



HyspIRI Mission Concept

DRAFT PRELIMINARY Level 1 Requirements

NASA Earth Science and Applications Decadal Survey

Robert O. Green, Simon Hook, Betsy Middleton, Woody Turner, Ben Phillips and the HyspIRI Team



Overview



Beginning in January 2007 a Mission Concept effort for HyspIRI has been under way with involvement of NASA HQ, JPL, GSFC, and a dedicated Science Study Group (SSG).

Input from the broad community has been received through the Data Product Symposia and Science & Science Applications workshops.

The HyspIRI Mission concept team has worked to develop a end-to-end concept for implementation of the HyspIRI Mission.

Based on this effort and with input from SSG and the relevant communities a set of Level 1 Requirements and Success Criteria have been developed in accordance with the required NASA process.

The Level 1 Requirements are a NASA Headquarters Document and provide an important basis for tracking the progress and judging the success of a HyspIRI type mission



HyspIRI Science Study Group



(Selected by NASA Program Science Leadership)

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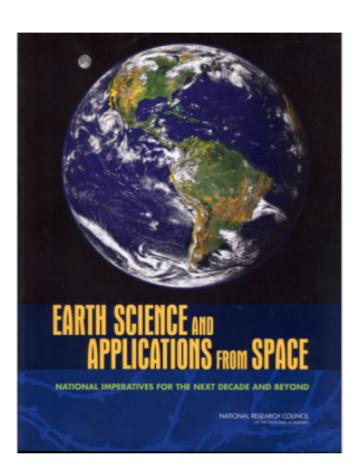
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Upitt

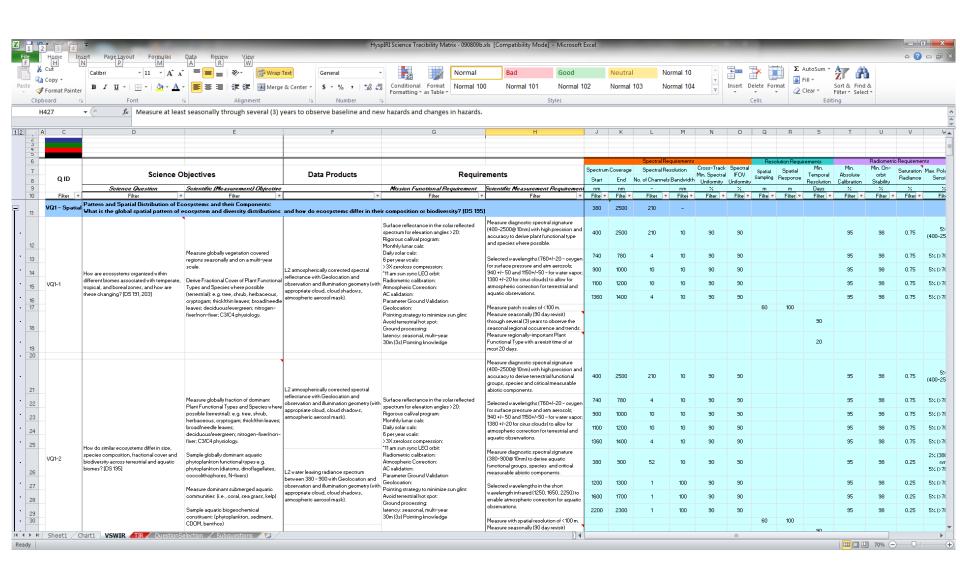
Michael Ramsey





HyspIRI Science Traceability Matrices







Level 1 Requirements Outline



1.0 Scope

- 2.0 Science Definition
 - 2.1 Baseline Science Objectives
 - 2.2 Science Instrument Summary Description
- 3.0 Project Definition
 - 3.1 Project Organization and Management
 - 3.2 Project Acquisition Strategy
- 4.0 Performance Requirements
 - 4.1 Science Requirements
 - 4.2 Mission and Spacecraft Performance
 - 4.3 Launch Requirements
 - 4.4 Ground System Requirements
 - 4.5 Mission Data Requirements

