wetlands Data Product Ranking and Requirements

RELEVANT SCIENCE QUESTIONS

CQ1: a-c	VQ1: a-d, f
CQ2: a-g	VQ3: c,d
CQ3: e	VQ4: a-e
CQ4: a-f	VQ5: a-f
CQ6: a,c	VQ6: a

DATA REQUIREMENTS :

- VSWIR surface reflectance.
- Surface temperature (contemporary).
- Geolocation (meter accuracy).
- Anciliary Data for Atmospheric Corr.
- Hyperspectral Library.

CANDIDATE DATA PRODUCT	(V/T/C)	Uniqueness	Feasibility	Relevance	Total Score
Wetland Delineation and Type (Marsh, Mangrove)	C	3	3	3	9
Fraction of Vegetation Coverage	V	3	2	3	8
Fraction of Open Water	V	3	2	3	8
Species Maps	V	3	1	3	7
Veg Indices	V	1	3	2	6
NDWI	V	1	3	2	6
Evaporation Rates	C	3	1	2	6
Soil Water Content	C	3	1	2	6
Substrate Type	V	3	1	2	6
Substrate Grain Size	V	3	1	2	6
Substrate Bearing Strength	V	3	1	2	6

INSTRUMENT REQUIREMENTS (ESTIMATED) **:**

- High spatial (4-60 m).
- High spectral resolution (5-20 nm).
- Spectral Range (400 – 2500 nm)
- Sun glint minimized.
- High SNR (target is dark).
- At least seasonal looks.
- Calibrated thermal bands.

HyspIRI CHARACTERISTICS

- ✓ 60 m
- ✓ 20 nm
- ✓ 380-2500 nm
- ✓ >12° from subsolar point.
- ✓ Adequate for open water.
- ✓ 19-day visitation period minus cloudy acquisitions.
- ✓

CANDIDATE
AQUATIC L3 & L4 DATA PRODUCTS

Wetlands

Coastline

Water Surface

Water-Column

Bathymetry

Benthic Environment

- Coastline maps
- Floods (eposidic events)
- Groundwater Discharge

VSWIR + TIR

EPISODIC OBSERVATIONS TO UNDERSTAND STRUCTURE AND DISTRIBUTION OF INDIVIDUAL EVENTS.

CANDIDATE
AQUATIC L3 & L4 DATA PRODUCTS

Wetlands

Coastline

Water Surface

Water-Column

Bathymetry

Benthic Environment

- **Water Surface Temperature**
- Microbial Mats
  - Trichodesmium spp.
  - Ulva prolifera (Sea Lettuce)
  - Sargassum spp.
  - Lyngbya spp.
- Oil slicks
- Floating Garbage and Flotsam

EPISODIC OBSERVATIONS TO UNDERSTAND STRUCTURE AND DISTRIBUTION OF INDIVIDUAL EVENTS.

CANDIDATE
AQUATIC L3 & L4 DATA PRODUCTS

Wetlands

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Benthic Environment

VSWIR + TIR

- **Front and Eddie Dynamics**
- Water Quality
- Inherent Optical Properties*
  - Absorption (a(l))
  - Backscattering (b_b(l))
- Apparent Optical Properties*
  - Remote Sensing Reflectance (R_{rs}(l))
  - Diffuse Attenuation Coefficient (K_d(l))
- Pigment Concentrations*
  - Chlorophyll a
  - Auxilliary Pigments
- Tripton (Suspended Matter)*
- Phytoplankon Functional Types*

* - HIGHLY SUSCEPTABLE TO GLINT.

EPISODIC OBSERVATIONS TO UNDERSTAND STRUCTURE AND DISTRIBUTION OF INDIVIDUAL EVENTS.

CANDIDATE
AQUATIC L3 & L4 DATA PRODUCTS

Wetlands

Coastline

Water Surface

Water-Column

Bathymetry

Benthic Environment

- **Shallow Water Depth**

GLINT IMPACT NEEDS FURTHER STUDY.

CANDIDATE
AQUATIC L3 & L4 DATA PRODUCTS

Wetlands

Coastline

Water Surface

Water-Column

Bathymetry

Benthic Environment

- **Coral Reef Maps**
- Submerged Aquatic Vegetation (SAV) Maps
- Kelp Forests Maps

PRELIMINARY RECOMMENDATIONS

- **Evaluate data quality for proposed data products.**
  - Set priority by rank, if necessary.
  - Leverage off air campaign where applicable.
  - Develop demonstation algorithms for operation use or community distribution.

