Earth Observing One (EO-1)

EO-1 Status and LCLUC Achievements

EO-1 Mission Scientist: Betsy Middleton (NASA/GSFC)

March 2009

Outline

- EO-1 Background
- Rapid Remote Sensing and SensorWebs for Disaster response – fire, flood, volcanoes
- Discrimination of land cover types, vegetation species composition – classifications
- Hyperion applications: Spectral un-mixing, Water content, Foliar chemistry etc.
- EO-1 MSO science products

EO-1 Mission

Designed to validate technologies and operational approaches applicable to future Earth observing (e.g. Landsat follow-on) missions

Launched on November 21, 2000 for 1 year mission, 1000 images

Currently in 9th year of continuous operations with more than 40,000 scenes in archive.

More information at http://eo1.gsfc.nasa.gov

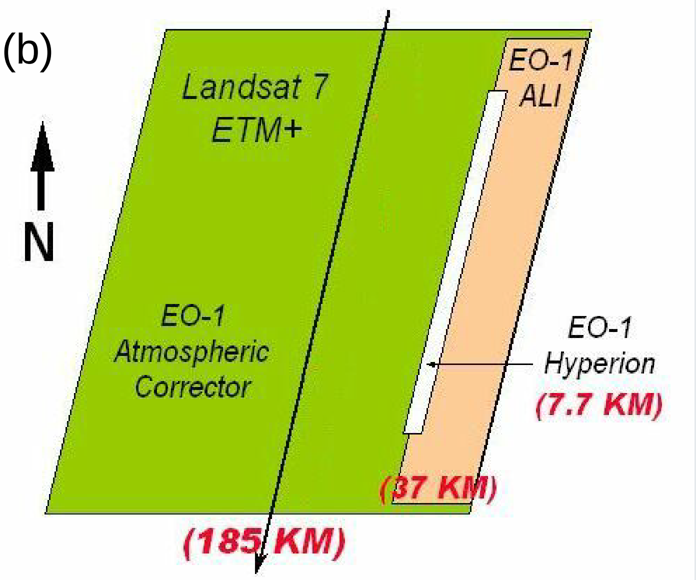
Data and tasking available to public via http://eo1.usgs.gov, http://earthexplorer.usgs.gov, http://glovis.usgs.gov .

EO-1 Background

(a)

Characteristics	Hyperion	ALI (µm)
Pan		Pan (0.48 – 0.69)
Blue	Continuous	MS-1p (0.433 – 0.453)
	spectra	MS-1 (0.45 – 0.515)
Green	242 bands	MS-2 (0.525 – 0.605)
Red	~ 0.01 µm wide	MS-3 (0.633 – 0.690)
NIR	0.4-2.4 µm	MS-4 (0.775 – 0.805)
SWIR	↓	MS-4p (0.845 – 0.890)
		MS-5 (1.2 – 1.3)
		MS-5p (1.55 – 1.75)
		MS-7 (2.08 – 2.35)
Spatial resolution	30 m	Pan 10 m, MS-1..7 30 m

(b)

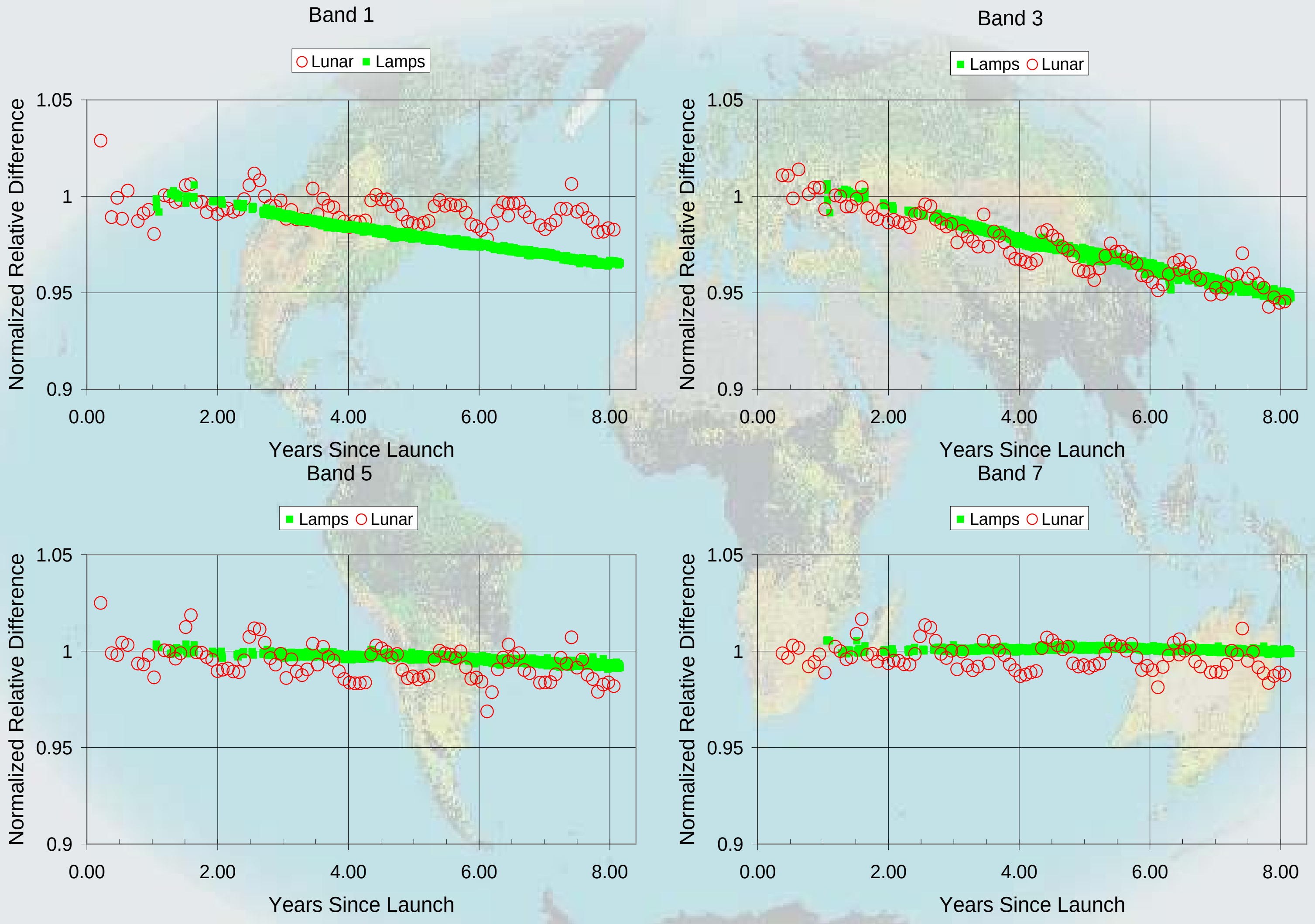


EO-1 specifications as compared to Landsat-7 ETM+

(a) EO-1 Instrument Characteristics (ALI’s spectral bands are named MS 1-7 after the Landsat bands, with the extra bands noted with “p”)

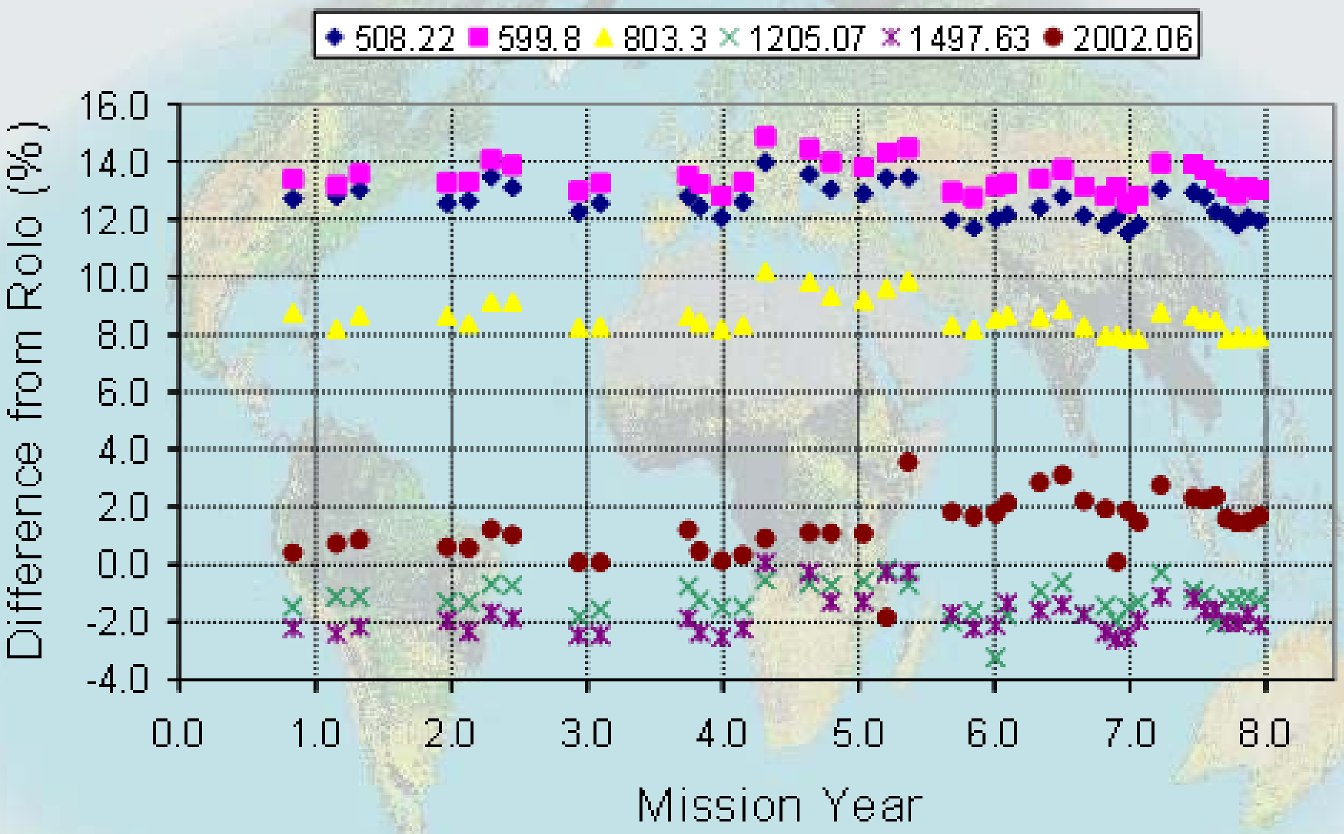
(b) Comparison between the cross-track swath of EO-1 and Landsat-7

Comparison of ALI Lunar and Lamp response for ALI (SCA 3)



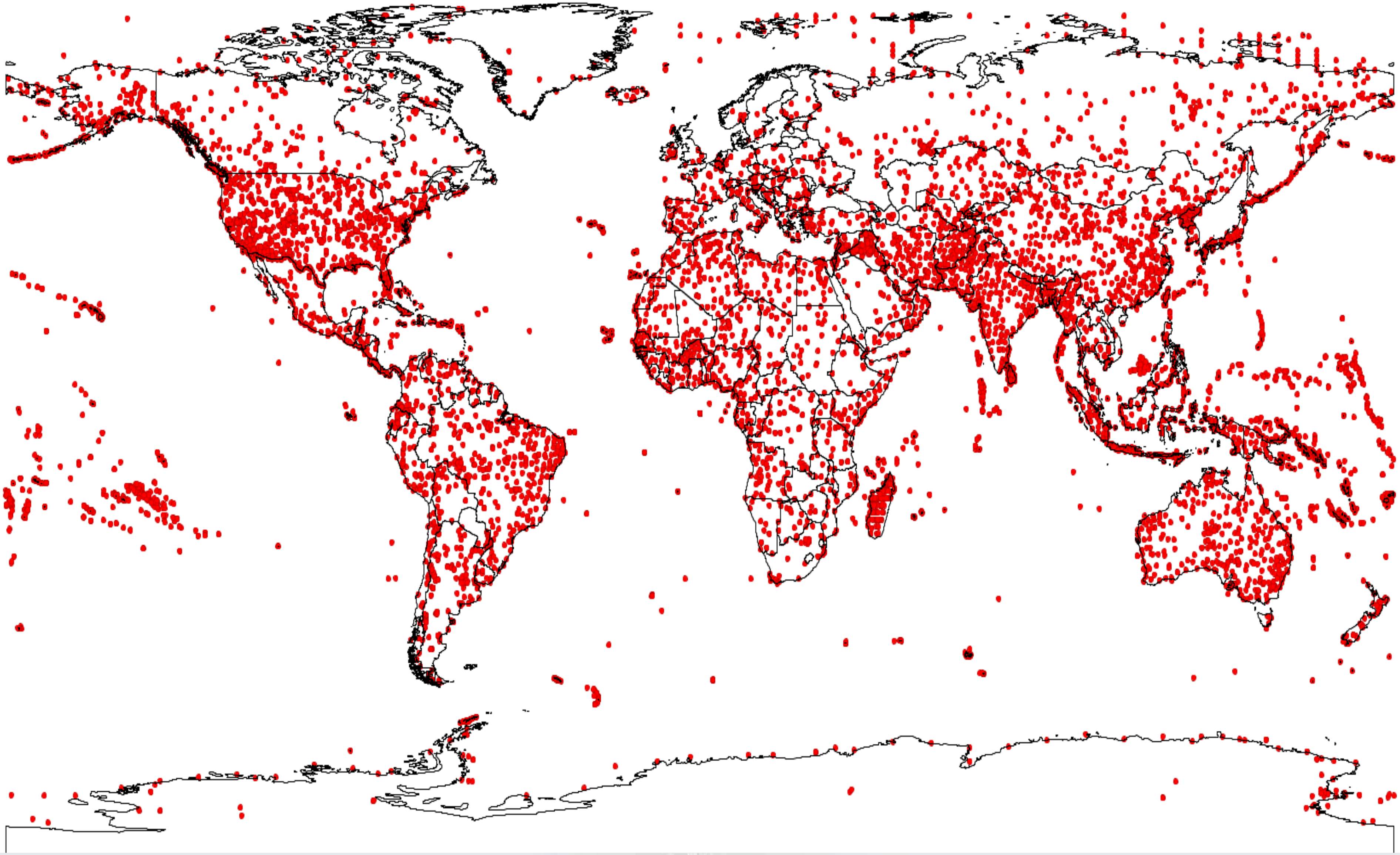
The change in the ALI shortwave bands (5', 5 and 7) over the last 8 years is less than ±2%.

Comparison of the Hyperion integrated lunar responses with the USGS ROLO Lunar model for selected bands

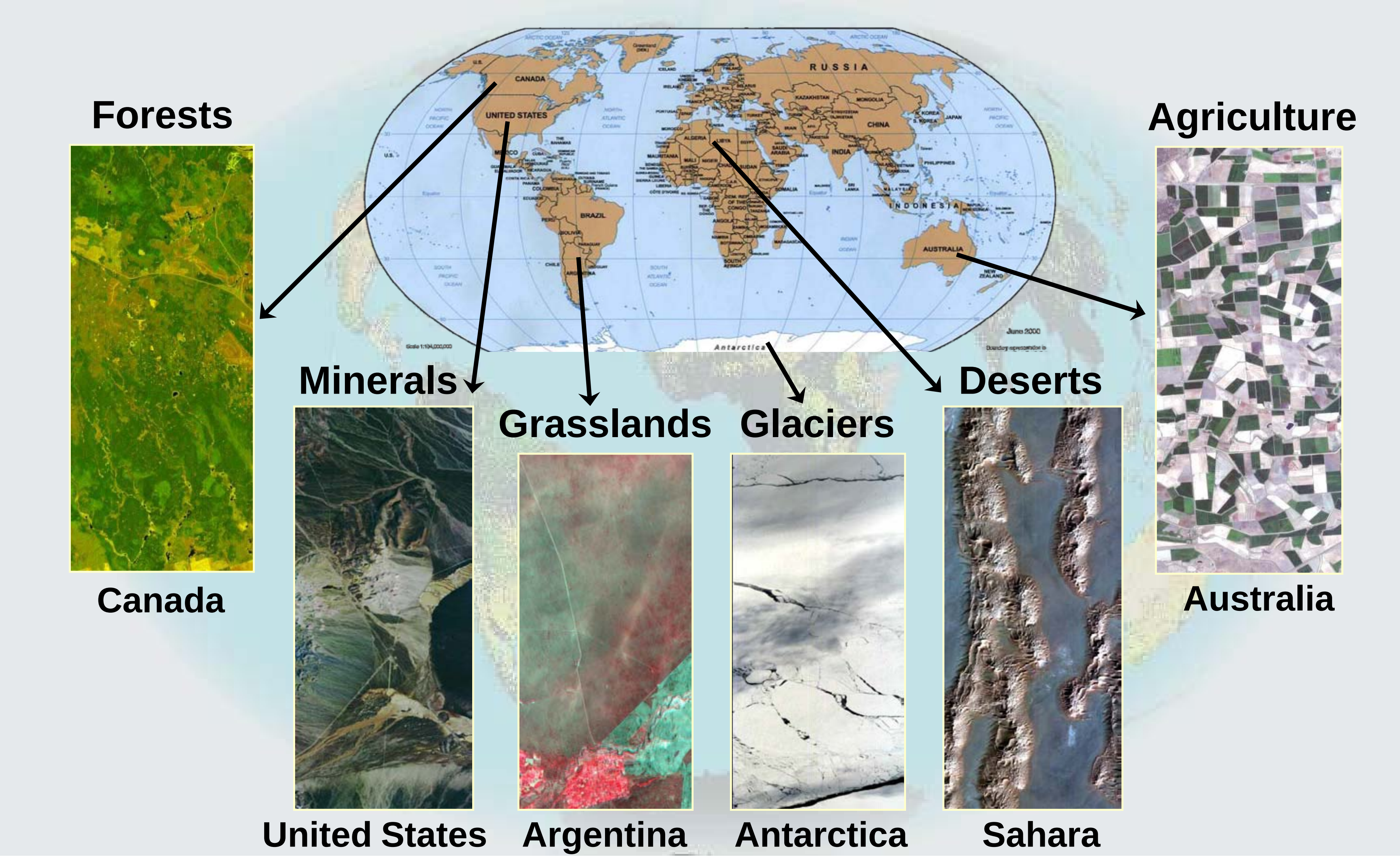


The Hyperion response has remained stable over the last eight years

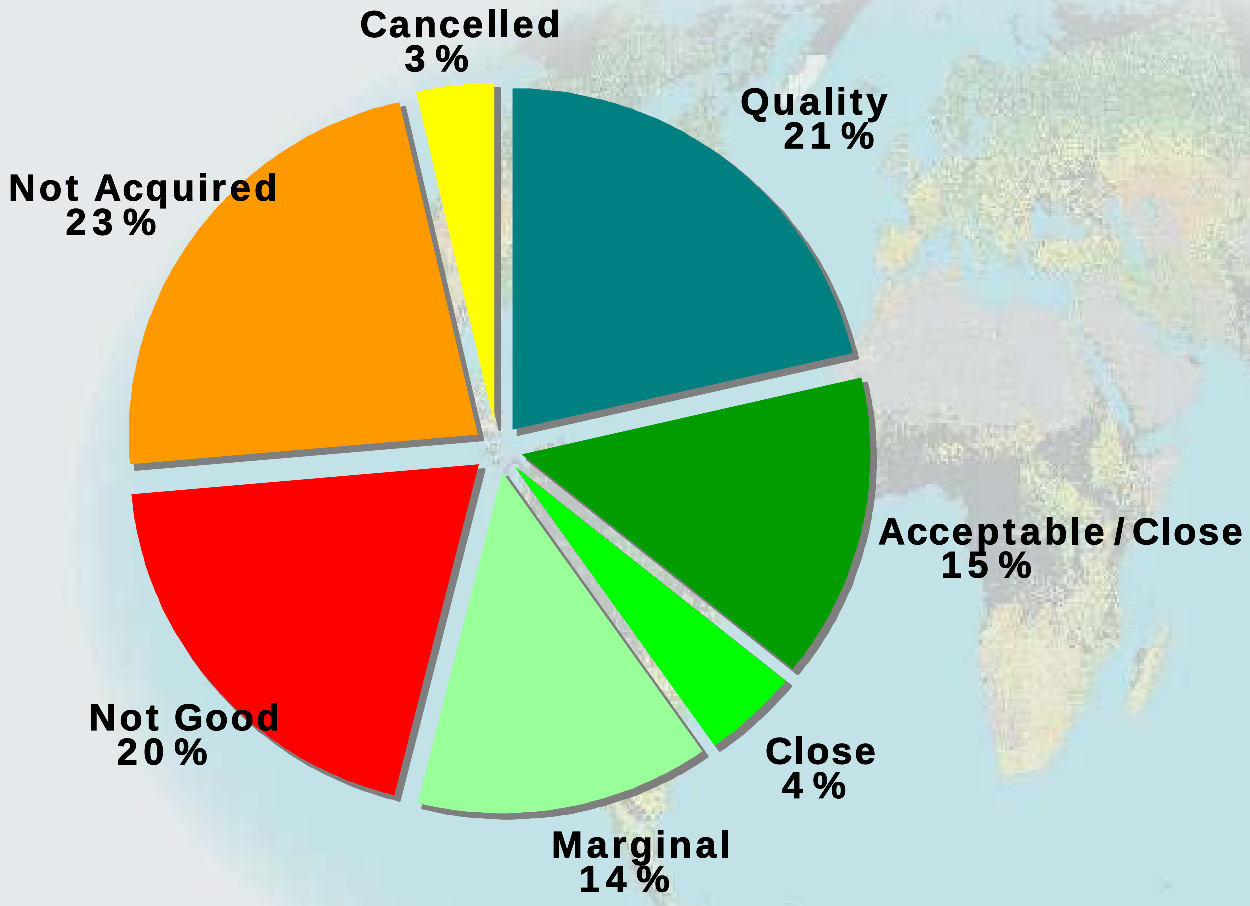
To date, over 40000 scenes have been acquired



