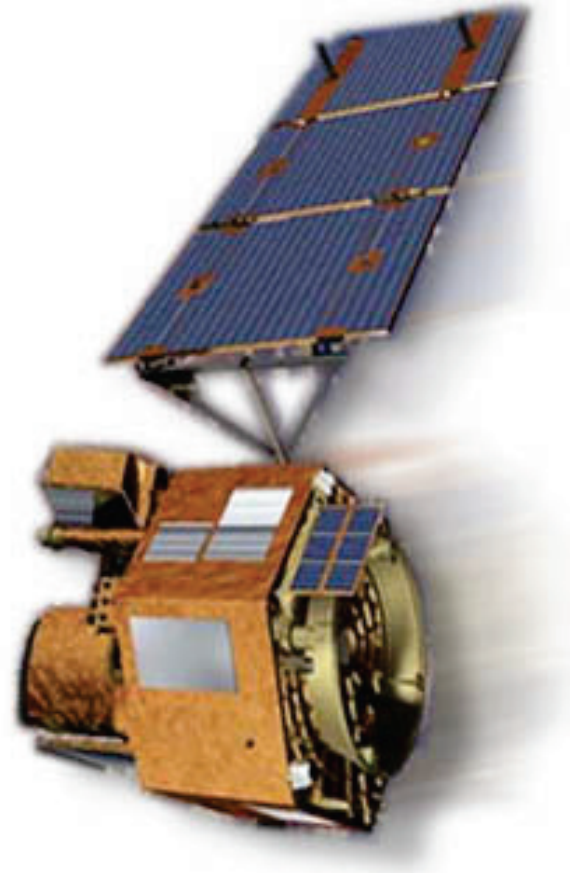


Commercial Application of Hyperion and ALI Data

Marty Evans and Laura Hall, ChevronTexaco;
Nurgul Amanova and Bradford Dean, Tengizchevroil;
James Ellis, Ellis GeoSpatial;
Hattie Davis, Artistic Earth;
Robert Turner, Boeing



*The Remote Sensing and Photogrammetry Society Annual Conference
RSPSoc2004 Mapping and Resources Management
7-10 September 2004, Aberdeen, Scotland*

Outline

- **An Aggressive Acquisition Program**
- **Planning & Decision Process**
- **Preprocessing Results & Issues**
- **Some Processing Results & Issues**

