HyspIRI Combined Questions (CQ)

Multi- and Inter-disciplinary Science
Requiring combined VIS, SWIR and TIR

http://HyspIRI.jpl.nasa.gov

Primary Science Justification

The combined use of HyspIRI TIR and VIS/SWIR will provide significant insight on biological and biogeochemical controls by small-scale physical processes and how these translate into small-scale ecosystem changes, globally

HyspIRI Combined (CQ) Science Questions

To answer these questions, combined multispectral TIR and hyperspectral VIS/ SWIR data are required

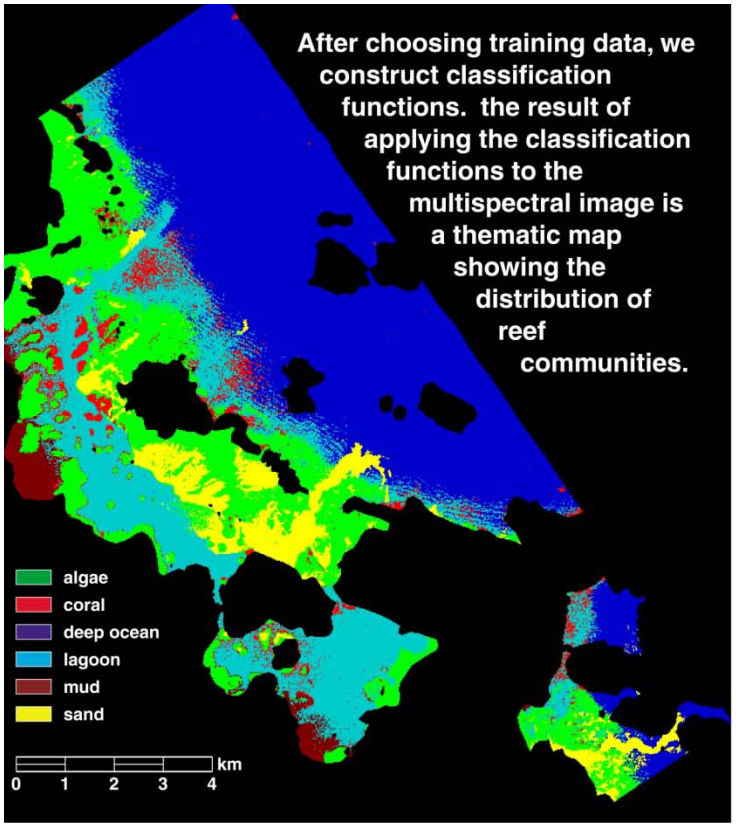
CQ1 – Coastal, ocean, and inland aquatic environments (Frank Muller-Karger)
CQ2 – Wildfires (Louis Giglio)
CQ3 – Volcanos (Robert Wright, Vince Realmuto)
CQ4 – Ecosystem Function and Diversity (Dar Roberts, Martha Anderson)
CQ5 – Earth surface composition and change (Lyle Mars, Anupma Prakash)
CQ6 – Human Health and Urbanization (Dale Quattrochi, Greg Glass)

