

Evaluation of the potential of Hyperion for fire danger assessment by comparison to AVIRIS

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- NASA Regional Earth Science Applications Center**
- NASA Solid Earth and Natural Hazards Program**

Why Map Fire Danger?

Fire is locally important in Southern California

Average annual cost of \$163 million in structural losses

Postfire effects may exceed the original cost

Fire danger is increasing along the wildland/urban interface

Fire danger may change if climate changes

Fire is a global problem

All Mediterranean ecosystems

Growing importance in tropics

Major disturbance in Boreal Forests

Why Map Wildfire Fuels?

- **Wildfire Fuels Represent one of the Greatest Sources of Uncertainty in Fire Danger**
 - **Spatial and temporal variability is high**
 - **Fuels depend on site quality and stand age**
- **Important Fuel Properties include**
 - **Fuel Moisture**
 - **Fuel Load (kg/m²)**
 - **Fuel Condition (proportion of live to dead fuels)**
 - **Fuel Type (National Fire Danger Rating System)**

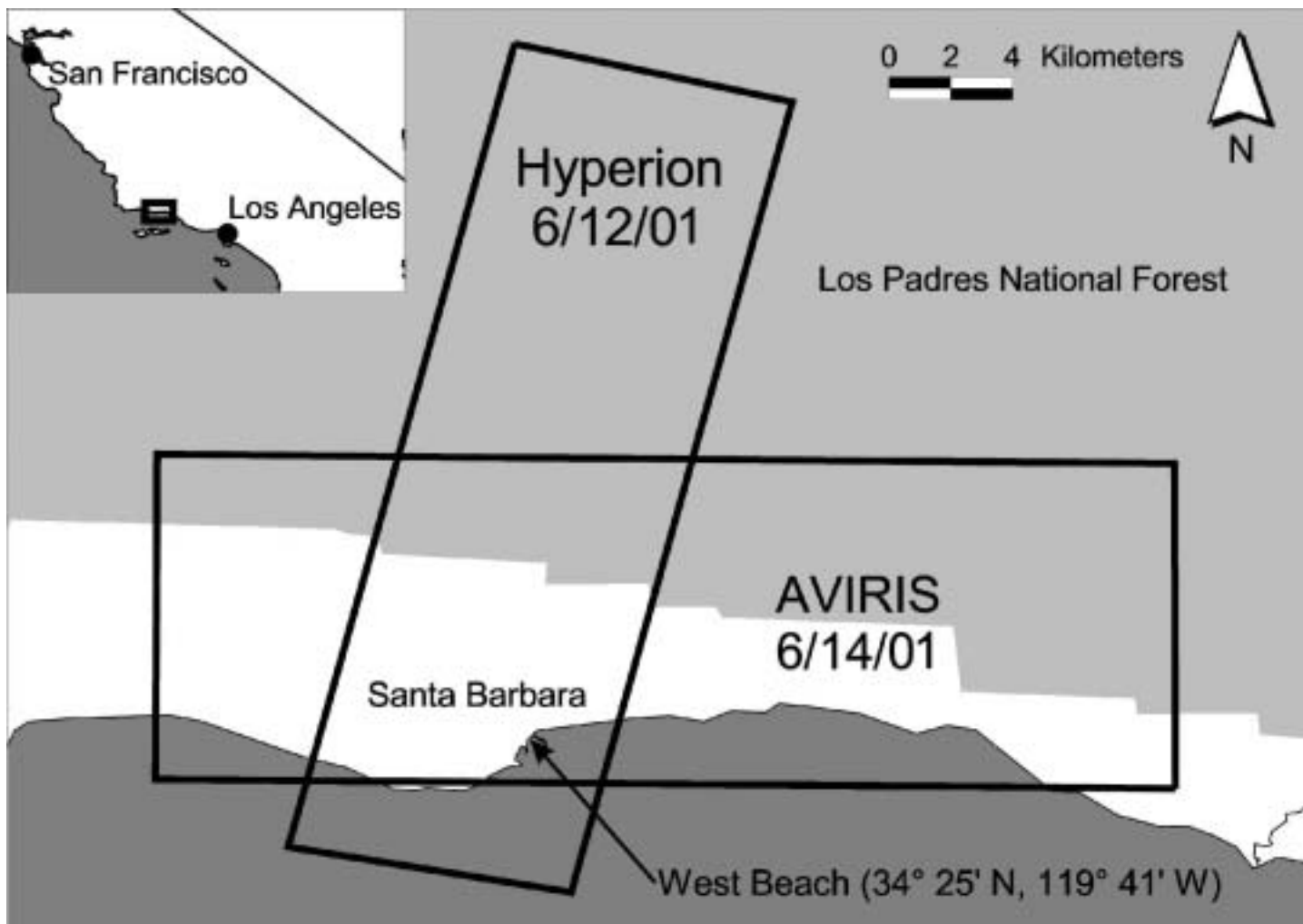
Applications of Hyperion

- **Improved Reflectance Retrieval**
 - Improved monitoring and fuels maps
- **Direct Measures of Fuel Moisture**
 - Hyperspectral measures of moisture
- **Improved mapping of Fuel Condition**
 - Spectral separability of senesced materials from soils
- **Improved maps of fuel type**
- **Improved temporal and spatial sampling**
 - 16 day repeat cycle
 - 7x185 km coverage

Specific Objectives:

- **Hyperion performance assessed using AVIRIS as a reference**
- **Assess the potential for accurate reflectance retrievals**
 - ACORN, applied to Hyperion and AVIRIS (2001)
- **Assess the potential of Hyperion for mapping fuel moisture**
 - $WI = 900\text{nm}/970\text{ nm}$ (Penuelas et al., 1993):
 - $NDWI = (R_{860} - R_{1240}) / (R_{860} + R_{1240})$ (Gao, 1996)
 - Water fits (Green et al., 1993; Roberts et al, 1997)
- **Compare estimates of fuel condition**
 - Spectral Mixture Analysis
 - Reference EMs for GV, NPV, Soil and Shade
- **Map fuel types**
 - Multiple Endmember Spectral Mixture Analysis
 - Improved spectral library organization and development

Study Site

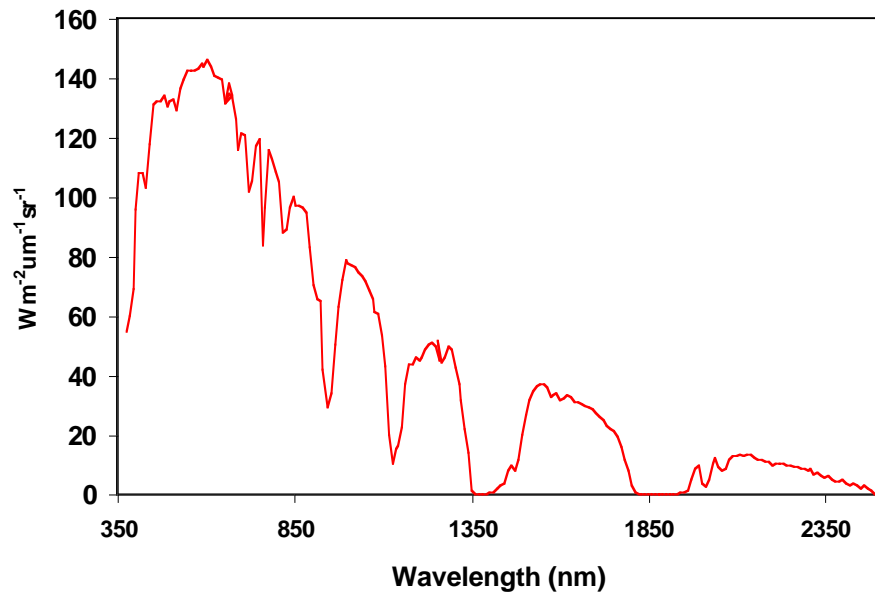


Data Sets

- **Imaging Spectrometry**
 - **Hyperion Acquisition: June 12, 2001**
 - **AVIRIS acquisition: June 14, 2001**
- **Field Spectra**
 - **Calibration targets, urban and natural targets**
 - **ASD full range instrument on loan from JPL**
- **Field Polygons**
 - **Percent Cover of Dominants in six cover classes**
0-10%, 10-25%, 25-50%, 50-75%, 75-90%, 90-100%.
 - **91 AVIRIS, 85 Hyperion, 79 overlapping**
 - **Accuracy assessment and spectral library development**

