EO-1 Tracing Vegetation Seasonal Dynamics

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Background

The Earth Observing One (EO-1) Mission, launched in November, 2000 as part of NASA's New Millennium Program, is in it's ninth year of operation. From the start it was recognized that a key criteria for evaluating the EO-1 technology and outlining future Earth science mission needs is the ability of the technology/strategy to characterize terrestrial surface state and processes. The EO-1 Science Validation Team conducted a range of investigations to ascertain how well the employed technology and acquisition strategy served to enhance the extraction of scientifically viable information. Investigators engaged in NASA's Terrestrial Ecology, Carbon Science, Land Use Change and other programs using the EO-1 Hyperion imaging spectrometer have achieved results with accuracies far exceeding those reached with the current space borne fleet of multispectral sensors.

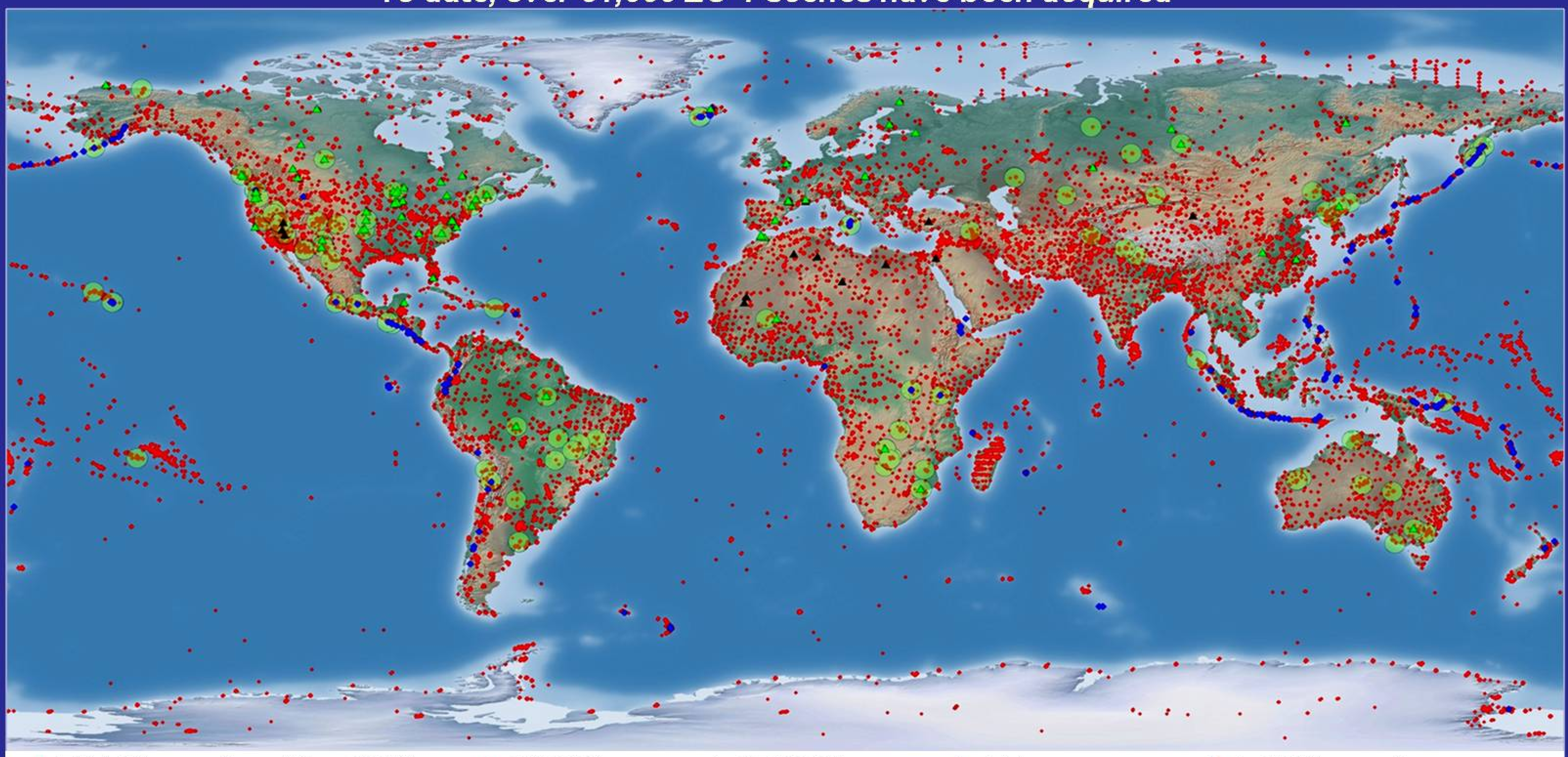
Current Status

EO-1 is participating in a broad range of investigations, demonstrating the utility of imaging spectroscopy in applications relating to forestry, agriculture, species discrimination, invasive species, desertification, land-use, vulcanization, fire management, homeland security, natural and anthropogenic hazards and