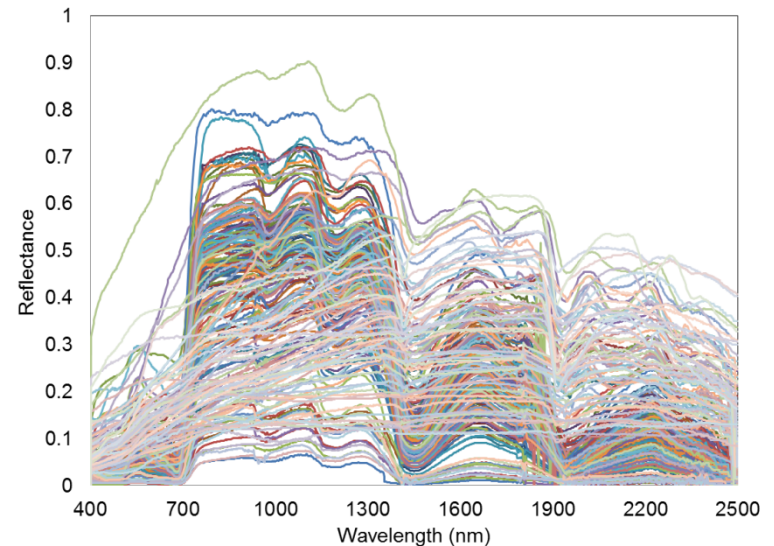


# HyspIRI Ecosystem Spectral Library



<http://HESL.jpl.nasa.gov>

Robert O. Green and the HESL Team



# Overview



- Challenge
- Objectives
- Initial Configuration
- Examples
- Summary and Conclusions
- Discussion



# Challenge



- There is an identified need to make past and future ecosystem spectral measurements more broadly available for science research and science applications
- There are currently 10s of locally held spectral libraries with 1000s of ecosystem related spectra that are not easily shared at present
- Assure acknowledgement is given to those who collected the spectra
- Address both the VSWIR and TIR to benefit HypsIRI Ecosystem related science and science applications



# Objective



- Form a HypsIRI Ecosystem Spectral Library (HESL) working group
- Work to develop a pilot HypsIRI Ecosystem Spectral Library to house a diverse set of existing ecosystem related spectra
- Test the pilot library and explore refinements to best support the HypsIRI and ecosystem community
- Understand issues with spectral protocols, quality control, meta data, distribution, etc.
- Provide feedback to NASA and the broader ecosystem and HypsIRI community