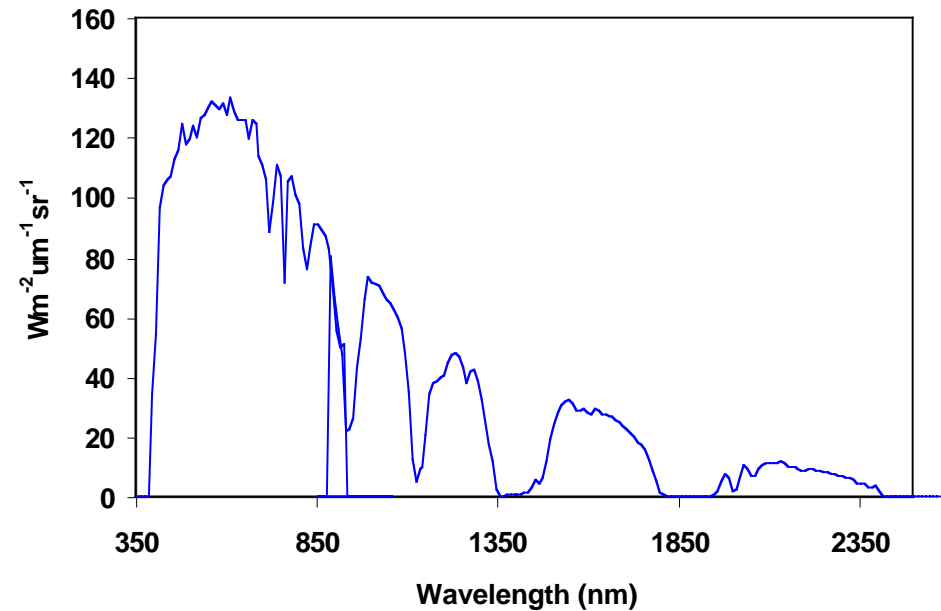
Hyperion and AVIRIS Radiance West Beach, Santa Barbara

AVIRIS Spectral Radiance



$\theta = 11.7^\circ$ N = 8

Hyperion Spectral Radiance

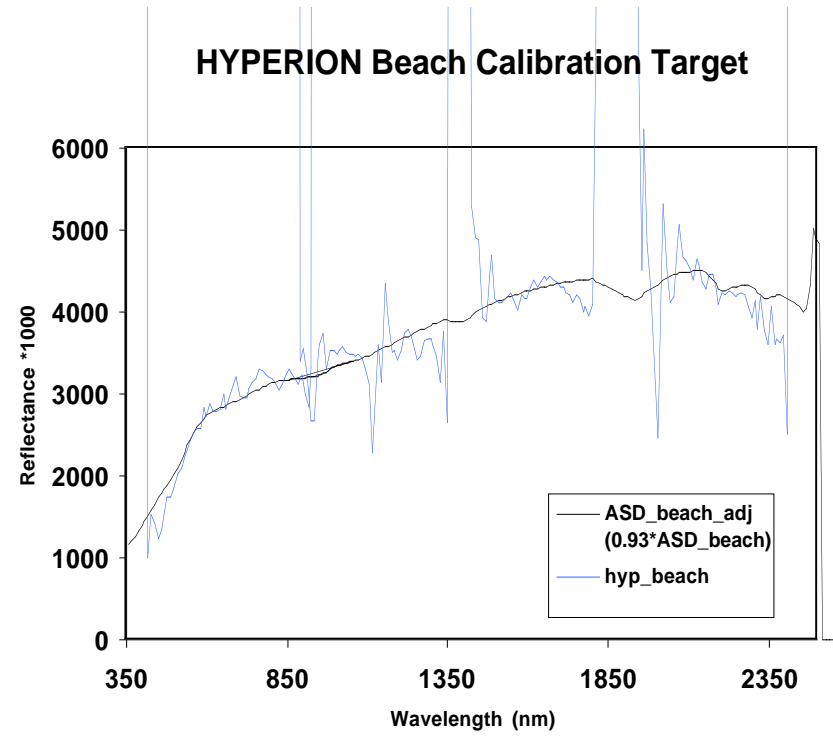
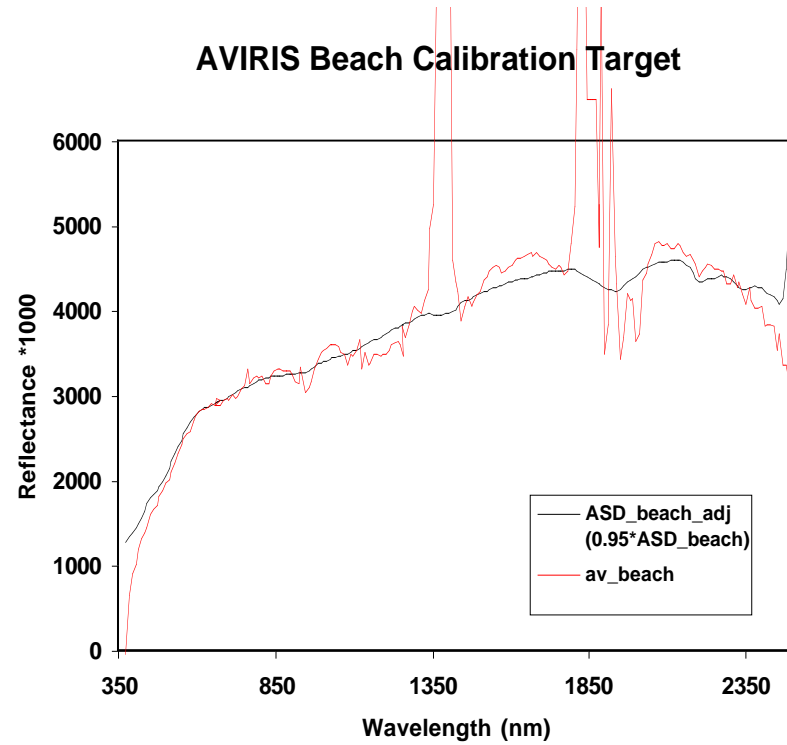


