



International Ocean Colour Science
Meeting 2015

Advancing Global
Ocean Colour
Observations

Breakout 7:

Advances in hyperspectral remote sensing science

HYPERSPECTRAL DATASETS FOR ALGORITHM DEVELOPMENT

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San Francisco, California USA
18 June 2015



Background

- Hyperspectral data is crucial to developing and demonstrating new algorithms for the upcoming hyperspectral missions.
 - Of course, these data need to be coincident with other relevant measurements.
- In support of the Hyperspectral Infrared Imager (HypIRI) mission and the coastal and inland aquatic remote sensing community, the HypIRI Aquatic Studies Group (HASG) was created (and more recently re-labeled AquaRS).
- On 5 June 2015, the HASG Aquatic Forum convened to discuss hyperspectral data sets that were available for algorithm development.
- This presentation provides a summary of the data sets that were discussed and some of the meetings recommendations.

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Arnold Dekker, CSIRO

Eric Hochberg, BIOS



PACE hyperspectral *in situ* dataset

Boss E., Craig S., Gray D., Gregg W.W., Kahru M., Lee Z., Maritonera S., McKinna L., Miller D., Mitchell G., Moses W.J., Reynolds R.A., Rousseaux C.S., Slade W., Tzortziou M., Werdell J.

- **Objective:** Create a high quality, diverse and complete dataset of existing multi- and hyperspectral IOP and R_{rs} data for the development and validation of algorithms for the PACE mission.
- Desire coincident IOPs, AOPs, and biogeochemical data covering a range of water types.
- Final dataset to be published (DOI TBD) and made publicly available in 2017.
- Any contributor will be co-author on this publication.
- Data contributed as part of this effort will also be submitted to and made available from SeaBASS.
- Contact: Cecile.S.Rousseaux@nasa.gov and Emmanuel.Boss@maine.edu.

*NASA's Pre-Aerosol, Clouds, and Ecosystem (PACE) satellite mission is intended to be a hyperspectral ocean color mission that provides extended data record on ocean ecology and biogeochemistry. Recently, a competitively selected PACE Science Team was assembled to address science challenges pertaining to the PACE mission. One of the objectives of the PACE Science Team is to create a high quality, diverse and extensive dataset of existing multi- and hyperspectral inherent and apparent optical properties (IOP/AOP) data for the validation of remote sensing products and the development of algorithms for the PACE mission. Both polarized and non-polarized datasets are sought. This is a call to the community to contribute **well-documented, quality controlled data sets consisting of synchronous IOP/AOP profiles and above-water radiometry that could be of interest in a global effort to build a database that would ultimately be published and made available to the public (estimated date of publication is 2017)**. All contributors to this dataset will actively take part in the quality assessment of the data and participate as co-authors on a publication that will arise from this effort.*

Data of interest for PACE *in situ* database

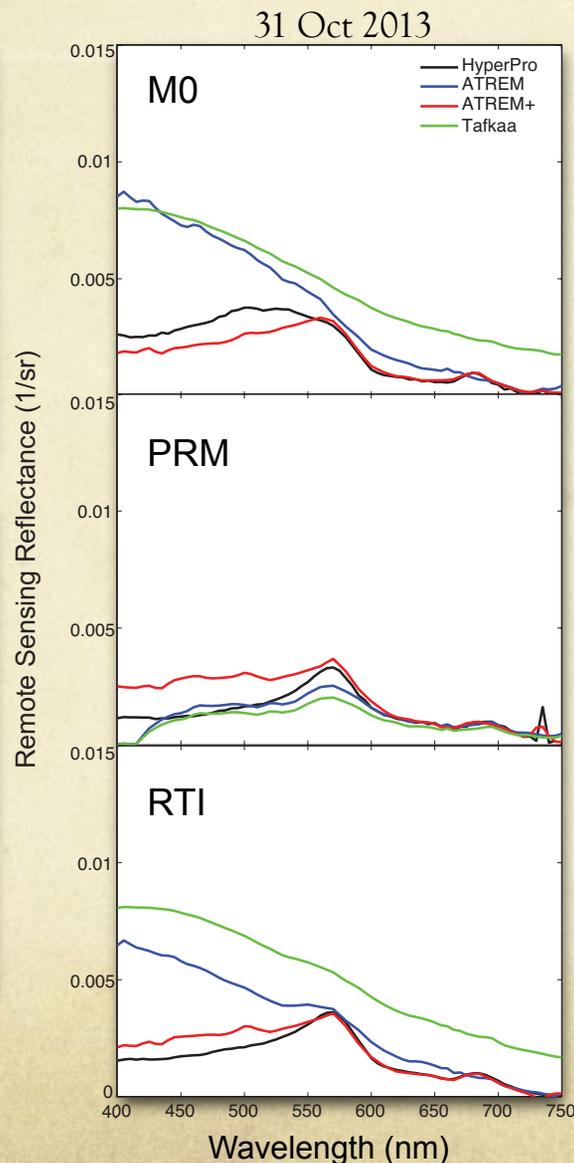
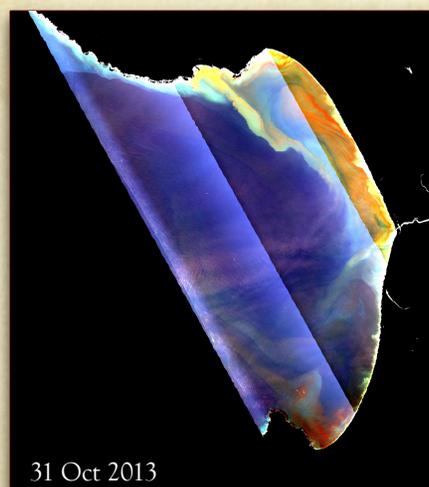
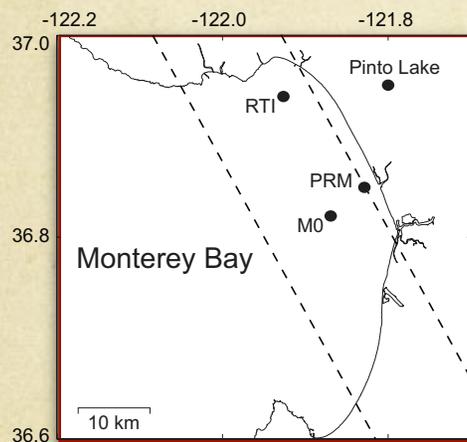
Location of data	
Latitude	
Longitude	
sst	Sea Surface Temperature
t_mld	Temperature MLD
wt	Water Temperature
sal	Salinity
depth	Depth of measurement
Rrs	Radiometry
Kd	Diffuse attenuation coefficient
a	Total absorption coefficient (aw+ap+ag)
a_p	Absorption coefficient of particles
ad	Absorption coefficient of non algal detritus
a_ph	Absorption coefficient of phytoplankton
agp	Absorption coefficient of Gelbstoff + particles
a_g	Absorption coefficient of Gelbstoff
bb	Total Backscattering Coefficient
bbp	Backscattering coefficient of particles
c_p	Beam attenuation coefficient of particles (ap+bb)
c	Beam attenuation coefficient
cgp (or cnw)	Attenuation coefficient of Gelbstoff+particles
VSF	Volume Scattering Function
cdmf	Fluorescence of CDOM
F_chl	Fluorescence of Chlorophyll
PSD	Particle Size Distribution
TSM	Total Suspended Matter
HPLC	HPLC Pigment
POC/DOC	Particulate Organic Carbon/Dissolved Organic Carbon
Inst	Instrument Details/other Information

