

Overview of the HypSIIRI Mission Concept, Measurements and Science

A Global Coverage VSWIR and TIR Mission



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²Goddard Space Flight Center



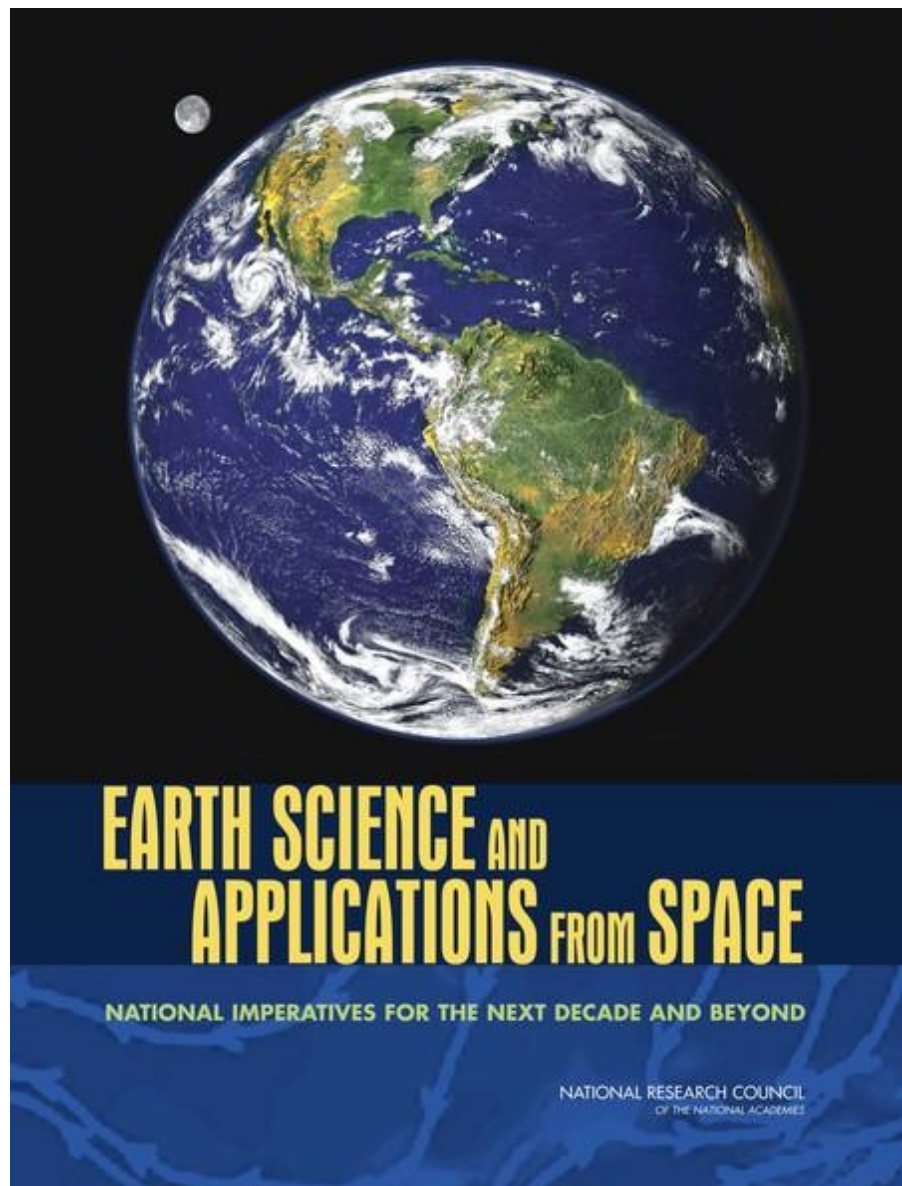
Overview



- 2007 Decadal HypsIRI Mission Concept
- Refinement of science with Science Study Group
- Implementation options
 - Original combined
 - ISS options
 - Separate free flyers
 - Latest combined
- High Level overview of latest instrumentation options and product maturity
 - VSWIR and L1 and L2
 - TIR and L1 and L2
 - IPM real time and higher products
- Inputs to the 2017 Decadal
- Summary and Discussion



2007 Decadal Survey



In its Decadal Survey Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond, the National Research Council of the National Academies recommended a satellite mission to produce global observations of multiple Earth surface attributes for a variety of terrestrial and aquatic studies, the management of terrestrial and coastal natural resources, and forecasting ecological changes and natural hazards.

Currently known as HypSIRI, this mission is in the conceptual design phase at NASA. It consists of an **imaging spectrometer in the visible to shortwave infrared (VSWIR)** regions of the electromagnetic spectrum and a **multispectral imager in the thermal infrared (TIR)** portion of the electromagnetic spectrum.



HyspIRI Science Study Group*



Mike Abrams	Jet Propulsion Laboratory
Rick Allen	University of Indiana
Martha Anderson	US Department of Agriculture
Greg Asner	Carnegie Institute of Science
Alex Chekalyuk	Lamont-Doherty
Ivan Csiszar	University of Maryland
Heidi Dierssen	University of Connecticut
John Gamon	University of Alberta
Louis Giglio	University of Maryland
Greg Glass	John Hopkins University
Robert Green	Jet Propulsion Laboratory
Eric Hochberg	Bermuda Institute of Science
Simon Hook	Jet Propulsion Laboratory
Jeff Luvall	Marshall Space Flight Center
John Mars	US Geological Survey, HQ
David Meyer	US Geological Survey, EROS
Betsy Middleton	Goddard Space Flight Center
Peter Minnett	University of Miami
Frank Muller Karger	University of South Florida
Scott Ollinger	University of New Hampshire
Thomas Painter	Jet Propulsion Laboratory
Anupma Prakash	University of Alaska, Fairbanks
Dale Quattrochi	Marshall Space Flight Center
Michael Ramsey	University of Pittsburg
Vince Realmuto	Jet Propulsion Laboratory
Dar Roberts	University of California, Santa Barbara
Dave Siegel	University of California, Santa Barbara
Phil Townsend	University of Wisconsin
Kevin Turpie	Goddard Space Flight Center
Steve Ungar	Goddard Space Flight Center
Susan Ustin	University of California, Davis
Rob Wright	University of Hawaii



VSWIR Science Questions

VQ1. Pattern and Spatial Distribution of Ecosystems and their Components

What is the global spatial pattern of ecosystems and diversity distributions and how do ecosystems differ in their composition or biodiversity?

VQ2. Ecosystem Function, Physiology and Seasonal Activity

What are the seasonal expressions and cycles for terrestrial and aquatic ecosystems, functional groups, and diagnostic species? How are these being altered by changes in climate, land use, and disturbance?

VQ3. Biogeochemical Cycles

How are the biogeochemical cycles that sustain life on Earth being altered/disrupted by natural and human-induced environmental change? How do these changes affect the composition and health of ecosystems, and what are the feedbacks with other components of the Earth system?

VQ4. Changes in and Responses to Disturbance

How are disturbance regimes changing, and how do these changes affect the ecosystem processes that support life on Earth?

VQ5. Ecosystem and Human Health

How do changes in ecosystem composition and function affect human health, resource use, and resource management?

VQ6. Earth Surface and Shallow-Water Benthic Composition

What is the current land surface soil/rock/cryosphere and shallow-water benthic compositions?



TIR Science Questions

TQ1. Volcanoes and Earthquakes

How can we help predict and mitigate earthquake and volcanic hazards through detection of transient thermal phenomena?

TQ2. Wildfires

What is the impact of global biomass burning on the terrestrial biosphere and atmosphere, and how is this impact changing over time?

TQ3. Water Use and Availability

How is consumptive use of global freshwater supplies responding to changes in climate and demand, and what are the implications for sustainable management of water resources?

TQ4. Urbanization/Human Health

How does urbanization affect the local, regional and global environment? Can we characterize this effect to help mitigate its impact on human health and welfare?

TQ5. Earth surface composition and change

What is the composition and thermal property of the exposed surface of the Earth? How do these factors change over time and affect land use and habitability?

CQ1. Coastal, ocean, and inland aquatic environments

What is the status of inland and coastal aquatic ecosystems in the context of local and regional thermal climate, land-use change, and other environmental factors?

CQ2. Wildfires

How are fires and vegetation composition coupled?

CQ3. Volcanoes

Do volcanoes signal impending eruptions through changes in the temperature of the ground, rates of gas and aerosol emission, temperature and composition of crater lakes, or health and extent of vegetation cover?

CQ4. Ecosystem Function and Diversity

How do species, functional type, and biodiversity composition within ecosystems influence the energy, water and biogeochemical cycles under varying climatic conditions?

CQ5. Earth surface composition and change

What is the composition of exposed terrestrial surface of the Earth and how does it respond to anthropogenic and non anthropogenic drivers?

CQ6 Human Health and Urbanization

How do patterns of human environmental and infectious diseases respond to leading environmental changes, particularly to urban growth and change and the associated impacts of urbanization?



HysplRI Science Traceability Matrices

[illegible]



Level 1 Requirements

Draft Preliminary

HyspIRI

Visible to Short Wavelength Infrared Imaging Spectrometer
and Thermal Infrared Imager (HyspIRI) Decadal Survey
Earth Science and Applications Mission

