# 2015 HyspIRI Science and Applications Workshop Summary

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**Introduction**

The proposed NASA Hyperspectral InfraRed Imager (HyspIRI) will address urgent Earth Science and applications challenges through a global-mapping satellite mission. The planned payload includes a scanning visible-to-shortwave infrared imaging spectrometer (VSWIR), covering a range between 380 and 2500 nm in 10-nm bands, and a scanning multispectral thermal infrared imager (TIR), with eight discrete bands between 3 and 12 µm.

HyspIRI was identified as a Tier 2 priority in the National Research Council's (NRC) 2007 Decadal Survey: *Earth Science and Applications from Space*[1]. Since then, the HyspIRI mission and its research community have worked to highlight and demonstrate how such a mission would fill critical measurement gaps and significantly improve our understanding of global biodiversity (including terrestrial, aquatic, and coastal ecosystems), volcanology, ecosystem function, and other critical science themes. Moreover, HyspIRI-like data have also been collected (via aircraft campaigns, mentioned below) and used to support multiple science applications, such as wildfire behavior, drought incidence, and snowpack characteristics. HyspIRI's mission concept also seeks to respond to the need for data consistency and continuity with the combined NASA/U.S. Geological Survey (USGS) Sustainable Land Imaging (SLI) program; for example, the team worked to update HyspIRI requirements for improved spatial and temporal resolution. In its current configuration, HyspIRI would provide global VSWIR and TIR coverage at 30 to 60 m (~98 to 177 ft) per pixel, every 5 to 16 days.

The HyspIRI community has demonstrated that technologies and the research and applications communities are ready for the HyspIRI mission. There have been several HyspIRI Airborne Campaigns aimed at reducing risks and uncertainties associated with the upcoming mission. These include a series of airborne missions in California (between 2013 and 2015) that studied terrestrial ecosystems, land use and land cover change, oceanography, geology, and atmospheric composition.

[1] See *www.nap.edu/catalog/11820/earth-science-and-applications-from-space-national-imperatives-for-the.*

A similar upcoming campaign in Hawaii (planned for 2016–2017) will use HyspIRI like instruments mounted on NASA's high-altitude ER-2 aircraft to study coral reefs and volcanoes. In addition, there have been calibration/validation studies for the Hyperion instrument onboard NASA's Earth Observing-1 (EO-1[2]). Risk reduction is also being achieved by leveraging resources such as the Prototype HyspIRI Thermal Infrared Radiometer (PHyTIR), which is now being integrated into the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) mission, scheduled to be launched and installed on the International Space Station in 2018.

**Meeting Overview**

In support of the mission, the 2015 HyspIRI Science and Applications workshop was held at the California Institute of Technology from October 13-15, 2015, with 118 attendees. The workshop was arranged into multiple thematic sessions that allowed participants to receive updates on various aspects of the status of HyspIRI science and applications research. The sessions included:

- Technology;
- Volcanoes and Wildfires;
- Aquatic Systems;
- Terrestrial Ecology;
- Methane and Atmosphere;
- Cryosphere; and
- Surface Composition and Geology.

In addition to these sessions related to HyspIRI, there was a special session on the ECOSTRESS mission—see *Special Session on ECOSTRESS* on page 25.

Outside of the sessions, participants had ample opportunities to meet with one another for informal discussions. Also, the workshop dedicated at least two hours

[2] To learn more about EO-1 please see "EO-1: 15 Years After the Start of Its 'One Year Mission'" on page 4 of this issue.

