What Unique HyspIRI Products Relevant to Climate Change Science can be Produced at the Global Scale?

Susan L. Ustin

University of California Davis

Workshop on Climate Modeling and HyspIRI

Global Science Products

Future Workshop on global HyspIRI Products

Plan to hold workshop near end of year at Carnegie Institution at Stanford with modeling community

Sponsored by: Mike Freilich, NASA HQ, Decadal Survey
Hosted by: Chris Field and Susan Ustin

Goal: White Paper on Global Products Relevant for Climate Research
Ecosystem and Climate Modeling Communities
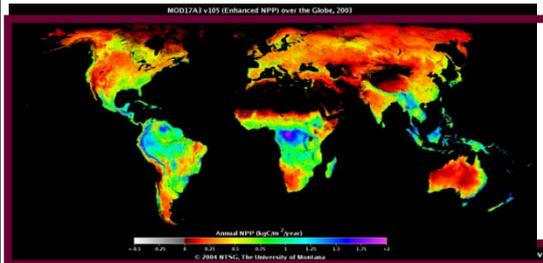
Request for HyspIRI Community Input:

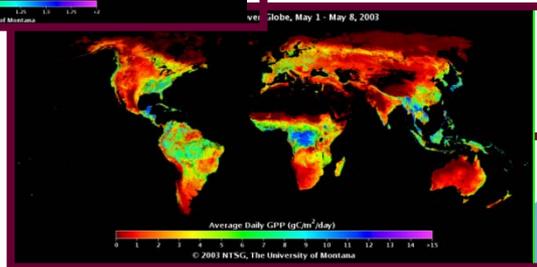Send ideas, papers, comments to me by email: slustin@ucdavis.edu

We must get HyspIRI products incorporated into the next generation Ecosystem Models

NEP = Annual GPP - Respiration (Auto+ Hetero)

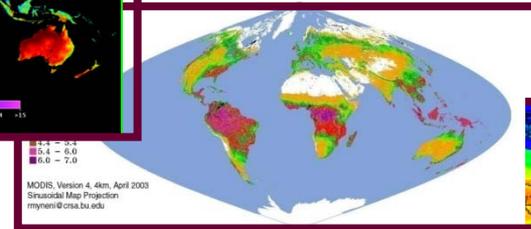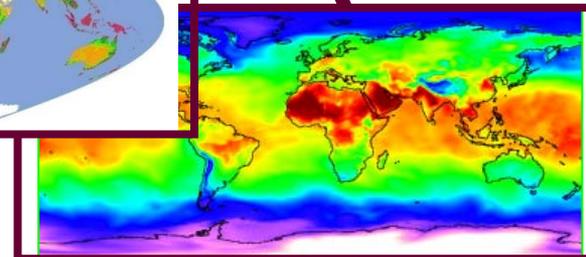$$NEP = \int GPP - (R_m + R_g + R_h)$$
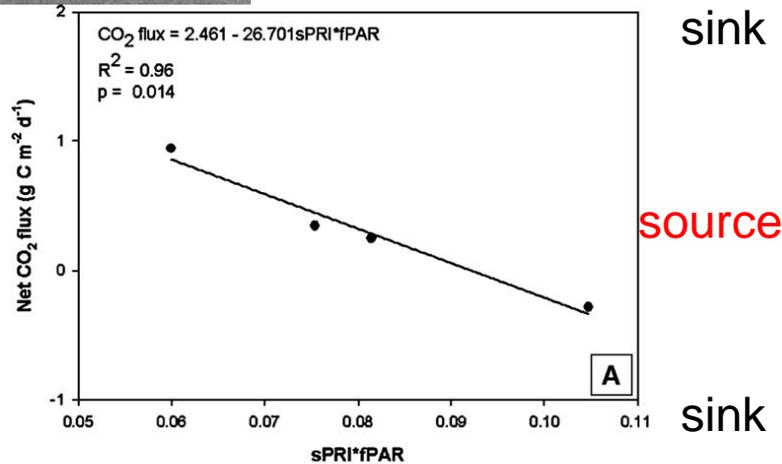

NEP

GPP

LAI

Temperature
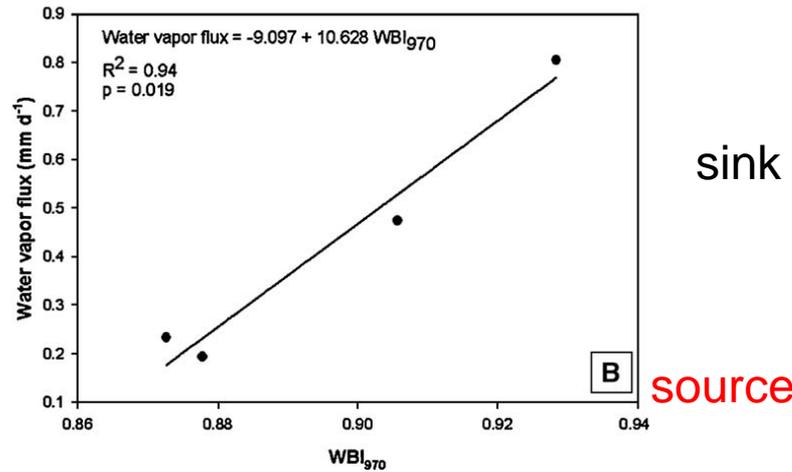
Biome Properties Look-Up Table

