



HyspIRI

DRAFT PRELIMINARY Level 1 Requirements

NASA Earth Science and Applications Decadal Survey

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Overview



Beginning in January 2007 a Mission Concept effort for HypsIRI 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 HypsIRI Mission concept team has worked to develop a end-to-end concept for implementation of the HypsIRI 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 HypsIRI

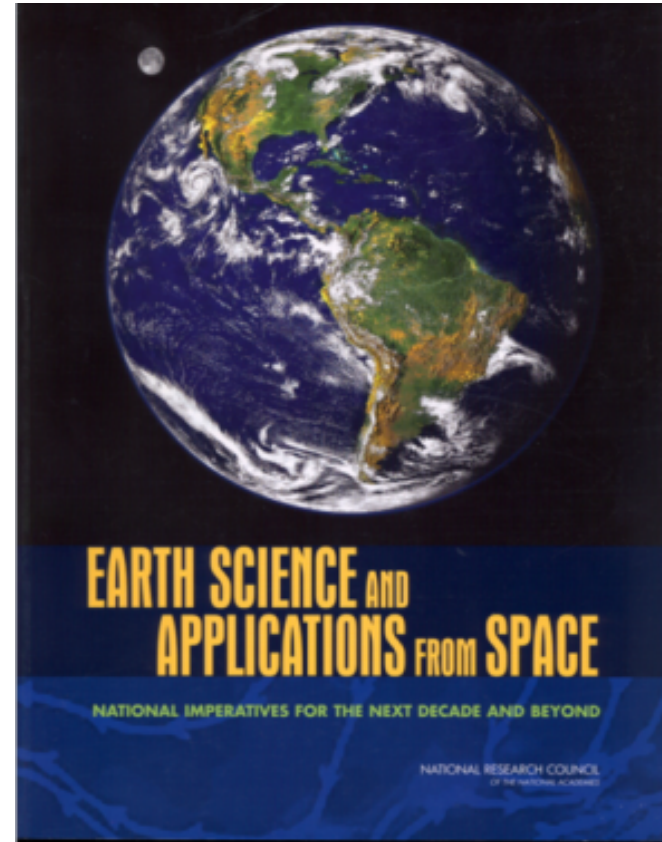


HyspIRI Science Study Group

(Selected by NASA Program Science Leadership)



- | | |
|---------------------|---------------|
| Mike Abrams | JPL |
| Rick Allen | UID |
| Martha Anderson | USDA |
| Greg Asner | Stanford, CIW |
| Paul Bissett | FERI |
| Alex Chekalyuk | Lamont-Doh. |
| James Crowley | USGS |
| Ivan Csiszar | UMD |
| Heidi Dierssen | U Conn. |
| Friedmann Freund | Ames |
| John Gamon | U A |
| Louis Giglio | UMD |
| Greg Glass | JHU |
| Robert Green | JPL |
| Simon Hook | JPL |
| James Irons | GSFC |
| Bob Knox | GSFC |
| John Mars | USGS |
| David Meyer | USGS EROS |
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| Peter Minnett | U. Miami |
| Frank Muller Karger | U. MA Dart. |
| Scott Ollinger | UNH |
| Thomas Painter | U. of Utah |
| Anupma Prakash | UAF |
| Jeff Privette | NOAA |
| Dale Quattrochi | MSFC |
| Vince Realmuto | JPL |
| Dar Roberts | UCSB |
| Dave Siegel | UCSB |
| Phil Townsend | U of Wisc. |
| Kevin Turpie | GSFC |
| Steve Ungar | GSFC |
| Susan Ustin | UC Davis |
| Rob Wright | UHI |
| Michael Ramsey | Upitt |





HyspIRI Science Traceability Matrices



HyspIRI Science Traceability Matrix - 090809b.xls [Compatibility Mode] - Microsoft Excel

H427 Measure at least seasonally through several (3) years to observe baseline and new hazards and changes in hazards.

