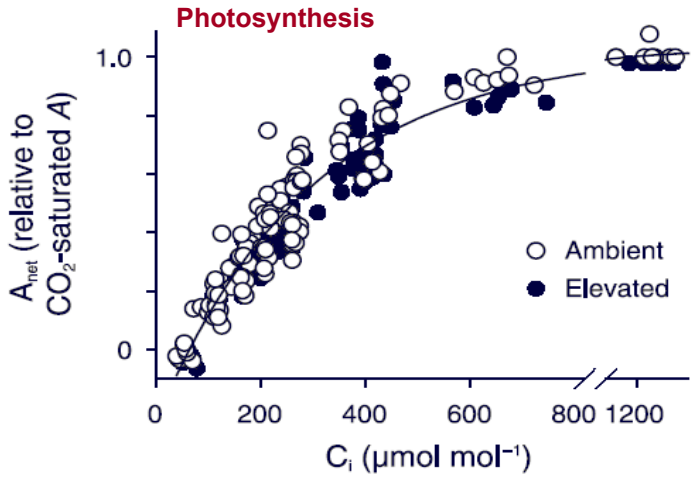
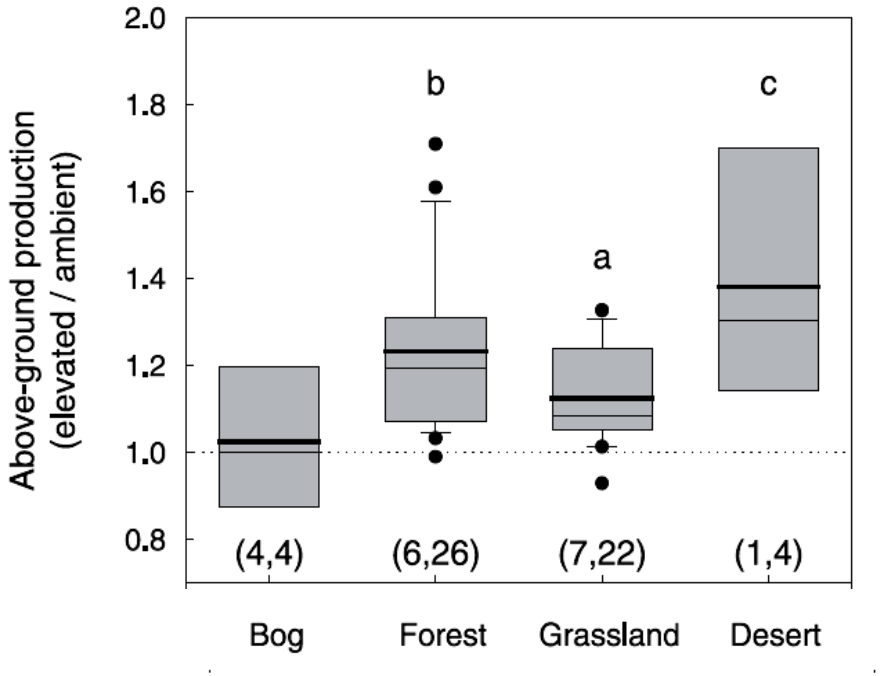
VQ3. Biogeochemical Cycles

How are the biogeochemical cycles that sustain life on Earth being altered/disrupted by natural and human-induced environmental change? How do these changes affect the composition and health of ecosystems and what are the feedbacks with other components of the Earth system?

VQ3a: How do changes in climate and atmospheric processes affect the physiology and biogeochemistry of ecosystems? [DS 194, 201]





Nowack et al. 2004

Science Issue:

Changes in climate, CO2 and other atmospheric processes can influence ecosystem function through a variety of mechanisms. These include temperature and CO2-induced changes in photosynthesis, altered rates of decomposition and nutrient cycling and changes in species composition and plant tissue chemistry resulting from a combination of the above. HyspIRI will greatly enhance our ability to predict, quantify and detect changes in these factors through a combination of approaches involving the composition, seasonality and canopy chemistry of ecosystems.