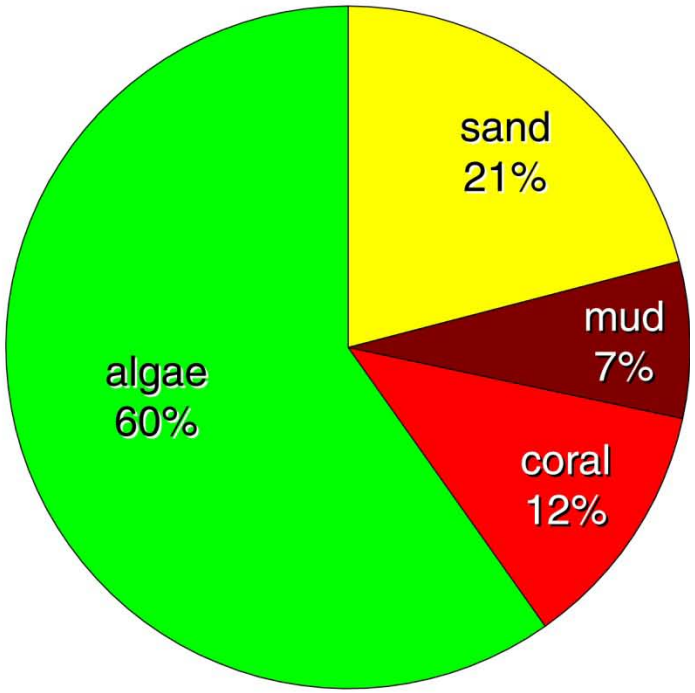
Combined Overarching Questions

- CQ1. Coastal, ocean, and inland aquatic environments, FM-K
  - What is the status of inland and coastal aquatic ecosystems in the context of local and regional thermal climate, land-use change, and other environmental factors?
- CQ2. Wildfires, LG
  - How are fires and vegetation composition coupled?
- CQ3. Volcanoes, RW, VR
  - Do volcanoes signal impending eruptions through changes in the temperature of the ground, rates of gas and aerosol emission, temperature and composition of crater lakes, or health and extent of vegetation cover?
- CQ4. Ecosystem Function and Diversity, DR, MA
  - How do species, functional type, and biodiversity composition within ecosystems influence the energy, water and biogeochemical cycles under varying climatic conditions?
- CQ5. Earth surface composition and change, JM, AP
  - What is the composition of exposed terrestrial surface of the Earth and how does it respond to anthropogenic and non anthropogenic drivers?
- CQ6 Human Health and Urbanization, DQ, GG
  - How do patterns of human environmental and infectious diseases respond to leading environmental changes, particularly to urban growth and change and the associated impacts of urbanization?

CQ1. Coastal, ocean, and inland environments

- What are the feedbacks between climate and habitat structure, biogeochemical cycling, biodiversity, and ecosystem productivity of shallow aquatic habitats?
- What are the ecological linkages of landscape-scale ocean-atmosphere interactions including the hydrologic cycle, aerosol production and transport, and cloud radiative forcing?
- How are small-scale processes in shallow benthic habitats related to changes in functional community types (coral reefs, submerged aquatic vegetation and floating aquatic vegetation), productivity, and biogeochemical cycling including material fluxes and water quality?
- How can these observations be used to guide the management and utilization of resources in the shallow aquatic environment?
- What are the seasonal expressions and cycles for terrestrial and shallow aquatic ecosystems, functional groups and diagnostic species? What is the susceptibility and likely response in the context of changes in climate, land use, and disturbance? [DS 191, 195, 203]