$\theta = 23^\circ$ N = 6

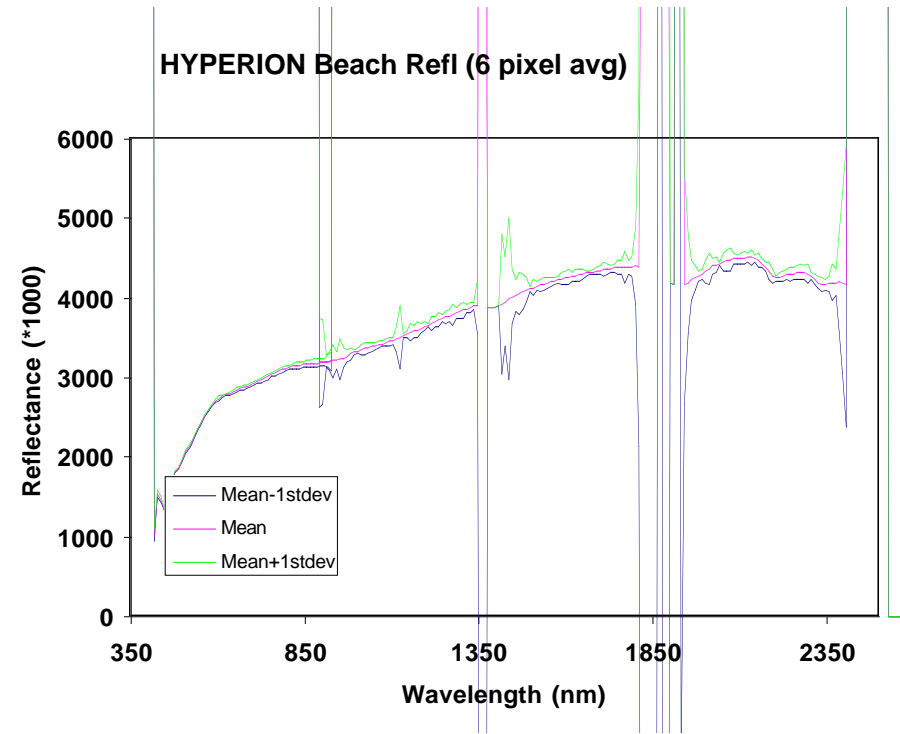
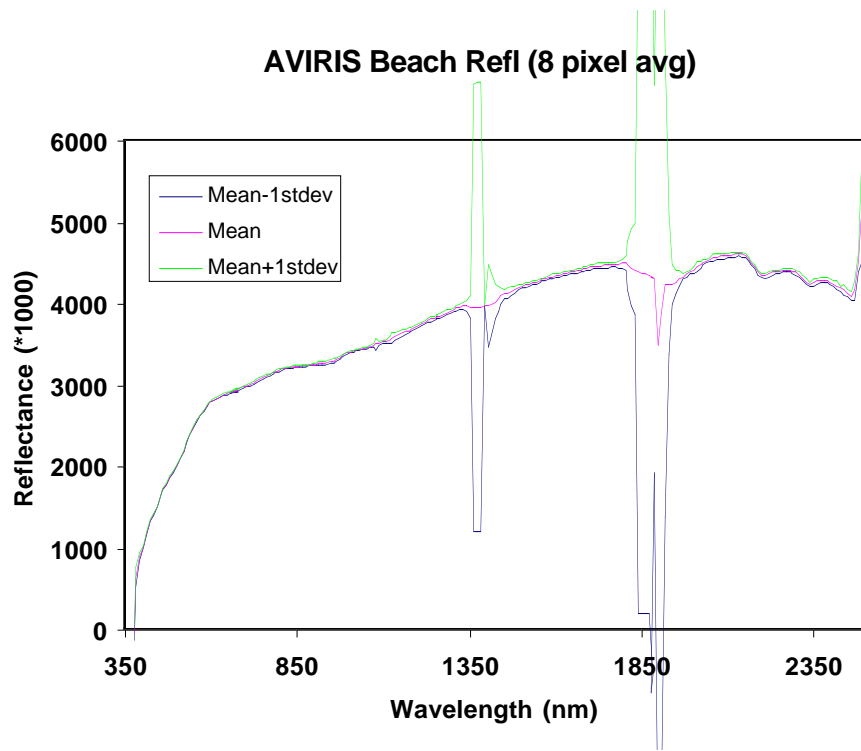
Hyperion: On Orbit Radiance Corrections

1.08 *VNIR, 1.18 *SWIR

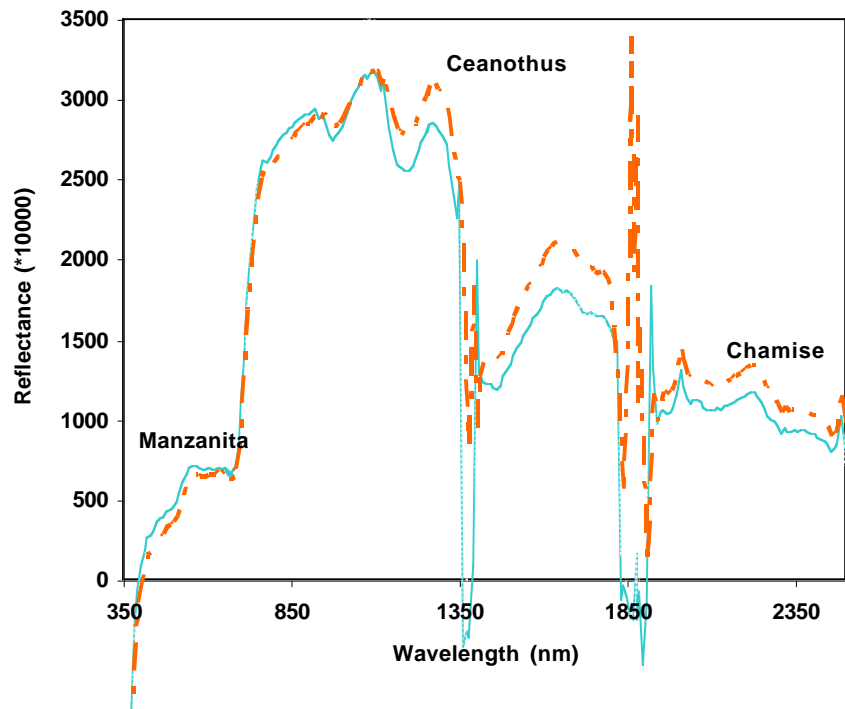
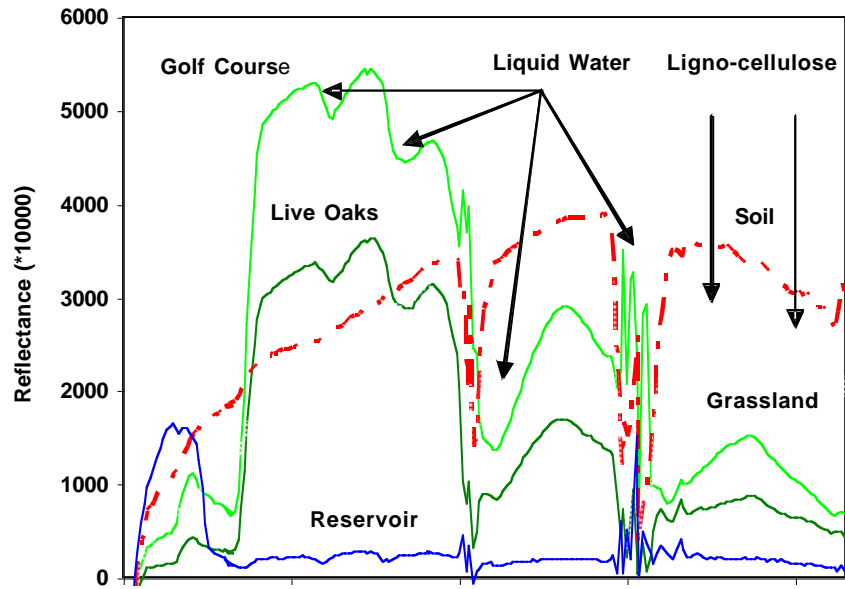
Reflectance Retrieval



