Opportunities for Collaboration with NASA/JPL

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Carbon Cycle and Ecosystems Discipline Program Manager
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Outline

- Research Scientists and current tasks
- Instrumentation
  - Spaceborne: ASTER, HyspIRI, SMAP
  - Airborne: AVIRIS, MASTER
- Ways to Collaborate

Research Scientists

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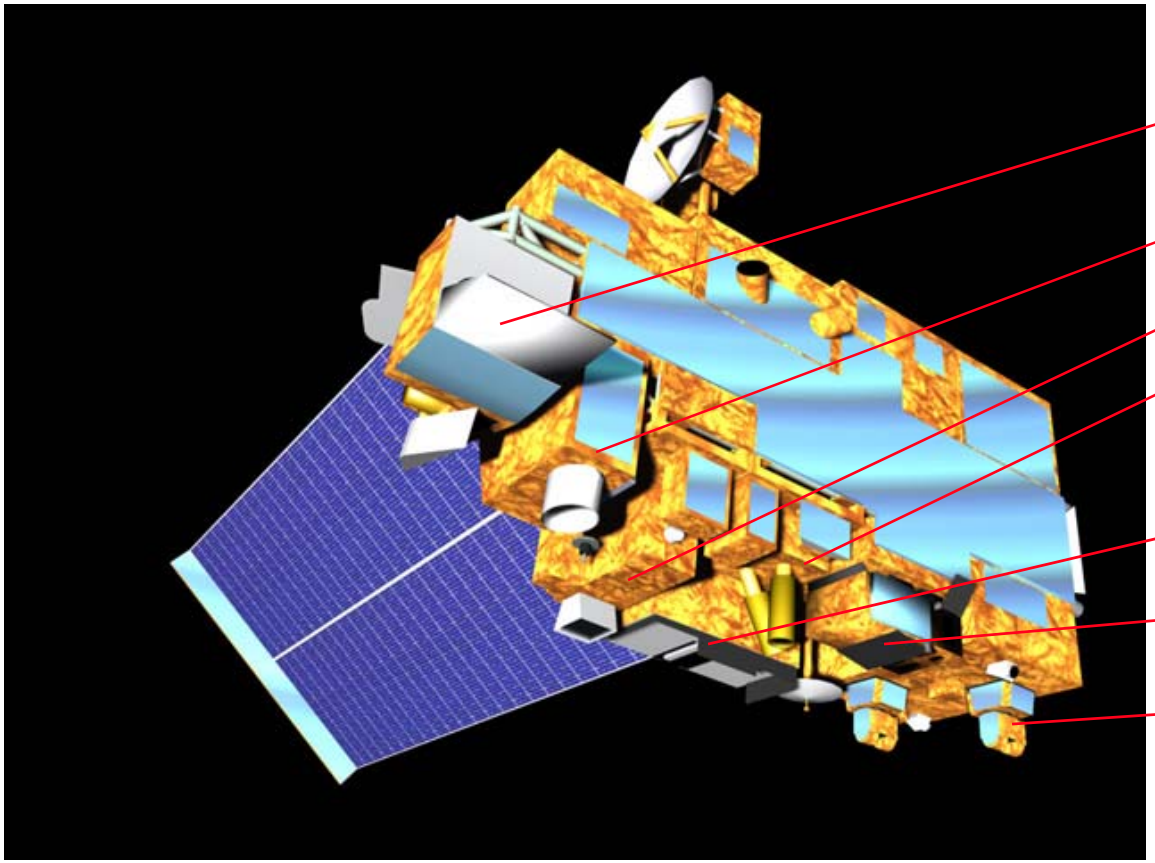
Example Tasks

- Amy Braverman
  - Statistical analysis of large data volumes
- Robert Green
  - Development of visible-shortwave infrared imaging spectrometers
- Simon Hook
  - Development of mid-thermal infrared imaging spectrometers
- Kyle McDonald
  - Understanding the freeze-thaw cycle and its impact on vegetation productivity and CO2 exchange
- Charles Miller
  - Molecular spectroscopy
- Erika Podest
  - Understanding the freeze-thaw cycle and its impact on vegetation productivity and CO2 exchange
- Sassan Saatchi
  - Mapping Boreal Forest Wetlands and Biomass, fusion of lidar and radar for measuring forest biomass
- Marc Simard
  - Vegetation 3D structure with inSAR and Lidar
- Geoff Toon
  - Atmospheric chemistry
- Robert Treuhaft
  - structure and biomass estimation from InSAR 3-D vegetation missions at L-band over tropical forests

Terra Satellite

Terra is the flagship of NASA's ESE (Earth Science Enterprise).

ASTER is the zoom lens of Terra!



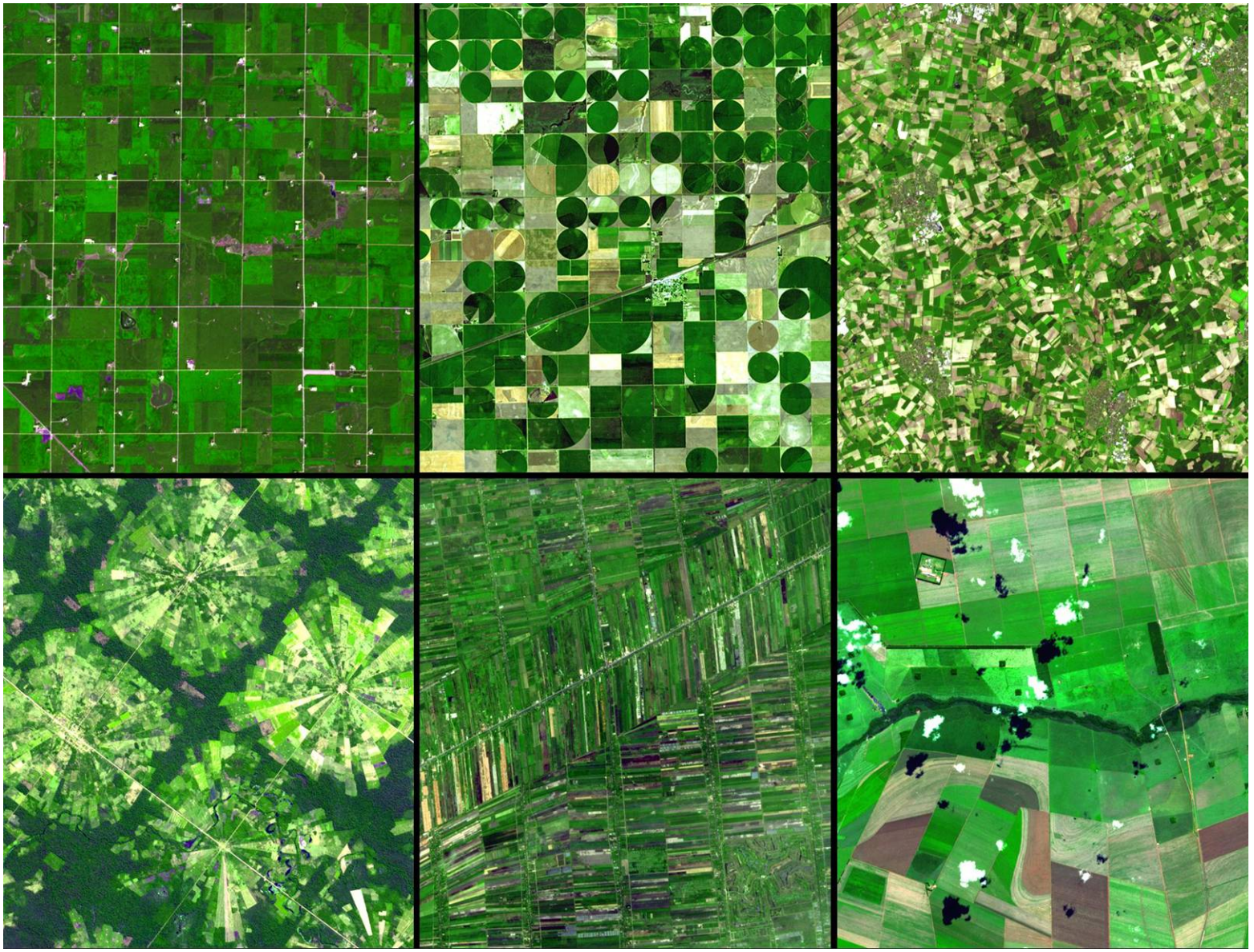
ASTER Instrument

- 1999 launch on Terra
- Joint Japan/US effort
- 15m visible, 30 m swir, 90 m tir
- 60 km swath
- < 16 day repeat cycle
- 10:30 am overpass