- 5.0 NASA Mission Cost Requirement Program Requirement
 - 5.1 Cost
 - 5.2 Cost Management and Scope Reduction
- 6.0 Multi-Mission NASA Facilities
- 7.0 External Agreements
- 8.0 Public Outreach and Education
- 9.0 Special Independent Evaluation
- 10.0 Waivers
- 11.0 Approvals and Concurrences



HyspIRI Draft 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





• 2.2. Science Objectives

• The HyspIRI Project will implement an earth observation space mission designed to collect and deliver global surface spectral reflectance, remote sensing reflectance over shallow water, thermal emissivity and surface temperature imaging measurements that will enable science and applications users to advance the current understanding of the Earth's ecology, biogeochemistry, biodiversity, coastal and inland water research, geology, natural hazards, hydrology, climate, climate change impact and adaptation, and studies of the carbon cycle[NRC DS].





4. Performance Requirements

4.1 Science Requirements

The science objectives in Section 2.2 can be achieved by either the baseline or minimum science mission requirements listed here, but the baseline mission provides substantially more value to NASA and the Earth Science Community.

- 4.1.1 Requirement: Baseline Science Mission
- The scientific requirements that must be achieved in order to fully satisfy the baseline science objectives.
- a) VSWIR
- b) TIR
- c) Combined





VSWIR (post 2015 guidance)

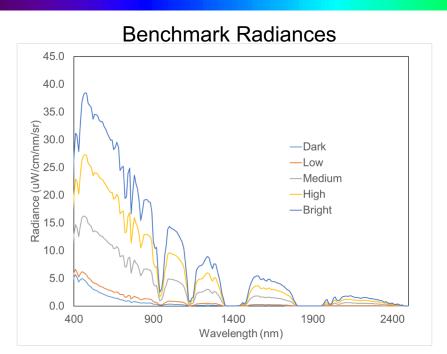
• a) To address the Decadal Survey and community identified science and application questions related to terrestrial and coastal ocean ecosystem composition, function, and change as well as surface composition (DS113-115), the baseline science mission shall provide global mapping measurements of the surface reflectance or remote sensing reflectance for shallow water regions across the solar reflected spectrum from 380 to 2510 nm at ≤10 nm sampling at the specified signal-to-noise ratio and accuracy with >95% spectral/spatial uniformity at ≤30 m nadir spatial sampling with <16 day revisit to provide >70% seasonal and >90% annual coverage of the terrestrial and shallow water regions of the Earth for at least three years with a subset of measurements available near-real-time for designated science and applications.

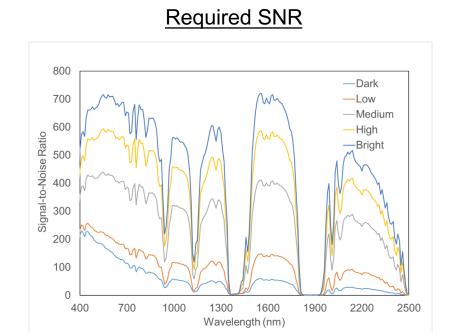


Level 1 Requirements (VSWIR)

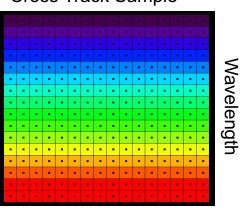
Uniformity Requirement







Cross Track Sample

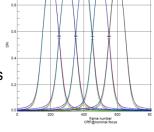


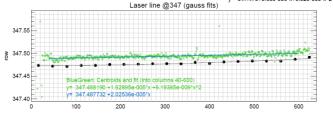
Depiction

- -Grids are the detectors
- -Dots are the IFOV centers
- -Colors are the wavelengths