disaster assessments and has provided characterization for a variety of instruments on EOS platforms. By generating a high spectral and spatial resolution data set for the corral reefs and islands, it is contributing for realizing the goals of the National Decadal survey and provides an excellent platform for testing strategies to be employed in the HyspIRI mission.

Preparing for HyspIRI

Tools and prototypes for new science products are being developed to provide vegetation biophysical parameters such as LAI and fAPAR at <100 m spatial resolution for selected EOS validation sites. These will be used to resolve variability in heterogeneous areas (e.g. agriculture, narrow shapes, urban and developed lands) and for managed ecosystems less than 10 km^2. A set of invariable reference targets (e.g. sun, moon, deserts, Antarctica) are being characterised to allow cross-calibration of EO sensors, comparison of land products generated by multiple sensors and retroactive processing of time series data. Such products are needed to develop Science Requirements for the next generation of hyperspectral satellite sensors and to address global societal needs .

To date, over 51,000 EO-1 scenes have been acquired

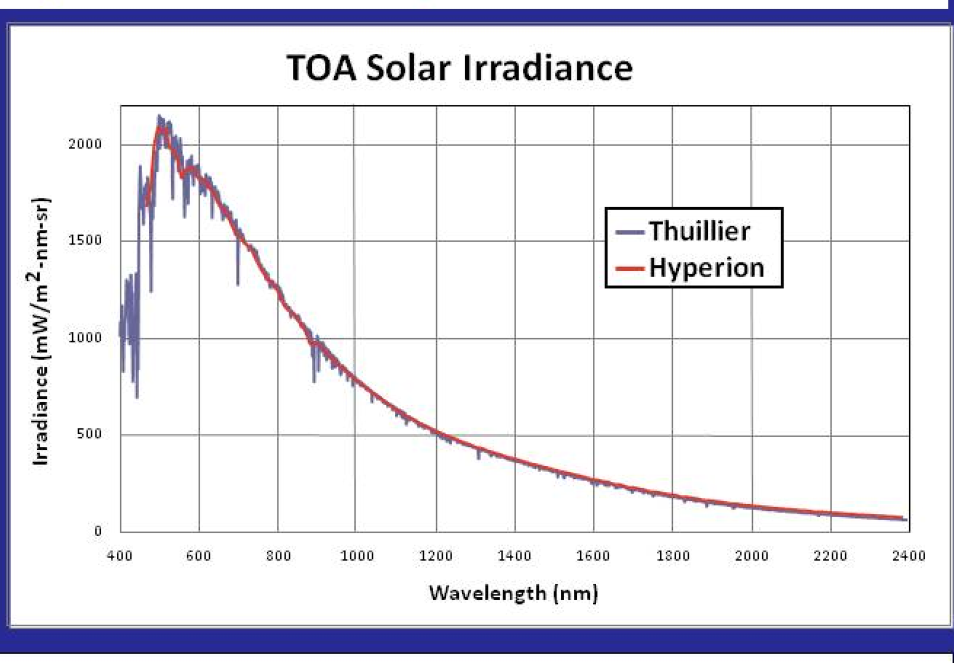


• EO-1 Observations (Nov. 2010) ▲ MSO Sites ▲ CEOS Sites ◆ Volcanoes ○ > 10 Observations