Land Use

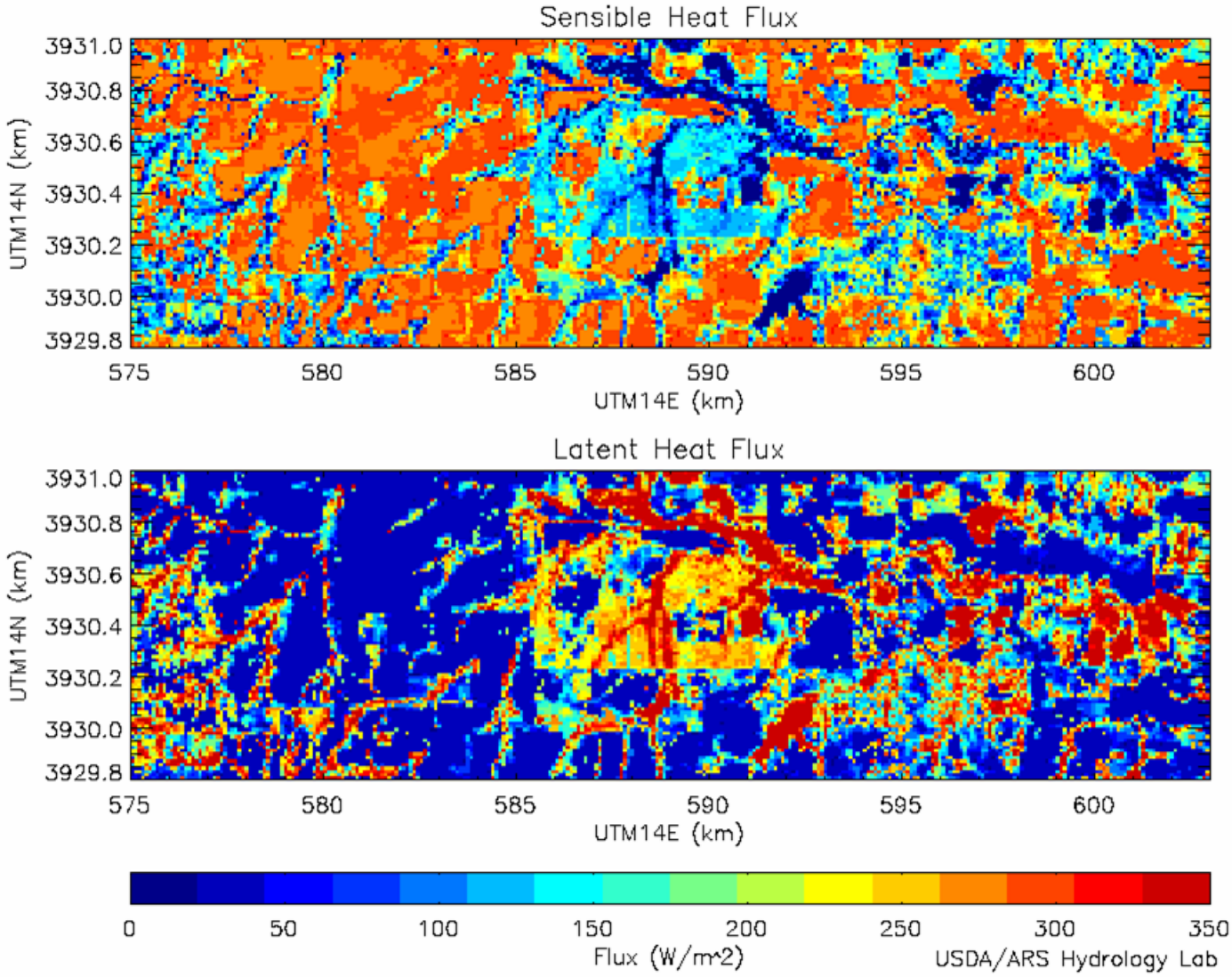
10 km

12km

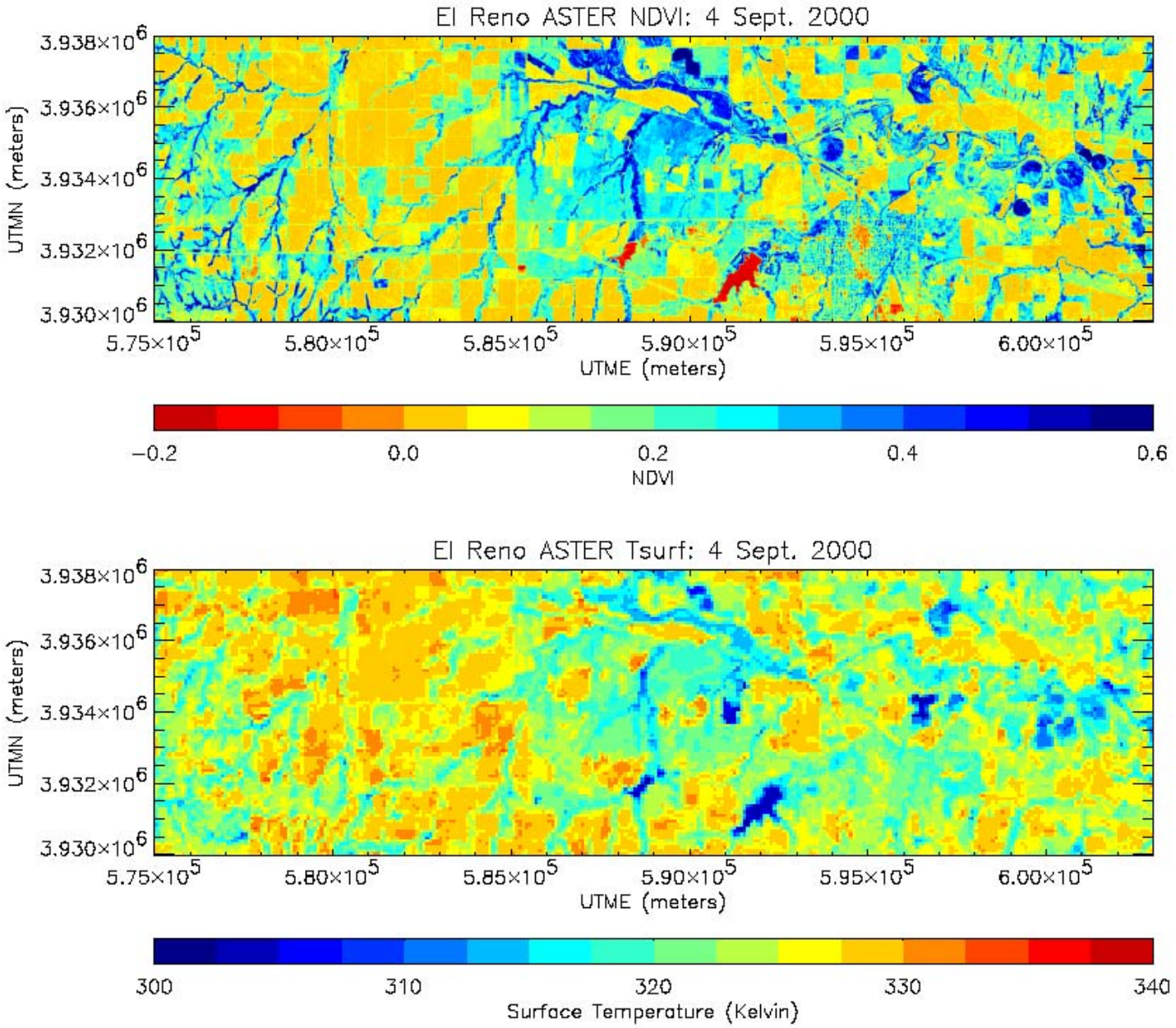


Surface Energy Balance from ASTER data

El Reno OK, 4-Sep-2000, Kustas & Norman 2-source model



ASTER data of El Reno OK, 4-Sep-2000: NDVI & Surface Temperature



NRC Decadal Survey

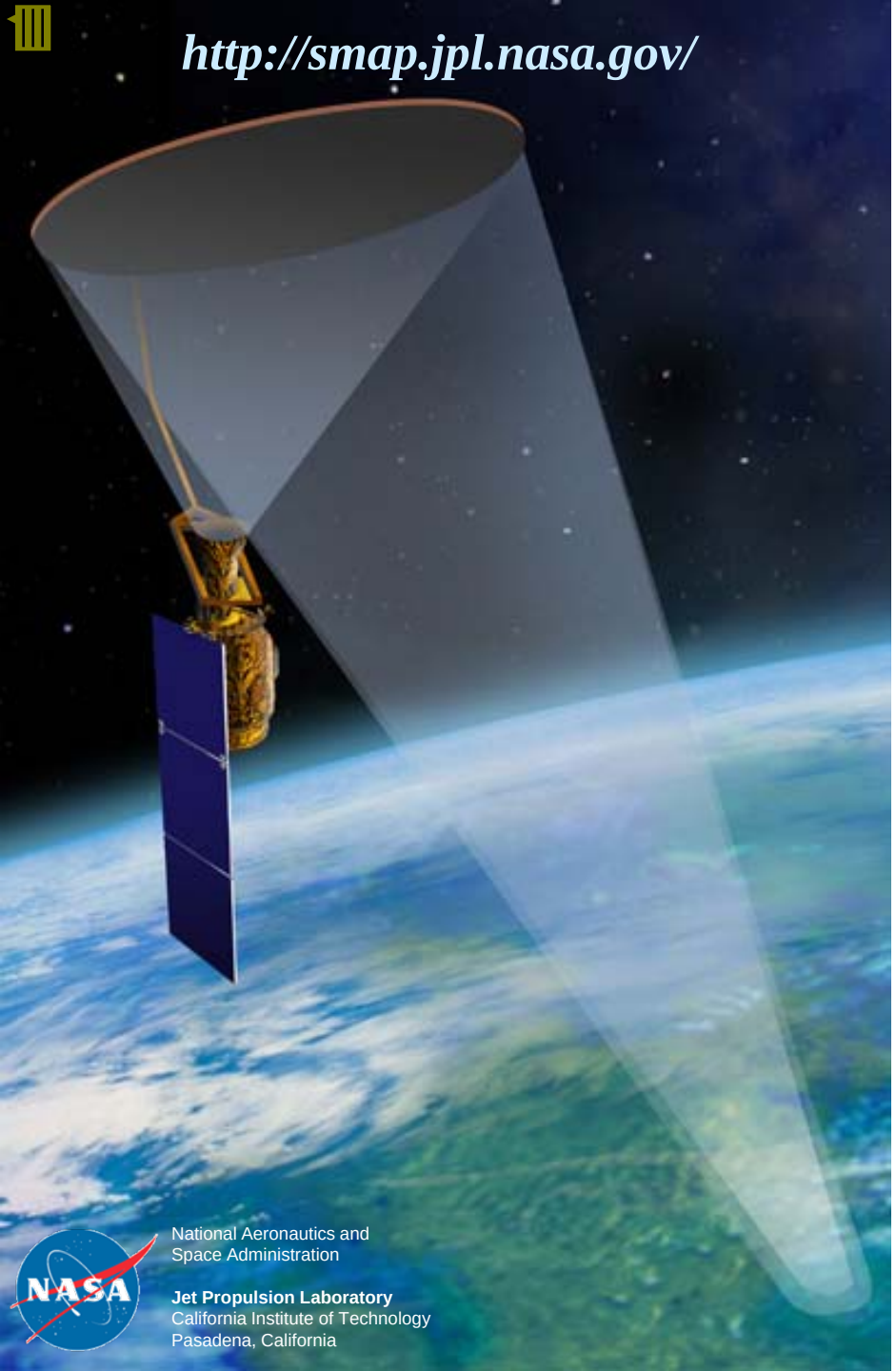
- January 2007: NRC releases Earth Science & Applications from Space report (the Decadal Survey) to NASA, NOAA, & USGS
- Calls for 17 satellite missions as an integrated set of space measurements in the decade 2010-2020 (14 NASA, 2 NOAA, 1 both)
- NRC places missions in 3 temporal tiers (2010-2013, 2013-2016, 2016-2020)
- Decadal Survey recommendations set boundary conditions for mission design efforts & discussions. We rarely stray from them & only do so for the most compelling reasons of science, cost, mission design, etc.