Q ID	Science Objectives	Data Products	Requirements	Spectral Requirements		Resolution Requirements			Radiometric Requirements										
				Spectrum Coverage	Spectral Resolution	Cross-Track	Spectral	Spatial	Min. Temporal	Min. Absolute	Min. On-orbit	Saturation	Max. Polt						
				Start	End	No. of Channels	Bandwidth	Min. Spectral Uniformity	IFOV	Sampling	Resolution	Calibration	Stability	Radiance	Sensi				
Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter							
WQ1 - Spatial	Pattern and Spatial Distribution of Ecosystems and their Components: What is the global spatial pattern of ecosystem and diversity distributions and how do ecosystems differ in their composition or biodiversity? [DS 195]			380	2500	210	-												
WQ1-1	How are ecosystems organized within different biomes associated with temperate, tropical, and boreal zones, and how are these changing? [DS 191, 203]	Derive Fractional Cover of Plant Functional Types and Species where possible (terrestrial): e.g. tree, shrub, herbaceous, cryptogam; thick/thin leaves; broad/needle leaves; deciduous/evergreen; nitrogen-fixing/non-fixing; C3/C4 physiology.	L2 atmospherically corrected spectral reflectance with Geolocation and observation and illumination geometry (with appropriate cloud, cloud shadows, atmospheric aerosol mask).	Surface reflectance in the solar reflected spectrum for elevation angles > 20. Rigorous cal/val program: Monthly lunar cal: Daily solar cal: 6 per year swals: > 3X zero-loss compression: *11 am sun sync LED orbit: Radiometric calibration: Atmospheric Correction: AC validation: Parameter Ground Validation Geolocation: Pointing strategy to minimize sun glint: Avoid terrestrial hot spot: Ground processing: latency: seasonal, multi-year 30m (3s) Pointing knowledge	Measure diagnostic spectral signature (400-2500@10nm) with high precision and accuracy to derive plant functional type and species where possible.	400	2500	210	10	90	90		95	98	0.75	5% (400-25			
				Selected wavelengths (760+/-20 - oxygen for surface pressure and atm aerosols; 940 +/- 50 and 1150+/-50 - for water vapor; 1380 +/-20 for cirrus clouds) to allow for atmospheric correction for terrestrial and aquatic observations.	740	780	4	10	90	90		95	98	0.75	5% (> 7				
				Measure patch scales of <100 m. Measure seasonally (90 day revisit) through several (3) years to observe the seasonal regional occurrence and trends. Measure regionally-important Plant Functional Type with a revisit time of at most 20 days.	300	1000	10	10	90	90		95	98	0.75	5% (> 7				
				1100	1200	10	10	90	90		95	98	0.75	5% (> 7					
WQ1-2	How do similar ecosystems differ in size, species composition, fractional cover and biodiversity across terrestrial and aquatic biomes? [DS 195]	Sample globally dominant aquatic phytoplankton functional types e.g. phytoplankton (diatoms, dinoflagellates, coccolithophores, N-fixers)	L2 water leaving radiance spectrum between 380 - 900 with Geolocation and observation and illumination geometry (with appropriate cloud, cloud shadows, atmospheric aerosol mask).	Surface reflectance in the solar reflected spectrum for elevation angles > 20. Rigorous cal/val program: Monthly lunar cal: Daily solar cal: 6 per year swals: > 3X zero-loss compression: *11 am sun sync LED orbit: Radiometric calibration: Atmospheric Correction: AC validation: Parameter Ground Validation Geolocation: Pointing strategy to minimize sun glint: Avoid terrestrial hot spot: Ground processing: latency: seasonal, multi-year 30m (3s) Pointing knowledge	Measure diagnostic spectral signature (400-2500@10nm) with high precision and accuracy to derive terrestrial functional groups, species and critical measurable abiotic components.	400	2500	210	10	90	90		95	98	0.75	5% (400-25			
				Selected wavelengths (760+/-20 - oxygen for surface pressure and atm aerosols; 940 +/- 50 and 1150+/-50 - for water vapor; 1380 +/-20 for cirrus clouds) to allow for atmospheric correction for terrestrial and aquatic observations.	740	780	4	10	90	90		95	98	0.75	5% (> 7				
				Measure diagnostic spectral signature (300-900@10nm) to derive aquatic functional groups, species and critical measurable abiotic components.	380	900	52	10	90	90		95	98	0.25	2% (38	nr	5% (> 7		
				Selected wavelengths in the short wavelength infrared (1250, 1650, 2250) to enable atmospheric correction for aquatic observations.	1200	1300	1	100	90	90		95	98	0.25	5% (> 7				
				Pointing strategy to minimize sun glint: Avoid terrestrial hot spot: Ground processing: latency: seasonal, multi-year 30m (3s) Pointing knowledge	Measure with spatial resolution of <100 m. Measure seasonally (90 day revisit)	1600	1700	1	100	90	90		95	98	0.25	5% (> 7			
				2200	2300	1	100	90	90		95	98	0.25	5% (> 7					