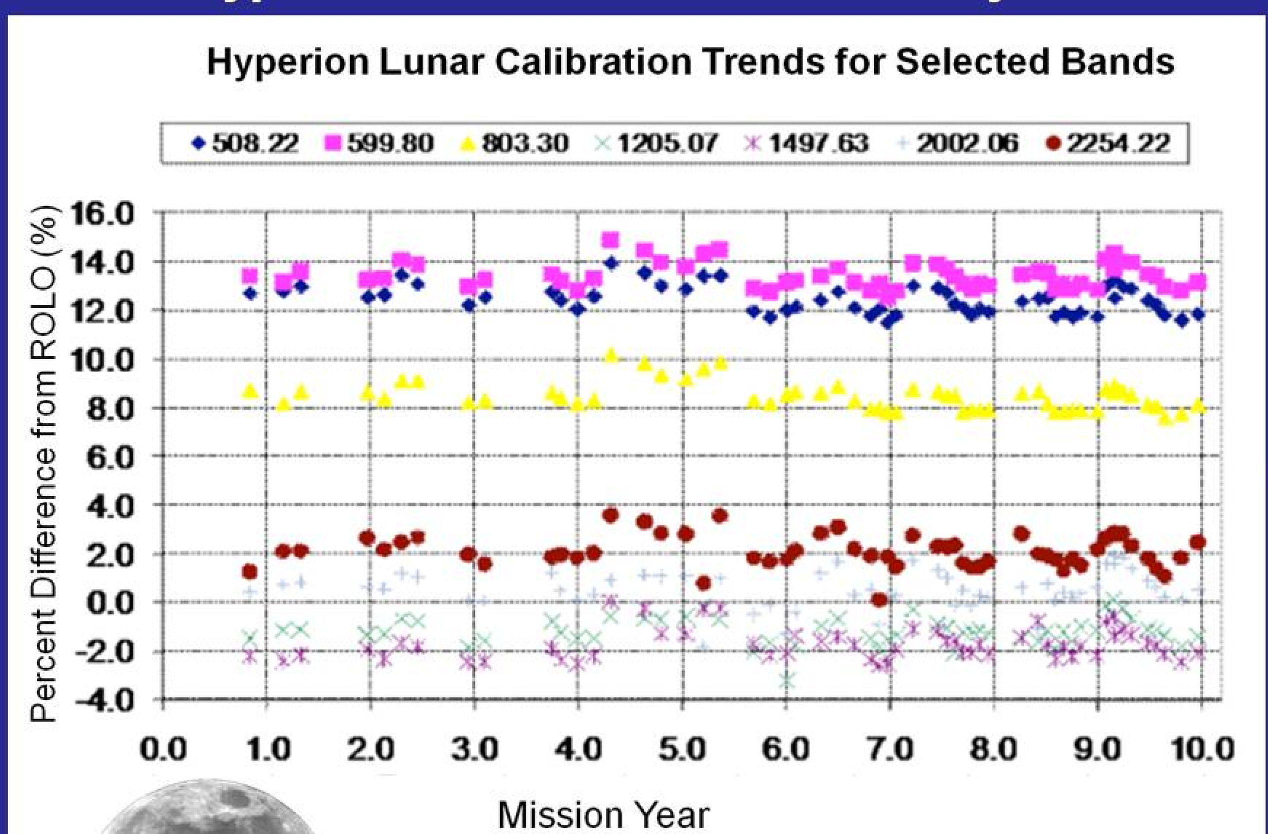
Hyperion Characteristics and Performance

Nominal Data Specification	
Spatial Resolution	30 m
Swath Width	7.5 km
Spectral Range	400- 2400 nm
Spectral Resolution	10 nm

Fully Calibrated Spectral Bands	Band #	Wavelength(nm)
VNIR	8 - 55	426- 895
	56 - 57	913- 926
SWIR	77 - 78	912- 923
	79 - 224	933- 2396



Hyperion Calibration and Stability



Hyperion lunar calibration trends are compared to the Robotic Lunar Observatory Model (ROLO).