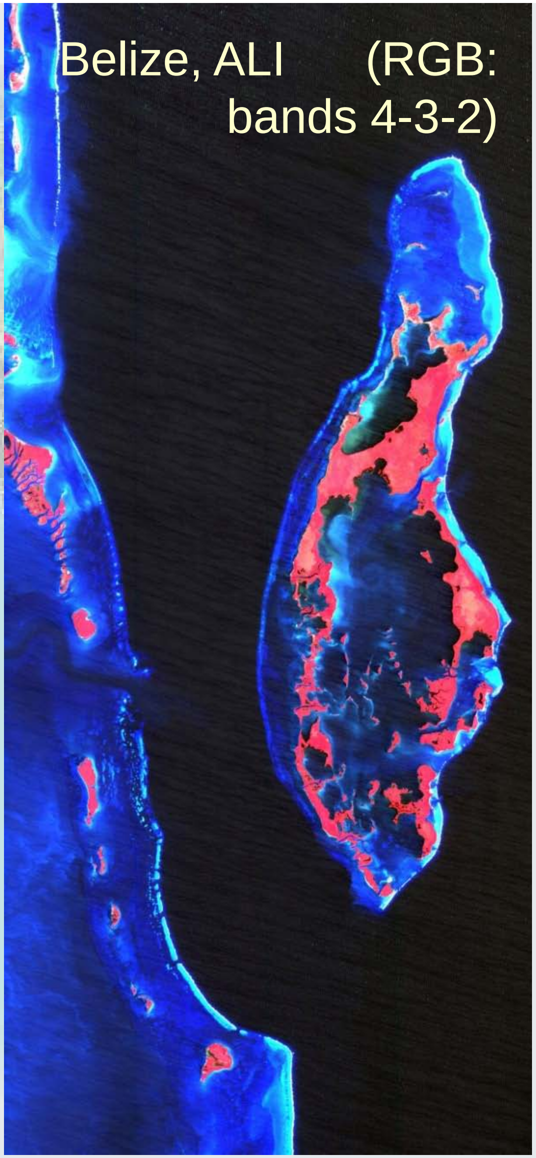
EO-1 Science and Technology Applications



EO-1 ALI data for reefs and islands are used in the Mid-Decadal Global Land Surveys: 2005 and 2010



EO-1 scenes used in the Mid-Decadal Global Land Survey (GLS2005)

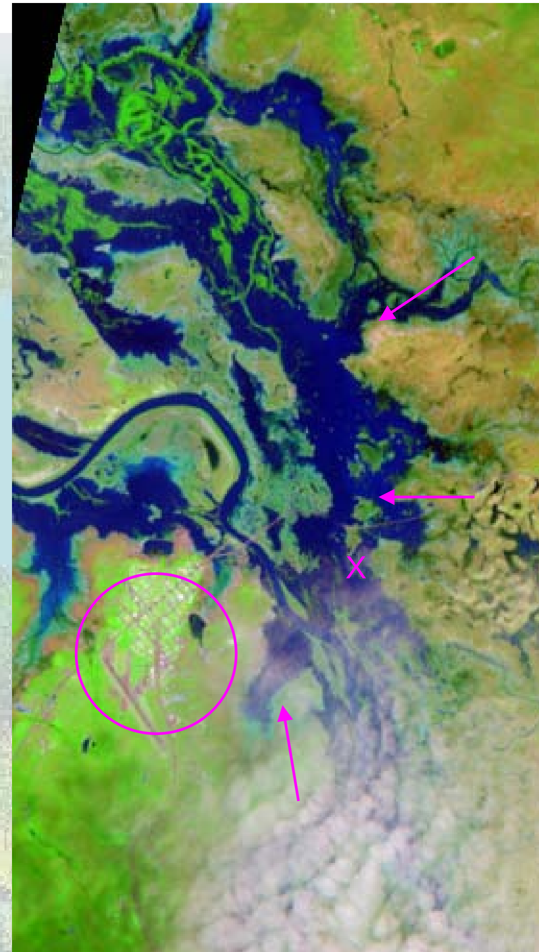


EO-1 as a Pathfinder for SensorWebs Enables Rapid Response with Remote Sensing

ALI Imagery of Australian Flood (March 2009)

March 12, 2009
True-Color Image
EO-1 ALI Image

In this true-color image, the water color is so muddy that it makes discerning the extent of the flooding difficult



March 12, 2009
False-Color Image
EO-1 ALI Flood Product

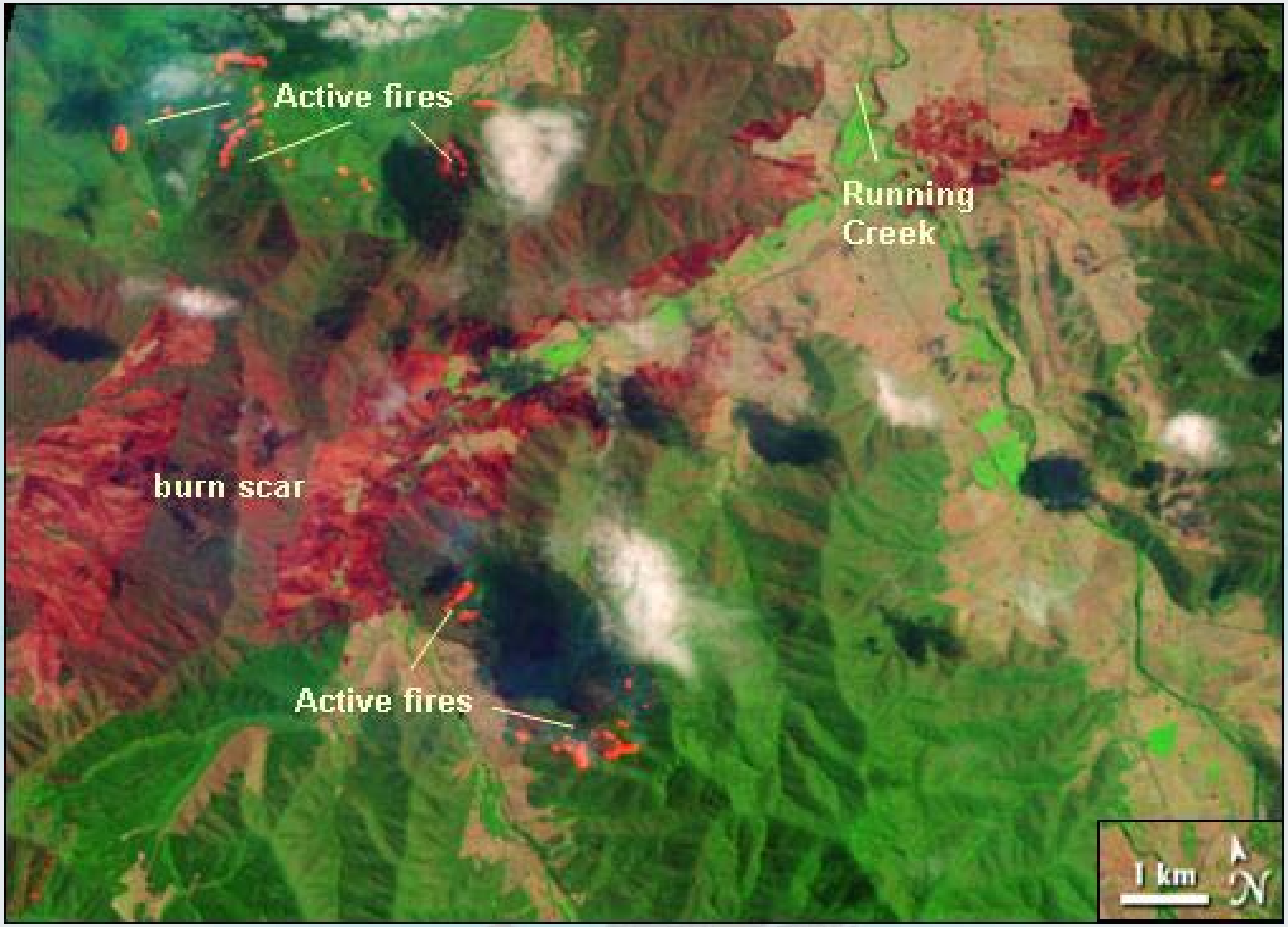
This false-color image combines infrared and visible bands, delineating the extent of the flooding. Water is dark blue, while plant-covered land is green, and bare earth is tan.

March 25, 2009
False-Color Image
EO-1 ALI Flood Product

Two weeks later, the flood waters have receded, which the EO-1 Flood Product makes evident.

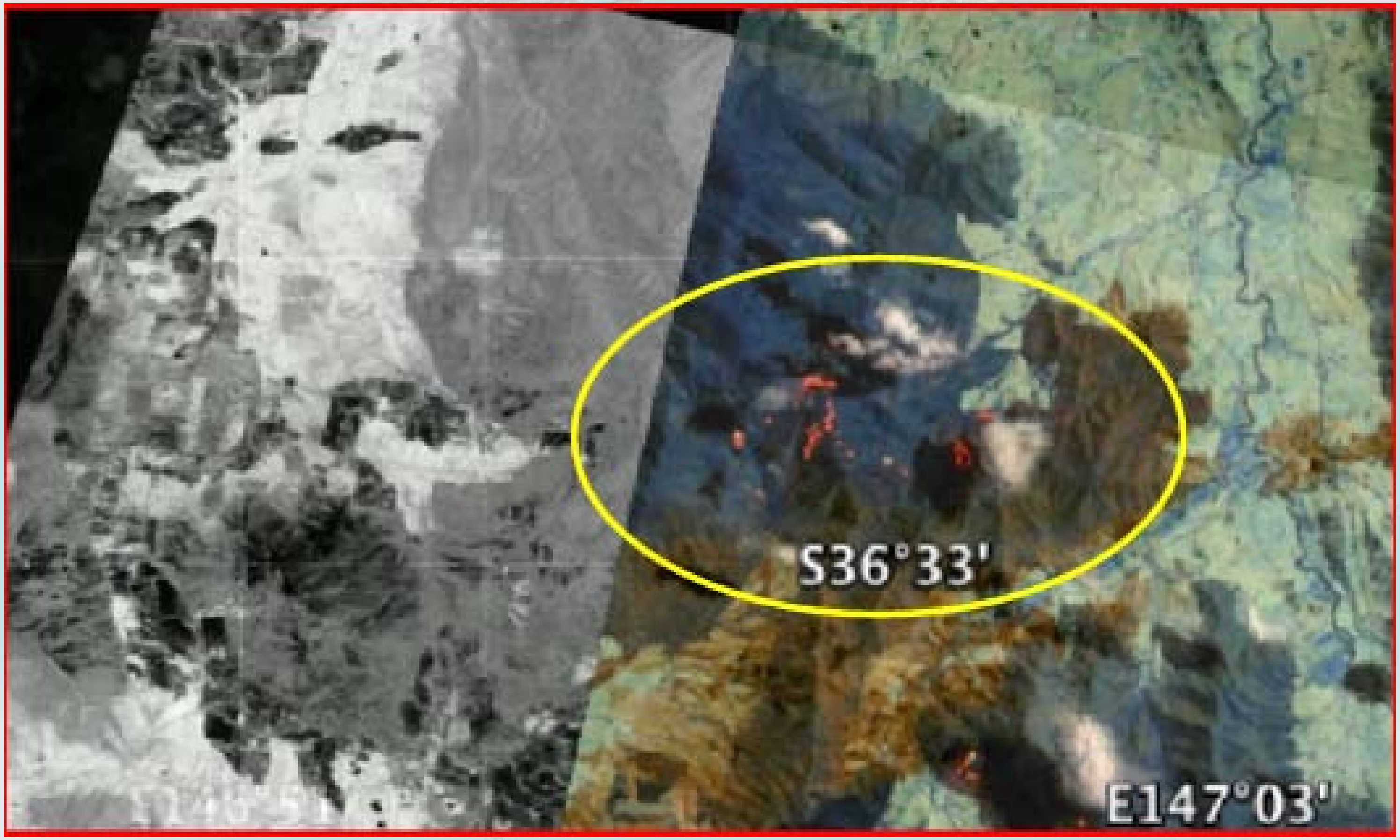
Images are from NASA's Earth Observatory web site (http://earthobservatory.nasa.gov/)

Australian wild fires, part of the 30,700-hectare Beechworth Fire



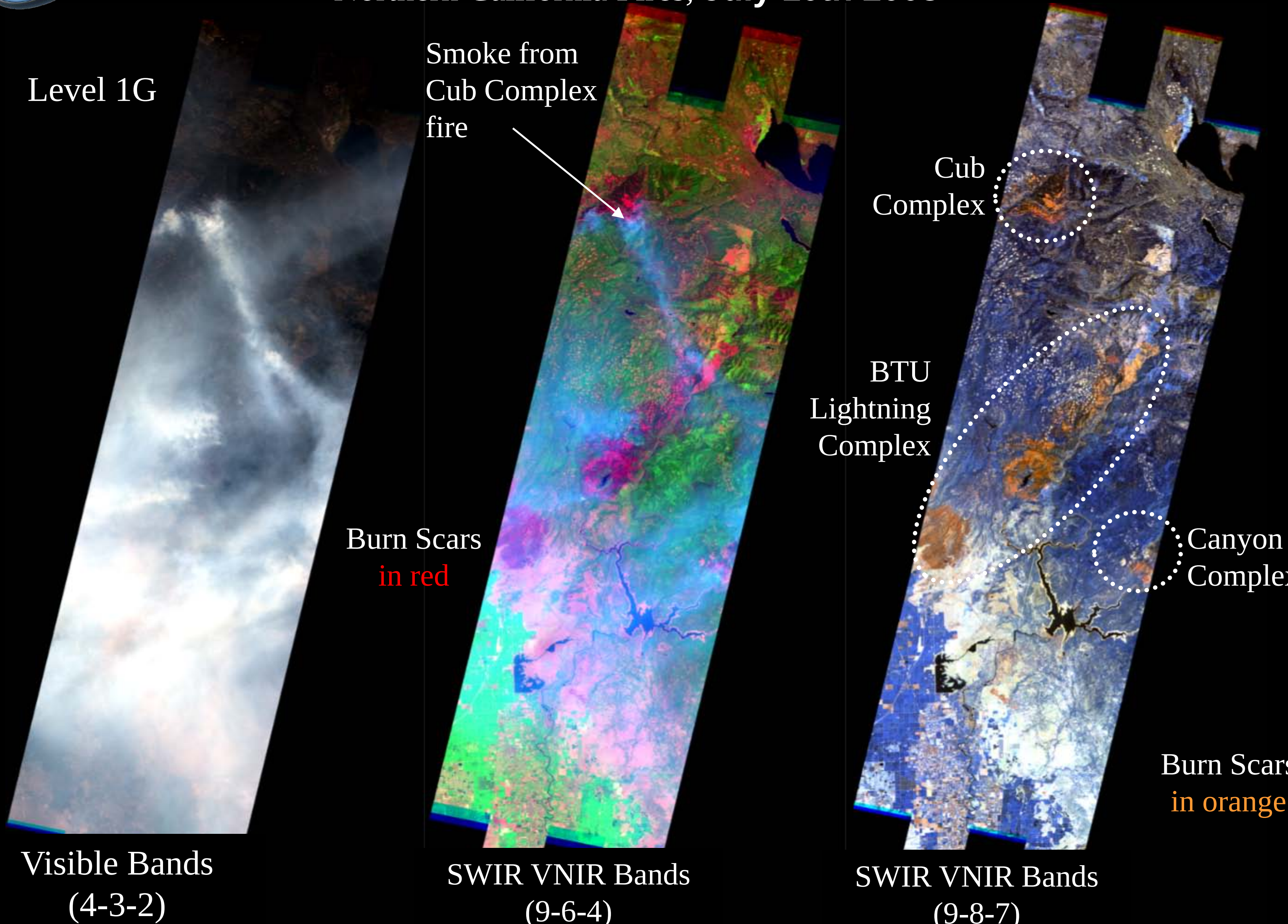
EO-1 ALI false-color image (RGB: 1.55, 0.85, 0.65 µm) acquired on February 10, 2009

Coordinated tasking between EO-1 and the FORMOSAT-2 satellite



Southern Australia Bright Fires (S36°33’, E147°03’) shown with EO-1 Shortwave Infrared (SWIR) bands from imagery acquired on Feb 10, 2009 overlaid on a FORMOSAT-2 panchromatic band acquired Feb 12, 2009.