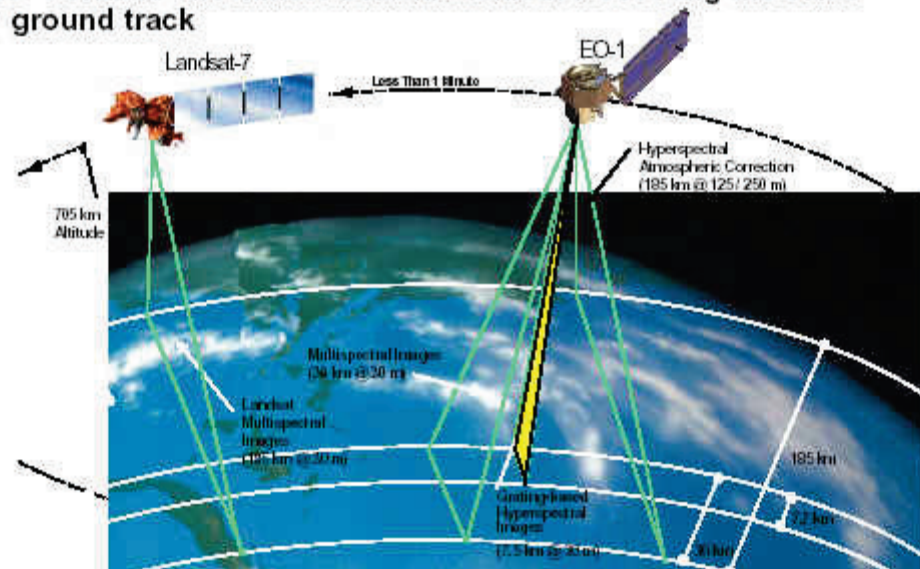
Planning an Acquisition Program



EO-1 Orbit



EO-1 orbit is one minute behind Landsat-7 covering the same ground track



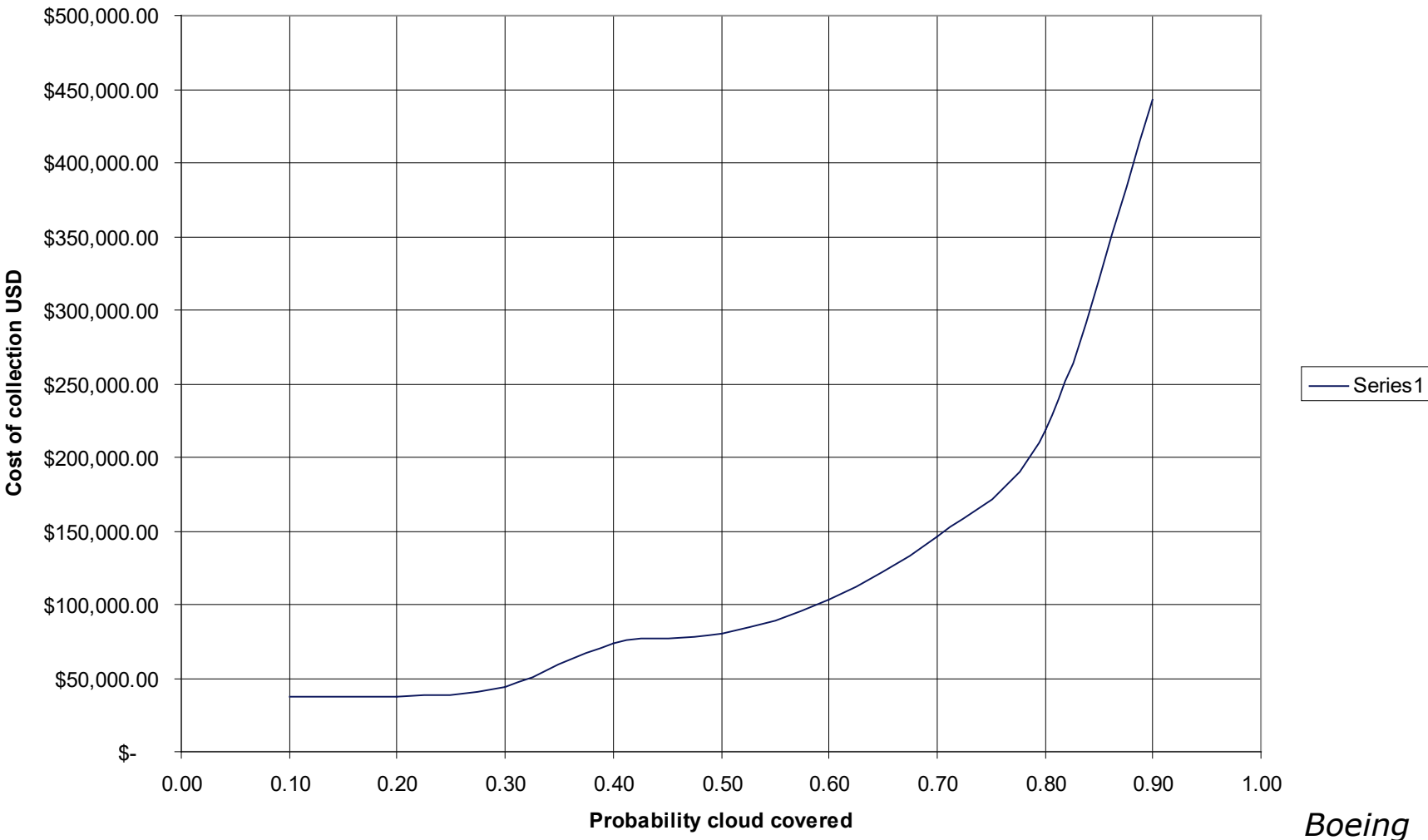
**With nadir viewing
~2 acquisition
attempts/month.**

Not Enough!