**Table**. Breakout session leaders and topics. Note that some of these topics are the same as the Thematic Sessions, which are summarized in the body of the article.

| **Lead** [Affiliation] | **Topic** |
|---|---|
| ***Day One*** | |
| **Kevin Turpie** [NASA's Goddard Space Flight Center (GSFC)] | Aquatic Studies |
| **Josh Fisher** [NASA/Jet Propulsion Laboratory (JPL)] | Evapotranspiration and Agriculture |
| **Rob Wright** [Hawaii Institute of Geophysics] | Volcanoes |
| **Sander Veraverbeke** and **E. Natasha Stavros** [both at JPL] | Wildfires |
| ***Day Two*** | |
| **Eric Hochberg** [Bermuda Institute of Ocean Sciences] | Aquatic Benthic Habitats |
| **Wendy Calvin** [University of Nevada, Reno] | Surface Composition and Geology |
| **Andrew Thorpe** [JPL] | Methane and Atmosphere |
| **Ryan Pavlik** [California Institute of Technology] | Biodiversity |
| ***Day Three*** | |
| **Phil Townsend** [University of Wisconsin, Madison] | Terrestrial Ecology and Plant Physiology |
| **Jeff Luvall** [NASA's Marshall Space Flight Center] | Human Health and Water Quality |
| **Tom Painter** [JPL] | Cryosphere Science |

each day to *white paper* breakout sessions—see **Table**. The objective of these discussions was to bring together representatives of the research and applications community so that they might collaborate on the development of white papers in response to the 2017 Earth Science Decadal Survey's request for input[3]. The lead or co-leads for each breakout session were tasked with capturing the discussions' contents and developing the white papers. Ultimately, this feedback will be used to help the Steering Committee succinctly identify and discuss critical science and applications challenges for the 2017 Decadal Survey.

Please visit *hyspiri.jpl.nasa.gov* to access presentations and posters presented during the workshop and links to white papers developed during breakout sessions. These white papers were all submitted to the Decadal Survey Request for Information.

**Day One**

The workshop began with a series of programmatic presentations. **Woody Turner** [NASA Headquarters—*Program Manager for Ecological Forecasting and Biological Diversity*] began with an overview of HyspIRI and its many potential contributions to the science and applications landscape. A series of presentations from the HyspIRI mission leads followed: **Robert Green** [NASA/Jet Propulsion Laboratory (JPL)] and **Simon Hook** [JPL] discussed the status of the HyspIRI Mission Concept and reviewed Level 1 data requirements, and **Elizabeth Middleton** [NASA's Goddard Space Flight Center (GSFC)] summarized the June 2015 HyspIRI Science Data Products Symposium[4].

After these overview presentations, the remainder of the first day was devoted to three of the thematic sessions, followed by breakout sessions (see Table).

*Technology*

**Dan Mandl** [GSFC] provided updates on recent technology developments including the Intelligent Payload Module, which will improve data latency and allow additional capabilities that will benefit both science and applications. **Bill Johnson** [JPL] and **Pantazis Mouroulis** [JPL] then gave presentations about TIR activities and the VSWIR Dyson Imaging Spectrometer, respectively. **Steve Chien** [GSFC] and **Sergio Cogliati** [University of Milano-Bicocca, Italy] also provided updates on technologies, including onboard instrument processing demonstrations from the EO-1 mission and automated field systems for collecting spectrometer measurements for calibration and validation.

*Volcanoes and Wildfires*

This session featured presentations from **Chad Deering** [Michigan Technological University], **Michael Ramsey** [University of Pittsburgh], and **Vince Realmuto** [JPL], all of whom have been recently selected as science team members for the upcoming 2016 coral reef and

[3] The next Earth Science Decadal Survey for Earth Science and Applications from Space (ESAS2017), covering the period 2017-2027, is now underway; it is again sponsored by NASA, the National Oceanic and Atmospheric Administration, and the U.S. Geological Survey. A website for the Decadal Survey (*www.nas.edu/esas2017*) has been created to provide a link for communications from the research community.

[4] To learn more about this meeting, visit *hyspiri.jpl.nasa.gov/events/2015-hyspiri-science-symposium*.

volcanoes airborne campaign in Hawaii, mentioned previously. (A separate *Planning Meeting for the HyspIRI Airborne Campaign: Volcanoes and Coral Reefs* took place on October 16 and is described in the sidebar on page 26.) Also during this session, **E. Natasha Stavros** [JPL] presented examples of synergistic uses of the AVIRIS and MASTER[5] sensors to document the 2014 California King Fire, and **Neil Pearson** [University of Nevada, Reno (UNR)] summarized work conducted over the Mono Basin and Long Valley Caldera.