NOTE: A task group is also being led by ZhongPing Lee to produce synthetic datasets using models.

HyspIRI Airborne Preparatory Campaign

Coastal and Inland Waters of California

PI: R Kudela, Co-I's: L Guild, S Palacios, J Torres-Pérez, K Negrey



Data Collected

- A robust *in situ* data set collected in Monterey Bay and Pinto Lake for all years and seasons: 2013, 2014, 2015
- Matchups for Santa Barbara Channel Plumes & Blooms cruises on 4/16/14 & 10/21/14
- Currently, only **two dates** of experimentally processed “scientific quality” AVIRIS images for Monterey Bay (4/10/2013 & 10/31/2013)

Data Management

- Preparing *in situ* data to target upload to SeaBASS in winter 2016
- AVIRIS over water targets, needs further discussion with JPL

Lessons Learned

- Hyperspectral imagery has special needs with respect to instrument calibration, signal-to-noise, and atmospheric correction
- It is possible to forecast blooms of the toxic cyanobacterium, *Microcystis*, using hyperspectral data

Portable Remote Imaging Spectrometer (PRISM)



Jet Propulsion Laboratory
California Institute of Technology

PI: Pantazis Mouroulis (JPL) & Science Co-I: Heidi Dierssen (U. Conn.)

<http://prism.jpl.nasa.gov>

- Addresses the challenges of coastal & inland ocean remote sensing
- Simple and robust airborne pushbroom imaging spectrometer
- High signal-to-noise ratio (SNR), high uniformity, low polarization
- UV-NIR range (350 – 1050 nm @ ~ 3 nm spectral sampling)
- Two-channel SWIR (1240 and 1610 nm)

Project Timeline

Development award: Sep. 2009
First cal/val flight: May 2012
First science flight: Aug. 2012

- Elkhorn Slough

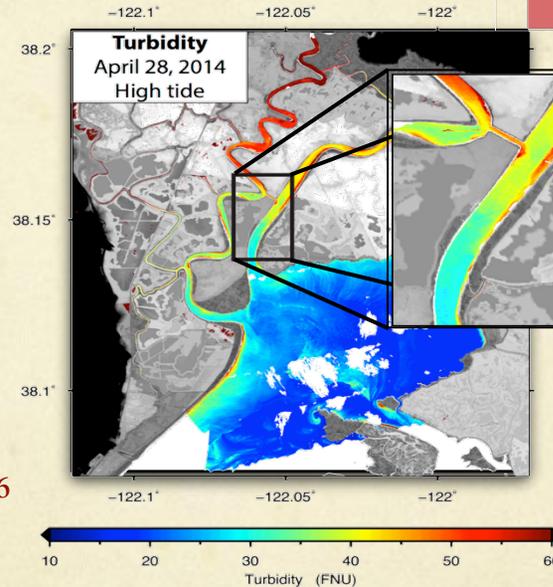
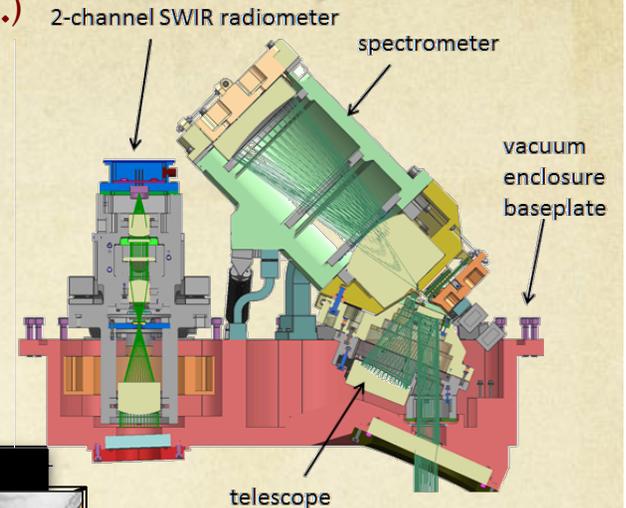
Additional science campaigns: 2014

- Florida Bay Jan. 2014
- Southern California Bight Apr. 2014
- Monterey Bay Apr. 2014
- Sacramento Bay Delta Apr. 2014

Future science campaigns: 2016

- ORCAS - Southern Ocean Jan.-Feb. 2016
- CORAL - Mainly Pacific Ocean 2016/2017

- All existing campaigns utilized Twin Otter aircraft (GRC and TOIL)
 - Typical altitude range < 10 kft, with maximum of ~ 20 kft reached in April 2014
- Future campaigns can additionally utilize ER-2 & NSF/NCAR Gulfstream-V (GV) aircrafts
 - ER-2 (NASA ESTO AITT - Oct. 2015) - altitude range 20-70 kft
 - GV (NASA Rapid Response - Jan. 2016) - altitude < 51kft