NRC Recommended Near-Term Missions (Tier 1)

Mission	Mission Description	Orbit	Instruments
CLARREO (NASA portion)	Solar and Earth radiation: spectrally resolved forcing and response of the climate system	LEO, Precessing	Absolute, spectrally-resolved interferometer
SMAP	Soil moisture and freeze/thaw for weather and water cycle processes	LEO, SSO	L-band radar L-band radiometer
ICESat-II	Ice sheet height changes for climate change diagnosis	LEO, Non-SSO	Laser altimeter
DESDynI	Surface and ice sheet deformation for understanding natural hazards and climate; vegetation structure for ecosystem health	LEO, SSO	L-band InSAR Laser altimeter

NRC Recommended Mid-Term Missions (Tier 2)

Mission	Mission Description	Orbit	Instruments
HyspIRI	Land surface composition for agriculture and mineral characterization; vegetation types for ecosystem health	LEO, SSO	Hyperspectral spectrometer TIR multispectral scanner
ASCENDS	Day/night, all-latitude, all-season CO_2 column integrals for climate emissions	LEO, SSO	Multifrequency laser
SWOT	Ocean, lake, and river water levels for ocean and inland water dynamics	LEO	Ka-band wide swath radar C-band radar
GEO-CAPE	Atmospheric gas columns for air quality forecasts; ocean color for coastal ecosystem health and climate emissions	GEO	High and low spatial resolution hyperspectral imagers
ACE	Aerosol and cloud profiles for climate and water cycle; ocean color for open ocean biogeochemistry	LEO, SSO	Backscatter lidar Multiangle polarimeter Doppler radar



Soil Moisture Active and Passive (SMAP) Mission

JPL-Ames Joint Workshop
Pasadena, CA

September 10, 2008

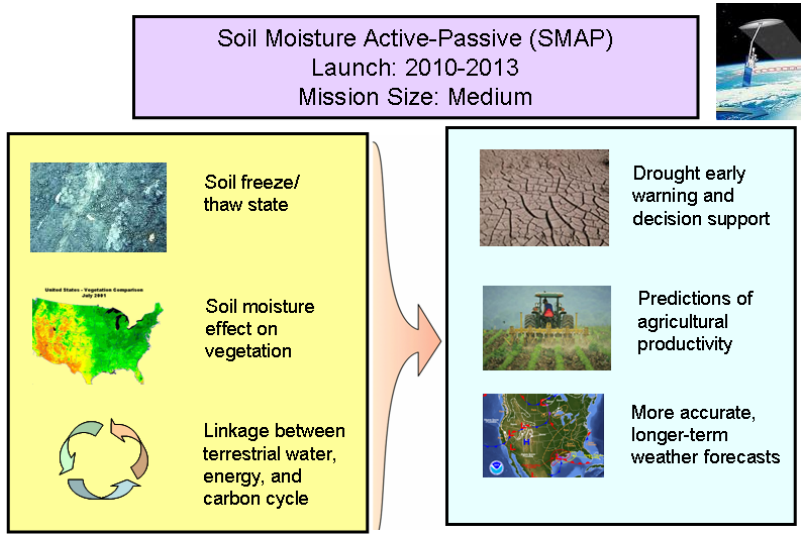
Kyle McDonald
Eni Njoku
Kent Kellogg

SMAP Science and Applications

Decadal Survey Panels	Cited SMAP Applications
Water Resources and Hydrological Cycle	1. Floods and Drought Forecasts 2. Available Water Resources Assessment 3. Link Terrestrial Water, Energy and Carbon Cycles
Climate / Weather	1. Longer-Term and More Reliable Atmospheric Forecasts
Human Health and Security	1. Heat Stress and Drought 2. Vector-Borne and Water-Borne Infectious Disease
Land-Use, Ecosystems, and Biodiversity	1. Ecosystem Response (Variability and Change) 2. Agricultural and Ecosystem Productivity 3. Wild-Fires 4. Mineral Dust Production

"…the SMAP mission is ready for "fast-track" towards launch as early as 2012, when there are few scheduled Earth missions. The readiness of the SMAP mission also enables gap-filling observations to meet key NPOESS community needs (soil moisture is "Key Parameter," see 4.1.6.1.6 in IORD-II Document)."

SMAP is one of four missions recommended by the NRC Earth Science Decadal Survey for launch in the 2010-2013 time frame



Applications and User Engagement

- **By providing direct measurements of soil moisture and freeze/thaw state, SMAP will enable a variety of societal benefits:**


Droughts


Floods/Landslides


Agriculture


Weather/Climate


Human Health

- **Near-term SMAP applications outreach will be focused on:**
  1. **Developing a community of end-users, stakeholders, and decision makers that understand SMAP capabilities and are interested in using SMAP products in their application (SMAP Community of Practice).**
  2. **Developing an assessment of current application benefits / requirements and needs for SMAP products (survey).**
  3. **Identifying a handful of "early adopters" who will partner to optimize their use of SMAP products, possibly even before launch as part of the extended OSSE activities ("targeted partners").**
  4. **Providing information about SMAP to the broad user community**

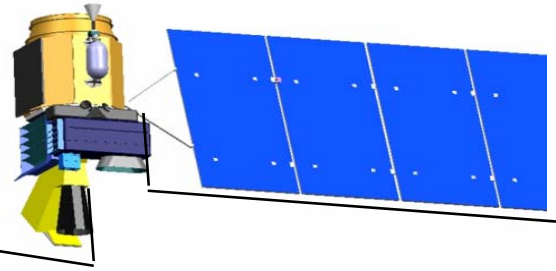
NRC Decadal Survey HyspIRI

Visible ShortWave InfraRed (VSWIR) Imaging Spectrometer

+

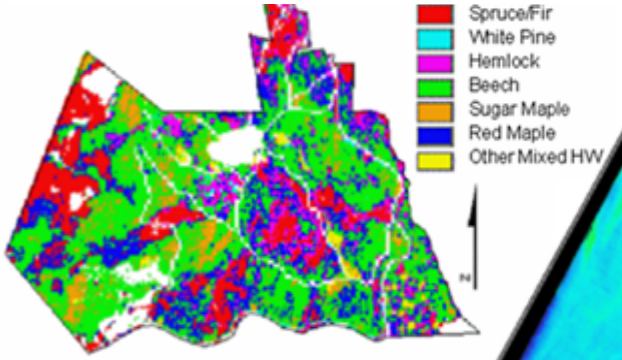
Multispectral Thermal InfraRed (TIR) Scanner

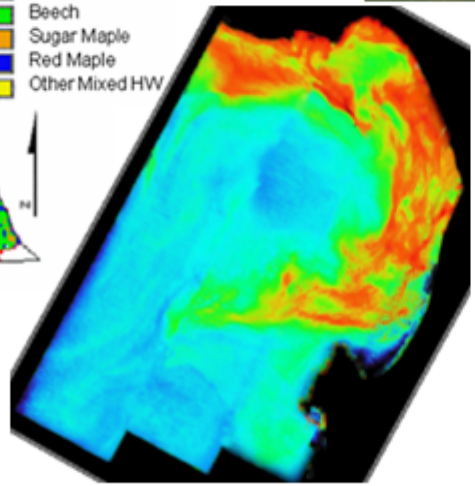
VSWIR: Plant Physiology and Function Types (PPFT)