Top of Atmosphere Reflectance for EO-1 Hyperion

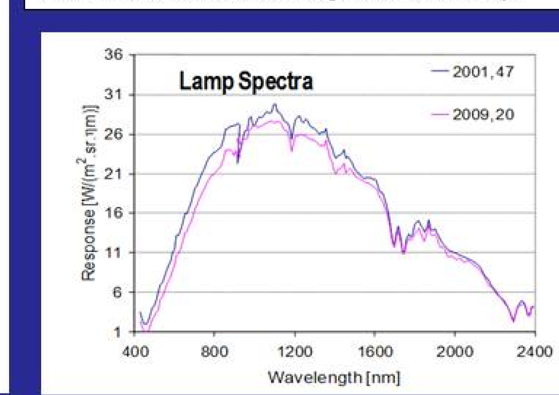
Use the Thuillier Solar Spectral Irradiance [E_k] model. Calculate a Solar Spectral Irradiance [E_n] for Hyperion band n by calculating a weighted average of the Thuillier E_k values within each Hyperion band pass. This is achieved by convoluting the Thuillier values with the Hyperion Gaussian spectral response [$f_n(\lambda)$] for the band under consideration.

$$E_n = \frac{\sum_{\lambda_i - \Delta\lambda_i}^{\lambda_i + \Delta\lambda_i} E_k \, f_n(\lambda_k)}{\sum_{\lambda_i - \Delta\lambda_i}^{\lambda_i + \Delta\lambda_i} f_n(\lambda_k)}$$

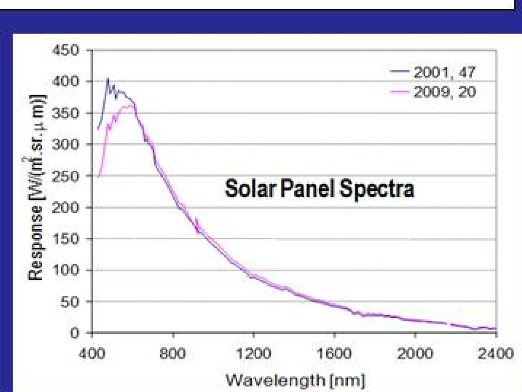
The conversion to exoatmospheric reflectance [ρ^*] is calculated as follows:

$$\rho_n^* = \frac{\pi L_n d^2}{E_n \sin(\theta)}$$

Where: $\mathbf{L_n}$ is the radiance for the Hyperion band centered at wavelength λ_n, $\boldsymbol{\theta}$ is the sun elevation as given in each scene's metadata, $\mathbf{E_n}$ is the mean Thuillier solar spectral irradiance value for band n as calculated from the description above, and **d** is the earth-sun distance in astronomical units which varies according to the Julian day.