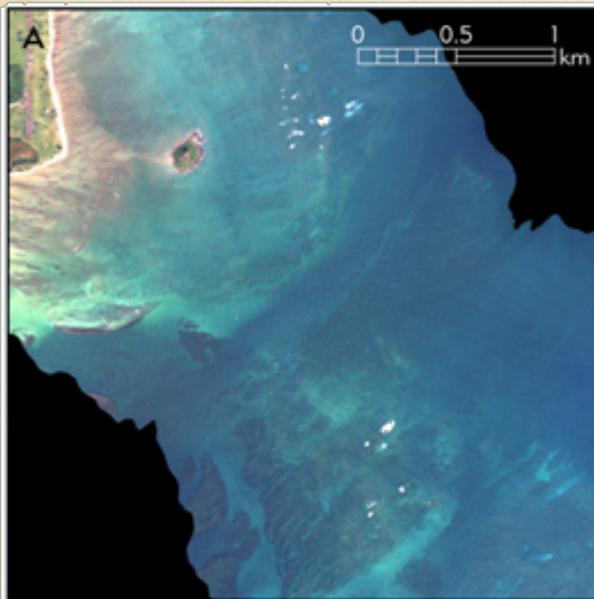


HyspIRI – Corals Reef Remote Sensing Science

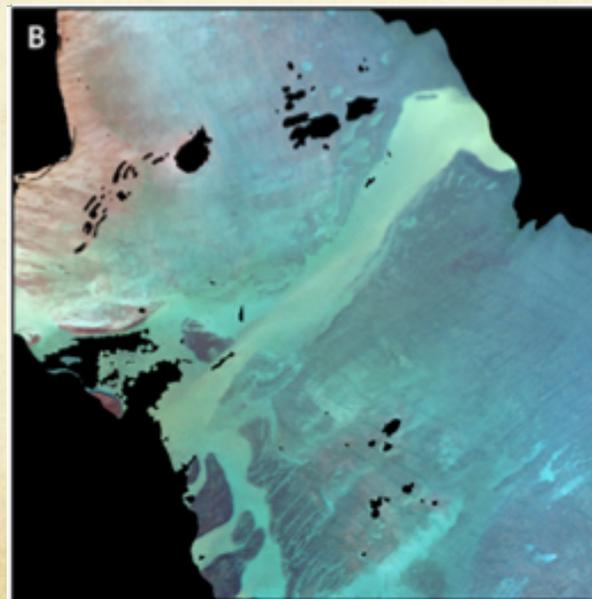
- Planning to have a Science Team by the end of September 2015
- 1st Science Team Meeting at October Workshop
- Flights in 2016 plan refined by Science Team
- All data products will be available