Many Possible HyspIRI Indexes:
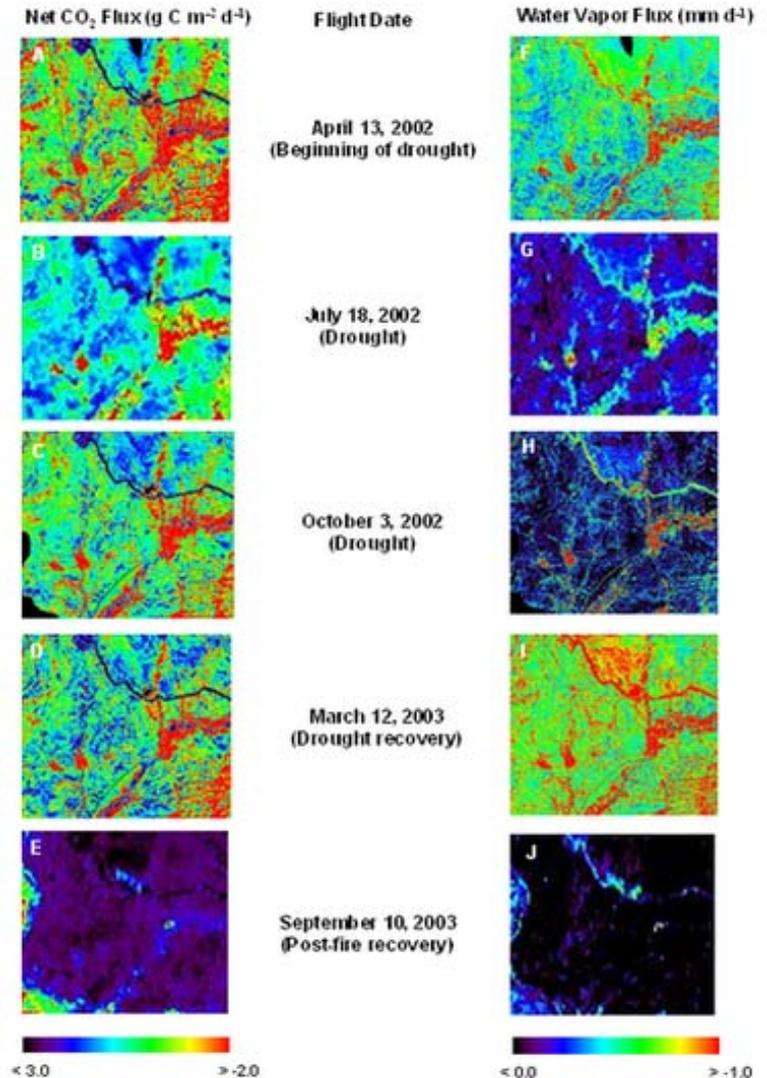## PVI Index tracks Carbon and Water Fluxes
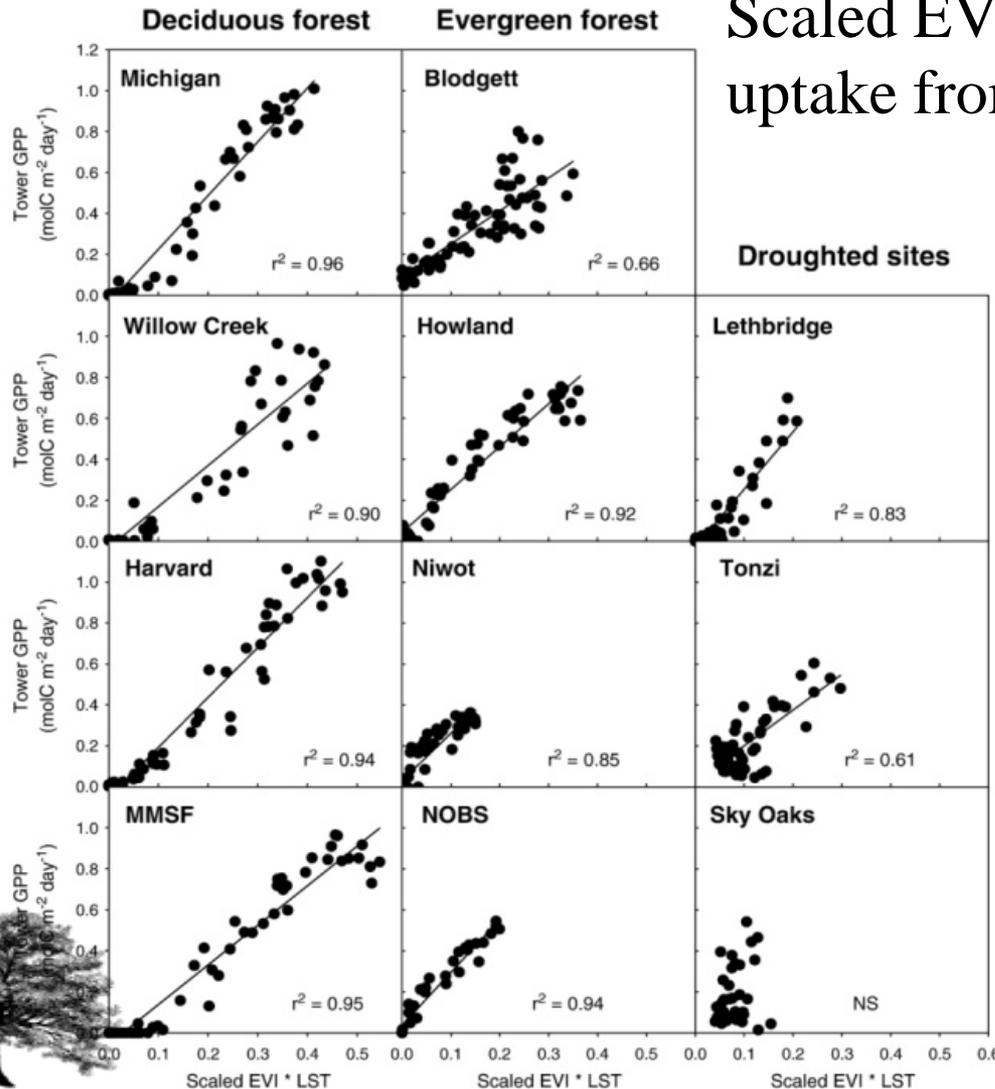

sink

source

sink

sink

source

Fuentes et al. 2006

An operational PRI product could improve ecosystem carbon flux estimates, capturing physological change under disturbance, stress, and changing vegetation composition

Scaled EVI*LST compared to carbon uptake from flux towers.

Improved estimates of carbon uptake using PRI established using flux data and AVIRIS

MODIS estimates of carbon uptake improved using LST, vegetation index and 60m pixels (from Sims et al., 2008)

Develop Robust Algorithms to Quantitatively Predict Photosynthetic Processes: Spectroscopy Provides Quantitative Measurements of OpticalProperties