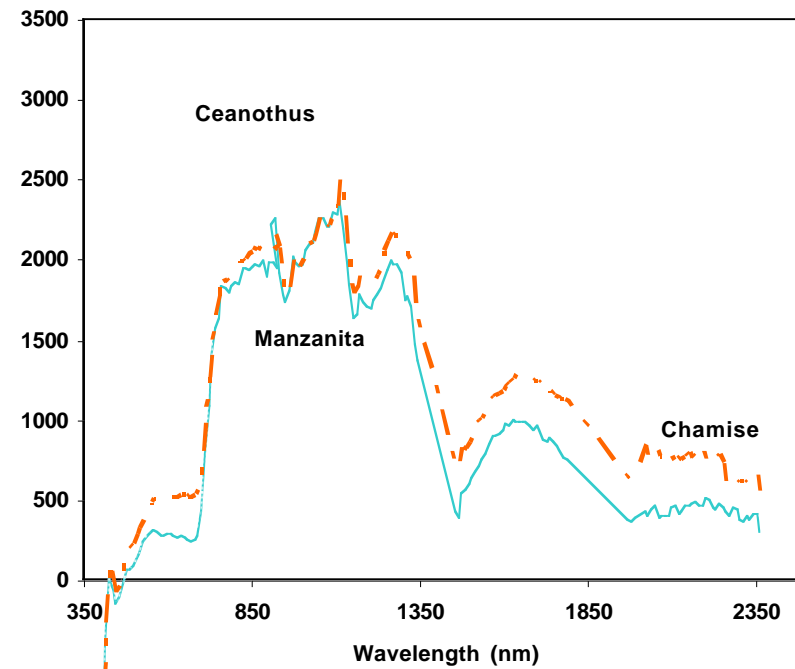
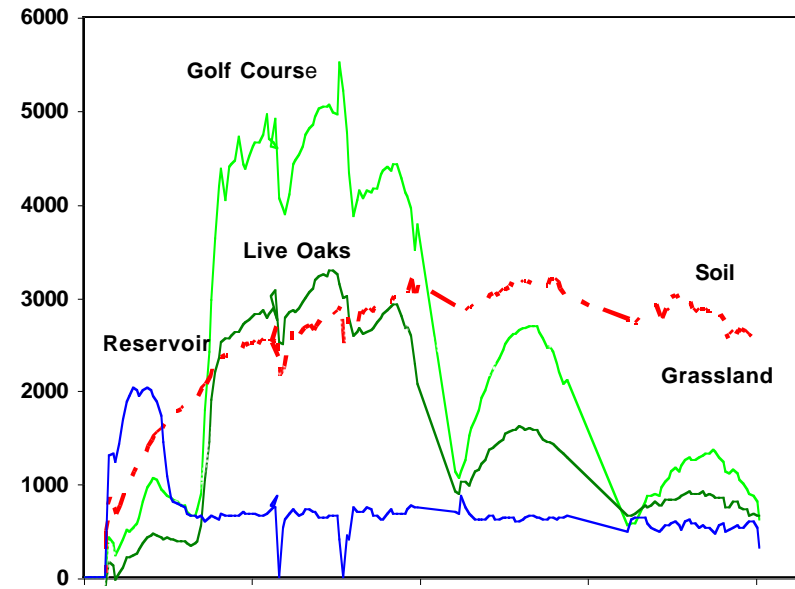
Ground-target Adjusted Reflectance



