HyspIRI Preparatory Activities Using Existing Imagery
Abstracts of selected proposals.
(NNH10ZDA001N-HyspIRI)

The National Aeronautics and Space Administration (NASA) Earth Science Division within the Science Mission Directorate solicited proposals for investigations for HyspIRI preparatory activities using existing satellite and airborne imagery in 2010, following up a similar solicitation in 2009.

In response to the National Research Council (NRC) report Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond, the solicitation requested research investigations supporting the development of concepts for a Hyperspectral Infrared Imager (HyspIRI) mission. In doing so, it sought to engage potential research communities in preparation for data from a future HyspIRI mission. The solicitation called for the assembly of HyspIRI-like data sets from existing high-altitude airborne and/or satellite platforms carrying imaging spectrometers (focused on the visible to shortwave infrared region of the electromagnetic spectrum) and multispectral thermal infrared instruments.

NASA received a total of 19 proposals and has selected 5 for funding at this time. The total funding to be provided for these investigations is approximately $600,000 over the next year. The investigations selected are listed below. The Principal Investigator, institution, investigation title and abstract are provided. Co-investigators are not listed here.

Andrew French/U.S. Arid Land Agricultural Research Center
Monitoring Arid Land Cover Change with Simulated HyspIRI Data

The proposed NASA mission, HyspIRI, offers an unprecedented opportunity to observe the earth's surface environment using a combination of satellite remote sensing technologies. This new combination would provide both high spectral and high spatial resolution at visible and infrared wavelengths, all at frequent observation intervals. In addition to the hyperspectral capabilities within visible and near infrared wavelengths, the HyspIRI mission notably offers multispectral thermal infrared imaging at 5 day repeat periods. The thermal bands can discriminate land cover and monitor land surface evapotranspiration in ways that are not feasible using more conventional remote sensing approaches.

This project capitalizes upon these innovations by initiating the synthesis of HyspIRI-like images from existing airborne and spaceborne remote sensing data. Data sets chosen will be derived from arid and semi-arid regions where the need for high quality remote sensing data is especially keen. Two data sets will be from New Mexico: the USDA Jornada Experimental Range, and the Sevilleta National Wildlife Refuge. A third data set will be from the Southern Great Plains of Oklahoma and Kansas.

Using archived MASTER, AVIRIS and ASTER data, 60-m remote sensing image data sets will be generated to help address three hydrological and climatological problems. The first problem is how to improve estimation accuracies of land surface temperature and emissivity for all land cover types. Focus for this problem will be placed on implementing calibration techniques for low spectral contrast surfaces. The second problem is how to improve land cover characterization over those achieved with more conventional approaches. Emphasis will be placed on techniques using both hyperspectral visible-infrared channels and multispectral thermal infrared channels; these techniques will help distinguish between short term soil moisture changes and long term vegetation changes. The third problem is how to improve the accuracy of evapotranspiration estimation with remote sensing instruments. Here we will demonstrate that improvements are possible by utilizing well-calibrated hyperspectral visible near infrared data in combination with multispectral thermal data to yield good quality ET estimates for a wide range of land cover conditions.

Rasmus Houborg/NASA Goddard Space Flight Center
Combining Observations in the Reflective Solar and Thermal Domains to Improve Carbon, Water and Heat Fluxes Simulated By a Two-Source Energy Balance Model

Satellite observations in the visible to the shortwave infrared (VSWIR) and thermal infrared (TIR) domains have great utility for monitoring the terrestrial biosphere and vegetation dynamics at spatial scales (<100 m) critically important to local water resource and agricultural management. In this project we propose to take advantage of the synergy between VSWIR and TIR wavebands in producing valuable remote sensing products for accurately monitoring carbon and water fluxes at field to regional scales.