PLSR waveband selection
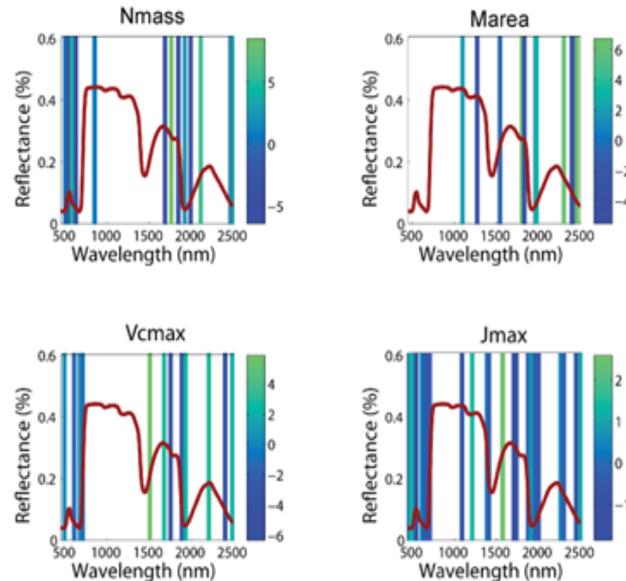
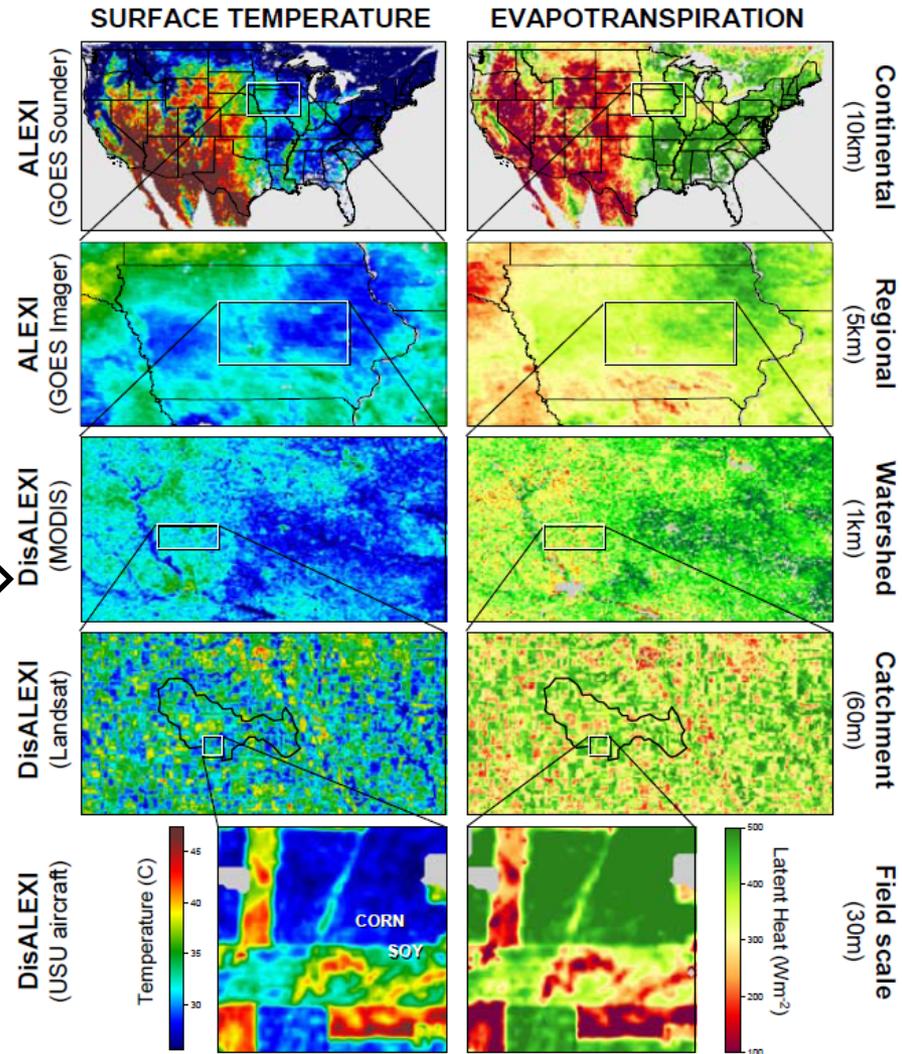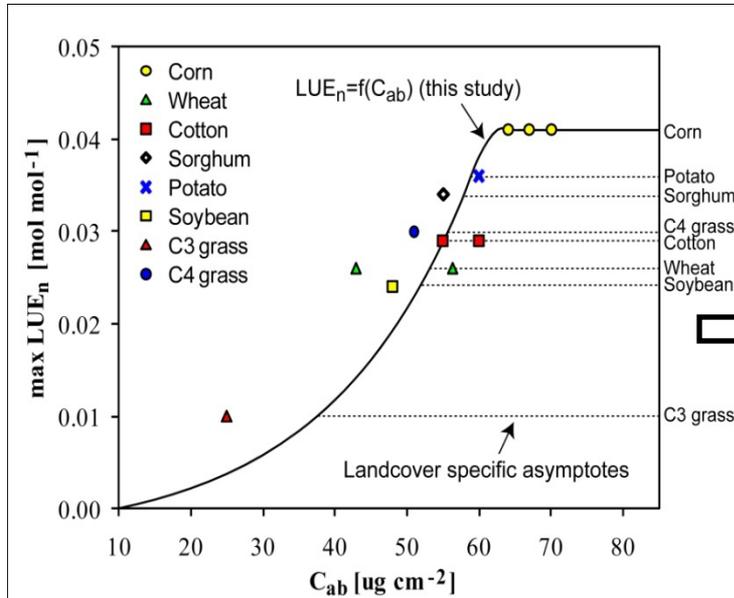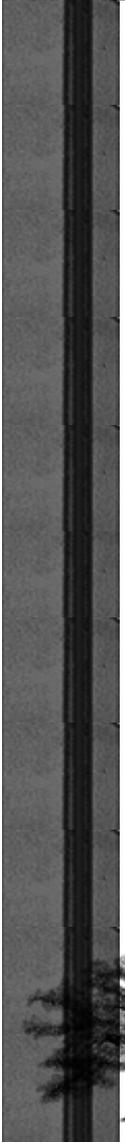**PLSR waveband selection and the state of knowledge**
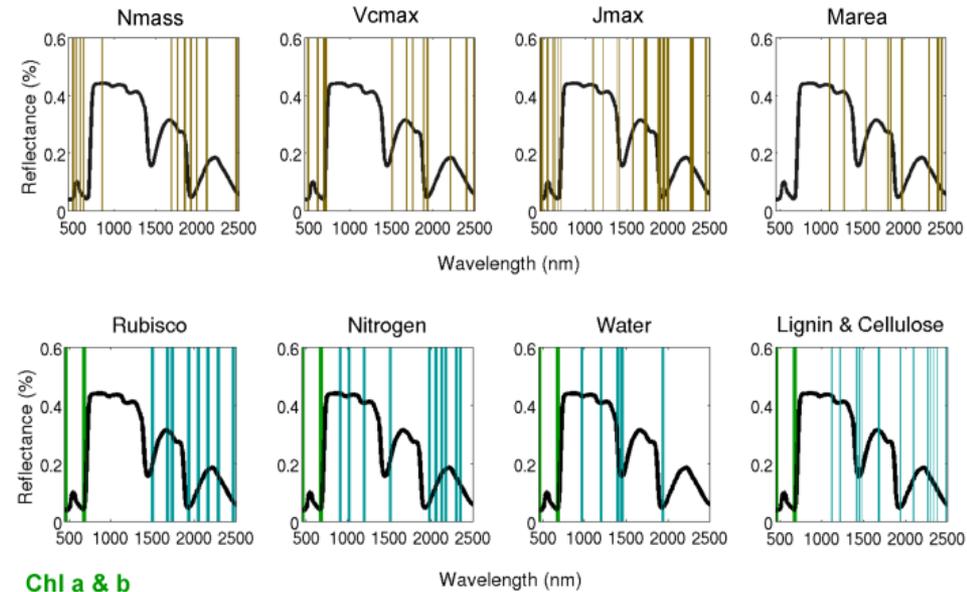
Nmass = nitrogen concentration

Marea = mass area^{-1}

Vcmax = Assimilation limit by Rubisco

Jmax = Assimilation limit by e$^-$ transport

Continuing large uncertainty in flux of CO_2 due to land use change.