AVIRIS

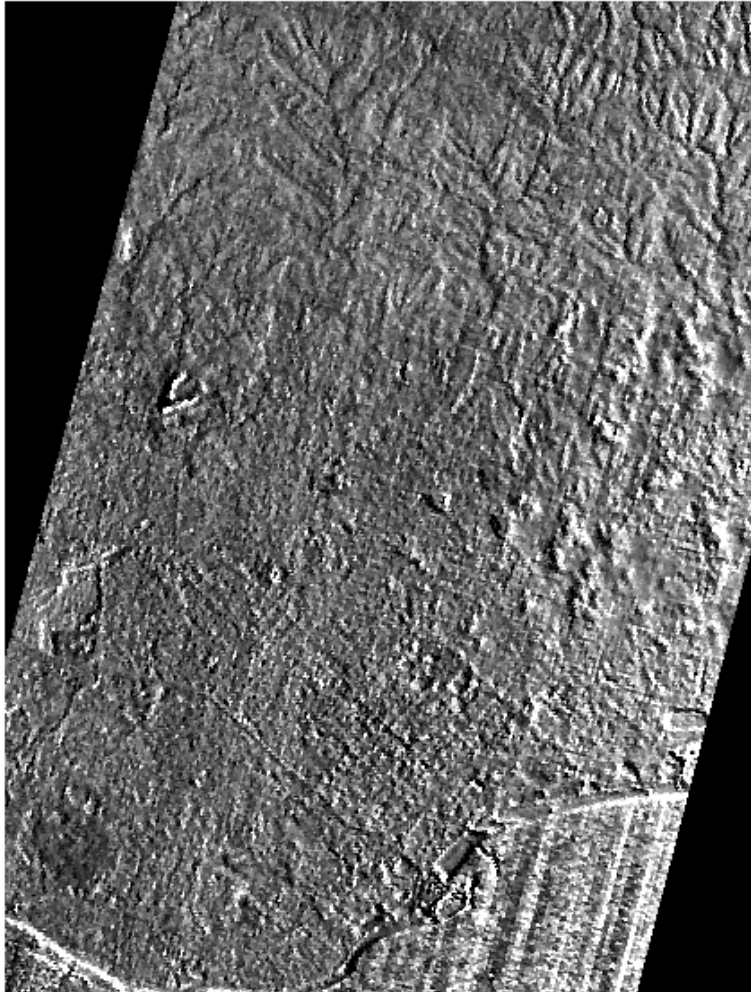


Hyperion



Moisture Retrieval: WI

HYPERION



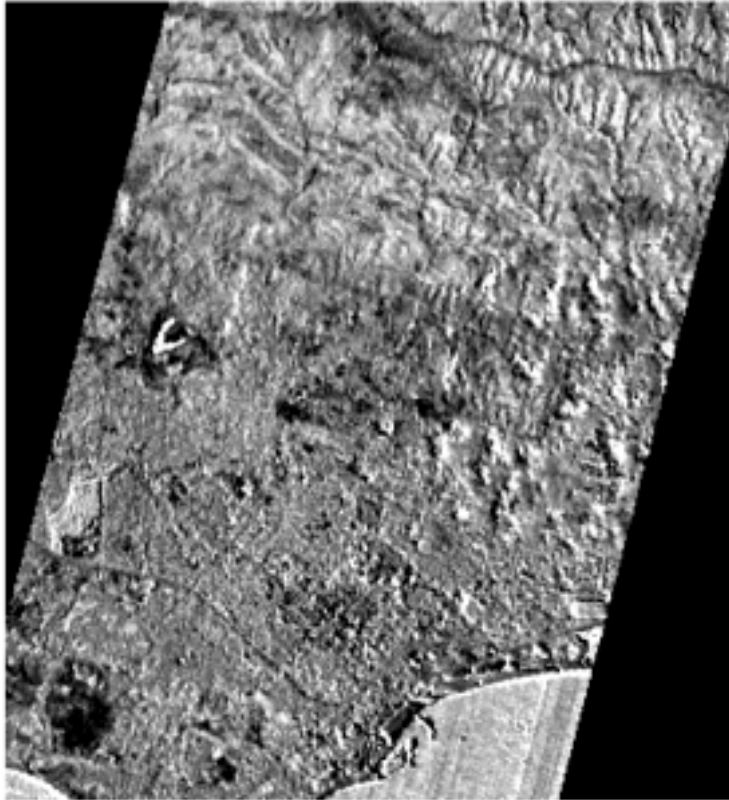
AVIRIS



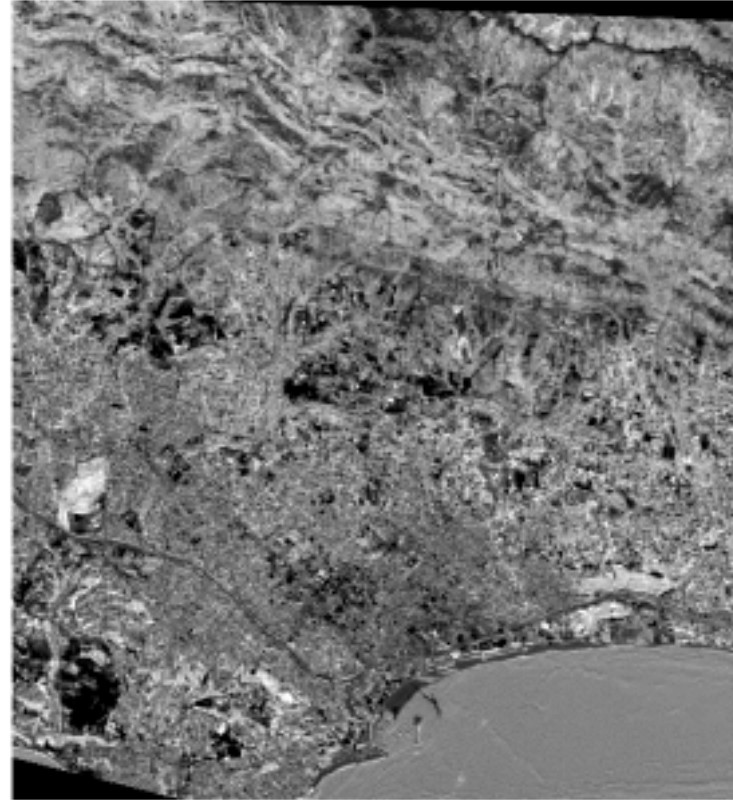
2 km

Moisture Retrieval: NDWI

HYPERION



AVIRIS



Legend

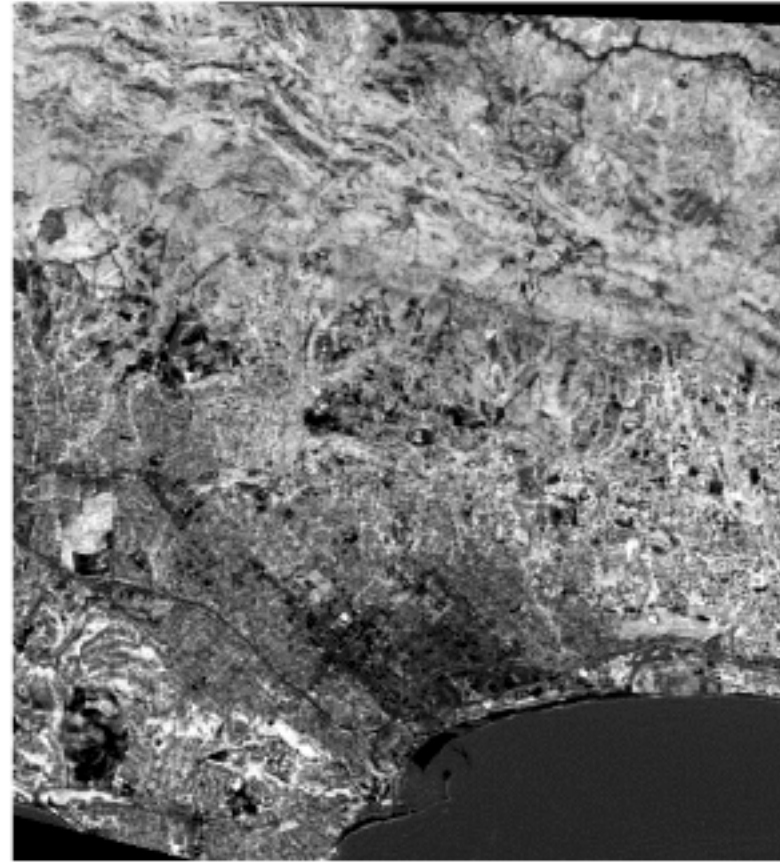
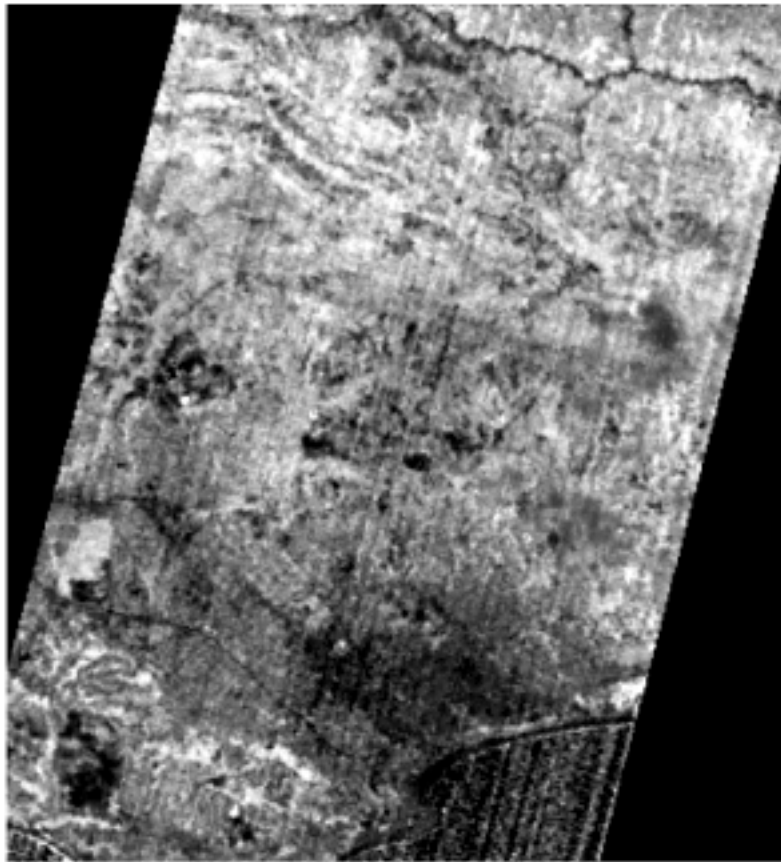


