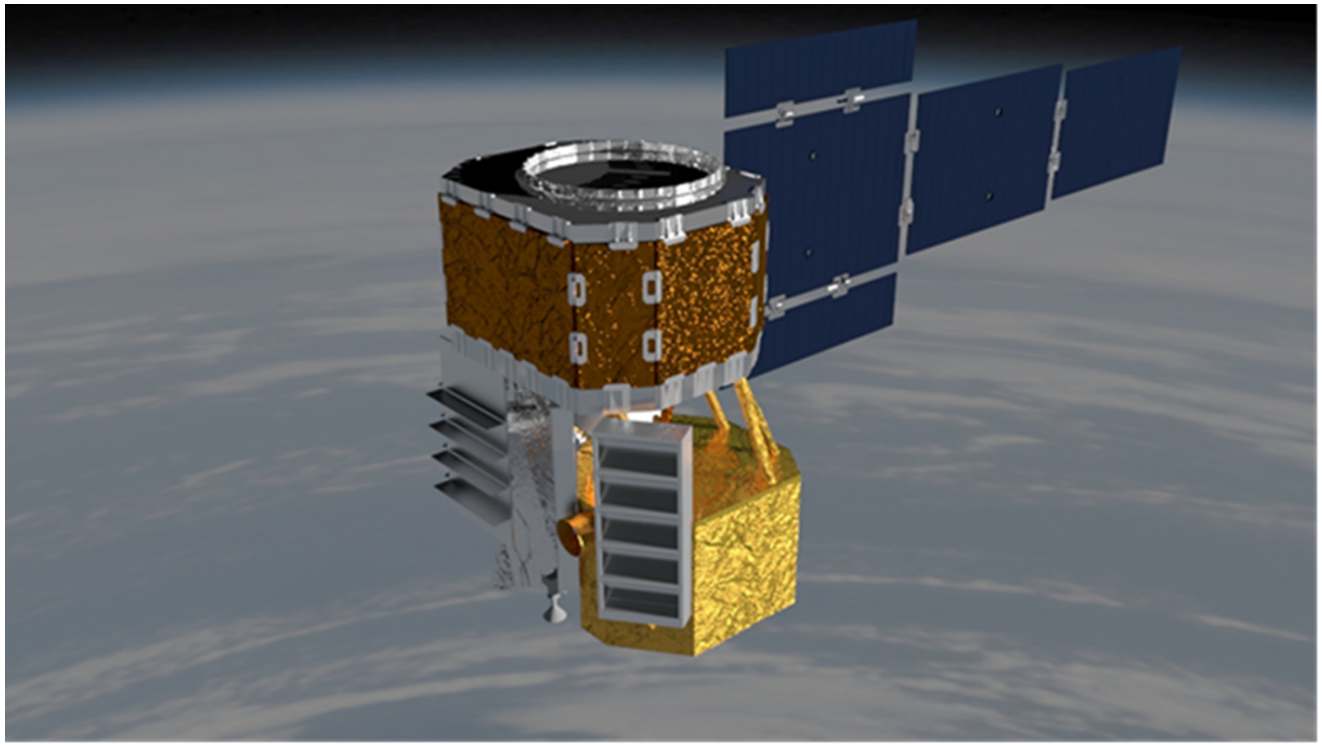
10th HysplRI Science and Applications Workshop

Overview and Update



Woody Turner and Ben Phillips

HysplRI Program Scientists

Earth Science Division

NASA Headquarters

October 17, 2017

HyspIRI Objectives and Approach

Key Global Science and Applications Research

Climate: Ecosystem biochemistry, condition & feedback; spectral albedo; carbon/dust on snow/ice; biomass burning; evapotranspiration

Ecosystems: *Global* biodiversity, plant functional types, physiological condition, and biochemistry including agricultural lands

Fires: Fuel status; fire frequency, severity, emissions, and patterns of recovery *globally*

