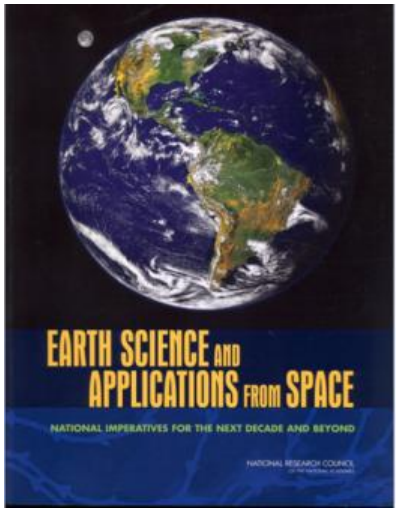
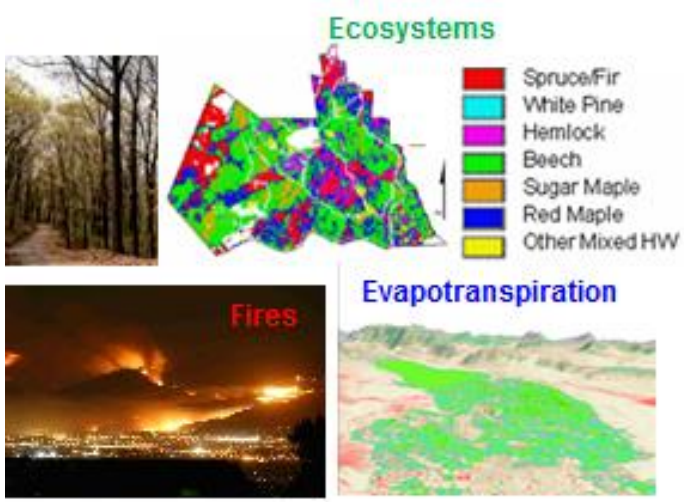
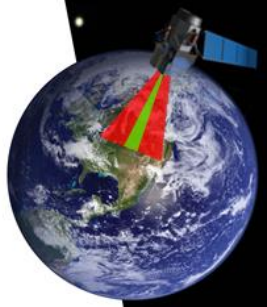
HyspIRI Preparatory Airborne Campaign
and
30 m, 185 km
VSWIR Dyson





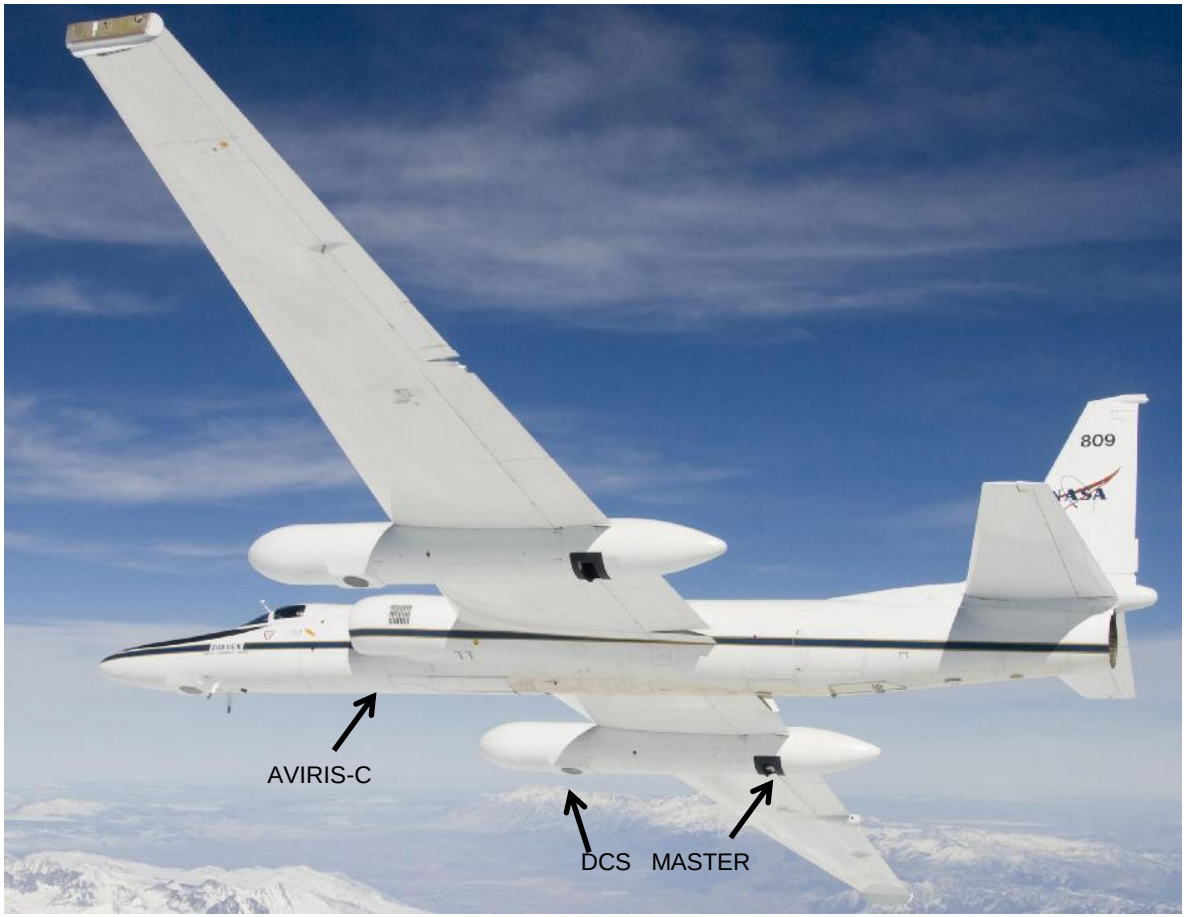
Robert O. Green and The HyspIRI Team



Current Preparatory Airborne Campaign

HyspIRI Configuration on ER-2

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

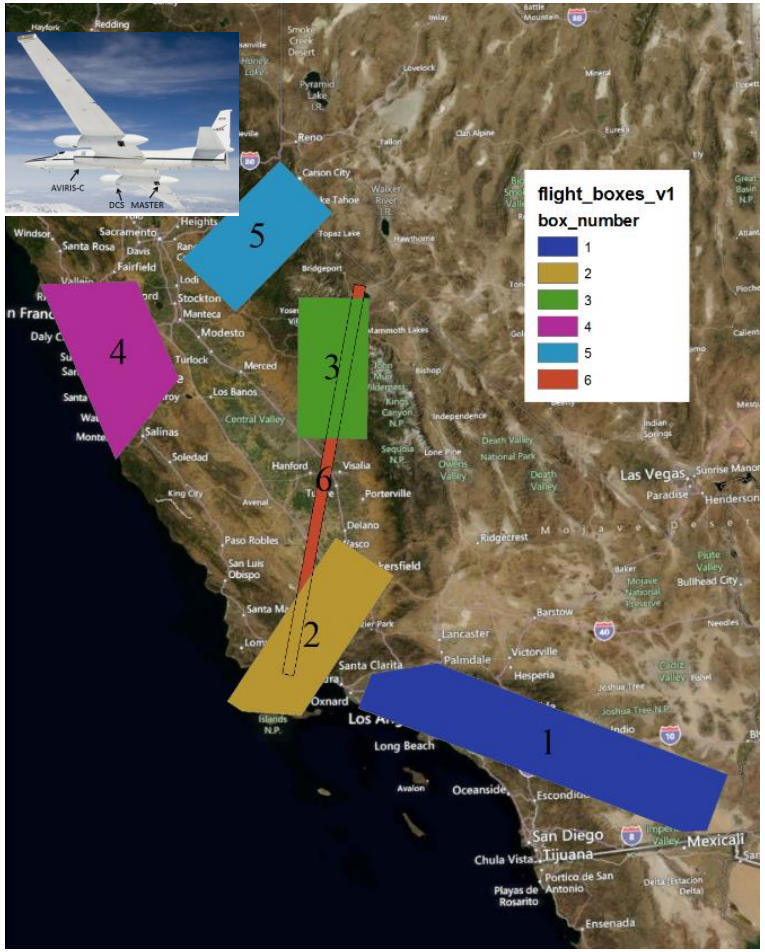


AVIRIS (VSWIR)
- 10 nm spectral resolution
- 224 bands
- 380 2510 nm
- 1 mrad IFOV
- 34 degree FOV

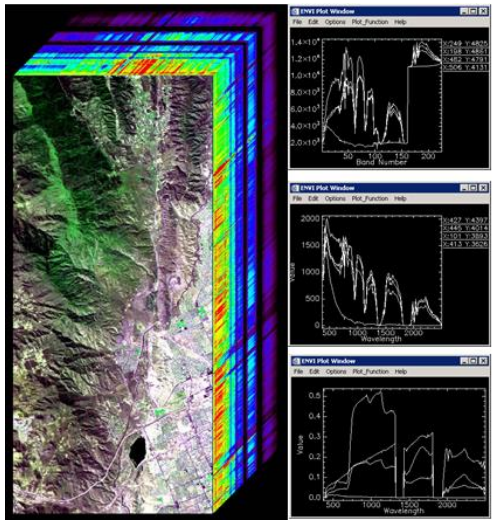
MASTER (TIR)
- 50 bands
- 0.4-13 um
- 2.5 mrad IFOV
- 85.92 degrees FOV