2 km

Moisture Retrievals: mNDWI

HYPERION

AVIRIS



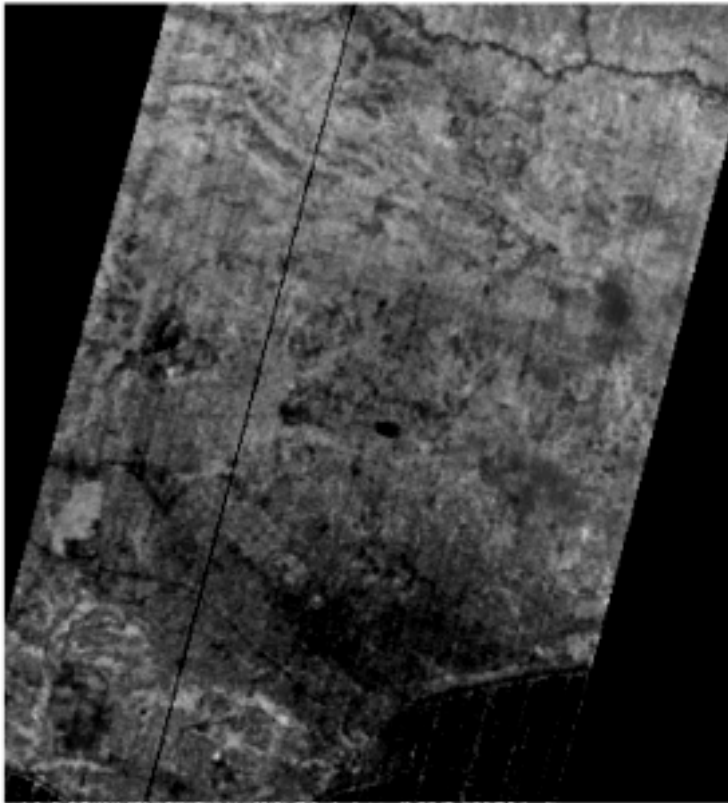
2 km

Modified NDWI = $(1070-1200)/(1070+1200)$

Light areas have high fuel moisture and low danger

Moisture Retrievals: EWT

HYPERION



AVIRIS

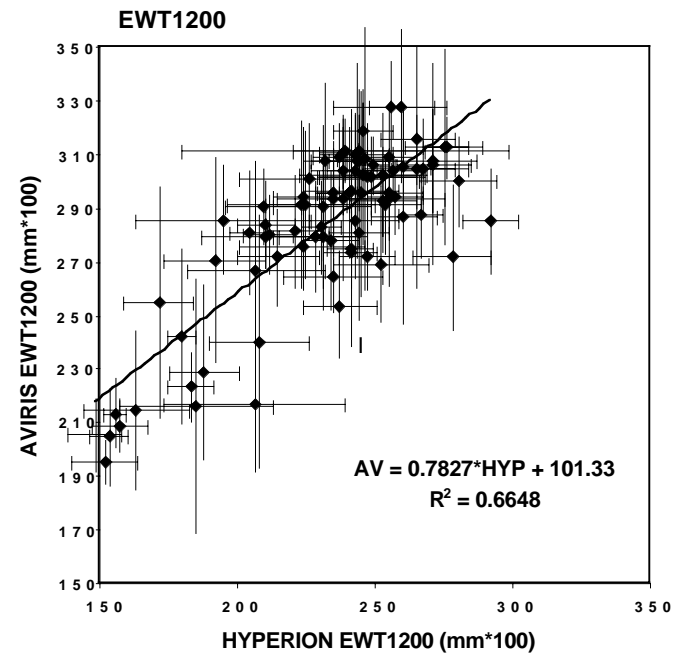
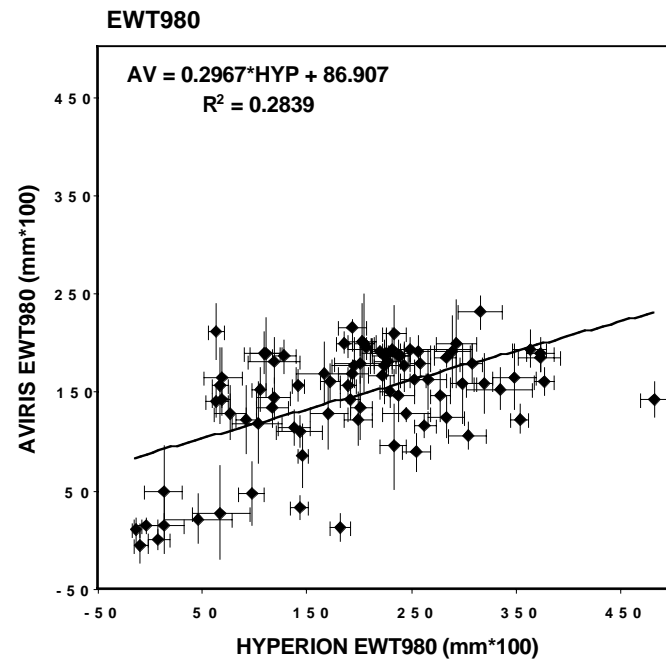
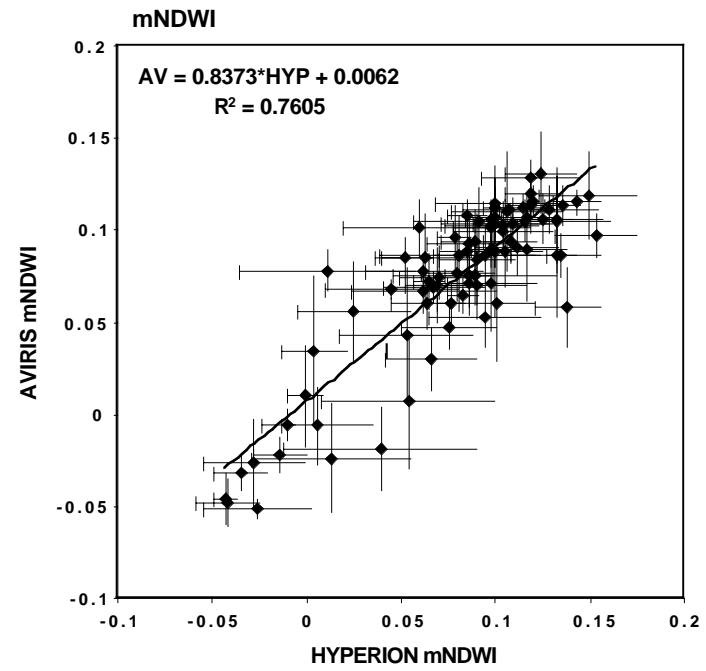
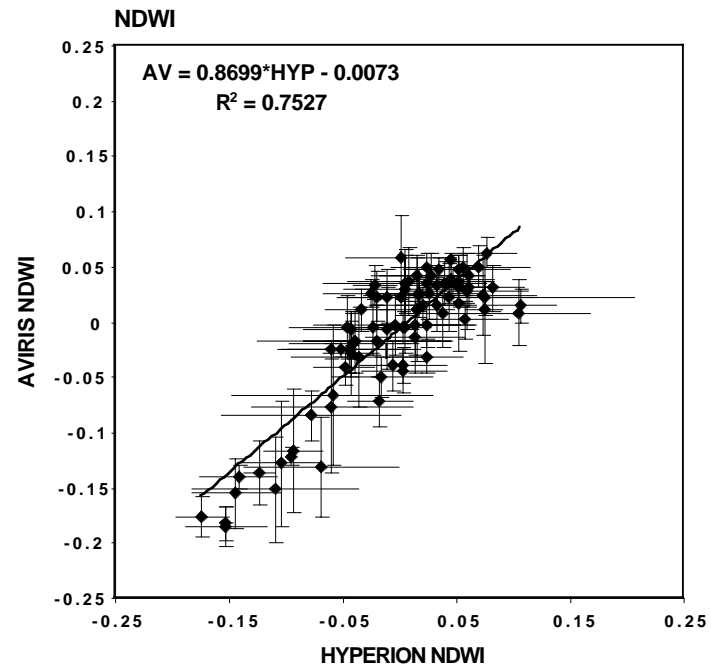