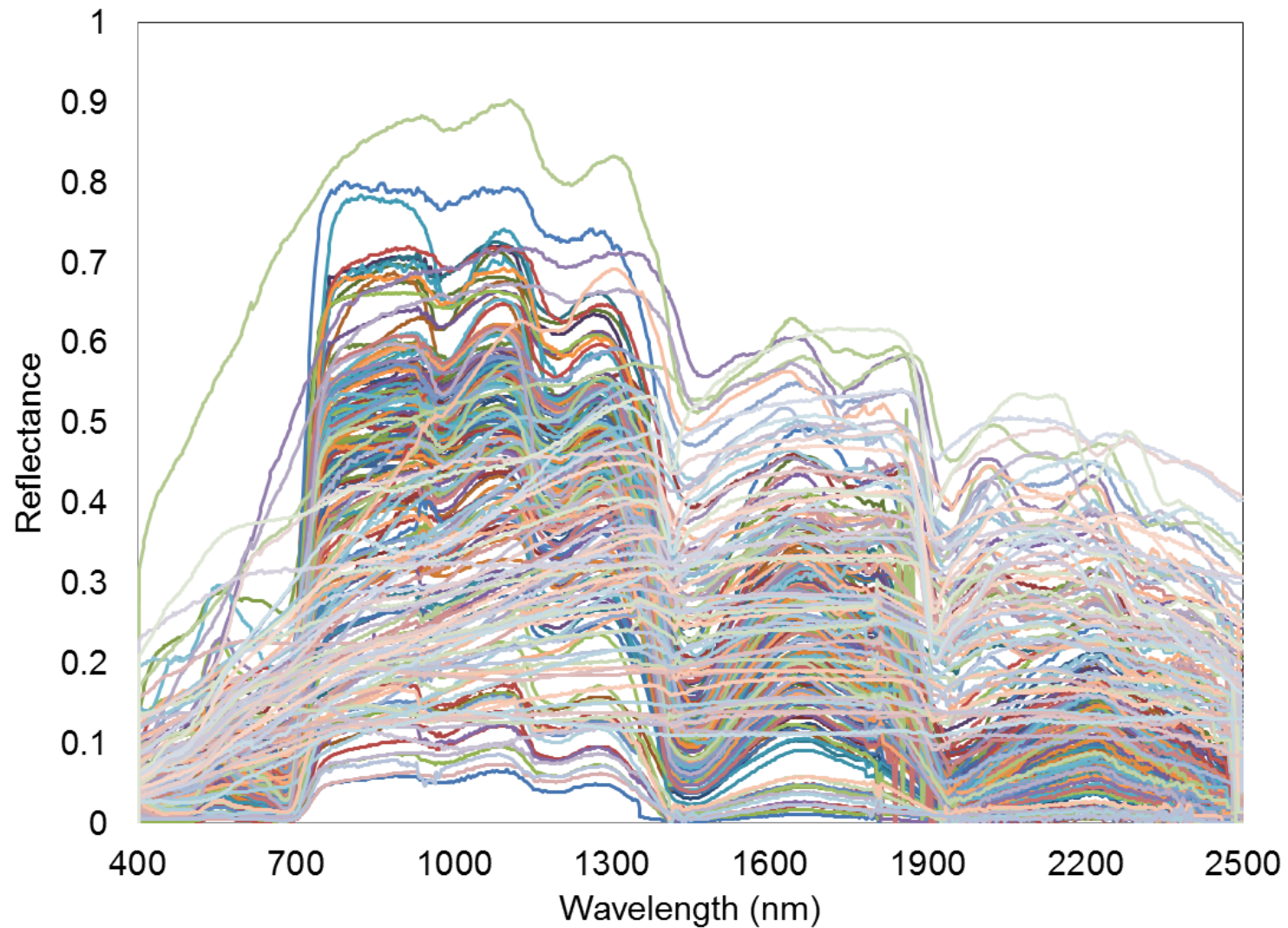
# Diversity of Ecosystem Materials



- Vegetation and constituents
  - Soils
  - Optical constants
  - Chemistry
  - Coral
  - In water constituents
  - Snow
  - Urban materials
  - Wetlands
  - etc
- 
- Full spectral range UV to Thermal Infrared



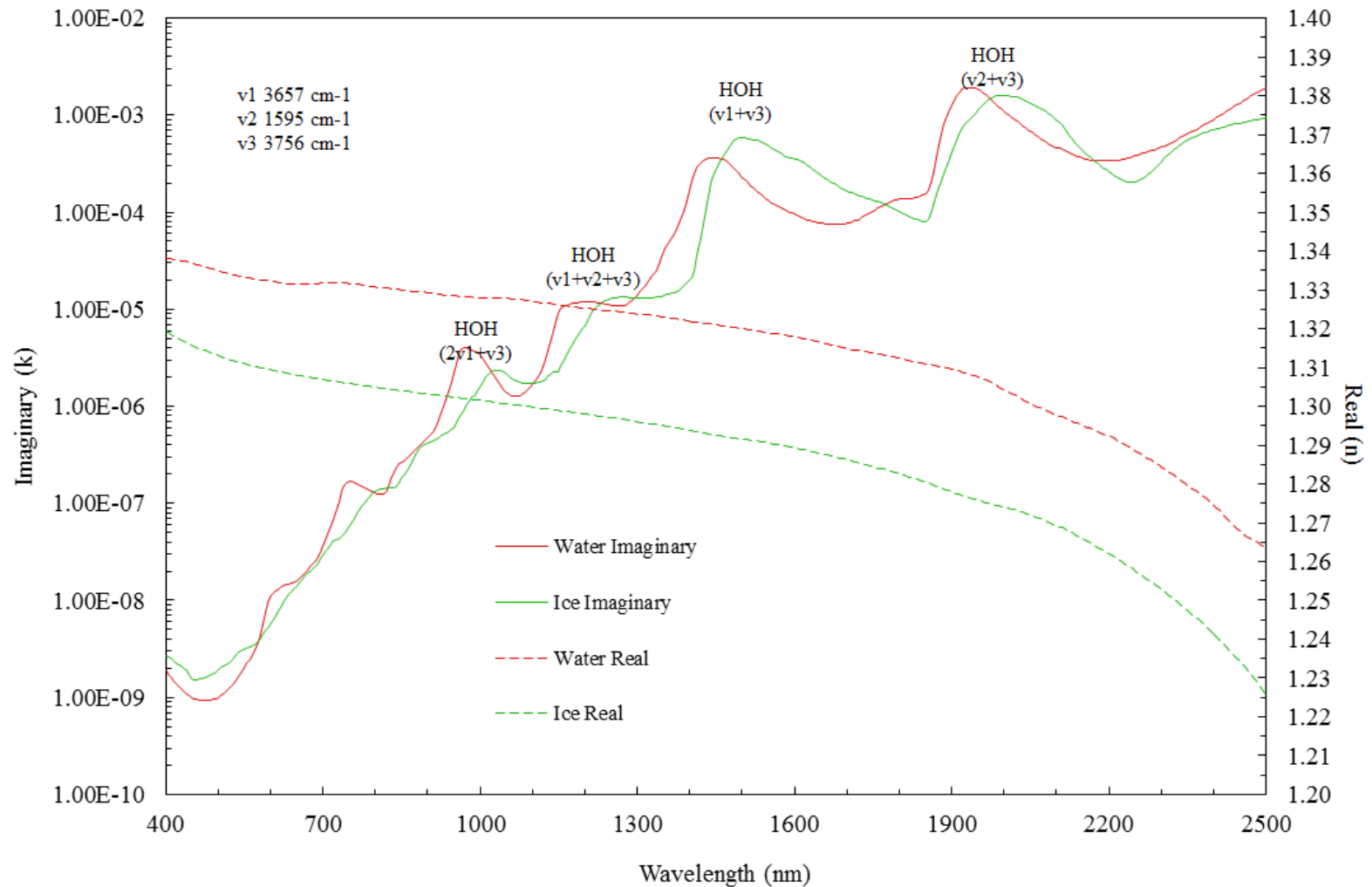
# Example of Spectra in Existing Locally Held Libraries