Coral reef and coastal habitats: *Global* composition and status

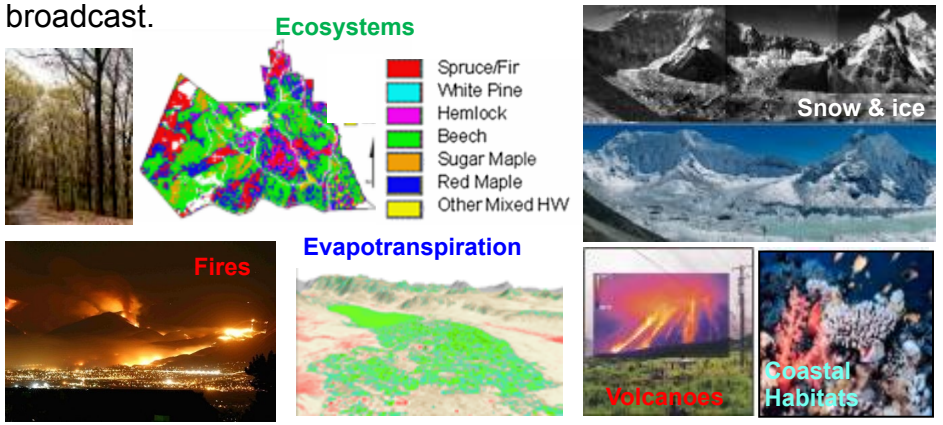
Volcanoes: Eruptions, emissions, regional and *global* impacts

Geology and resources: *Global* distributions of surface mineral resources and improved understanding of geology and related hazards

Applications: Disasters, EcoForecasting, Health/AQ, Water

Global Mission Urgency

The HyspIRI science and applications objectives are critical today and uniquely addressed by the combined imaging spectroscopy, thermal infrared measurements, and IPM direct broadcast.



Measurement

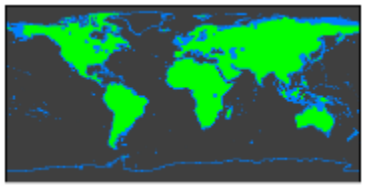
Imaging Spectrometer (VSWIR)

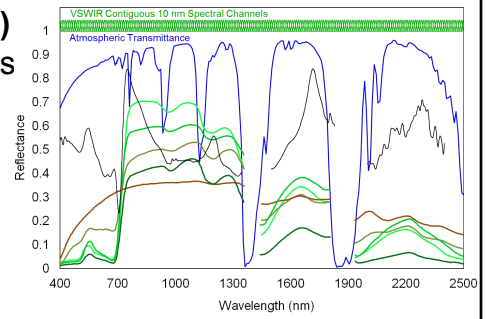
- 380 to 2510nm in ≤10nm bands
- 30 m spatial sampling
- 16 days revisit
- Global land and shallow water

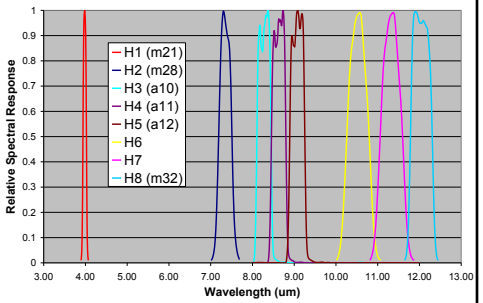
Thermal Infrared (TIR)

- 8 bands between 4-12 µm
- 60 m spatial sampling
- 5 days revisit; day/night
- Global land and shallow water

IPM-Low Latency data subsets







Mission Concept Status

Level 1 Measurement Requirements: Vetted by community at workshops and in literature (many refereed journal articles)

Payload: VSWIR Imaging Spectrometer, **TIR** Multi-spectral Radiometer, and **Intelligent Payload Module (IPM)**

Original 60 m option: Mature

ISS options: VSWIR & TIR Mature, ECOSTRESS EVI selected

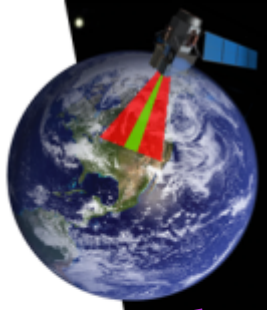
Separate Smallsat Mission option: VSWIR and TIR solutions developed with TEAM I/X

2016 Option: HyspIRI VSWIR evolved to 30 m and 16 day global revisit. Requires F/1.8 Dyson spectrometer architecture and other current technologies.

Preparatory Airborne Campaigns: Measurements used to advance and refine science, applications, algorithms, and processing

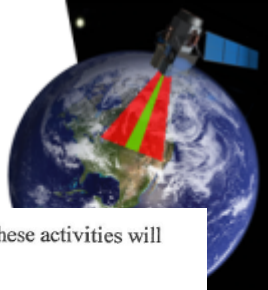
Current Decadal Survey: >25 HyspIRI-related Dec. Sur. RFIs

Workshop Overview



- **Tuesday**
  - *Overview of HyspIRI Mission Concept and Recent Airborne Campaigns*
  - *Science Talks across Disciplines (including results from airborne campaigns and Decadal Survey papers)*
- **Wednesday**
  - *Science Talks*
  - *Poster Session and AVIRIS-NG in India PI Meeting*
  - *ECOSTRESS Talks*
  - *Evening: Hawaii HyspIRI Preparatory Campaign PI Meeting*
- **Thursday**
  - *Talks on HyspIRI Data Product Generation and Product Calibration/Validation*
  - *Science Talks*
  - *Related Sensor Talks*
  - *Technology Development*