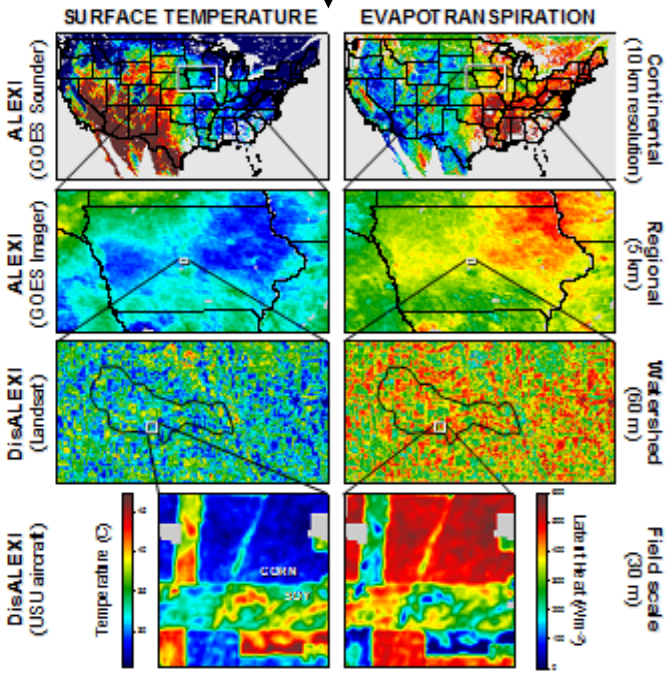
Multispectral TIR Scanner

Map of dominant tree species, Bartlett Forest, NH





Red tide algal bloom in Monterey Bay, CA



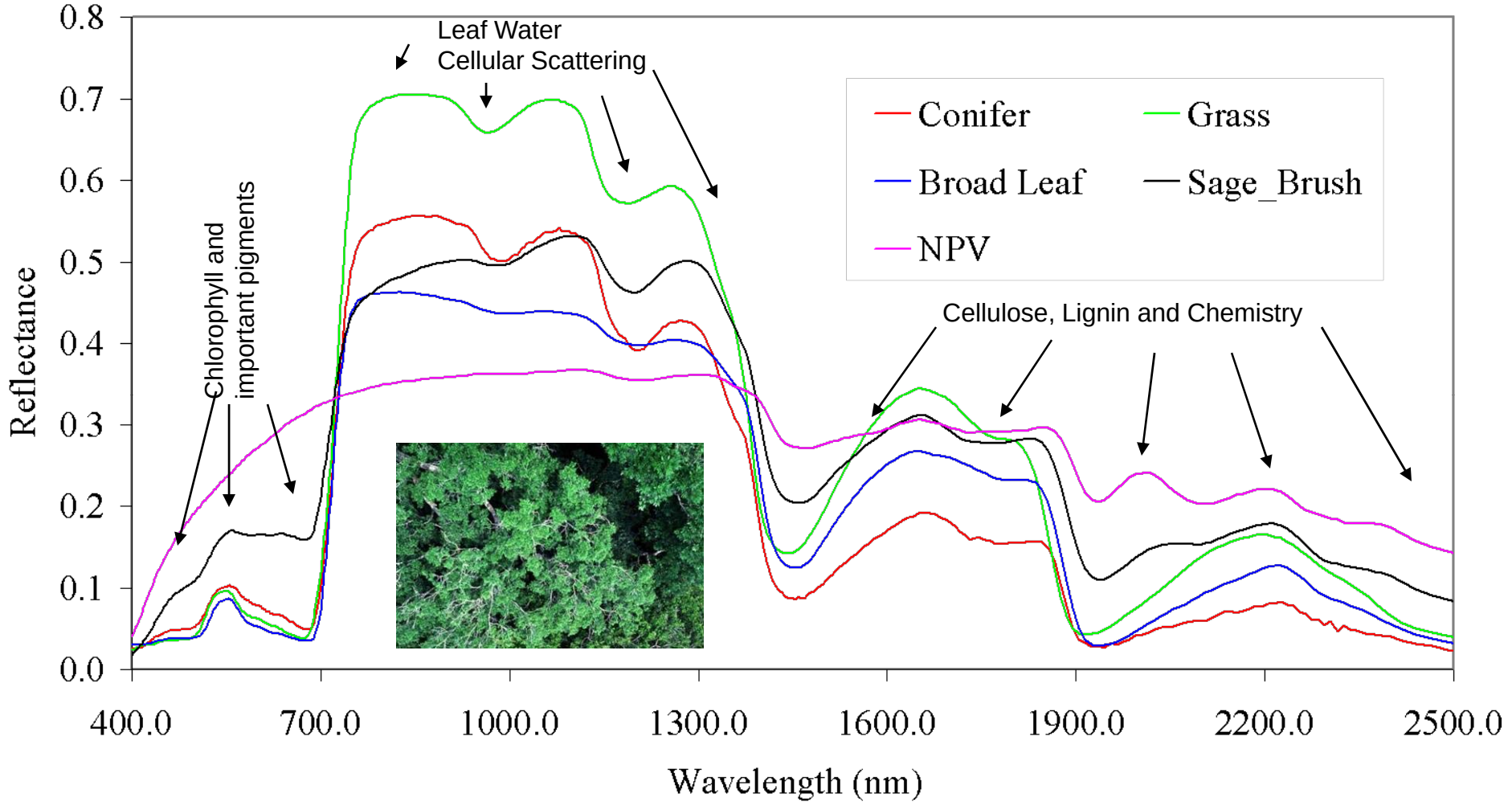
HyspIRI Mission Overview

HyspIRI Key Science Questions

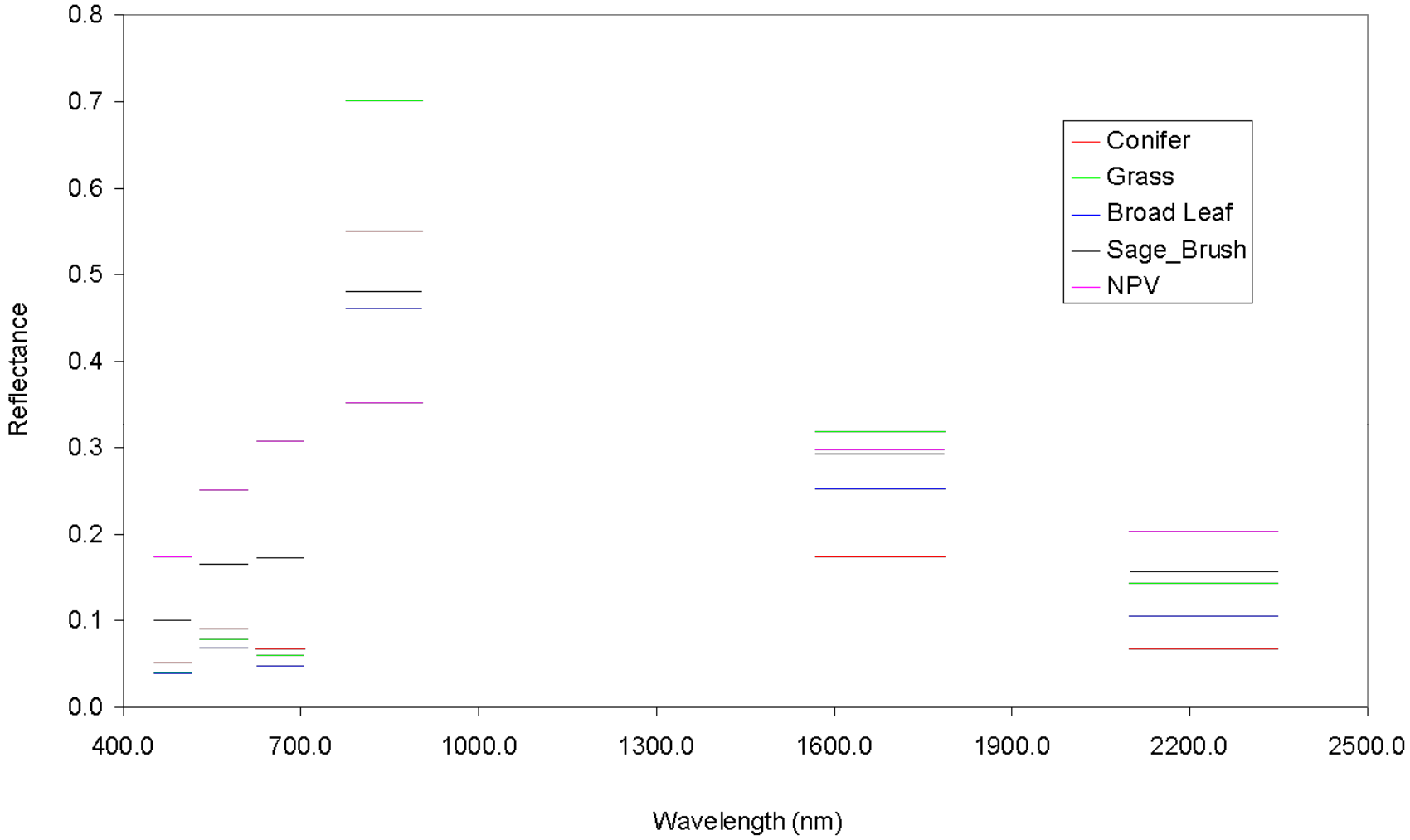
What are the spatial distributions of different plant functional groups, diagnostic species, and ecosystems? How do changes in the physical, chemical, and biotic environment affect the productivity, carbon storage and biogeochemical cycling processes of ecosystems? How do human-caused and natural disturbances affect the distribution, biodiversity and functioning of ecosystems? How do changes in ecosystem composition and function affect human health, resource use, and resource management?

What are the changes in the behavior of active volcanoes? What is the impact of global biomass burning on the terrestrial biosphere and atmosphere? How can we better characterize trends in local and regional water use? How does urbanization affect the environment? What is the composition and temperature of the exposed surface of the Earth?

HypsIRI Measurement of Vegetation with Imaging Spectroscopy



Multi Spectral Remote Sensing of Vegetation



Important vegetation spectral signatures are missing

HyspIRI Science Study Group

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2009 HyspIRI Workshop

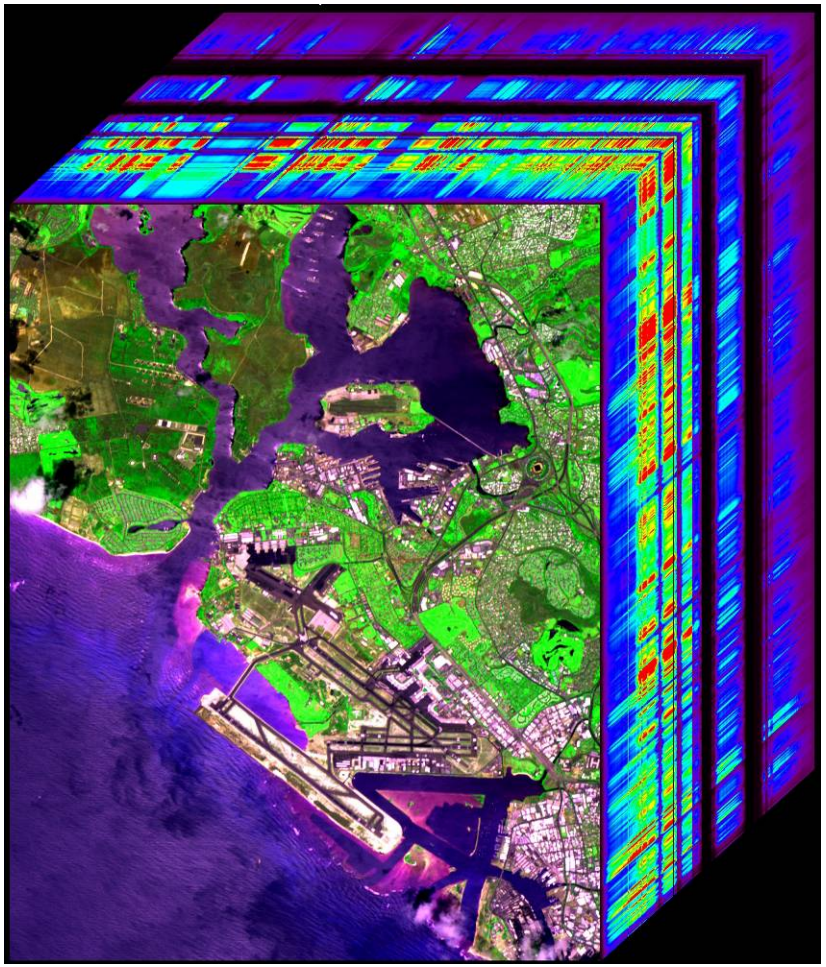
NASA will convene a science community workshop on August 11-13, 2009, in Pasadena, CA. The primary goal of this workshop will be to discuss and review a draft white paper containing the scientific rationale for the HyspIRI mission. This white paper will focus on: the scientific questions the HyspIRI mission will address: the objectives of the mission; potential mission products; and resulting mission requirements.