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



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: August 27, 2010

Owner: NASA Decadal Survey HyspIRI Program Executive and Program Scientist

Draft Preliminary



Level 1 Requirements



- **2.2. Science Objectives**

- The HypsIRI 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].



Level 1 Requirements



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



Level 1 Requirements



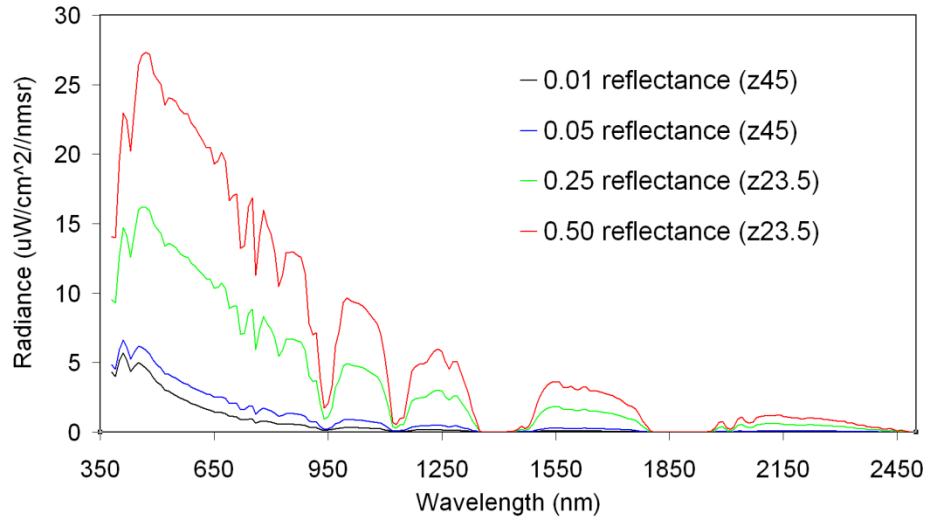
VSWIR

- 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 2500 nm at ≤ 10 nm sampling at the specified signal-to-noise ratio and accuracy with $>95\%$ spectral/spatial uniformity at ≤ 60 m nadir spatial sampling with <20 day revisit to provide $>60\%$ seasonal and $>80\%$ 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.