TIR data provide valuable information about the sub-surface moisture status, and land surface temperature can be an effective substitute for in-situ surface moisture observations and a valuable metric for constraining land surface fluxes at sub-field scales. The satellite signal in the VSWIR region of the electromagnetic spectrum can be related to biophysical and biochemical properties of the vegetation surface such as leaf area index (LAI) and leaf chlorophyll (Cab). Chlorophylls function as vital pigments for photosynthesis, and Cab has great potential for constraining light-use-efficiency (LUE) and thus carbon fluxes. We propose to synthesize these advantages by integrating novel retrievals of LAI and Cab into a thermal-based Two-Source Energy Balance (TSEB) model that quantifies processes of carbon assimilation and transpiration using a LUE-based model of canopy resistance. The LUE component incorporates modifications from a nominal (species-dependent) value (LUEn) in response to short-term variations in environmental conditions. We will use satellite estimates of Cab as an additional constraint on LUEn to accommodate changes in physiological condition resulting from changes in nutrient status and vegetation stress levels.

We propose to refine a novel vegetation parameter retrieval tool (REGFLEC) for application to hyperspectral reflective observations acquired from Hyperion onboard the EO-1 satellite. REGFLEC currently relies on multi-spectral observations in green, red and near-infrared wavebands and the integration of hyperspectral datasets is expected to improve the accuracy of the retrievals as it allows identification of bands and indices with optimized sensitivity to changes in Cab.

The integrated REGFLEC-TSEB modeling system will be applied to flux tower study sites across the U.S. for investigating the benefit of combining data streams from a hyperspectral imaging spectrometer (Hyperion) and multi-spectral thermal infrared imagers (ASTER and Landsat) for estimating coupled carbon, water and heat fluxes at the field scale.

Alexander Koltunov/University of California, Davis
Toward monitoring the Relationship Between Vegetation Conditions and Volcanic Activity with HyspIRI

Our study is an initial step toward addressing two mutually related synergistic science questions:
1. What are the spatial and temporal impacts of volcanic activity and industrial pollutants on the surrounding vegetation?
2. Given measured changes in vegetation extent and properties, what changes in volcanic activity can be inferred to be occurring or to have occurred?

We propose to experimentally demonstrate that changes in the extent and health of vegetation in proximity to a degassing volcano will be observable in data from the upcoming HyspIRI mission.

Toward this goal, we will investigate the impact of the recent (March 2008) opening of the vent at Halemaumau, Hawaii, on the vegetation surrounding Kilauea volcano. We will create a time series of HyspIRI-like images by fusing the available 2006-2010 near coincident Hyperion and ASTER datasets in the Big Island. We will analyze this multi-date dataset to assess the changes to vegetation health and distribution that may be related to the new vent, which for the past two years has been releasing ~1,500 to 2,000 tons of SO_2 per day.

Specifically, we will characterize the biophysical/biochemical and structural properties of the vegetation on the eastern side of the Island by inverting PROSAILH radiative transfer model, using relevant remote sensing vegetation indexes, and computing a normalized canopy brightness temperature pattern. We will assess the apparent change in these characteristics between 2006 through 2010. The spatial distribution of the vegetation changes will then be compared to an average SO_2 distribution pattern for the eastern side of the Island compiled using high-resolution HY-SPLIT dispersal model and historic observational data.

The results of this work will serve as a foundation for future in-depth studies of biospheric effects of volcanic, industrial, or other point sources of toxic emissions, and eruption precursors, using HyspIRI and other remote sensing data sets.

Dar Roberts/University of California, Santa Barbara
Evaluation of Synergies Between VNIR-SWIR and TIR Imagery in a Mediterranean-climate Ecosystem

Much of the potential of a combined VNIR-SWIR imaging spectrometer and TIR imaging system for the analysis of vegetation remains largely unexplored. Obvious synergies include hyperspectral measures of plant stress and physiological function, such as the Photochemical Reflectance Index (PRI) and canopy temperature, in which plant stress would be expected to be expressed both as a change in the type of xanthophyll activated as well as a change in canopy temperatures. Another synergy is the potential of VNIR-SWIR imagery as a means improving temperature emissivity separation by providing column water vapor. VNIR-SWIR estimates of fractional cover should help partition temperatures between green leaves, senesced canopy materials and bare soil. Finally, combined VNIR-SWIR & TIR data provide the opportunity to evaluate how canopy dominants (expressed by plant species or functional types) modify retrieved canopy temperatures and how temperatures in a landscape vary among vegetation types and phenophase.