2 km

***The 980 nm band produced very poor fits**

***The 1200 nm band is more difficult to work with, but does work**

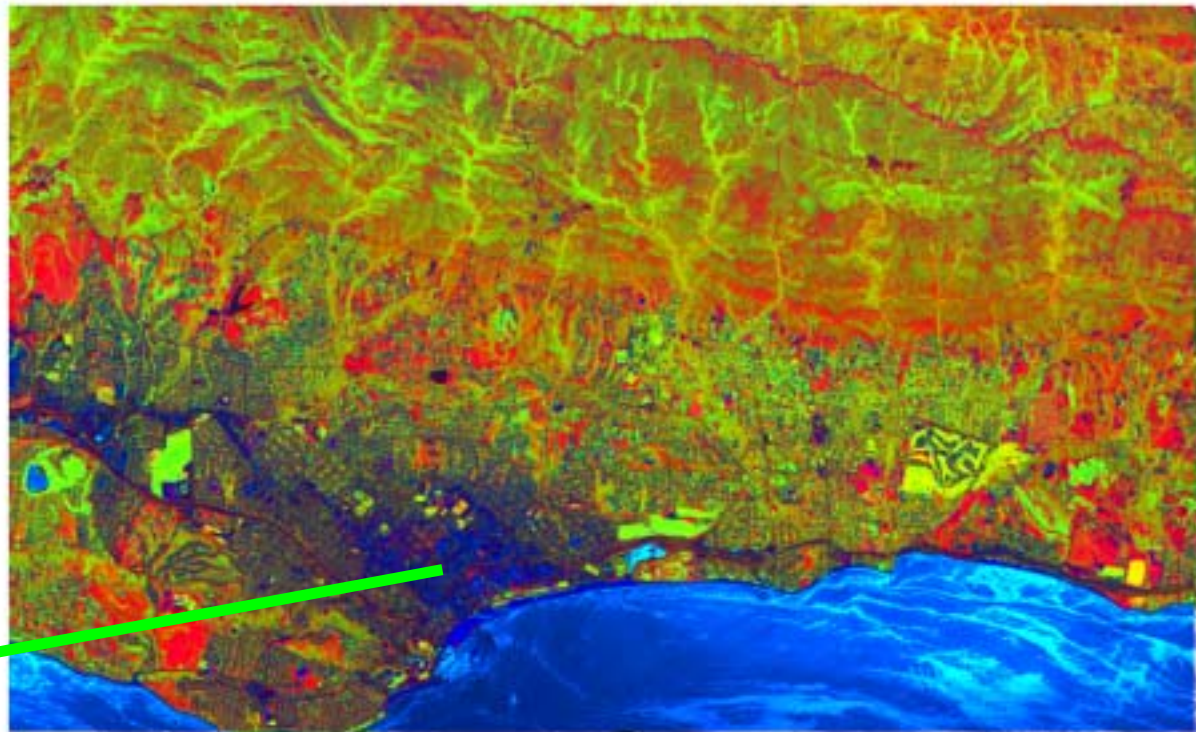
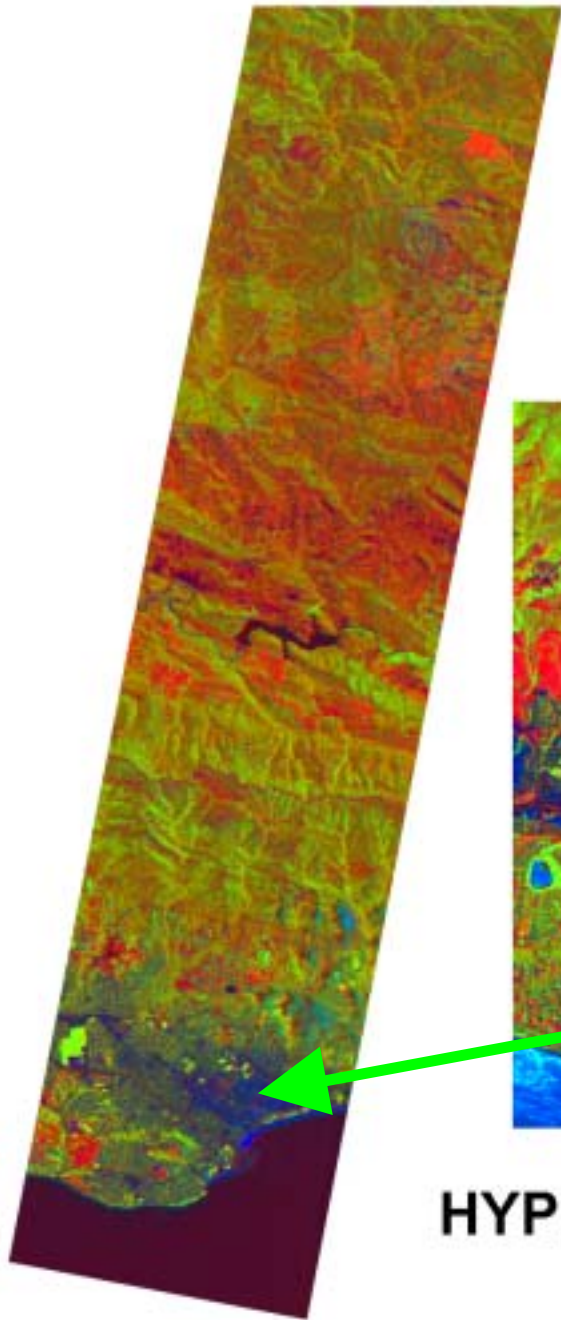
Water Indices



Example: Fuel Condition

Hyperion provides comparable measures to AVIRIS over a larger geographic region

AVIRIS: June 14, 2001

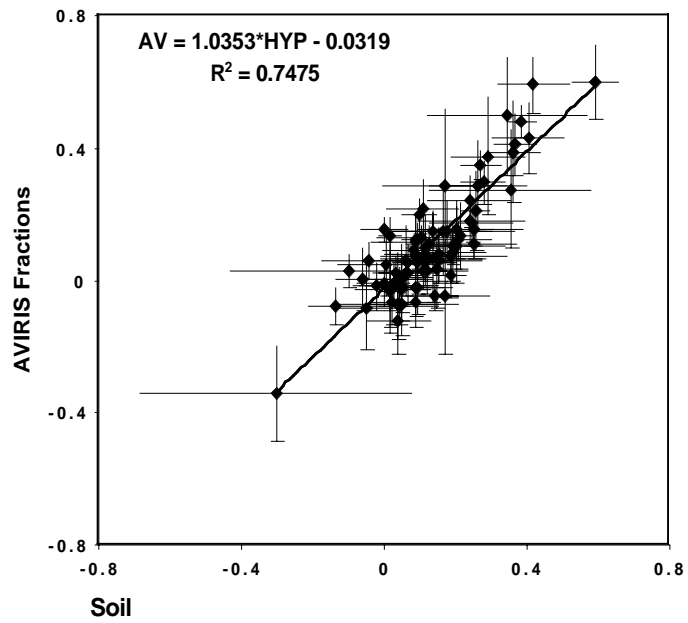


HYPERION: June 12, 2001

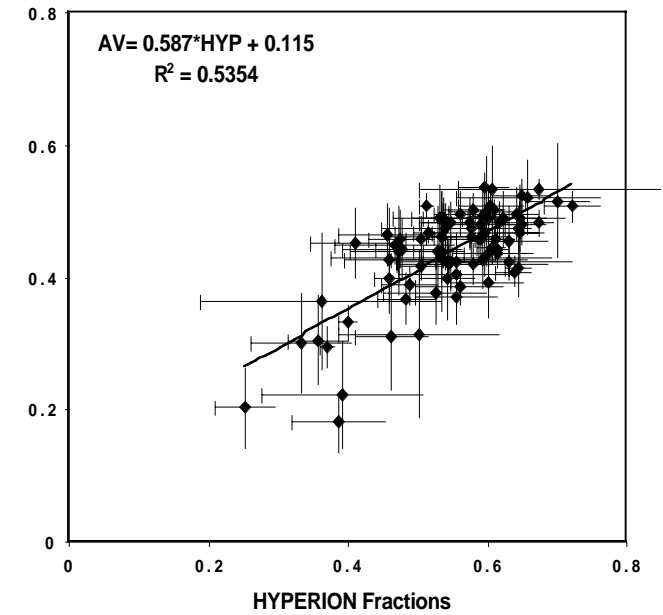
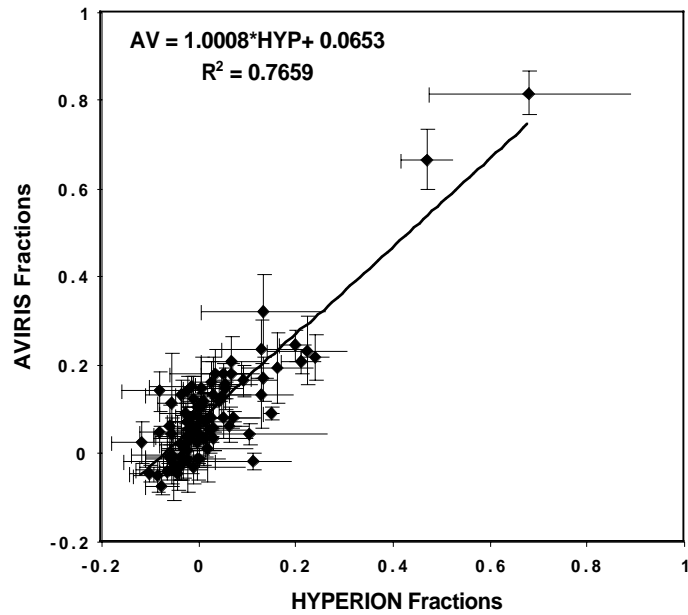
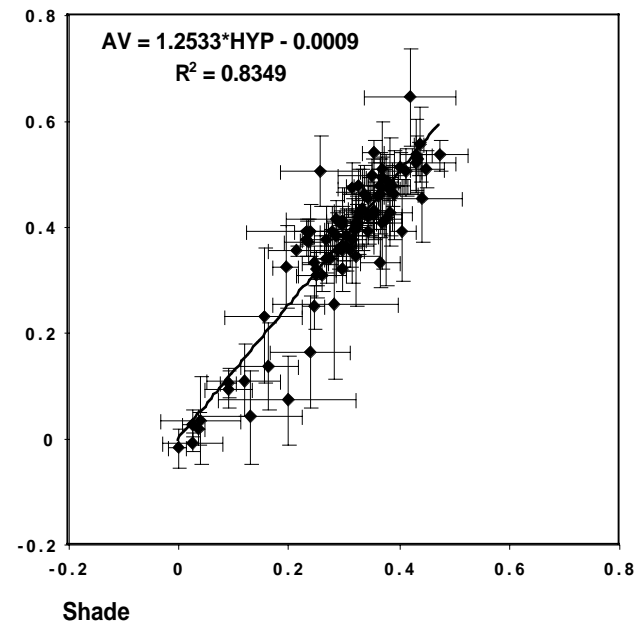
Red = Senesced, Green = Live