Requirement

Spectral Cross-Track





>90% cross-track uniformity {<0.5 nm min-max over swath}

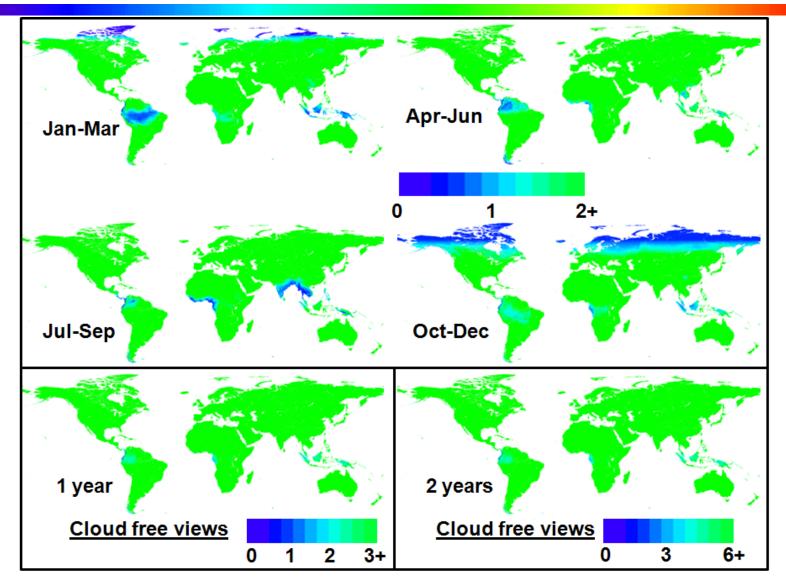
Spectral-IFOV-Variation

>90% spectral IFOV uniformity {<5% variation over spectral range}



VSWIR Cloud Cover Analysis





Mercury, M., R. Green, S. Hook, B. Oaida, W. Wu, A. Gunderson, M. Chodas, "Global cloud cover for assessment of optical satellite observation opportunities: A HyspIRI case study," Remote Sensing of Environment, Volume 126, November 2012, Pages 62–71





TIR

b) To address the Decadal Survey and community-identified science and application questions related to volcanoes, wild fires, water usage, urbanization and surface composition (DS113-115), the baseline science mission shall provide global mapping measurements of the surface radiance, temperature and emissivity with 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 to provide >60% Monthly, >70% seasonal and >85% annual coverage of the terrestrial and shallow water regions of the Earth for at least three years with a subset of measurements available near-real-time for designated science and applications.



Specified NEdT



		Spectral Bandwidth	Min Nominal Radiance and Temperature	Max Nominal Radiance and Temperature	NEGI at Min nominal Temperature	NEGI at Max Nominal Temperature	NEdT at 300 K
	(microns)	(microns)	(W/m^2/micron/sr)	(W/m^2/micron/sr)	Kelvin	Kelvin	Kelvin
Band 1	3.98	0.08	14 (400 K)	9600 (1400 K)	1	0.12	11.2
Band 2	7.35	0.32	0.34 (200 K)	110 (500 K)	2.8	0.22	0.28
Band 3	8.28	0.34	0.45 (200 K)	100 (500 K)	2	0.22	0.24
Band 4	8.63	0.35	0.57 (200 K)	94 (560 K)	1.6	0.24	0.24
Band 5	9.07	0.36	0.68 (200 K)	86 (500 K)	1.2	0.24	0.22
Band 6	10.53	0.54	0.89 (200 K)	71 (500 K)	0.64	0.22	0.16
Band 7	11.33	0.54	1.1 (200 K)	58 (500 K)	0.56	0.26	0.16
Band 8	12.05	0.52	1.2 (200 K)	48 (500 K)	0.52	0.3	0.18