Global Monitoring of Physiological Processes using HyspIRI Thermal-based Flux Mapping

USDA Beltsville

Carbon budgets are sensitive to:

1. Land cover characteristics
2. Disturbance period & Successional stages
3. Species composition
4. Land use history/management
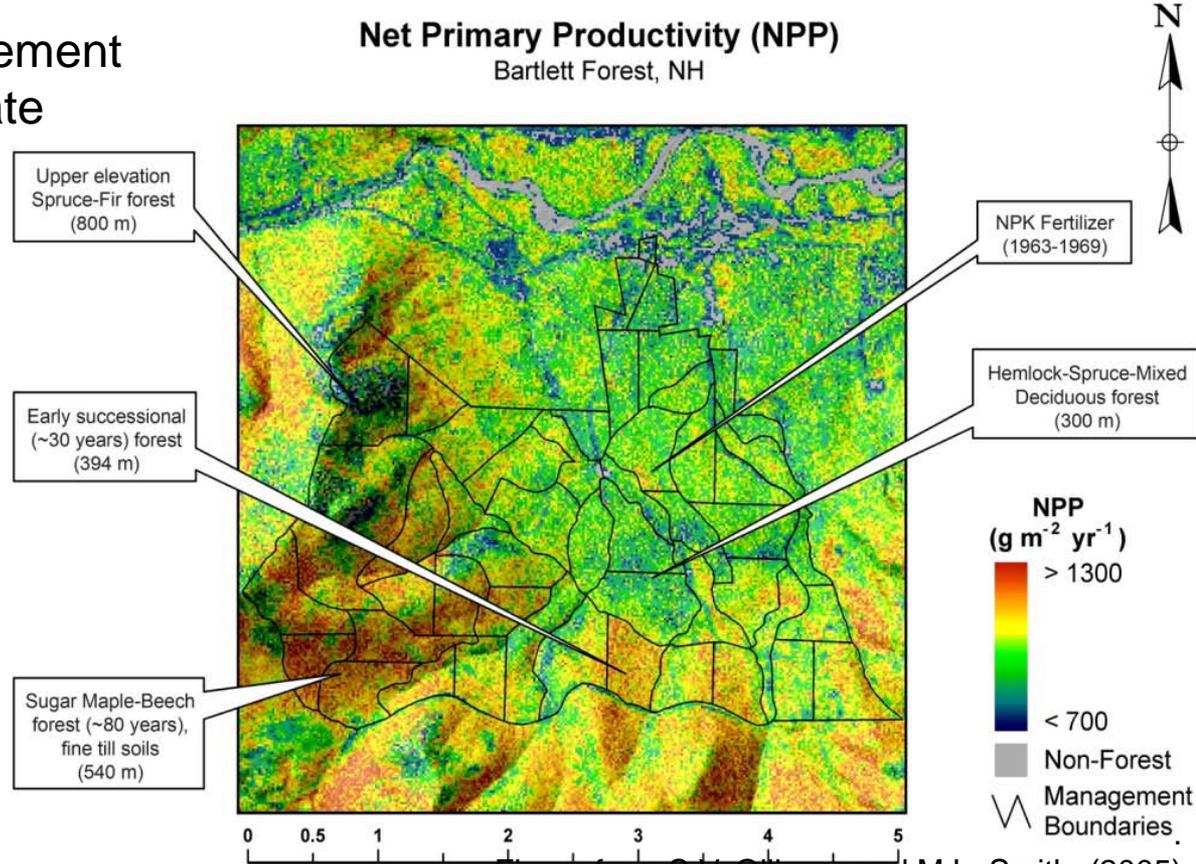5. Variable weather & climate
6. Nutrient status, LAI

Net Primary Productivity (NPP)
Bartlett Forest, NH

N

Upper elevation
Spruce-Fir forest
(800 m)

NPK Fertilizer
(1963-1969)

Hemlock-Spruce-Mixed
Deciduous forest
(300 m)

Early successional
(~30 years) forest
(394 m)

NPP
(g m^{-2} yr^{-1})

> 1300

< 700

Non-Forest

Management
Boundaries

Sugar Maple-Beech
forest (~80 years),
fine till soils
(540 m)

0   0.5   1   2   3   4   5

Figure from S.V. Ollinger and M.L. Smith, (2005)

What HyspIRI products can be produced routinely at the global scale?
Relevant for Climate Research? Identified as Climate Relevant?

➢ Plant Functional Types

➢Spectral Endmember Composition & Changes in Endmembers over time

➢All commonly used spectral indexes (>50 for plants, soil, snow, etc.)

➢Types of disturbance, frequency & land use change

➢ Quantify snow/water partitioning & extent

Species Map
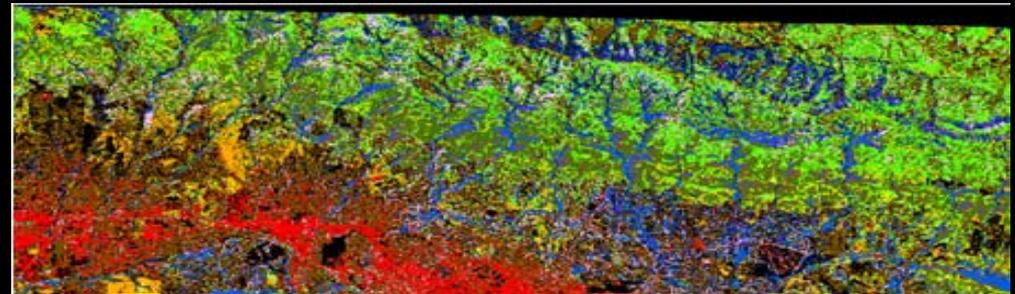
■chamise, ■ sagebrush, ■ manzanita, ■ mustard, ■bigpod ceanothus, ■ redheart ceanothus, ■ grass, ■ coast live oak, ■ scrub oak, ■ California bay, ■ yucca, ■ soil, ■ urban, ☐ unclassified