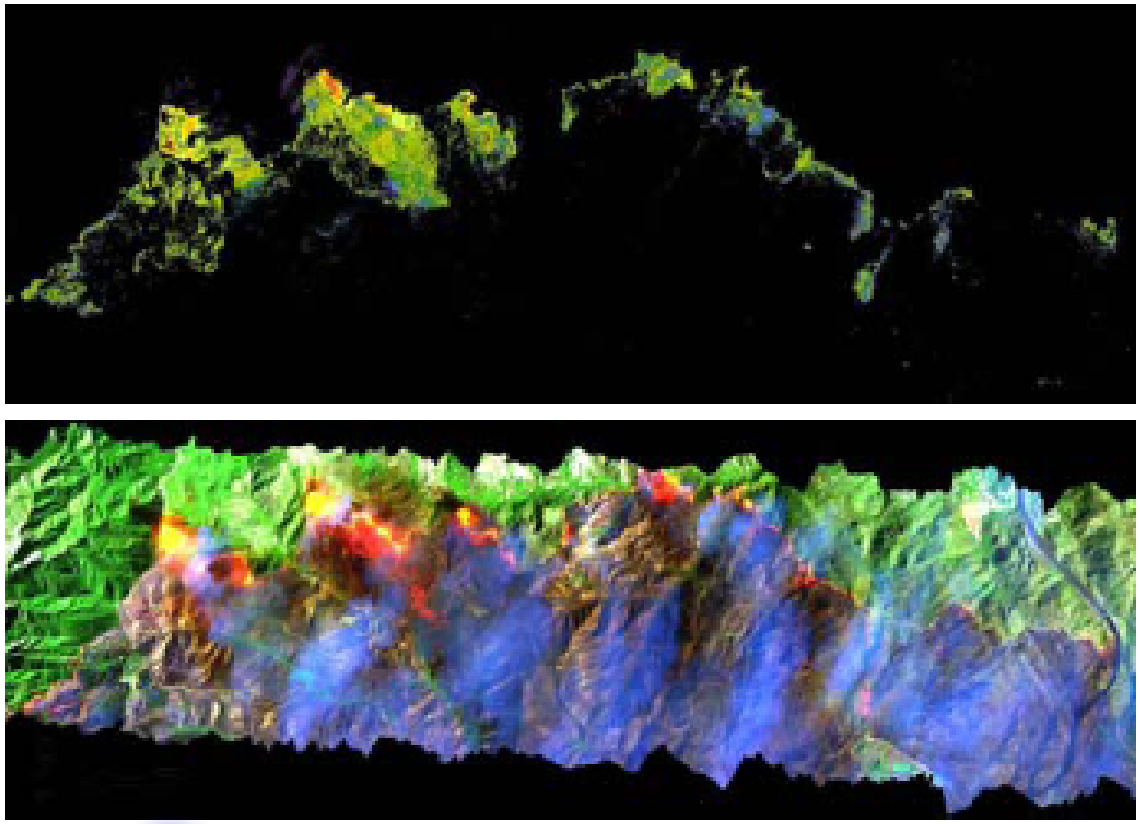




Fractional cover of bottom types derived from AVIRIS imagery of Kaneohe bay, Hawaii. (Courtesy: Eric Hochberg)

CQ2. Wildfires (LG)

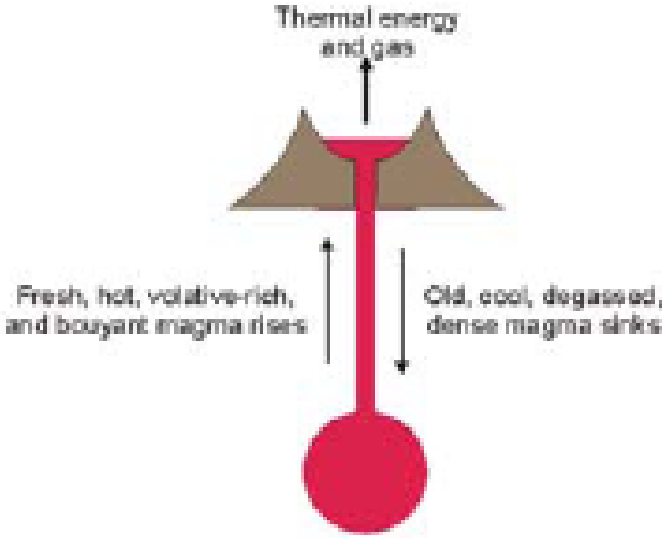
- How does the timing, temperature and frequency of fires affect long-term ecosystem health?
- How does vegetation composition and fire temperature impact trace gas emissions?
- How do fires in coastal biomes affect terrestrial biogeochemical fluxes into estuarine and coastal waters and what is the subsequent biological response? [DS 198]
- What are the feedbacks between fire temperature and frequency and vegetation composition and recovery?
- How does vegetation composition influence wildfire severity?
- On a watershed scale, what is the relationship of vegetation cover, soil type, and slope to frequency of debris flows?
- How does invasive vegetation cope with fire in comparison to native species?