Digitization @ min radiance	Digitization @ max radiance	Digitization @ 300 K
(W/m^2/micron/sr)	(W/m^2/micron/sr)	(W/m^2/micron/sr)
4.0e-2 (0.12 K)	4.0e-2 (0.01 K)	5.0e-2 (1.4 K)
5.6e-3 (0.30 K)	5.6e-3 (0.009 K)	5.6e-3 (0.03 K)
4.8e-3 (0.23 K)	4.8e-3 (0.009 K)	4.8e-3 (0.03 K)
4.5e-3 (0.19 K)	4.5e-3 (0.009 K)	4.5e-3 (0.03 K)
4.1e-3 (0.15 K)	4.1e-3 (0.010 K)	4.1e-3 (0.03 K)
2.5e-3 (0.08 K)	2.5e-3 (0.008 K)	2.5e-3 (0.02 K)
2.2e-3 (0.07 K)	2.2e-3 (0.010 K)	2.2e-3 (0.02 K)
2.1e-3 (0.06 K)	2.1e-3 (0.012 K)	2.1e-3 (0.02 K)

Notes

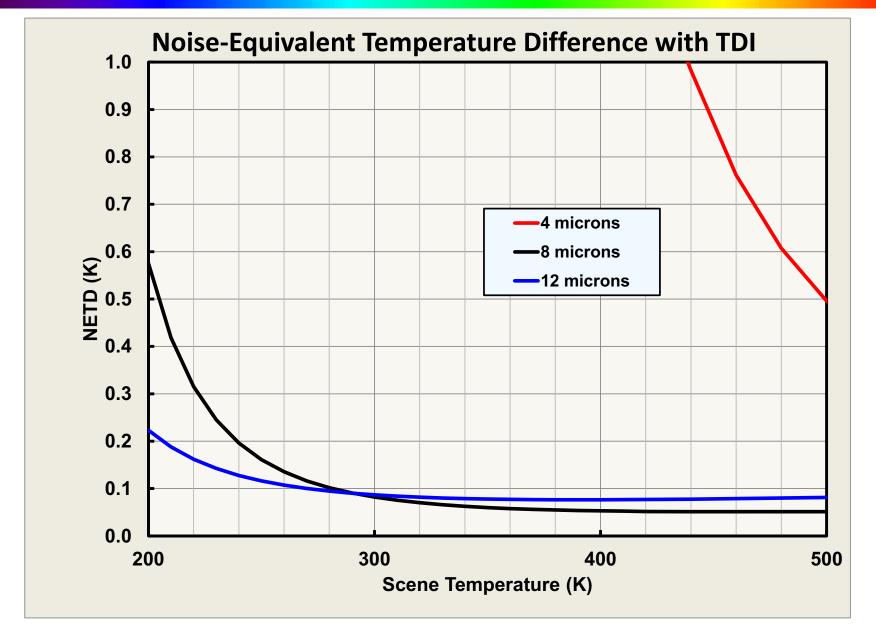
Center wavelength is the average of the max and min wavelengths at the FWHM Spectral bandwidth is the FWHM

Minimum nominal radiance is 200K except for 4 um band where it is 400K Maximum nominal radiance is 500K except for 4 um band where it is 1400K



Performance

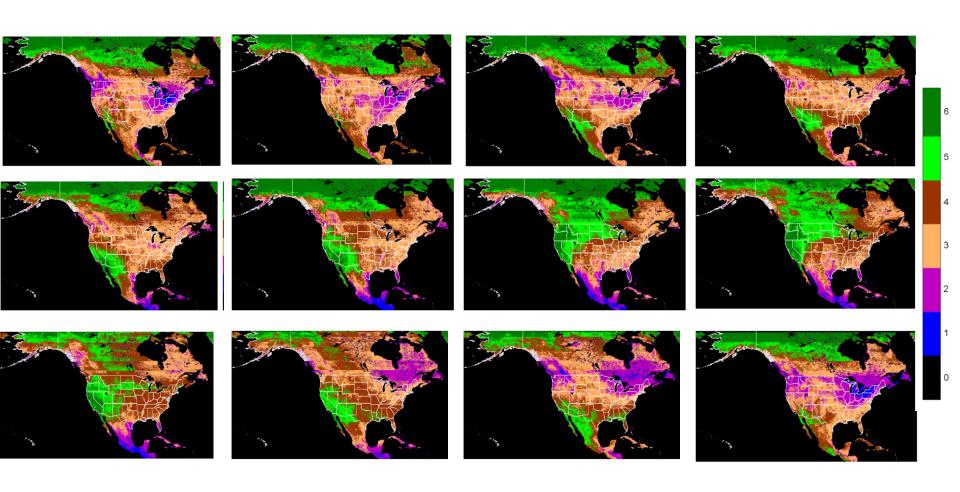






Number of daytime cloud-free views by TIR each month





Top Row: Jan, Feb, Mar Apr Middle Row: May, Jun, Jul, Aug Bottom Row: Sep, Oct, Nov, Dec