Functional Type Map
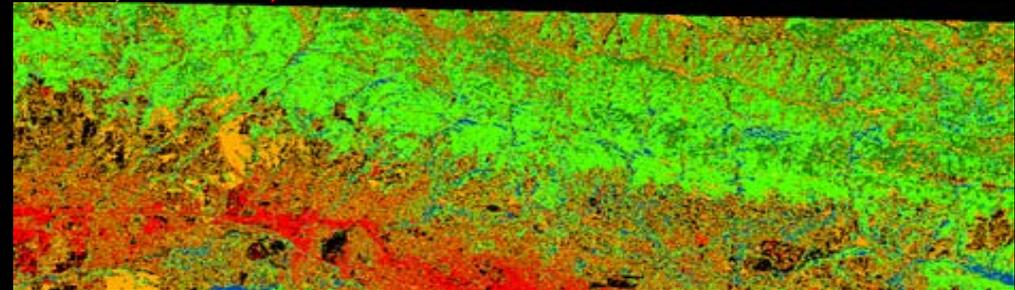
■Annual grass, ■ annual herb, ■ Evergreen broadleaf shrub, ■ evergreen broadleaf tree, ■ evergreen needleleaf shrub, ■ evergreen succulent, ■ soil, ■ urban, ☐ unclassified
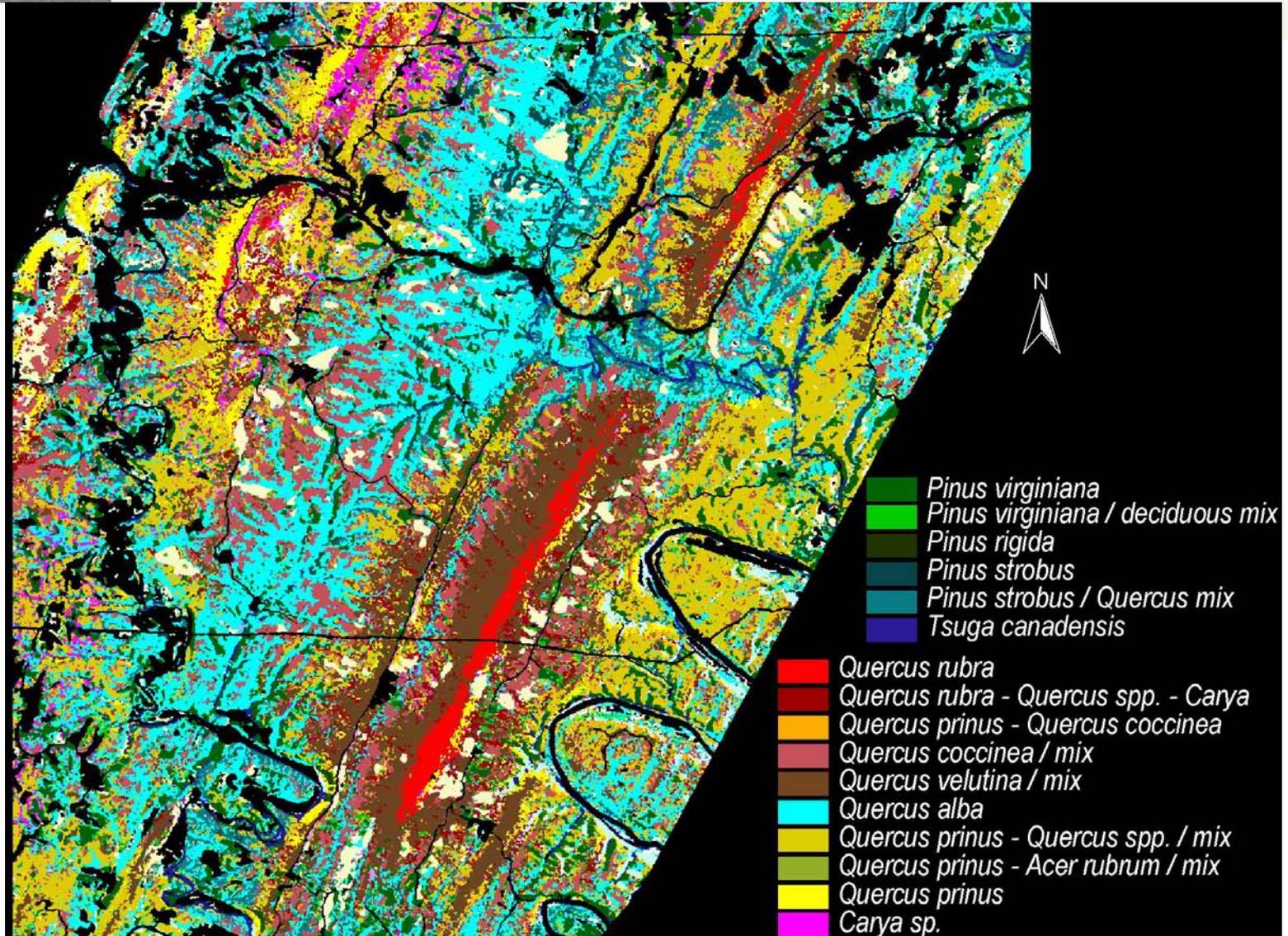
Santa Barbara Front Range Species Distribution
(AVIRIS 07/06/2004; Dar Roberts)

