HyspIRI Preparatory Airborne Campaigns

Western US: Diversity

Hawaii: Volcanoes and Coral Reefs

Robert O. Green1 and The HyspIRI Community

1Jet Propulsion Laboratory, California Institute of Technology
Preparatory Measurements to Simulate HyspIRI Flights Over California Based from NASA Armstrong

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<th></th>
<th>ER-2</th>
<th>AVIRIS</th>
<th>AVIRIS</th>
<th>MASTER</th>
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<tr>
<td>Altitude</td>
<td>65,000 ft</td>
<td>20 m</td>
<td>12 km</td>
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<td>Resolution</td>
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<tr>
<td>Swath</td>
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**AVIRIS (VSWIR)**
- 10 nm spectral resolution
- 224 bands
- 400-2500 nm
- 1 mrad IFOV
- 34 degree FOV

**MASTER (TIR)**
- 50 bands
- 0.4-13 um
- 2.5 mrad IFOV
- 85.92 degrees FOV
Key HyspIRI Measurements Characteristics

- Global terrestrial and coastal VSWIR spectroscopy at 30 m, 16 days and multispectral TIR at 60 m.
Example 2013 Spring Mosaics

3 Seasons and 3 Years
# Original 14 Investigations

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<td>UC Santa Barbara</td>
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<td>Philip Townsend</td>
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<td>Bo-Cai Gao</td>
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<td>UC Santa Cruz</td>
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<td>Shunlin Liang</td>
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<td>Jan van Aardt</td>
<td>RIT</td>
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<td>Wendy Calvin</td>
<td>UNV</td>
<td><strong>Energy and Mineral Resources</strong>: Surface composition mapping that identifies resources and the changes and impacts associated with their development</td>
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**Objective**
- Determine the impacts of California’s record drought on vegetation species cover and condition.

**Approach**
- HyspIRI VSWIR data can resolve differences between non-photosynthetic vegetation (NPV) and soil, measure canopy water absorption, and map dominant vegetation species.
- Increased NPV fractional cover indicates senescence and canopy dieback.
- Decreased liquid water thickness, a measure of canopy water content, indicates loss of leaf area and moisture.
- Fractional cover and liquid water were calculated from simulated HyspIRI VSWIR products for 2013 and 2014 (2nd and 3rd year of drought).

**Results**
- Grassland and coastal sage scrub phenology dominate the short term change in fractional cover and liquid water when comparing April 2013 to June 2013.
- Evergreen chaparral has strong increases in NPV fraction, indicating canopy dieback, when comparing April 2013 to June 2013 and November 2013.
- Rainfall in late February/early March 2014 resulted in (likely temporary) recovery in NPV fraction, but minimal recovery in liquid water.
- Ceanothus is more sensitive to long term drought compared to chamise, but also exhibits more recovery in GV and NPV fractions following rain.

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<th>Date</th>
<th>NPV</th>
<th>Liquid Water (mm)</th>
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<td>0.7</td>
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<td>10/18/2013</td>
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<td>5/6/2014</td>
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HyspIRI VSWIR Vegetation Species Mapping Across Seasons
Kenneth Dudley (grad student), Phil Dennison – Univ. of Utah, Dar Roberts – UC Santa Barbara

- **Objective:** Evaluate the ability of imaging spectroscopy data from the HyspIRI Preparatory Campaign to map vegetation species across a range of dates and illumination conditions
  - Imaging spectroscopy contains detailed spectral information that can be used to distinguish vegetation species and functional types
  - Hypothesis: Species can be mapped using a uniform approach even though their phenology varies over space and through time.

- **Key Finding:** A species map retrieval algorithm that accounts for the range of phenological variability in species reflectance can map species as well as any single date classification
  - A single spectral library created from a range of dates can be applied to any date, allowing species mapping without knowing phenological state in advance

Reflectance of different vegetation species vary through time due to vegetation phenology. Subtle spectral differences can be used to distinguish a) Blue Oak from b) Chamise.