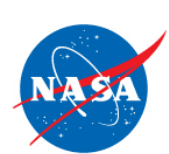


- UCSB Library



# Optical Constants





# Initial HESL Members

Quattrochi, Dale A.	<a href="mailto:dale.quattrochi@nasa.gov">dale.quattrochi@nasa.gov</a>	Urban
Kevin R Turpie	<a href="mailto:Kevin.R.Turpie@NASA.gov">Kevin.R.Turpie@NASA.gov</a>	Wetlands
Dar A. Roberts	<a href="mailto:dar@geog.ucsb.edu">dar@geog.ucsb.edu</a>	Terrestrial
Susan Ustin	<a href="mailto:slustin@ucdavis.edu">slustin@ucdavis.edu</a>	Terrestrial
Campbell, Petya K.	<a href="mailto:petya.k.campbell@nasa.gov">petya.k.campbell@nasa.gov</a>	Terrestrial
John Gamon	<a href="mailto:jgamon@gmail.com">jgamon@gmail.com</a>	Terrestrial
Thomas Bell	<a href="mailto:thomas.bell@lifesci.ucsb.edu">thomas.bell@lifesci.ucsb.edu</a>	Coastal
Dave Siegel	<a href="mailto:davey@icess.ucsb.edu">davey@icess.ucsb.edu</a>	Coastal
Robert O. Green	<a href="mailto:Robert.O.Green@jpl.nasa.gov">Robert.O.Green@jpl.nasa.gov</a>	VSWIR and optical constants
Simon Hook	<a href="mailto:Simon.J.Hook@jpl.nasa.gov">Simon.J.Hook@jpl.nasa.gov</a>	Thermal
Beatriz Ribeiro da Luz	<a href="mailto:bribeirodaluz@usgs.gov">bribeirodaluz@usgs.gov</a>	Coral and Coastal
Eric Hochberg	<a href="mailto:eric.hochberg@bios.edu">eric.hochberg@bios.edu</a>	Coral and Coastal
Thomas Painter	<a href="mailto:Thomas.Painter@JPL.nasa.gov">Thomas.Painter@JPL.nasa.gov</a>	Snow and Ecosystems
Fred Huemmrich	<a href="mailto:karl.f.huemmrich@nasa.gov">karl.f.huemmrich@nasa.gov</a>	Boreal
Phil Townsend	<a href="mailto:ptownsend@wisc.edu">ptownsend@wisc.edu</a>	Terrestrial
<a href="#">Frank Muller-Karger</a>	<a href="mailto:carib@marine.usf.edu">carib@marine.usf.edu</a>	Coastal
<a href="#">Gerardo Toro-Farmer</a>	<a href="mailto:torofarmer@mail.usf.edu">torofarmer@mail.usf.edu</a>	Coastal
Shawn Serbin	<a href="mailto:sserbin@illinois.edu">sserbin@illinois.edu</a>	Terrestrial

- The group is open. Please send an email to be on the email and telecon list



# Early Ideas, Plans, and Activity



- Consensus that a rapid pilot effort demonstrating a HypsIRI Ecosystem Spectral Library is the best way to proceed and explore options to address the larger need
- The members of the HESLWG identified a simple initial format for meta data and spectra that can be ingested in the pilot HESL
- Simon Hook and Gerardo Rivera offered to create and host the pilot HESL based on a modified copy of the existing ASTER spectral library with the meta data fields identified by the HESLWG.
- Members of the HESLWG have volunteered to provide ~10 ecosystem spectra each in the agreed format to populate the pilot HESL.