Lamps intensity indicates some degradation over the entire spectral range

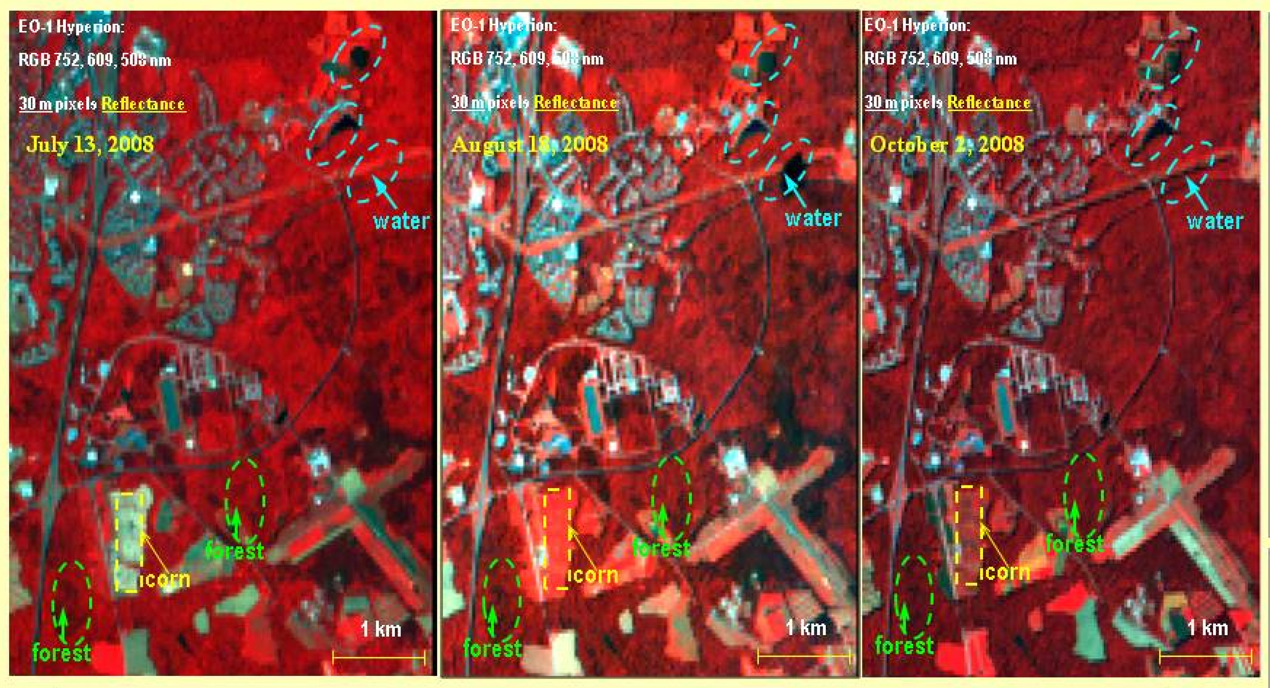


Spectra from the solar panel show large degradation in the shorter wavelengths

Prototyping Tools and Reflectance Products with EO-1 Hyperion

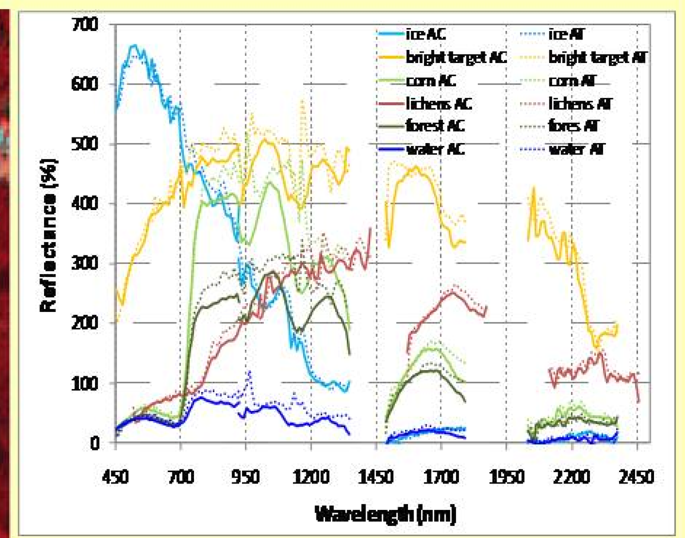
spectral indicators of chlorophyll, water content, albedo, fAPAR, LAI, …..

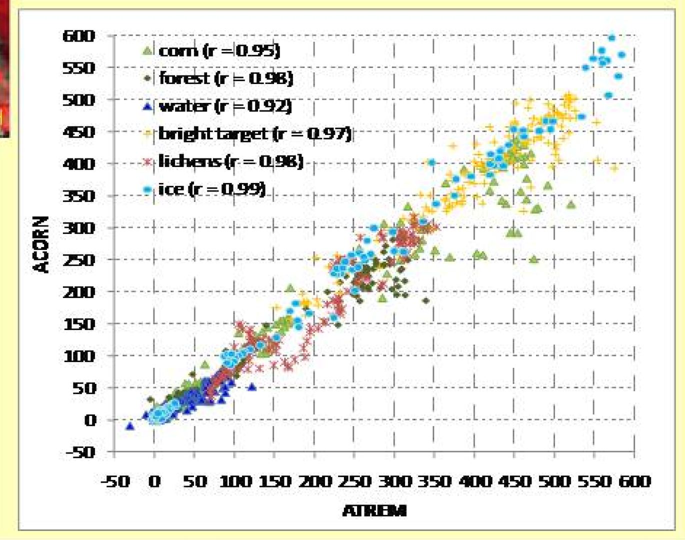
Seasonal Dynamics of Major Land Cover Types, USDA ARC, Greenbelt, MD