Level 1 Requirements and Mission Success Criteria



Version X-8.0

Date: |

Owner: NASA Decadal Survey HyspIRI Program Executive and Program Scientist

Draft Preliminary



Key Preliminary Draft Level 1 Requirements*

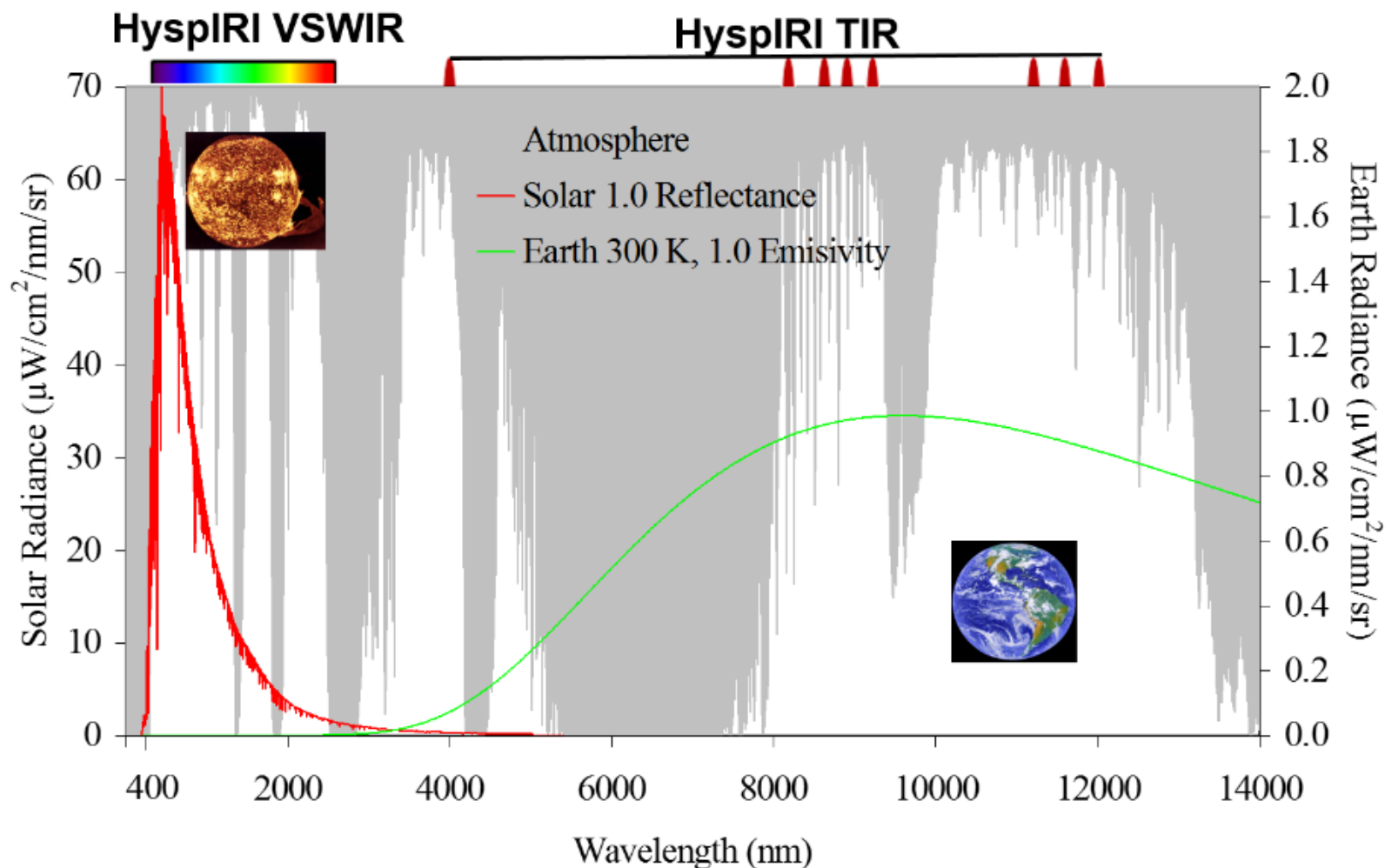
Baseline	Threshold (Mission Success)
VSWIR:380 to 2500 nm at ≤ 10 nm sampling at the specified signal-to-noise ratio and accuracy with <u>$\geq 95\%$</u> spectral/spatial uniformity at ≤ 30 m nadir spatial sampling with < 16 day revisit to provide	VSWIR:380 to 2500 nm at ≤ 10 nm sampling at <u>$\geq 80\%$</u> of the specified signal-to-noise ratio and accuracy with <u>$\geq 90\%$</u> spectral/spatial uniformity at ≤ 30 m nadir spatial sampling with < 16 day revisit to provide
VSWIR: <u>$\geq 60\%$</u> seasonal and <u>$\geq 80\%$</u> annual coverage of the terrestrial and shallow water regions of the Earth	VSWIR: <u>$\geq 50\%$</u> seasonal and <u>$\geq 70\%$</u> annual coverage of the terrestrial and shallow water regions of the Earth
<u>three years</u> with a subset of measurements available <u>near-real-time</u> for designated science and applications.	<u>two years.</u>
TIR: 8 spectral bands from the 3-5 micron and 8-12 micron regions of the spectrum at the specified noise-equivalent-delta-temperature and accuracy at ≤ 60 m nadir spatial sampling with ≤ 5 day revisit	TIR: 8 spectral bands from the 3-5 micron and 8-12 micron regions of the spectrum at <u>$\geq 80\%$</u> the specified noise-equivalent-delta-temperature and accuracy at ≤ 60 m nadir spatial sampling with ≤ 5 day revisit
TIR: <u>$> 60\%$</u> Monthly, <u>$> 70\%$</u> seasonal and <u>$> 85\%$</u> annual coverage of the terrestrial and shallow water regions of the Earth	TIR: <u>$> 40\%$</u> Monthly, <u>$> 60\%$</u> seasonal and <u>$> 70\%$</u> annual coverage of the terrestrial and shallow water regions of the Earth

*30 m, 16 Day VSWIR



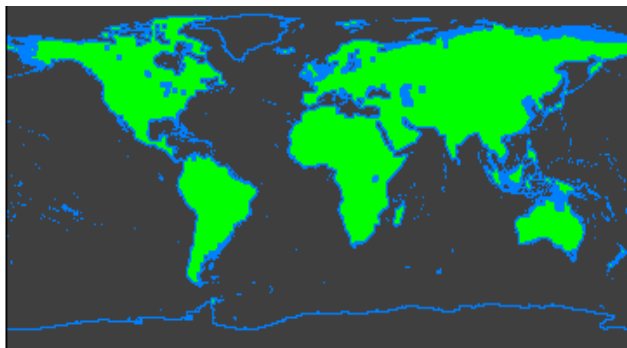
HyspIRI Measurements

- Global terrestrial and coastal VSWIR spectroscopy and multispectral TIR with real-time downlink of selected products for both.

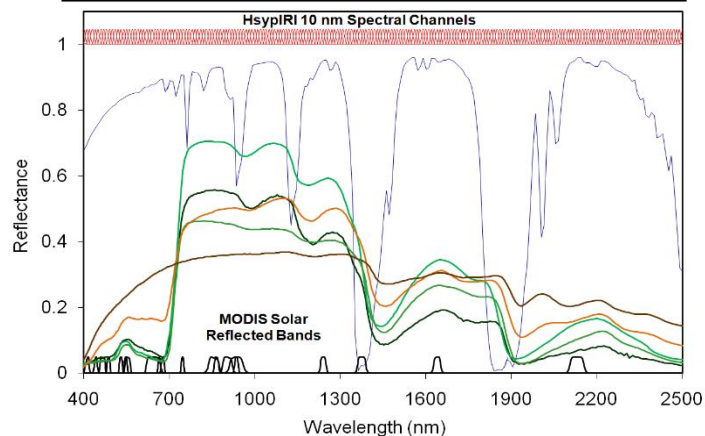




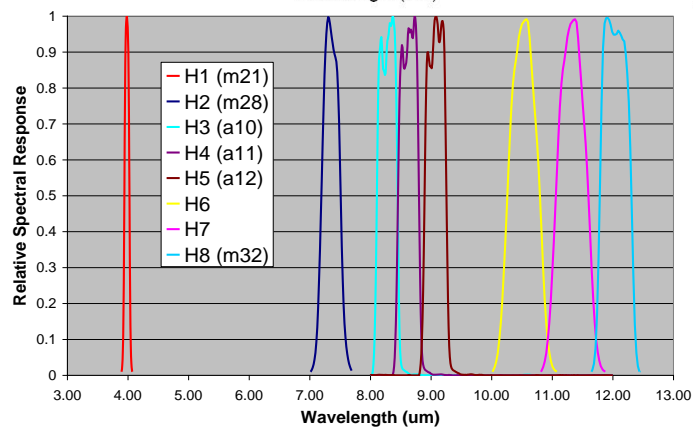
HyspIRI Science Measurements



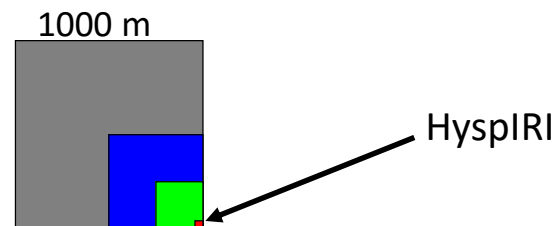
HyspIRI is a global mission, measuring land and shallow aquatic habitats and deep oceans at 1km every 5 days (TIR) and every ≤ 16 days (VSWIR)



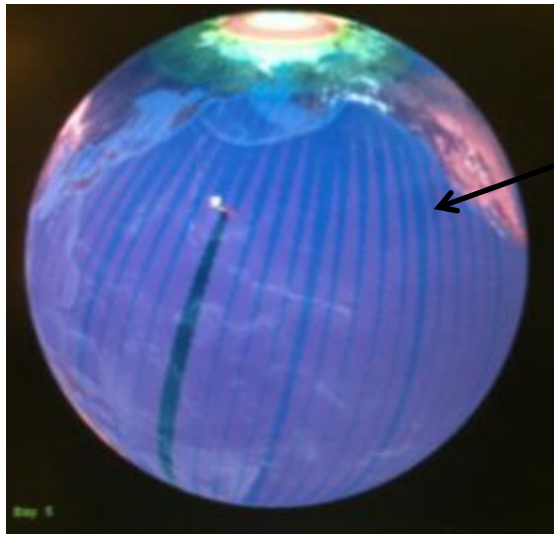
HyspIRI's VSWIR imaging spectrometer (30 m) directly measures the full solar reflected spectrum of the Earth from 380 – 2500nm at 10 nm.



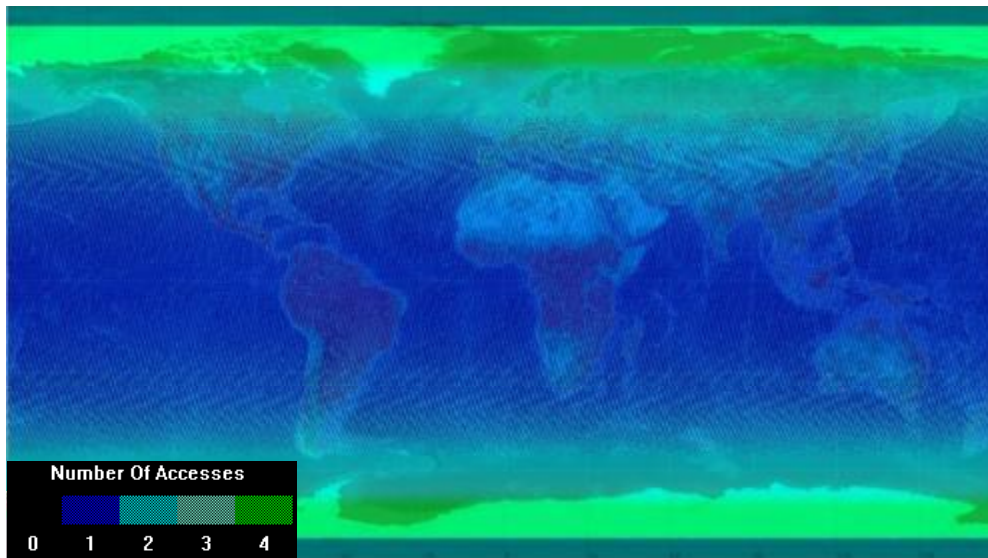
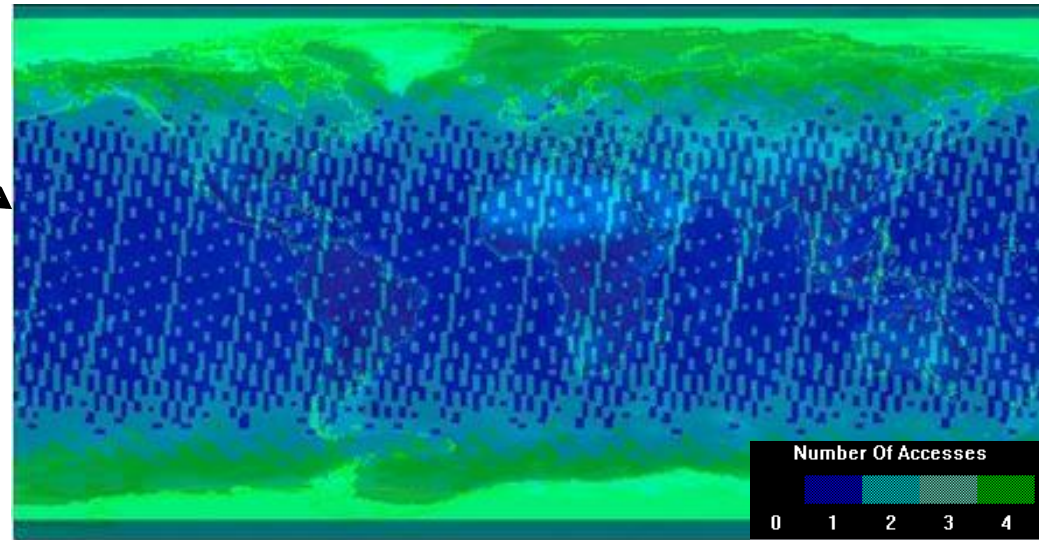
HyspIRI's TIR (60 m) directly samples the Earth's emitted thermal energy in 7 bands between 7-12 μm , & 1 band between 3-5 μm