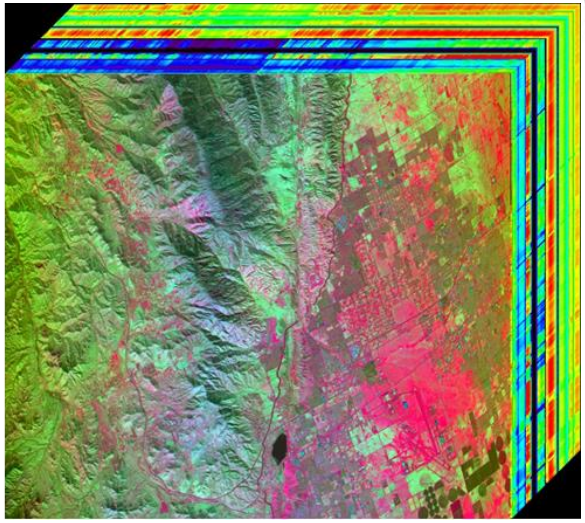
Finishing Western US High Diversity HyspIRI Preparatory Airborne Campaign

- Campaign
  - *science team with 14 PIs*
  - *Delivered Level 1 and Level 2 data products*
- Ecosystems, Seasonal, Climate, Coastal, Urban, Resources
- 6 zones, 3 seasons, 3 years

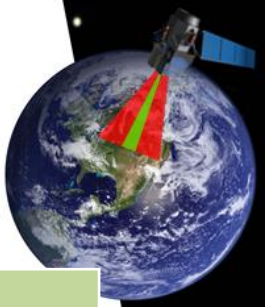


- Objective: Advance HyspIRI Mission Science and Algorithm Readiness
  - *Ecosystem composition, function, biochemistry, seasonality, structure, and modeling*
  - *Coastal ocean phytoplankton functional types, habitat*
  - *Urban land cover, temperature, transpiration*
  - *Surface energy balance*
  - *Atmospheric characterization and local methane sources*
  - *Surface geology, resources, soils, hazards*





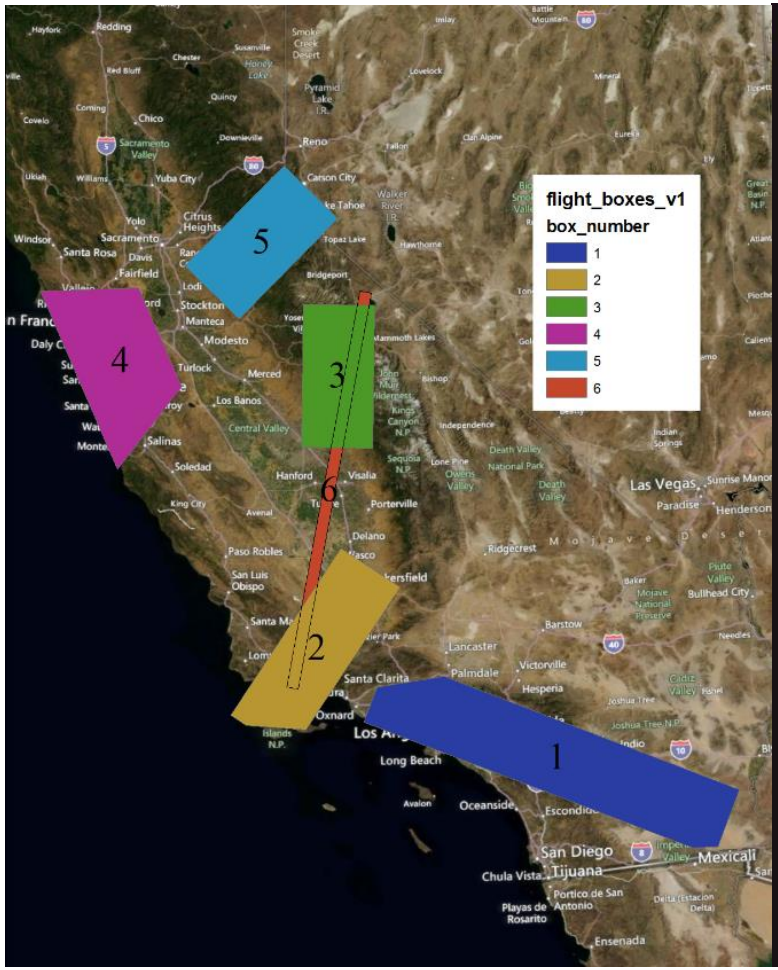
Western US 14 Investigations

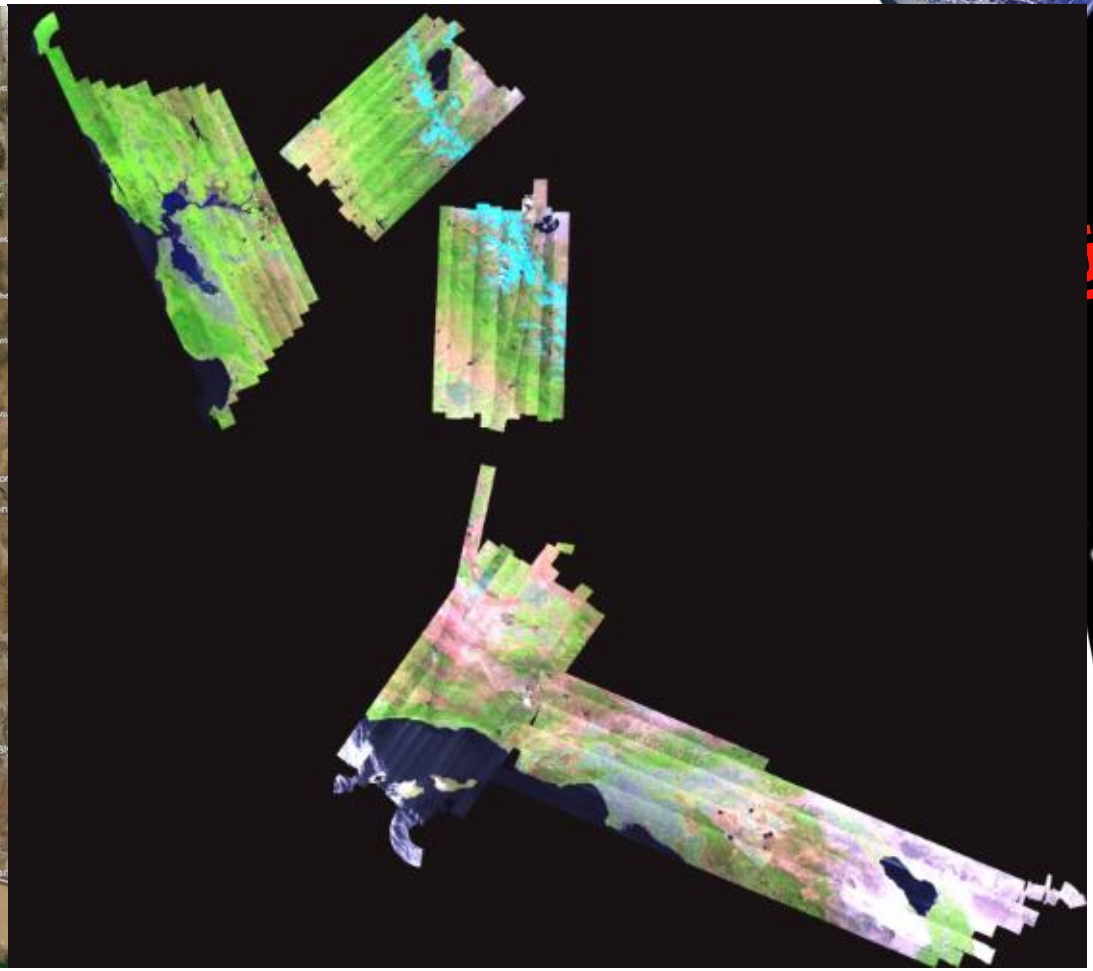


HyspIRI

PI	Organization	Investigation
Paul Moorcroft	Harvard	Linking Terrestrial **Biosphere Models** with Imaging Spectrometry Measurements of Ecosystem Composition, Structure, and Function
Dar Roberts	UC Santa Barbara	HyspIRI discrimination of **plant species** and functional types along a strong environmental-temperature gradient
Philip Townsend	UWI	Measurement of **ecosystem metabolism** across climatic and vegetation gradients in California for the 2013-2014 NASA AVIRIS/MASTER airborne campaign
Susan Ustin	UC Davis	Identification of **Plant Functional Types** By Characterization of Canopy Chemistry Using an Automated Advanced Canopy Radiative Transfer Model
Matthew Clark	Sonoma State	Spectral and temporal discrimination of **vegetation cover** across California with simulated HyspIRI imagery
Bo-Cai Gao	NRL	Characterization and **Atmospheric Corrections** to the AVIRIS-Classic and AVIRISng Data to Support the HyspIRI Preparatory Airborne Activities
Bernard Hubbard	USGS	Using simulated HyspIRI data **for soil mineral mapping**, relative dating and flood hazard assessment of alluvial fans in the Salton Sea basin, Southern California
George Darrel Jenerette	UC Riverside	Assessing Relationships Between **Urban Land Cover, Surface Temperature, and Transpiration** Along a Coastal to Desert Climate Gradient
Thomas Kampe	NEON	Synergistic high-resolution airborne measurements of ecosystem structure and process at **NEON** sites in California
Raphael Kudela	UC Santa Cruz	Using HyspIRI at the Land/Sea Interface to Identify **Phytoplankton Functional Types**
Ira Leifer	Bubbleology	Hyperspectral imaging spectroscopic investigation of California natural and anthropogenic fossil **methane** emissions in the short-wave and thermal infrared
Shunlin Liang	UMD	Characterizing **surface energy budget** of different surface types under varying climatic conditions from AVIRIS and MASTER data
Jan van Aardt	RIT	Investigating the impact of spatially-explicit **sub-pixel structural variation** on the assessment of vegetation structure from HyspIRI data
Wendy Calvin	UNV	**Energy and Mineral Resources**: Surface composition mapping that identifies resources and the changes and impacts associated with their development

