



# HyspIRI VSWIR Level 1 Validation

### NASA Earth Science and Applications Decadal Survey



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# HyspIRI VSWIR Science Measurement Characteristics



#### **Spectral**

•	
Range	380 to 2500 nm in the solar reflected spectrum
Sampling	<= 10 nm {uniform over range}
Response	<= 1.2 X sampling (FWHM) {uniform over range}
Accuracy	<0.5 nm
Radiometric	
Range & Sampling	0 to 1.5 X max benchmark radiance, 14 bits measured
Accuracy	>95% absolute radiometric, 98% on-orbit reflectance, 99.5% stability
Precision (SNR)	See spectral plots at benchmark radiances
Linearity	>99% characterized to 0.1 %
Polarization	<2% sensitivity, characterized to 0.5 %
Scattered Light	<1:200 characterized to 0.1%
Spatial	
Range	>150 km (12 degrees at 700 km altitude)
Cross-Track Samples	>2500
Sampling	<=60 m
Response	<=1.2 X sampling (FWHM)
Uniformity	
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}

>95% spectral IFOV uniformity {<5% variation over spectral range}



#### HyspIRI VSWIR Science Measurements Key SNR and Uniformity Requirements



# Benchmark Radiances

#### Required SNR



#### Uniformity Requirement

#### Cross Track Sample



#### 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}





#### Laboratory calibration

 Prerequisite to flight is a complete laboratory characterization of the sensor. This verifies as-built performance, and properties that are predicted to remain invariant on-orbit.

#### Need for in-flight radiometric calibration

- Calibration in the flight/ orbital environment is the only calibration that matters!
  - Radiometric response specific to thermal environment
  - On-orbit sensors degrade with time, and response coefficients must be updated

#### • Vicarious Calibration

- VC is the determination of the calibration or validation of flight sensors using homogenous desert playa
- Measure the surface and atmosphere at a homogeneous ground target and independently predict the upwelling spectral radiance at the time of imaging spectrometer data acquisition
- Use the predicted upwelling radiance spectrum to validate the spectral and radiometric calibration of the imaging spectrometer in the flight environment



### **Reflectance determination**





ASD: Analytical Spectral Devices Measures from 350-2500 nm at 1 nm intervals. Resolution is from 1-10 nm in going from the visible to short-wave IR wavelengths.



#### Aerosol determination





Left: Reagan sunphotometer Center: Microtops Bottom: Cimel (AERONET) at Railroad Valley







#### JPL Experience



20+ years of JPL experience in vicarious calibration

- Multi-spectral: AVIRIS (late 1980s)
- Multi-angle: Used to establish on-orbit calibration of EOS/ MISR in 2000
- Large footprint: JAXA/ GOSATin 2009



MISR "reflectomobile"





# AVIRIS Image Calibration Target, Leoncito, Argentina







# Leoncito, Team Argentina







### **MODTRAN** Predicted Radiance







# Predicted Compared to Measured



96% Average absolute agreement across the spectrum



For JPL internal use only; not cleared for external release.





4. Vicarious
 Calibration of
 GOSAT TANSO FTS



# Railroad Valley Test sites







# Panel comparison study







#### PARABOLA





PARABOLA: The Portable Apparatus for Rapid Acquisition of Bidirectional Observation of the Land and Atmosphere

The sensor is a sphere-scanning 8 channel radiometer that measures sky and ground. In 3 minutes it measures 72 azimuthal and 37 elevation positions. It observes a Spectralon panel at nadir once each scan.



#### BIDIRECTIONAL REFLECTANCE FUNCTION

Sun Angle = 24,4220

Surface Type = Desert Playa





#### PARABOLA measured BRF

Bi-directional reflectance
factor (BRF) at 441, 533, 551, 650,
861, and 948 nm, sun zenith angle
of 24.42°. Forward scattering
lobe is noted



#### Polarization







Polarization measured at GOSAT view angles

- Data collected averaged over a 30x50 m site at Basecamp
- Polarization was measured between 650-900 nm and determined to be less than 2% at TANSO-FTS wavelengths

#### The LSpec Automated Vicarious Calibration Facility





### The LSpec Concept



• The <u>L</u>ED-based <u>Spec</u>tral surface monitoring (LSpec) vicarious calibration test site was established at Frenchman Flat, Nevada, November 2005.

– The site uses autonomous atmosphere and surface measurements in-lieu of manned campaign measurements





### Web-site data access



• Measurements are made every 5 minutes and automatically downloaded to JPL and processes.

• Data available to registered users via a public website <u>http://LSpec.Jpl.Nasa.Gov</u>

• Measurements are used with a Radiative Transfer Model to provide at-sensor radiances

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				Get Data		



# LSpec endorsed by CEOS



- Committee on Earth Observing Satellites (CEOS)
  - International working group designed to coordinate spaceborne missions
  - Catalog and endorse test-sites for on-orbit calibration, see
  - http://calval.cr.usgs.gov/sites\_catalog\_map.php





### Summary



- Vicarious calibration is a mature technology
  - Provides in-flight calibration typically to 3% nadir viewing uncertainty for clearsky, low aerosol conditions
  - Surface bi-directional reflectance measurements can be made to support offnadir view angles
- LSpec
  - LSpec autonomous facility provides calibration data to the civil remote sensing community