Mixture Models

NPV

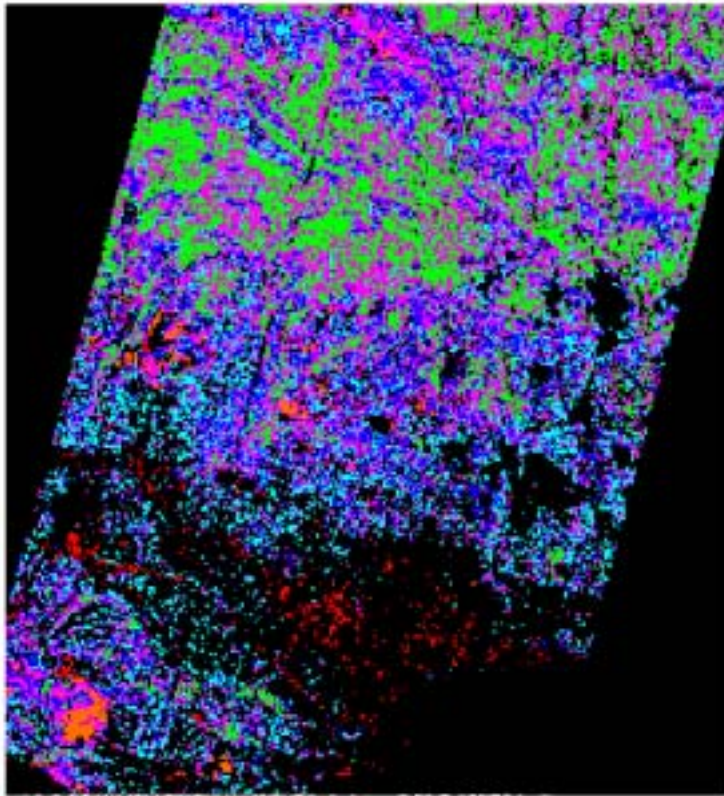


GV

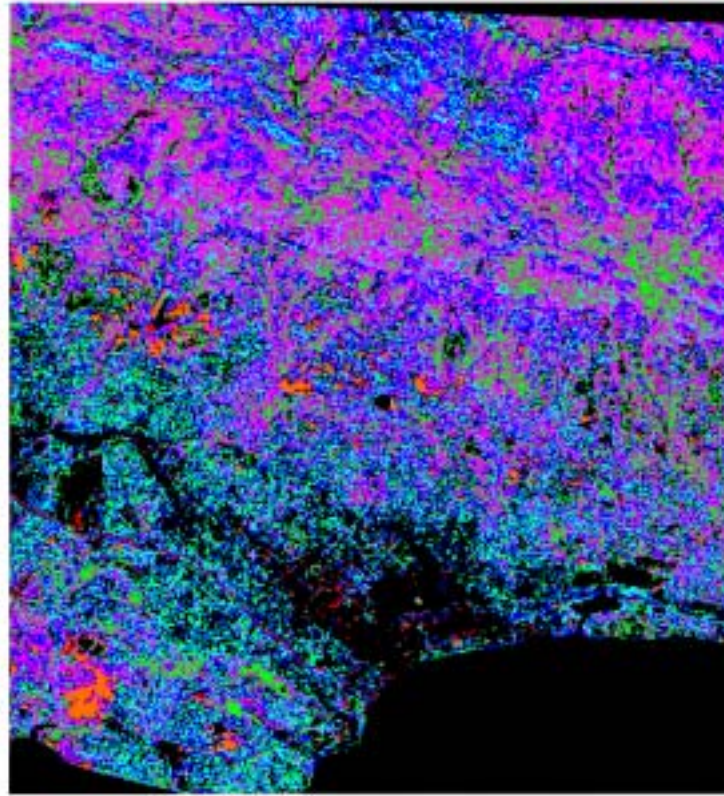


MESMA Vegetation Type Mapping

HYPERION



AVIRIS



Legend

- Soil
- Senesced Grass
- Chamise
- Ceanothus
- Manzanita
- Live Oak

2 km

Classification Accuracy Assessment

Table 2) Error Matrix for AVIRIS. Column totals are for reference data, rows image classes. Includes 7 classes, soil, grass, chamise, Ceanothus (ceano), manzanita (manzan), oak, unclassified (uncl), Producers (Prod), Users and overall accuracies (Accur).

	soil	grass	chamise	ceano	manzan	oak	uncl	Totals	Users
soil	6							6	1
grass		15						15	1
chamise			12	1				13	0.923
ceano			1	31	5	2		39	0.795
manzan					2			2	1
oak				6		6		12	0.5
uncl	1		3					4	
Totals	7	15	16	38	7	8			91
Prod	0.857	1	0.75	0.816	0.286	0.75			72
								Accur	0.791
	Kappa	0.722							

Table 3) Error Matrix for HYPERION. Column totals are for reference data, rows image classes. Includes 7 classes, soil, grass, chamise, Ceanothus (ceano), manzanita (manzan), oak, unclassified (uncl), Producers (Prod), Users and overall accuracies (Accur).

	soil	grass	chamise	ceano	manzan	oak	uncl	Totals	Users
soil	2							2	1
grass		9						9	1
chamise			6					6	1
ceano		1	9	21	7	3		41	0.512
manzan			1		1			2	0.5
oak			2	17		4		23	0.174
uncl		1		1				2	
Totals	2	11	18	39	8	7	0		85
Prod	1	0.818	0.333	0.538	0.125	0.571			43
								Accur	0.506
	Kappa	0.318							

Summary

- **Post-launch radiometric calibration looks good**
 - The instrument appears radiometrically stable
- **SNR is low, NEDL 5* AVIRIS**
- **Reflectance Retrieval is good**
- **WI non-usable, NDWI marginal**
 - Band ratios are sensitive to poor signal
 - Modified NDWI can be designed
 - Liquid water fits work using the 1200 nm band
- **Fractions Comparable**
 - GV and Shade comparable
 - NPV and Soils, more confused by Hyperion than AVIRIS, but still could be distinguished
- **Vegetation Mapping Promising**
 - Soils and grasslands differentiated
 - Chamise has high users accuracy (correct where mapped)

What's Next?

- **Improved Spatial and Temporal Comparisons**
- **Other Measures**
 - **Red Edge**
- **West Coast Nature Reserve (Greg Okin)**
 - **Spectral library development**
 - **Invasive Species**
 - **Fire**
 - **Desertification**