A multi-temporal endmember library provides equivalent performance for mapping species compared to single date classifications.
Discriminating Canopy Structural Types from Optical Properties using AVIRIS Data in the Sierra National Forest in Central California, Margarita Huesca Martinez, University of California Davis, Davis, CA, United States

Discriminating plant species across California’s diverse ecosystems using airborne VSWIR and TIR imagery, Susan Meerdink, University of California Santa Barbara, Santa Barbara, CA, United States

Effect of Spatial Resolution for Characterizing Soil Properties from Imaging Spectrometer Data, Debosunder Dutta, University of Illinois at Urbana Champaign, Urbana, IL, United States

Field, Laboratory and Imaging spectroscopic Analysis of Landslide, Debris Flow and Flood Hazards in Lacustrine, Aeolian and Alluvial Fan Deposits Surrounding the Salton Sea, Southern California, Bernard Emanuel Hubbard, USGS, Reston, VA, United States

HyspIRI Measurements of Agricultural Systems in California: 2013-2015, Philip A Townsend, University of Wisconsin, Madison, WI, United States

Mapping land surface energy budget from the AVIRIS and MASTER data, Dongdong Wang and Shunlin Liang, University of Maryland College Park, College Park, MD, United States; Mapping land surface energy budget from the AVIRIS and MASTER data

Monitoring the Impacts of Severe Drought on Plant Species in Southern California Chaparral, Philip D Dennison, University of Utah, Salt Lake City, UT, United States

Multiseasonal Changes in Leaf and Canopy Traits Measured by AVIRIS over Ecosystems with Different Functional Type Characteristics Through the Progressive California Drought 2013-2015, Susan Ustin, University of California Davis, Davis, CA, United States

Multi-temporal Imaging Spectroscopy Analysis for the Identification of Coniferous Forest Mortality Related to Drought Stress in the Central Sierra Nevada, California Zachary Tan, US Forest Service Sacramento, Sacramento, CA, United States; University of California Santa Barbara, Geography, Santa Barbara, CA, United States

Refining atmospheric correction for aquatic remote spectroscopy, David R Thompson, Jet Propulsion Laboratory, Pasadena, CA, United States

Seasonal and Inter-Annual Patterns of Phytoplankton Community Structure in Monterey Bay, CA Derived from AVIRIS Data During the 2013-2015 HyspIRI Airborne Campaign, Sherry L. Palacios, NASA Ames Research Center, Moffett Field, CA, United States; Bay Area Environmental Research Institute Moffett Field, Moffett Field, CA, United States

Spectral Age Dating of Volcanic Materials, Neil Pearson, University of Nevada Reno, Reno, NV, United States

Urban Heat Island Variation across a Dramatic Coastal to Desert Climate Zone: An Application to Los Angeles, CA Metropolitan Area, Amin Tayyebi, University of California Riverside, Center for Conservation Biology, Riverside, CA, United States and Darrel Jenerette, University of California Riverside, Riverside, CA, United States

Using HyspIRI Campaign Data for Sub-pixel Classification of the Urban Land Surface, Erin B Wetherley, University of California Santa Barbara, Santa Barbara, CA, United States

Using Imaging Spectrometry to Identify Crops in California’s Central Valley, Sarah Shivers, University of California Santa Barbara, Santa Barbara, CA, United States

Assessment of Forest Vulnerability to Climate Change from Imaging Spectroscopy, Gregory Paul Asner, Carnegie Institution for Science, Department of Global Ecology, Stanford, CA, United States and Carnegie Airborne Observatory Team

Constructing Virtual Forest Scenes for Assessment of Sub-pixel Vegetation Structure From Imaging Spectroscopy, Wei Yao, Rochester Institute of Technology, Rochester, NY, United States and Jan A van Aardt, Rochester Institute of Technology, Rochester, NY, United States

A Hyperspectral Thermal Emission Spectrometer (HyTES) for High Altitude Applications, Jonathan M Mihaly, NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, United States

Advances in Mineral Dust Source Composition Measurement with Imaging Spectroscopy at the Salton Sea, CA, Robert O Green, NASA Jet Propulsion Laboratory, Pasadena, CA, United States