Guidance Through March 2018 (1/2)



National Aeronautics and Space Administration
Headquarters
Washington, DC 20546-0001

November 1, 2016

To: Program Executive, HyspIRI
Program Scientists, HyspIRI

From: Associate Director, Flight Programs, Earth Science Division

Subject: FY17 and FY18 Guidance for HyspIRI Study Team

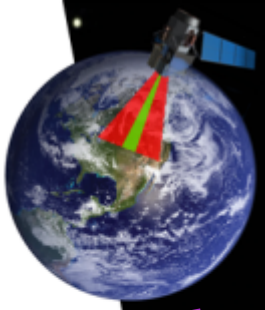
We have completed the review of the pre-formulation materials presented by the HyspIRI study team. The HyspIRI team has carefully addressed the guidance provided in FY16. Once again, excellent coordination is evident across all of the ESD program elements: ESTO, Research, Flight, and Applied Sciences as well as with the relevant research and applications communities outside NASA. The team continues to develop technology for a compact VSWIR Dyson spectrometer with a wide swath and a 30 m spatial resolution. Such a spectrometer would be suitable both for a HyspIRI risk reduction flight with significant science and applications value on the ISS or other platforms as well as a hyperspectral technology demonstration for Sustainable Land Imaging (SLI). Preparations for launch of the ECOSTRESS sensor to the ISS in 2018 continue to mature and reduce risk for the HyspIRI TIR element. Algorithm and cal/val techniques were advanced through the HyspIRI preparatory airborne campaign in California, with another campaign planned for early 2017 in Hawaii to focus on observations of coral reefs and volcanoes. Intelligent Payload Module (IPM) technology for the generation of onboard products and direct downlink of HyspIRI data was validated. In particular, the ability of the IPM to handle the required 3.9 Gbps output rate of the VSWIR for onboard processing with common low-end space-validated commercial processors was demonstrated. The team further demonstrated a 4.8 Gbps output rate, exceeding the requirement, which provides a cushion to include TIR data.

As noted previously, for a Tier II Decadal Survey mission, the HyspIRI concept is relatively mature and would address compelling research and applications needs within multiple Earth science disciplines; however, a dedicated HyspIRI mission is not in the near term program budget. ECOSTRESS will substantially further the TIR element of HyspIRI. The team should continue to pursue opportunities for flight of a compact VSWIR Dyson spectrometer on ISS or other platforms to advance the VSWIR imaging spectrometer element towards a mission with 30 m sampling and 16-day revisit. The team should also continue to focus on instrument evolution, onboard data pipeline efficiency and processing with the IPM, synthetic analyses of existing archives, data management, and science and applications data product development activities, along with alternate implementation options. These activities will reduce costs, lower risk, and grow the user community.

For FY17, the following guidance is given to the HyspIRI team.

1. Continue to build broad community understanding and support by conducting science and applications workshops, data product symposia, and other community fora.
2. Continue to conduct HyspIRI data product generation and benchmarking with airborne and satellite data.
3. Continue to carry out instrument mission trade studies, including smallsat and ISS opportunities, to provide lower cost and more adaptable instrument and/or mission approaches (including enhanced data throughput rates and the provision of advanced low latency products from the IPM to enable onboard real-time event monitoring) and risk reduction concepts.
4. Continue to explore options to ensure that the HyspIRI VSWIR and TIR instruments meet the SLI measurement requirements, including compatibility with heritage data product resolutions and new inter-sensor band synthesis methods.
5. Utilize the ECOSTRESS mission development for HyspIRI risk reduction.
6. Continue to engage potential international and domestic partners in addressing opportunities to lower the cost of a potential mission while maintaining Level 1 mission requirements, and strengthen synergies with upcoming NASA (e.g., PACE, GEO-CAPE) and international missions (e.g., EnMAP, Sentinels, Fluorescence Explorer).
7. Prepare materials, as necessary, updating the National Research Council's 2017 Earth Science Decadal Survey effort on the status and value of a HyspIRI mission and provide the NRC with options for accomplishing that mission.
8. Refine and update the HyspIRI comprehensive development report that documents and provides broad access for the NRC and other organizations to the work completed by the HyspIRI team.
9. Refine the capability of the Intelligent Payload Module (IPM) to generate science quality, low-latency products (atmospherically corrected and geolocated) onboard in near-real-time.
10. Mature capability for the additional TIR bands required for HyspIRI but not part of the ECOSTRESS instrument
11. Mature the detector engineering and on-board high-rate data compression required for the planned wide swath to allow for 16-day revisit and 30 m spatial sampling.