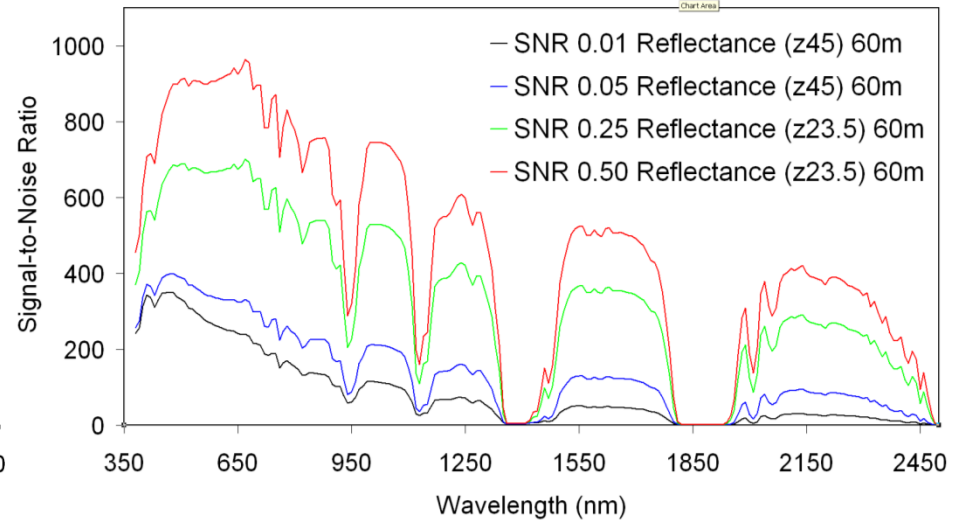


Level 1 Requirements (VSWIR)

Benchmark Radiances

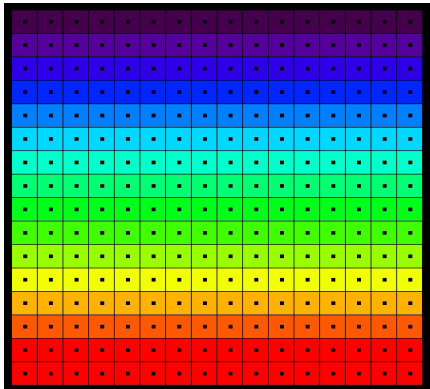


Required SNR



Uniformity Requirement

Cross Track Sample



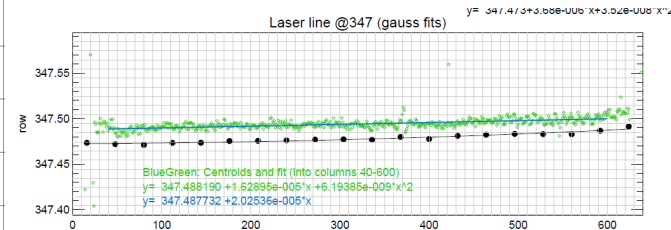
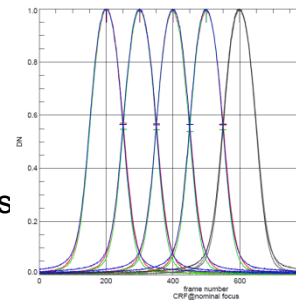
Wavelength