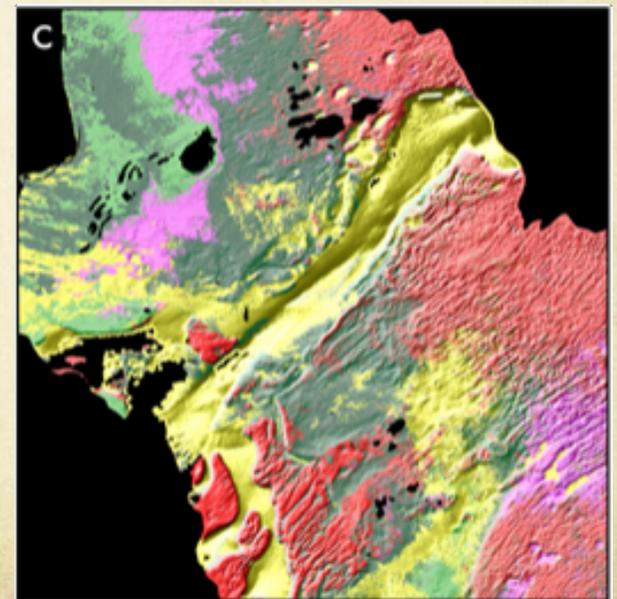
AVIRIS Image of Kaneohe Bay, HI



At-Sensor Reflectance RGB



Bottom Reflectance RGB

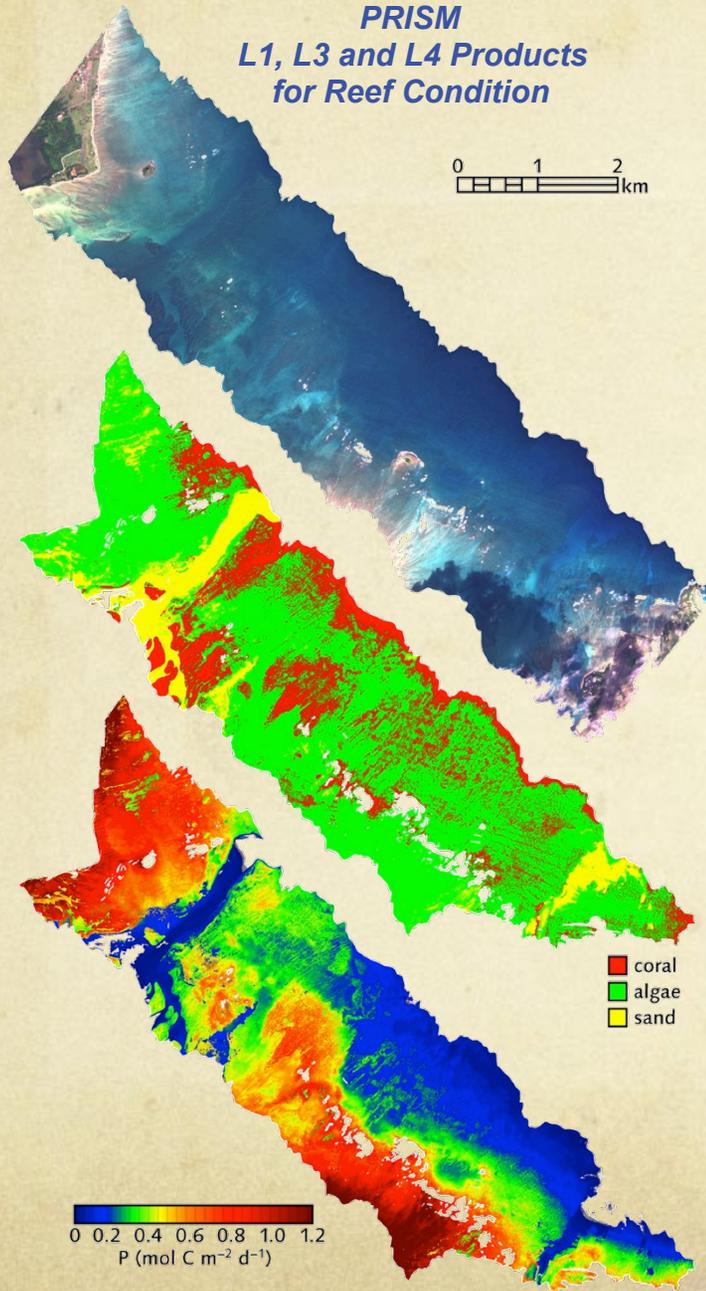


Bottom Classification

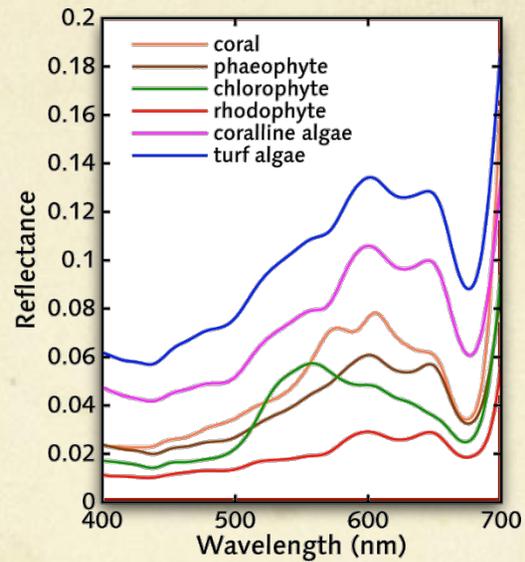
CORAL: COral Reef Airborne Laboratory

PI: Eric Hochberg

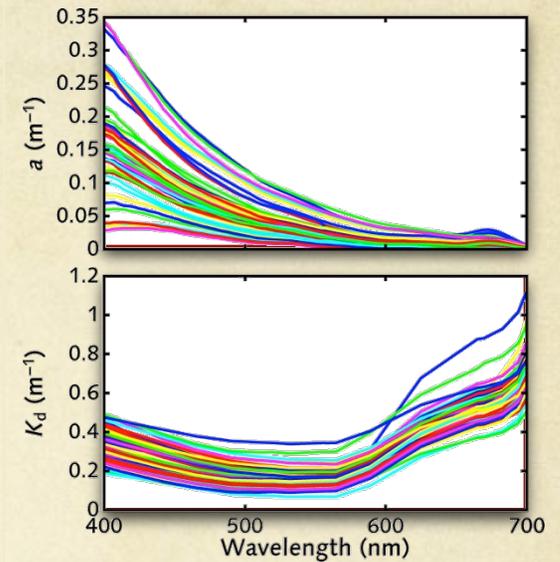
PRISM
L1, L3 and L4 Products
for Reef Condition



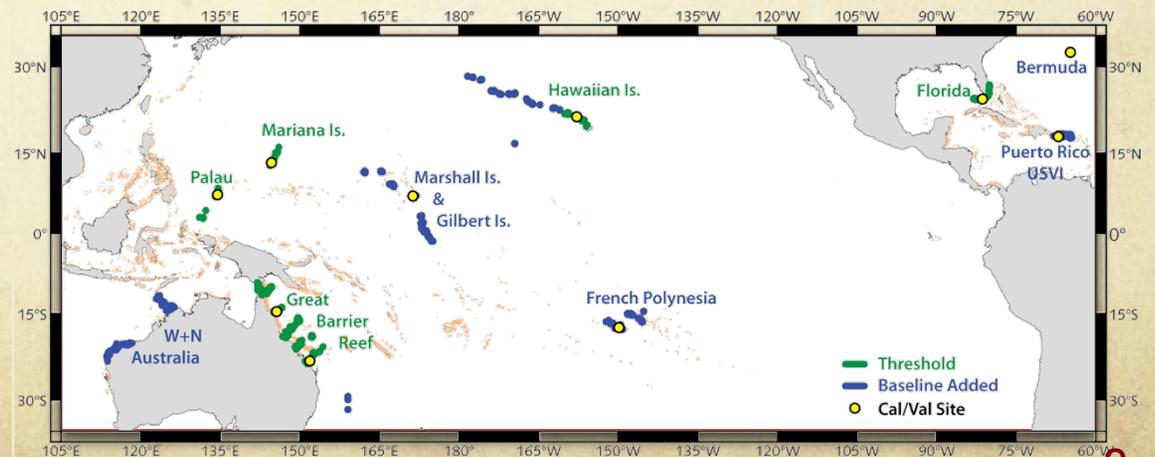
Benthic Reflectance Cal/Val



Water IOP/AOP Cal/Val



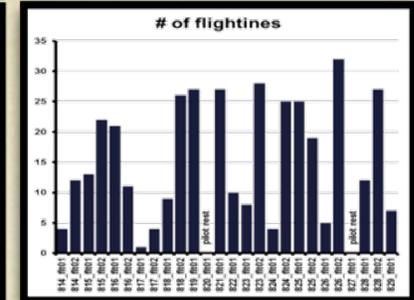
Threshold and Baseline Investigation Regions



Lake Erie Airborne Hyperspectral Campaign

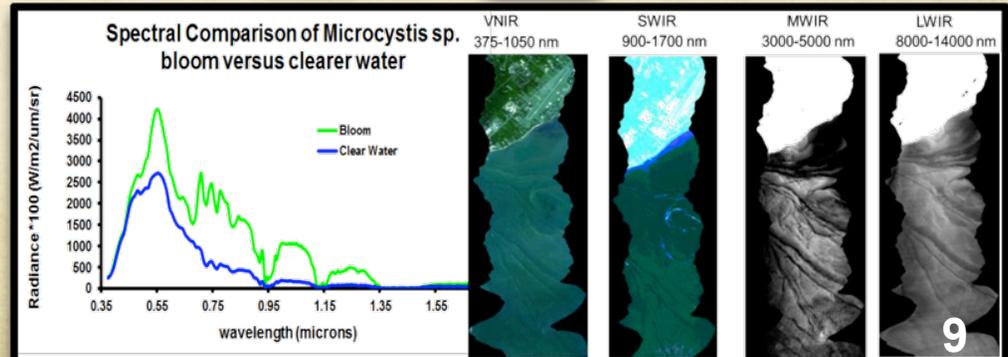
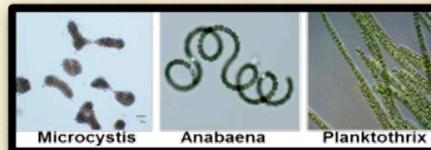