Guidance Through March 2018 (2/2)



HyspIRI

The FY17 approved budget for the HyspIRI mission is shown below, along with a preliminary budget for six months of FY18 funding. This budget assumes any remaining FY16 funding will continue to be used to support completion of FY16 tasks and planned FY17 activities. Final FY18 funding levels for the first six months of FY18 will take into consideration unobligated and uncosted funds as of September 30, 2017. Funding beyond the initial FY18 increment will be informed by the anticipated 2017 NRC Earth Science Decadal Survey. The HyspIRI team should submit an annual budget plan by Center to the ESM Program office by November 30, and should work with the program office to prepare a quarterly cost phasing plan for FY17 by December 16, 2016. Additional guidance on the FY18 funding, will be provided by September 30, 2017.

HyspIRI	**FY16**	**FY17**	**FY18**
	Total	Total	Total
$K	2,360	2,600	1,300

If the HyspIRI team concludes that the FY17 guidance given above cannot be accomplished within the total approved FY17 funding, they may submit a reclama within 45 days of receipt of this guidance. This reclama should use the FY17 cost phasing plans to show the approved FY17 funding is insufficient to support the work approved in this guidance letter.

Please contact Eric Ianson if you require clarification of this guidance.

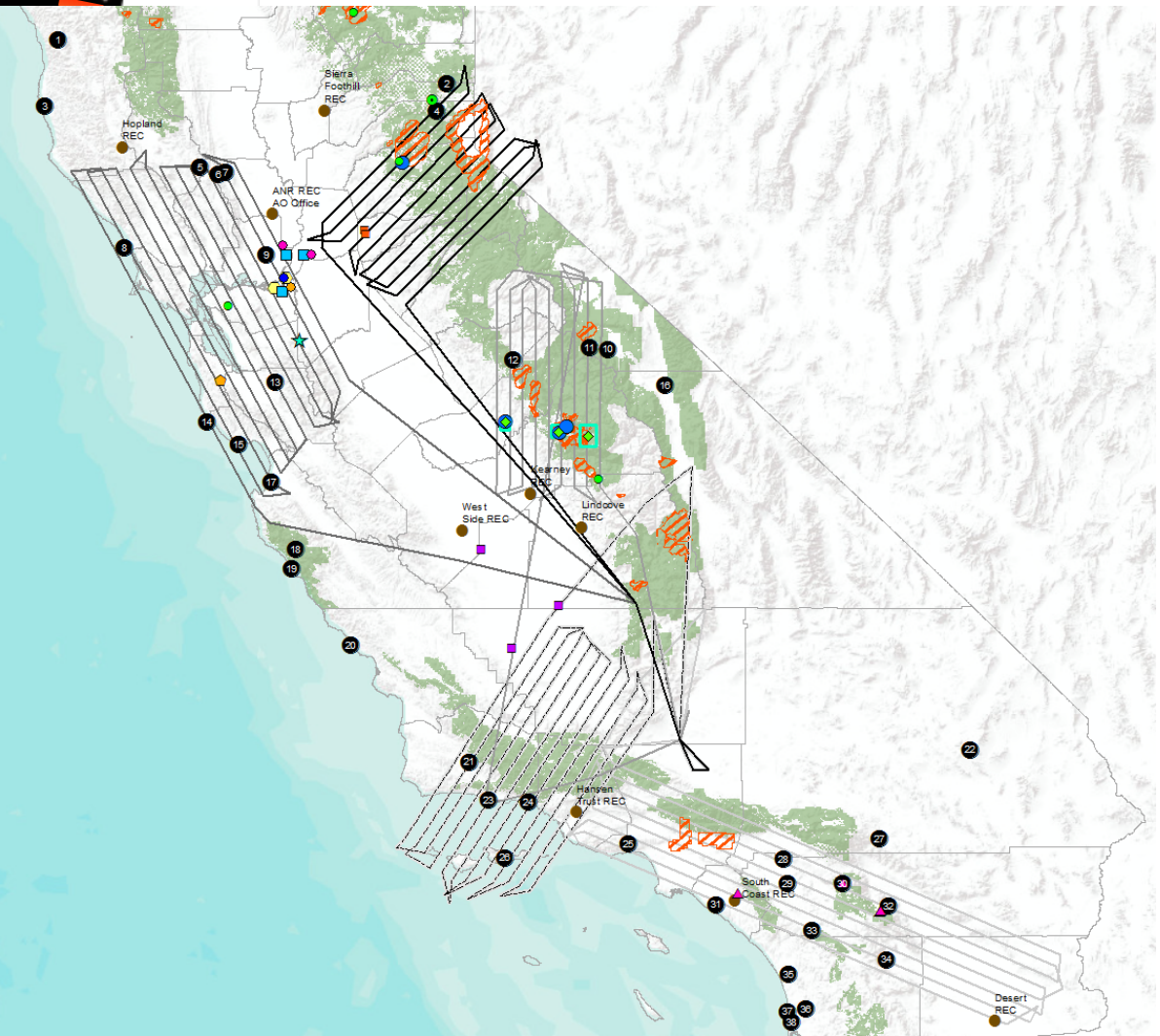