# Pilot HESL Meta Data and Spectra Format



Field Name	Field Value	Field Format
Name (REQ):	Brackish Sedge Marsh	text
Type (Vegetation, Soil, NPV, Coral, Aquatic, etc) (REQ):	Aquatic Emergent Vegetation	text
Level 1 (Kingdom):	Plantae (Angiosperms, Monocots, commelinids)	text
Level 2 (Family):	Cyperaceae	text
Level 3 (Genus):	Schoenoplectus	text
Level 4 (species)	americanus	text
Scale (leaf, canopy, mixed):	canopy	text
Age (material age):	mixed	text
Height (canopy height, water depth):	1.2 meter canopy height	text
Description (large field) (REQ):	per_imperv=pervious, form=erectophile gram	text
Document link:		text, URL may also be provided
Picture link:		text, URL may also be provided
Measurement Type (Lab, Field, Remote) (REQ):	Field	text
Instrumentation (REQ):	Ocean Optics USB2000+ spectrometer, 20 m dual mode optical cable with 14 deg aperture Gershon tube probe.	text
Illumination Geometry (REQ):	solar zenith = 32.1495 deg, solar azimuth = 201.674 deg	text
Observation Geometry w/ FOV and Distance (REQ):	Transect azimuth = 211.84 deg, nadir view, 14 deg FOV, 1.5m from ground	text
Acquisition Conditions (REQ):	Clear sky	text
Location (lat, lon, elv) (REQ):	38.397911, -76.063408, 0	3 numbers separated by commas, if unknown enter -99
Time ( Date, Time [UTC]) (REQ):	2008-09-01 13:49 GMT	UTC time yyyy-mm-dd hh:mm
Calibration (eg type of reflectance, spectralon ratio, etc) (REQ):	bi-directional reflectance factor using spectralon panel	text
Chemistry (1 to N):		
Biophysical Properties (specific leaf area, thickness, etc):	five equidistant points	text
User designated field:		text
Comments (objectives of the study):	Support Spectral BRDF Modeling of Marsh Canopies	text
Affiliation (REQ):	UMCP NASA USFWS	text
Point of Contact:	K. R. Turpie, kevin.r.turpie@nasa.gov	text
Reference Document:		text
Acknowledgement:		text
Spectrum_ID:	Site 1 transect, nadir view	text
Columns (wvl, refl, fwhm) (REQ):	wavelength, reflectance factor, fwhm	text
Column units (nanometers, percent, nanometers) (REQ):	nanometers, unitless, nanometers	text
Number of values:		2048 number
<b>Data values below this point</b>		
wavelength	reflectance factor	fwhm
339.93	0	10
340.31	0	10
340.69	0	10
341.06	0	10
341.44	0	10
341.82	0	10
342.2	0	10
342.57	0	10
342.95	0	10
343.33	0	10



# HyspIRI Ecosystem Spectral Library



- <http://hesl.jpl.nasa.gov>

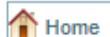


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[Home](#)



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## HyspIRI Ecosystem Spectral Library

Welcome to Version 1.0 of the HyspIRI Ecosystem spectral library, a compilation of ecosystem related spectra developed to support the HyspIRI mission and Terrestrial Ecology Program.

The HyspIRI Ecosystem Spectral Library is a compilation of data from other Ecosystem spectral libraries.

If you use data from the HyspIRI Ecosystem Spectral Library in a publication we ask that you reference the contact person within the spectral library.

*Reproduced from the HyspIRI Ecosystem Spectral Library through the courtesy of the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California. Copyright © 1999, California Institute of Technology. ALL RIGHTS RESERVED.*

### Contact information:


Cognizant Scientist: [Simon.J.Hook@jpl.nasa.gov](mailto:Simon.J.Hook@jpl.nasa.gov)

« October 2012 »

Su	Mo	Tu	We	Th	Fr	Sa
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			



- Search




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
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 Home

 News

 Documents

 Order

 Search

### Spectra Measurement Search

The HyspIRI ecosystem spectral library includes a comprehensive search tool which allows you to search the library database for your ecosystem related material. The search returns a list of materials that match your search criteria, you can click on any of the items in the returned list to see a scaled plot of the spectrum.

In order to search the spectral library, complete the form below and click on the button labeled "Search". You do not need to complete all the fields.

Enter Name:  Spectra Measurement Name

Enter Type:  (for example:Vegetation, Soil, Coral, etc)

Max hits to return:

Questions? Comments? Please contact [Simon Hook](#).