- **Begin scoping Cal/Val program to support radiometric validation, lunar or vicarous calibration efforts.**

- **Establish data base of instrument characteristics for refinement of calibration.**

PRELIMINARY RECOMMENDATIONS

- **Integrate coastal and in-water spectrum (AOPs and IOPs) into spectral library to support validation and algorithm development.**

- **Re-adapt depth mask for 60 m resolution to accommodate regions of interest with greater depths.**

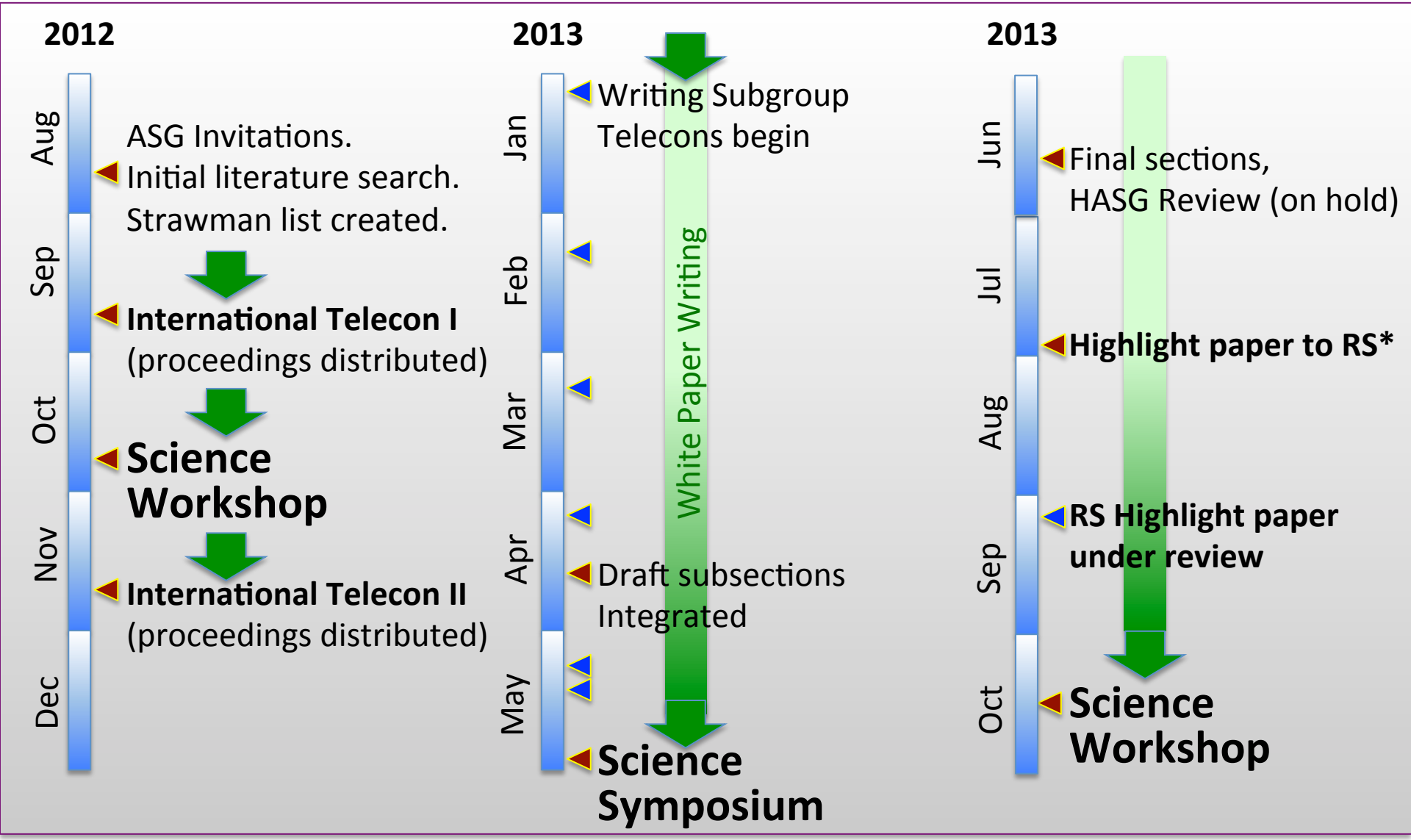
- **Assess the impact of separating VSWIR and TIR questions based on aquatic science questions.**

Some work is being done at GSFC to support HICO processing and in preparation for PACE and ACE. However, some work may need to be done through the community.