*Aquatic Systems*

This session included presentations from **Eric Hochberg** [Bermuda Institute of Ocean Sciences—*Principal Investigator (PI) for COral Reef Airborne Laboratory*[6]] on monitoring kelp forests; **Tom Bell** [University of California (UC), Santa Barbara] on identifying phytoplankton functional types; **Liane Guild** [NASA's Ames Research Center (ARC)] on harmful algal bloom monitoring in Lake Erie; **Jeff Luvall** [NASA's Marshall Space Flight Center (MSFC)] on water quality studies; and **Steve Ackleson** [Naval Research Laboratory] on coral reef studies. In addition, **Kevin Turpie** [GSFC] summarized the HyspIRI Aquatic Studies Group (HASG) report (*go.nasa.gov/1RpHoX6*), which provides a review of critical areas in aquatic and coastal ecosystems studies that would be significantly advanced with the HyspIRI mission.

**Day Two**

The second day began with a presentation from **Ian McCubbin** [JPL] on field campaigns for HyspIRI airborne instruments in California and upcoming campaigns focusing on Hawaiian coral reefs and volcanoes. **Andre Hollstein** [GeoForschungsZentrum (GFZ), Potsdam, Germany] described a German hyperspectral mission, Environmental Mapping and Analysis Program (EnMAP). **Robert Green** [JPL] reported on the planned AVIRIS-Next Generation airborne campaigns in Asian Environments.

[5] AVIRIS stands for Airborne Visible InfraRed Imaging Spectrometer; MASTER stands for the MODIS/ASTER airborne simulator.

[6] CORAL is a sub-orbital mission, one of the winning selections from the Earth Venture Sub-Orbital-2 (EVS-2) Announcement of Opportunity.

## Special Session on ECOSTRESS

The special session on ECOSTRESS provided an opportunity to explore the status of the mission, instrument, and science objectives. As members of the ECOSTRESS Science Team, **Simon Hook** [JPL—*PI for ECOSTRESS*], **Joshua Fisher** [JPL—*Science Lead for ECOSTRESS*], and **Glynn Hulley** [JPL—*Science Team Member*] discussed topics such as how ECOSTRESS will be used to study vegetation water stress and to understand diurnal variability of evapotranspiration, as well as how data products (such as Level 2 land surface temperature and emissivity) will be developed. **Johan Perret** [EARTH University] described a partnership in which his institution could assist with calibration and validation activities and other application development in support of ECOSTRESS. **Bill Johnson** [JPL] closed the session with a discussion of instrument design. More information about this mission can be found at *ecostress.jpl.nasa.gov*.

*Terrestrial Ecosystems*

**Greg Asner** [Stanford University (SU)] gave a keynote presentation on the Carnegie Airborne Observatory, a three-dimensional laser imager[7]. **Dana Chadwick** [SU] then summarized findings on imaging spectroscopy of canopy nutrients in the Amazon. The session also included presentations from **Paul Gader** [University of Florida], **Wei Yao** [Rochester Institute of Technology], and **Karine Adeline** [UC, Davis] on processing methods, evaluating vegetation structure, and characterizing canopy chemistry, respectively. Additionally, **Dar Roberts** [UC, Santa Barbara], **Phil Townsend** [University of Wisconsin, Madison], and **John Gamon** [University of Alberta] presented information on vegetation distribution in anthropogenic landscapes, ecosystem physiology, and assessing biodiversity and productivity, respectively. **Matthew Clark** [Sonoma State], **Amin Tayyebi** [UC, Riverside], and **Paul Moorcroft** and **Stacy Bogan** [both from Harvard University] touched on a variety of topics such as land cover, climate change adaptation, vegetation signatures, ecosystem composition, and plant functional types. **Dongdong Wang** [University of Maryland, College Park] concluded the session with a presentation on land surface radiation and the energy budget.