# HyspIRI Ecosystem Spectral Library



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Search

HyspIRI Ecosystem Spectral Library - Search Results

Name	Plots	Type	Measurement Type	Illumination Geometry	Location	Time	Calibration
Montipora flabellata	<a href="#">view plot</a>	coral	Field	solar zenith = 34.133, solar azimuth = 260.898, direct solar beam blocked, supplemented with xenon dive light	21.4439, -157.8026	2004-08-19 21:23 UTC	reflectance factor using Spectralon (10%) reference target
Porites lutea	<a href="#">view plot</a>	coral	Field	solar zenith = 34.195, solar azimuth = 260.905, direct solar beam blocked, supplemented with xenon dive light	21.4647, -157.8215	2004-08-19 21:31 UTC	reflectance factor using Spectralon (10%) reference target
Porites compressa	<a href="#">view plot</a>	coral	Field	solar zenith = 34.142, solar azimuth = 260.904, direct solar beam blocked, supplemented with xenon dive light	21.4439, -157.8026	2004-08-19 21:24 UTC	reflectance factor using Spectralon (10%) reference target
Porites compressa	<a href="#">view plot</a>	coral	Field	solar zenith = 35.213, solar azimuth = 260.933, direct solar beam blocked, supplemented with xenon dive light	21.4647, -157.8215	2004-08-20 23:00 UTC	reflectance factor using Spectralon (10%) reference target
Porites lobata	<a href="#">view plot</a>	coral	Field	solar zenith = 35.057, solar azimuth = 261.855, direct solar beam blocked, supplemented with xenon dive light	21.4554, -157.8121	2004-04-24 20:47 UTC	reflectance factor using Spectralon (10%) reference target
Porites lobata	<a href="#">view plot</a>	coral	Field	solar zenith = 35.144, solar azimuth = 261.907, direct solar beam blocked, supplemented with xenon dive light	21.4554, -157.8121	2004-04-24 20:56 UTC	reflectance factor using Spectralon (10%) reference target
Porites lobata	<a href="#">view plot</a>	coral	Field	solar zenith = 35.220, solar azimuth = 261.953, direct solar beam blocked, supplemented with xenon dive light	21.4554, -157.8121	2004-04-24 21:04 UTC	reflectance factor using Spectralon (10%) reference target
Porites lutea	<a href="#">view plot</a>	coral	Field	solar zenith = 35.537, solar azimuth = 262.141, direct solar beam blocked, supplemented with xenon dive light	21.4554, -157.8121	2004-04-24 21:37 UTC	reflectance factor using Spectralon (10%) reference target
Porites lutea	<a href="#">view plot</a>	coral	Field	solar zenith = 33.913, solar azimuth = 260.758, direct solar beam blocked, supplemented with xenon dive light	21.4439, -157.8026	2004-08-19 21:00 UTC	reflectance factor using Spectralon (10%) reference target



# HESL Example: Vegetation



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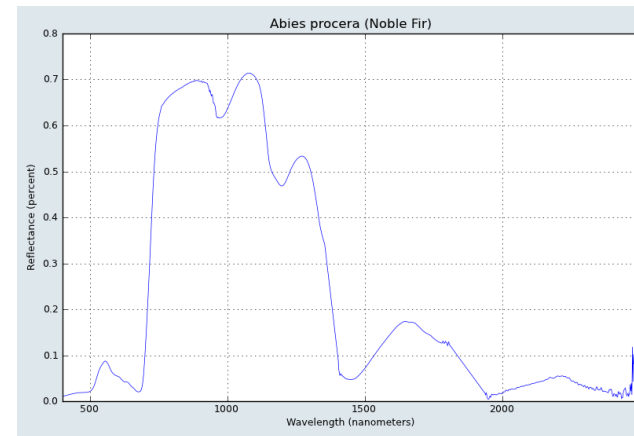
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### Search

**Name (REQUIRED):** *Abies procera* (Noble Fir)  
**Type (Vegetation, Soil, NPV, Coral, Aquatic, etc) (REQUIRED):** Vegetation  
**Level 1 (Kingdom) :** Plantae  
**Level 2 (Family) :** Pinaceae  
**Level 3 (Genus) :** *Abies*  
**Level 4 (species) procera**  
**Scale (leaf, canopy, mixed) :** branch  
**Age (material age) :** > 1 year  
**Height (canopy height, water depth) :**  
**Description (large field) (REQUIRED):** per\_imperv=pervious, Class=gv, form=tree, phenology=evergreen, leaform=needle\_leaf, Dominant=*Abies procera*, Source=asd, Photo=none, Scale=branch, Date=990903e, Notes=b24\_120 Average of three field measurements Standard; Spectralon panel collected within 4 minutes of any spectral measurement  
**Document link :**  
**Picture link :**  
**Measurement Type (Lab, Field, Remote) (REQUIRED):** bi-directional reflectance  
**Instrumentation (REQUIRED):** ASD Full range instrument  
**Illumination Geometry (REQUIRED):** 45.85 zenith, -41.5 azimuth (west)  
**Observation Geometry w/ FOV and Distance (REQUIRED):** nadir, 22 deg, 0.5 m height  
**Acquisition Conditions (REQUIRED):** clear sky  
**Location (lat, lon, elev) (REQUIRED):** 45.916667, -121.883333, unknown  
**Time ( Date, Time [UTC]) (REQUIRED):** 1999-09-03 22:09 GMT  
**Calibration (eg type of reflectance, spectralon ratio, etc) (REQUIRED):** spectralon ratio  
**Chemistry (1 to N) :**  
**Biophysical Properties (specific leaf area, thickness, etc) :**  
**User designated field :**  
**Comments (objectives of the study) :** Develop spectral library for PNW  
**Affiliation (REQUIRED):** UCSB  
**Point of Contact :** Dar A. Roberts (dar@geog.ucsb.edu)  
**Reference Document :** Roberts, D.A., Ustin, S.L., Ogunjemiyo, S., Greenberg, J. Dobrowski, S.Z., Chen, J. and Hinckley, T.H., 2004, Spectral and Structural Measures of Northwest Vegetation at Leaf to Landscape Scales, Ecosystems, 7: 543-562.  
**Acknowledgement :** NIGEC Cooperative Agreement no. DE-FC03-90ER61010  
**Spectrum\_ID :** u9abpr09-av  
**Columns (wvl, refl, fwhm) (REQUIRED):**  
**Column units (nanometers, percent, nanometers) (REQUIRED):** nanometers, percent  
**Number of values:** 1050