Eric E. Ianson

HysplRI Airborne Preparatory Mission

3 Seasonal Flights Over 5 Boxes/Soda Straw in 2013, 2014, 2015

To Simulate HysplRI Satellite Imagery - **Plus Summer 2016 & 2017!**

ER-2	*AVIRIS*	*AVIRIS*	*MASTER*	*MASTER*
Altitude	*Resolution*	*Swath*	*Resolution*	*Swath*
65,000 ft	*20 m*	*12 km*	*50 m*	*35 km*

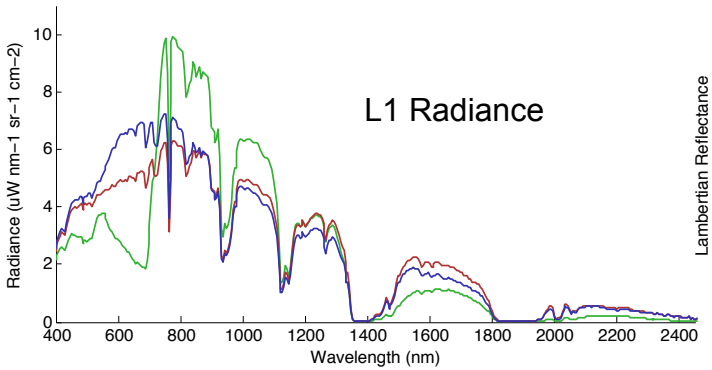


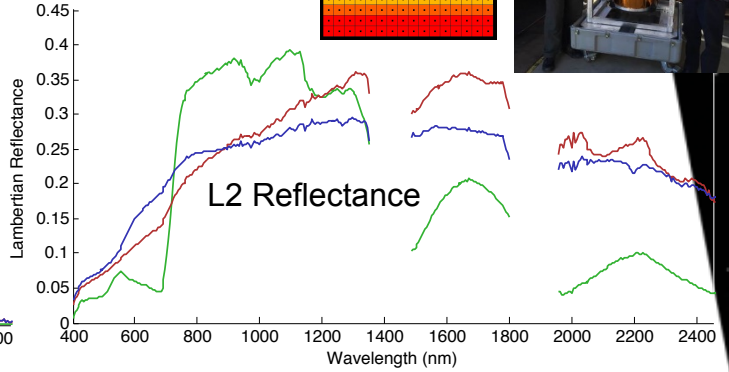
PI TEAM:
- Wendy Calvin/University of Nevada - Reno
- Matthew Clark/Sonoma State University
- Bo-Cai Gao/Naval Research Laboratory
- Bernard Hubbard/U. S. Geological Survey
- Darrel Jenerette/University of California, Riverside
- Thomas Kampe/NEON
- Raphael Kudela/University of California, Santa Cruz
- Ira Leifer/University of California, Santa Barbara
- Dongdong Wang/University of Maryland
- Paul Moorcroft/Harvard University
- Dar Roberts/University of California, Santa Barbara
- Philip Townsend/University of Wisconsin-Madison
- Susan Ustin/University of California, Davis
- Jan van Aardt/Rochester Institute of Technology

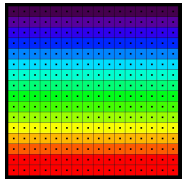
Joint ISRO and NASA AVIRIS-NG Campaign

- AVIRIS-NG measurements acquired for all 57 planned phase I sites (2015/16)
- Measurements calibrated to radiance, atmospherically corrected, and delivered to NASA and ISRO
- Phase 2 campaign – January to April 2018

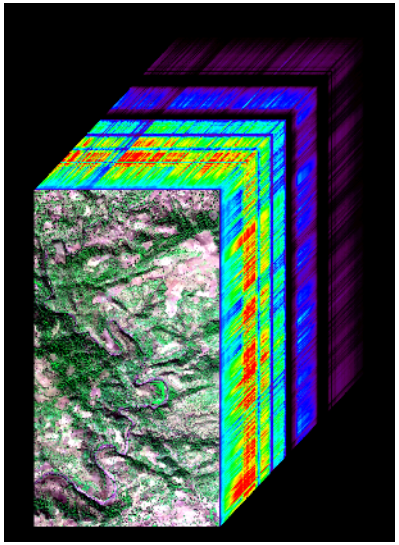
Example Spectroscopic Quality from Joint Campaign