EO1 ALI Product " Burn scars through smoke "
Northern California Fires, **July 10th 2008**

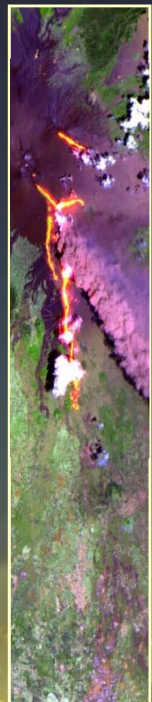


Eruption of Mt. Etna, Sicily

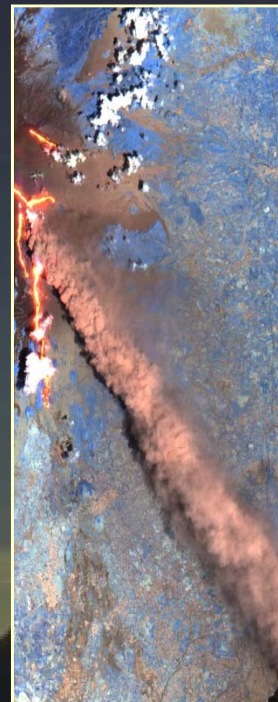
July 22, 2001

ALI Pan Enhanced Bands 3-2-1

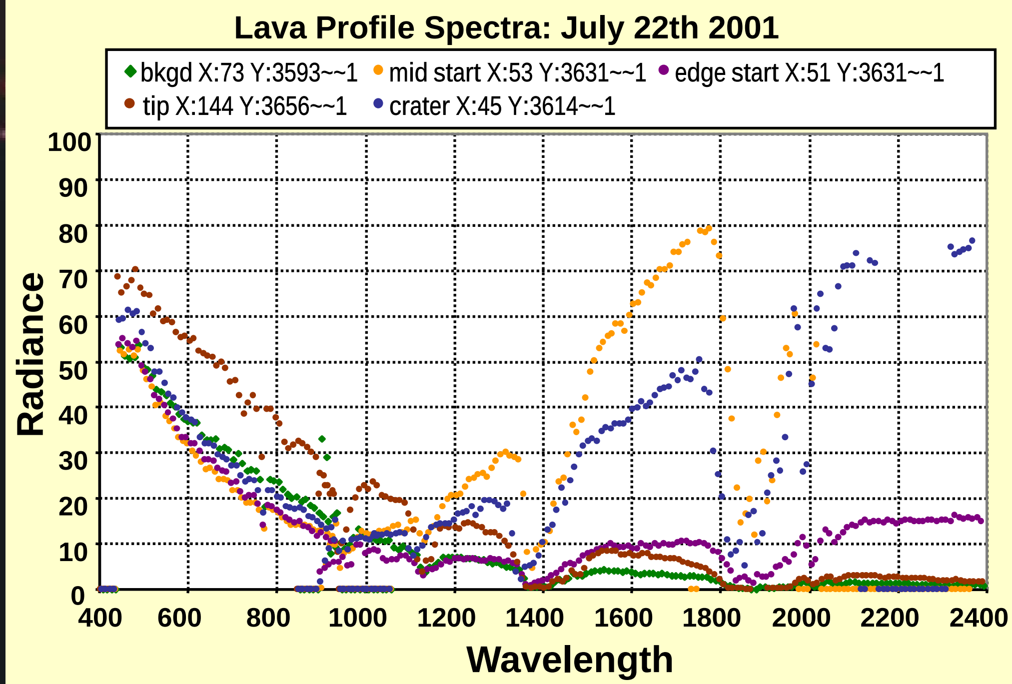
Hyperion 7-5-4 Equiv



EO-1 ALI Bands 7-5-5'



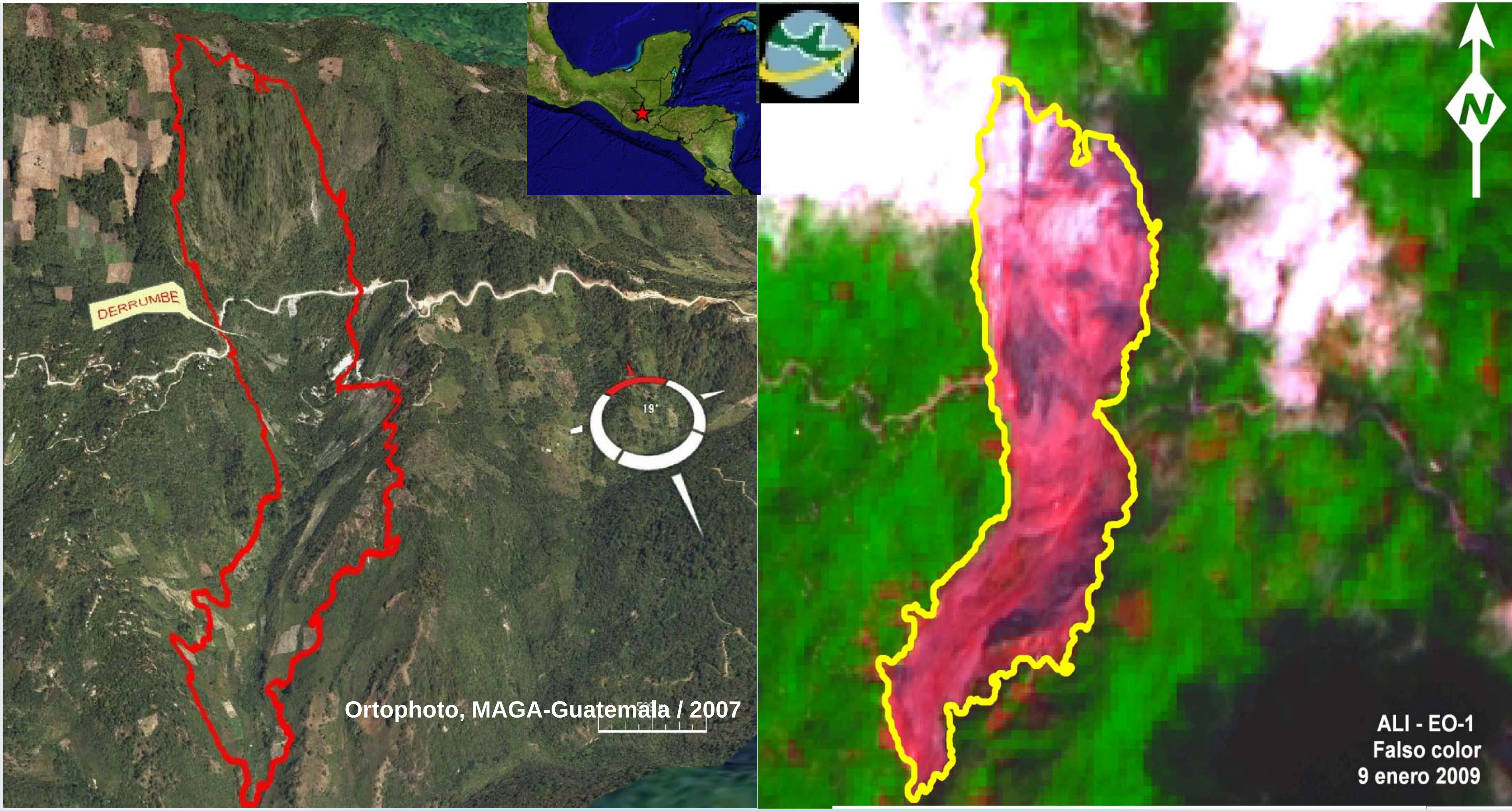
EO-1 Hyperion Spectra



Hyperion Temperatures for Etna

Spectrum	Crust T°C	Hot ToC	Area Hot
J 13-CTB	346 C	994 C	0.0025
J 13-MM	874 C	876 C	0.45
J 13-CTS	976 C	978 C	0.47
J 13-TipX	210 C	900 C	0.00034
J 22-MS	726 C	1075 C	0.090
J 22-CX	487 C	1075 C	0.022
J 22-RS*	1054 C	1058 C	0.690

EO-1 ALI image of a landslide in Guatemala on Jan 9, 2009



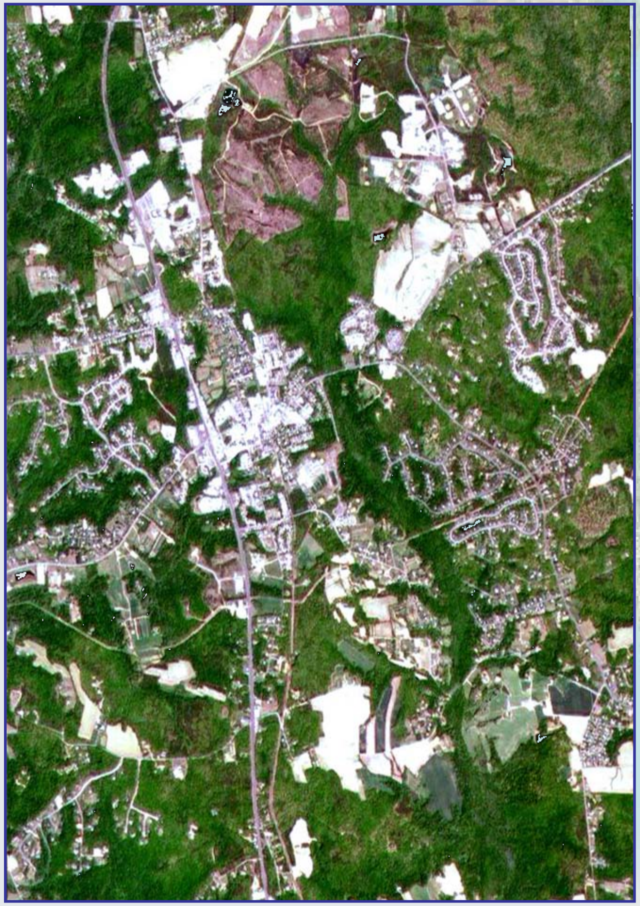
CATHALAC SERVIR NASA USAID CCAD

ALI pan-sharpened images acquired just two days apart, clearly showing the receding flood waters.

La Plata, MD Tornado: After-effects still visible one year later.

EO-1 ALI Pan-sharpened images (Ungar, 2003)

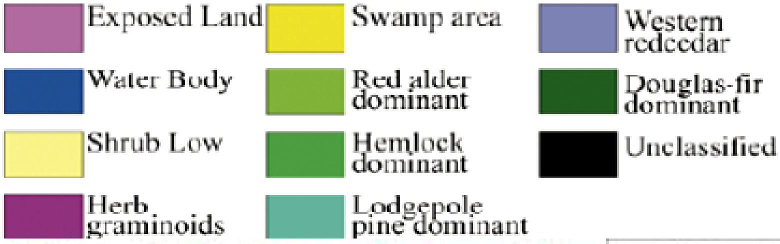
April 24, 2002

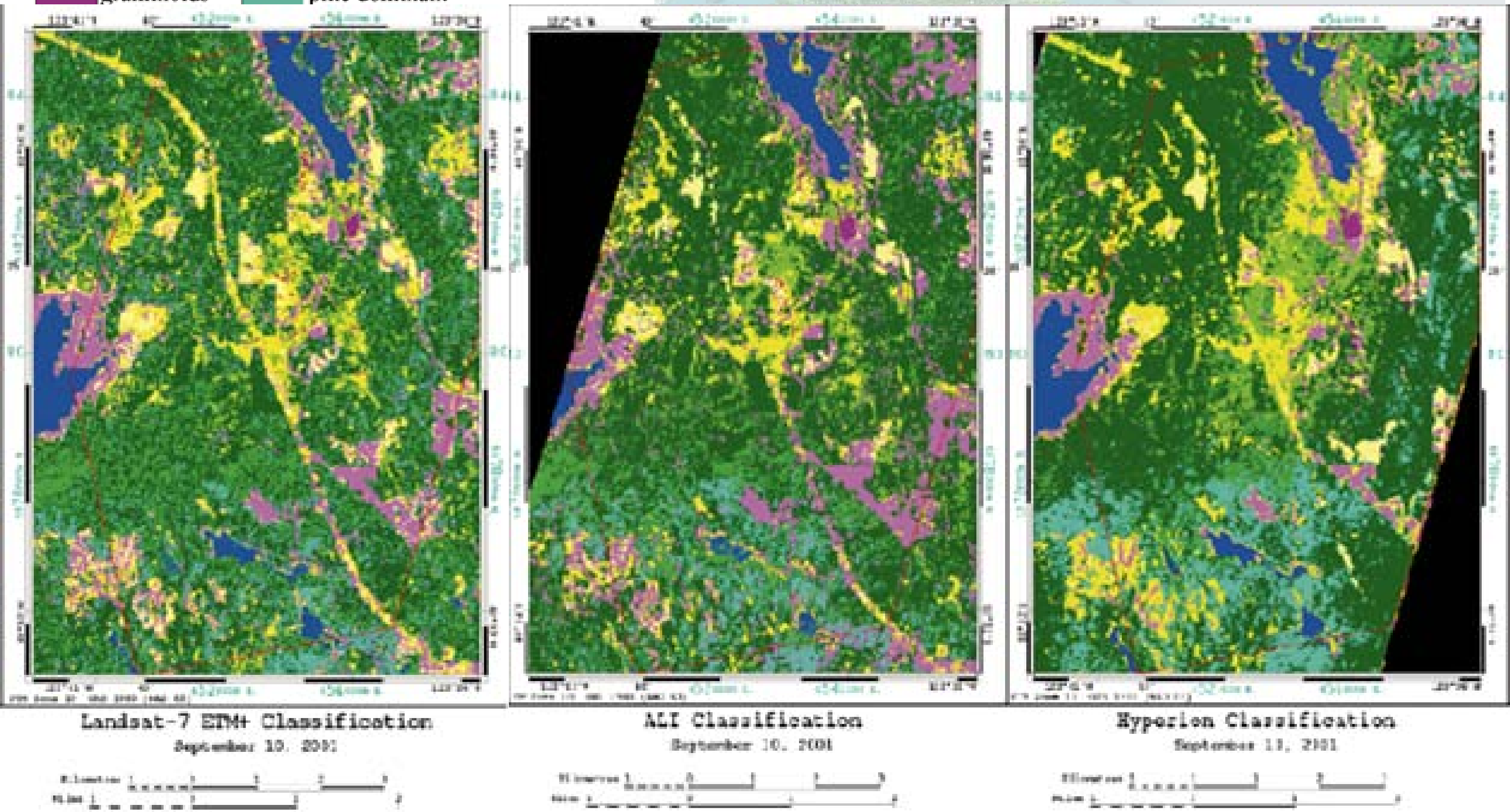


May 1, 2002

April 27, 2003

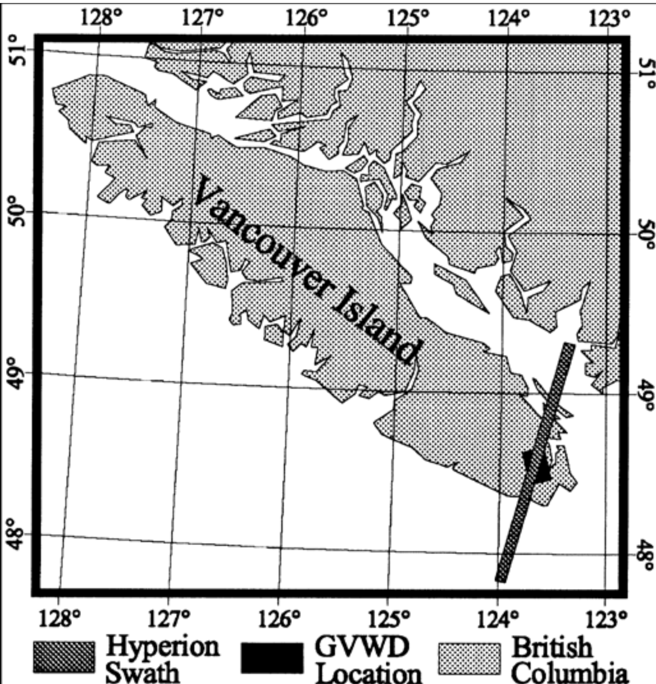
Evaluation of Hyperion and ALI for Forest Classification





Goodenough *et al. (2003)*

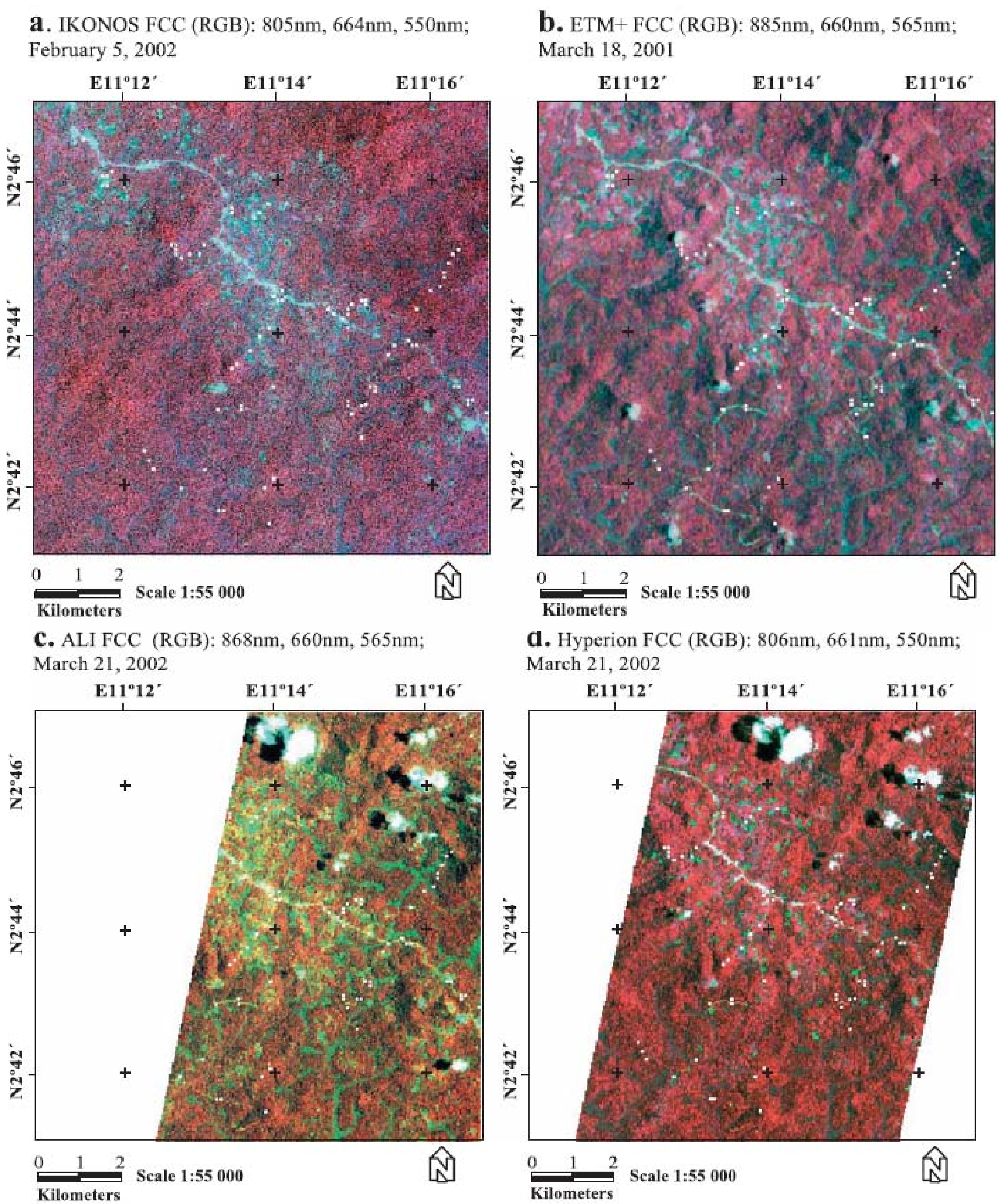
Evaluation of Hyperion and ALI for Forest Classification



Location of the Greater Victoria watershed district (GVWD) study area (15 km 23 km) on Vancouver Island with the Hyperion swath overlaid.