Western US Finishing 2015



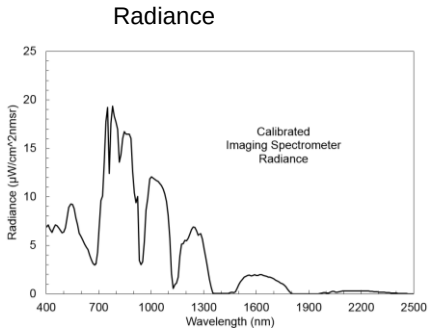


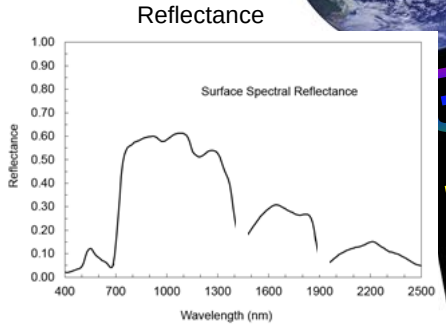
3 Seasons in 2013, 3 Seasons in 2014, Staring 2015

Data is Available

Download AVIRIS-CL data using the AVIRIS Flight Locator Tool. http://aviris.jpl.nasa.gov/alt_locator/

AVIRIS Classic Data Volumes by Year			
Flight Year	**L0 (GB)**	**L1B (GB)**	**L2 (GB)**
2010	1700	2669	-
2011	1769	2117	-
2012	331	318	-
2013	1498	1566	912
2014	1265	3630	844
Total (GB)	**18377**	**19013**	**1756**
Total (TB)	**17.9 TB**	**18.6 TB**	**1.71 TB**





2006-2014 AVIRIS Flight Locator Tool

SEARCH DATA

Attribute Filter

Conditional Filters: (•) Thresholds ( ) Text Search

Year	2006	AND Year	2014		
Month	1	AND Month	12		
Day	1	AND Day	31		
Run	1	AND Run	40		
PixelSize	0.6	AND PixelSize	19.4		
Rotation	-90	AND Rotation	90		
Solar_Elev	0	AND Solar_Elev	90		
Solar_Azimuth	0	AND Solar_Azimuth	360		

Pixel size unit is meters. Rotation, Solar Elevation, and Solar Azimuth are degrees.

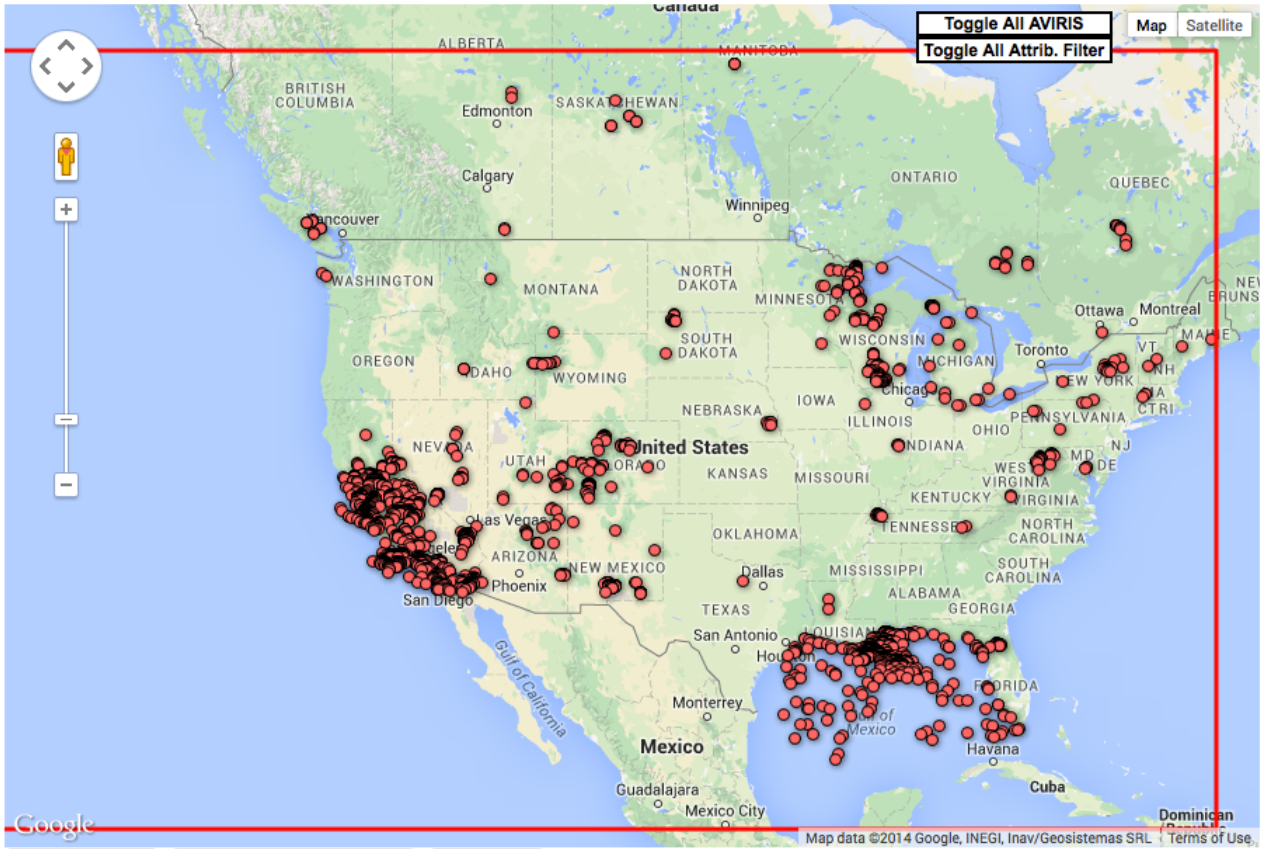
Spatial Filter

Enter WGS-84 Latitude and Longitude in Decimal Degrees Format, e.g. Latitude=34.86 and Longitude=-125.94 (West negative).
- Then click **Images** or **Map** button under *View Results* below.

(•) NONE
( ) RECTANGLE: (Select on Google Earth)
(Upper Left) Latitude= Longitude=
(Lower Right) Latitude= Longitude=

VIEW RESULTS

Image Display 10% Images | Small Map HELP



Proposed 2015 AGU Special Session

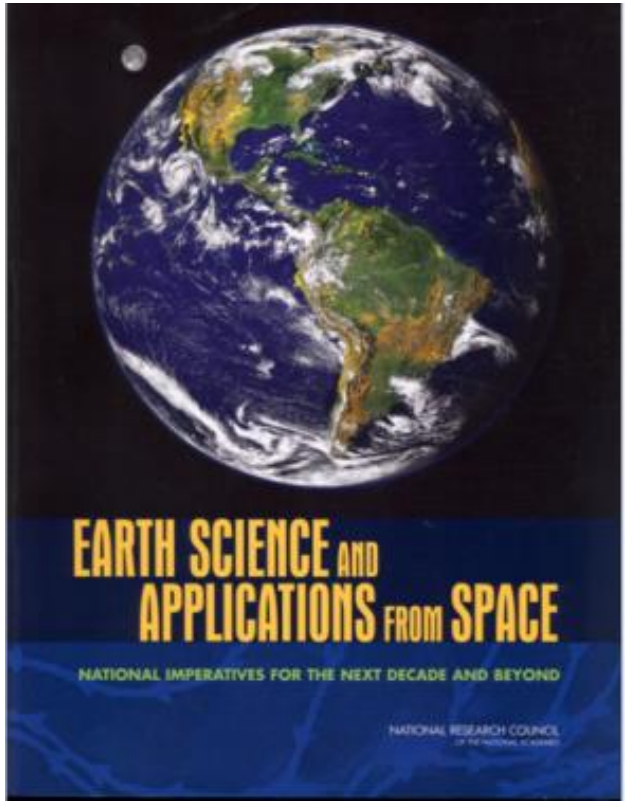
Research Results from the Multi-Season, Multi-Year Western U.S. NASA Remote Measurement Science Campaign

In order to quantify ecosystem characteristics, composition and dynamics with measurements from the visible through thermal infrared. NASA has conducted a multi-season, multi-year science campaign over 6 large regions of the western United States in preparation for the future HyspIRI Mission. Full visible through short wavelength infrared imaging spectroscopy as well as thermal infrared images have been acquired. These data capture diverse surface types including the coastal zone, mountains, forests, deserts, agriculture, urban areas. Results span: ecosystem composition, function, biochemistry, seasonality, and modeling; coastal ocean phytoplankton functional types; urban land cover, temperature, evapotranspiration; surface energy balance; atmospheric characterization and local methane sources; surface geology, resources, soils, and hazards. The campaign captured the onset of the most severe draught in California's history and includes the Rim and King fire impact zones. These data have already been used in post-fire mitigation, providing an early demonstration of the measurements' great value for basic and applied sciences.