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# HESL Example: Coral



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[Home](#) [News](#) [Documents](#) [Order](#) [Search](#)

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### Search

Name (REQUIRED): *Montipora flabellata*

Type (Vegetation, Soil, NPV, Coral, Aquatic, etc) (REQUIRED): coral

Level 1: Animalia

Level 2: Cnidaria

Level 3: Anthozoa

Level 4: Scleractinia

Level 5: Acroporidae

Level 6: Montipora

Level 7: flabellata

Scale (leaf, canopy, mixed) : 10 cm^2

Age (material age) : Indeterminate

Water Depth (m): 15

Description (large field) (REQUIRED): form=encrusting

Document Link:

Picture Link:

Measurement Type (Lab, Field, Remote) (REQUIRED): Field

Instrumentation (REQUIRED): Ocean Optics USB2000 in underwater housing, 2 m-long, 400 micron-diameter multimode fiber, no fore-optics; Spectralon 5x5 inch, 10% reflectance target; xenon dive light to supplement red-NIR wavelengths

Illumination Geometry (REQUIRED): solar zenith = 34.133, solar azimuth = 260.898, direct solar beam blocked, supplemented with xenon dive light

Observation Geometry w/ FOV and Distance (REQUIRED): ~19 deg FOV, ~10 cm from coral surface

Acquisition Conditions (REQUIRED): clear sky

Location (lat, lon, elev) (REQUIRED): 21.443894, -157.802575, -15.00

Time (Date, Time [UTC]) (REQUIRED): 2004-08-19 21:23 UTC

Calibration (eg type of reflectance, spectralon ratio, etc) (REQUIRED): reflectance factor using Spectralon (10%) reference target

Chemistry: chlorophyll a (ug/cm^2): 8.63

Chemistry: chlorophyll c2 (ug/cm^2): 0.66

Chemistry: peridinin (ug/cm^2): 4.58

Chemistry: diatoxanthin (ug/cm^2): 0.28

Chemistry: diadinoxanthin (ug/cm^2): 2.97

Chemistry: beta-carotene (ug/cm^2): 0.09

Biophysical Properties: 10-20 spectra over ~5x5 cm of coral surface

User Designated Field: If using in publication, please reference Hochberg EJ, Aprill AM, Atkinson MJ, Bidigare RR (2006) Bio-optical modeling of photosynthetic pigments in corals. Coral Reefs 25:99-109

Comments: For bio-optical modeling of coral pigments

Affiliation (REQUIRED): Bermuda Institute of Ocean Sciences

Point of Contact: Eric J. Hochberg, eric.hochberg@bios.edu

Reference Document:

Acknowledgement: Pigment data from Amy Aprill

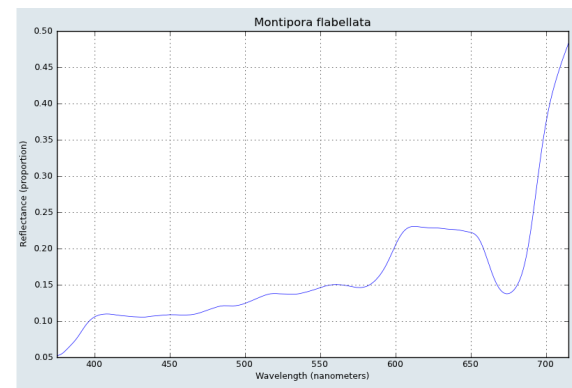
Spectrum ID:

Columns (wvl, refl, fwhm) (REQUIRED): wavelength, reflectance factor

Column units (nanometers, percent, nanometers) (REQUIRED): nanometers, proportion

Number of values: 341

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# HESL Example: Aquatic Emergent Vegetation



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### Search

**Name (REQUIRED):** Brackish Sedge Marsh - Site 2 - 45 deg backscatter reflectance factor

**Type (Vegetation, Soil, NPV, Coral, Aquatic, etc) (REQUIRED):** Aquatic Emergent Vegetation

**Level 1 (Kingdom) :** Plantae (Angiosperms, Monocots, commelinids)

**Level 2 (Family) :** Cyperaceae

**Level 3 (Genus) :** Schoenoplectus

**Level 4 (species) :** americanus

**Scale (leaf, canopy, mixed) :** canopy

**Age (material age) :** mixed

**Height (canopy height, water depth) :** 1.0 meter canopy height

**Description (large field) (REQUIRED):** per\_imperv=pervious, form=erectophile graminoid, phenology=late growing season senescence, leaform=sedge, Dominant=Schoenoplectus americanus, Source=ocean optics USB2000+, Photo=none, Scale=Canopy, Date=1 Sept 2008, Notes=Site 2 average of 480 reflectance factor measurements along 30m transect along west side of Maple Dam Road in Black Water National Wildlife Refuge. Surface conditions: soil saturated, puddles and small ponds present, canopy moderately to highly dense and senescent - recent drought, Distichlis spicata also present; Spectralon panel collected within 4 minutes of any spectral measurement.