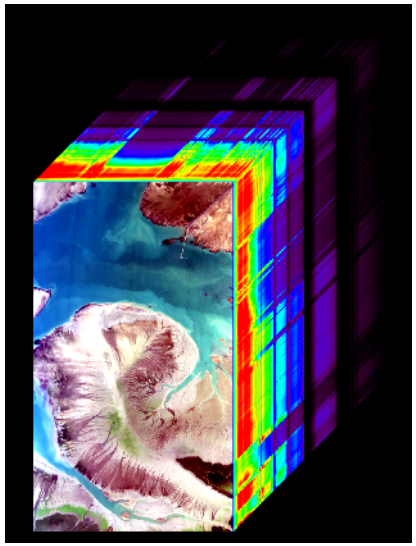




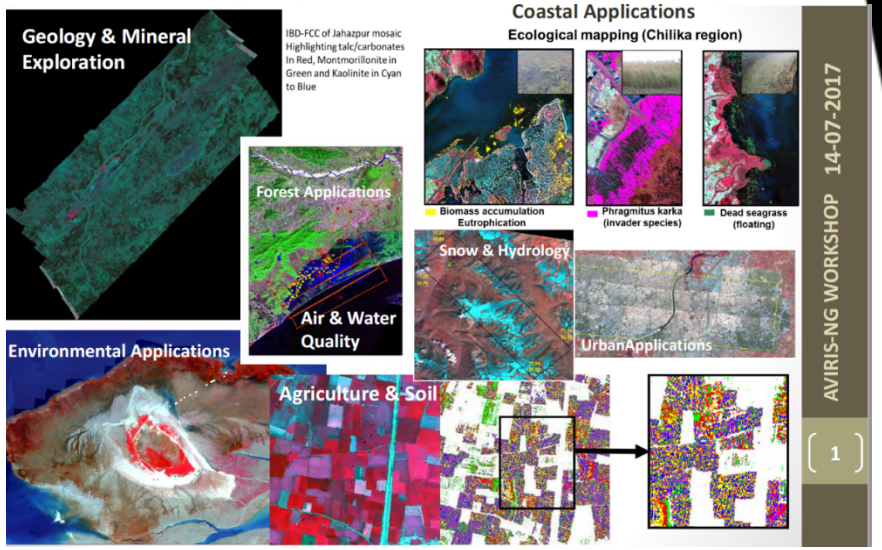
Forestry: Shoolpaneshwar, Gujarat



Costal Ocean: Pirotan



Early Results from 2015/16 Campaign



NASA AVIRIS-NG India Investigations

	Thomas Painter	Spatial Dynamics of Grain Size, Radiative Forcing by Impurities, and Spectral Albedo from AVIRIS-NG Data in the Indian Himalaya	Jet Propulsion Laboratory	thomas.painter@jpl.nasa.gov
	David Thompson	Improving Atmospheric Correction across the Indian Subcontinent	Jet Propulsion Laboratory	david.r.thompson@jpl.nasa.gov
	Margarita Huesca Martinez	Biodiversity assessment along a moisture gradient in tropical deciduous forests in India using AVIRIS-NG data	University of California, Davis	mhuescamartinez@ucdavis.edu
	Bruce Kindel	The quantification and analyses of AVIRIS-India aerosol atmospheric correction.	University of Colorado, Boulder	kindel@lasp.colorado.edu
	Philip Townsend	Vegetation functional amplitudes along a rainfall gradient in Indian ecosystems using AVIRIS-NG	University of Wisconsin, Madison	ptownsend@wisc.edu
	William Farrand	Using AVIRIS-NG Data to Assess the Role of Mining Activities in Affecting Water Quality in Gujarat and Rajasthan, India	Space Science Institute	farrand@spacescience.org
	Bo-Cai Gao	Use of AVIRISng Data Collected from the Airborne Campaign in India for the Study of Inland Lake, River, and Coastal Waters	Naval Research Lab	gao@nrl.navy.mil
	Sakthi Kumaran Subburayalu	Using AVIRIS Imagery to Map Spatial Variability of Soil Carbon Across Diverse Agricultural Management Systems	(Ohio State University) now Central State University	ssubburayalu@centralstate.edu
	Philip Dennison	Improved Trace Gas Plume Detection using Indian and US AVIRIS-NG Data	University of Utah, Salt Lake City	dennison@geog.utah.ed
	Snehamoy Chatterjee	Minerals and rock type mapping using Airborne Visible/ Infrared Imaging Spectrometer-Next Generation (AVIRIS-NG) data	Michigan Tech	schatte1@mtu.edu

Collaborations with India investigators in work.
All investigators have the L1 and L2.