Vegetation Mapping at local scales is well established.
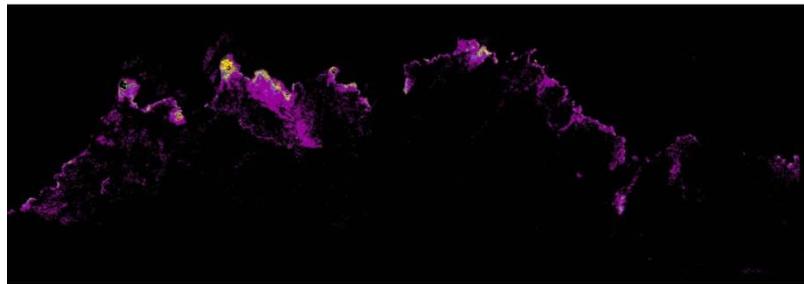Can HyspIRI improve global vegetation maps?
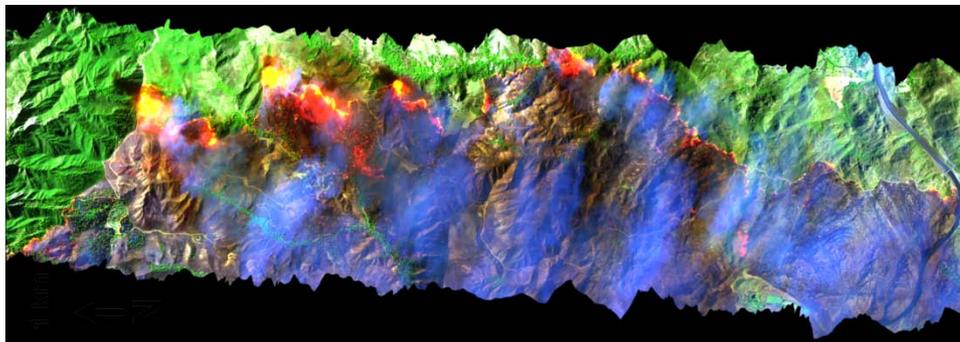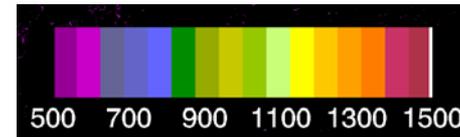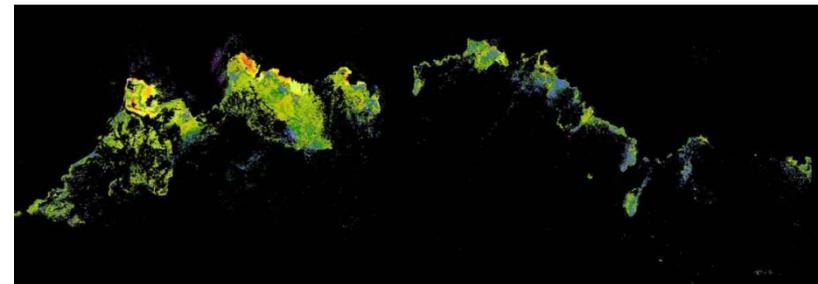Can we demonstrate or develop a path to do this?

Changing Land Cover Causes Major Uncertainty in Carbon Budgets:
HyspIRI can Monitor and Quantify Land Use Change and Changing Disturbance Regimes

Increased Wildfire Frequency and Extent will lead to net increased CO_2 emissions
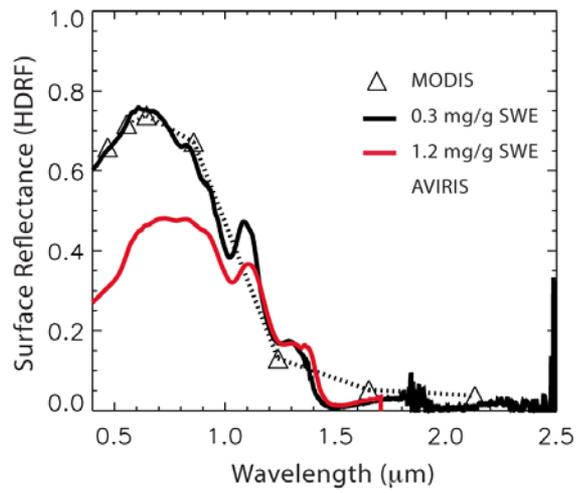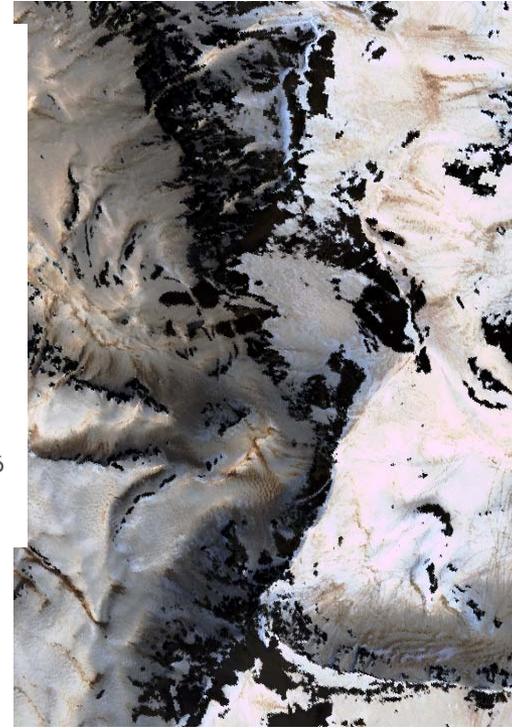
Sub-Pixel Fire Fraction
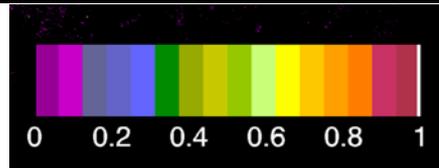
Sub-Pixel Fire Temperature
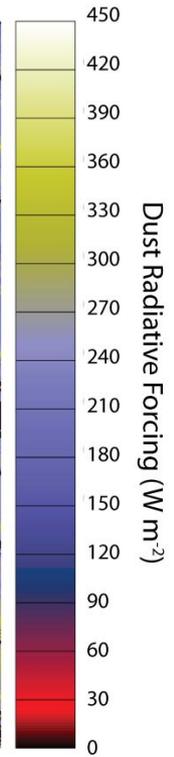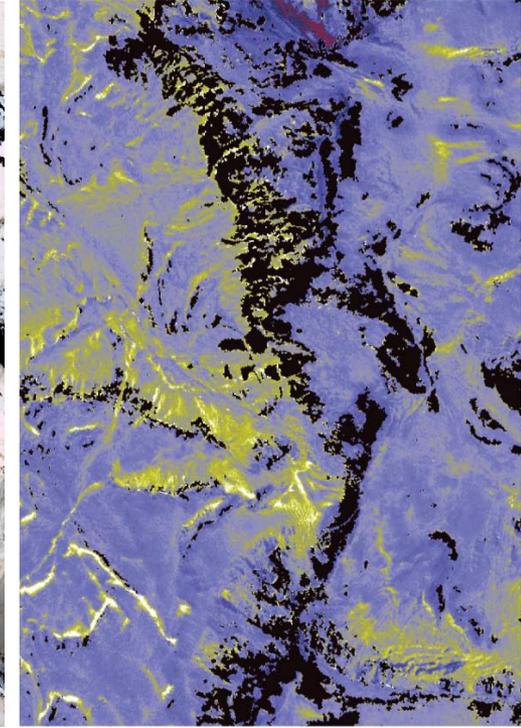
AVIRIS 2003
Dennison et al. 2006