Class Label	ETM+ Accuracy % Training	ETM+ Accuracy % Check	Hyperion 1B (2-12) Accuracy % Training	Hyperion 1B (2-12) Accuracy % Check	ALI Accuracy % Training	ALI Accuracy % Check
Exposed land	100	100	100	100	100	100
Recent cuts<6 mo	100	100	100	97.3	98.8	100
Water	100	99.5	99.8	100.0	100.0	99.0
Shrub low	92.6	85.2	100.0	96.3	98.1	96.3
Old clear cuts	97.6	100.0	100.0	95.2	92.9	95.2
Herb Graminoids	93.5	87.0	100	100	100	100
Swamp	92.0	91.2	97.1	100	98.6	94.1
Red alder	62.7	64.5	91.5	87.1	79.7	80.6
Hemlock 60% Dense	56.7	24.3	74.6	45.9	46.3	43.2
Hemlock 60% Open	68.9	39.1	91.1	52.2	84.4	56.5
Lodgepole pine	38.0	31.2	87.7	79.6	62.6	57.0
Western redcedar 60%	83.3	N/A	83.3	N/A	75.0	N/A
DF Dense 60 yr	77.9	63.5	73.7	65.4	73.7	59.6
DF Dense 110 yr	60.9	51.4	79.9	73.6	74.0	79.2
DF Open 40 yr	13.9	13.9	70.8	63.9	22.2	19.4
DF Open 200+ yr	29.1	23.0	66.0	57.4	61.5	51.6
DF Sparse 40 yr	50.7	45.1	86.8	81.9	77.1	68.8
Overall accuracy	**67.5**	**61.3**	**87.4**	**81.6**	**79.5**	**74.8**

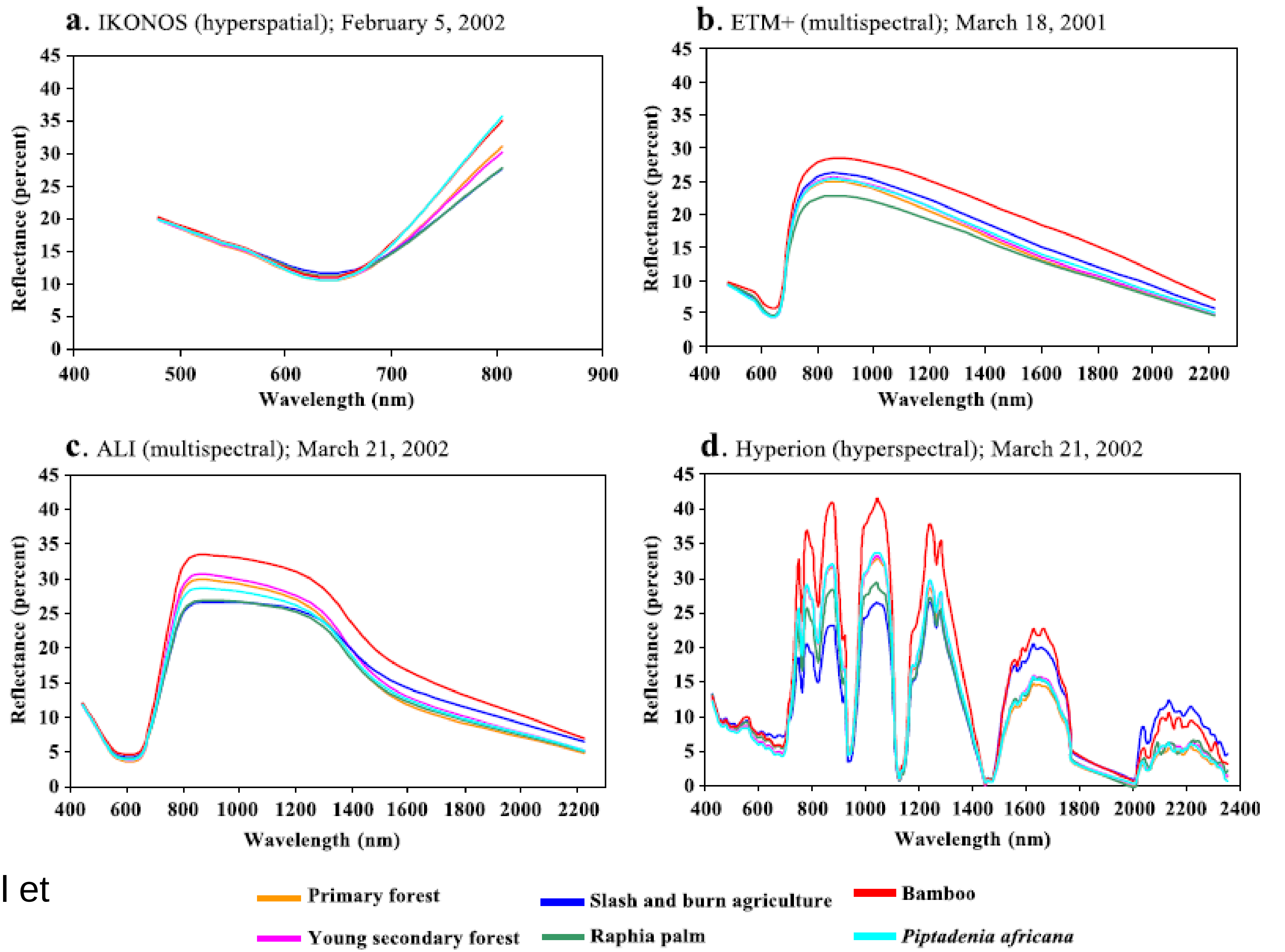
Goodenough *et al. 2003*



Hyperion, IKONOS, ALI, and ETM+ sensors studying African rainforests

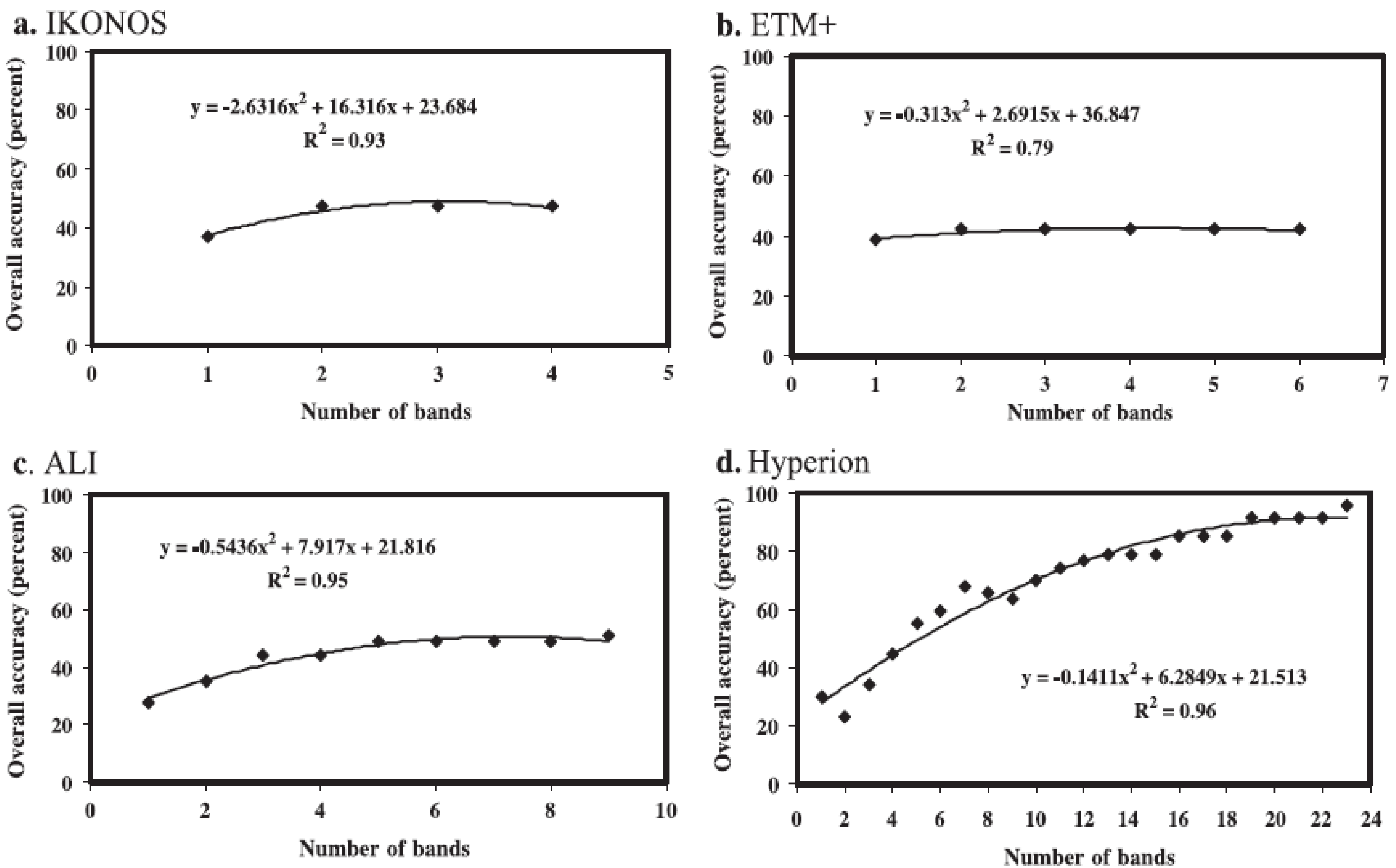
Thenkabail et al. 2004

Mean spectral profile of rainforest vegetation using (a) hyperspatial; (b and c) advanced multispectral; and (d) hyperspectral sensors



Thenkabail et al. 2004

Overall accuracies for rainforest LULC classification vs. number of bands used

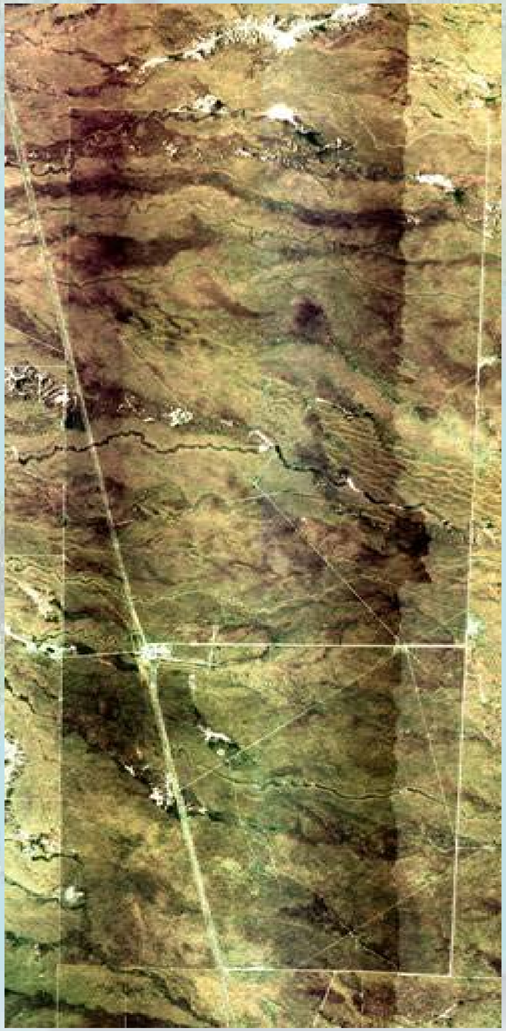


Thenkabail et al. 2004

Comparing AVIRIS and Hyperion

Desertification in Central Argentina

Hyperion (30m)



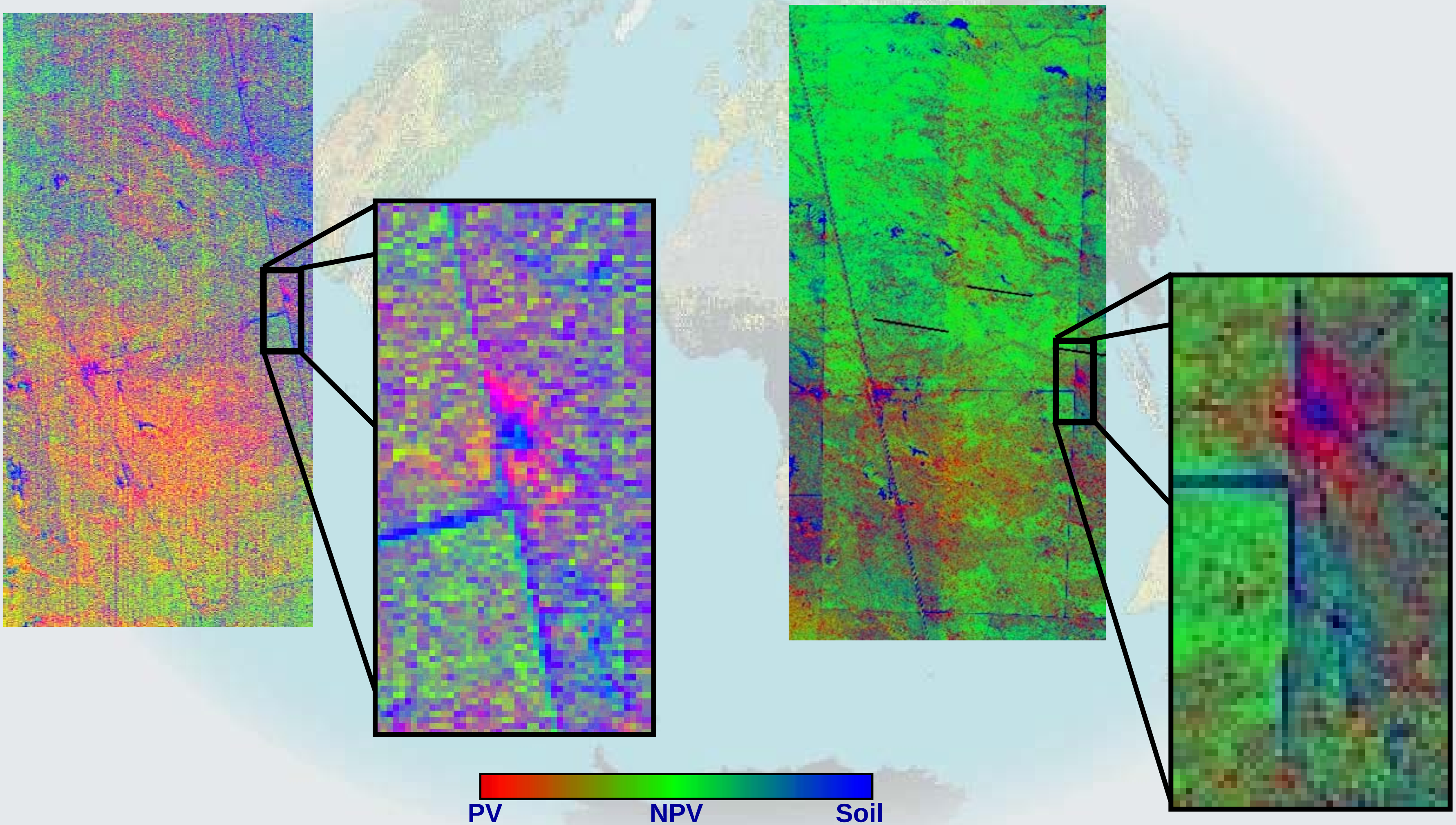
AVIRIS (4m)

AVIRIS (30m)

Asner et al.