2016 HyspIRI Preparatory Airborne Campaign Continued: Volcanoes & Coral Reefs

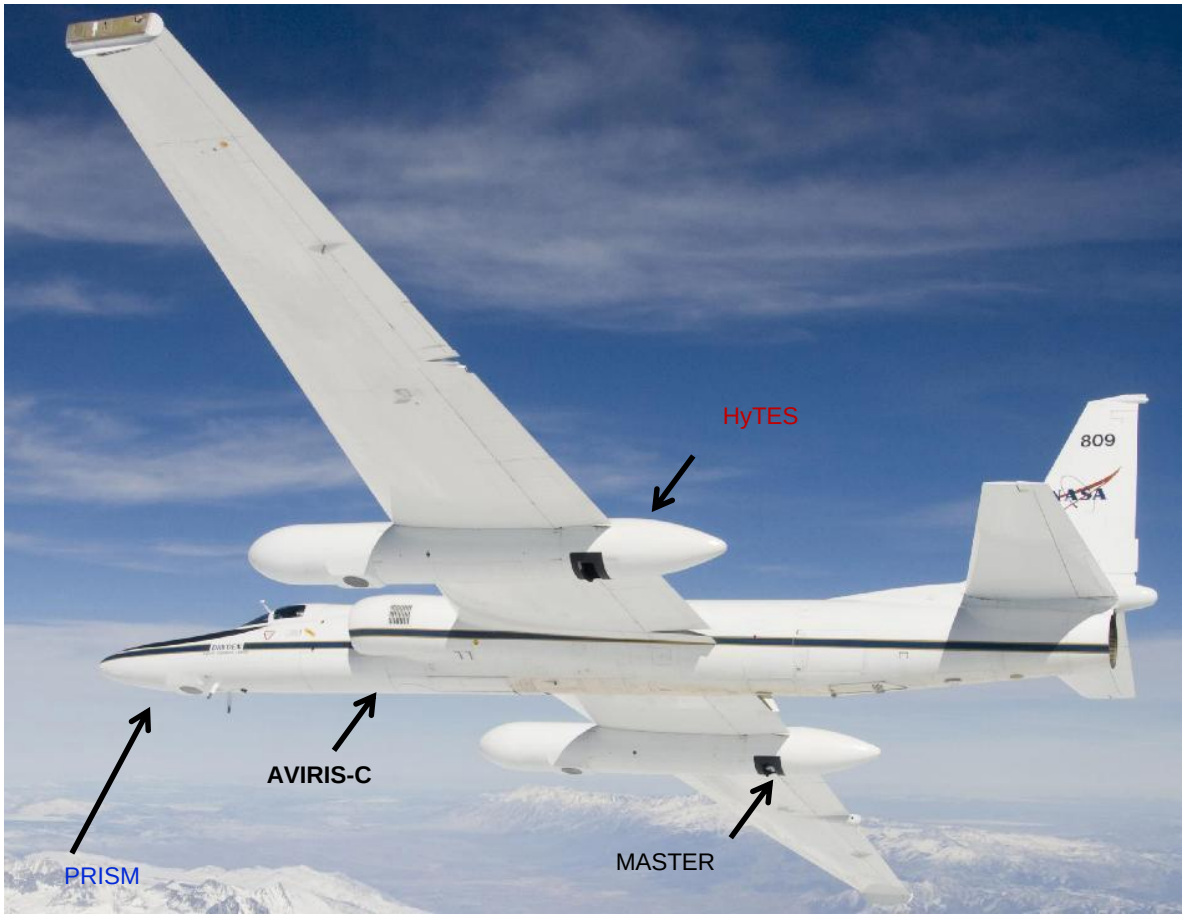
Robert O. Green and the HyspIRI Team

Coral Reefs and Volcanoes Identified in Decadal Survey as Key Elements of of HyspIRI



HyspIRI Configuration on ER-2 for Hawaii PLUS possible PRISM and HyTES

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



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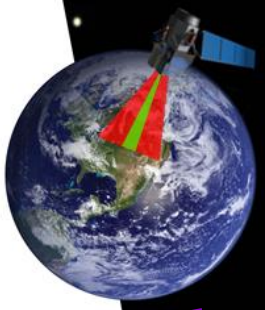
2016 Volcanoes and Coral Reef Campaign



- A.45 HYSPIRI PREPARATORY AIRBORNE ACTIVITIES AND ASSOCIATED SCIENCE: CORAL REEF AND VOLCANO RESEARCH

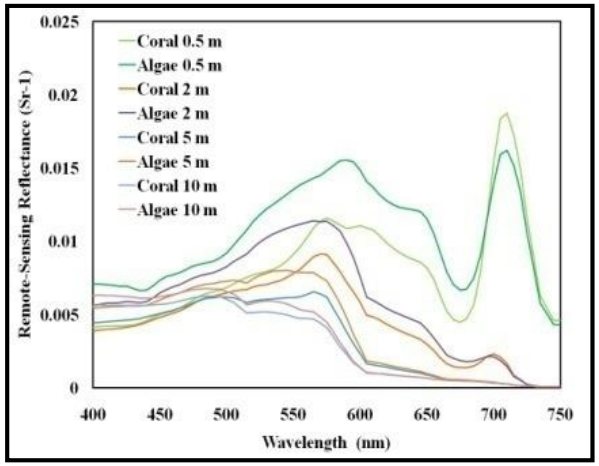
- This NASA ROSES element is soliciting proposals for volcano and coral reef research resulting from a single campaign of flights in 2016 to the Hawaiian Islands by the ER-2 aircraft carrying the AVIRIS and MASTER instruments. For the purposes of this solicitation, Hawaiian Islands extends from the Big Island of Hawaii through the Northwestern Hawaiian Islands or Leeward Islands to Kure Atoll.

- NASA anticipates the potential of using this planned campaign to evaluate further the performance and utility of a new generation of airborne spectrometers. These are the Hyperspectral Thermal Emission Spectrometer (HyTES) and the Portable Remote Imaging Spectrometer (PRISM)

Hawaii Preparatory Opportunity

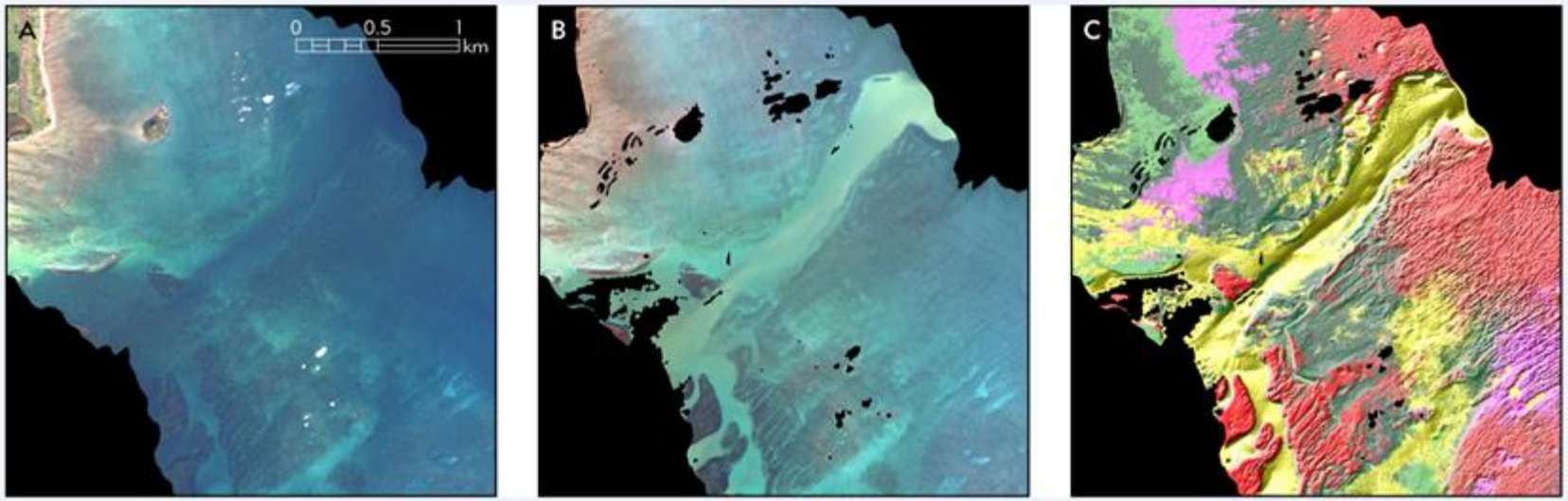
HyspIRI

Previous Shallow Water Spectroscopy Corals

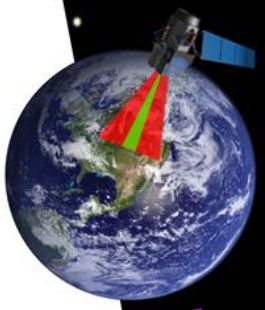


- Composition
- Condition
- Productivity
- Bathymetry
- Water quality

AVIRIS Image of Kaneohe Bay, HI
Classification of the bottom of coastal zones and coral reef types