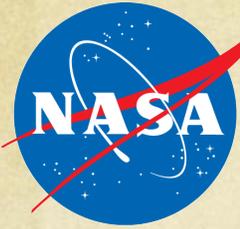
- NRL collected VNIR-SWIR hyperspectral and broadband IR over Lake Erie in August 2014
- >350 flightlines were flown over turbid and clear waters
- Significant groundtruth available for validation from collaborators



SENSORS

- Itres CASI-1500 VNIR
 - 72 bands, 375 to 1053 nm, 9.6 nm FWHM, 1500 pixels, 40° FOV, pixel size ~0.75m
- Surface Optics SWIR-1700
 - 253 bands, 950-1675 nm, 3.3 nm FWHM, 640 pixels, 35° FOV, pixel size ~2.3m
- FLIR- SC600 MWIR Imager
 - 3-5 microns, 640x512 pixels, 40° FOV
- Sofradir-EC ATOM LWIR Microbolometers
 - 8-14 microns, 1024x768 pixels, 40° FOV





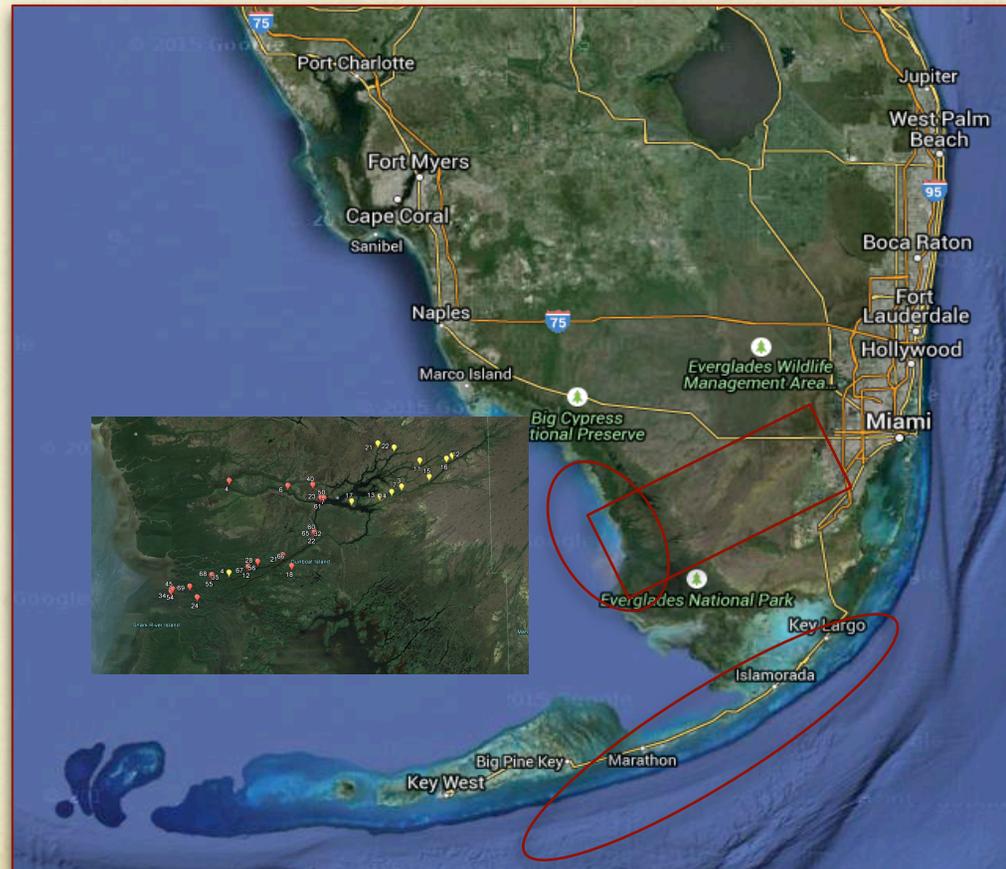
Everglades and Florida Bay Airborne Campaign

Carlos E. Del Castillo, Bruce Cook, John Moisan, Tiffany Moisan,
Kevin Turpie, Christy Hansen

Addressing uncertainties in the export of carbon from mangrove environments

Components:

- Extensive field campaigns in the Shark River and its basin, coastal everglades, and the Florida Keys.
- One airborne campaign during May, 2015 to the Shark River Basin, and the Shark river Plume using the **Goddard LIDAR, Hyperspectral, and Thermal (G-LiHT)** imager.
- One planned air campaign with field validation to the Shark River Plume and Florida Keys with the **Airborne Sensor for Hyperspectral Reflectance Imaging of Marine Pigments (AirSHRIMP)**.
- All data to be available through the Ocean Color web site.
<http://oceancolor.gsfc.nasa.gov>



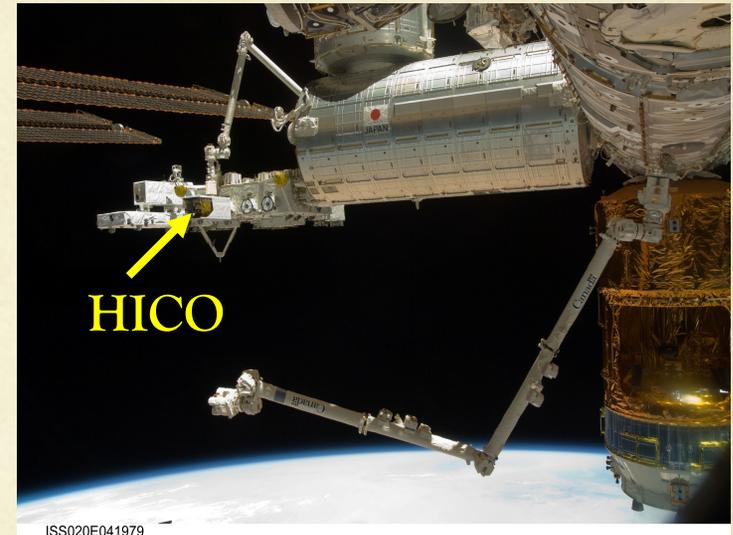
General area for field work and airborne campaigns shown in red.