Depiction

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

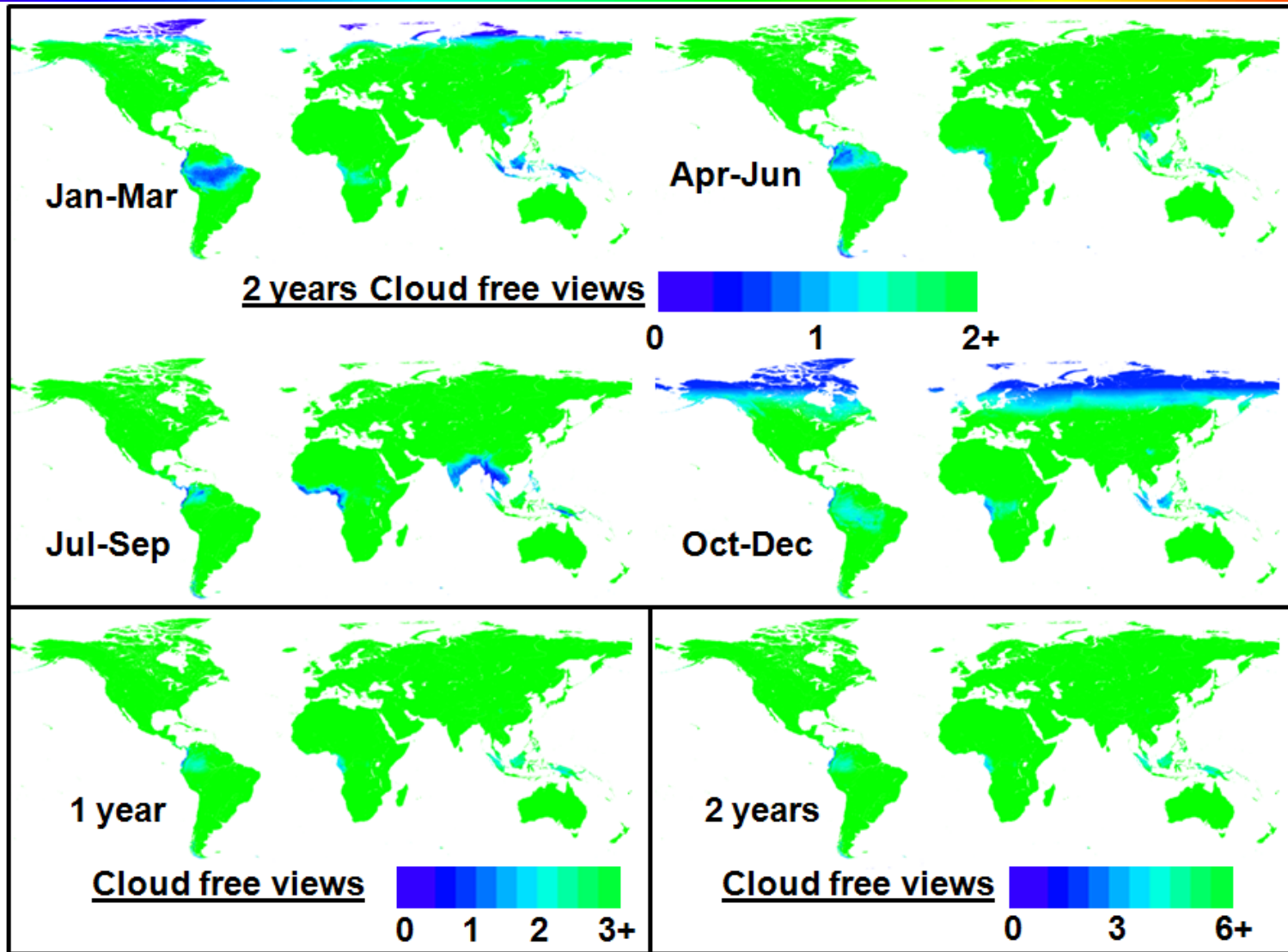
Requirement

- Spectral Cross-Track >95% cross-track uniformity {<0.5 nm min-max over swath}
- Spectral-IFOV-Variation >95% spectral IFOV uniformity {<5% variation over spectral range}





VSWIR Cloud Cover Analysis





Level 1 Requirements



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



	Wavelength	Spectral Bandwidth	Min Nominal Radiance and Temperature	Max Nominal Radiance and Temperature	NEdT at Min nominal Temperature	NEdT 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