**Document link :**

**Picture link :**

**Measurement Type (Lab, Field, Remote) (REQUIRED):** Field

**Instrumentation (REQUIRED):** Ocean Optics USB2000+ spectrometer, 20 m dual mode optical cable with 14 deg aperture Gershon tube probe.

**Illumination Geometry (REQUIRED):** solar zenith = 37.7968 deg, solar azimuth = 222.749 deg

**Observation Geometry w/ FOV and Distance (REQUIRED):** Transect azimuth = 203.800 deg, 30 deg backscatter view, 14 deg FOV, 1.5m from ground

**Acquisition Conditions (REQUIRED):** Clear sky

**Location (lat, lon, elv) (REQUIRED):** 38.388229, -76.067886, near sea level

**Time ( Date, Time [UTC]) (REQUIRED):** 2008-09-01 14:43 GMT

**Calibration (eg type of reflectance, spectralon ratio, etc) (REQUIRED):** bi-directional reflectance factor using spectralon panel

**Chemistry (1 to N) :**

**Biophysical Properties (specific leaf area, thickness, etc) :** LAI at five equidistant points spanning transect length : 3.06000 3.05000 2.43000 3.82000 3.85000

**User designated field :**

**Comments (objectives of the study) :** Support Spectral BRDF Modeling of Marsh Canopies

**Affiliation (REQUIRED):** UMCP NASA USFWS

**Point of Contact :** K. R. Turpie, kevin.r.turpie@nasa.gov

**Reference Document :**

**Acknowledgement :**

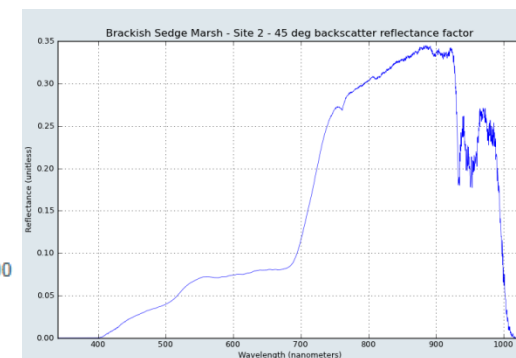
**Spectrum\_ID :** Site 2 transect, 45 deg backscatter view

**Columns (wvl, refl, fwhm) (REQUIRED):** wavelength, reflectance factor, fwhm

**Column units (nanometers, percent, nanometers) (REQUIRED):** nanometers, unitless, nanometers

**Number of values:** 2048

[View Data File](#) [Interactive Graph](#)