In this research, we propose to evaluate synergies between a VNIR-SWIR and TIR imaging system utilizing AVIRIS and MASTER data acquired over Coal Oil Point, California on June 19, 2008. We will augment the 2008 AVIRIS analysis, which is limited to the coastal region and one date, with additional with field spectra, ecophysiological analyses, thermal radiometer measurements and destructive harvests to explore seasonal changes in plant biophysical, physiological, and optical properties. To account for regions burned during the 2008 and 2009 fires in the Santa Barbara Front Range and expand spatial coverage we will rely on a 2004 AVIRIS image that has already been mapped to plant species at the 20 m and 64 m resolutions. Specific questions we will address include:

1) What is the potential for improved temperature emissivity separation using VNIR-SWIR column water vapor?
2) What is the relationship between moisture content and emissivity?
3) What is the relationship between common hyperspectral measures of plant stress and physiological function (i.e., PRI, leaf water content) and canopy temperature in imagery (16 and 64 m) and observed in ground-based measurements?
4) How does canopy temperature vary as a function of plant functional type and species at these scales? This question can be addressed using MASTER data and AVIRIS from 2008 augmented by data from 2004.
5) How is canopy temperature and emissivity impacted by changes in canopy cover, notably changes in green leaf fraction, non-photosynthetic vegetation and bare soil? How is temperature partitioned among the various components of cover?

This research complements existing NASA supported research evaluating the temporal, spatial and spectral requirements for mapping plant functional types and species by adding a thermal element. It leverages extensively off of existing research in the area and routine measures of environmental conditions at Coal Oil Point. If an additional

MASTER-AVIRIS pair authorized for acquisition are obtained in 2010, these will be included in the analysis.

Prasad Thenkabail/US Geological Survey
Water Use and Water Productivity of Key World Crops using Hyperion-ASTER, and a Large Collection of in-situ Field Biological and Spectral Data in Central Asia

The overarching goal of this study is to assess water use and water productivity of key world crops using Hyperion-ASTER and a large collection of in-situ field biological and spectral data. The study will be based on existing datasets, collected during the 2006 and 2007 crop growing seasons, over large-scale irrigated areas of the arid Syr Darya river basin (444,000 km2) in Central Asia where recent studies show snowmelt water supplies from Himalayas are on swift decrease. The irrigated cropland data acquired include: (a) Hyperion narrow-band data (5 images) from Earth Observing-1, (b) spectroradiometer data in 400-2500 nanometer, (c) broad-band data from ASTER as well as ETM+, ALI, IKONOS, and Quickbird, and (d) field-plot biological data. The field-plot data of 5 crops (wheat, cotton, maize, rice and alfalfa) were collected, every 15-20 days, throughout the summer crop growing seasons (April-October) of 2006 and 2007 for a total of 1003 sample locations and consisted of: several thousand spectral measurements, crop variables (e.g. biomass, yield), soil salinity, water variables (e.g., inflow, outflow), and meteorological data (e.g., rainfall, ET).

The study of 5 crops using Hyperion-ASTER-field spectral and biological data will: (a) develop and test water productivity models (WPMs), (b) establish shifts in phenology depicting canopies' integrated response to environmental change and\or controlled-planted by humans, (c) highlight best performing hyperspectral water indices (HWIs); and (d) establish chief causes of water productivity variations and identify hyperspectral wavebands and indices that are most sensitive to them.
The outcome of the research will lead to: 1. Determining proportion of irrigated areas in low, medium, or high water productivity and their drivers (e.g., management practices, soil salinity); 2. Establishing water use of 5 irrigated crops, 3. Determining dynamics of water and nutrient stress; 4. Recommending optimal Hyperion wavebands required to best study irrigated cropland characteristics; and 5. Comparing the performances of narrow-band data with broad-band data.