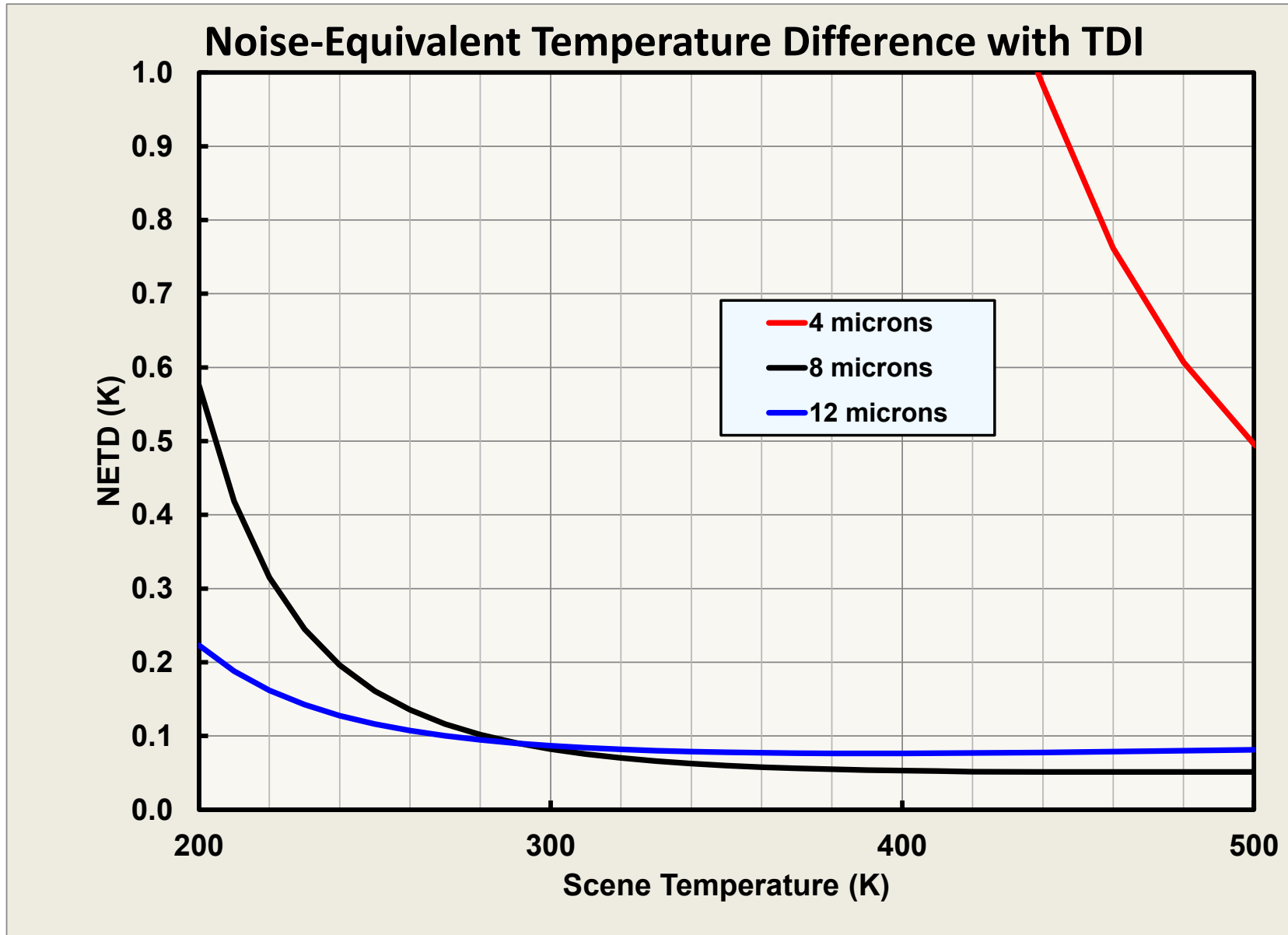
Digitization @ min radiance	Digitization @ max radiance	Digitization @ 300 K
(W/m ² /micron/sr)	(W/m ² /micron/sr)	(W/m ² /micron/sr)
4.0e-2 (0.12 K)	4.0e-2 (0.01 K)	5.0e-2 (1.4 K)
5.6e-3 (0.30 K)	5.6e-3 (0.009 K)	5.6e-3 (0.03 K)
4.8e-3 (0.23 K)	4.8e-3 (0.009 K)	4.8e-3 (0.03 K)
4.5e-3 (0.19 K)	4.5e-3 (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