COMBINED

c) To address Decadal Survey and community-identified science and application questions (DS113-115), requiring combined reflectance, emissivity and temperature measurements, the baseline mission shall provide combined global mapping data sets.





Threshold Science Requirements

 Threshold (or minimum) scientific requirements (the "science floor") that are required to scientifically justify performing the mission.





Threshold Science Requirements

4.1.2 Threshold Science Requirements

a) [VSWIR] To address the Decadal Survey and community identified science and application questions related to terrestrial and coastal ocean ecosystem composition, function, and change as well as surface composition (DS113-115), the baseline science mission shall provide global mapping measurements of the surface reflectance or remote sensing reflectance for shallow water regions across the solar reflected spectrum from 380 to 2500 nm at ≤10 nm sampling at >80% of the specified signal-to-noise ratio and accuracy with > 80% spectral/spatial uniformity at ≤30 m nadir spatial sampling with <16 day revisit to provide > 50% seasonal and >70% annual coverage of the terrestrial and shallow water regions of the Earth for at least two years.





Threshold Science Requirements

- b) [TIR]To address the Decadal Survey and community identified science and application questions related to volcanoes, wild fires, water usage, urbanization and surface composition (DS113-115), the baseline science mission shall provide global mapping measurements of the surface temperature as well as emissivity and surface radiance in 8 spectral bands from the 3-5 micron and 8-12 micron regions of the spectrum at >80% the specified noise-equivalent-delta-temperature and accuracy at ≤60 m nadir spatial sampling with ≤5 day revisit to provide > 40% Monthly, > 60% seasonal and >70% annual coverage of the terrestrial and shallow water regions of the Earth for at least two years.
- c) [COMBINED] To address Decadal Survey and community identified science and application questions requiring combined reflectance, emissivity and temperature measurements, the threshold mission shall provide combined global mapping data sets.



Baseline vs Minimum (Threshold)



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



Summary and Conclusions



Program Level Requirements (or Level 1 Requirements) are a required gate

product

KDP-A: Draft

KDP-B: Updated Draft Baseline

KDP-C: Baseline Update

In the pre Phase A period of the HyspIRI Mission concept input to the Level 1 Requirements are requested from the SSG and Community.

The Level 1 Requirements are a NASA Headquarters Document and provide an important basis for tracking the progress and judging the success of HyspIRI

The HyspIRI Mission concept developed a viable set of draft preliminary Level 1 Requirements that are available to support the 2017 Decadal Survey



Questions



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

Measurement

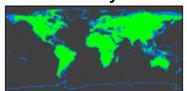
Imaging Spectrometer (VSWIR)

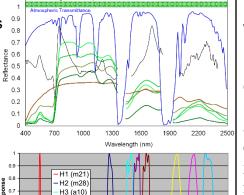
- 380 to 2510nm in ≤10nm bands
- 30 m spatial sampling
- 16 days revisit
- Global land and shallow water

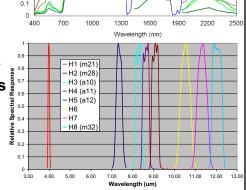
Thermal Infrared (TIR)

- 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

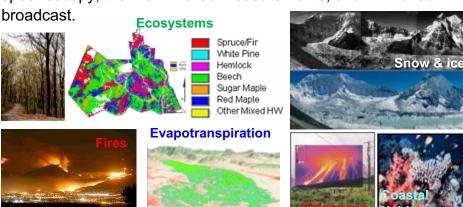






Global Mission Urgency

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



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