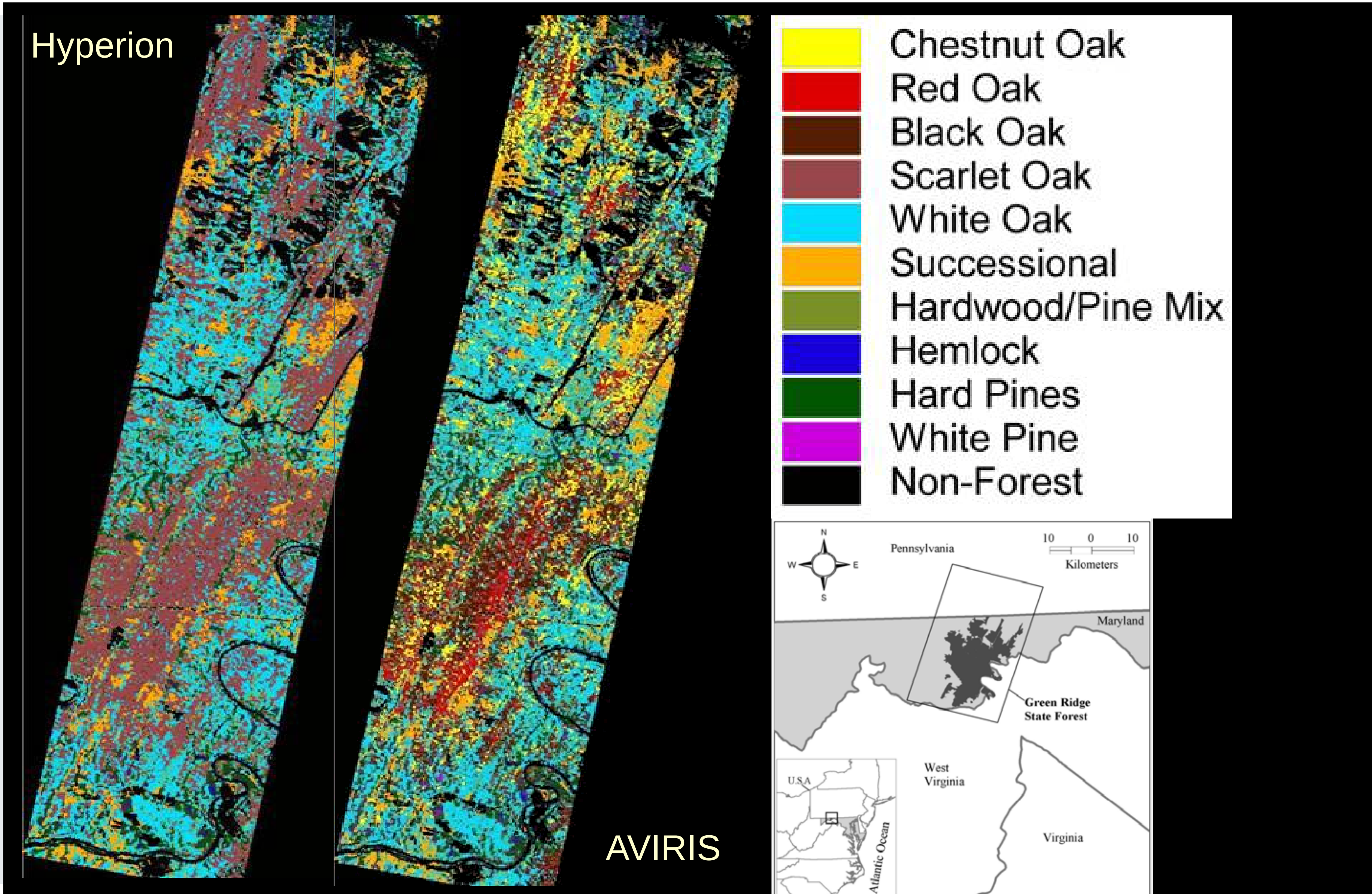
Desertification in Central Argentina

Hyperion MC Unmixing | **AVIRIS-30m MC Unmixing**

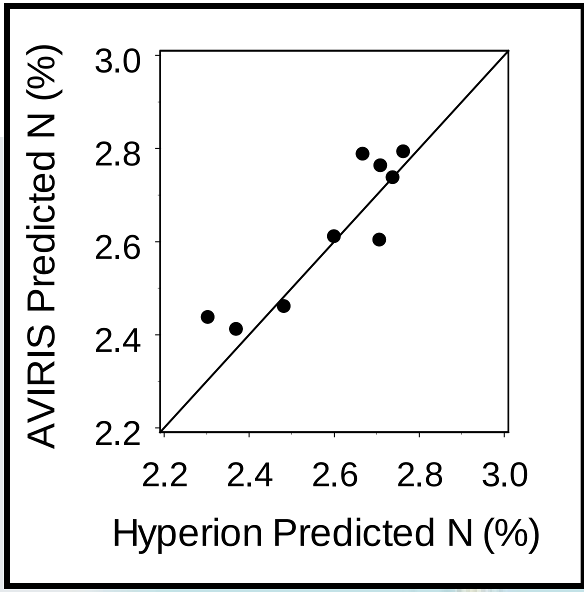


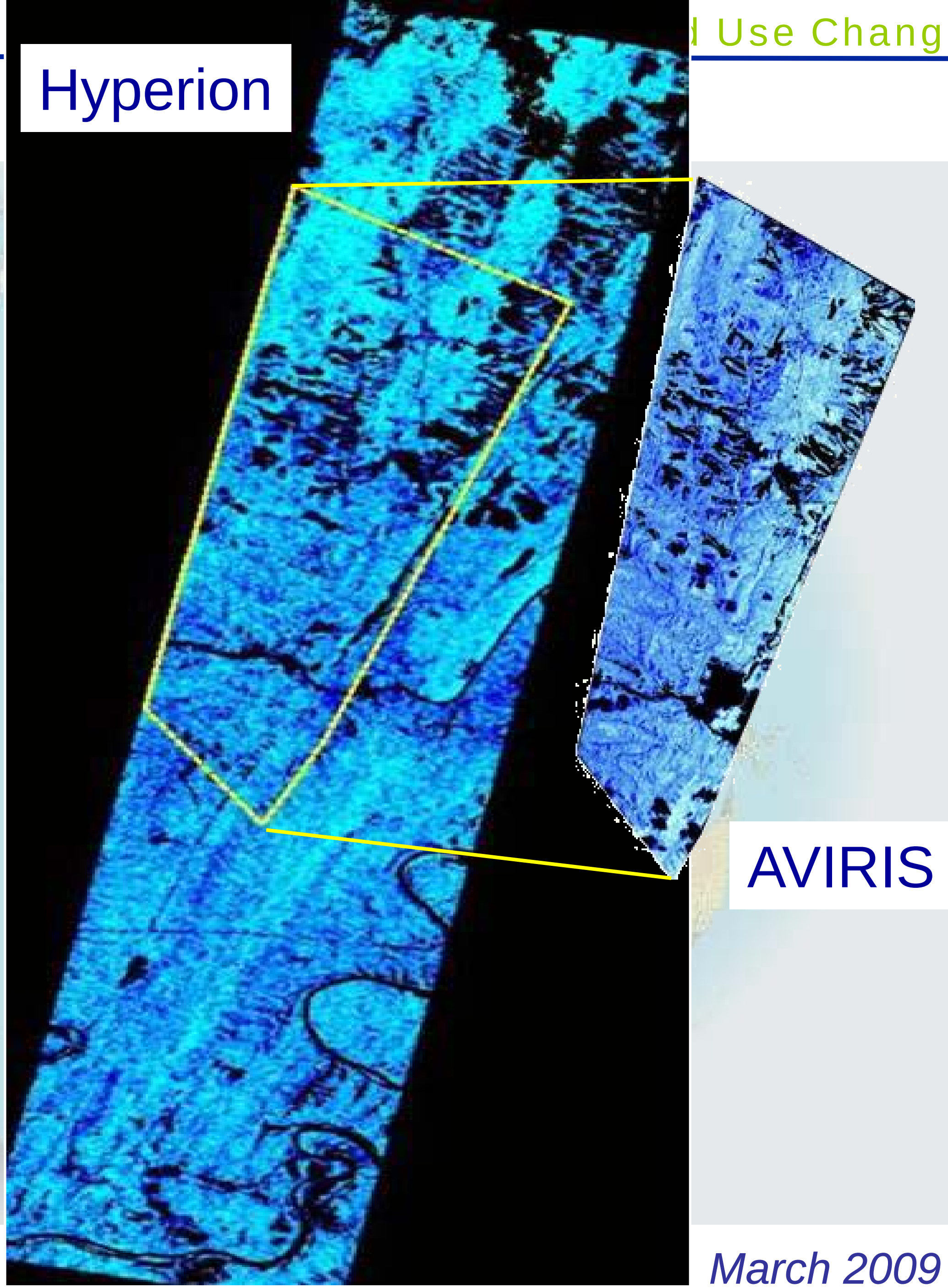
Asner et al.

Species Mapping with EO-1 Hyperion



Townsend et al. (2003)





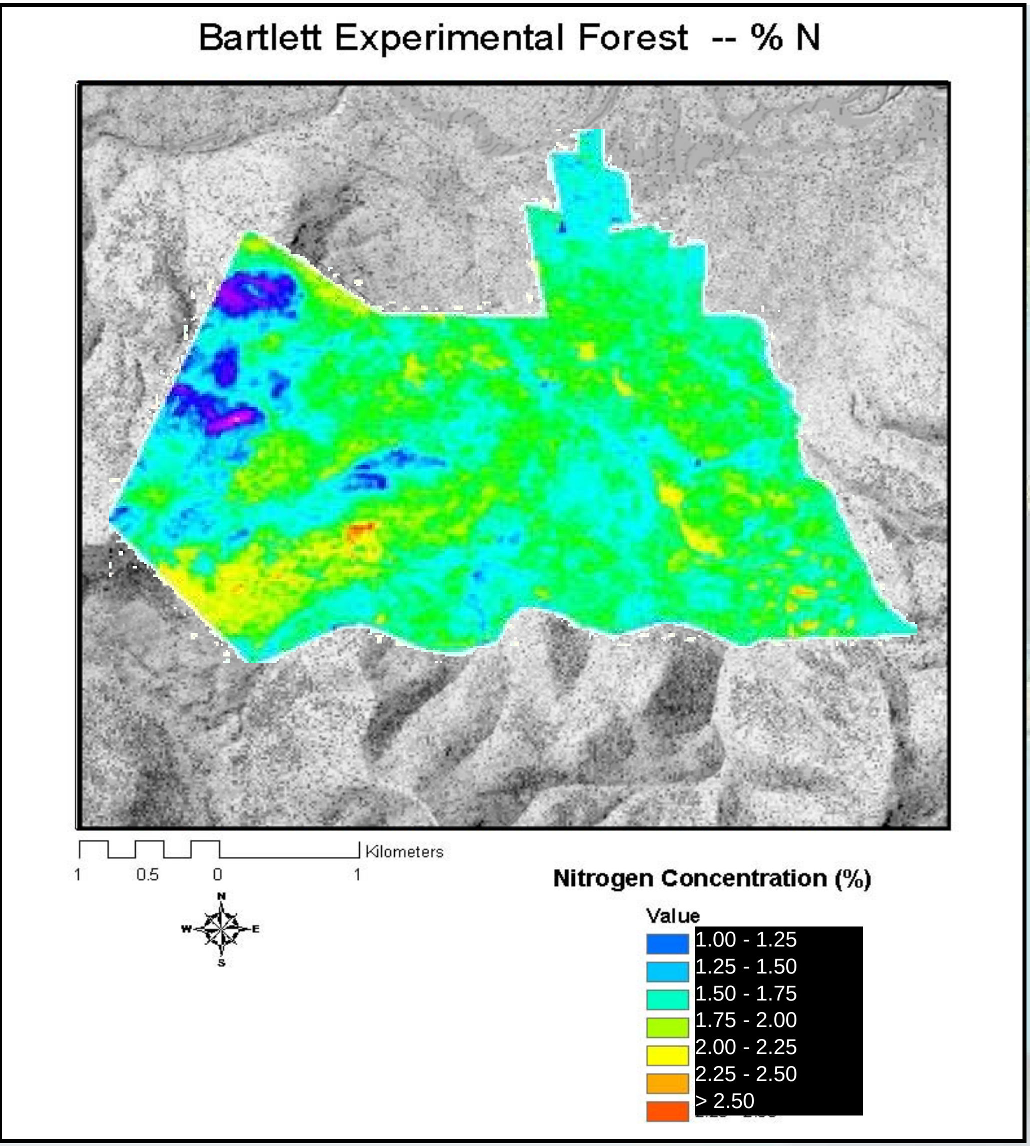
Plot N Conc. 2.02 – 3.17%

Leaf N Conc. 1.23 – 4.12%

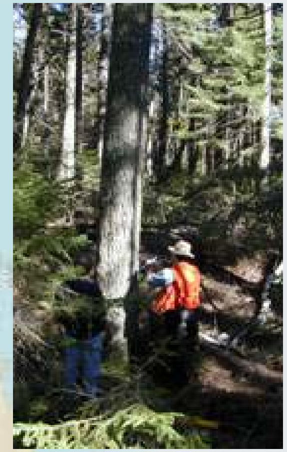
Townsend et al. (2003)

March 2009

Predicted Canopy Nitrogen

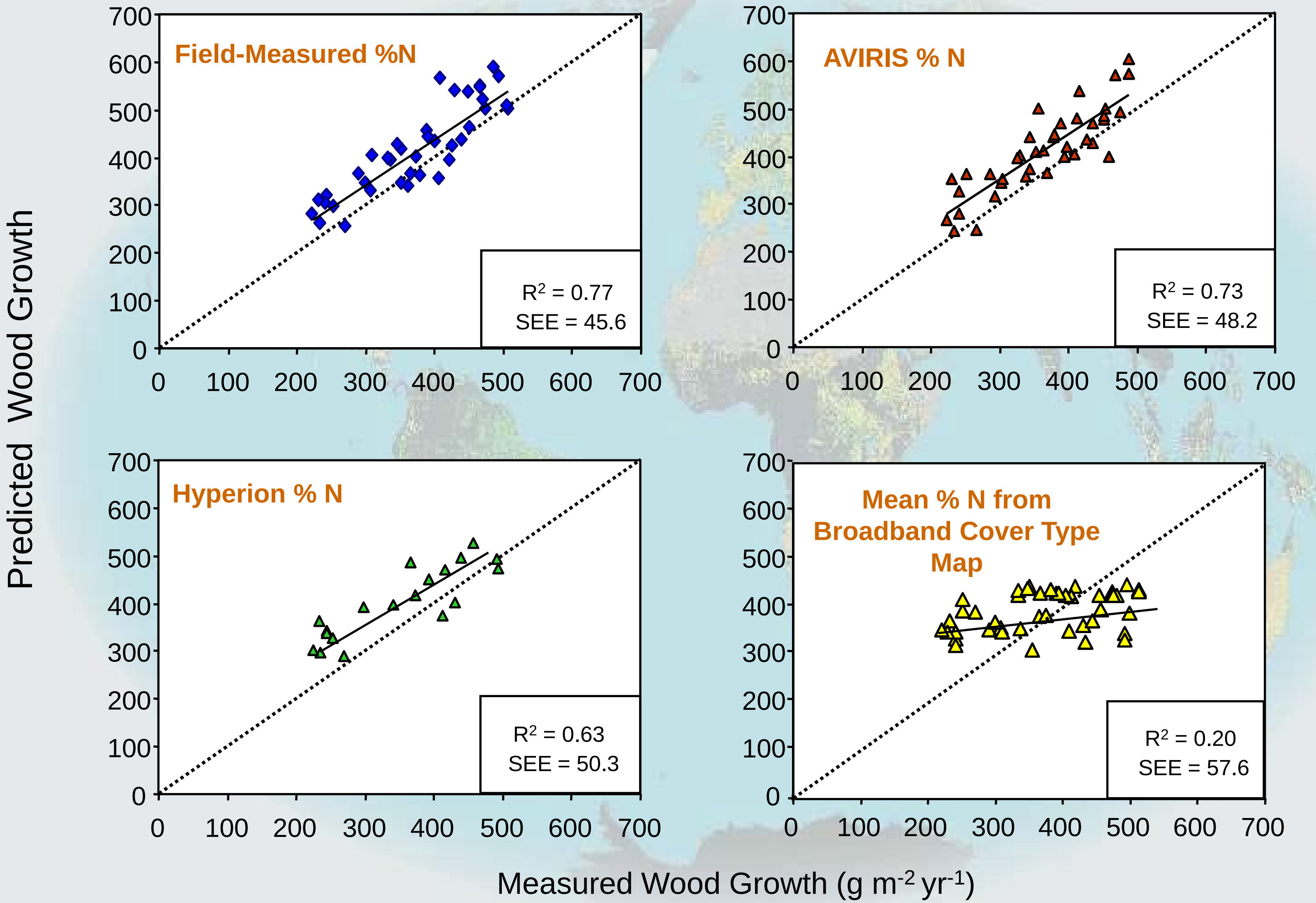


Field Sampling for Canopy Structure, Canopy Chemistry & Wood Growth



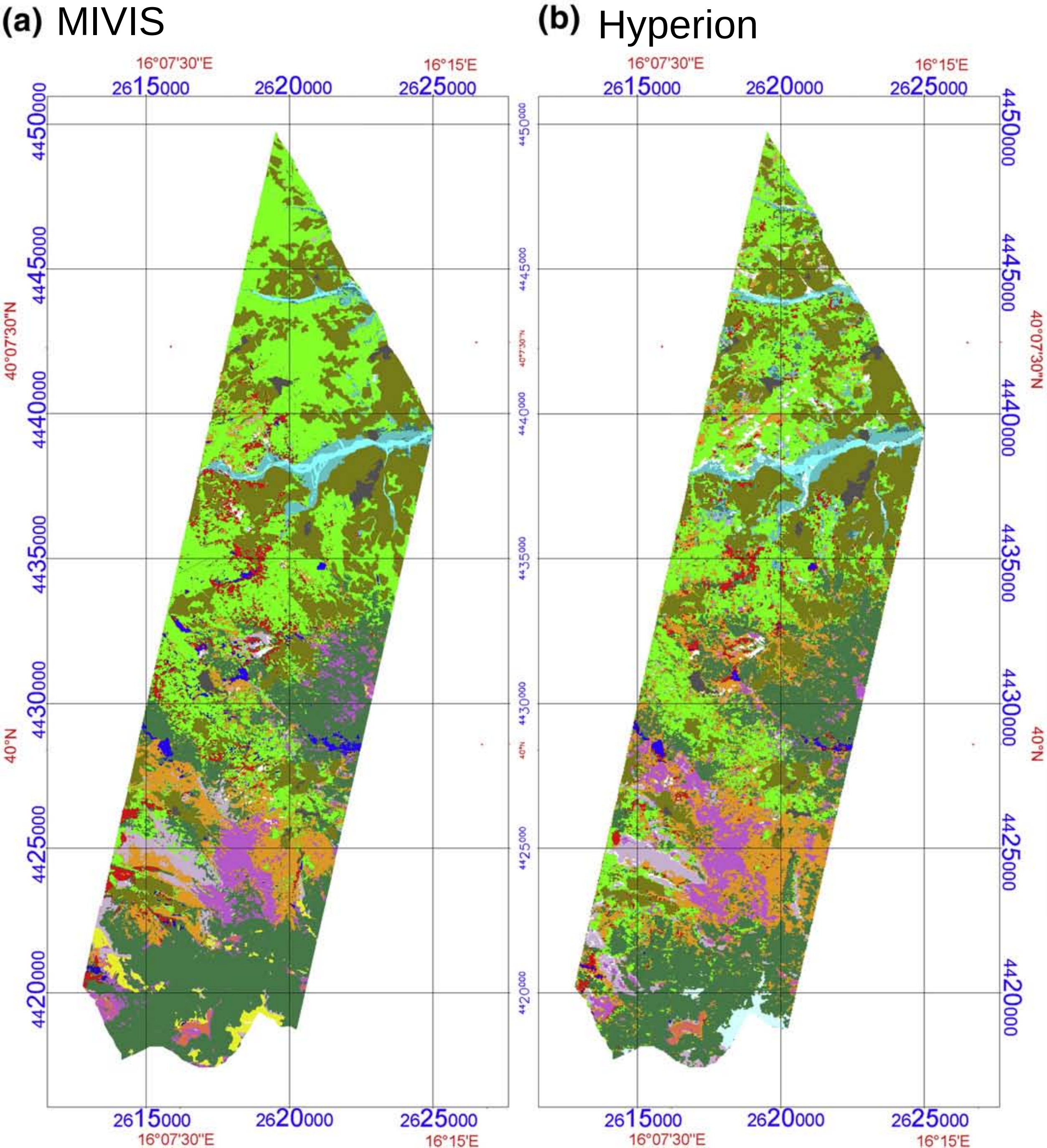
Ollinger et al. (2003)

4-way model validation, Bartlett Experimental Forest



Ollinger et al. (2003)

Mapping land cover and vegetation diversity in a fragmented ecosystem

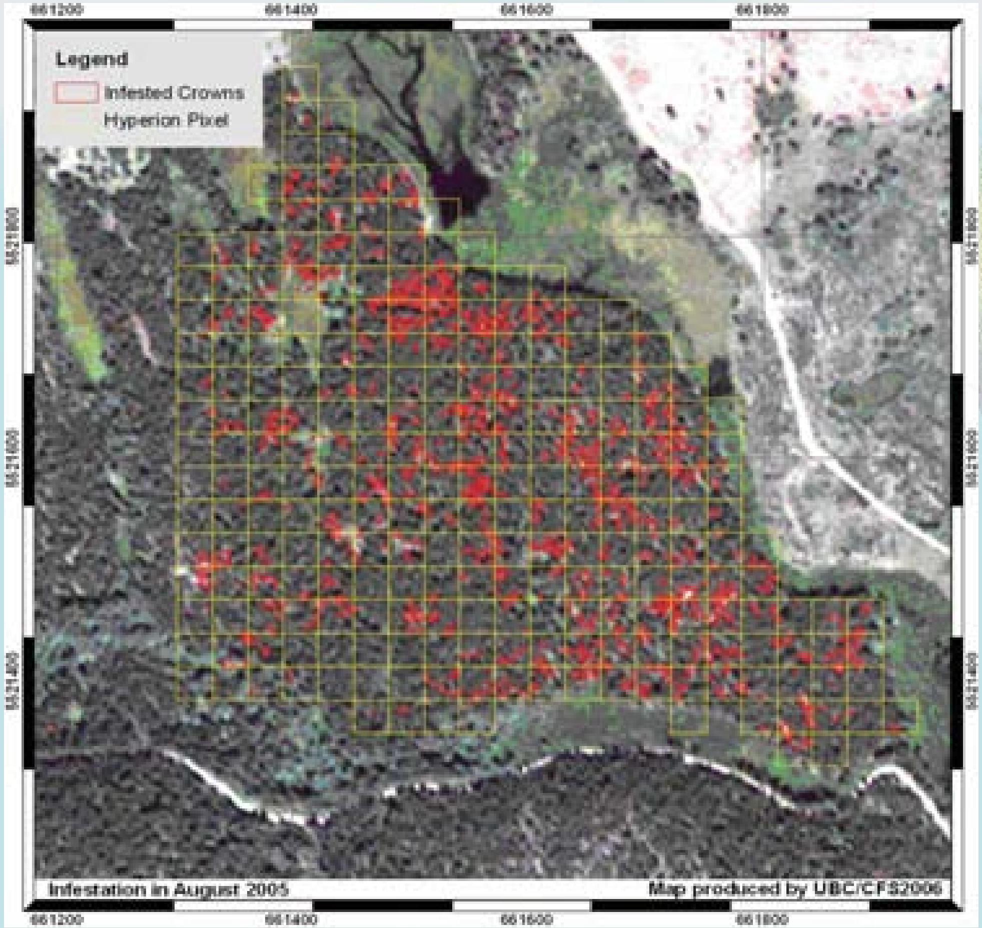


Ability to map up to the 4th level of the CORINE legend

CORINE Land Cover 2000

Pignatti et al. (2009)

Detection of mountain pine beetle red attack damage, using Hyperion moisture stress indices (MSI)



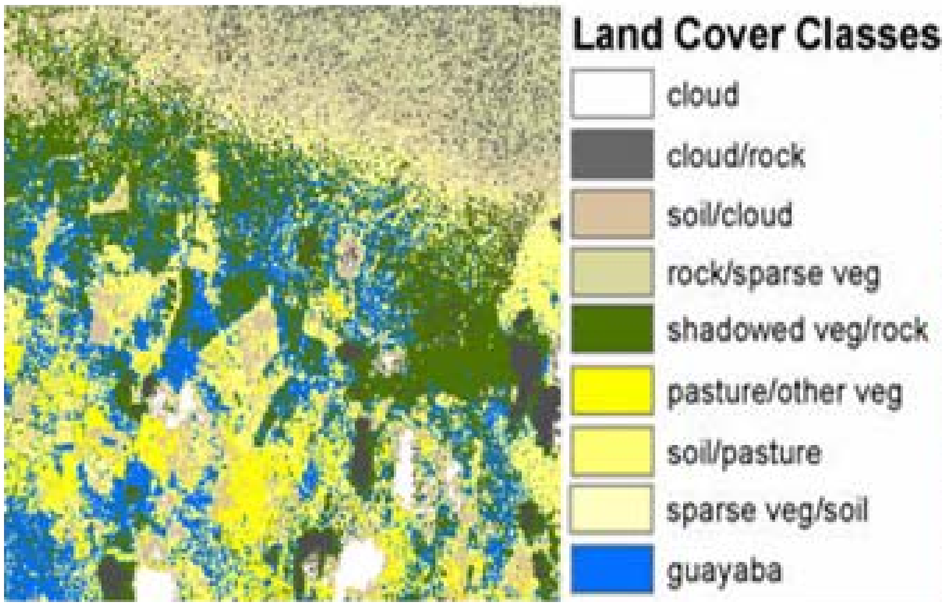
Individual tree crowns with mountain pine beetle red attack damage (delineated in red) were identified using the Hyperion spectra & then overlaid on a QuickBird image.