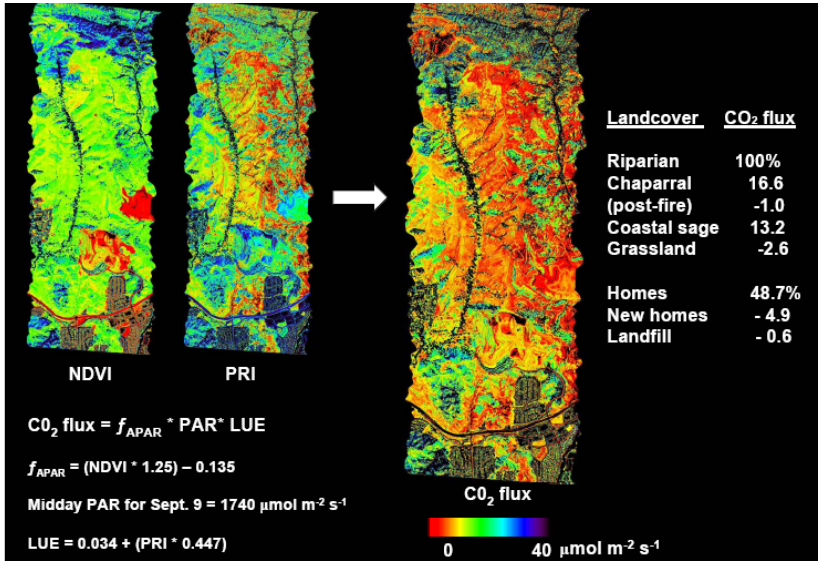
Tools:

A wide variety of HyspIRI spectral bands used to along with ecosystem models and ancillary climate data.

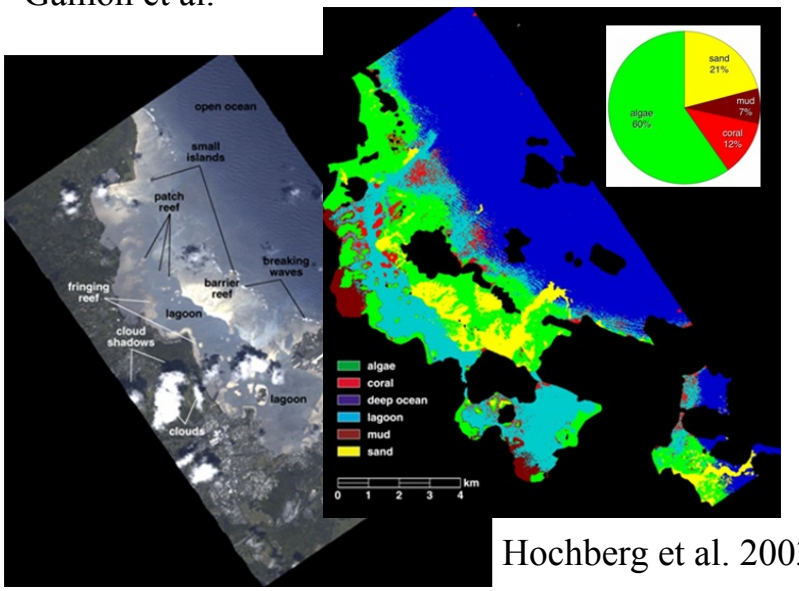
Approach:

HyspIRI-derived estimates of physiological properties and plant functional types combined with models designed to simulate long-term effects of changing climate and CO2.

VQ3b: What are the consequences of uses of land and coastal systems, such as urbanization and resource extraction, for the carbon cycle, nutrient fluxes and biodiversity? [DS 196, 197]



Gamon et al.



Hochberg et al. 2003

Science Issue:

The effects of human-induced changes in land and coastal systems have profound impacts on carbon and nutrient cycling which can in turn affect species biodiversity. For example, runoff from fertilization can lead to replacement of coastal communities (e.g., coral reefs replaced by algae). Accurate estimation of CO2 and nutrient fluxes as well as species composition in terrestrial and coastal systems over time is therefore key to understanding the consequences of land and resource uses at local and regional scales.