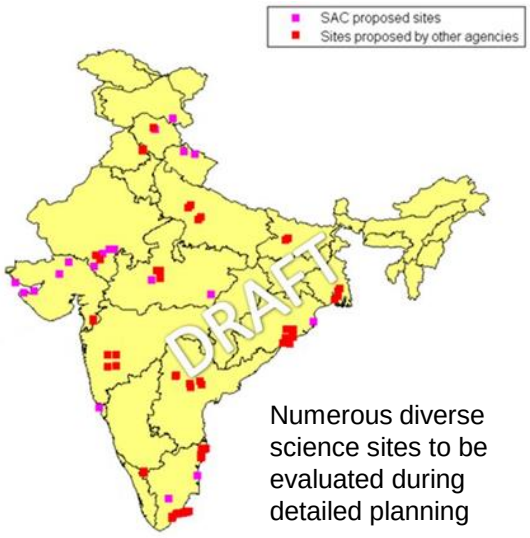
Summary



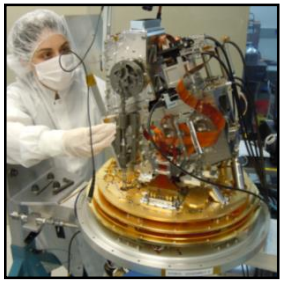
HyspIRI

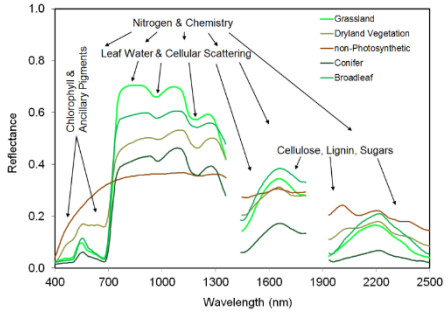
- Planning to have a Science Team Announced by the end of September 2015
- 1st Science Team Meeting at October Workshop
- Flights in 2016 plan refined by Science Team
- All data products available
- **Future Possible India Deployment of AVIRIS-NG for Asia Environments**

AVIRIS-NG NASA and ISRO Airborne Campaign in India

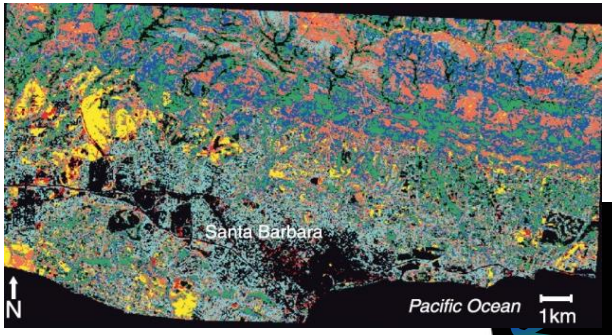


Numerous diverse science sites to be evaluated during detailed planning

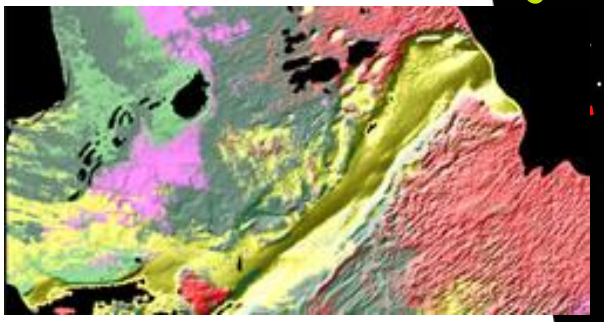




Ecosystem and Agriculture

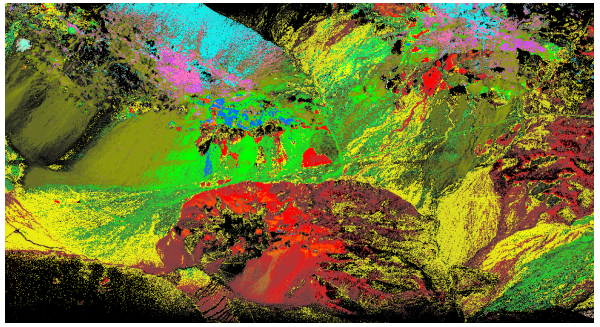


Asian Coastal Waters & Coral



Dust and Black Carbon on Snow & Ice

New geological regimes



- This airborne campaign would provide the <u>first of their kind</u> high fidelity imaging spectroscopy measurement of a diverse set of <u>Asian environments</u> for NASA
- This campaign would enable new scientific and applications research in these unique environments
  - *Natural ecosystems (Humid, Temperate, Dry)*
  - *Water resources: Snow and Ice (Dust and black carbon)*
  - *Geology and Natural Hazards (floods, droughts, fire …)*
  - *Coastal and inland waters, Coral reefs*
  - *Agricultural lands and Urban areas*
- This campaign builds upon the current plan for AVIRIS-NG to fly on a US B-200 aircraft in 2015 (and ER-2 in 2016)

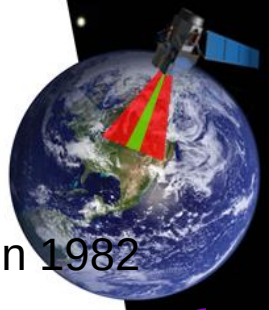
India B200 Aircraft with Port

Evolved HyspIRI
VSWIR Imaging Spectrometer

Following Guidance from HQ

185 km Swath and 30 m Sampling

Imaging Spectrometers & Advancements



HyspIRI

1982

- First Imaging Spectrometer AIS proposed in 1979 first flights in 1982

1986

- AVIRIS imaging spectrometer > 700 refereed journal articles

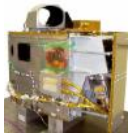
1989

- NIMS imaging spectrometer to Jupiter

1997

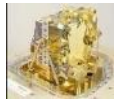
- VIMS imaging spectrometer to Saturn

2000



1998

- MICAS Miniature Integrated Camera and Imaging Spectrometer to Com



2005

- Enabling partner in Hyperion-Earth, CRISM-Mars and ARTEMIS-Earth imaging spectrometers (gratings, designs, calibration, science)

2009

2008

- Proposed and Developed NASA Moon Mineralogy Mapper (M3)

24 Months

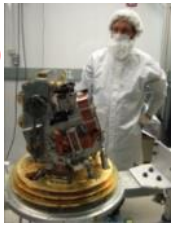
- > 7 Airborne/Rover-type Imaging Spectrometer operating at cryogenic temperature and in a vacuum (2005-2014)