Can we develop robust estimates of dust concentration on snow?
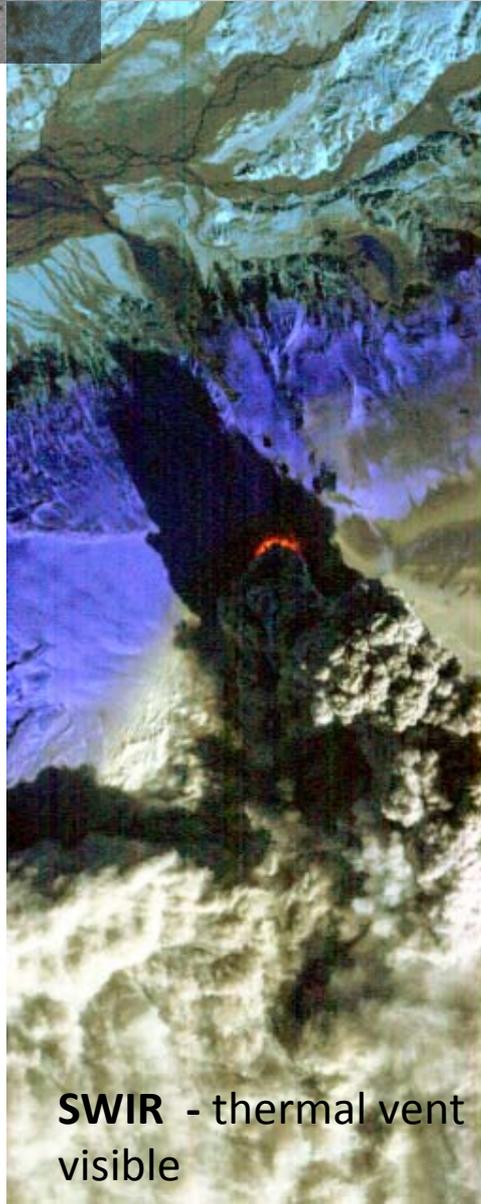

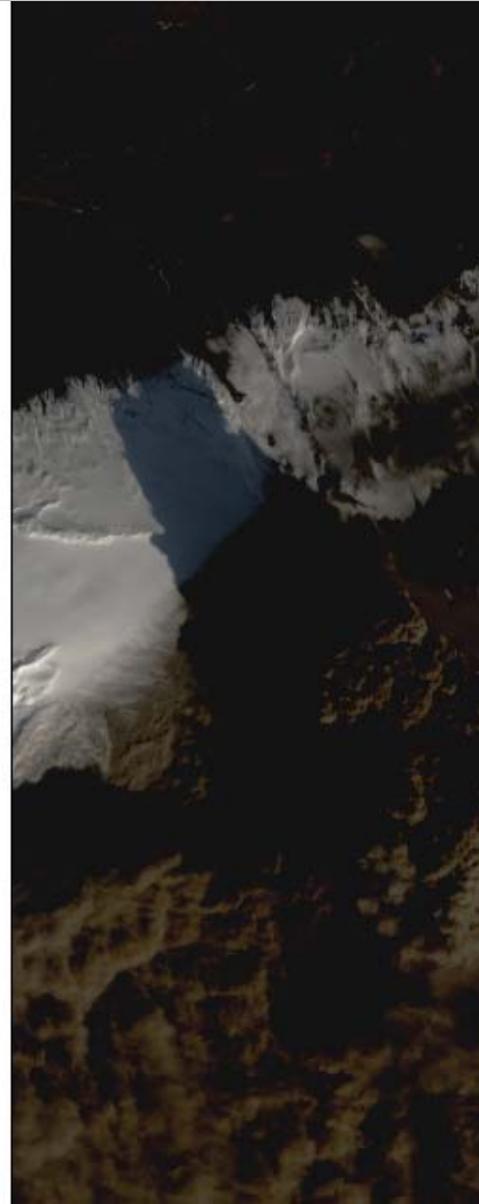True Color Composite

Dust Radiative Forcing

AVIRIS, Senator Beck Basin, CO May 19, 2004 – AVI-DRFS model *Painter et al 2010*

# Societal Applications: Monitoring Global Environmental Disasters and Conditions

Imaging of Eyjafjallajökull Volcano Eruption 17 April 2010

VIS -plumes coating everything to the South-East making the ice brown/gray

TIR imager will make daily passes at latitude of Iceland

SWIR - thermal vent visible

Responding to Environmental Disasters: Deepwater Oil Spill


AVIRIS Oil Flight 100506r17
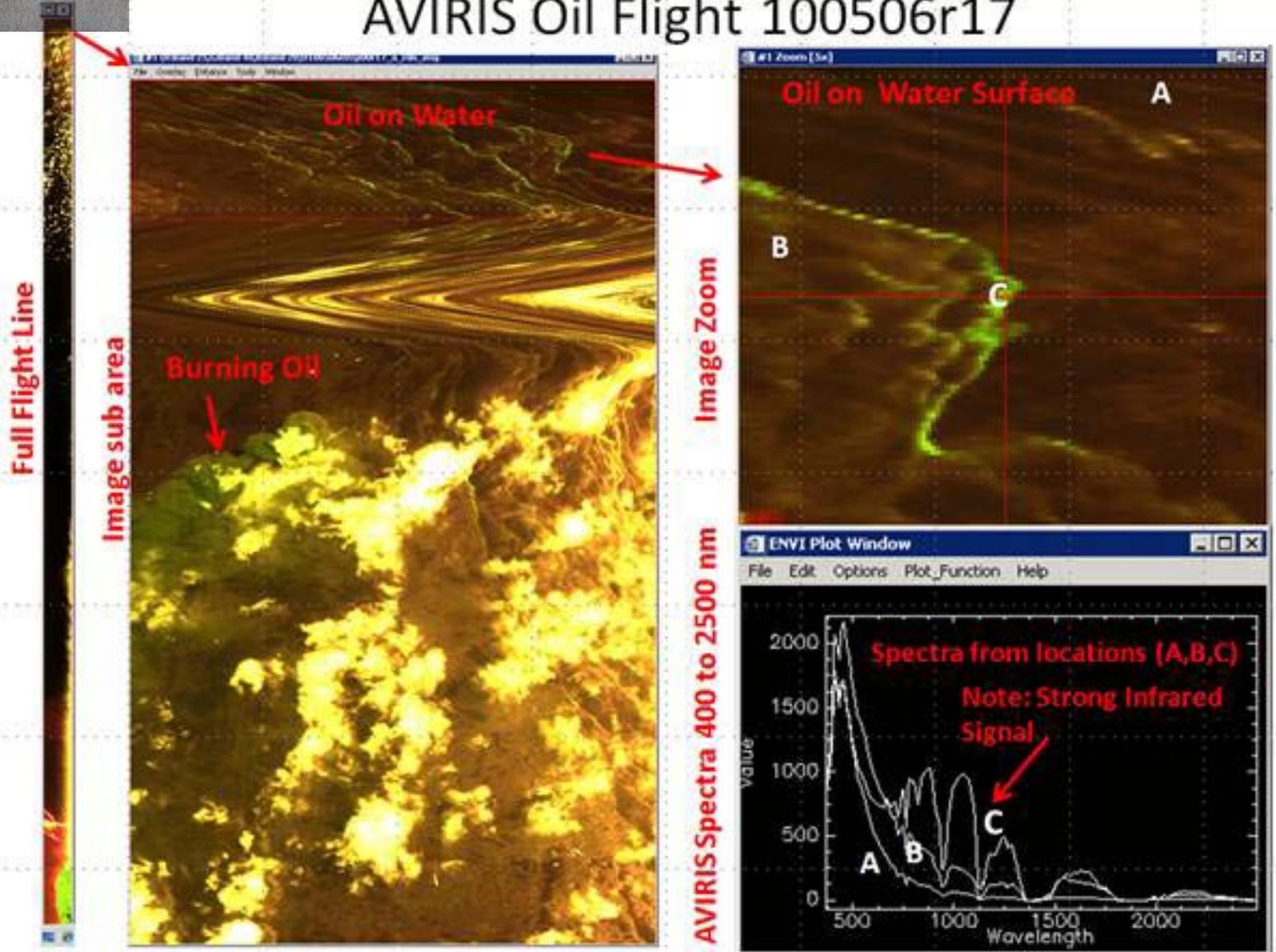
"A hyperspectral sensor combined with a multispectral thermal sensor in low Earth orbit **is part of an integrated mission concept** that is relevant to several panels, ***especially the climate variability panel***." p. 368.