HICO

Hyperspectral Imager of the Coastal Ocean

- VNIR Hyperspectral data
 - 350 – 1080 nm (400 – 900 nm recommended) at 5.7 nm res
- Spatial footprint is 50 x 200 km, with ~ 100m pixels
- Focus on coastal oceans
- 5 years of operations on International Space Station
 - Sept 2009 – Sept 2014
- Pre- and post-launch calibration documented
 - Some inconsistencies remain, possibly due to polarization sensitivity
- ~ 10,000 images archived in 2 locations
 - NASA's Ocean Color Website:
<http://oceancolor.gsfc.nasa.gov>
 - OSU's HICO Website:
<http://hico.coas.oregonstate.edu>



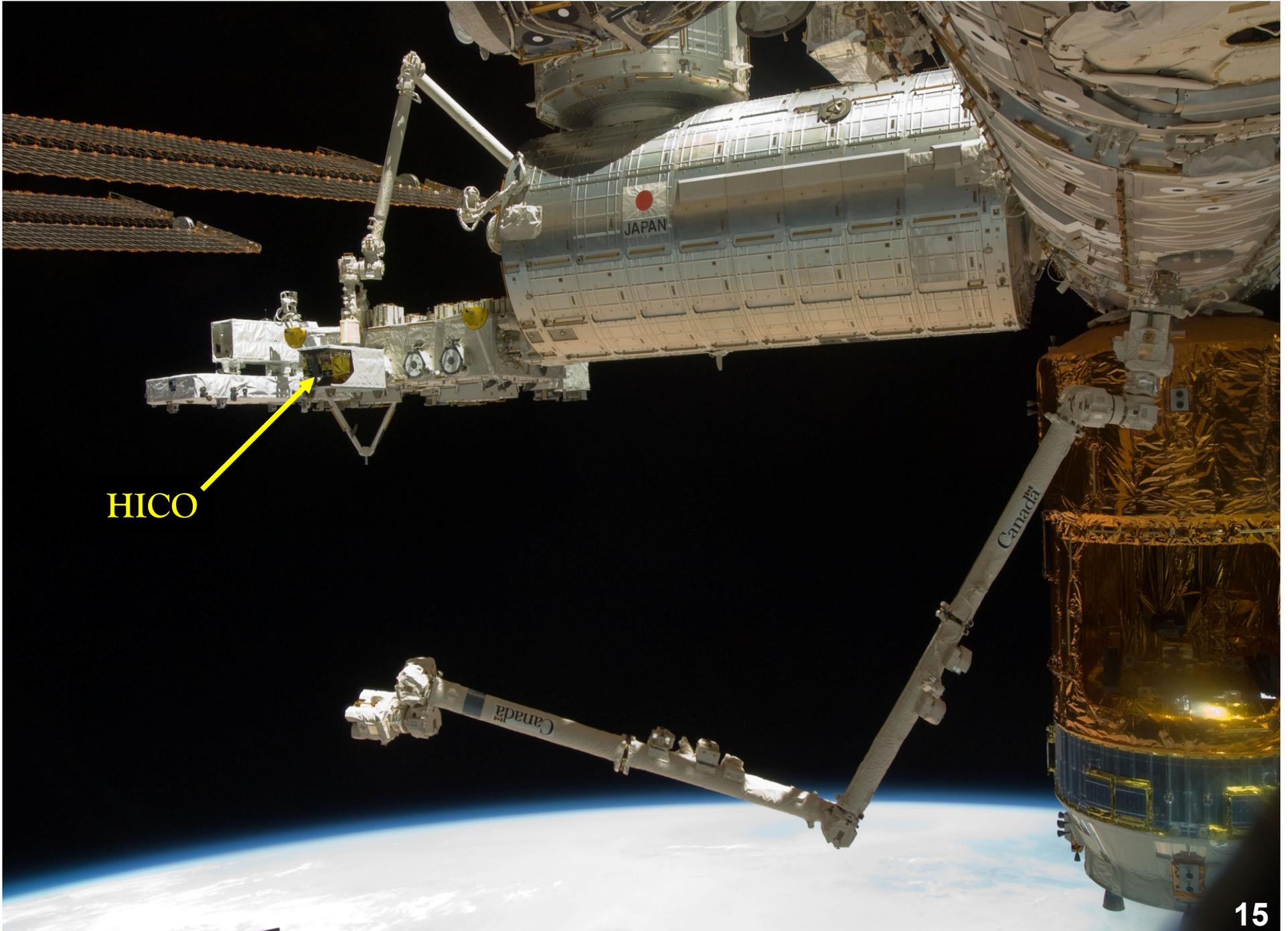
Conclusions

- PACE team is developing a hyperspectral data library of *in situ* and synthetic hyperspectral data and requesting contributions.
- HICO hyperspectral imagery is available through two websites.
 - Need to identify coincident *in situ* data.
- Recent airborne hyperspectral data (USA govt funded):
 - **AVIRIS** - e.g., HypsIRI Preparatory Campaign, California
 - **G-LiHT** - e.g., flights over the Everglades, Florida Bay Campaign, Florida Key, San Andros Island.
 - **NRL, NASA Glen Research Center** and others have multiple campaigns with various aircraft and payloads over the Great Lakes, USA.
 - **PRISM** has been flown over coastal sites in California and Florida.
 - Need to reach out to the international community.
- Upcoming airborne campaigns :
 - **AVIRIS/PRISM(?)** - HypsIRI Preparatory Campaign, Hawaii
 - **AirShrimp** - Everglades and Florida Bay Campaign
 - **CORAL** - Selected Coral Reefs
 - **ORCAS** - Southern Ocean
 - **NAAMES** - High Latitude Study