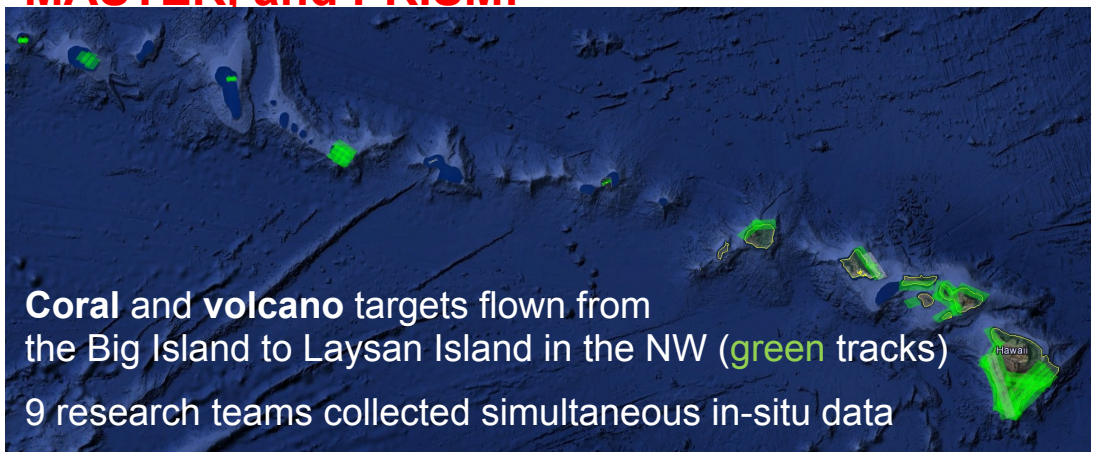
AVIRIS-NG SCIENCE MEET, SAC-ISRO,AHMEDABAD

12th -14th July 2017

HyspIRI Hawaii Preparatory Airborne Campaign

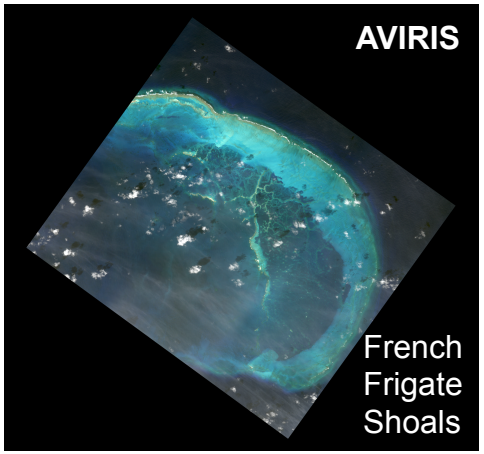
January 19 – March 3, 2017

- **AVIRIS-C & MASTER aboard the ER-2 Aircraft c**ollected data informing **coral reef condition** and **volcanic activity for 11 investigations**
- Overlap with **EV-S CORAL campaign** carrying the PRISM spectrometer
- **ER-2 returning to HI for one month January 2018 with AVIRIS-C, HyTES, MASTER, and PRISM!**



Coral and **volcano** targets flown from the Big Island to Laysan Island in the NW (green tracks)

9 research teams collected simultaneous in-situ data



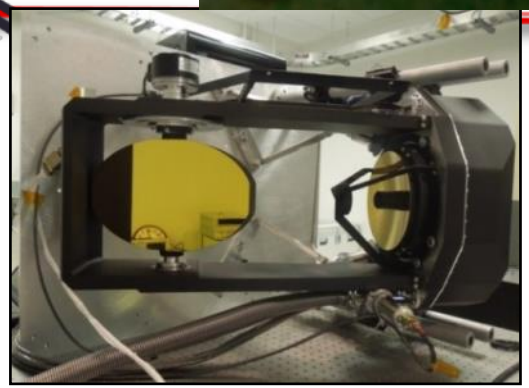
Successful media day yielded Front page *Star Advertiser* feature story, Facebook Live Stream (315,000 views), Local ABC (KITV) Article, and *Scientific American* Article