Cover Type	Hyperion, 2008	V1	PRI	REIP	Dmax	WBI	Albedo
Corn	13-Jun	1.03	-0.04	712	0.36	0.96	0.461
	18-Aug	1.81	-0.06	722	0.75	1.09	0.197
	3-Oct	1.15	0.04	721	0.51	0.98	0.155
Forest	13-Jun	1.12	-0.06	712	0.89	1.00	0.257
	18-Aug	1.56	-0.03	722	0.51	1.01	0.140
	3-Oct	1.61	-0.10	712	0.42	0.94	0.127
Water	13-Jun	0.15	0.01	712	0.16	1.23	0.058
	18-Aug	0.52	0.02	712	0.10	1.46	0.031
	3-Oct	0.62	-0.07	712	0.08	0.93	0.036

Comparison of ATREM and ACORN

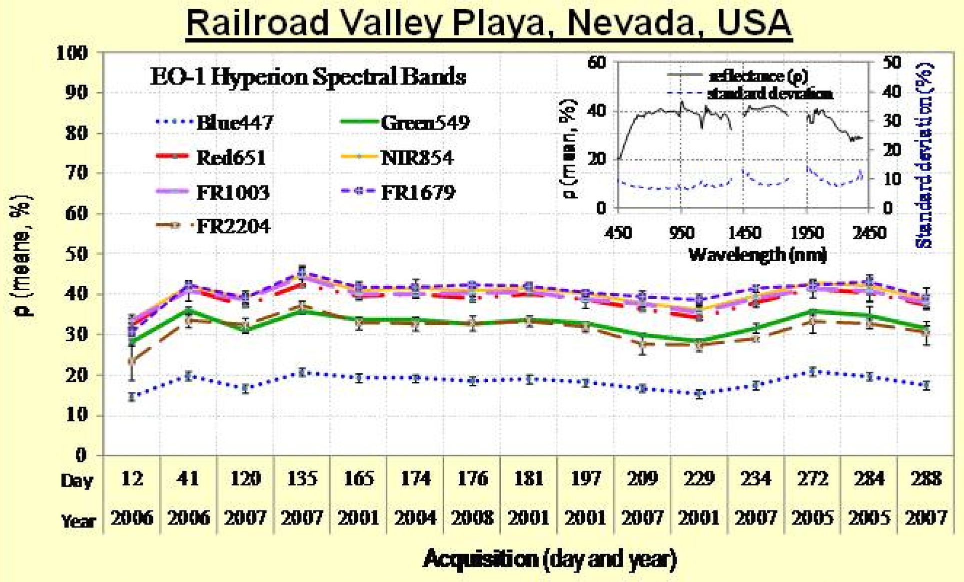




Hyperion Time Series for Science Studies

Spectral Stability at Semi-invariant Sites

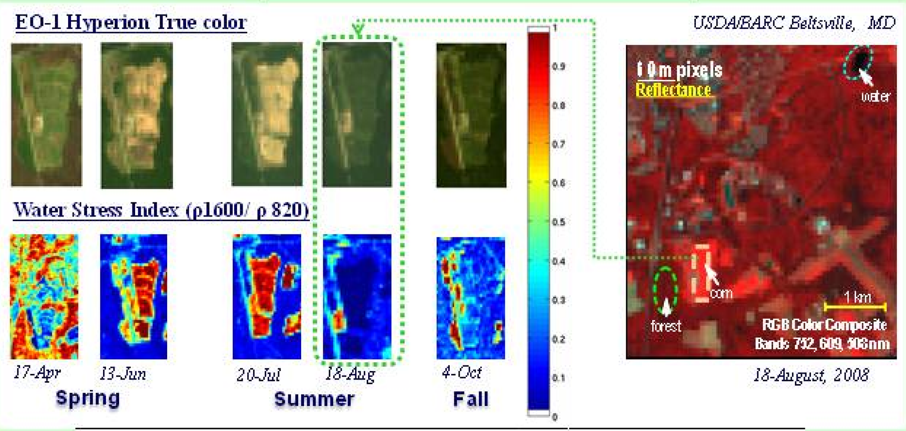
Railroad Valley Playa, Nevada, USA



Linear temporal profile of Hyperion 's spectra over the calibration site at Railroad Valley (NV) demonstrates the relative stability of the spectral characteristics, as indicated for selected bands.