MaRS 2005

24 Months

24 Months

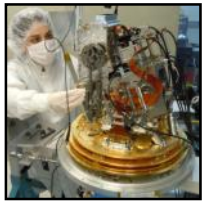
CAO 2010



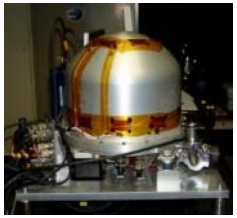
< 18 Months

MSS 2011

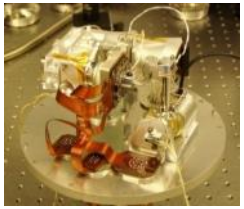
AVIRIS-NG 2012



PRISM 2012



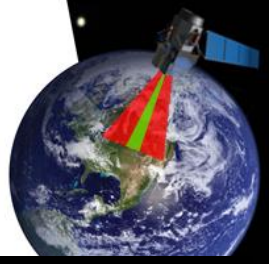
UCIS 2013

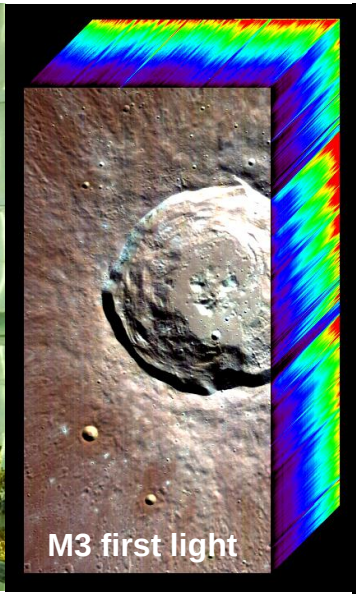


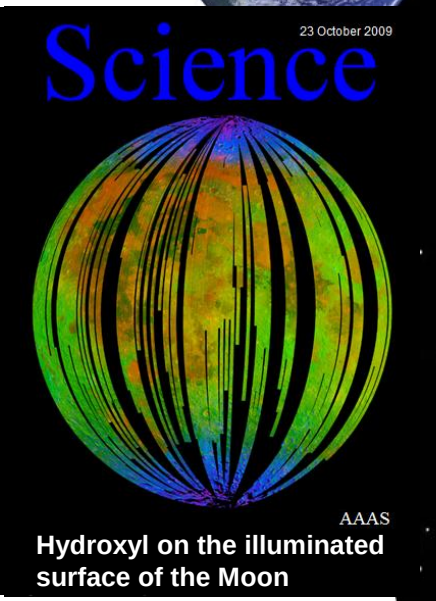
ESWIRS 2014

CWIS 2015

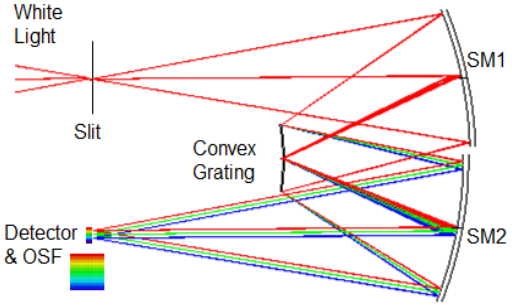
A key Technology Investment Area



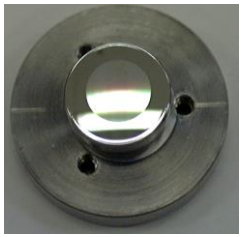
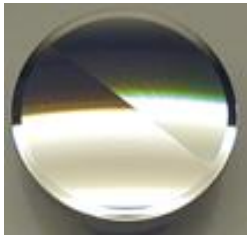
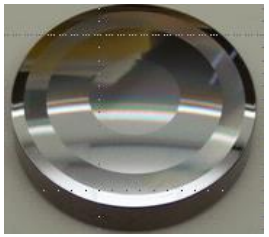
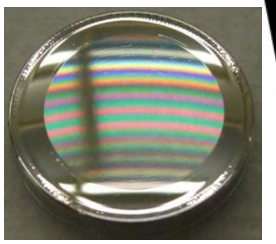
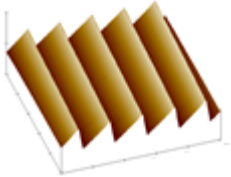
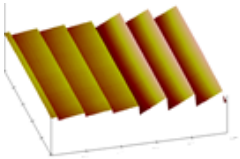
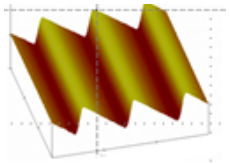
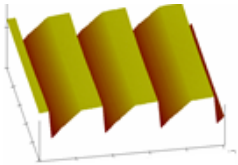
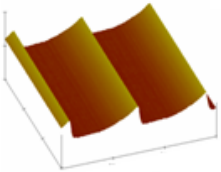




JPL Offner Imaging Spectrometer

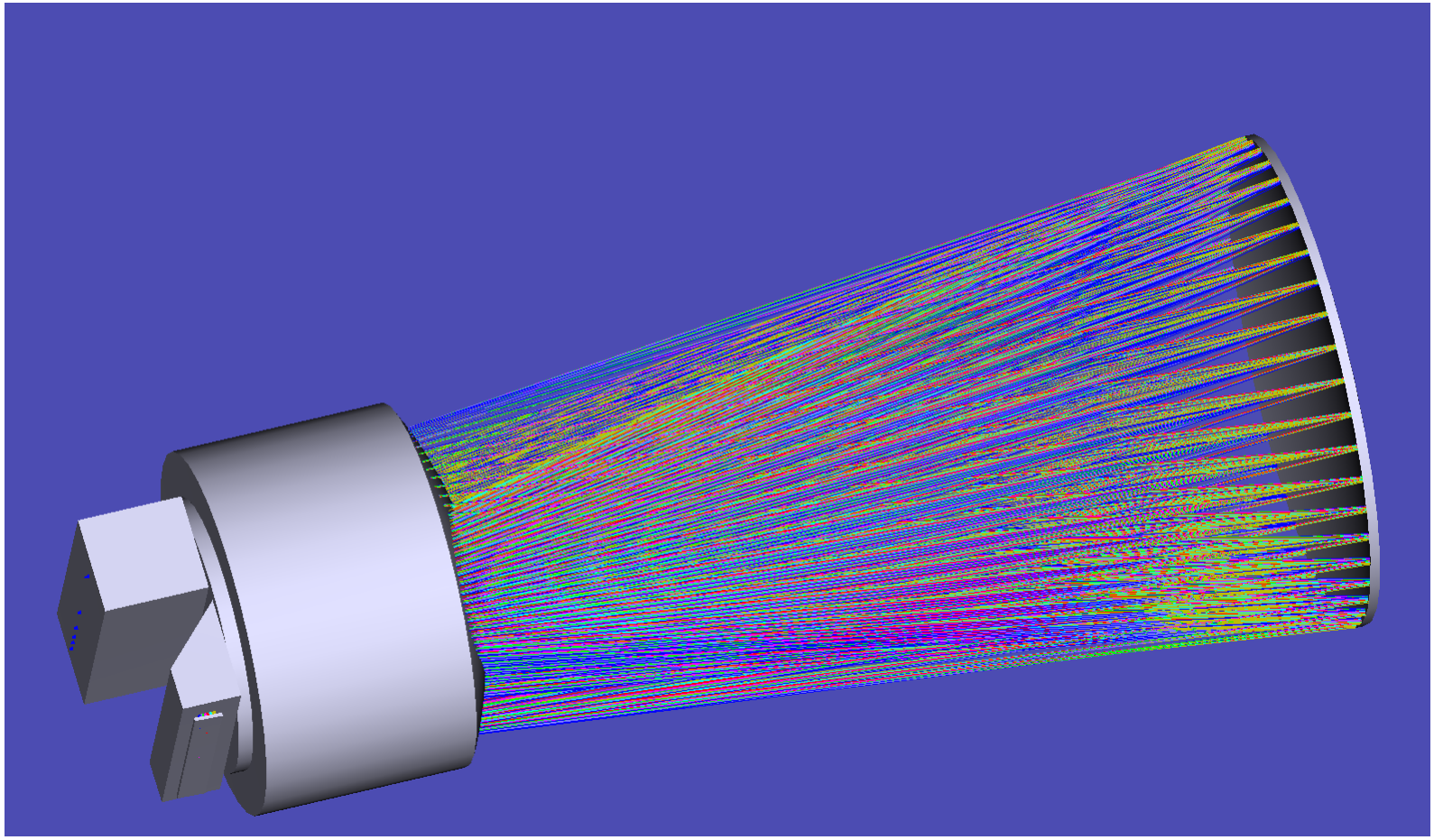


Evolution of JPL electron-beam lithography gratings on a curved surface to enable compact spectrometers that delivers excellent science. Atomic force micrographs of gratings 2000 to 2014.

Single Blaze	Area Weighted Blaze	Concentric Blaze	Uniform Facet Blaze	Fully Structured Blaze
				
2000 Earth Hyperion	2005 Mars CRISM	2005 Earth Airborne	2008 Moon M3 2009 Earth ARTEMIS	2014 Ultracompact Development Model
				

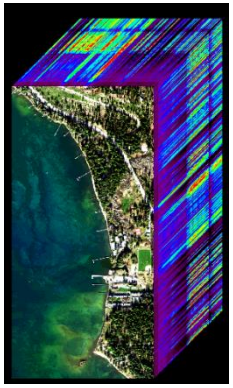
For 185 km Swath at 30 Sampling

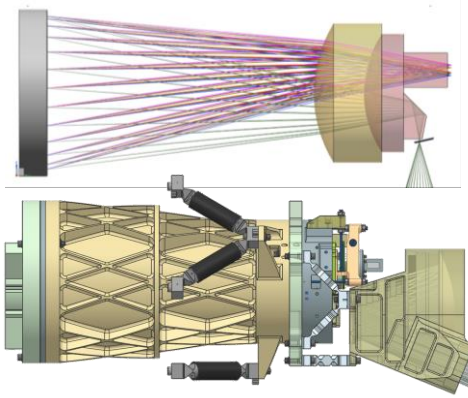
Dyson Spectrometer is Optically Fast F/1.8

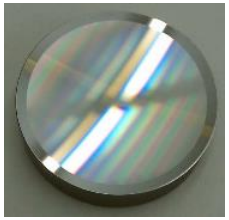


F/1.8 VSWIR-Dyson Imaging Spectrometer for Space

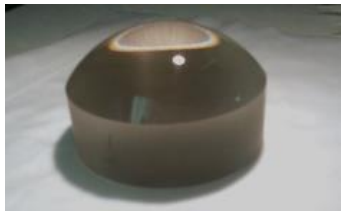
State-of-the-art evolved Dyson spectrometer.







CWIS Dyson grating, optics and main mount



Measurement Characteristics

Spectral

system	Single spectrometer, single detector
Range	≤380 to ≥2510 nm
Sampling	7 nm {uniform over range}
Accuracy	±0.25 nm

Radiometric

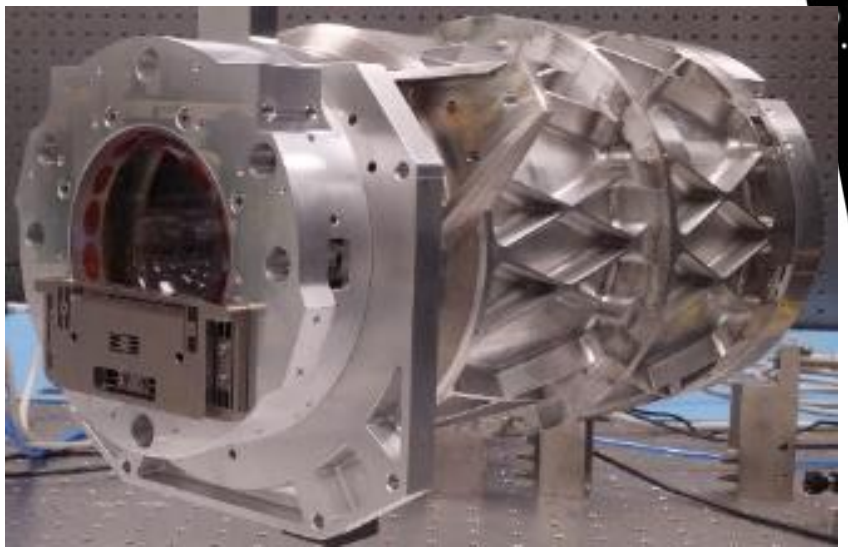
Range & Sampling	0 to max benchmark radiance, 14 bits
Accuracy	≥95% absolute radiometric
Precision (SNR)	≥600 in VNIR and ≥400 SWIR