Top panel: Retrieved fire temperature (in kelvins) from an AVIRIS scene spanning a portion of the large Southern California Fire Complex from October 2003. Bottom panel: False color SWIR-NIR-red composite of the original AVIRIS scene. (Dennison et al. 2006).

CQ3. Volcanos (RW, VR)

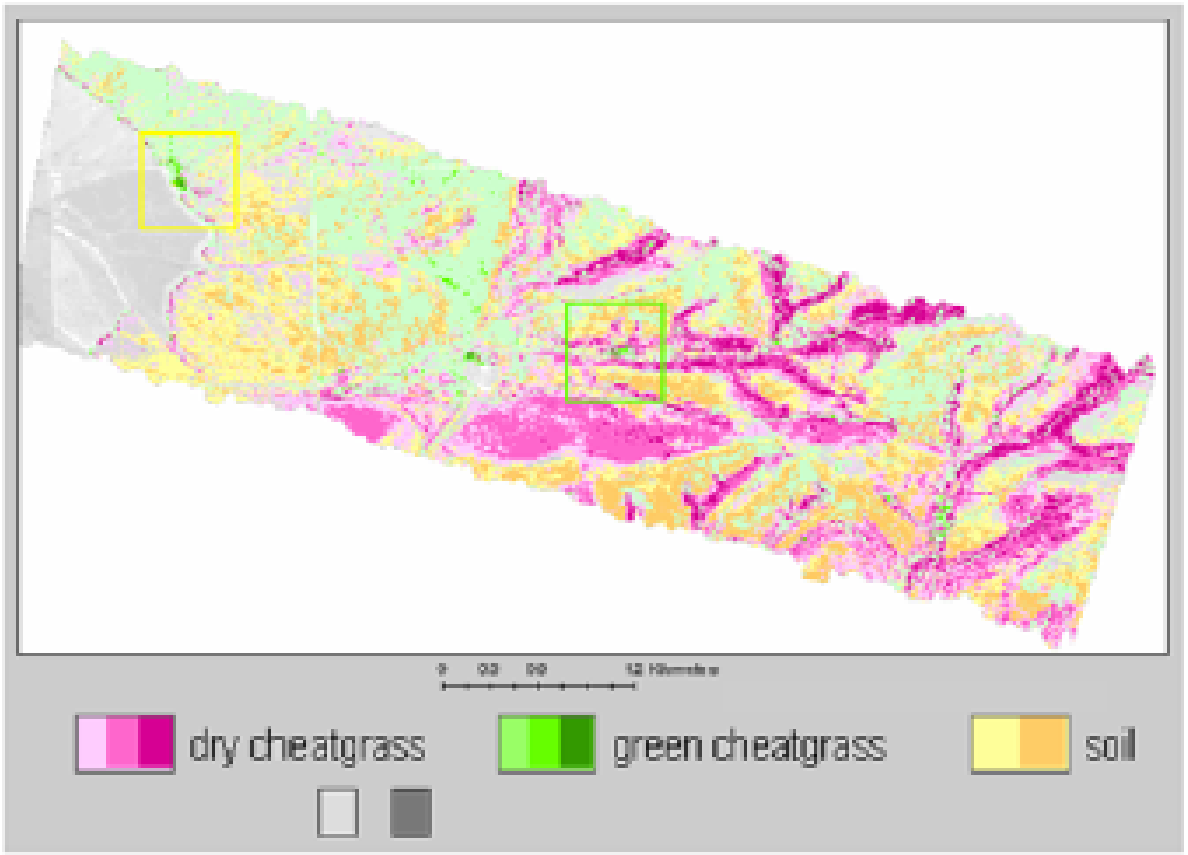
- What do comparisons of thermal flux and SO2 emission rates tell us about the volcanic mass fluxes and the dynamics of magma ascent? [DS 227; 230]
- Does pressurization of the shallow conduit produce periodic variations in SO2 flux and lava dome surface temperature patterns that may act as precursors to explosive eruptions? [DS 50; 227; 230]
- Can measurements of the rate at which lava flows cool allow us to improve forecasts of lava flow hazards? [DS 50; 226]
- Does the temperature and composition of volcanic crater lakes change prior to eruptions? [DS 226; 227].
- Do changes in the health and extent of vegetation cover indicate changes in the release of heat and gas from crater regions? [DS 230; 231]