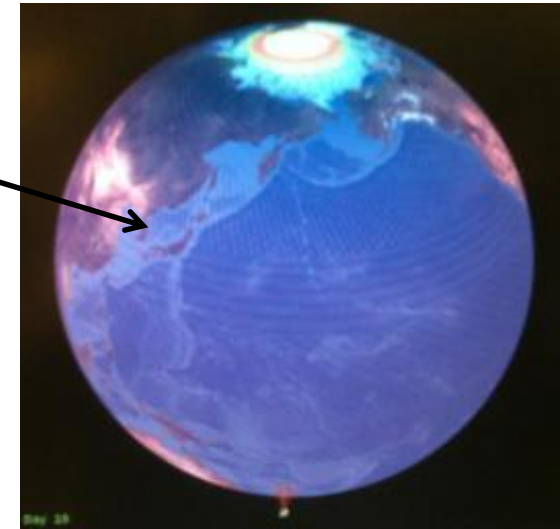
HyspIRI Global Coverage

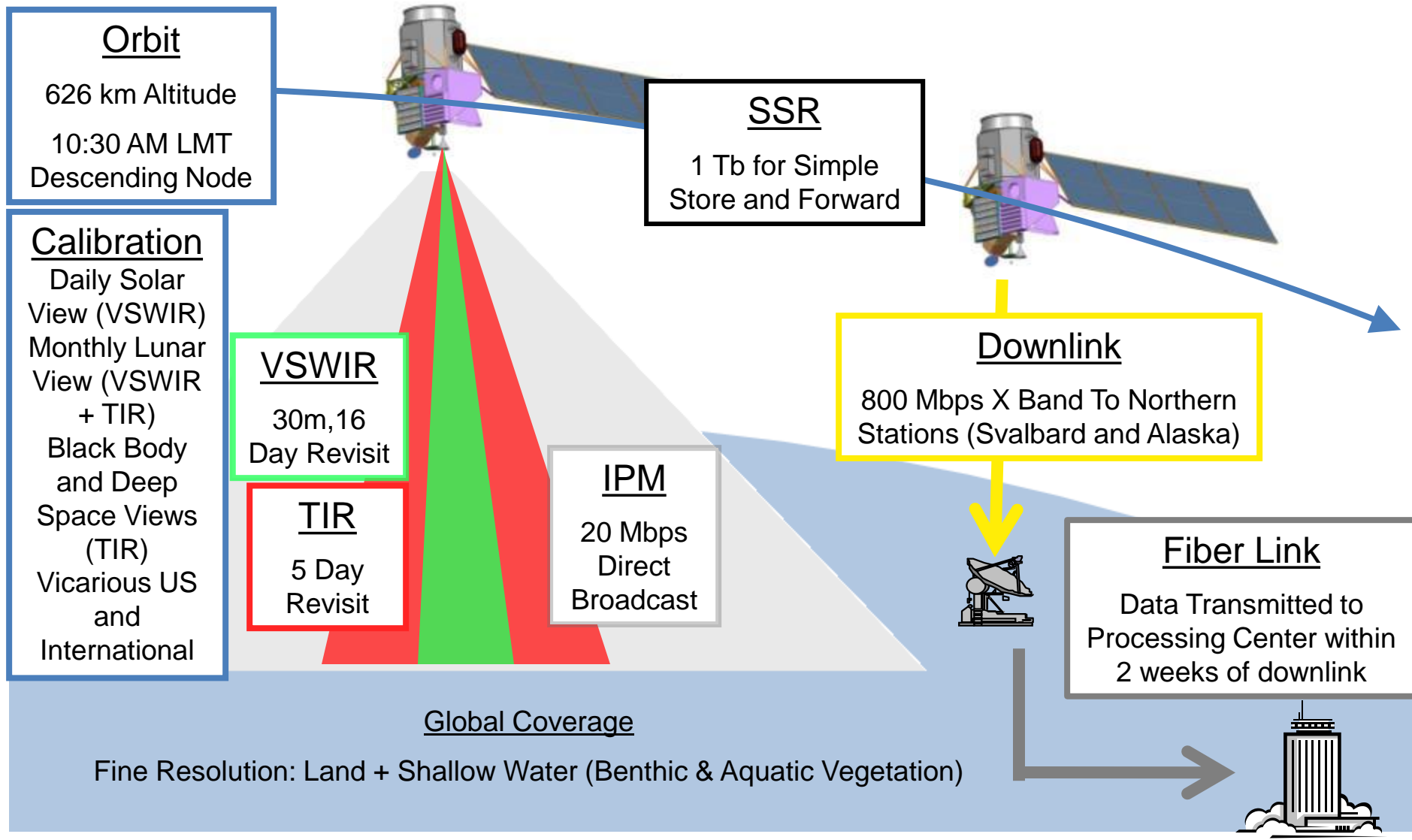


TIR Coverage
after 5 days



VSWIR
Coverage after
16 days





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

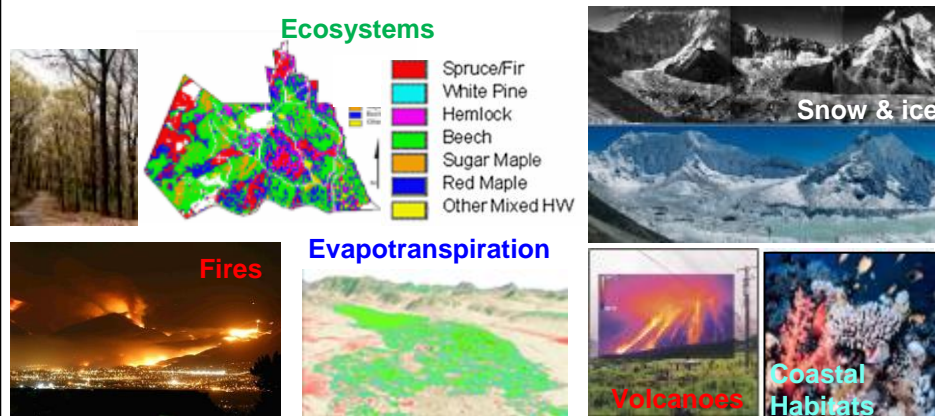
Volcanoes: Eruptions, emissions, regional and *global* impacts

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

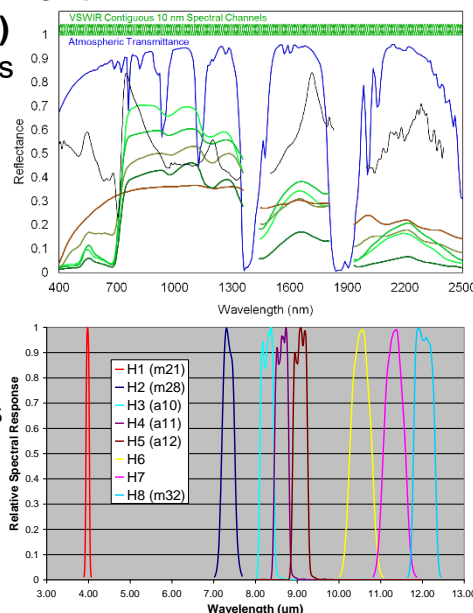
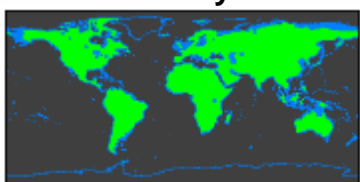
Imaging Spectrometer (VSWIR)

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

Thermal Infrared (TIR)

- 8 bands between 4-12 μ m
- 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. RFI



Implementation Options

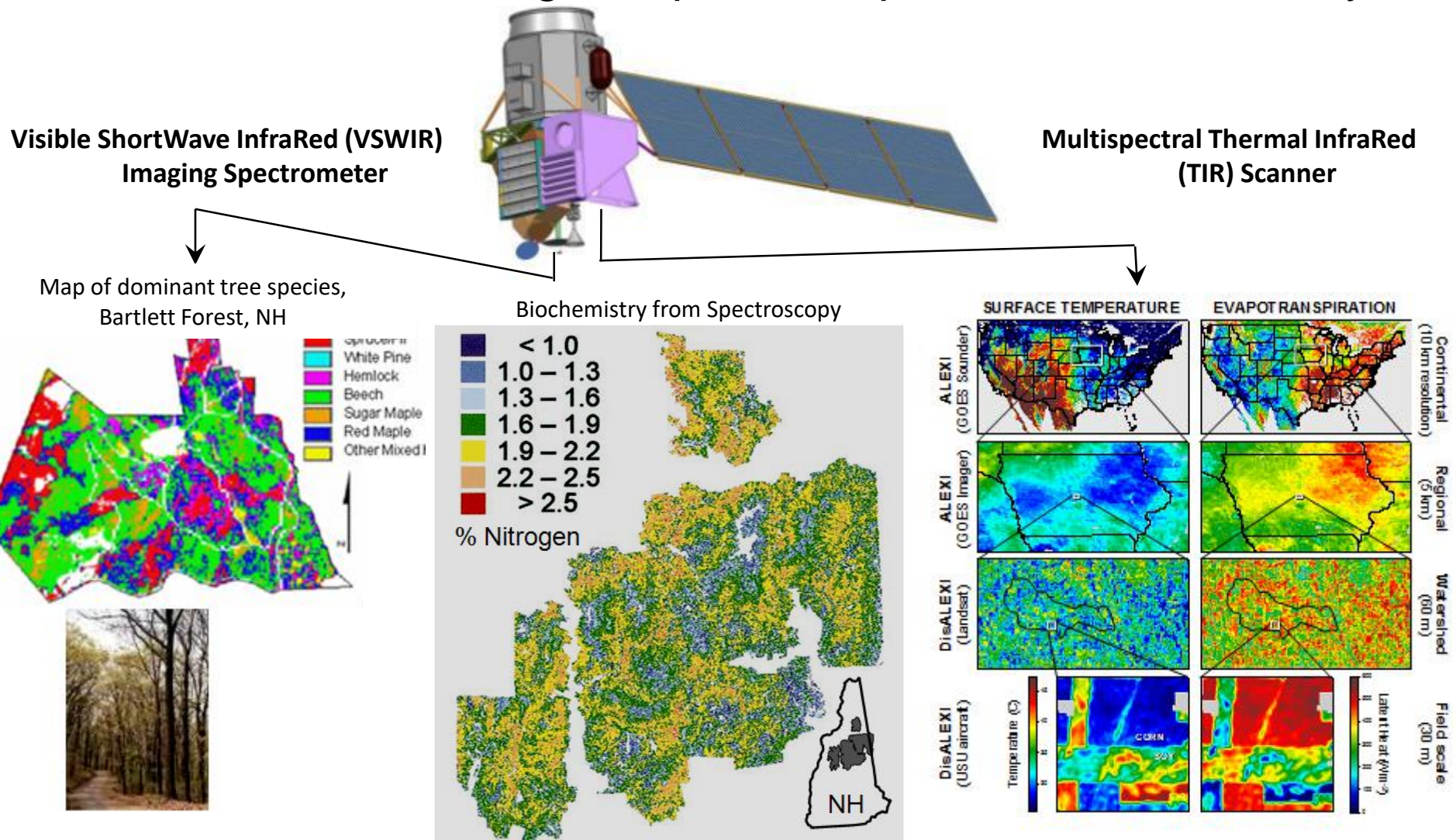


(1) The HypsIRI Dedicated Combined Polar Orbiter is Available for Implementation



Earth Science and Science Applications

Global: Climate Change, Impact, Adaptation, & Vulnerability





HyspIRI Mission Concept - 2012



Payload

Science Instruments:

- **VSWIR: Imaging Spectrometer**
 - 380-2500 nm in 10 nm bands
 - 60m spatial resolution
 - Day-side (23% duty cycle)
 - 55 Kg, 41 W
- **TIR: Thermal Infrared Scanner**
 - 8 bands between 3-12 μm
 - 60m spatial resolution
 - Day and night-side (100% duty cycle)
 - 60 Kg, 103 W

Intelligent Payload Module (IPM)

- 24/7 Direct Broadcast capability
- subset of science data
- X-band @ 20 Mbps
- 11 Kg, 86 W

Implementation

Launch Date:

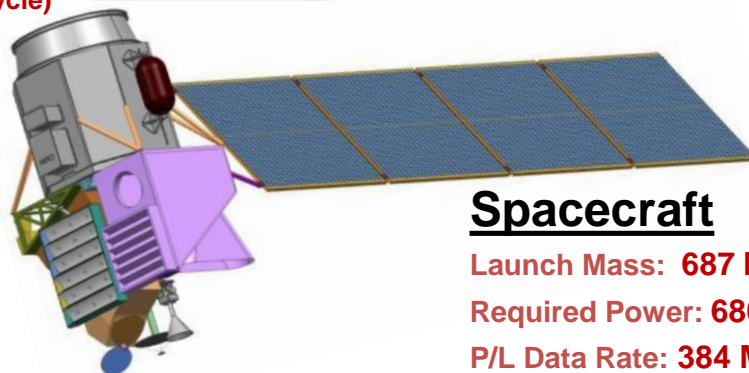
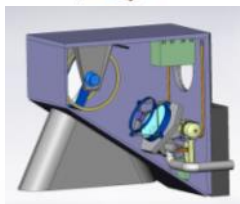
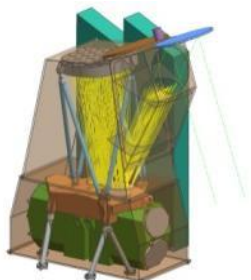
Lifetime: 3 years, with consumables for 5

Cost : Low to Moderate cost Mission

Partners: JPL, GSFC

Mission Class: C, with selected redundancy

Hardware Model: Protoflight



Mission Architecture

- **Orbit:** 626 km Sun-Synchronous, 10:30am LTDN
- **Repeat:** 19 day VSWIR / 5 day TIR
- **Downlink:** Contacts nearly every orbit to Svalbard (North) and Troll (Antarctica)
- **Science Data:** 5.7 Tbits/day
- **Launch Vehicle:** Taurus 3210, 2m fairing, 790 kg capability

Spacecraft

Launch Mass: 687 kg, JPL DP Margin: 30%

Required Power: 680W, 7.1 m² array (965 W capability)

P/L Data Rate: 384 Mbps

Downlink Data Rate: 800 Mbps Dual-pol X-band

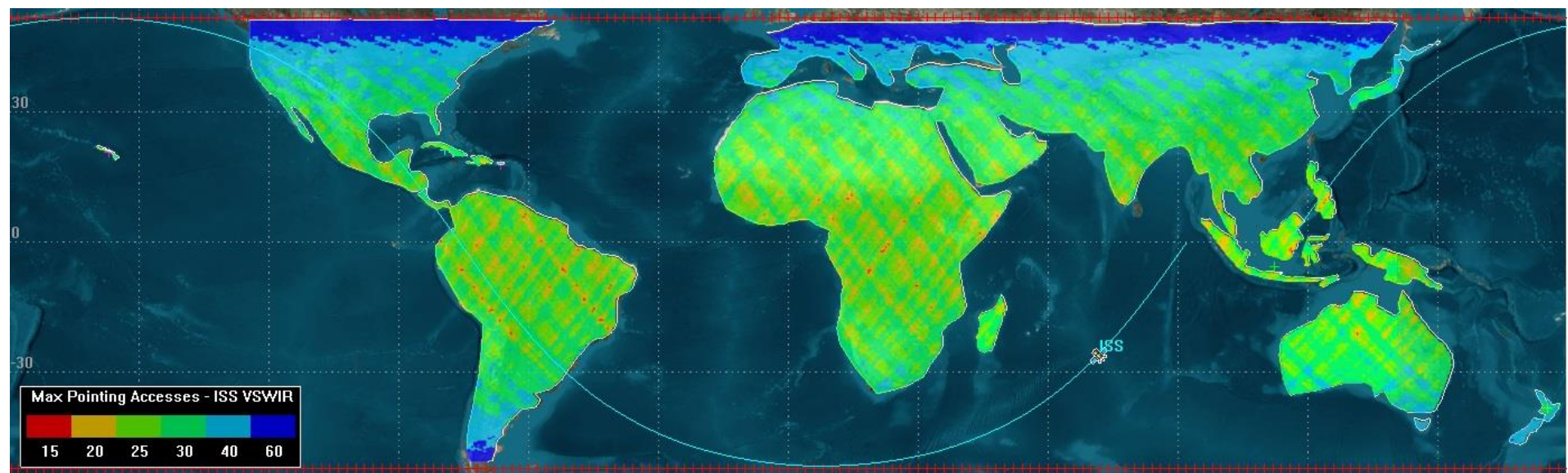
Stabilization: 3-axis

Pointing: Control = 720 arcsec (per axis 3 σ)

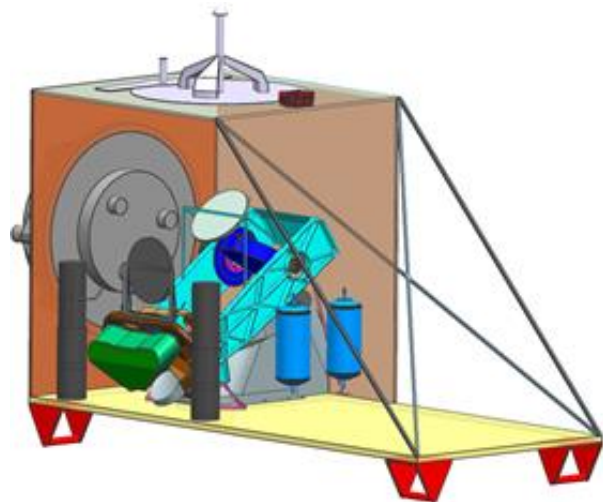
Knowledge = 5.6 arcsec (Pitch/Roll axis 3 σ);

15 arcsec (Yaw axis 3 σ)

Stability = 5 arcsec/sec (per axis 3 σ)



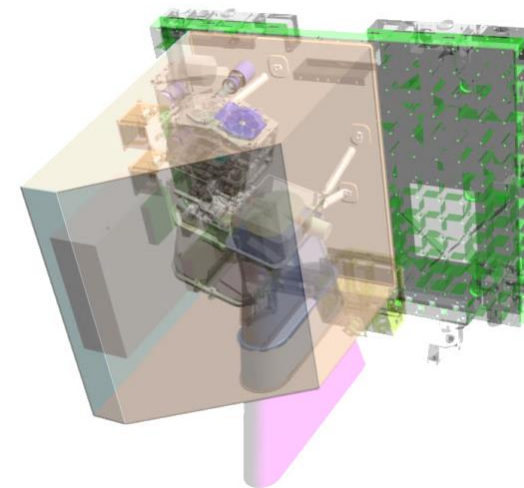
TIR



+IPM



VSWIR

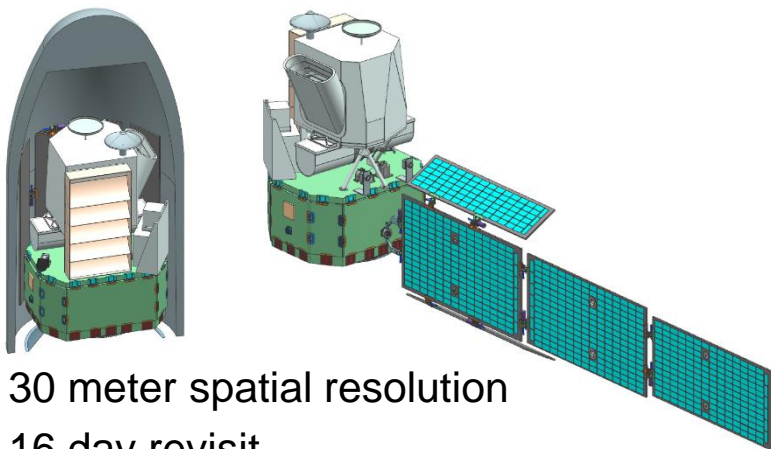




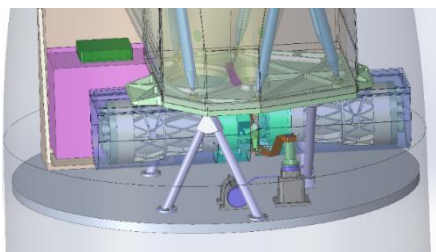
HyspIRI SmallSat Compatibility (2015)



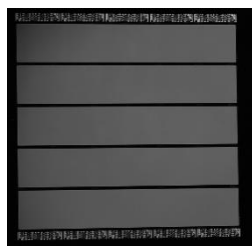
VSWIR-Dyson



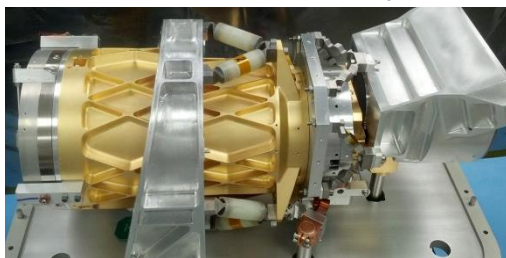
- 30 meter spatial resolution
- 16 day revisit
- Full VSWIR Spectroscopy