Tools:

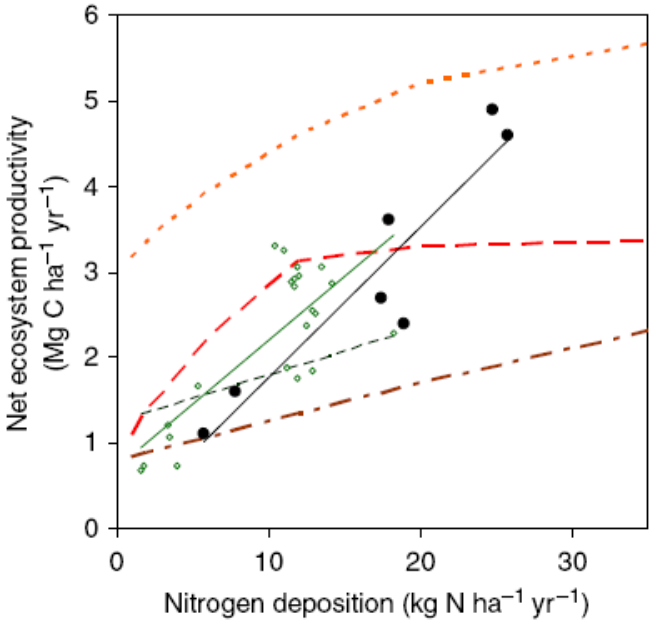
VSWIR data from HysPIRI, combined with Landsat and MODIS for estimating land cover/species composition, land use/land change, and ocean chlorophyll, as well as calculating indices such as WBI and PRI.

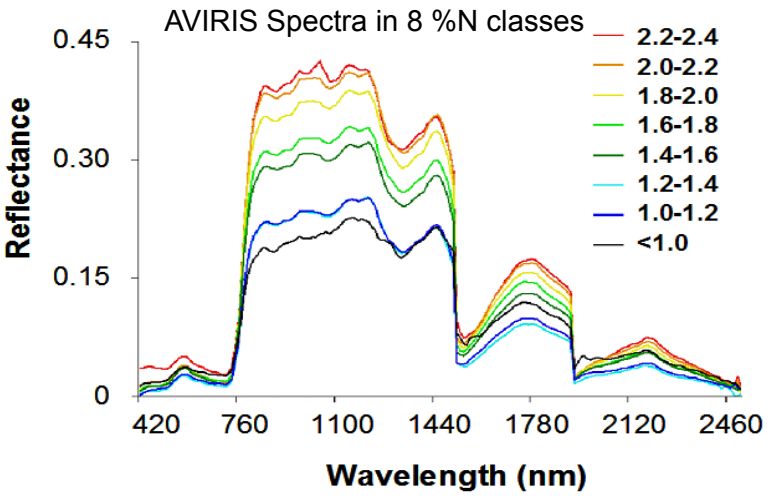
Eddy covariance flux tower data for a range of vegetation, including fertilized v. unfertilized sites, agriculture v. forest sites, harvested v. young and mature forest stands.

Approach:

Change detection for land use/conversion related to estimates of CO2 flux over time. Coastal communities and diversity related estimates of runoff, eutrophication, dissolved organic matter.

VQ3c: What are the consequences of increasing nitrogen deposition for carbon cycling and biodiversity in terrestrial and coastal ecosystems? [DS 195, 196]





Sutton et al. 2008; Ollinger et al. 2008

Science Issue:

Nitrogen is a key limiting resource in most terrestrial and marine ecosystems and recent research highlights the importance of N deposition and canopy nitrogen in studies of carbon assimilation and sequestration. Nitrogen deposition is also known to influence the composition of ecological communities, favoring those adapted to N rich environments. HyspIRI's VSWIR instruments will allow the effects of N deposition on C assimilation and vegetation composition to be more accurately quantified through detection of plant functional groups and N concentrations in foliage.