Spatial

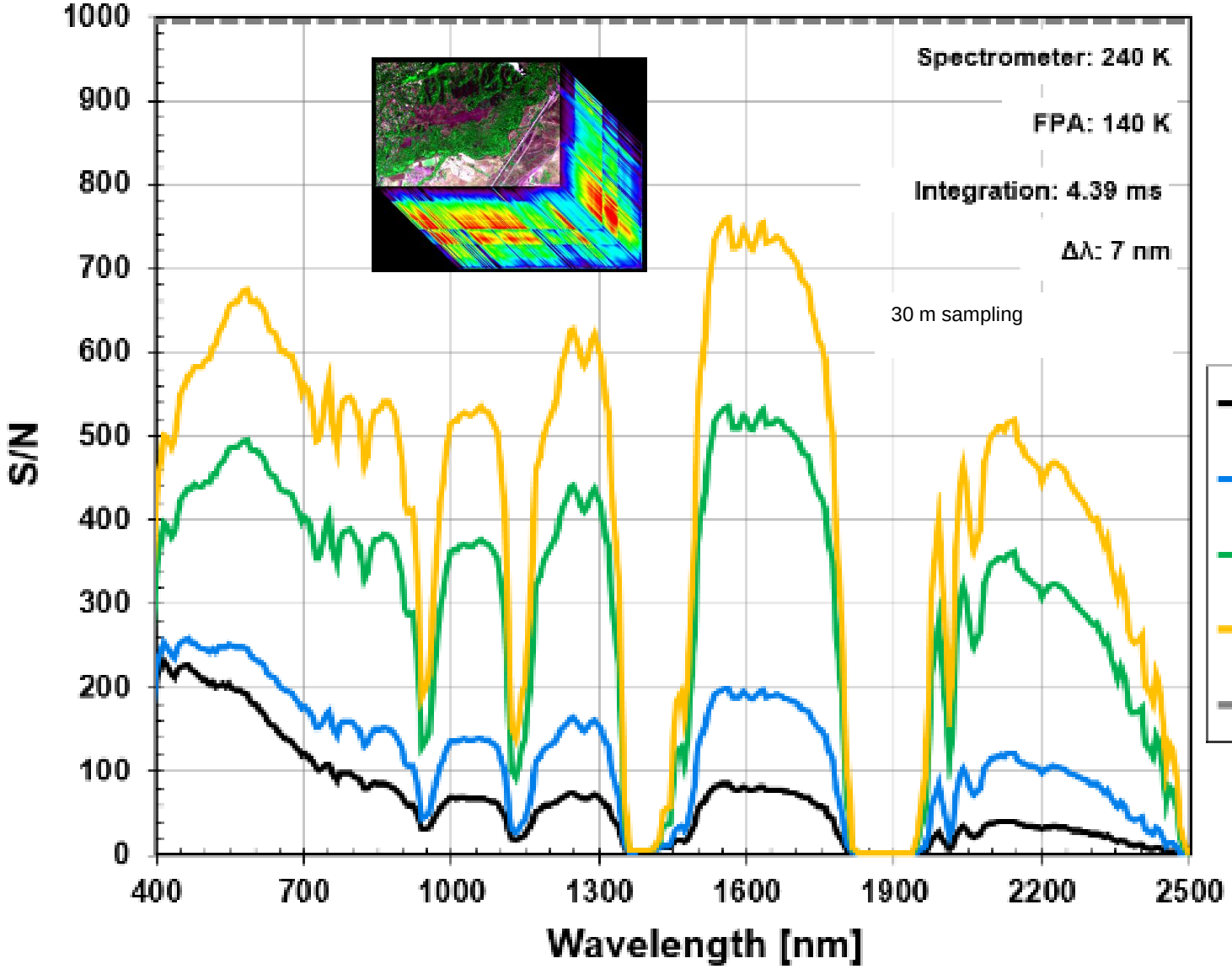
Cross-Track Samples	6200
Swath	185 km nadir
Ground Sampling	30 m nadir
Pointing	30 m 1sigma Knowledge

Uniformity

Spectral Cross-Track	≥95% cross-track uniformity
Spectral-IFOV-	≥95% spectral IFOV uniformity

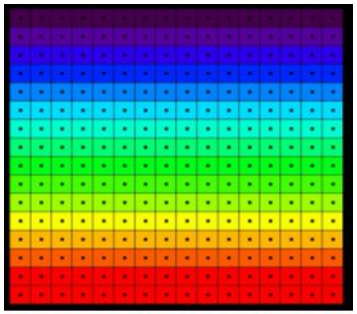


VSWIR-Dyson Measurement Signal-to-Noise Ratio

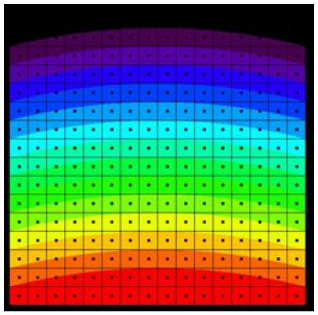


Uniformity, SNR and Calibration

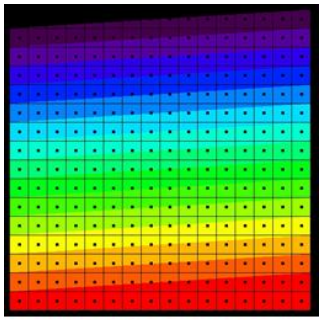
- Uniformity (spectral, radiometric, spatial)
  - *Enables spectroscopy across the image*



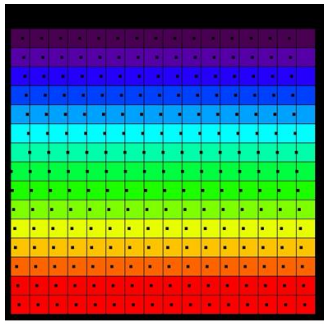
Requirement



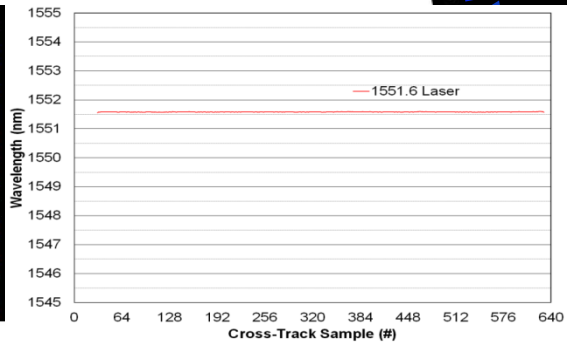
Failure by Frown



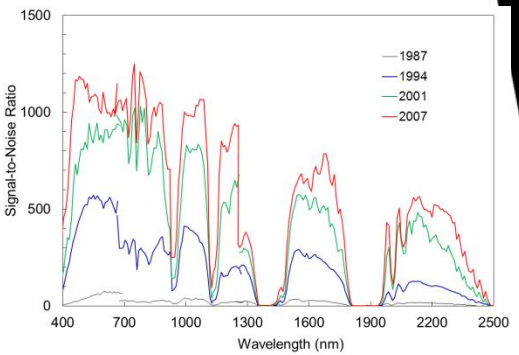
Failure by Twist



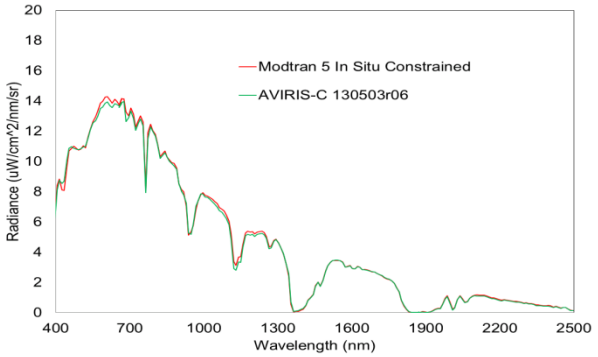
Failure by Spectral-IFOV-Shift



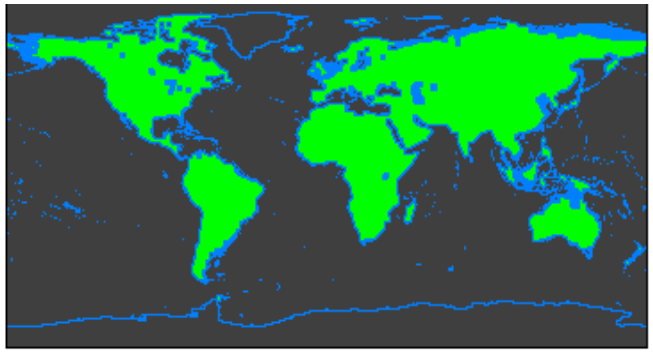
- High Precision (SNR)
  - *Information from spectra*
  - *Number of materials measurable and separable is a function of SNR*