Hyperion SWIR image of Erta Ale volcano, Ethiopia, showing the active lava lake. Hyperspectral VSWIR and TIR data will allow the cooling rate and gas flux from the lake to be determined. Right: model of cooling and degassing-driven magma convection within an open system volcano. The heat and gas flux data are important boundary conditions for determining magma ascent dynamics and circulation within the conduit (adapted from Frances et al. 1993).

CQ4. Ecosystem Function and Diversity, (DR, MA)

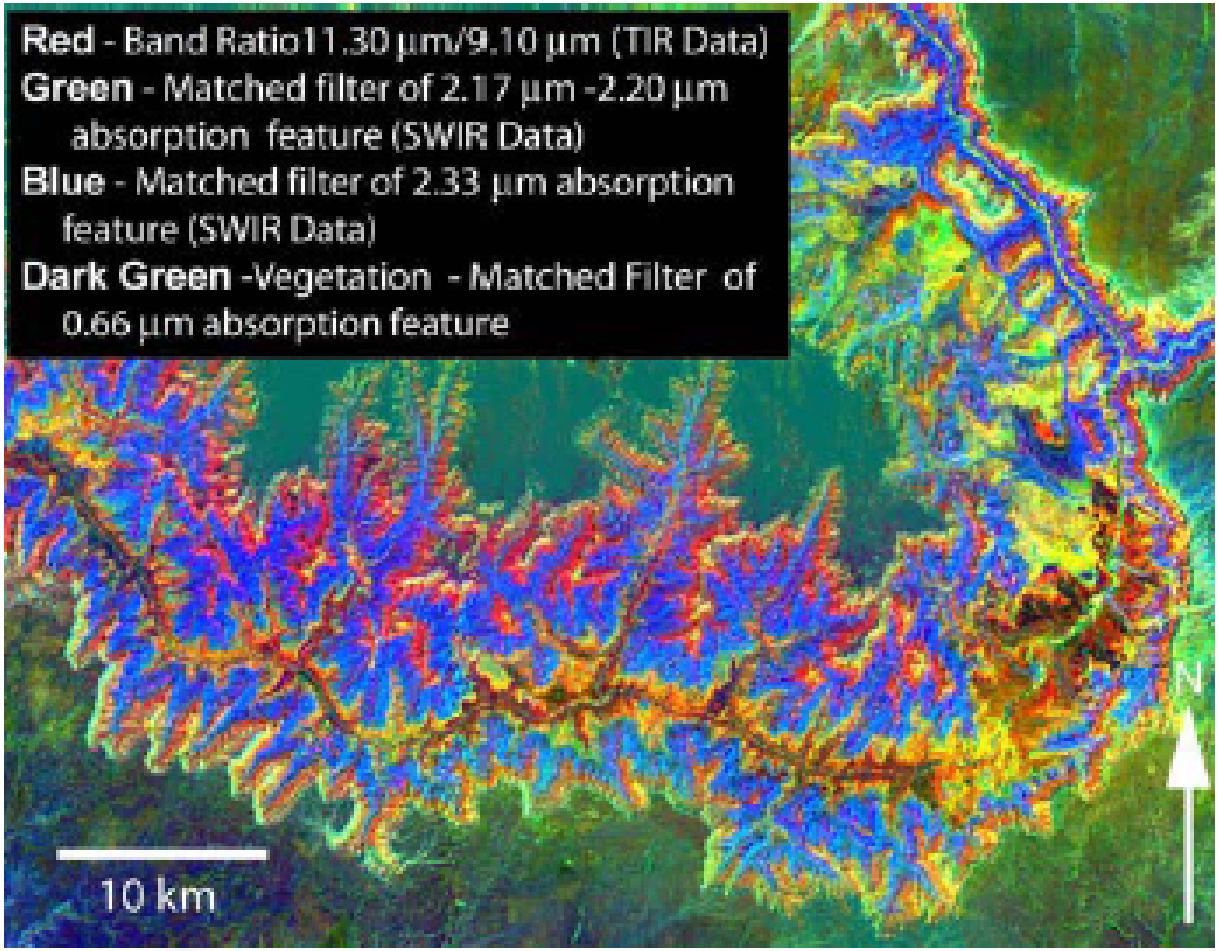
- How can we enhance phenological & stress characterization through synergy between reflective and emitted radiation with higher frequency temporal sampling? [DS194, 195]
- How is energy partitioned between latent and sensible heat fluxes as a function of different plant types and fractional cover and how does this impact hydrology? [DS 203]
- How is physiological function affecting water and carbon exchange expressed at the ecosystem scale, especially seasonal down-regulation due to environmental stress factors? [DS 166, 196, 203, 206, 368]
- What is the vegetation phenological response to seasonal and interannual changes in temperature and moisture due to climate change and how does this response vary at the community/species level? [DS 196, 203, 206]
- What are the feedbacks between changes in canopy composition, mortality and retrieved canopy temperatures resulting from disturbances (e.g., disease, moisture deficiency, insect attack, fire, land degradation, fragmentation) in natural and managed ecosystems? [DS 166, 196, 203, 206]
- How do climate-induced temperature and moisture changes impact the distribution and spread of invasive and native species? [DS 196, 203]