Selected Airborne Instrument Activities at JPL

AVIRIS – R. Green

MASTER – S. Hook

AVIRIS: Characteristics



Spectral

Range	360 to 2500
Sampling	9.8 nm
Accuracy	0.5 nm

Radiometric

Range	0 to Max Lambertian
Sampling	16 bits
Accuracy	>96 percent
Precision*	>1000 VNIR, >500 SWIR

Spatial (ER2 / WB57 / Proteus / Twin Otter aircraft)

Swath	11 / 8 / 5 / 2.5 km
Sampling	20 / 15 / 8 / 4 m
Accuracy	20 / 15 / 8 / 4 m

Full INU/GPS geo rectification

*for AVIRIS reference radiance

MODIS/ASTER Airborne Simulator (MASTER)

Simon Hook and Jeff Myers

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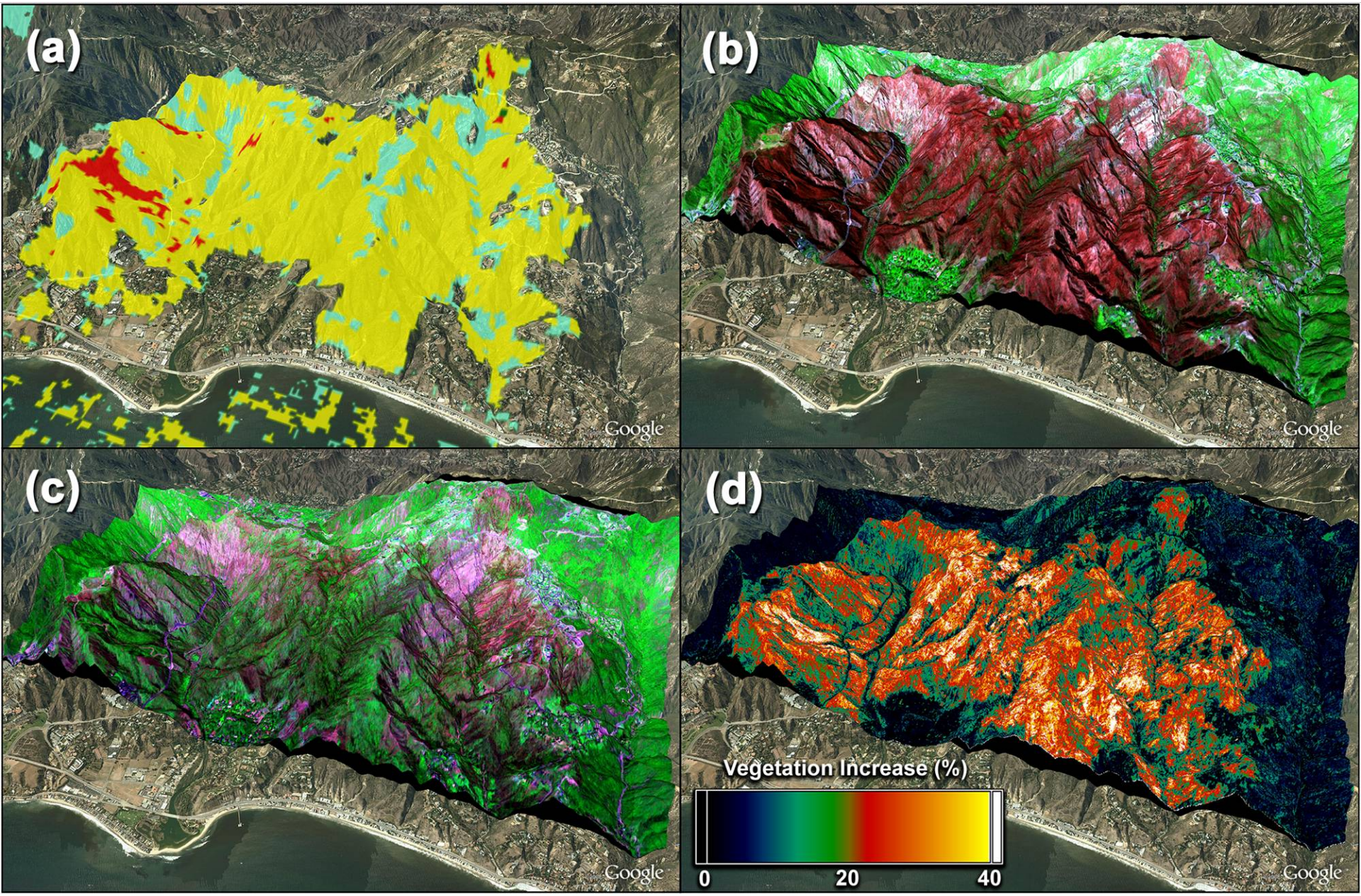
jmyers@mail.arc.nasa.gov

http://masterweb.jpl.nasa.gov

Instrument Characteristics

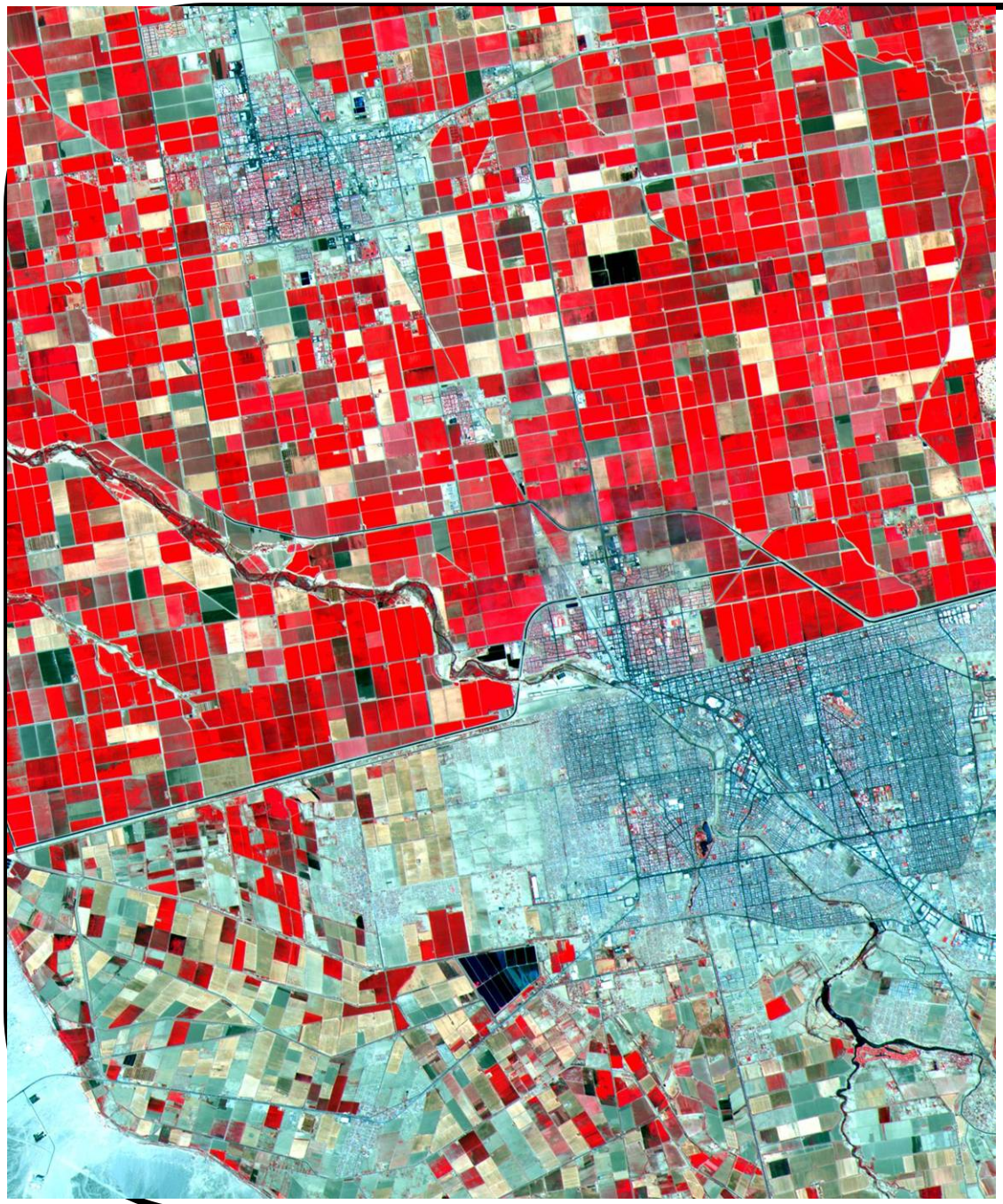
Wavelength range	0.4-13 micrometers
Number of channels	50
Number of pixels	716
Instantaneous Field of View	2.5 milliradians
Total Field of View	85.92 degrees
Platforms	Department of Energy KingAir Beachcraft B200 NASA ER-2 NASA DC8
Pixel size DC-8	10-30 m
Pixel size ER-2	50 m
Pixel size B200	5-20 m
ER-2 Range (without refueling)	3700 statute miles
B200 Range (without refueling)	700 statute miles
DC-8 Range (without refueling)	5400 nautical miles
Scan speeds	6.25/12.5/25 rps
Products	Radiance at sensor (Level 1B)
Calibration VIS-SWIR	Laboratory Integrating Sphere
Calibration MIR-TIR	2 On-board Blackbodies
Data Format	Hierarchical Data Format (HDF)
Digitization	16-bit


(a)
(b)
(c)
(d)
Google
Google
Google
Google
Vegetation Increase (%)
0
20
40

Ways to collaborate

- Check out the ROSES calls:
  - http://nspires.nasaprs.com/external/
  - (Generally look under Terrestrial Ecology (TE) and Applications)
- Get involved in a future instrument workshop
  - Both SMAP and HyspIRI will have workshops this year
  - http://smap.jpl.nasa.gov
  - http://hyspiri.jpl.nasa.gov
- Get some data, historical data is normally free, e.g. ASTER, MASTER
  - http://masterweb.jpl.nasa.gov
  - http://asterweb.jpl.nasa.gov
- Got a research idea for an upcoming call and want a JPL Co-I. Email me and I will let you know who might be a good match