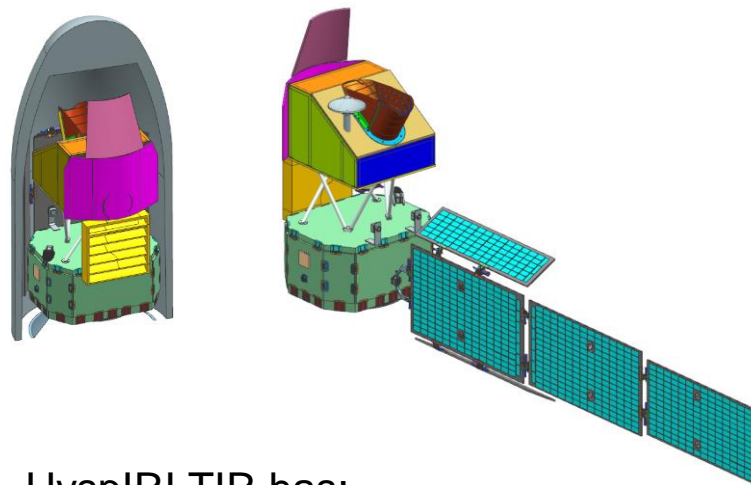
3072 x512



F/1.8 VSWIR Dyson

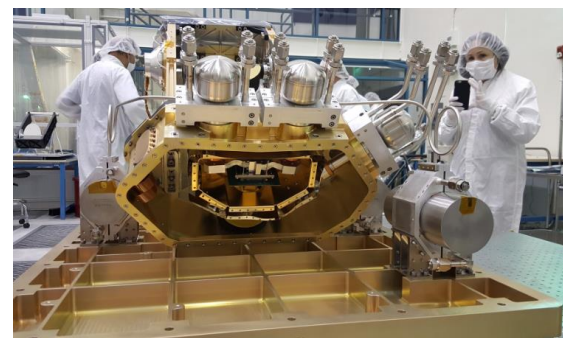


TIR



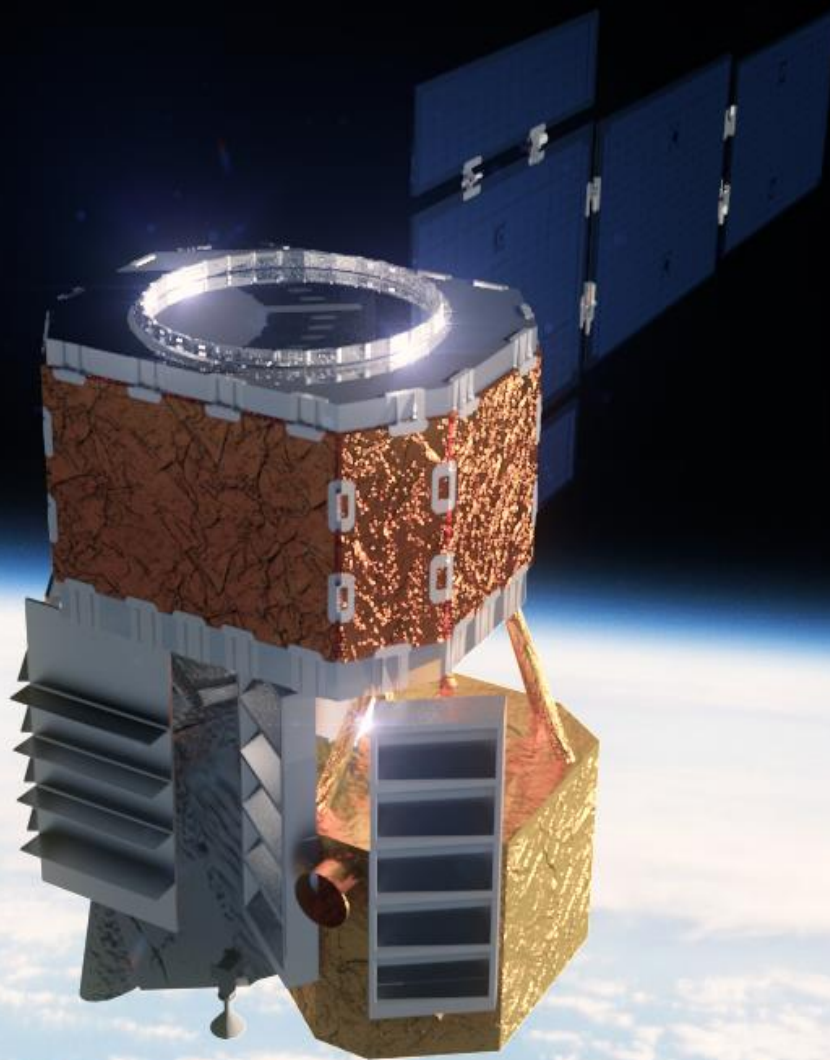
- HyspIRI TIR has:
 - 60 m spatial resolution
 - 5 day revisit (day + night)
 - 8 bands

ECOSTRESS





2016 HypsIRI Mission Concept Study: Combined VSWIR, TIR and IPM With Current Technology



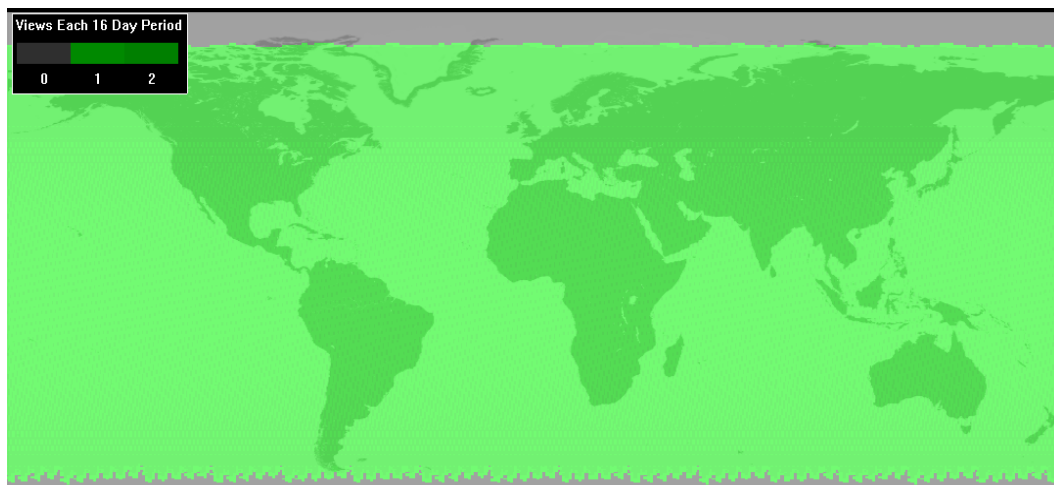


Orbit and Coverage



504 km Sun Synchronous Orbit (10:30 AM LMTDN)

- ≤ 16 day global coverage for VSWIR



- ≤ 5 day global coverage for TIR
 - Full coverage in 5 days



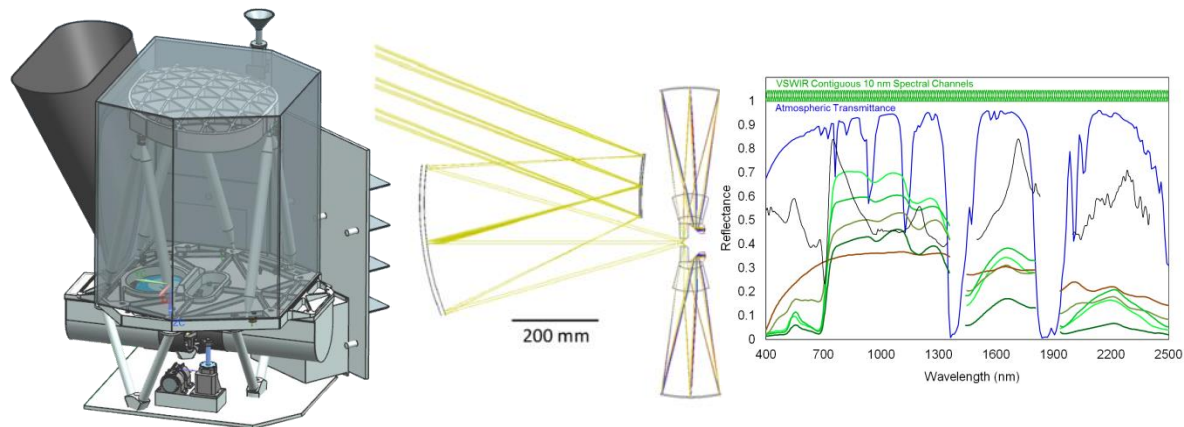


HyspIRI

Instrument Element and Algorithm Maturity

• VSWIR

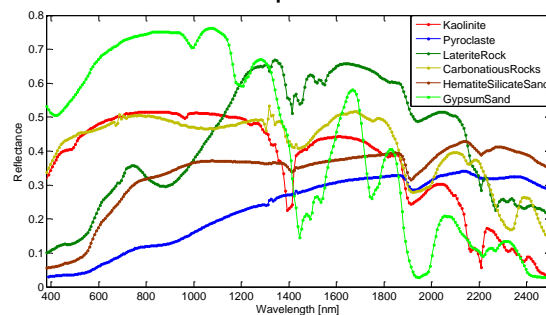
- 2x CWIS Dyson spectrometers
- 185 km swath
- 30 m resolution
- 83 kg
- 100 W