Map of *Bromus tectorum* (Cheatgrass) generated using imaging spectrometry. Cheatgrass spreads through a combination of disturbance and strategic use of soil moisture. It alters fire regimes, promoting its spread while early germination of Cheatgrass enables it to produce seed in advance of native plants while reducing available water for competitors. (Noujdina and Ustin 2008).

CQ5. Surface Composition and Change (JM,AP)

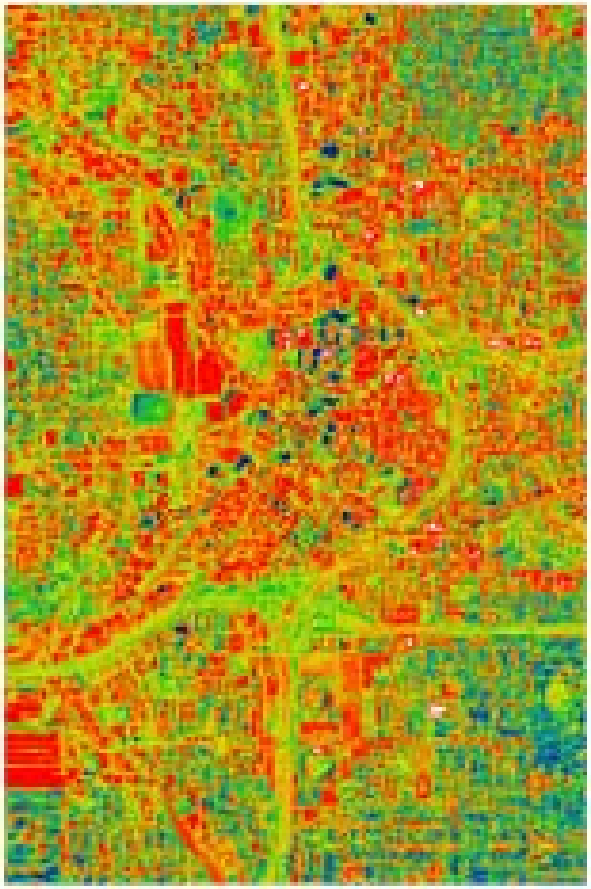
- What is the composition of the exposed terrestrial surface of the Earth? [DS 220]
- How does the surface mineralogy and soil composition relate to the plant physiology and function on the terrestrial surface of the Earth? (DS 114)
- How is the composition of exposed terrestrial surface responding to anthropogenic and non anthropogenic drivers (desertification, weathering, disturbance e.g. logging, mining)? (DS 114)
- How do types and distributions of altered rocks define regional trends in hydrothermal fluid flow for magmatic arcs and tectonic basins, better define hydrothermal deposit models, and assist in the discovery of new economic deposits? (DS 227)
- How do regional trends of minerals and shale thermal maturity within basins better define depositional models and assist in the discovery of new hydrocarbon reserves? (DS 235)