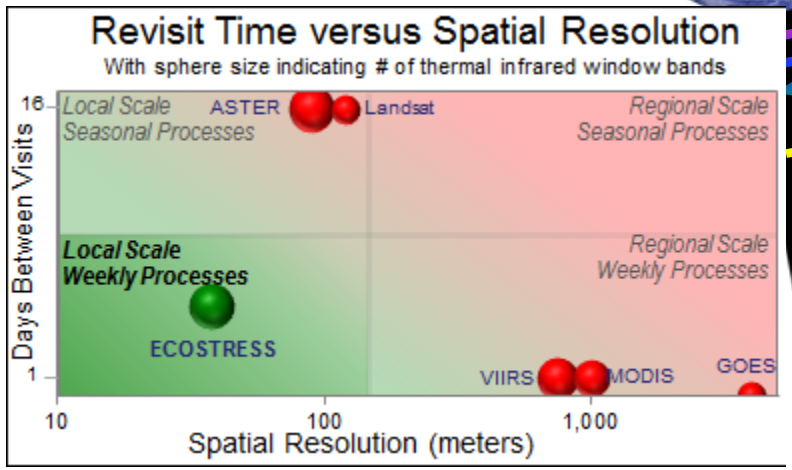
STUDYING EARTH FROM ABOVE

Scientists are investigating Hawaii's volcanoes and reefs as part of NASA's study of the planet

HONOLULU Star-Advertiser

ECOSTRESS

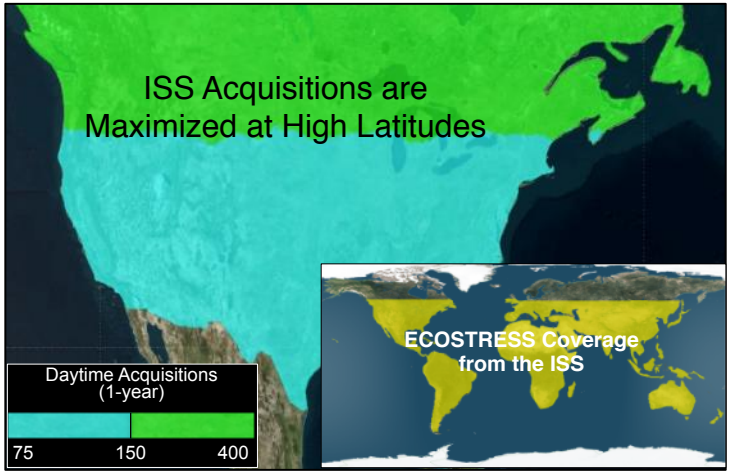




HyspIRI

Mission

- Class D $30M cost cap
- 31-months from project start to delivery
- JPL implementation and management
- 69-month project duration (Phase A-F)
- On ISS-JEMS Module
- 12-month Science Operations (Phase E)

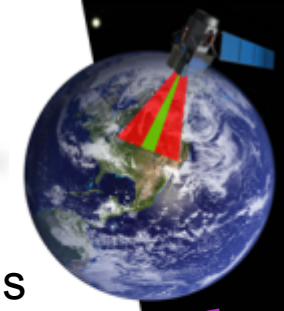


The inclined, precessing ISS orbit enables ECOSTRESS to sample the diurnal cycle in critical regions across the globe at spatiotemporal scales missed by current instruments in Sun-synchronous polar and high-altitude geostationary orbits.

Instrument

- Leverages functionally-tested PHyTIR space-ready hardware developed under the NASA Instrument Incubator Program:
  - Spectral resolution: 5 bands in the thermal infrared window (8-12.5 µm) part of the electromagnetic spectrum
  - Noise equivalent delta temperature: ≤ 0.2 K
  - Spatial resolution: 39 m x 68 m
  - Swath width: 384 km (51°)
- *Well understood measurement and algorithms based on prior missions, such as ASTER, MODIS, and Landsat*

Critical Take Aways



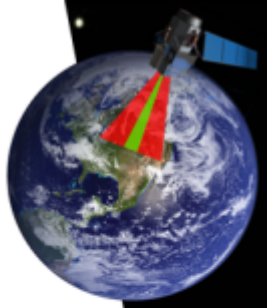
- HyspIRI-enabled science and applications are unique and urgent in this period of rapid global change.

- The technologies are ready for HyspIRI now.
  - ECOSTRESS is maturing the TIR capability for a subset of HyspIRI-TIR bands.
  - The F/1.8 VSWIR-Dyson is maturing the VSWIR solution for 30m and 16-day revisit.
  - The IPM is lowering mission management and data management barriers.

- We await the release of the 2017 NRC Decadal Survey.

- There are potential international partnership opportunities at multiple levels.

- The JPL and GSFC HyspIRI Mission Concept team has performed exceptionally well. The team is committed to supporting NASA in the future, as appropriate, to achieve the HyspIRI science and applications research objectives.



HyspIRI

THANK YOU