THANK YOU

Auxiliary Slides

HyspIRI ASG Activities



* - Water-column retrievals section slated for special issue of Remote Sensing.
Wetland section and other sections will be targeted for separate publications.
HyspIRI overview for aquatic remote sensing targeted for other journals.

HASG Status

White Paper

- Final draft currently estimated to be between 75-100 pp.
- General HASG review was originally scheduled for the summer, but too few people available.
- Shifts in attention at GSFC on other aquatic missions and Govt shutdown hasn't helped this.
- Review will likely be carried out later this fall.
- This would be likely supported with another international telecon.

HASG Status

Further Work

HASG writing team has given a critical look at specific challenges pertaining to each proposed data product.

Ideally we will refine our ranking of individual data products with a more critical look at :

- **Uniqueness** to the HyspIRI mission.
- **Relevance** to the mission Science Questions, and *Decadal Survey,* or is of compelling importance.
- **Feasibility**.

HASG Status

Further Work

- Section on water-column retrievals (2.4) is under review for submission as an article in a special of *Remote Sensing* on phytoplankton remote sensing.

- Section on wetlands (2.1) being prepared for special issue of Remote Sensing of Environment on HyspIRI.

- About five or so papers are expected to be submitted from the HASG writing group to the spectial RSE issue.

Atmospheric Correction

- It was suggested that a new approach is needed for atmospheric correction over open water. Concerns include: adjacency effects, high spatial and temporal variability of trace gas absorption (e.g., NO2 or tropospheric Ozone), and coastal aerosols. Also, need to be sure that cloud masking is effective over water.

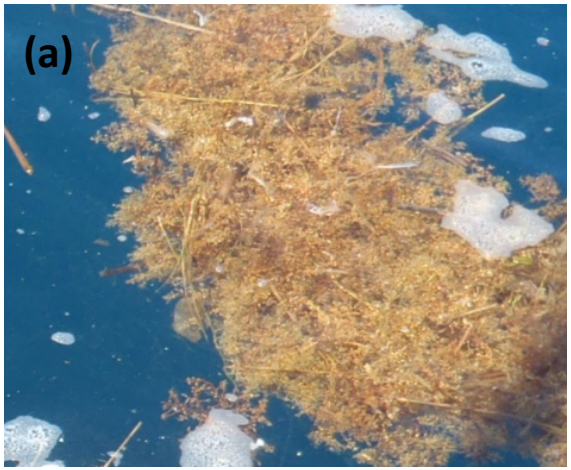
- Thermal (10um) would be useful to mask clouds, and less sensitive to sun glint. This is further argument to keep thermal and SWIR sensors together.

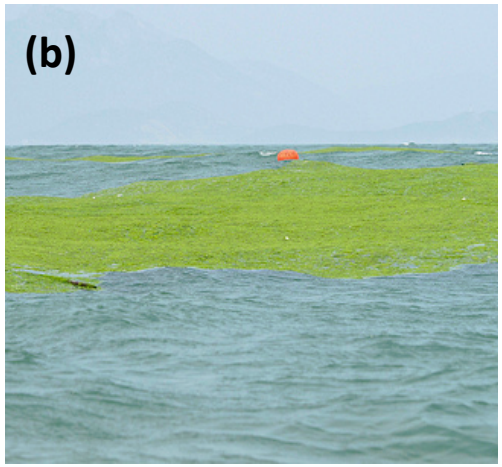
- What methods are being employed to determined water surface temperature?

- Recommend forming a working group to evaluate atmospheric correction for HyspIRI (led by Bo-Cai). Some limited funding supporting efforts in this area may be useful.

- Discussion with other hyperspectral coastal efforts may be productive. E.g., Sindy Sterckx at VITO in Belgium is looking at adjacency effects and use of the SWIR bands.