**Solution: Roll the sensor East-West to
enable 8-10 acquisition attempts/month**

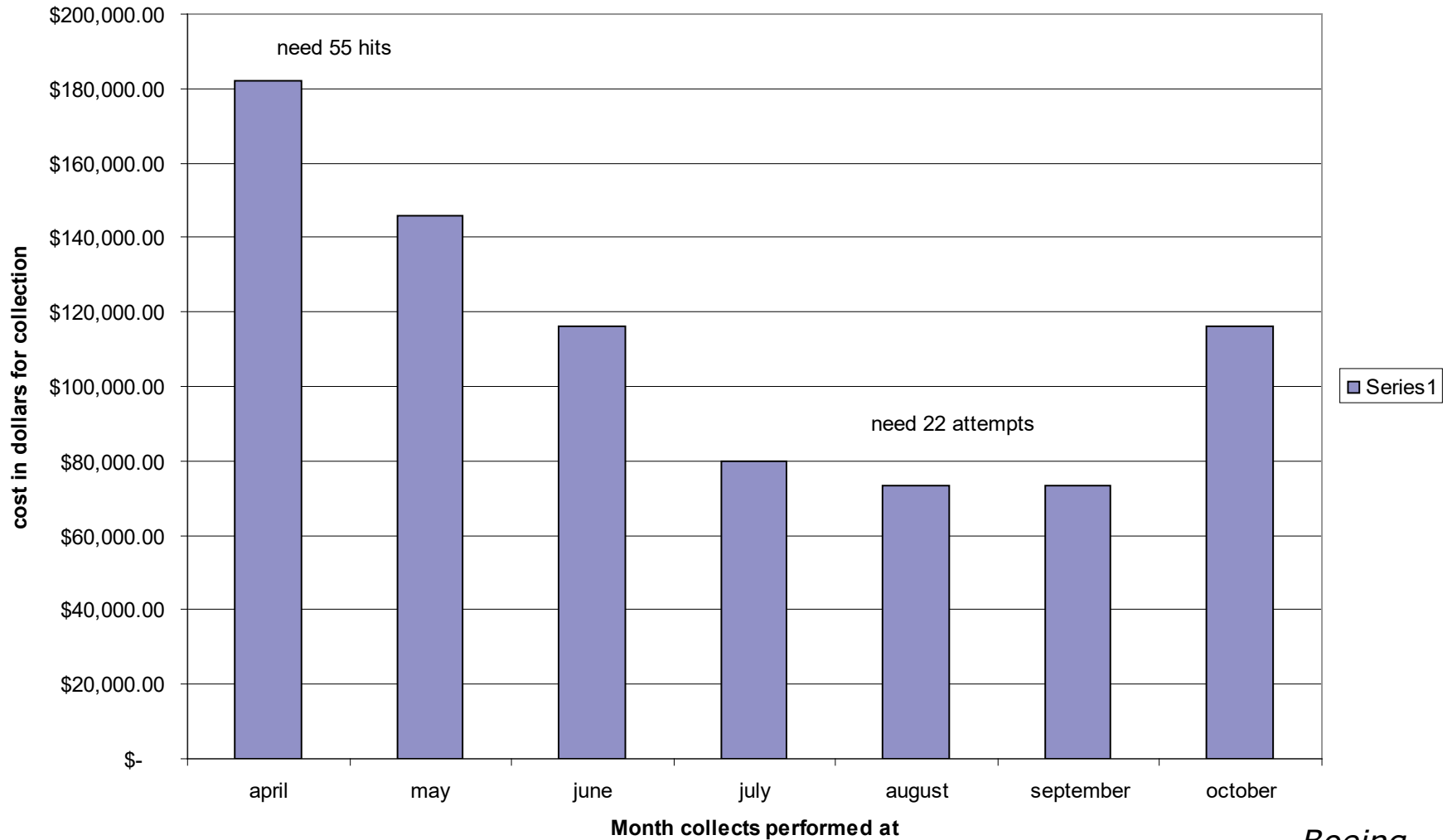
Impact of Clouds on Cost - Constrains Acquisition Window

Cost of collection versus cloud probability



Cost Scenario using Cloud Probability

Cost of collection



Boeing

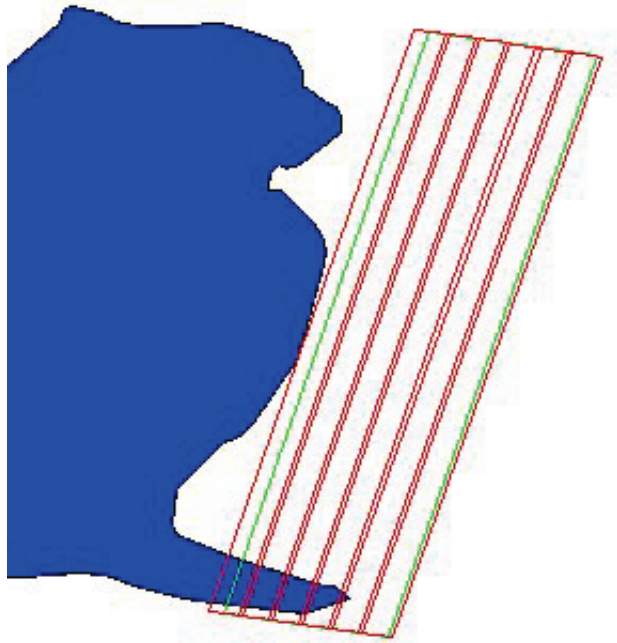
Acquisition program for 11 Hyperion orbital strips with priority, off-nadir viewing, and timing shown