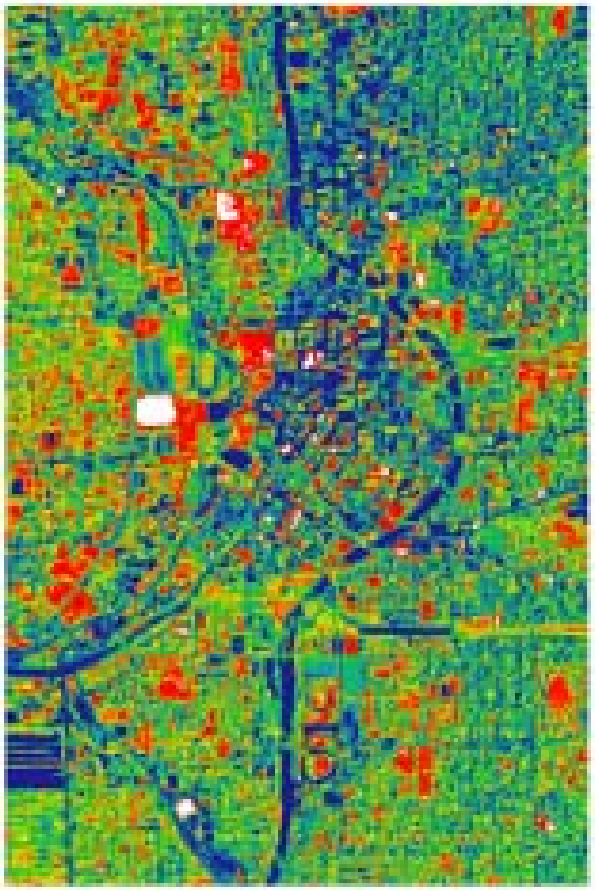
False color composite HyspIRI simulated image of Grand Canyon, Arizona derived from TIR (red band - quartz-rich rocks), SWIR (green band - clay and muscovite-rich rocks; blue band - carbonate-rich rocks), and VNIR (dark green - green vegetation) data.

CQ6. Human Health and Urbanization (DQ, GG)

- How do land surface characteristics such as vegetation state, soil moisture, temperature, and land cover composition affect heat and drought, and vector- and animal-borne diseases? (DS 156, 158, 160, 183-184, 198)
- What changes can be observed and measured in emissivities of urban surfaces and how do emissivities change for different cities around the world as they impact the urban heat island and associated land-atmosphere energy balance characteristics? (DS 167-168)
- How does the distribution of urban and peri-urban impervious surfaces affect regional energy balance fluxes, hydrologic processes, biogeochemical fluxes, and what is the response of ecosystems to these changes? (DS 167-168, 198, 203)



Temperature



Albedo

Atlanta, GA - May 1997

Temperature and albedo measurements for the Atlanta, GA central business district as derived from multispectral aircraft data (Quattrochi et al. 2009)

TASKS TO ACCOMPLISH

- Measurement requirements have been incorporated into the Science Traceability Matrix
- Alignment with Decadal Survey has been confirmed and documented
- Identify the precursor science needed
- Level 3 products (spatial, temporal res., etc.)
  - Being defined
- Validation approach for Level 0-3+ products
  - To be defined
    - Coordinate with NPP, ACE, Geo-Cape, other teams