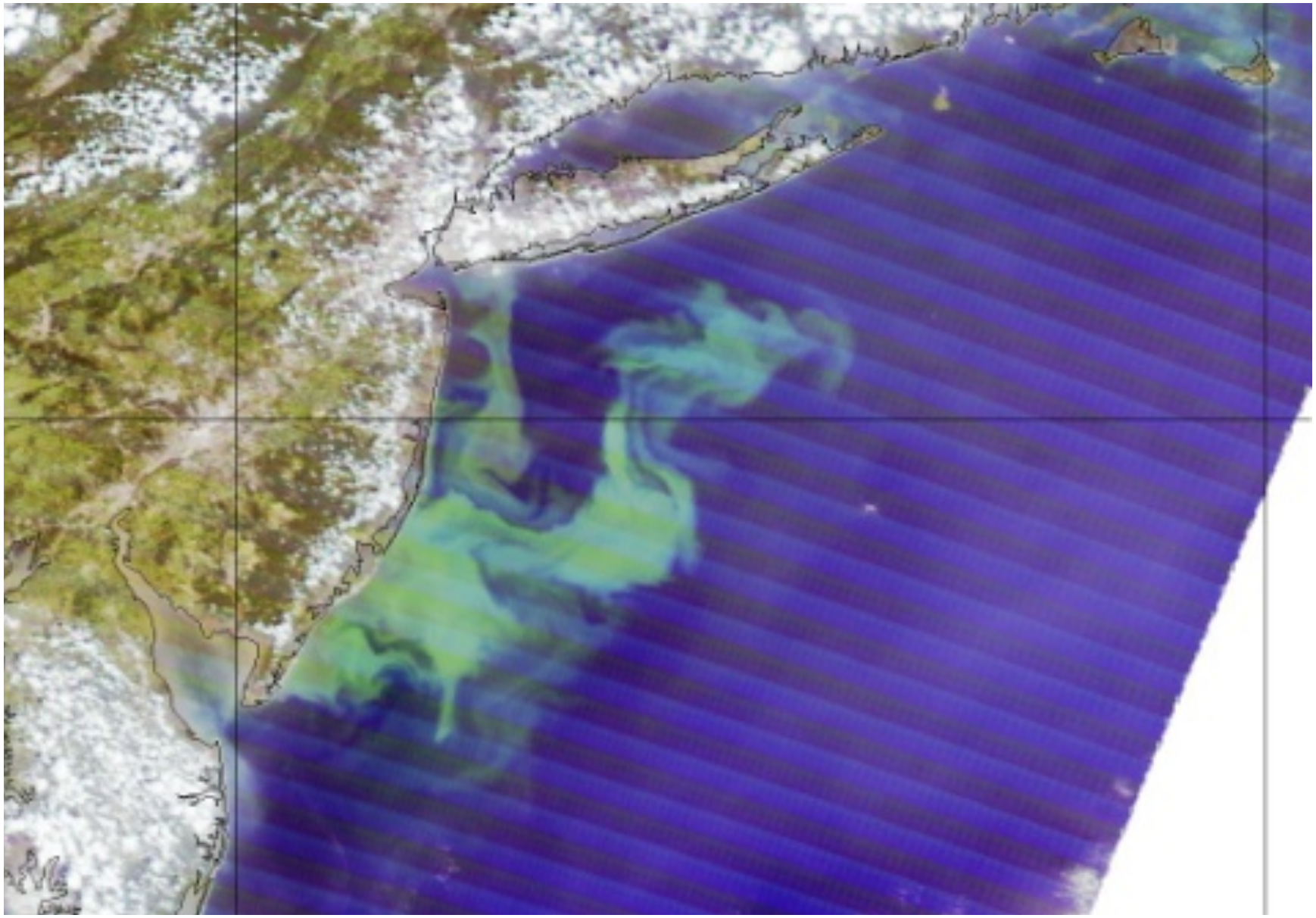
Water surface features





Materials and marine plants floating on the ocean surface. (a) *Sargassum spp.* in the Gulf of Mexico; (b) *Ulva prolifera* bloom off Qingdao, China; (c) *Trichodesmium* mats in the GOM; (d) Weathered oil from the Deepwater Horizon oil spill in the GOM; (e) Marine garbage patch (fishing net, plastic, other debris) in the Pacific ocean.

Bloom in August 17, 2012



Remote Sensing of Aquatic Regions

Mississippi Delta regions 13 days after Hurricane Ike (late Sept, 2008).
Coastal regions are complex and require hyperspectral measurements.