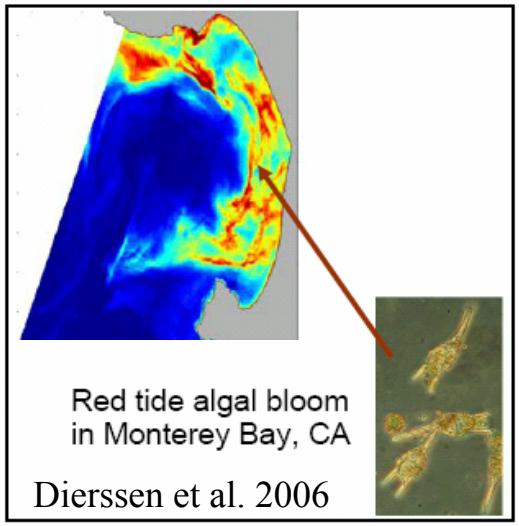
Tools:

HyspIRI VSWIR full spectral reflectance, radiative transfer models, ecosystem C cycling models.

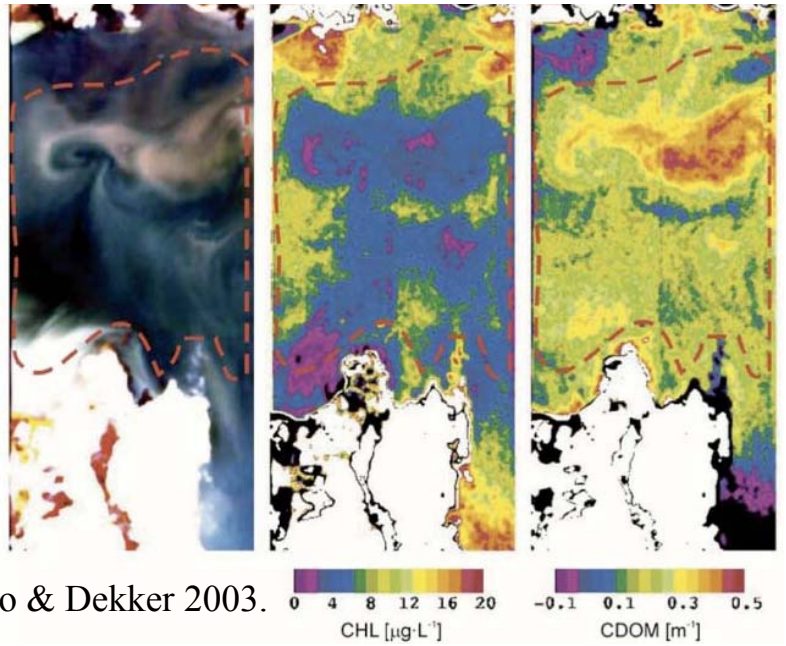
Approach:

Application of PLS calibration algorithms and radiative transfer models to mid growing season HyspIRI imagery. Comparison against spatial N deposition data layers and incorporation into ecosystem models requiring plant N status

VQ3d: How do changes in hydrology, pollutant inputs and sediment transport affect freshwater and coastal marine ecosystems? [DS 196]



Dierssen et al. 2006



Brando & Dekker 2003.

Science Issue:

Pollutant and nutrient runoff from terrestrial to freshwater and marine ecosystems can represent severe perturbations by causing eutrophication as well as changes in oxygen levels and water temperatures. Similarly, alterations to hydrologic flows and sediment transport rates can influence salinity, light availability and sediment properties along with a host of other environmental properties. HyspIRI will allow detection and quantification of these changes by providing detailed data regarding turbidity, plankton communities and chlorophyll concentrations.