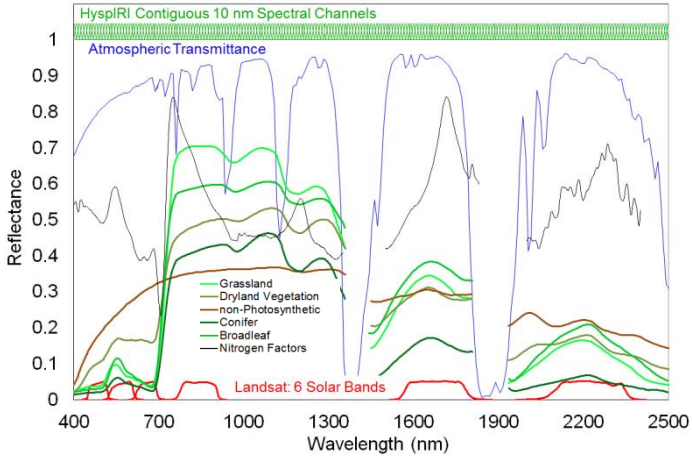
- Calibration (spectral, radiometric, spatial)
  - *Required for the physics, chemistry, and biology of spectroscopy*
  - *Allows autonomous compensation for the atmosphere*



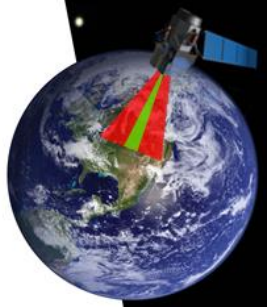
HyspIRI VSWIR Measurements



HyspIRI is a global mission, measuring land and shallow aquatic habitats at 30 meters and deep oceans at 1km every 16 Days (VSWIR)



HyspIRI's VSWIR imaging spectrometer directly measures the full solar reflected spectrum of the Earth from 380 – 2510 nm at 10 nm with a high signal-to-noise ratio



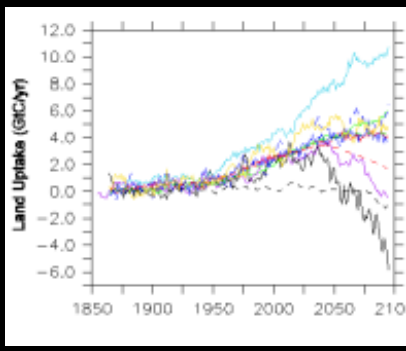
HyspIRI

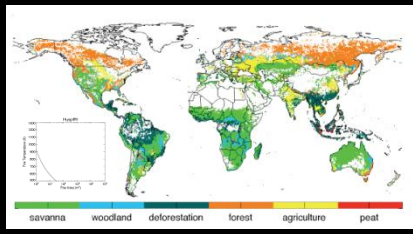
2015 HyspIRI Science Workshop

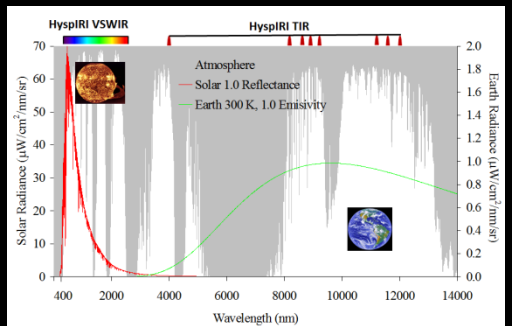
2015 HyspIRI Science Workshop
13-15 October 2015
Decadal Survey Mission

Workshop Objectives

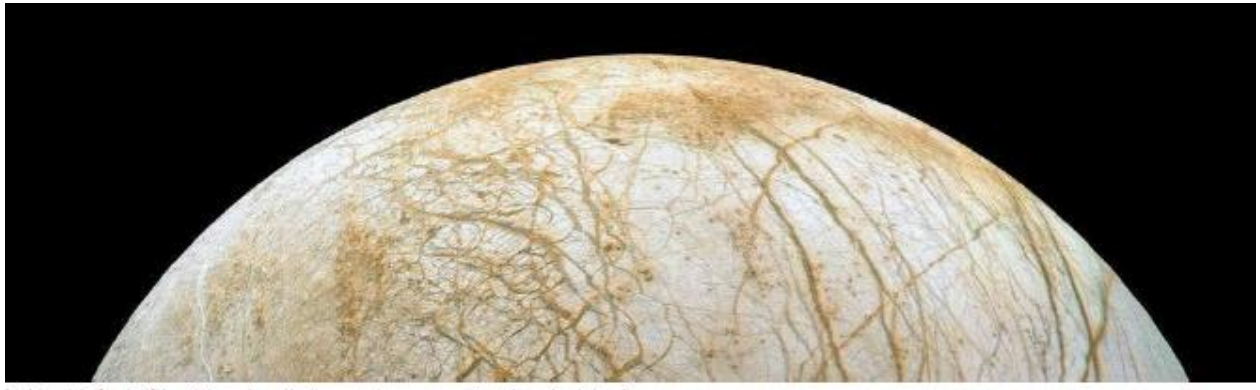
- Interact with broad science community
- Review HyspIRI Mission Concept and next Decadal Survey
- Discuss ECOSTRESS TIR instrument headed to the ISS
- Present new relevant Science and Science Applications
- Review results from the 1st and 2nd year of the HyspIRI preparatory airborne campaign
- Discuss mission concepts for smallsat compatible HyspIRI measurement options(including options for the VSWIR at 30 m sampling and 16-day revisit)
- Report activities tied to Sustainable Land Imaging (SLI), including backward compatibility with bands of MSS, and LandSat 4,5,7,8







Select the 26th of May 2015



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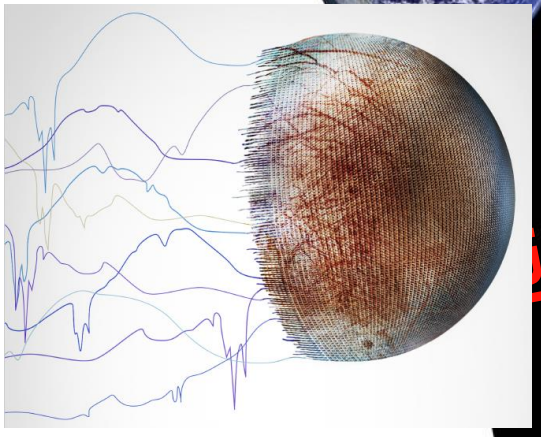


Mapping Imaging Spectrometer for Europa (MISE) -- principal investigator Dr. Diana Blaney of JPL. This instrument will probe the composition of Europa, identifying and mapping the distributions of organics, salts, acid hydrates, water ice phases, and other materials to determine the habitability of Europa's ocean.

May 26, 2015
15-104

NASA's Europa Mission Begins with Selection of Science Instruments

NASA has selected nine science instruments for a mission to Jupiter's moon Europa, to investigate whether the mysterious icy moon could harbor conditions suitable for life.

NASA's Galileo mission yielded strong evidence that Europa, about the size of Earth's moon, has an ocean beneath a frozen crust of unknown thickness. If proven to exist, this global ocean could have more than twice as much water as Earth. With abundant salt water, a rocky sea floor, and the energy and chemistry provided by tidal heating, Europa could be the best place in the solar system to look for present day life beyond our home planet.

"Europa has tantalized us with its enigmatic icy surface and evidence of a vast ocean, following the amazing data from 11

(/sites/default/files/thumbnails/image/15-104a.jpg)
Bizarre features on Europa's icy surface suggest a warm interior. This view of the surface of Jupiter's moon Europa was obtained by NASA's Galileo mission, and shows a color image set within a larger mosaic of low-resolution monochrome images. Galileo was able to survey only a small fraction of Europa's surface in color at high resolution; a future mission would include a high-resolution imaging capability to capture a much larger part of the moon's

Mapping Imaging Spectrometer for Europa (MISE)
Revealing the Geochemical Tapestry Of Europa

MISE will produce maps of organic compounds, salts, hot spots, and ices to answer key science questions about Europa ocean and its habitability.

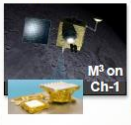
Links surface geology and composition. | Does Europa's ocean have organics? | What does surface chemistry tell us about habitability? | Is Europa currently active? | How do changes in ice crystal structure relate to the age of Europa's surface?

MISE Science Goals:

- **Goal 1**: Assess the habitability of Europa's ocean by understanding the inventory and distribution of surface compounds.
- **Goal 2**: Investigate the geologic history of Europa's surface and search for areas that are currently active.

JPL-APL Partnership:

- Imaging Spectrometer Heritage from JPL (Discovery M³ on India's Chandrayaan-1) and APL (CRISM on MRO).
- Joint JPL/APL team has been working on MISE concept since 2008.
- **JPL:** PI, Project Management, System Engineering, SMA, Spectrometer, FPA, FPIE, Calibration and Archiving.
- **APL:** Deputy PI, Data Processing Unit, Scanner, Flight Software, and Science Tools.



MISE Team:

PI: Diana Blaney (JPL)
Deputy PI: Karl Hibbitts (APL)
Project Manager: Carl Bruce (JPL)
Deputy Project Manager: Andrew Santo (APL)

Science Team:

- Rob Green, Instrument Scientist (JPL)
- Roger Clark (PSI)
- Brad Dalton (JPL)
- Ashley Davies (JPL)
- Matt Hedman (U. Idaho)
- Yves Langevin (U. Paris)
- Jonathan Lunine (Cornell)
- Tom McCord (Bear Fight)
- Chris Paranicas (APL)
- Frank Seelos (APL)
- Jason Soderblom (MIT)