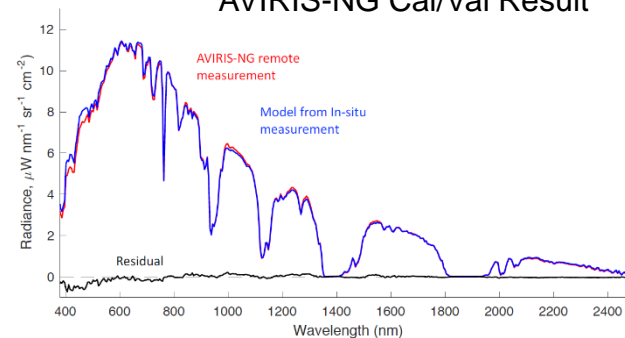
F/1.8 VSWIR Dyson



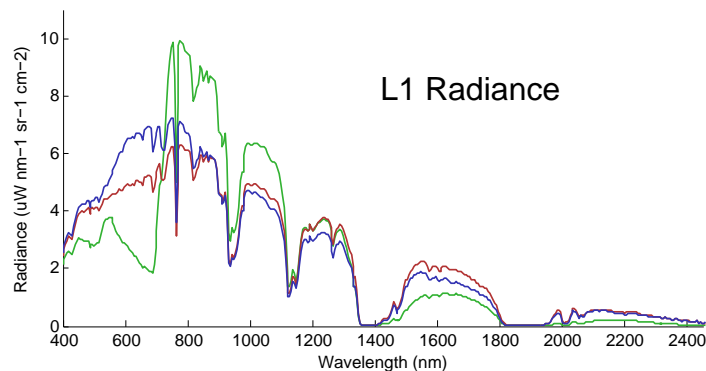
CWIS Lab Spectra



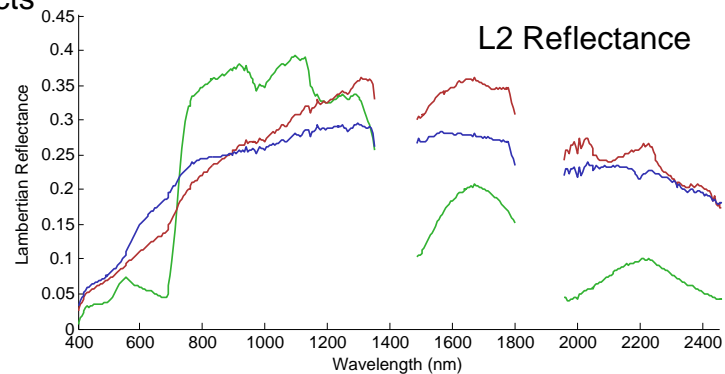
AVIRIS-NG Cal/Val Result



Routine L1 and L2 products



L1 Radiance

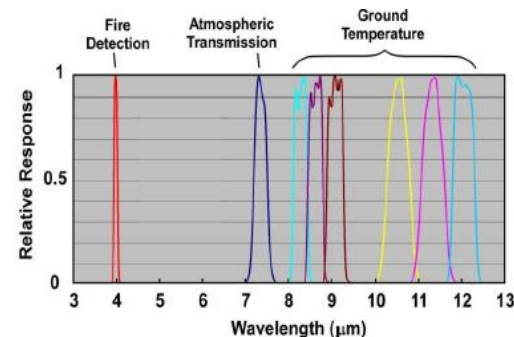
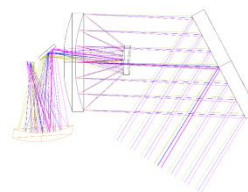
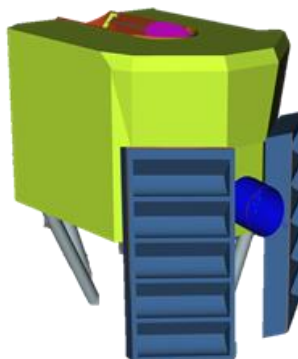


L2 Reflectance

HyspIRI: TIR

• TIR

- PhyTIR Demo on ECOSTRESS
- 518 km swath
- 60 m resolution
- 48 kg
- 170 W



ECOSTRESS



Credit: NASA-JPL/Caltech

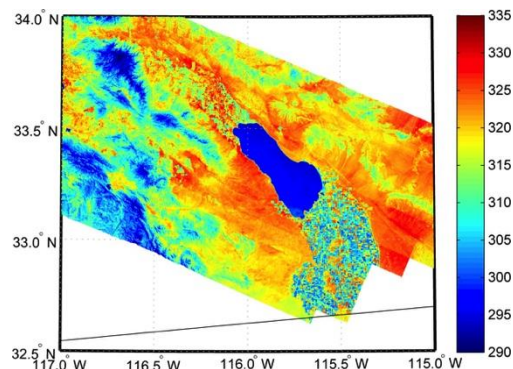
Airborne campaign validation of L1 and L2 algorithms

- Generate MASTER L2 Surface Temperature and Spectral Emissivity products using MASTER LWIR bands 42-50.
- Distribute the data via online ordering tool (http://masterprojects.jpl.nasa.gov/L2_products)

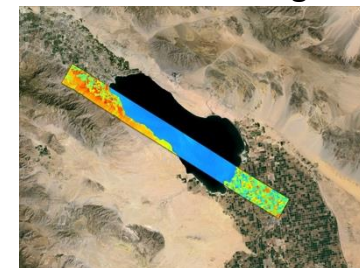
Testing validation and calibration update approaches

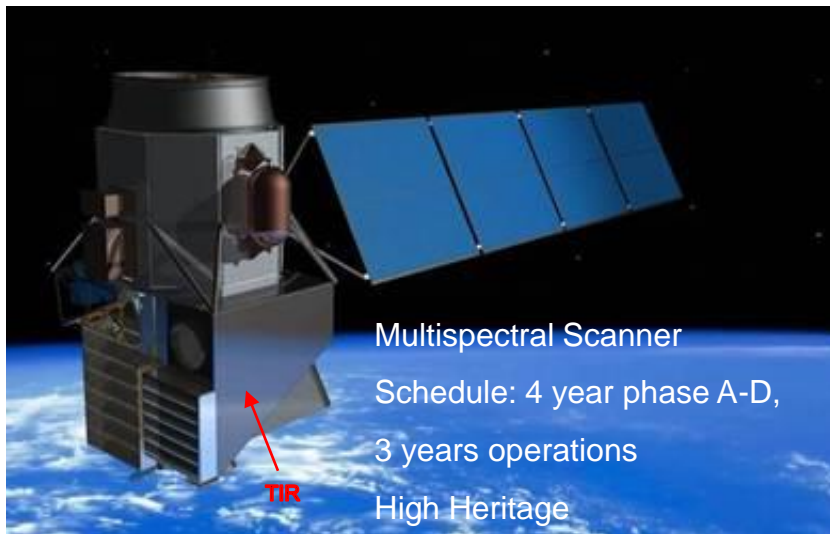
- Calibrate MASTER L1B radiance at sensor using Lake Tahoe and Salton Sea in situ validation data.
- Validate MASTER L2 products using Lake Tahoe and Salton Sea in situ validation data as well as field measurements from pseudo-invariant sand sites.

LST (resampled to HyspIRI TIR 60-m)



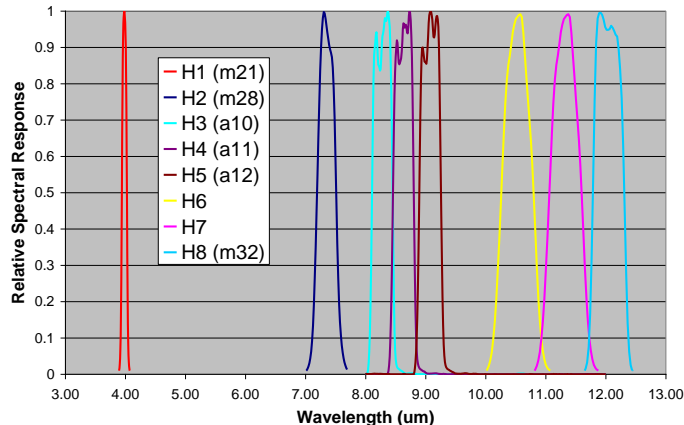
KML browse image





Measurement:

- 7 bands between 7.5-12 μm and 1 band at 4 μm
- 60 m resolution, 5 days revisit
- Global land and shallow water



Science Questions:

TQ1. Volcanoes/Earthquakes

- How can we help predict and mitigate earthquake and volcanic hazards through detection of transient thermal phenomena?

• TQ2. Wildfires

- What is the impact of global biomass burning on the terrestrial biosphere and atmosphere, and how is this impact changing over time?

• TQ3. Water Use and Availability

- How is consumptive use of global freshwater supplies responding to changes in climate and demand, and what are the implications for sustainable management of water resources?

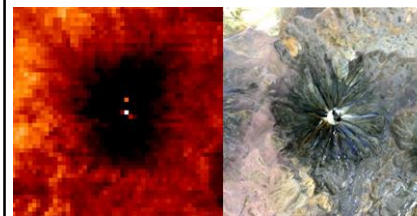
• TQ4. Urbanization/Human

- How does urbanization affect the local, regional and global environment? Can we characterize this effect to help mitigate its impact on human health and welfare?

• TQ5. Earth surface composition and change

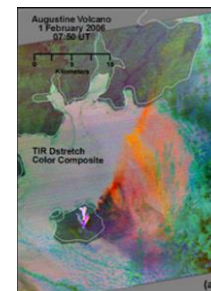
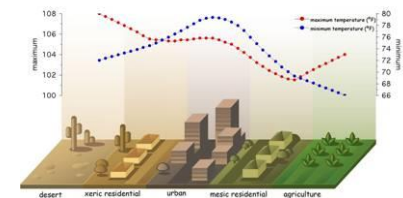
- What is the composition and temperature of the exposed surface of the Earth? How do these factors change over time and affect land use and habitability?