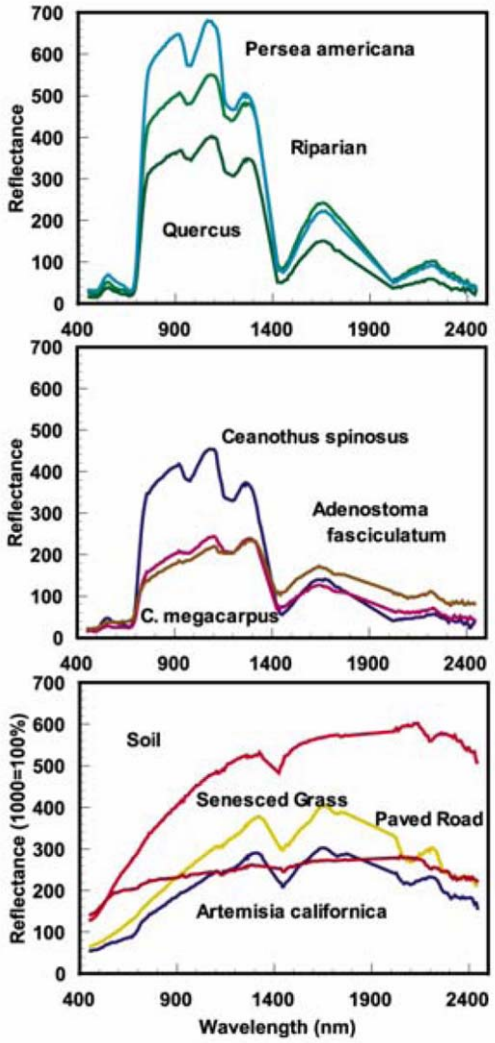
Backup



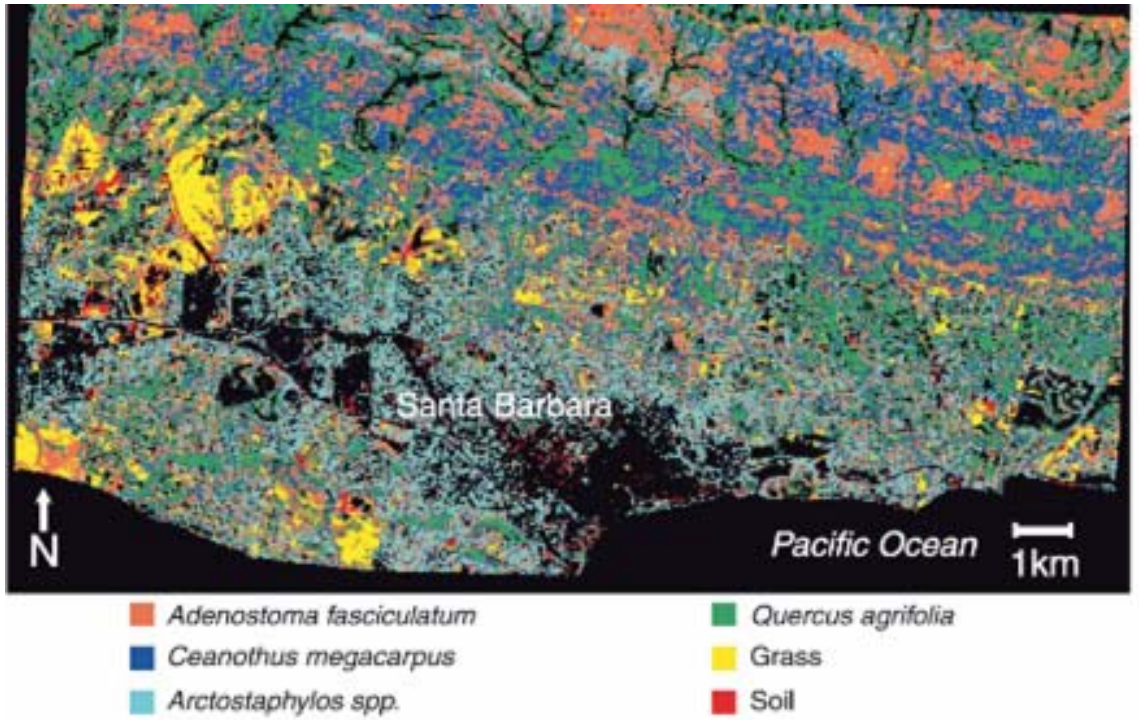
US-Mexico border
at Mexicali

Science Questions
Ecosystem Function and Diversity

Reflectance Spectra
400 to 2500 @ 10 nm



Species Type 90% Accurate

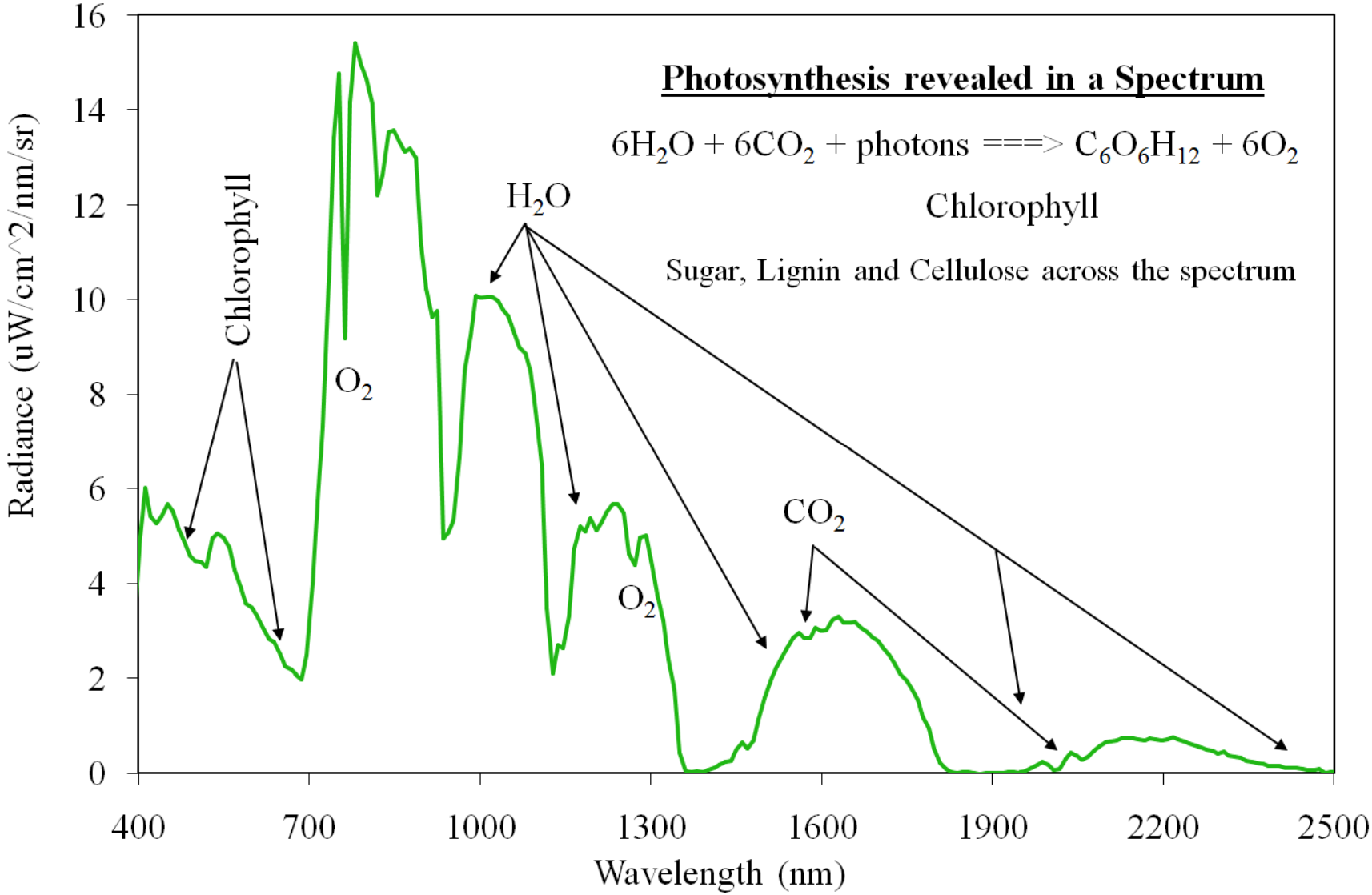


Measurement of the spectral signature of vegetation over this complete spectral range at 10 nm resolution enables direct mapping of species-type and fractional cover.

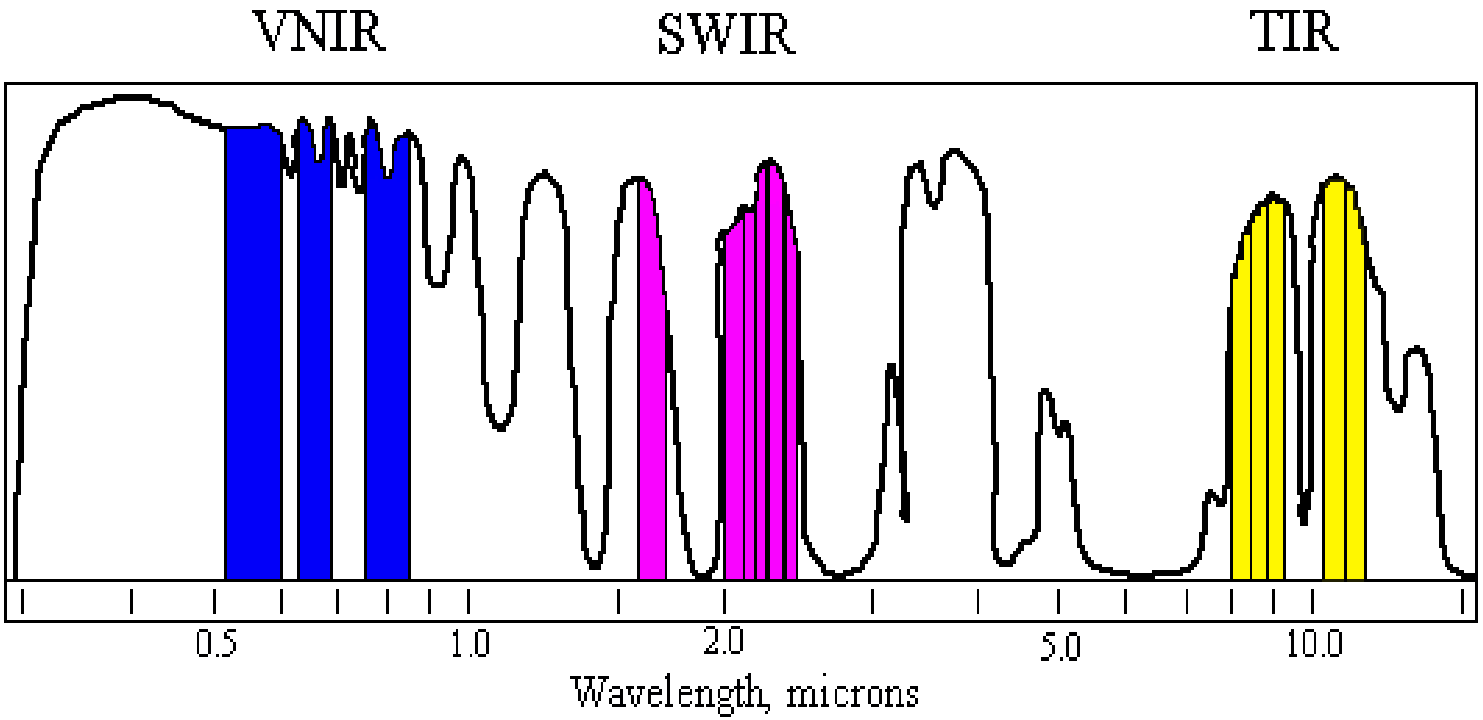
With measurement of species-type and fractional cover the ecosystem functional type, diversity, and status is determined