Characterizing Geology and Mineralization at High Latitudes in Alaska Using Airborne and Field-Based Imaging Spectrometer Data, Raymond F Kokaly, US Geological Survey, Denver, CO, United States

Comparison of Hyperspectral and Multispectral Satellites for Discriminating Land Cover in Northern California, Matthew L Clark, Sonoma State University, Rohnert Park, CA, United States

Coral Reef Color: Remote and In-Situ Imaging Spectroscopy of Reef Structure and Function, Eric J Hochberg, Bermuda Institute of Ocean Sciences, St George’s, GE, Bermuda

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Overview of the technical and scientific status of the EnMAP imaging spectroscopy mission, Luis Guanter, Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Potsdam, Germany

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Forest Service use of Measurements from HyspIRI Airborne Campaign

This map represents a time-series analysis of images acquired by the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS; http://aviris.jpl.nasa.gov/) from Spring 2013 to Fall 2015. Mortality for Summer 2015 was manually interpreted from Worldview imagery from Spring - Summer 2015 and used for the training the statistical-learning classifier. Landcover was classified into shrub dominant, green conifer dominant, and newly killed (red-attack) conifer dominant. Spectral mixture analysis was used to evaluate the Fall 2015 mortality by comparing 2013 - 2015 changes in the cover fractions and flagging changes greater than 10% in the non-photosynthetic vegetation fraction in Fall 2015 imagery.

Vegetative Condition (below 2,200 m elevation)
- Green conifer
- Spike in dead vegetation - summer 2015 to Fall 2015
- >50% red-attack conifer mortality
Dimensionality of the Earth System Captured with Imaging Spectroscopy

A single HyspIRI airborne campaign flight line has 50 content rich eigen images.

A single scene show up to 30 content rich eigen images.

This demonstrates huge dimensionality available for access with imaging spectroscopy for new Earth system science.
Some HyspiIRI Related Papers


A.45 HyspIRI Preparatory Airborne Activities and Associated Science: Coral Reef and Volcano Research
- 10 investigations selected
- Test Level 1 and 2 products for VSWIR and TIR HyspIRI-type measurement
- Advance maturity of higher level products and related algorithms
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<td><strong>Chad Deering</strong>/Michigan Technological University</td>
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<td><strong>Eric Hochberg</strong>/Bermuda Institute of Ocean Science (BIOS), Inc.</td>
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<td>Mapping the Composition and Chemical Evolution of Plumes from Kilauea Volcano</td>
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2000 Coral Spectroscopy Measurements

- Composition
- Condition
- Productivity
- Bathymetry
- Water quality

AVIRIS Image of Kaneohe Bay, HI
Classification of the bottom of coastal zones and coral reef types
### HyspIRI Related Inputs to Decadal RFI2
### Many Tied to Airborne Campaigns

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<td>Global Measurement of Non-Photosynthetic Vegetation</td>
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<td>Assessing Transient Threats and Disasters in the Coastal Zone with Airborne Portable Sensors</td>
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<td>Understanding anthropogenic methane and carbon dioxide point source emissions</td>
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<td>Robert Green</td>
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<td>Eric Hochberg</td>
<td>Coral Reefs: Living on the Edge</td>
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<td>Luvall Jeffrey</td>
<td>A Thermodynamic Paradigm For Using Satellite Based Geophysical Measurements For Public Health Applications</td>
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<td>Measuring the Earth's Surface Mineral Dust Source Composition for Radiative Forcing and Related Earth System Impacts</td>
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<td>Kevin Turpie</td>
<td>GLOBAL OBSERVATIONS OF COASTAL AND INLAND AQUATIC HABITATS</td>
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<td>Robert Wright</td>
<td>PREDICTING CHANGES IN THE BEHAVIOR OF ERUPTING VOLCANOES, AND REDUCING THE UNCERTAINTIES ASSOCIATED WITH THEIR IMPACT ON SOCIETY AND THE ENVIRONMENT</td>
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