Andean volcano heats up

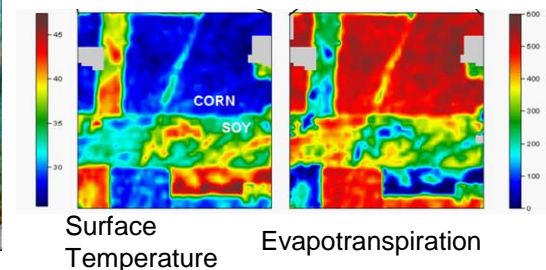


Volcanoes

Urbanization

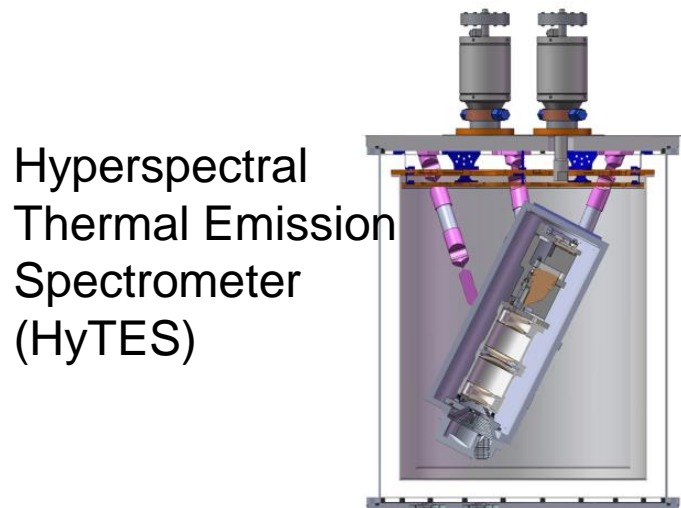


Water Use and Availability

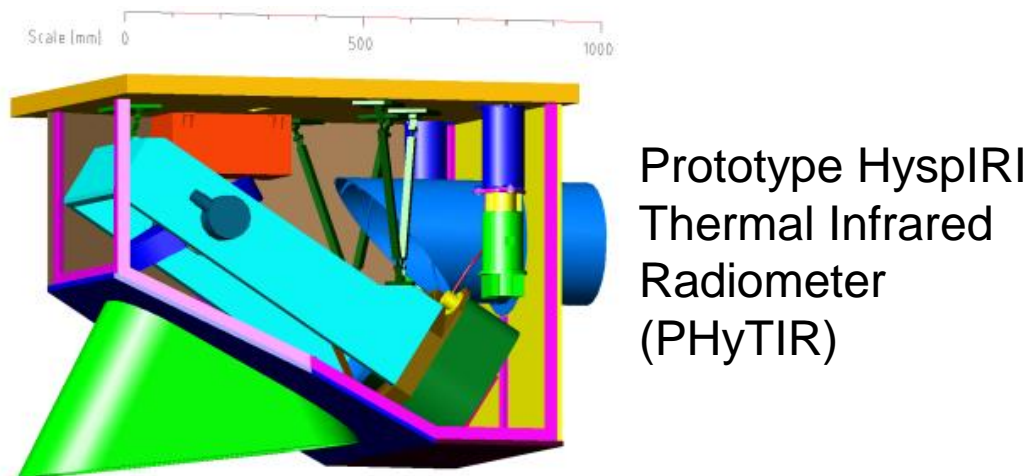


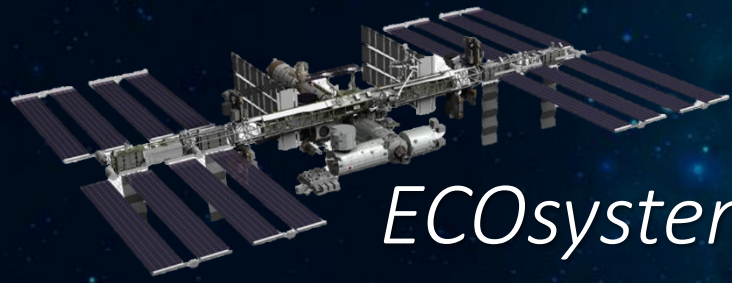


Science Risk Reduction



Engineering Risk Reduction

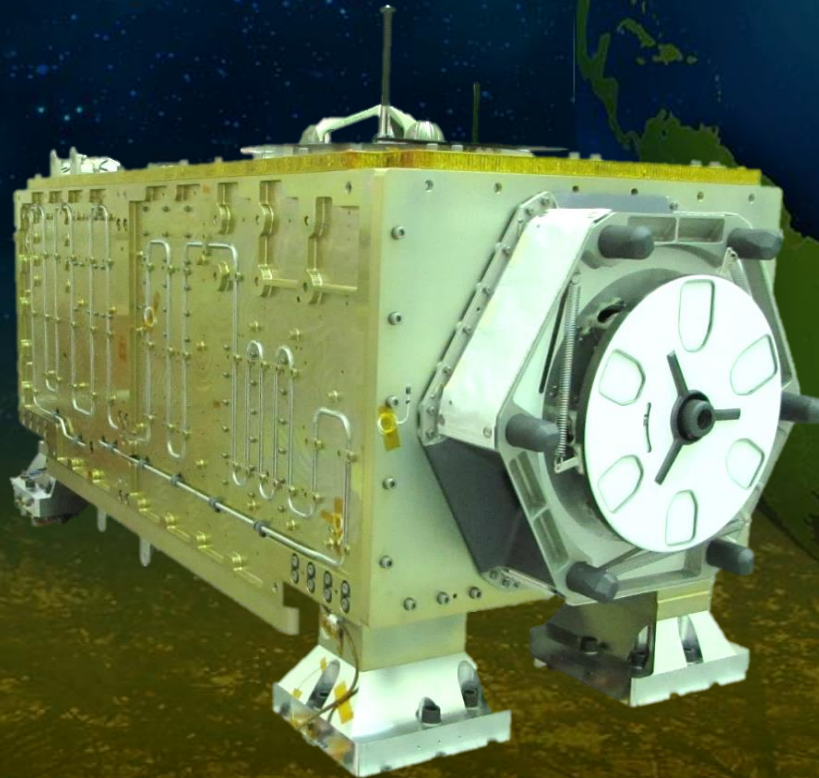




*ECOsysteM Spaceborne Thermal
Radiometer Experiment on Space Station*



ECOSTRESS



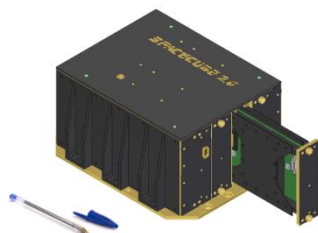
Data Product	Description	Initial Availability to NASA DAAC	Median Latency in Product Availability to NASA DAAC after Initial Delivery	NASA DAAC Location
Level 0	Raw collected telemetry	6 months after IOC	12 weeks	To be assigned by NASA SMD/ESD
Level 1	Calibrated Geolocated Radiances	6 months after IOC	12 weeks	To be assigned by NASA SMD/ESD
Level 2	Surface temperature and emissivity	6 months after Level 1 data products are available	12 weeks	To be assigned by NASA SMD/ESD
Level 3	Evapotranspiration	2 months after Level 2 data products are available	12 weeks	To be assigned by NASA SMD/ESD
Level 4	Water use efficiency and evaporative stress index	2 months after Level 3 data products are available	12 weeks	To be assigned by NASA SMD/ESD



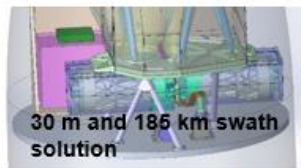
HyspIRI: IPM

- IPM

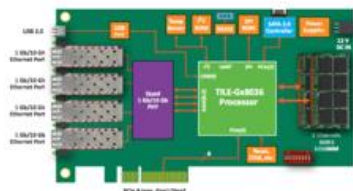
- Four Card Flight Unit
- 5 x 7 x 9 inches
- 5.8 kg
- 20 watts (typical)



VSWIR-Dyson with IPM



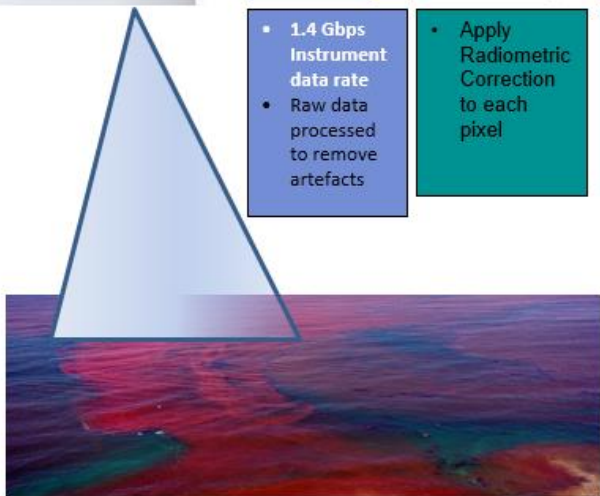
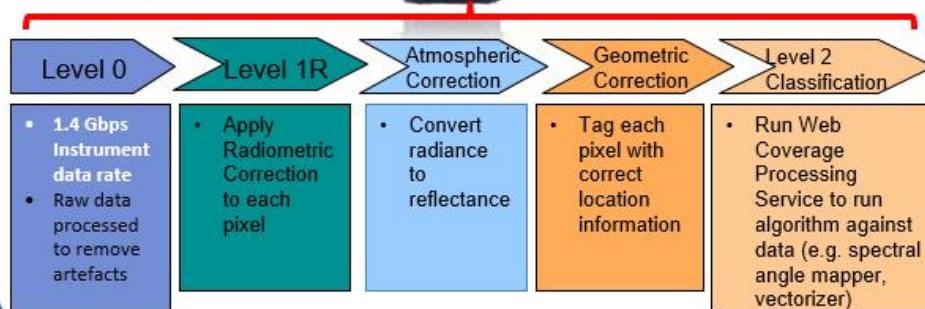
30 m and 185 km swath solution



Onboard multicore processor or single Linux processor



FPGA Onboard Accelerator



Downlink via TDRSS S-Band 1 Mbps RT Algal Bloom Maps to Users on Bay



IPM – Intelligent Payload Module

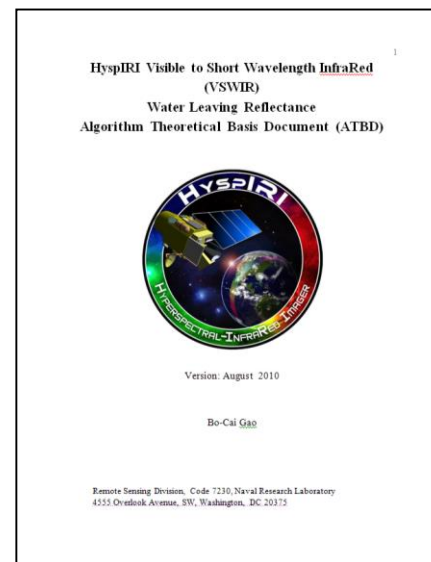
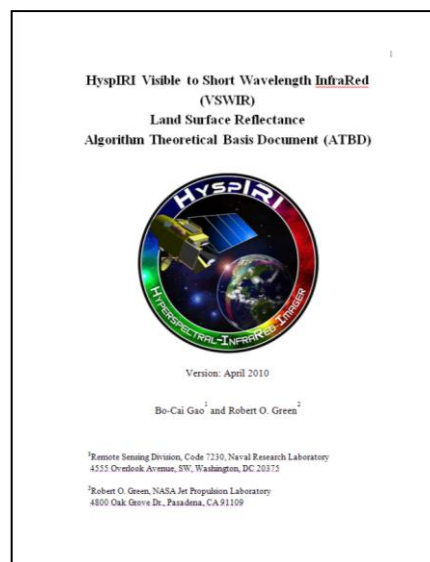


HyspIRI Draft Product Algorithm Theoretical Basis Documents



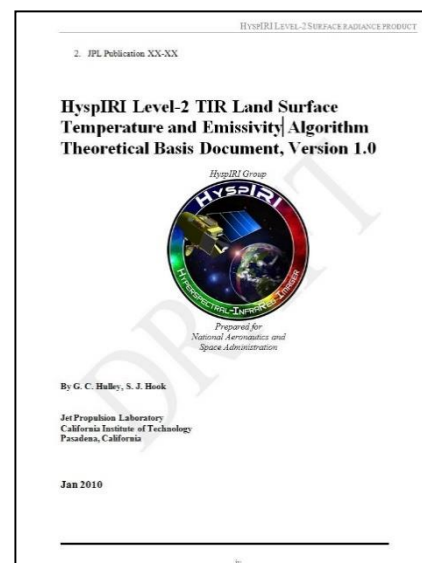
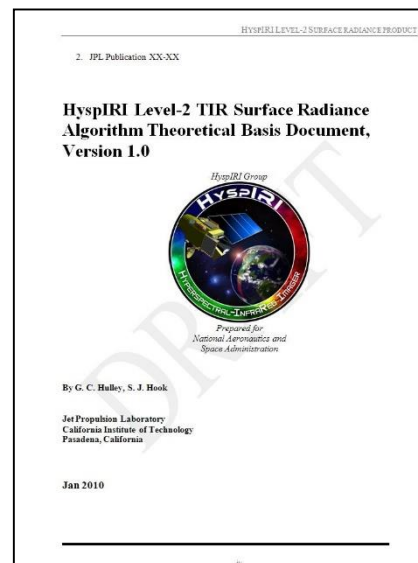
- VSWIR Level 2 products.

- Land Surface Reflectance
- Water RS Reflectance



- TIR Level 2 products.