Seasonal Spectral Dynamics of Vegetation

USDA/ARC Beltsville, MD



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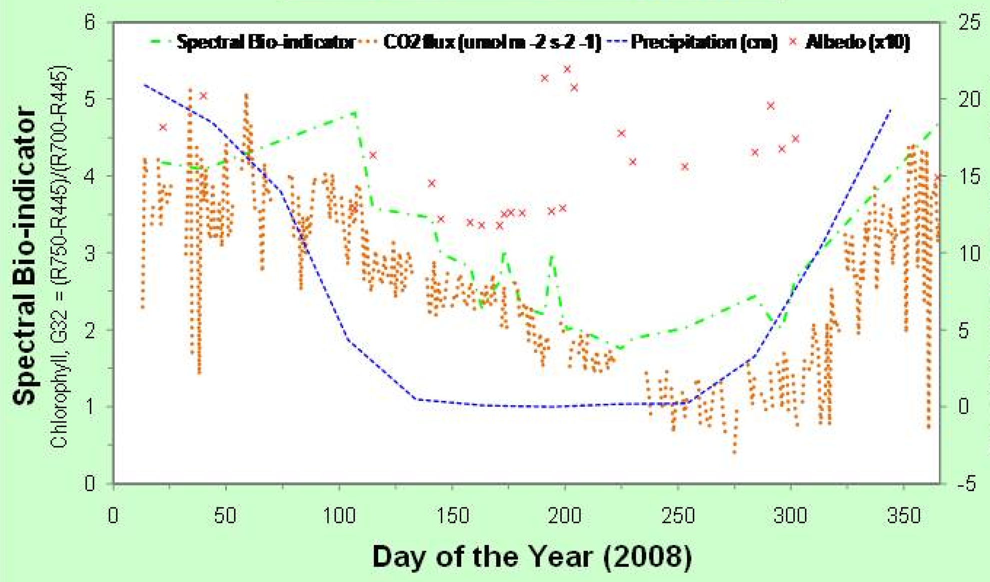
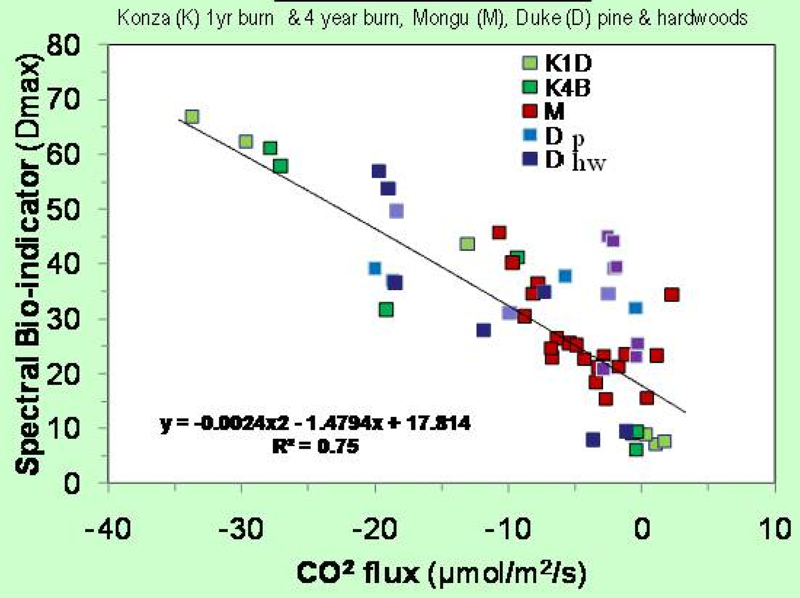
Mongu, Zambia, South Africa