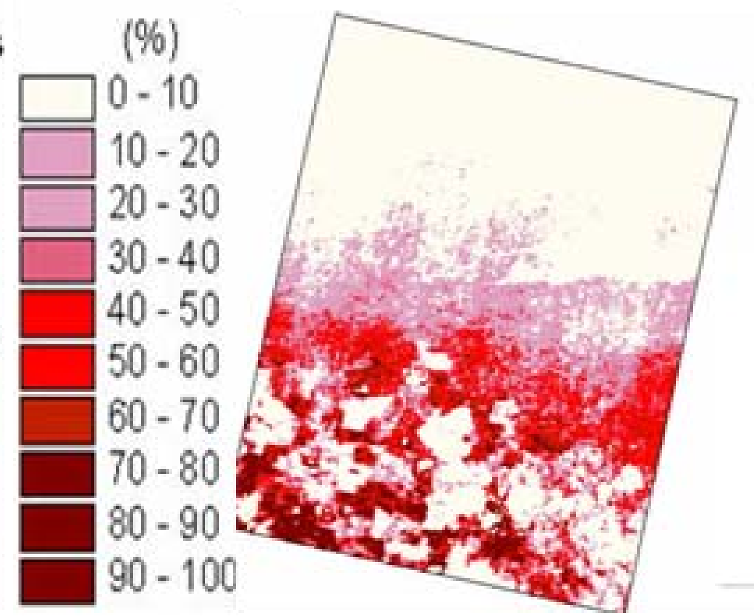
White et al. (2007)

Detection of Invasive Plants in the Galapagos National Park and Archipelago, Ecuador by merging Hyperion and *QuickBird*

Classification of guava (blue) and other land cover types

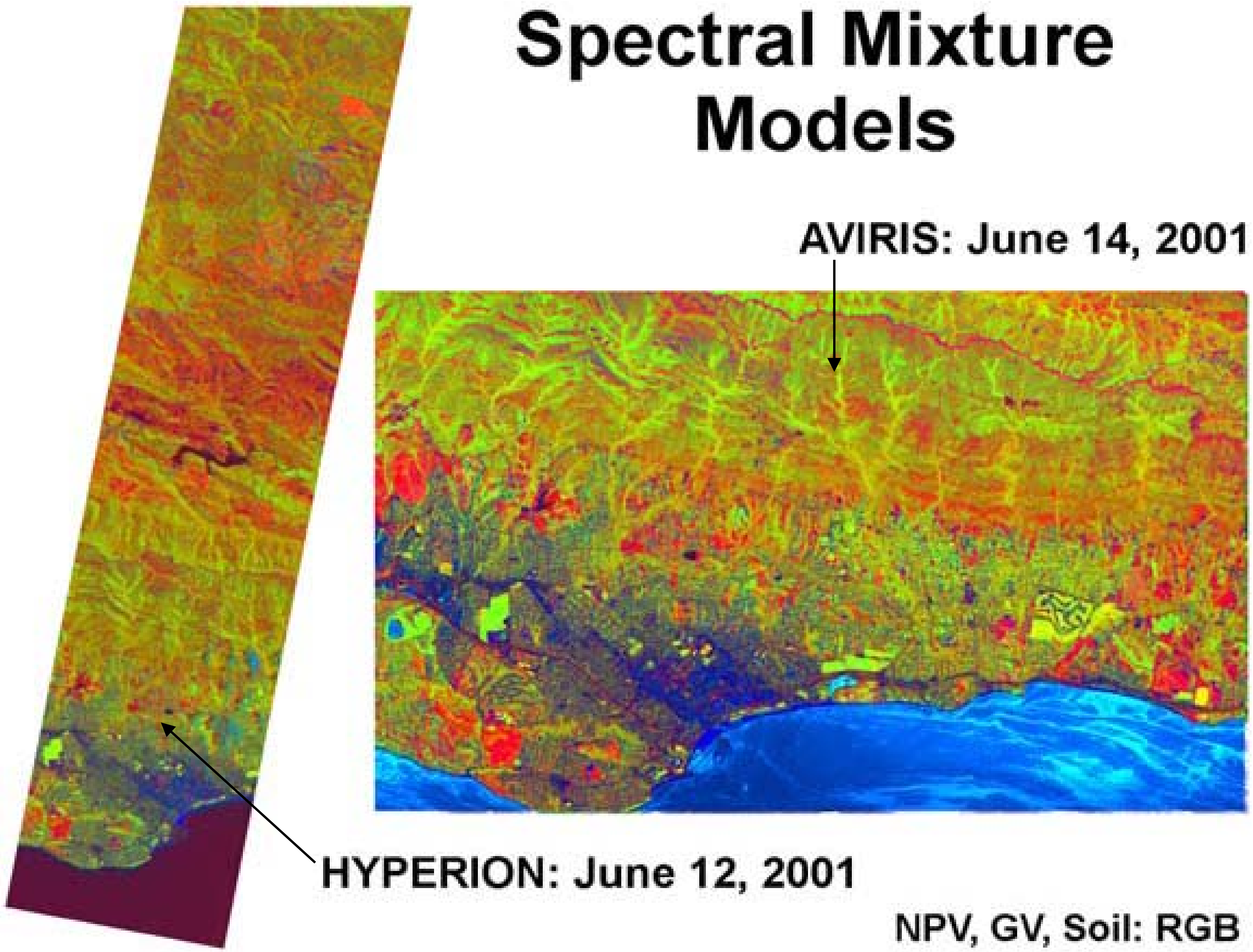
Spectral un-mixing of Hyperion data for the characterization of guava (%)





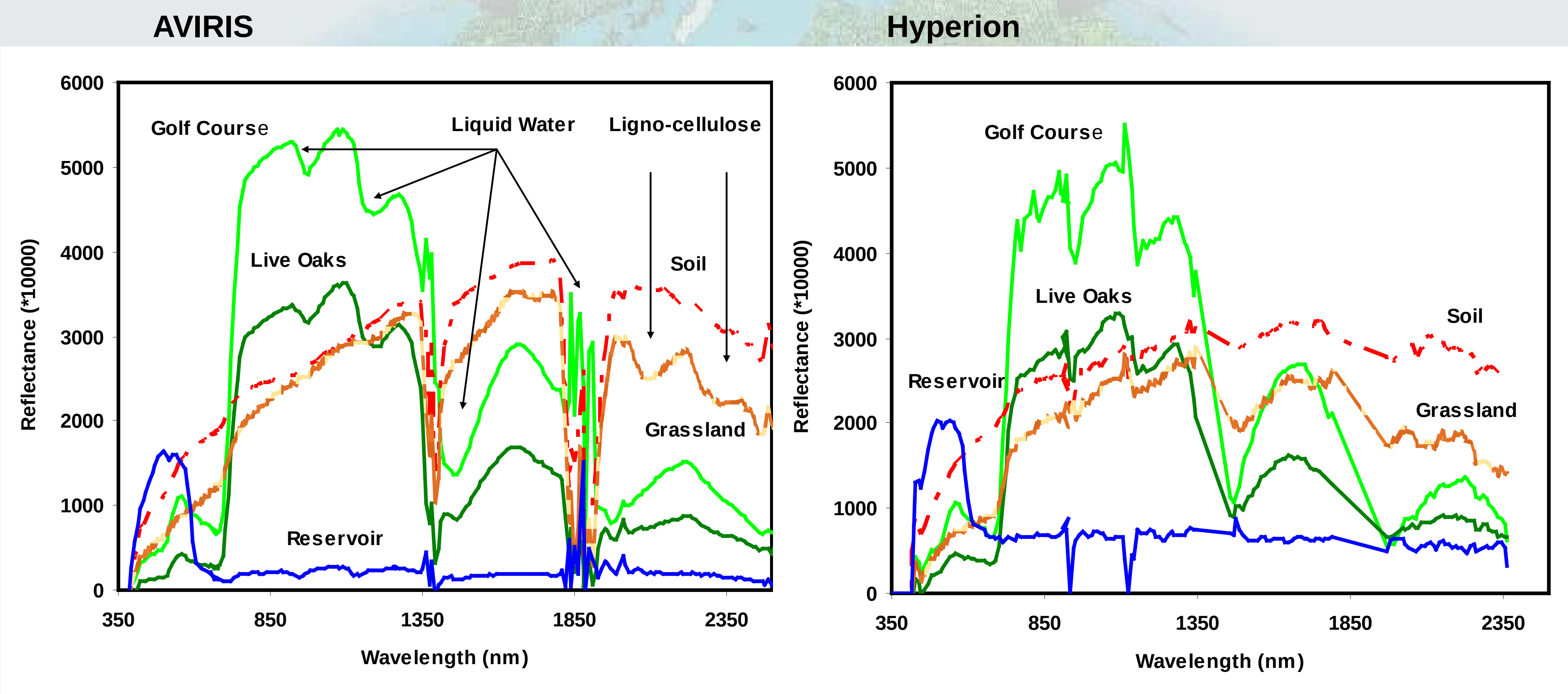
Walsh et al. (2008)

Mapping Fuel Condition: Hyperion provides comparable measures to AVIRIS over a larger geographic region



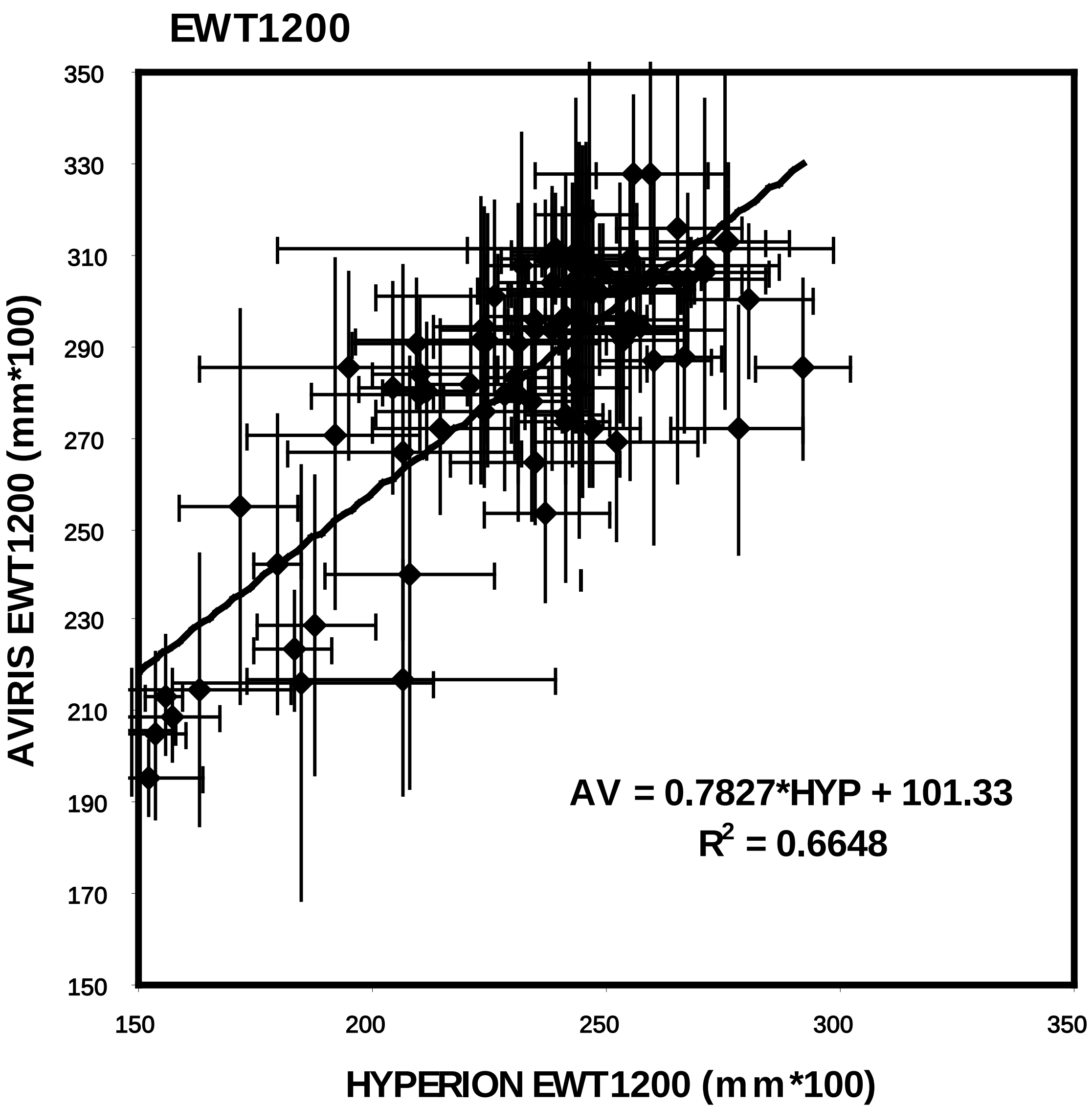
Roberts et al. (2003)

Differences in Sensor Performance



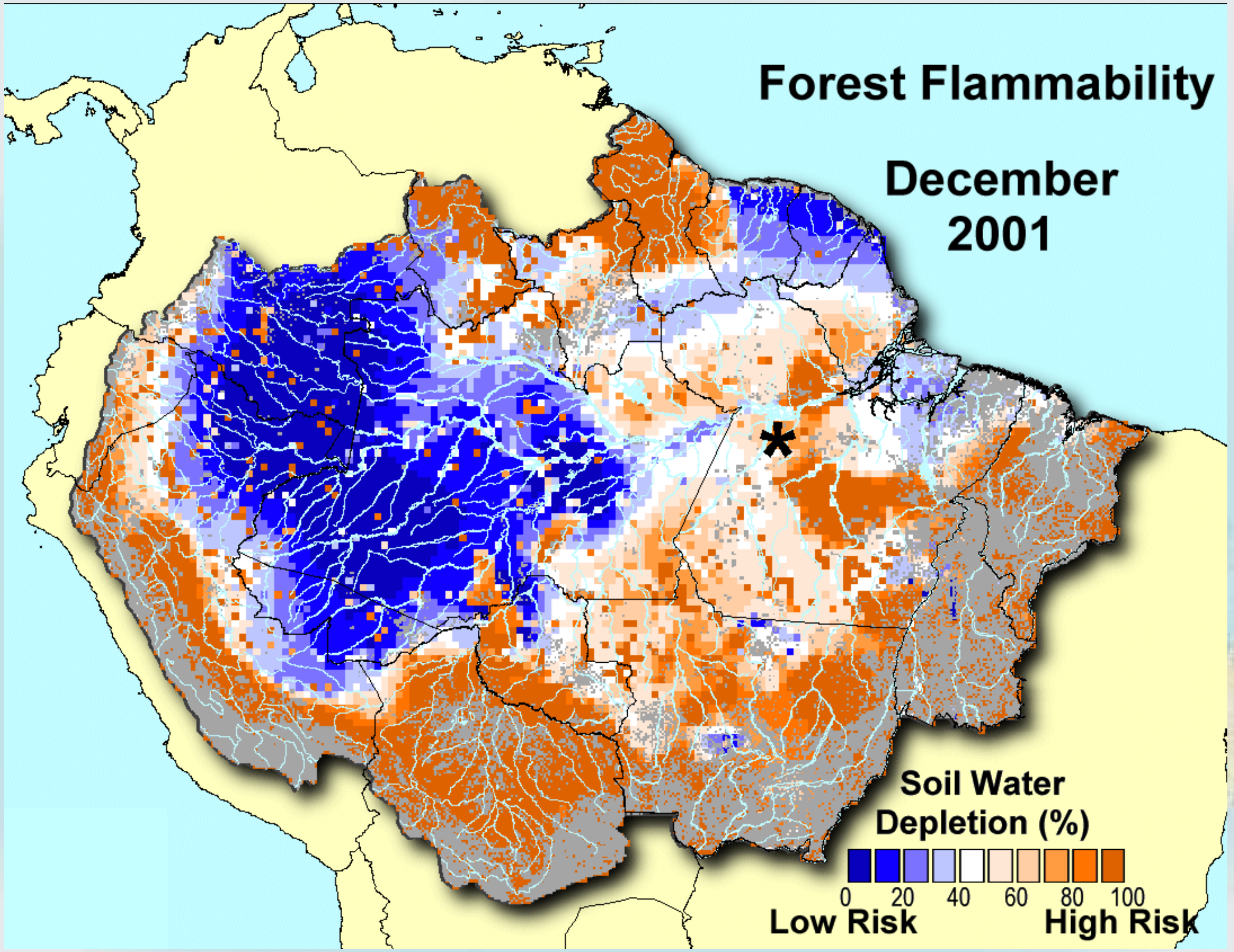
Roberts et al. (2003)

Differences in Sensor Performance



Roberts et al. (2003)

Canopy Water, Drought, and NPP in Dense Tropical Forest (EO-1 Hyperion)

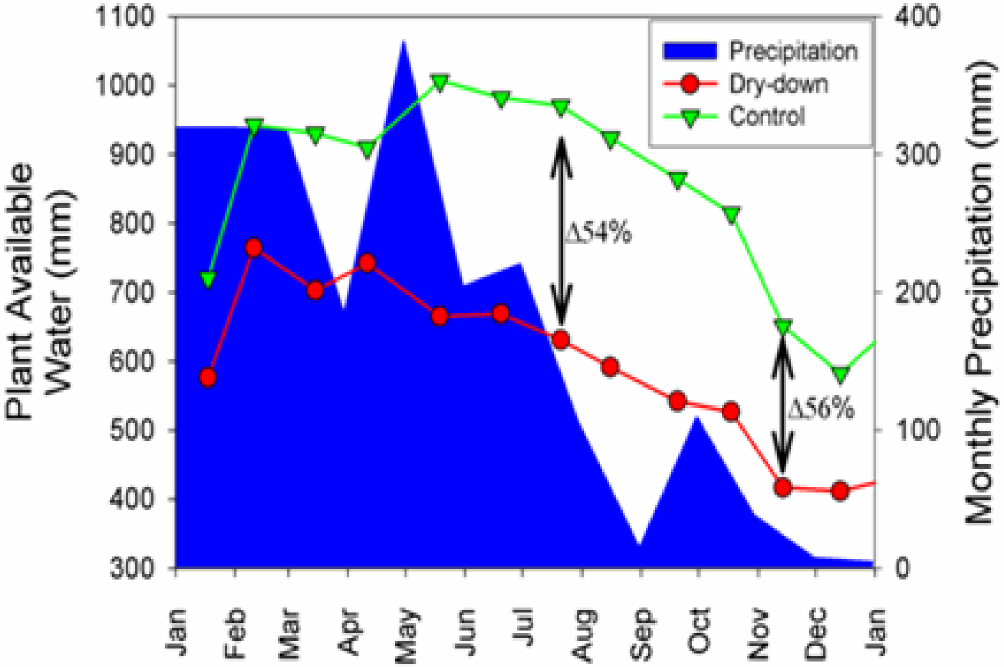


Estimated drought stress throughout the Amazon Basin in December 2001, derived from the RisQue fire model. The approximate location of the forest dry-down experiment is shown with an asterisk.