			Interval	0	2	5	2	2	5	2	5	2		
			Date	5/3/2002	5/5/2002	5/10/2002	5/12/2002	5/14/2002	5/19/2002	5/21/2002	5/26/2002	5/28/2002		
			Interval Number	37379	37381	37386	37388	37390	37395	37397	37402	37404		
			major cycle #	1	1	1	1	1	2	2	2	2		
			minor cycle number	4	2	5	3	1	4	2	5	3		
			Landsat path #	+1	-1	+2	0	-2	+1	-1	+2	0		
													Total data collection events	Total Frame collections
Longitude	Latitude	priority	85											
XX.XXX	yy.yyy	3	1	0	0	0	0	0	0	0	0	0	4	2
XX.XXX	yy.yyy	3	2	0	0	0	0	0	0	0	0	0	4	2
XX.XXX	yy.yyy	3	3	0	0	1	0	0	0	1	0	0	4	2
XX.XXX	yy.yyy	2	4	1	0	0	0	0	0	0	0	0	6	3
XX.XXX	yy.yyy	1	5	0	0	0	1	0	0	0	0	0	8	4
XX.XXX	yy.yyy	1	6	0	1	0	0	0	0	0	0	1	8	4
XX.XXX	yy.yyy	2	7	0	0	0	0	1	1	0	0	0	6	3
XX.XXX	yy.yyy	3	8	0	0	0	0	0	0	0	1	0	4	2
XX.XXX	yy.yyy	3	9	0	0	0	0	0	0	0	0	0	4	2
XX.XXX	yy.yyy	3	10	0	0	0	0	0	0	0	0	0	4	2
XX.XXX	yy.yyy	3	11	0	0	0	0	0	0	0	0	0	4	2
				1	1	1	1	1	1	1	1	1	56	28

Phase 1 of Operational Acquisition Program - 6 Hyperion Orbital Strips, core highest priority

				Date	6/4/2002	6/6/2002	6/11/2002	6/13/2002	6/15/2002	6/20/2002	6/22/2002	6/27/2002	6/29/2002	7/1/2002	7/6/2002	7/8/2002	7/13/2002	7/15/2002	7/17/2002
				Interval Number	37411	37413	37418	37420	37422	37427	37429	37434	37436	37438	37443	37445	37450	37452	37454
				major cycle #	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3
				minor cycle number	4	2	5	3	1	4	2	5	3	1	4	2	5	3	1
				Landsat Path #	+1	-2	+2	0	-2	+1	-1	+2	0	-2	+1	-1	+2	0	-2
Sensor	center point Longitud	Center Point Latitude	priority	collection strip #															
Hyperion	xx.xxx	yy.yyy	3	1	1	0	0	1	0	0	0	0	1	0	0	0	0	1	0
Hyperion	xx.xxx	yy.yyy	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hyperion	xx.xxx	yy.yyy	1	3	0	1	0	0	0	0	0	1	0	1	0	1	0	0	0
ALI Central	xx.xxx	yy.yyy	1	4A	1	0	0	0	1	0	0	0	1	0	0	0	0	1	0
Hyperion	xx.xxx	yy.yyy	1	4	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0
Hyperion	xx.xxx	yy.yyy	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hyperion	xx.xxx	yy.yyy	3	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					1	1	1	1	0	1	1	1	1	1	1	1	0	1	0
				accumulative total of data collection events	1	2	3	4	4	5	6	7	8	9	10	11	11	12	12