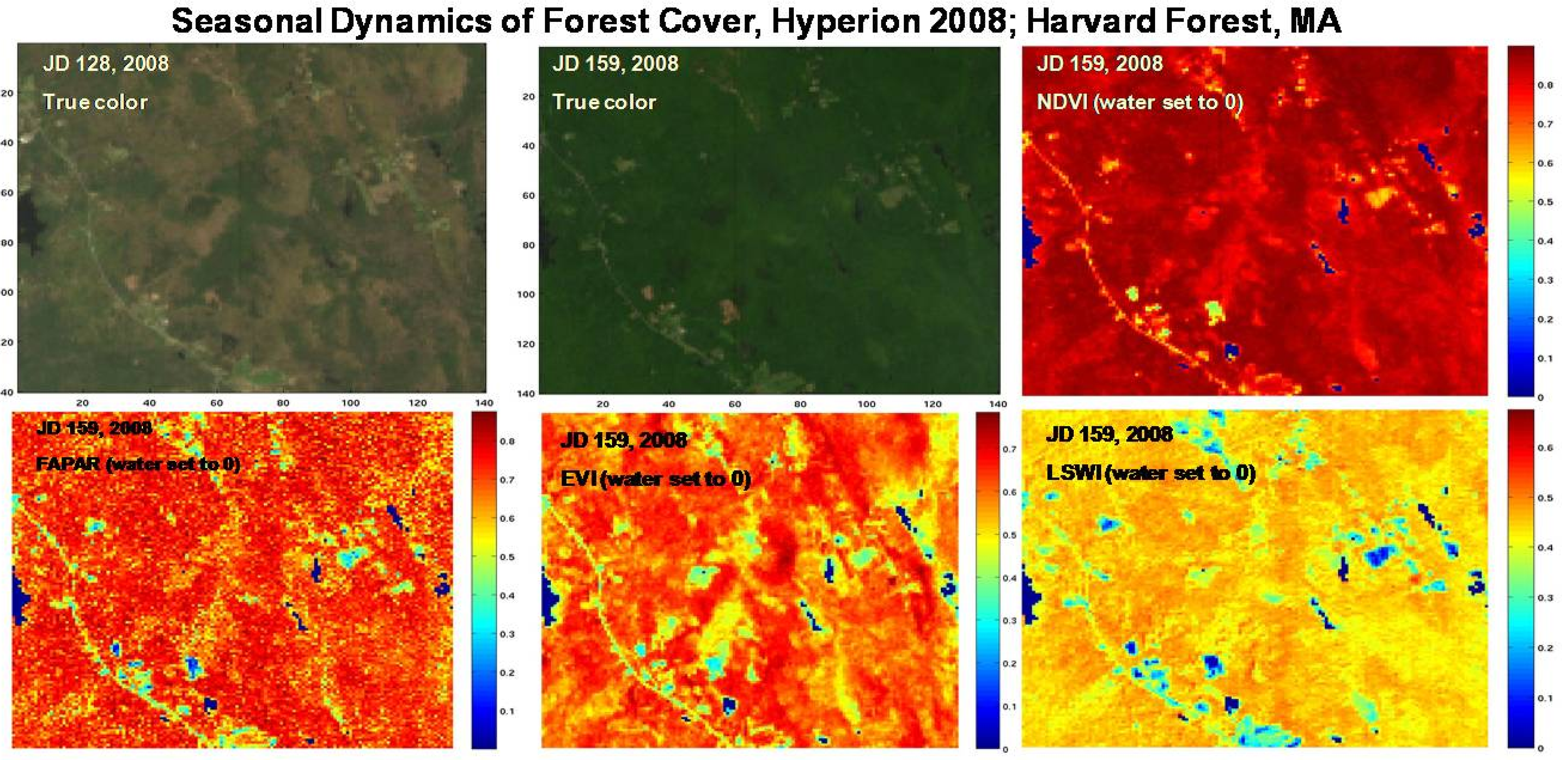
The temporal profile a spectral bio-indicator associated with chlorophyll content (G32, green line) captured the dynamics in vegetation phenology at the flux site Mongu, Zambia.

Multiple Flux Sites



At a number of sites with vastly different vegetation type, the derivative spectral bio-indicator (Dmax) reflected vegetation dynamics and was negatively correlated with CO_2 flux.

Seasonal Dynamics of Forest Cover, Hyperion 2008; Harvard Forest, MA



NASA Land-Cover and Land-Use Change Science Team Meeting, Adelphi, MD, March 28 – 30, 2011