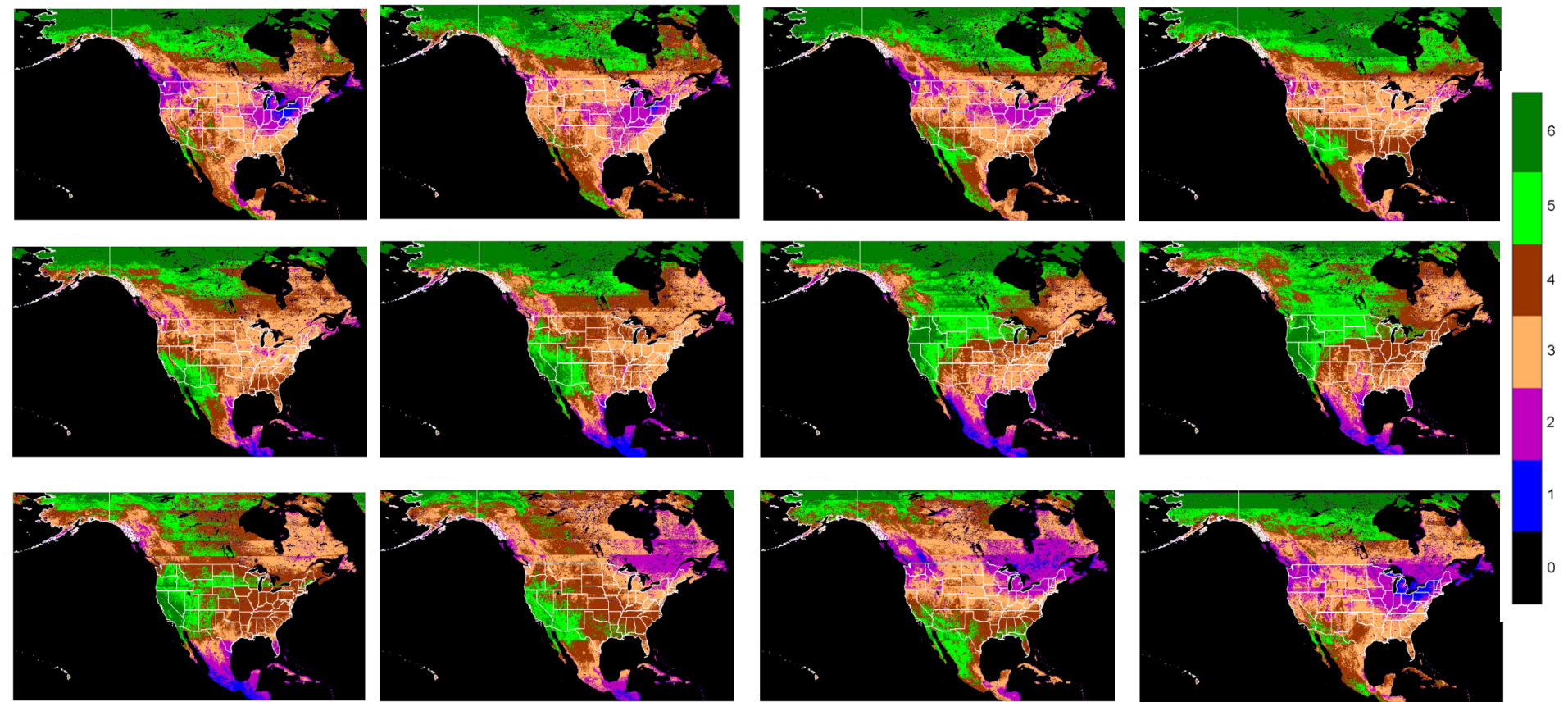


Performance





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



Level 1 Requirements



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.



Level 1 Requirements



Threshold Science Requirements

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



Level 1 Requirements



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 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 $> 90\%$ spectral/spatial uniformity at ≤ 60 m nadir spatial sampling with < 20 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.