Asner et al. (2004)

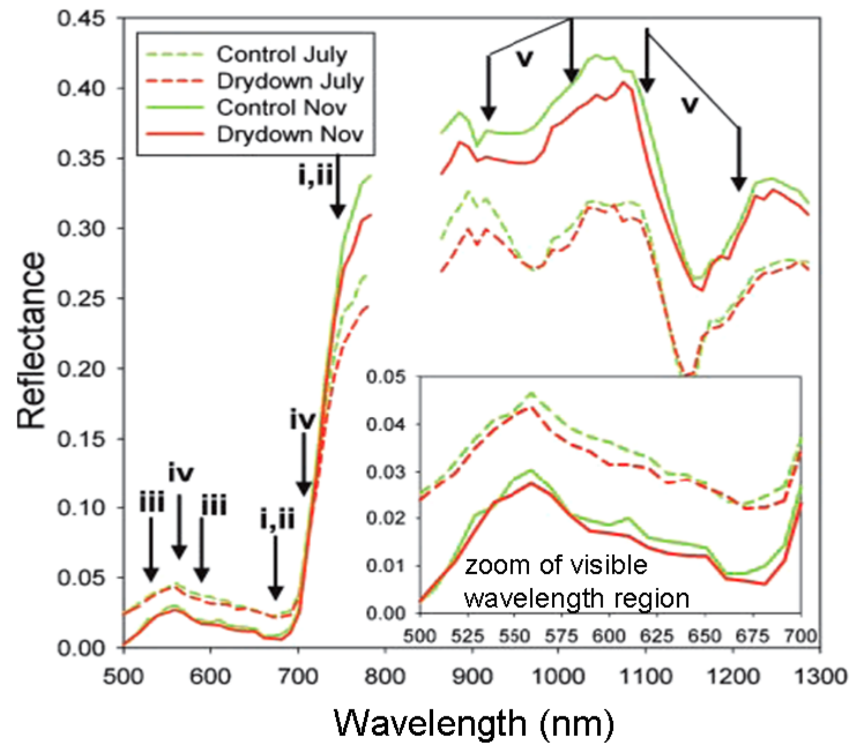
Canopy Water, Drought, and NPP in Dense Tropical Forest

Field Observations



Seasonal precipitation cycle (blue) and plant-available soil water in dry-down (red) and control (green) sites, measured from January 2001 to 2002.

Hyperion

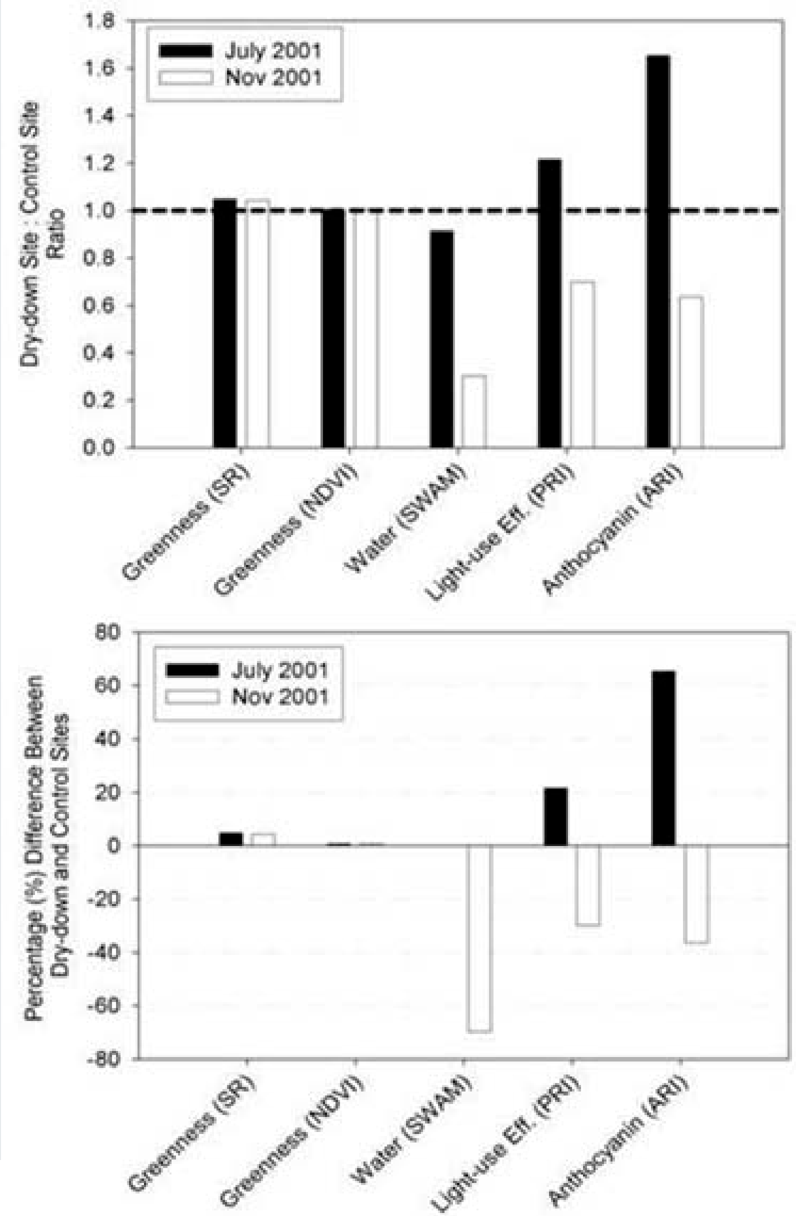


Atmospherically-corrected spectra extracted from the imagery. Inset shows zoom of visible wavelength region.

Asner et al. (2006)

Tropical Forest NPP from Field, Remote Sensing and Modeling Combinations

Spectral Bio-Indicators, Hyperion

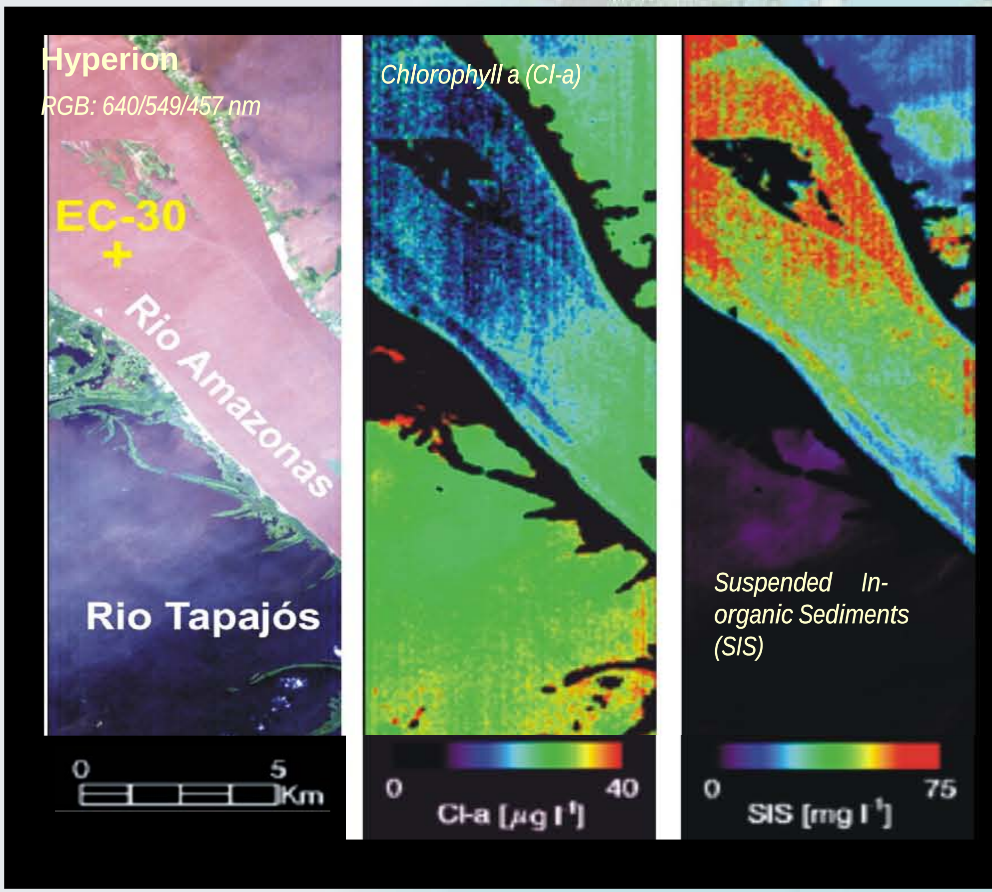


Ratio of net primary production in dry-down and control forest stands ($NPP_{d:c}$) for the year 2001, simulated using satellite data and the CASA model (Field et al. 1995).

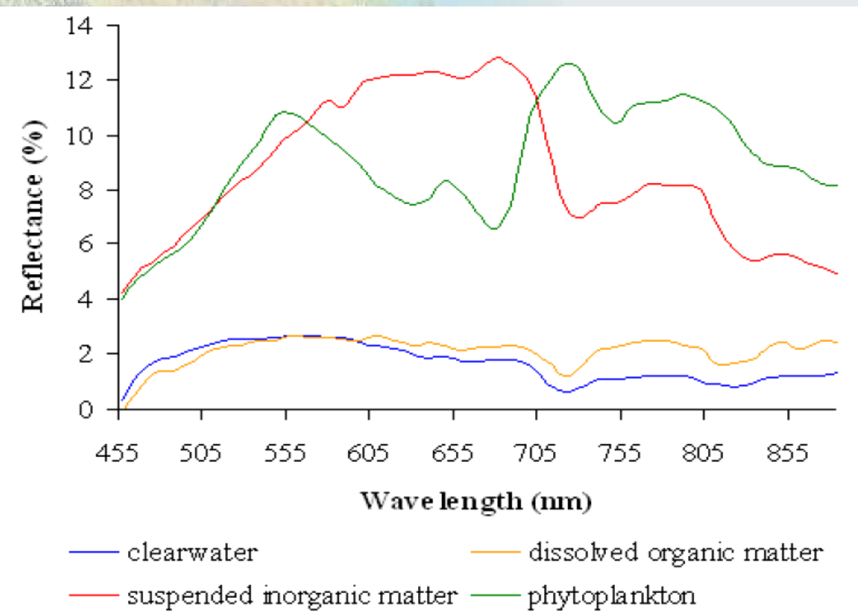
Scenario	$NPP_{d:c}$(2001)
(1) NDVI	0.98
(2) NDVI, PRI	0.85
(3) SWAM	0.69
(4) SWAM, PRI	0.67
(5) LAI	0.99
(6) LAI, PRI	0.84
(7) Field measurements	0.73

Asner et al. (2006)

Composition of Inland Tropical Amazon Floodplain Waters Using Hyperion Derivative Analysis



Hyperion end-members spectra of waters dominated by optically active substances

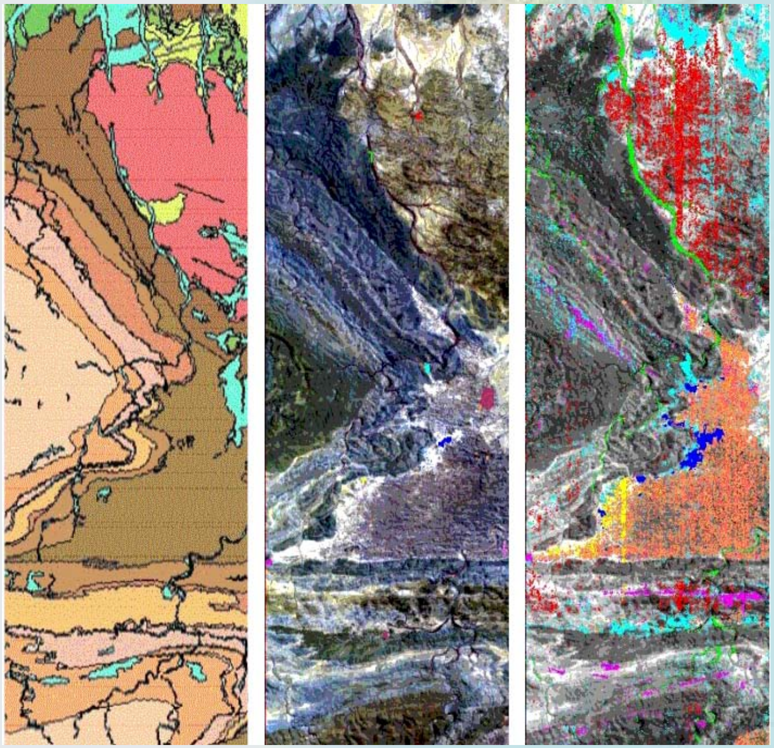


Rudorff et al. (2007)

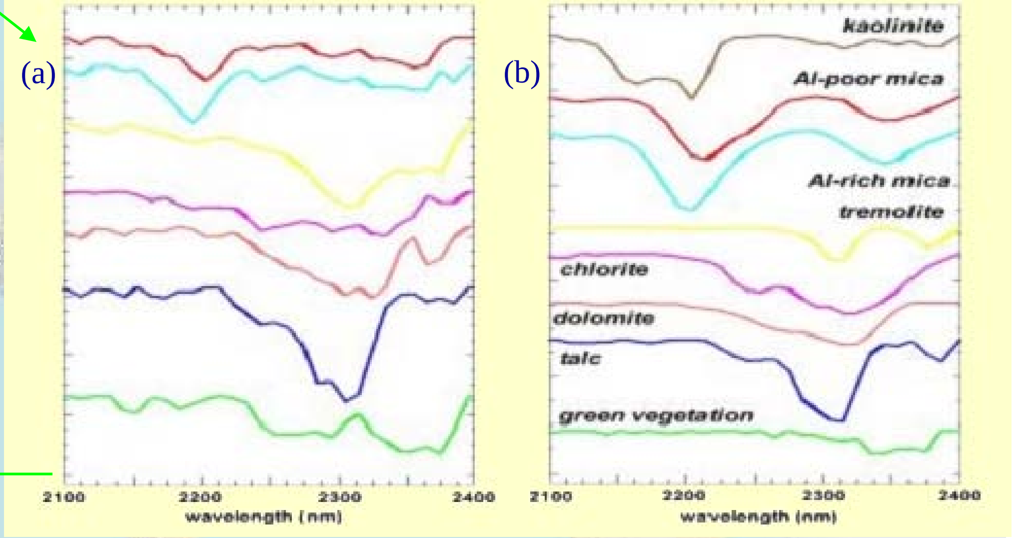
Hyperion Maps Mt. Fitton Geology

Hyperion-based apparent reflectance compares with library reference spectra

(1) (2) (3)



Hyperion Spectra **Reference Spectra**



Hyperion surface composition map agrees with known geology of Mt. Fitton in South Australia

(1) Published Geologic Survey Map

(2) Hyperion three color image (RGB) showing regions of interest

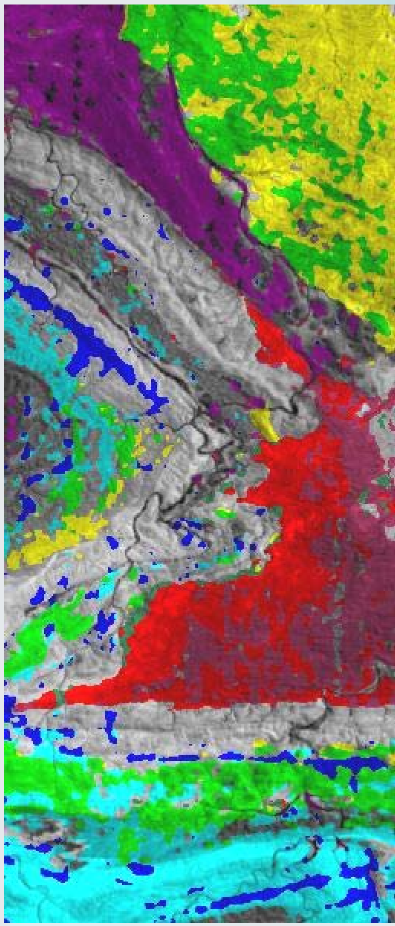
(3) Hyperion surface composition map using SWIR spectra above

Courtesy of CSIRO, Australia

Hyperion Maps Mt. Fitton Geology

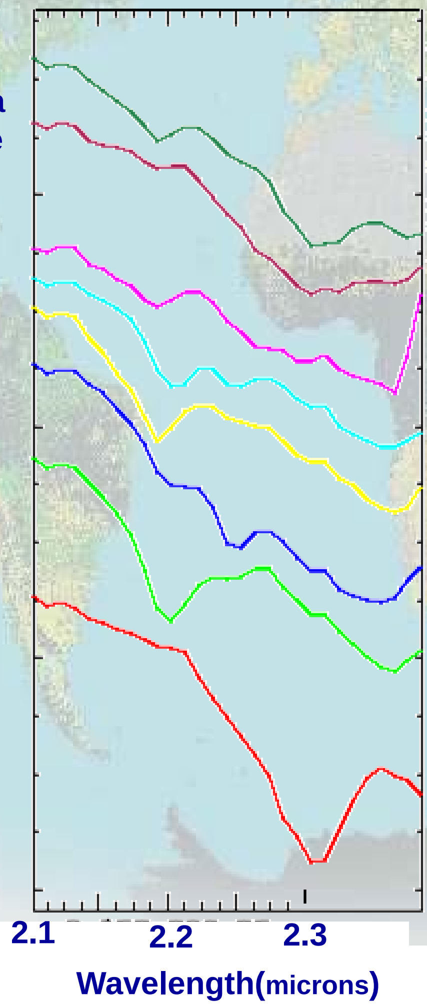
Automatic mineral mapping algorithm creates, in 30 seconds, a quick-look mineral map (left & centre). More precise detail is on right.