- Surface Radiance
- Temperature and Emissivity





HyspIRI Comprehensive Development Report



Comprehensive Report

- [Comprehensive Development Report](#)

HyspIRI Mission TRL Assessment

- [Comprehensive Development Report](#)

Appendix

Reports and Whitepapers

- [Compiled Reports and Whitepapers from 2008-2014](#)

Individual Report files

- [2014 HyspIRI Separate Platforms Whitepaper](#)
- [2014 PHYTIR Test Results](#)
- [2012 Workshop Report](#)
- [2012 TIR Band Study Report](#)
- [2011 Workshop Report](#)
- [2011 Symposium Report](#)
- [2011 Sun Glint Report](#)
- [2011 High Temperature Saturation Report](#)
- [2010 Workshop Report](#)
- [2009 Workshop Report](#)
- [2008 Whitepaper and Workshop Report](#)
- [TRL Assessment Report](#)

HyspIRI Workshop Material

- [2014 Compiled Workshop](#)
- [2013 Compiled Workshop](#)
- [2012 Compiled Workshop](#)
- [2011 Compiled Workshop](#)
- [2010 Compiled Workshop](#)
- [2009 Compiled Workshop](#)
- [2008 Compiled Workshop](#)

Individual Workshop files

- [2014 Workshop Agenda and Presentations](#)
- [2013 Workshop Agenda and Presentations](#)
- [2012 Workshop Agenda and Presentations](#)
- [2011 Workshop Agenda and Presentations](#)
- [2010 Workshop Agenda and Presentations](#)
- [2009 Workshop Agenda and Presentations](#)
- [2008 Workshop Agenda and Presentations](#)

HyspIRI Symposium Material

- [2014 Compiled Symposium](#)
- [2013 Compiled Symposium](#)
- [2012 Compiled Symposium](#)
- [2011 Compiled Symposium](#)
- [2010 Compiled Symposium](#)

Individual Workshop files

- [2014 Symposium Agenda and Presentations](#)
- [2013 Symposium Agenda and Presentations](#)
- [2012 Symposium Agenda and Presentations](#)
- [2011 Symposium Agenda and Presentations](#)
- [2010 Symposium Agenda and Presentations](#)

TeamX ISS Accommodation Studies

- [VSWIR ISS Study](#)
- [TIR ISS Study](#)

2014 Small Spacecraft Vendor Presentation

Algorithm Theoretical Basis Documents (ATBDs)

- [TIR Level 2 Surface Radiance](#)
- [TIR Level 2 Surface Temperature and Emissivity](#)
- [TIR Cloud Mask](#)
- [VSWIR Level 2 Water Leaving Reflectance](#)
- [VSWIR Level 2 Land Surface Reflectance](#)

Science Application Summaries

- [Disasters](#)
- [Water resources](#)
- [Health and Air Quality](#)

Science Application White Papers

- [HyspIRI Volcanoes](#)
- [Public Health](#)

<http://hyspiri.jpl.nasa.gov/comprehensive-development-report>

Data Products Symposium at GSFC



Science and Applications Workshop at Caltech



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

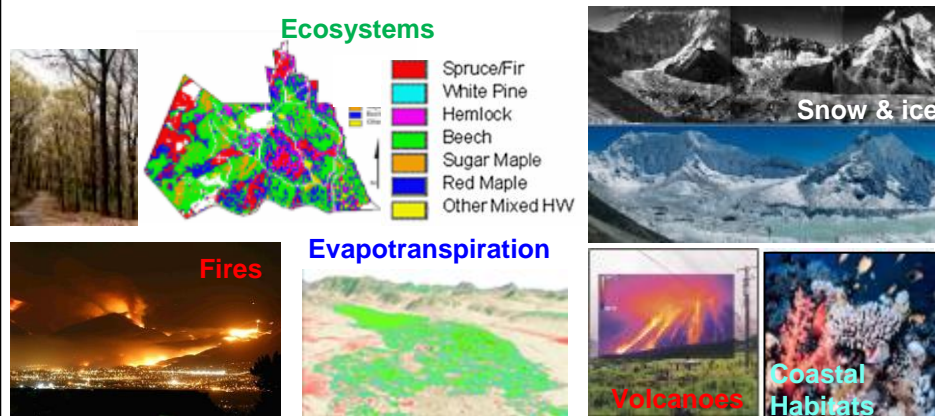
Volcanoes: Eruptions, emissions, regional and *global* impacts

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

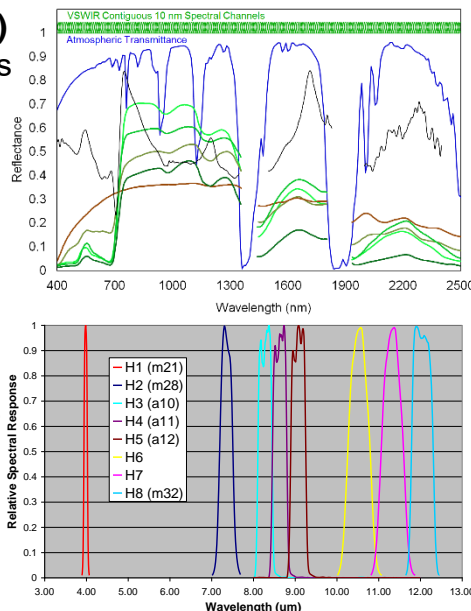
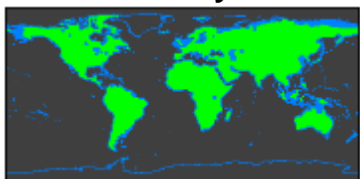
Imaging Spectrometer (VSWIR)

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

Thermal Infrared (TIR)

- 8 bands between 4-12 μ m
- 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

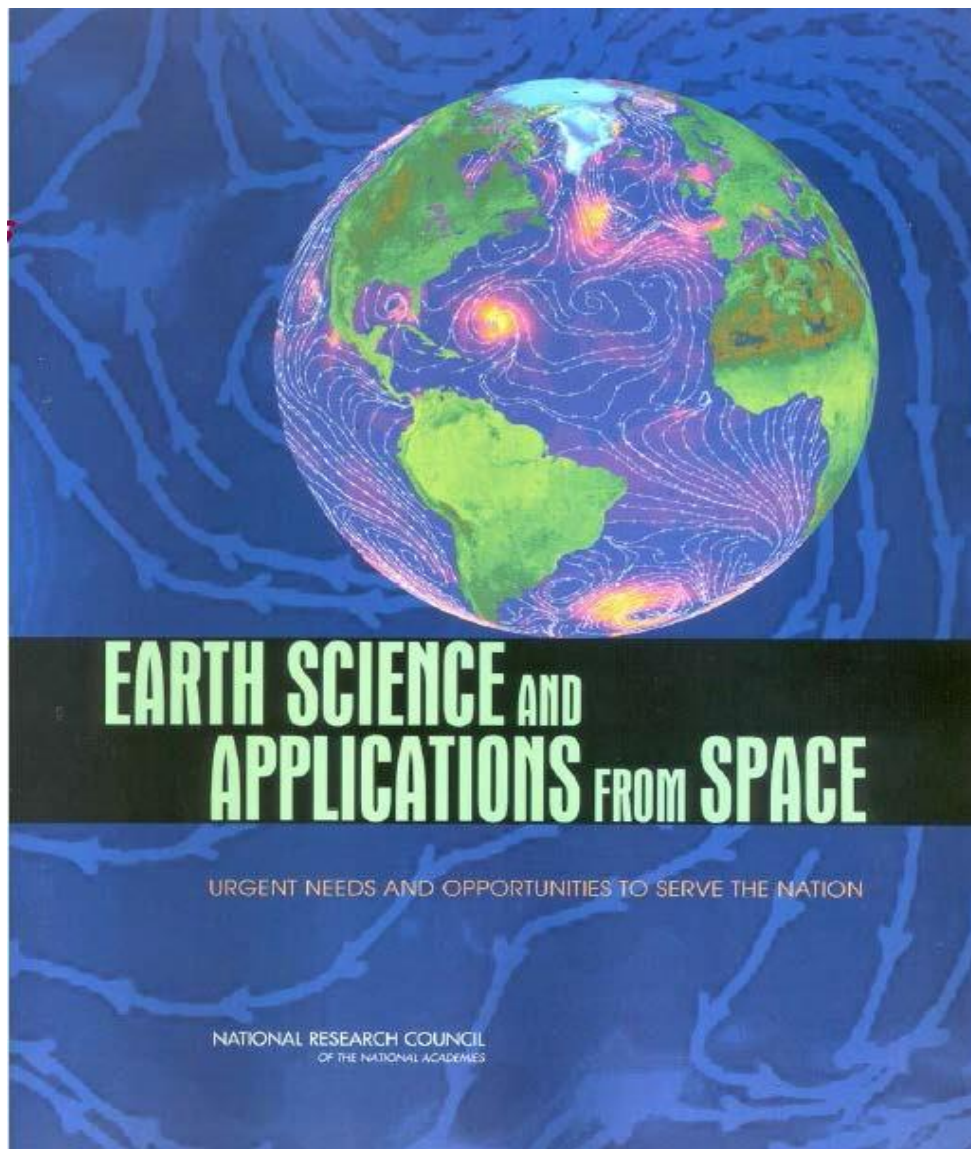
2016 Option: HyspIRI VSWIR evolved to 30 m and 16 day global revisit. Requires F/1.8 Dyson spectrometer architecture and other current technologies.

Preparatory airborne campaigns: Measurements used to advance and refine science, applications, algorithms, and processing

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



2017 Decadal Survey



Luvall	Jeffrey	A Thermodynamic Paradigm For Using Satellite Based Geophysical Measurements For Public Health Applications
Heidi	Dierssen	Assessing Transient Threats and Disasters in the Coastal Zone with Airborne Portable Sensors
Ryan	Pavlick	Biodiversity
Simon	Hook	Carbon Emissions from Biomass Burning
Eric	Hochberg	Coral Reefs: Living on the Edge
Wendy	Calvin	Earth Surface Geochemistry and Mineralogy: Processes, Hazards, Soils, and Resources
Joshua	Fisher	Evapotranspiration: A Critical Variable Linking Ecosystem Functioning, Carbon and Climate Feedbacks, Agricultural Management, and Water Resources
Tamlin	Pavelsky	From the Mountains to the Sea: Interdisciplinary Science and Applications Driven by the Flow of Water, Sediment, and Carbon II
Philip	Dennison	Global Measurement of Non-Photosynthetic Vegetation
Kevin	Turpie	Global Observations of Coastal and Inland Aquatic Habitats
Philip	Townsend	Global Terrestrial Ecosystem Functioning and Biogeochemical Processes
Dale	Quattrochi	High Spatial, Temporal, and Spectral Resolution Instrument for Modeling/Monitoring Land Cover, Biophysical, and Societal Changes in Urban Environments
Steve	Greb	Inland Waters
Natalie	Mahowald	Measuring the Earth's Surface Mineral Dust Source Composition for Radiative Forcing and Related Earth System Impacts
Frank	Muller-Karger	Monitoring Coastal and Wetland Biodiversity from Space
Robert	Wright	Predicting Changes in the Behavior of Erupting Volcanoes, and Reducing the Uncertainties Associated with their Impact on Society and the Environment
Robert	Green	Science and Application Targets Addressed with the 2007 Decadal Survey HyspIRI Mission Current Baseline
Natasha	Stavros	The role of fire in the Earth System
Riley	Duren	Understanding anthropogenic methane and carbon dioxide point source emissions
Thomas	Painter	Understanding the controls on cryospheric albedo, energy balance, and melting in a changing world

Questions and Discussion



Overview of the HypsIRI Mission Concept, Measurements and Science

A Global Coverage VSWIR and TIR Mission