Santa Ynez Front Range, California (Dennison and Roberts 2003)

Photosynthesis Revealed via Spectroscopy



ASTER Bands



http://emissivity.jpl.nasa.gov

Jet Propulsion Laboratory
California Institute of Technology

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North American Land Surface Emissivity Project

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« April 2009 »

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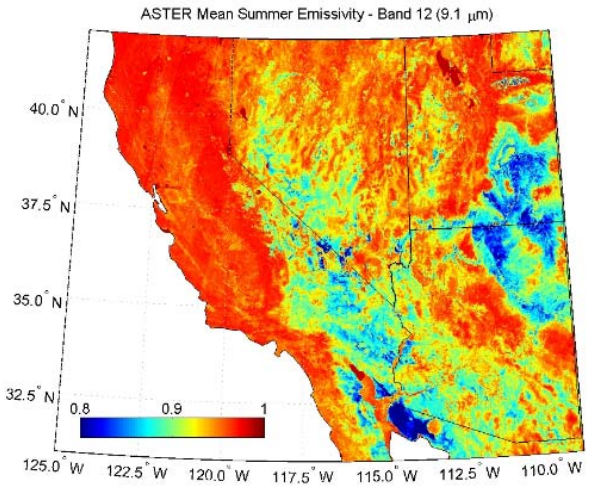
20	21	22	23	24	25	26
27	28	29	30			

North American Land Surface Emissivity Project

Welcome to the website for the North American Land Surface Emissivity Project. The goal of the project is to create a seamless database of emissivity from standard ASTER emissivity products for use in climate research. The Earth emits energy at wavelengths we cannot normally see, that energy is a function of the temperature and the emissivity of the surface. The surface emissivity primarily depends on the composition of the surface. Thus as the surface composition changes through, for example, land cover land use change, so does the surface emissivity. The land surface emissivity is measured by several instruments mounted on satellites and aircraft. Some of the most well known satellite sensors are AIRS, ASTER and MODIS.

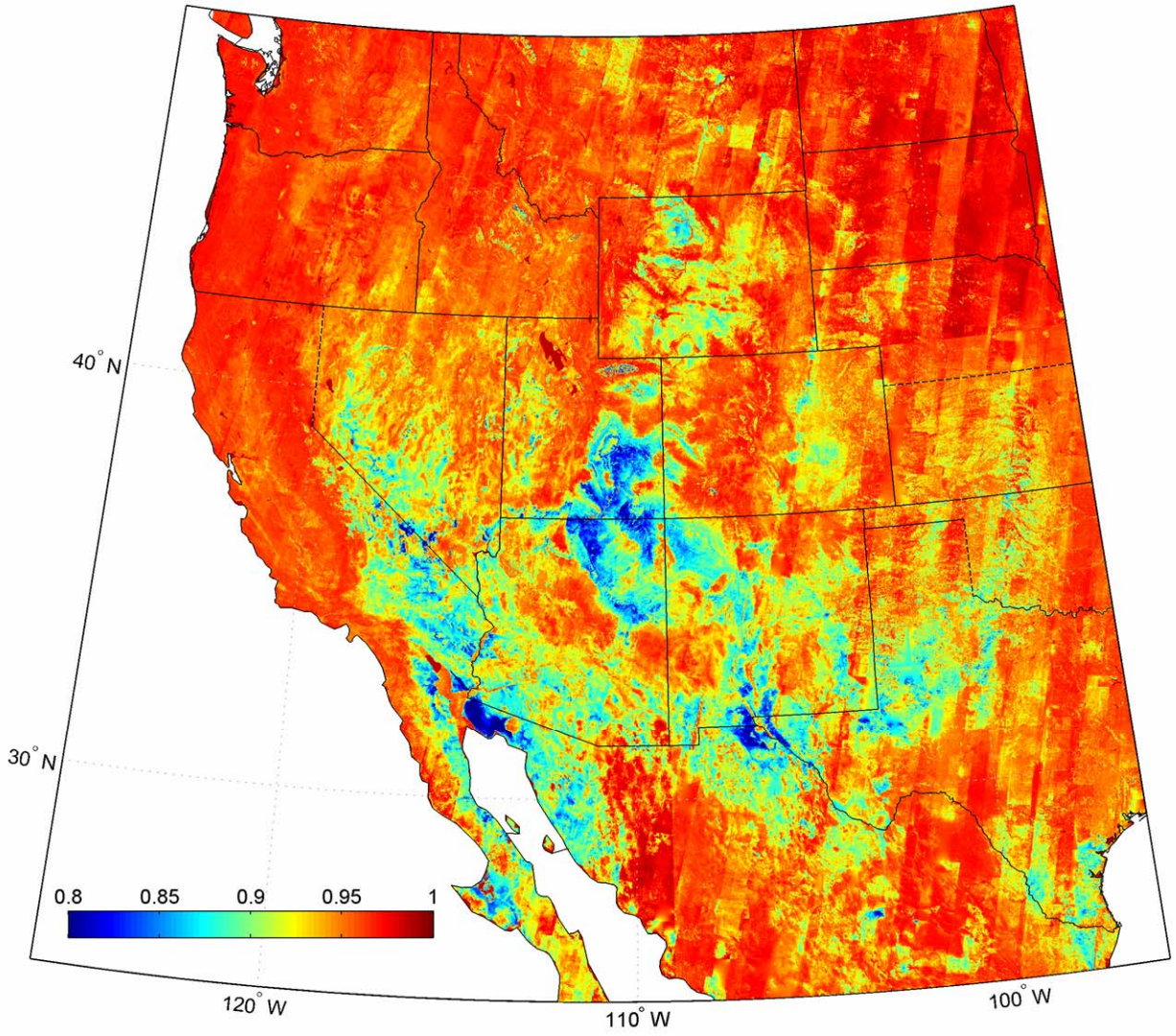
Of these three satellite sensors, ASTER provides the most detailed emissivtiy images with a pixel spatial resolution of 90m. The image below was created by merging together all the ASTER emissivity data ever acquired over California, Nevada, Arizona and Utah under clear skies from 2000-2008 for the months July, August and September.



In the image above areas of red correspond to areas with large amounts of vegetation cover which has a high emissivity and areas of blue correspond to areas with low emissivities such as the desert regions of the southwest USA. The lowest emissivities are associated with sand dunes. Greens and yellows indicate transition areas as you move from the desert regions to more heavily vegetated regions.

Print

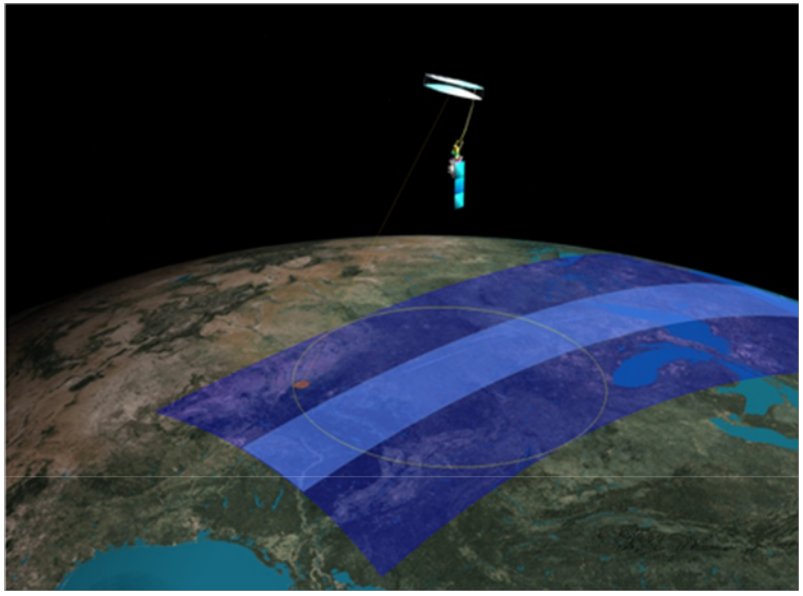
ASTER Mean Summer Emissivity, Band 12 (9.1 µm) - 18,242 Scenes



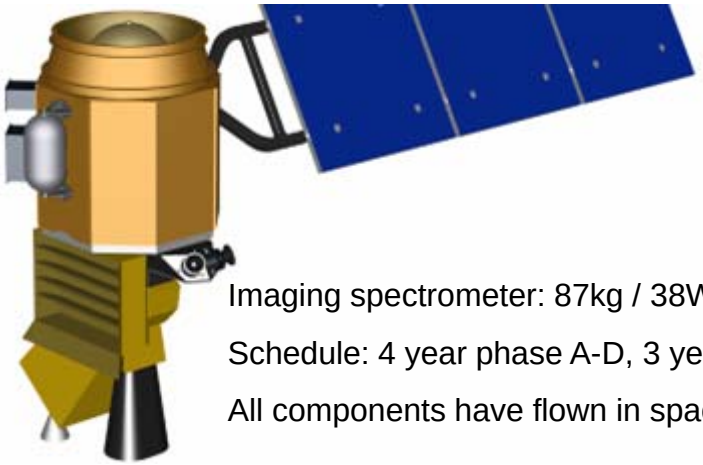
SMAP Mission Concept

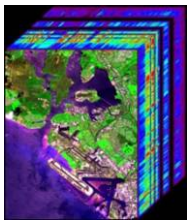
- Orbit:
  - *Sun-synchronous, 6 am/pm orbit*
  - *670 km altitude*
- Instruments:
  - *L-band (1.26 GHz) radar*
    - *High resolution, moderate accuracy soil moisture*
    - *Freeze/thaw state detection*
    - *SAR mode: 3 km resolution*
    - *Real-aperture mode: 30 x 6 km resolution*
  - *L-band (1.4 GHz) radiometer*
    - *Moderate resolution, high accuracy soil moisture*
    - *40 km resolution*
  - *Shared instrument antenna*
    - *6-m diameter deployable mesh antenna*
    - *Conical scan at 14.6 rpm*
    - *Constant incidence angle: 40 degrees*
      - *1000 km-wide swath*
      - *Swath and orbit enable 2-3 day revisit*

- Mission Development Schedule
  - *Phase A start:* *September 2008*
  - *SRR/MDR:* *February 2009*
  - *PDR:* *December 2009*
  - *CDR:* *December 2010*
  - *SIR:* *October 2011*
  - *Instrument Delivery* *April 2012*
  - *LRD:* *March 2013*
- Mission operations duration: 3 years