*Poster Session*

The second day also included a lunchtime poster session, with fourteen posters covering several thematic areas. The poster session allowed for direct interaction with speakers and provided an additional medium to present research for those who did not give an oral presentation.

**Day Three**

The third day began with talks on methane and aerosols followed by talks on the cryosphere. Next, there was a special session on the upcoming ECOSTRESS mission, as described in the box above. There were also several talks on surface composition and geology and an Applied Sciences working lunch, led by **Christine Lee** [JPL], to explore processes for HyspIRI and ECOSTRESS

[7] To learn more, please visit *carnegiescience.edu/projects/uncovering-canopy-chemistry-carnegie-airborne-observatory*.

meeting summaries

## Planning Meeting for the HyspIRI Airborne Campaign: Volcanoes and Coral Reefs

Following the HyspIRI Science and Applications Workshop, the HyspIRI Hawaii Principal Investigator (PI) team held a meeting at NASA/Jet Propulsion Laboratory (JPL). In addition to the members of the PI team, members of the HyspIRI Steering Committee from NASA Headquarters, GSFC, and JPL participated. Members of the instrument and aircraft teams gave presentations for MASTER, AVIRIS, and NASA's ER-2 aircraft. The PI(s) gave a presentation on the goals of their specific projects, planned field activities, and desired data collection dates. There was also discussion to work out the schedule for the campaign and collaborative validation activities.

applications through an Early Adopter program. Several more breakout sessions took place in the afternoon—refer again to the Table on page 24. The meeting ended with two presentations and a discussion about how to summarize advances in science and applications research and technology as a potential reference for the 2017 Earth Science Decadal Survey.

*Methane and Atmosphere*

This session included talks from **Jun Wang** [University of Nebraska] and **Andrew Thorpe** [JPL], who discussed methods for assessing aerosol properties and using AVIRIS-Next Generation (learn more at *avirisng.jpl.nasa.gov*) for mapping methane emissions, respectively.

*Cryosphere*

This session featured presentations from **Felix Seidel** [JPL] on snow properties in the Sierra Nevada and Rocky Mountains using AVIRIS and from **Tom Painter** [JPL] on snow and ice radiative forcing and albedo using the Airborne Snow Observatory imaging spectroscopy measurements.

*Surface Composition and Geology*

**Dutta Dubsunder** [University of Illinois], **Gwen Davies** [UNR], **Robert Green**, **Bernard Hubbard** [USGS], and **Wendy Calvin** [UNR] delivered presentations on soil properties, acid mine drainage, mineral dust source composition, mineral maps for landslide and debris flow studies, and resource exploration, respectively.

*Concluding Presentations and Plans for the 2017 Decadal Survey*

Two presentations ended the day. **Robert Green** described the Tetracorder 5 software program for improved imaging spectroscopy data processing, and **Miguel Velez-Reyes** [University of Texas, El Paso] reported on how to better separate signal and noise in hyperspectral data signatures.

**Woody Turner** and the HyspIRI team leads then led a closing discussion of the proposed HyspIRI mission and its potential consideration in the 2017 Earth Science Decadal Survey. They underscored the mission's unique capability to address a wide variety of science and applications questions such as global biodiversity, terrestrial ecosystems and disturbances, aquatic studies and benthic habitats, geological surface composition, and other areas. Participants identified "next steps" to keep the community active and engaged in the process. In particular, the community summarized key science and application challenges *via* white papers for the Decadal Survey's request for information.

**Summary**

The HyspIRI community continues to describe the fundamental science- and applications-related contributions that this mission could provide in the future, through HyspIRI airborne campaigns, flights of opportunity, technology demonstrations, domestic and international partnerships, or Earth Venture missions such as CORAL and ECOSTRESS. HyspIRI has the unique capability to address urgent, widespread, and diverse science questions and societal needs. ■