Mineral Map



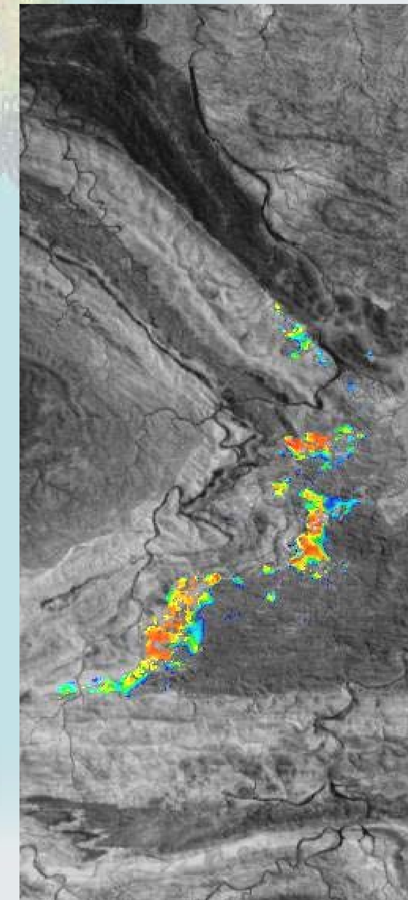
Colours of spectra match the thematic image to left.

Mineral Spectra



Colours to the right indicate the relative abundance of talc/tremolite . → Red shows areas of greatest abundance and blue gives the least.

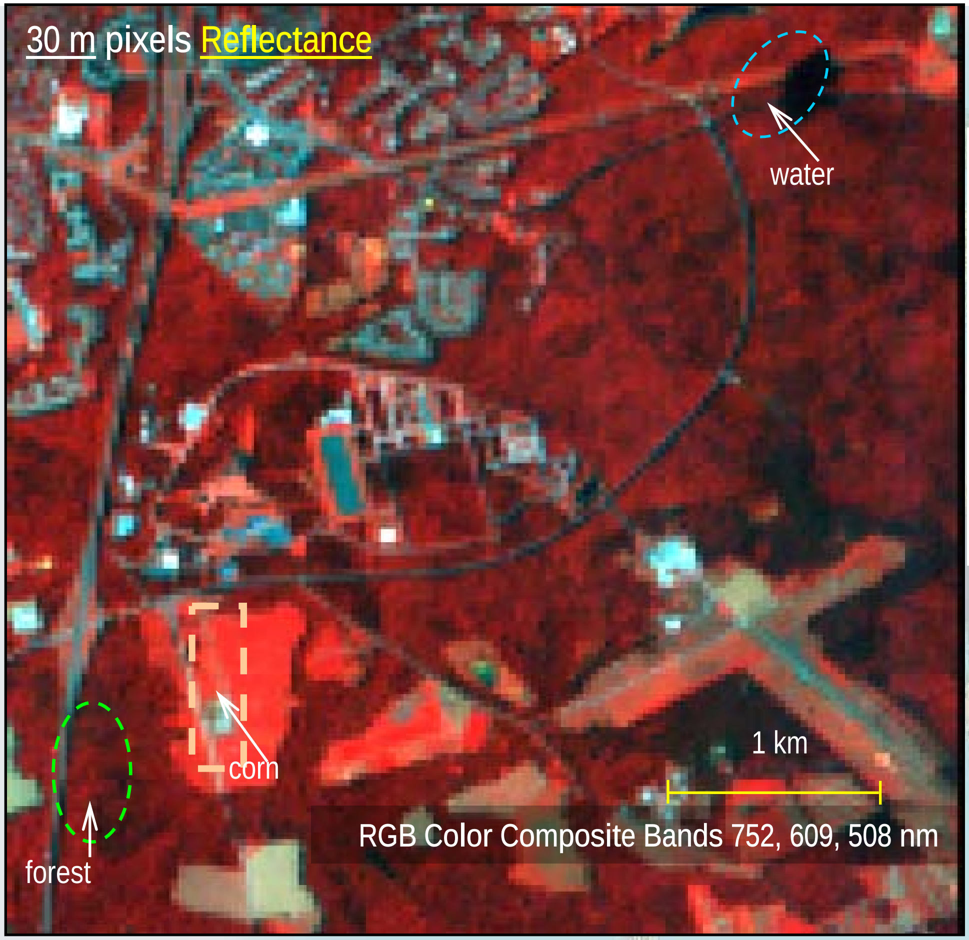
Detailed Talc-Tremolite Map

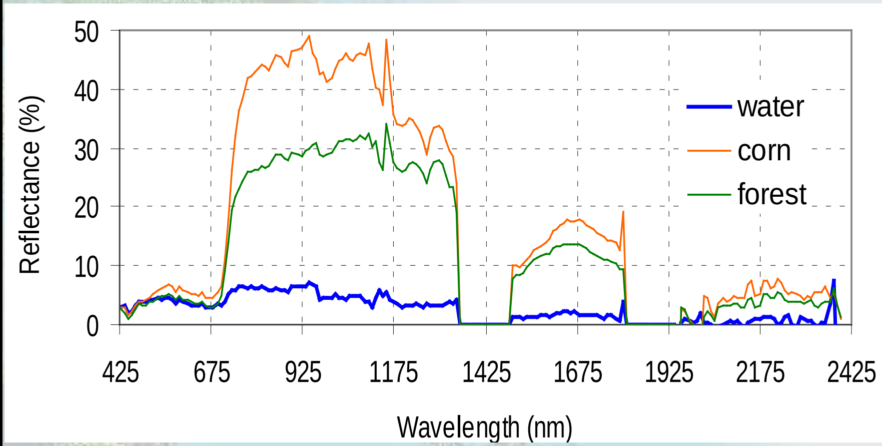


(Courtesy of CSIRO Australia)

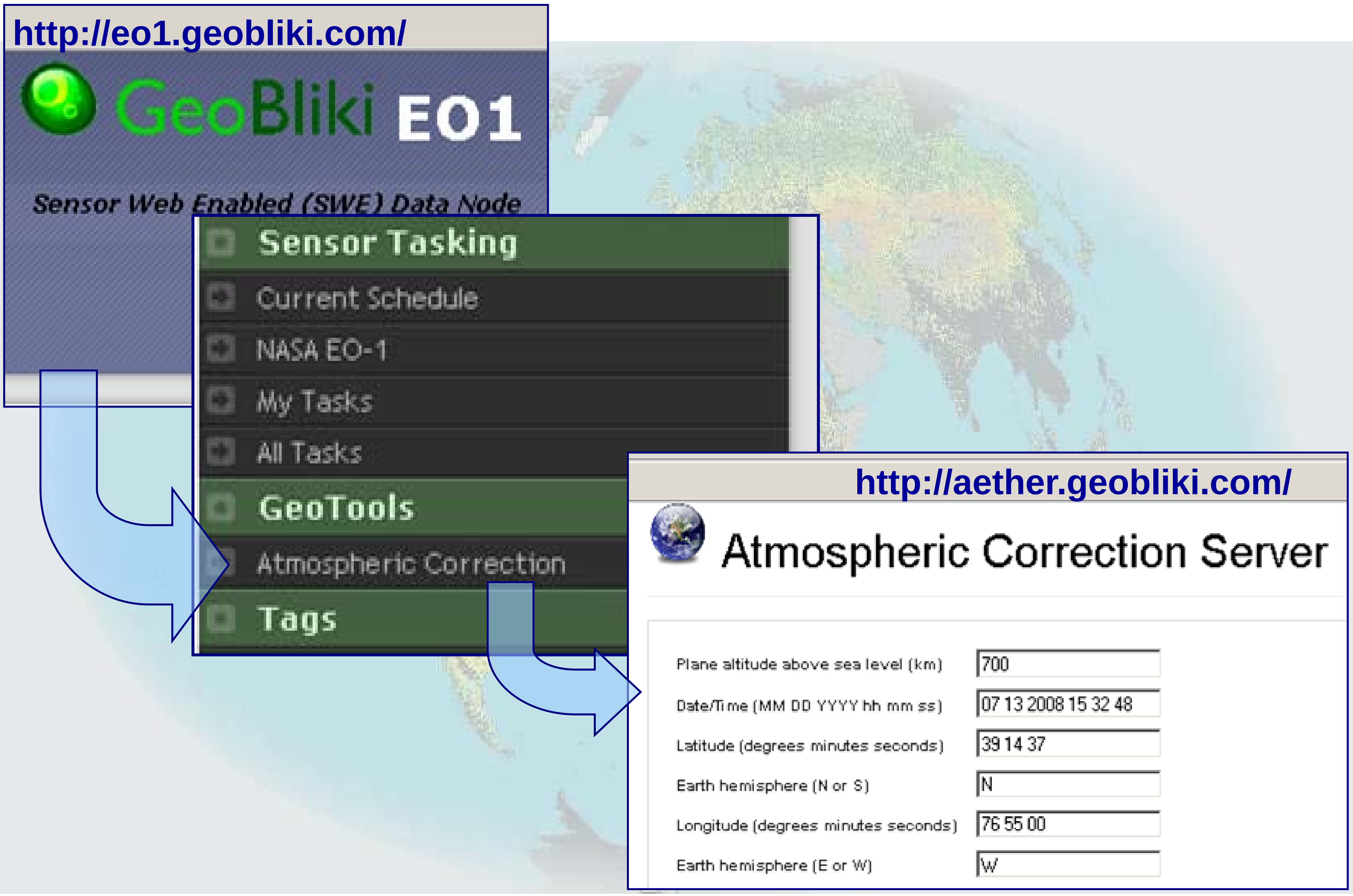
March 2009

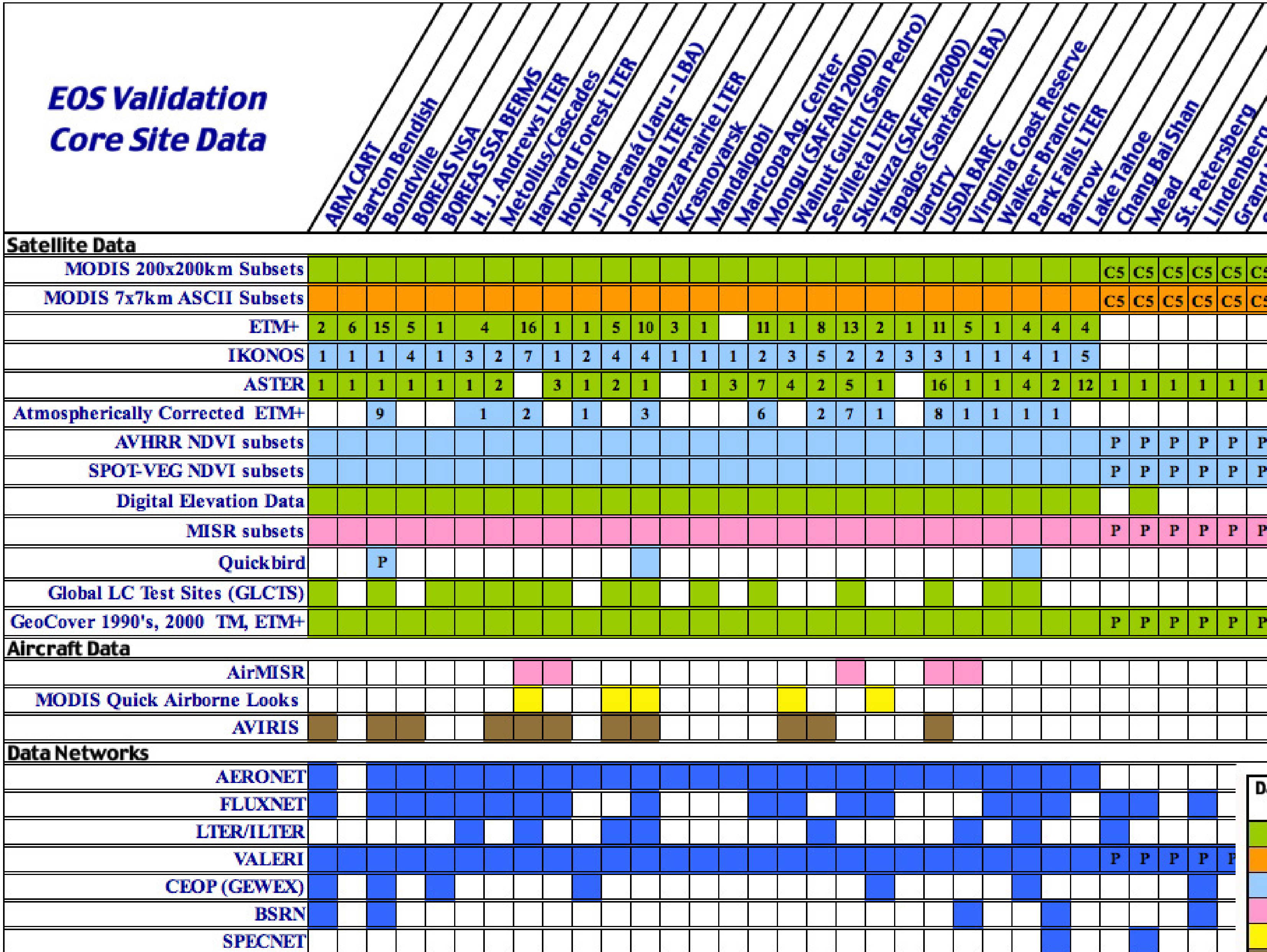
EO-1 is Developing Hyperion Vegetation Reflectance Products

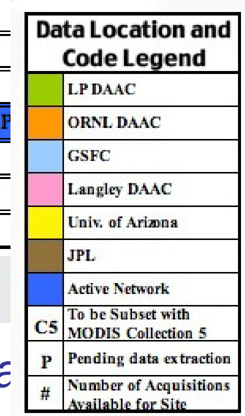




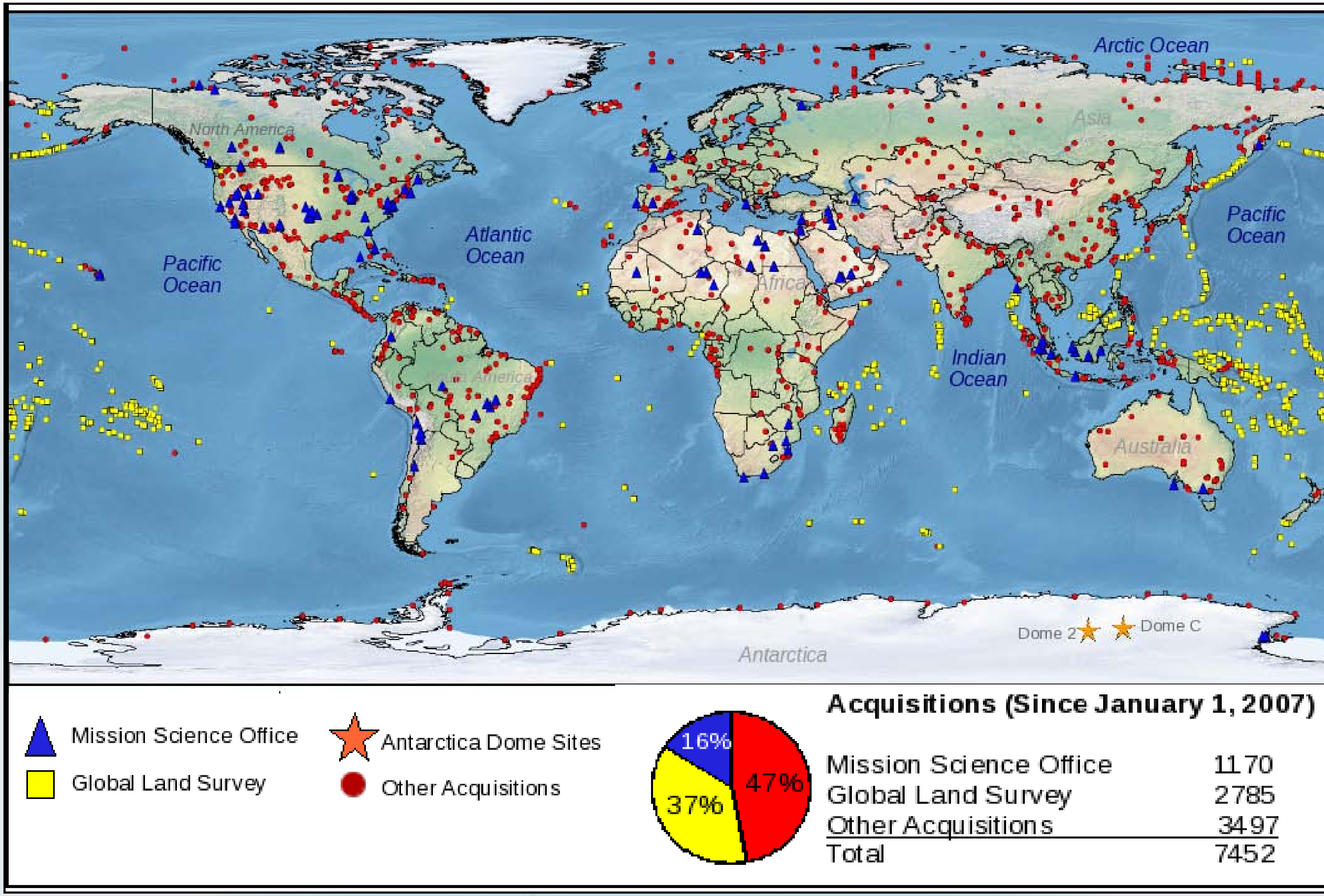
Pixel	Vegetation Indices:						Albedo		
size	V1	PRI	REIP	Dmax	NDWI	NDVI	water	corn	forest
30 m	1.81	-0.14	721	0.749	0.14	0.81	0.03	0.20	0.14
60 m	1.88	-0.15	721	0.748	0.15	0.82	0.04	0.20	0.13


http://eo1.geobliki.com/
GeoBliki EO1
Sensor Web Enabled (SWE) Data Node
Sensor Tasking
Current Schedule
NASA EO-1
My Tasks
All Tasks
GeoTools
Atmospheric Correction
Tags
http://aether.geobliki.com/
Atmospheric Correction Server
Plane altitude above sea level (km)
700
Date/Time (MM DD YYYY hh mm ss)
07 13 2008 15 32 48
Latitude (degrees minutes seconds)
39 14 37
Earth hemisphere (N or S)
N
Longitude (degrees minutes seconds)
76 55 00
Earth hemisphere (E or W)
W





Nickeson, J., J. Morisette, J. Privette, C. Justice, D. Wickland, 2007. Coordinating Earth Observing System Land Validation, *EOS Transactions*, 88(7)81-82.



EO-1 acquisitions during 2007-2009, summarized into three main categories: 1] Science and disaster response, 2] Global Land Surveys (GLS2005 and GLS2010), and 3] Calibration collects.

March 2009