HyspIRI Imaging Spectroscopy Science Measurements





Imaging spectrometer: 87kg / 38W

Schedule: 4 year phase A-D, 3 years operations

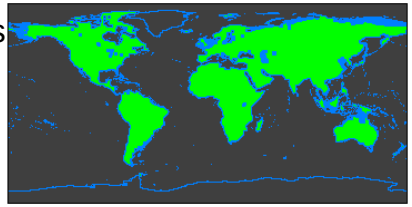
All components have flown in space

Science Questions:

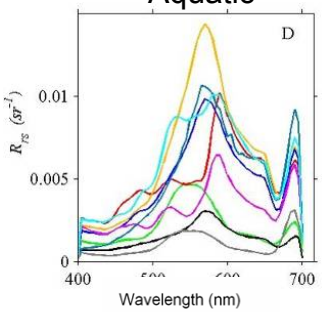
- *What is the composition, function, and health of land and water ecosystems?*
- *How are these ecosystems being altered by human activities and natural causes?*
- *How do these changes affect fundamental ecosystem processes upon which life on Earth depends?*

Measurement:

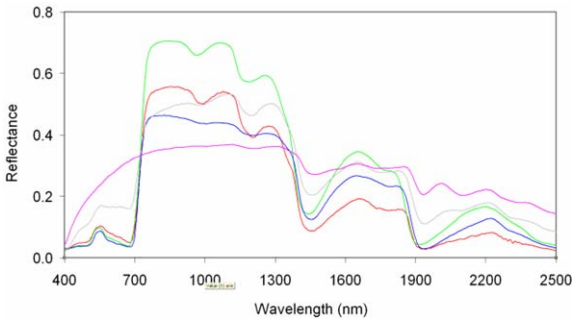
- 380 to 2500 nm in 10nm bands
- Accurate 60 m resolution
- 19 days revisit
- Global land and shallow water



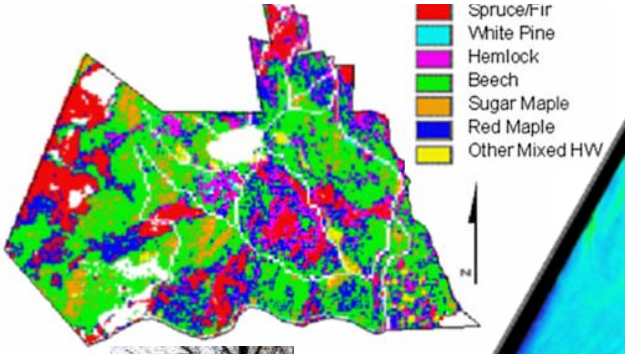
Aquatic

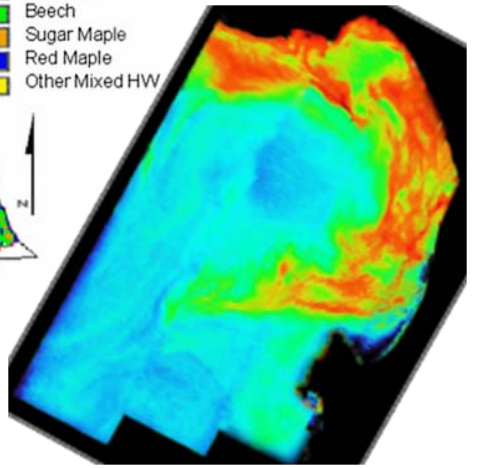


Terrestrial



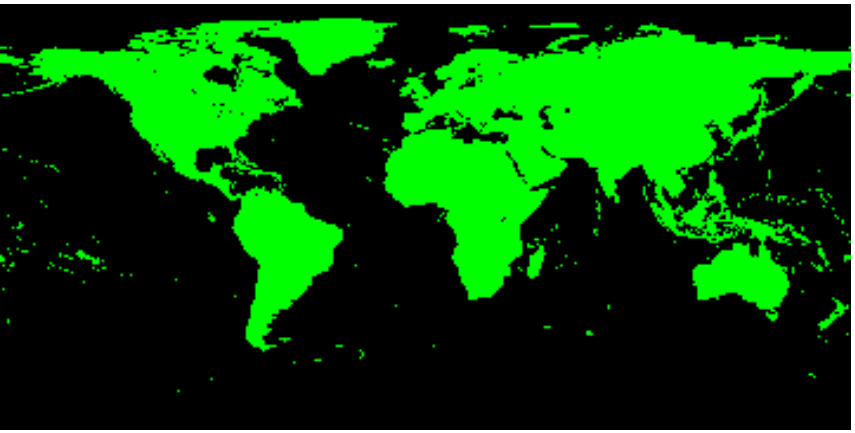
Map of dominant tree species, Bartlett Forest, NH





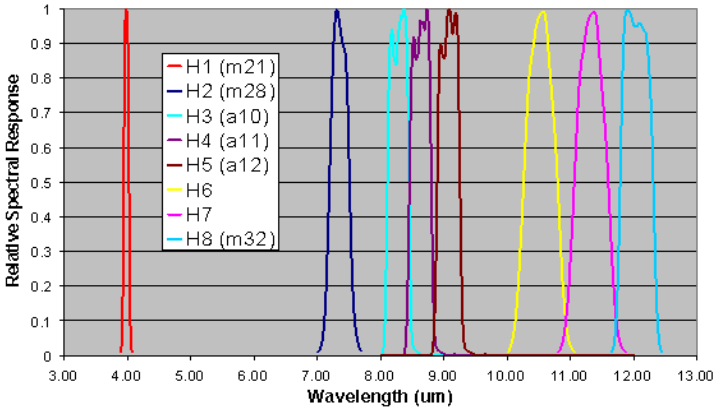
Red tide algal bloom in Monterey Bay, CA

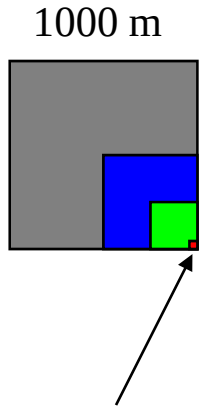
HyspIRI Thermal Infrared Science Measurements



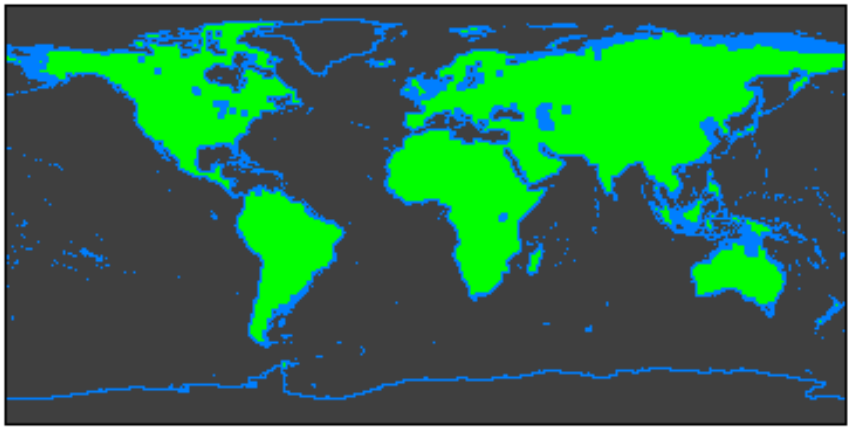
- Measure the land surface temperature and emissivity
- 5 day equatorial revisit to generate monthly, seasonal and annual products.
- 60 m spatial resolution

- 7 bands between 7.5-12 µm and 1 band between 3-5 µm
- 3-5 µm band saturates at 1400K
- 7.5-12 µm bands saturate at 400K



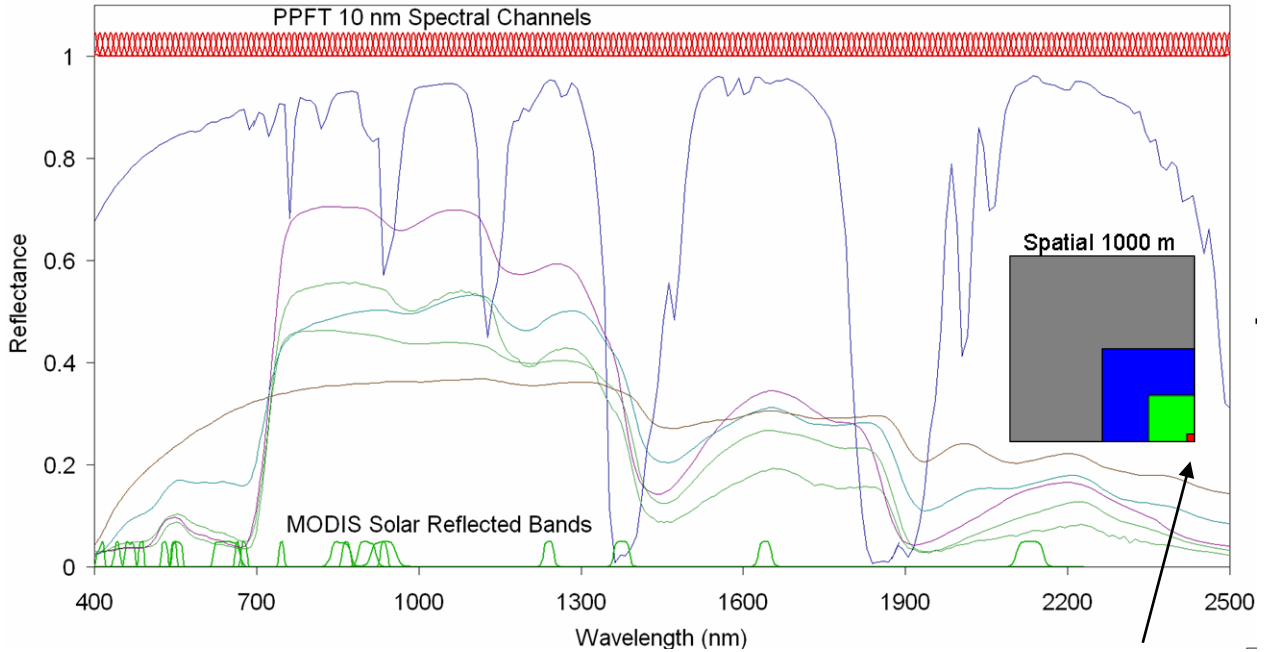


HyspIRI VSWIR Science Measurements



- Measure the **global** land and coastal/shallow water (> -50m).
- 19 day equatorial revisit to generate seasonal and annual products.

- Measure the molecular absorption and constituent scattering signatures in the spectral range from 380 to 2500 nm at 10 nm, and at 60 m spatial sampling.



PPFT at 60 m