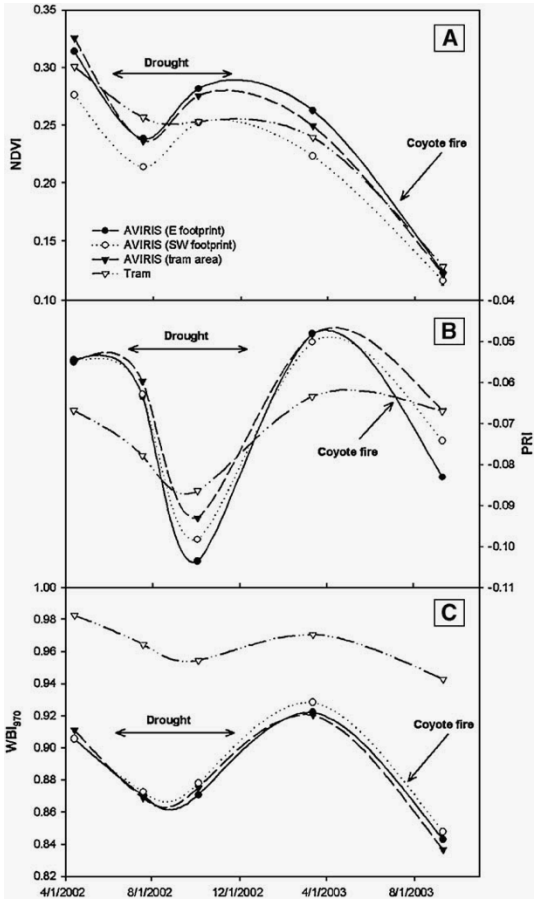
Tools:

HyspIRI VSWIR and TIR data to map freshwater and marine plant and animal communities as well as water temperature.

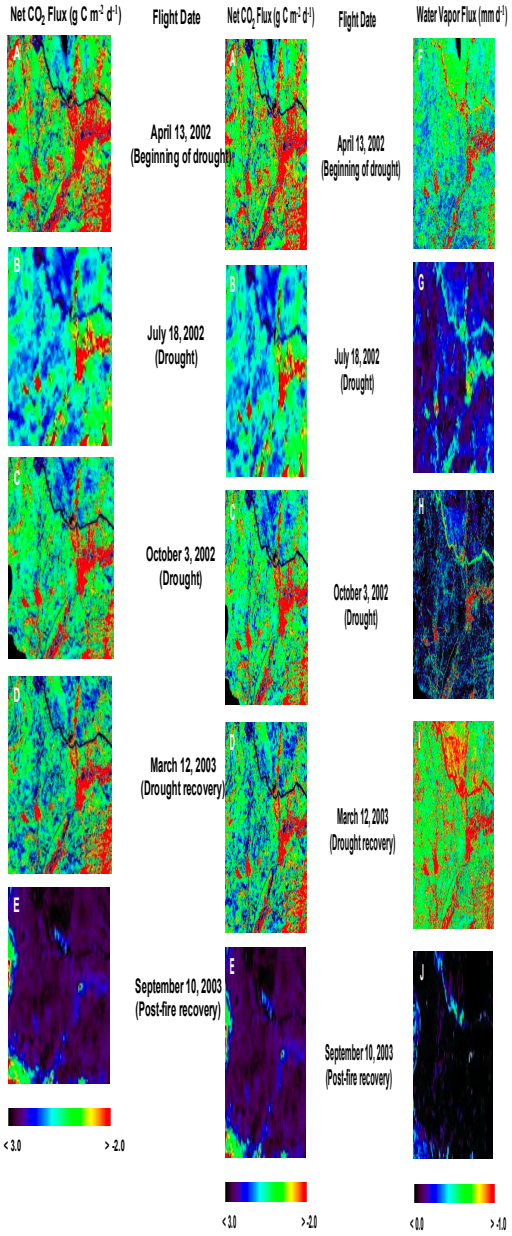
Approach:

Map nutrient levels, turbidity and plankton composition in relation to runoff quantity, chemistry and sediment loads. Use as baseline data to model effects of changes in hydrology, pollutant inputs and sediment transport.

VQ3e: How do changing water balances affect carbon storage by terrestrial ecosystems? [DS 196]



Fuentes et al. 2006



Science Issue:

Water availability is one of the most important constraints on ecosystem carbon metabolism, yet available instruments and methods cannot adequately capture variation in plant and soil moisture status. HyspIRI's VSWIR and TIR instruments will provide data necessary to map and monitor changes in evapotranspiration and plant and soil water status to better quantify variation in ecosystem carbon storage.

Tools:

•HyspIRI's VSWIR data for plant and soil water indices (820, 860, 900, 970, 1240, 1600 nm).