HyspIRI Concept
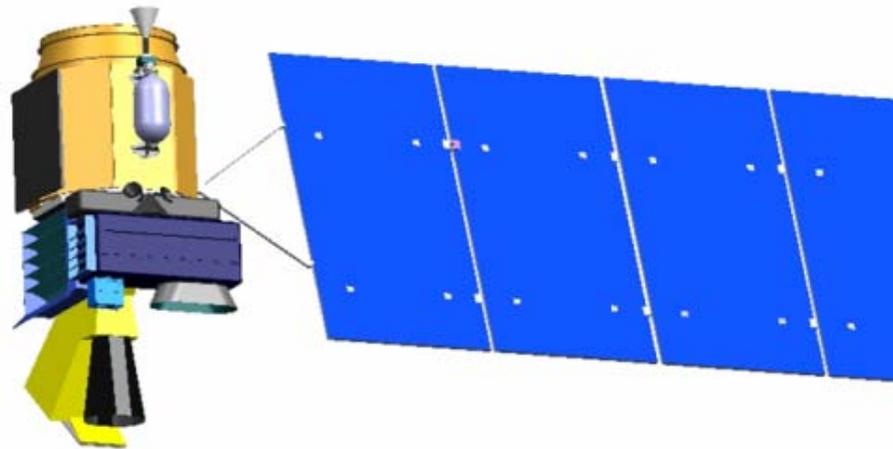
Visible ShortWave InfraRed (VSWIR) Imaging Spectrometer
+
Multispectral Thermal InfraRed (TIR) Scanner

Spectral Bands Identified As Useful by Discipline
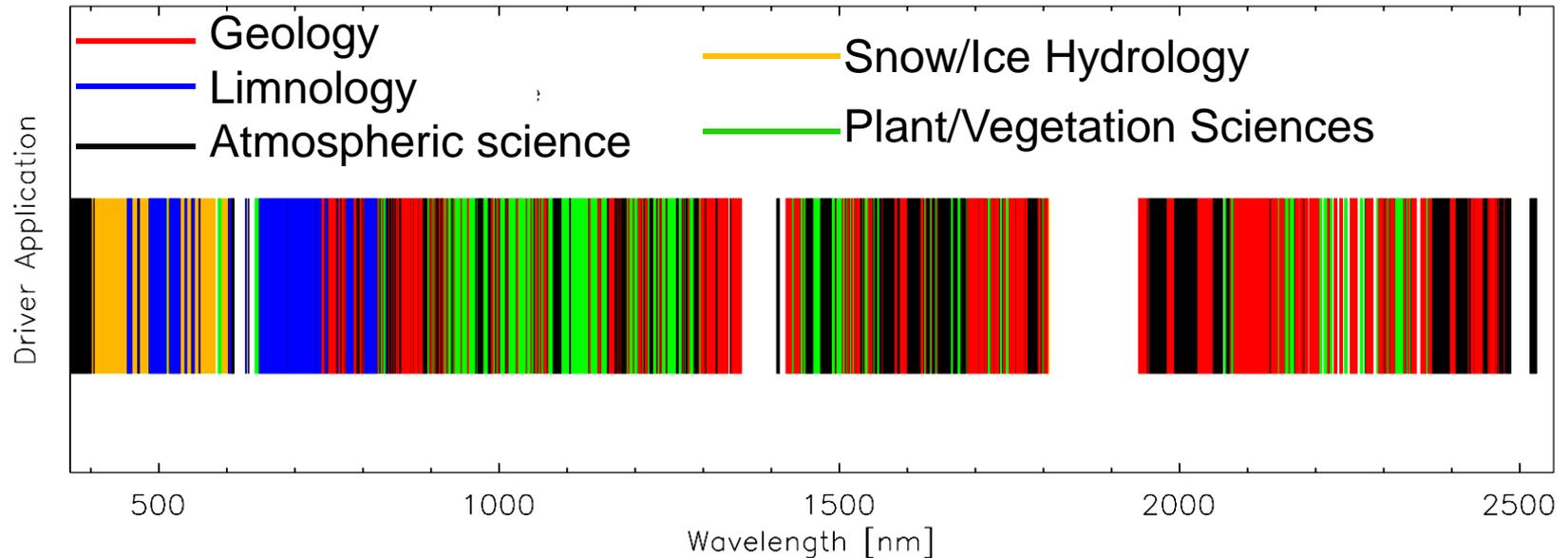
All Bands Seem Relevant to Some Discipline:
Can we prioritize development of global climate relevant products?

Schläpfer, D., & Schaepman, M.E. (2002). Modeling the noise equivalent radiance requirements of imaging spectrometers based on scientific applications. *Applied Optics, 41, 5691-5701*