# Summary and Conclusion

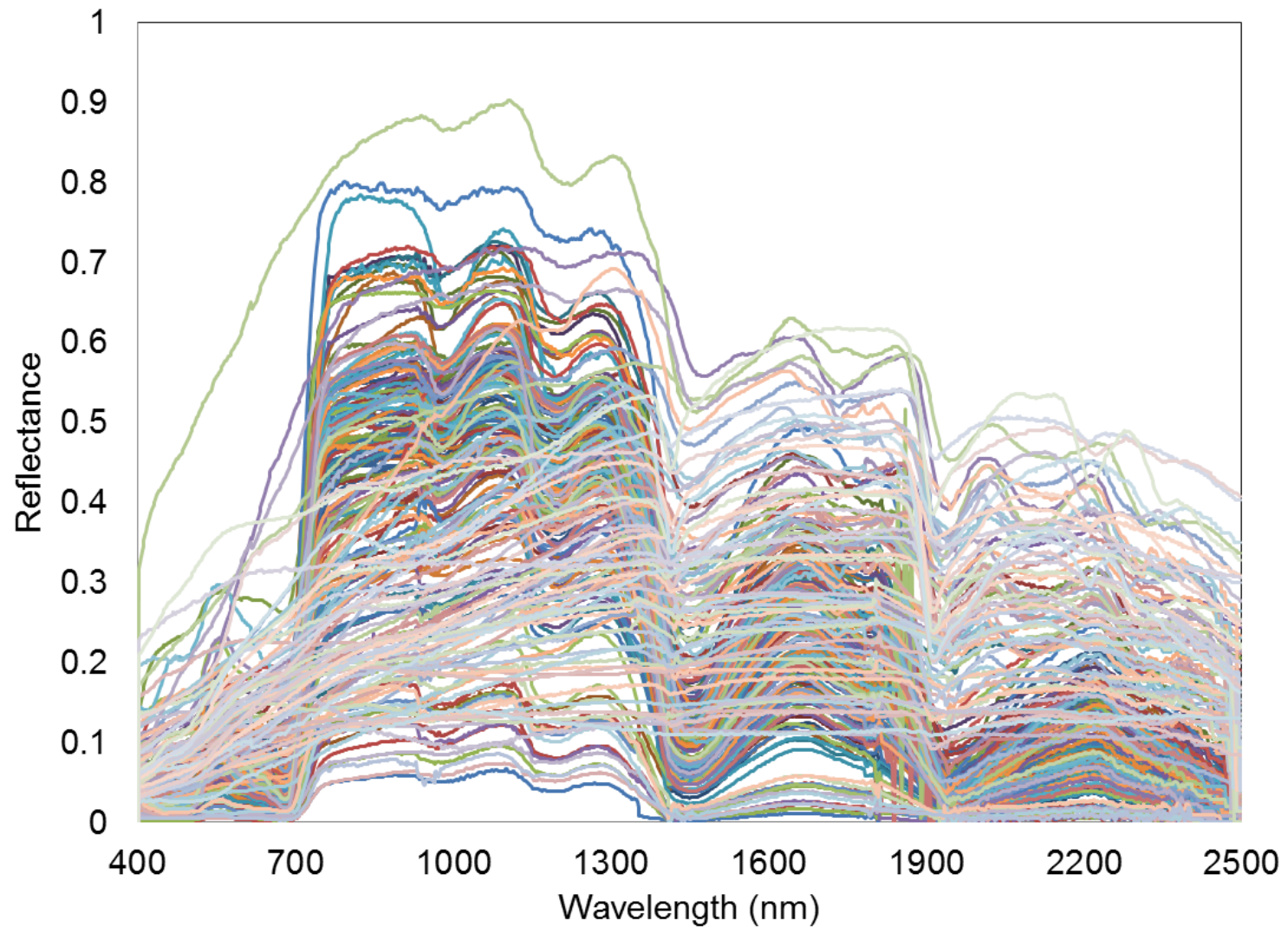


- A HysplRI need for a broadly accessible ecosystem spectral library has been identified
- The HysplRI Ecosystem Spectral Library Working Group has been formed and held a series of telecons and email interactions
- The initial focus is on making currently existing spectra more broadly available
- A concept for a pilot HESL has been formulated and implemented based upon the widely used ASTER spectral library
- The pilot HESL is on-line and initial spectra have been upload
- To add spectra to the pilot HESL, please provide spectra in the template that is available upon request ([Robert.O.Green@jpl.nasa.gov](mailto:Robert.O.Green@jpl.nasa.gov))





# Discussion



- UCSB Library

## 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.

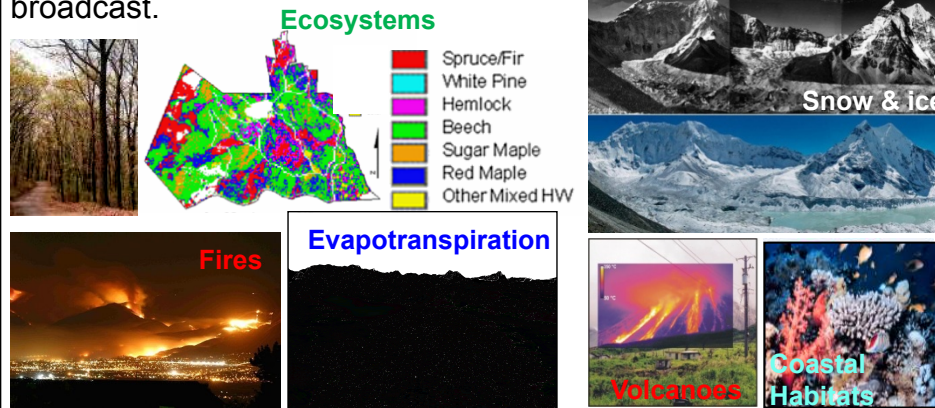
**Coral reef and coastal habitats:** Global composition and status.

**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.



## Measurement:

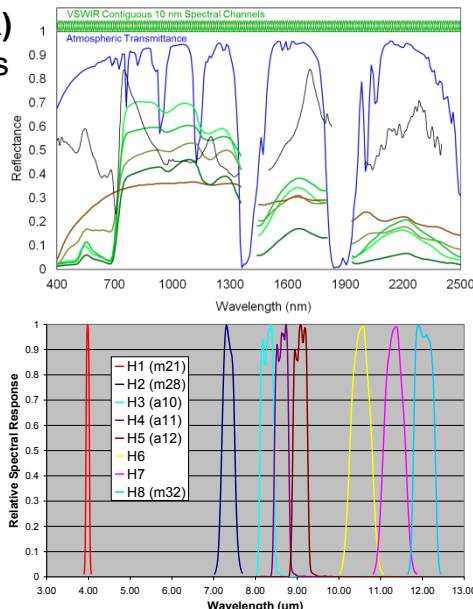
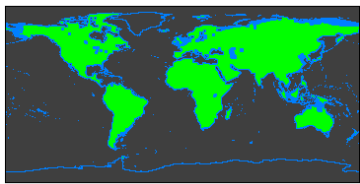
### Imaging Spectrometer (VSWIR)

- 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  $\mu\text{m}$
- 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.



Backup