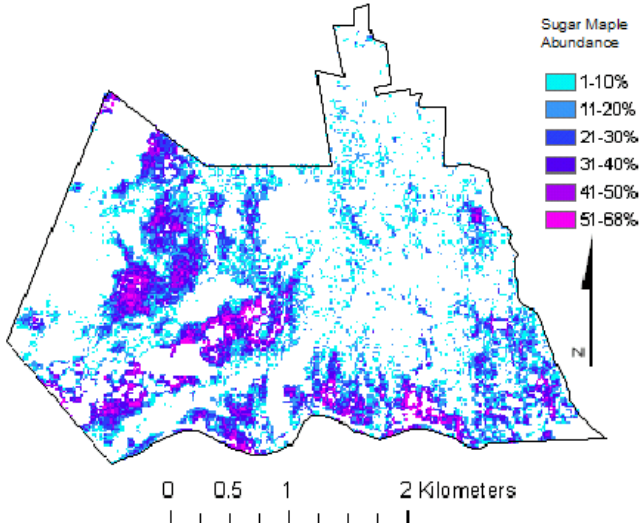
•TIR bands for evapotranspiration and soil water.

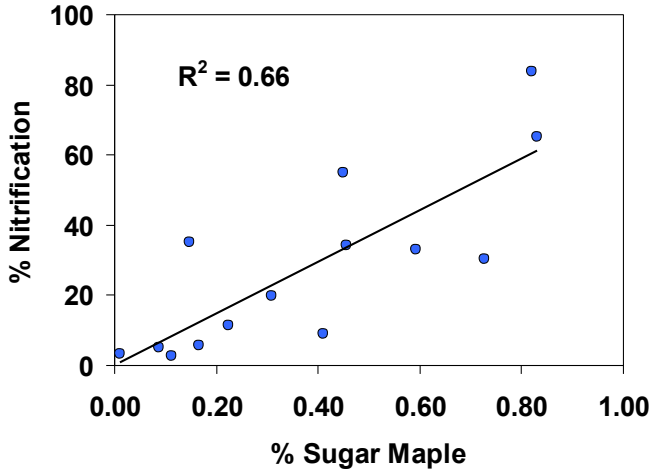
Approach:

HyspIRI data used to provide baseline plant and soil moisture data, and data for input and validation of soil models used in prediction of ecosystem carbon cycling.

VQ3f: What are the key interactions between biogeochemical cycles and the composition and diversity of ecosystems? [195, 196]

Species Composition and Biogeochemistry: Effects of Sugar Maple on the Nitrogen Cycle





Plourde et al. 2007

Science Issue:

Because plant species and functional groups often have distinct nutrient requirements and tissue chemistries, species composition and diversity are integral components of biogeochemical cycles. Plant species distribution and abundance have become vital to studies in biogeochemistry, where there is increasing evidence that changes in health and distribution of individual tree species have implications to C and N cycling.

Tools:

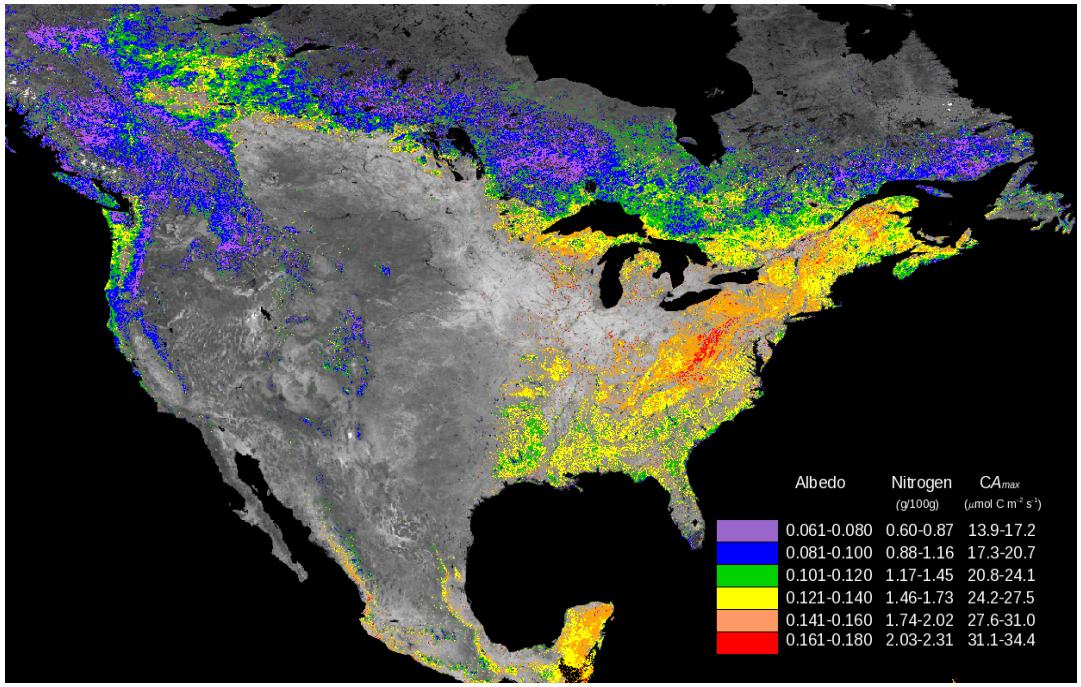
•HyspIRI's VSWIR sensor data, as well as data from airborne hyperspectral sensors and multispectral satellite data, such as Landsat.

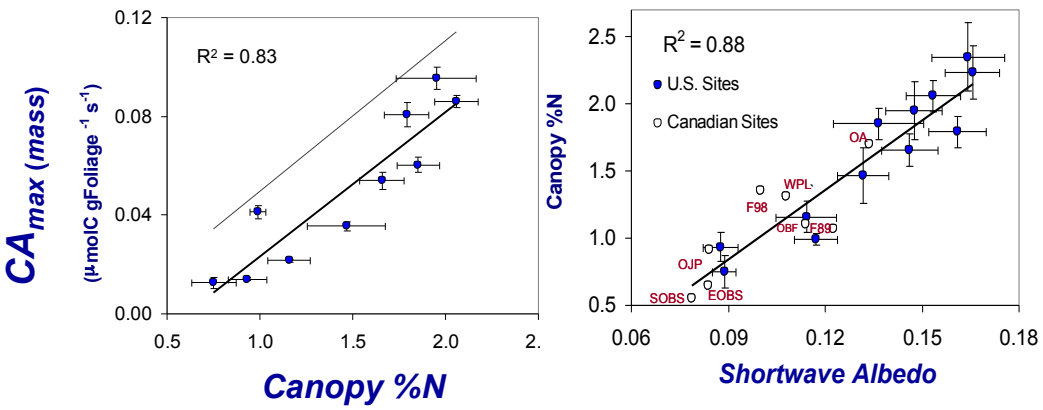
•Ecosystem models such as PnET.

Approach:

By identifying the distribution of species and functional groups, patterns in nutrient cycling can be identified and changes monitored over time. Species distribution data can also serve to better parameterize ecosystem models, resulting in improved predictions of numerous biogeochemical transformations.

VQ3g: How do changes in biogeochemical processes feed back to climate and other components of the Earth system? [DS 190, 192, 195]





Ollinger et al. 2008

Science Issue:

Because ecosystems are an integral component of the Earth's climate system, changes in composition and biogeochemistry can have important consequences for regional and global patterns of climate. Ecosystem-climate feedbacks can take place through alterations to the carbon cycle, which influences atmospheric CO2, or through changes in vegetation surface properties such as albedo.

Tools:

The high resolution and full spectral coverage of HyspIRI's VSWIR bands allows simultaneous detection of physiological properties that control C assimilation such as the the photochemical reflectance index (PRI) and foliar %N as well as vegetation albedo and other surface properties.

Approach:

Improved detection of vegetation physiology and surface properties to **(a)** provide input for land surface-climate models and (b) provide a baseline for future change detection analyses.