Conclusions

- Recommendations from the HypsIRI Aquatic Studies Group (HASG) Forum:
 - Establish a group to identify applicable airborne hyperspectral datasets.
 - Create a single website linking to sites distributing data.
 - Work to establish a dialog between data owners/distributors and with users.
 - Encourage or facilitate availability of datasets.
 - Explore standards for format, metadata and documentation.
 - Intercompare datasets to determine applicability to algorithm development

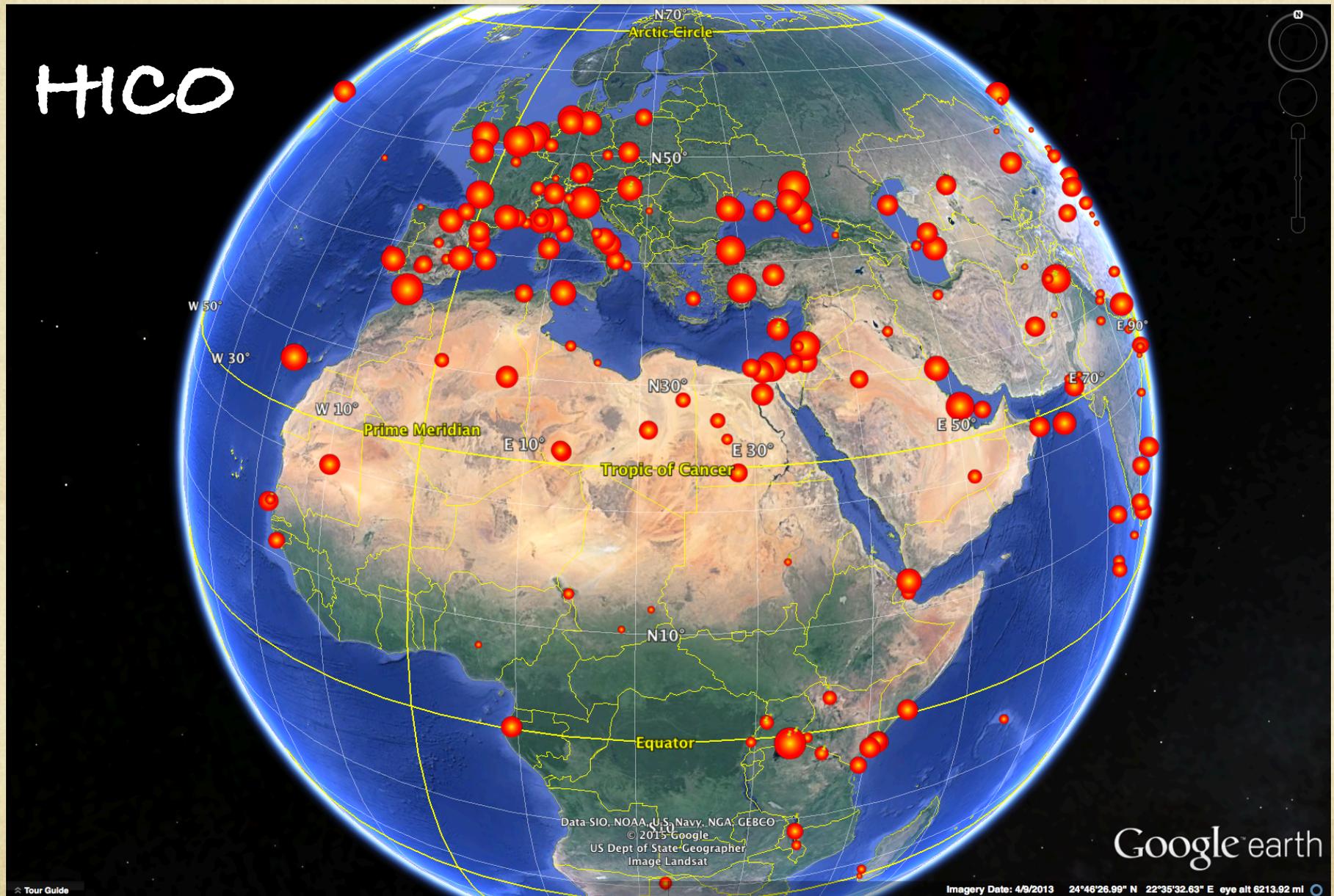
Thank You