Level 1 Requirements



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>>95%</u> spectral/spatial uniformity at ≤ 60 m nadir spatial sampling with <20 day revisit to provide	380 to 2500 nm at ≤ 10 nm sampling at <u>$\geq 80\%$</u> of the specified signal-to-noise ratio and accuracy with <u>>90%</u> spectral/spatial uniformity at ≤ 60 m nadir spatial sampling with <20 day revisit to provide
<u>>60%</u> seasonal and <u>>80%</u> annual coverage of the terrestrial and shallow water regions of the Earth	<u>> 50%</u> seasonal and <u>>70%</u> annual coverage of the terrestrial and shallow water regions of the Earth
three <u>years</u> with a subset of measurements available <u>near-real-time</u> for designated science and applications.	<u>two years.</u>
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
<u>>60%</u> Monthly, <u>>70%</u> seasonal and <u>>85%</u> annual coverage of the terrestrial and shallow water regions of the Earth	<u>> 40%</u> Monthly, <u>> 60%</u> seasonal and <u>>70%</u> annual coverage of the terrestrial and shallow water regions of the Earth

Note: We will keep you informed of any changes such as the change in the saturation limit of the MIR band to 1200K



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 HypsIRI 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 HypsIRI

HypsIRI has a viable set of draft preliminary Level 1 Requirements.

Over the next year we will review these requirement in the context of different possible implementation options for HypsIRI.



HyspIRI Decadal Survey Mission



Key Science and Science Applications

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

Ecosystems: Global plant functional-type, physiological condition, and biochemistry including agricultural lands.

Fires: Fuel status, fire occurrence, severity, emissions, and patterns of recovery globally.

Coral reef and coastal habitats: Global composition and status.

Volcanoes: Eruptions, emissions, regional and global impact.

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

Mission Urgency:

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

Ecosystems

Fires

Evapotranspiration

Snow & Ice

Volcanoes

Coastal Habitats

Measurement:

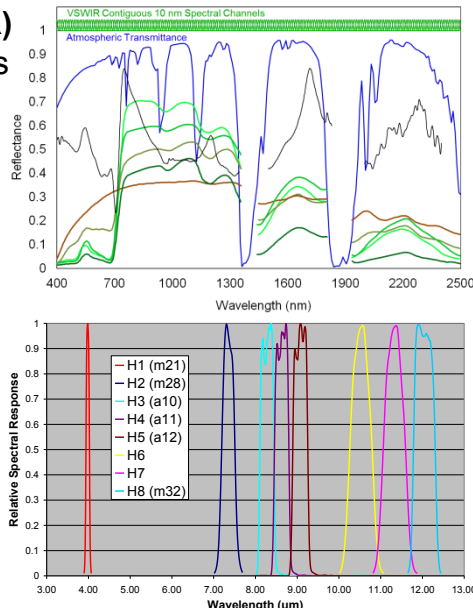
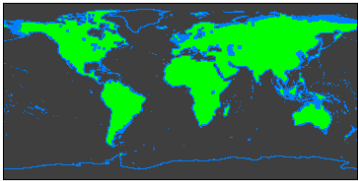
Imaging Spectrometer (VSWIR)

- 380 to 2500 nm in 10nm bands
- 60 m spatial sampling
- 19 days revisit
- Global land and shallow water

Thermal Infrared (TIR):

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

IPM-Direct Broadcast



Mission Concept Status:

Preliminary Draft Program Level 1 Requirements: Stable

Payload: Imaging Spectrometer, Thermal Infrared Imager, and IPM-Direct Broadcast subset

Spacecraft: Small

Payload: JPL/GSFC

Launch Vehicle: ~1000 kg class

Launch date: TBC (partner opportunities)

Mission: Class C 3-5 years

Trajectory or Orbit: LEO, Sun sync.

S/C & Instrument Mass: 561 kg (30% margin)

S/C & Instrument Power: 650W (66% margin)



The HyspIRI mission concept is mature and stable with excellent heritage, low risk and modest cost.