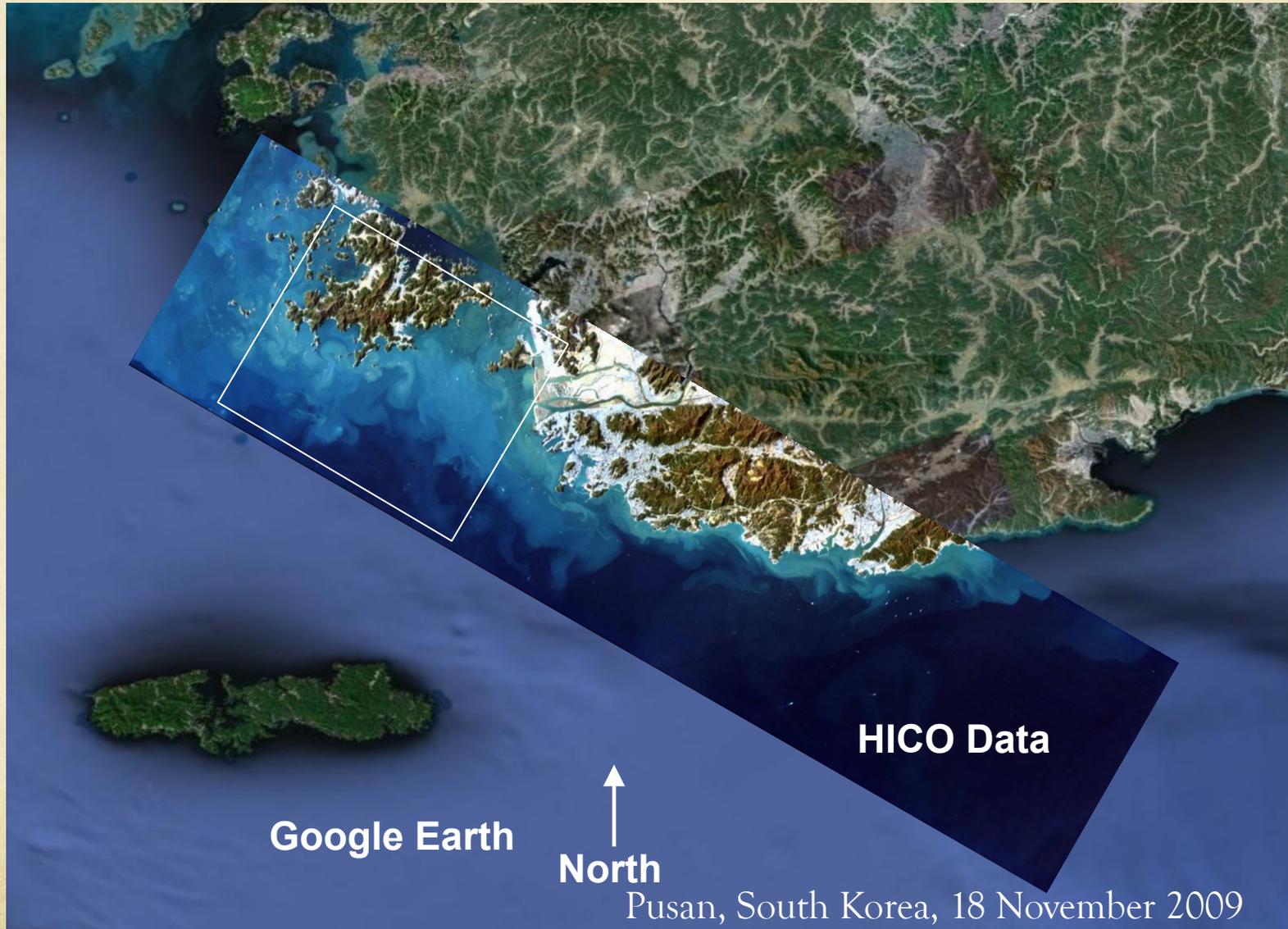
HICO

Example Distribution of Collections

HICO

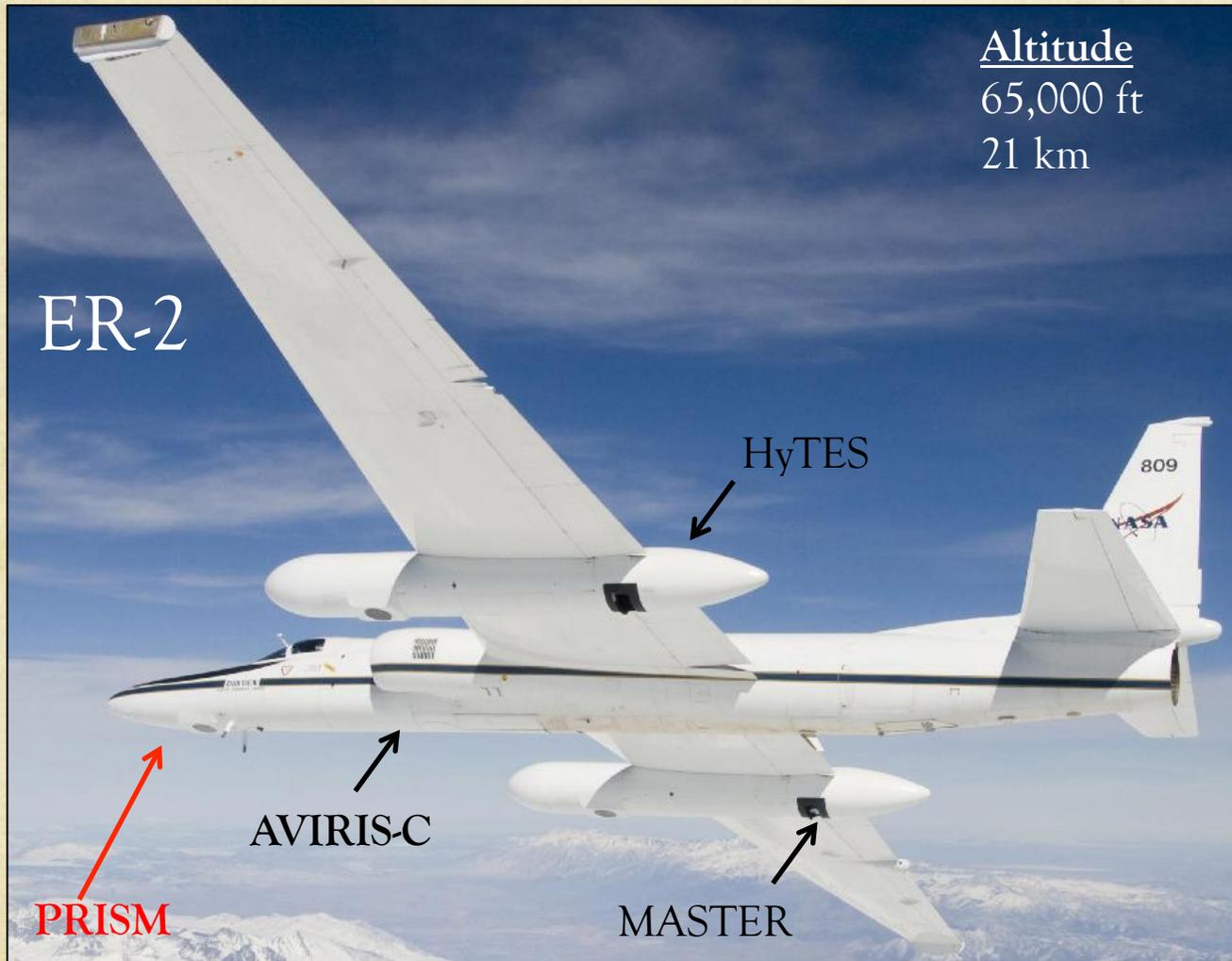


HICO High Signal to Noise Ratio for Dark Water Scenes



HyspIRI Configuration on ER-2 for Hawaii

PLUS possible PRISM and HyTES



AVIRIS (VSWIR)

10 nm spectral res
224 bands
380 2510 nm
1 mrad IFOV
34 degree FOV
20 m spatial res
12 km swath

MASTER (TIR)

50 bands
0.4-13 μm
2.5 mrad IFOV
85.92 degrees FOV
50 m resolution
35 km swath

ER-2 in Hangar at Armstrong Flight Facility



Disregard the clod in the foreground.