Boeing

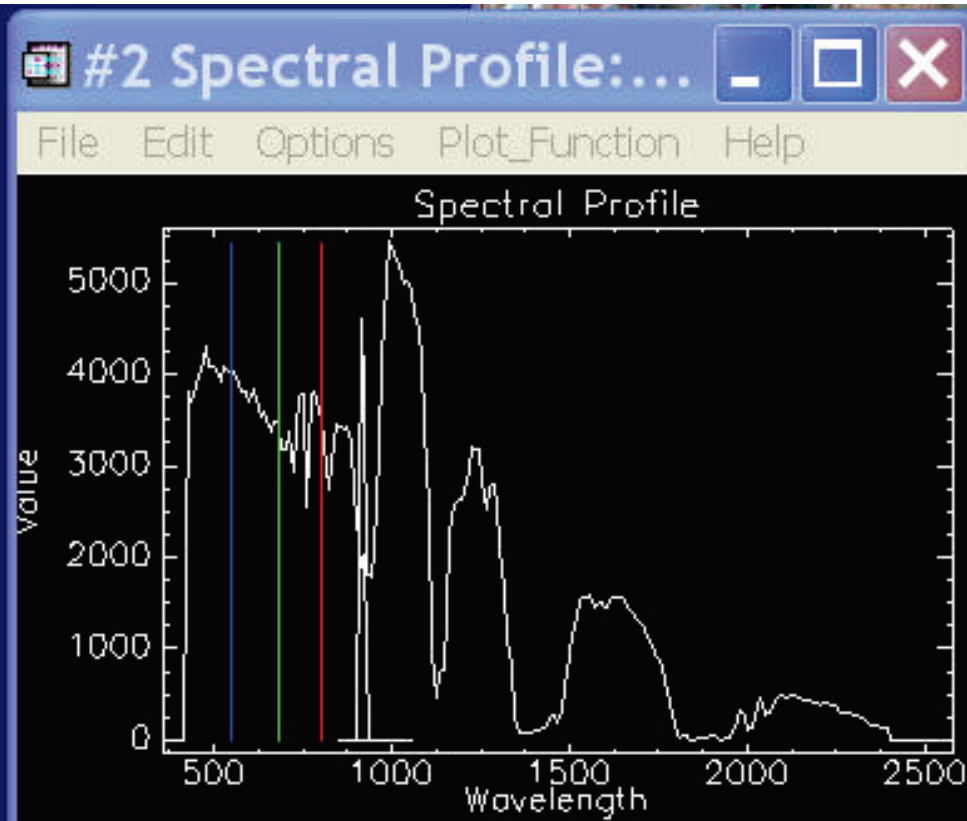
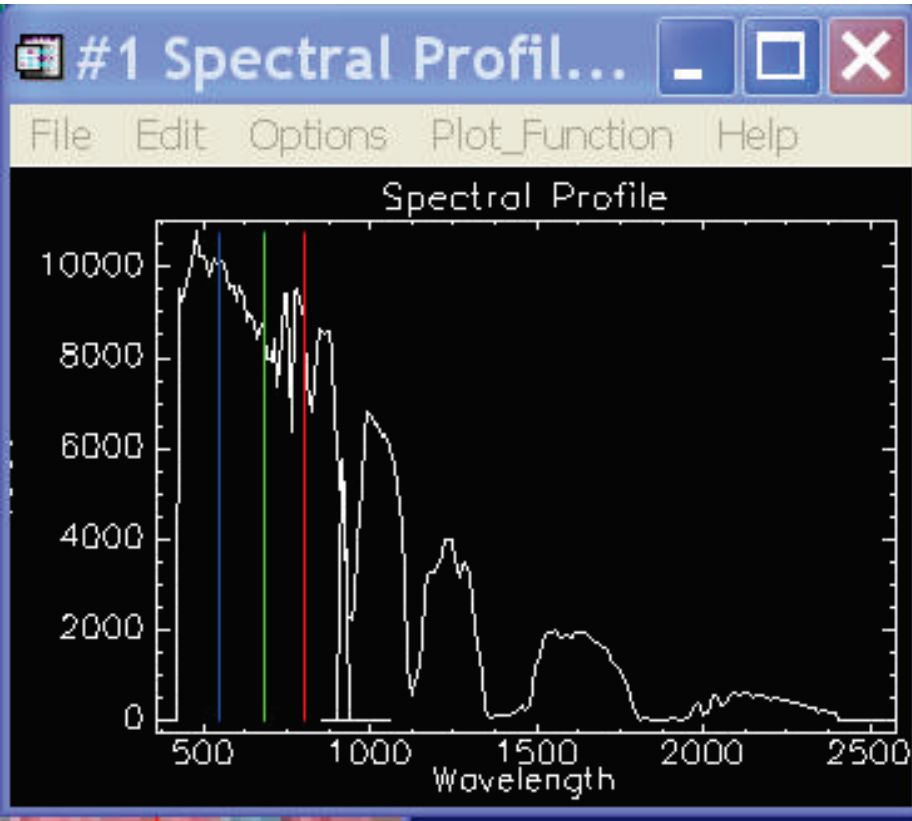


**Six hyperspectral
Hyperion orbital swaths
prioritized for
acquisition with
same-day multispectral
(9-band) Advanced
Land Imager (ALI)**

Preprocessing

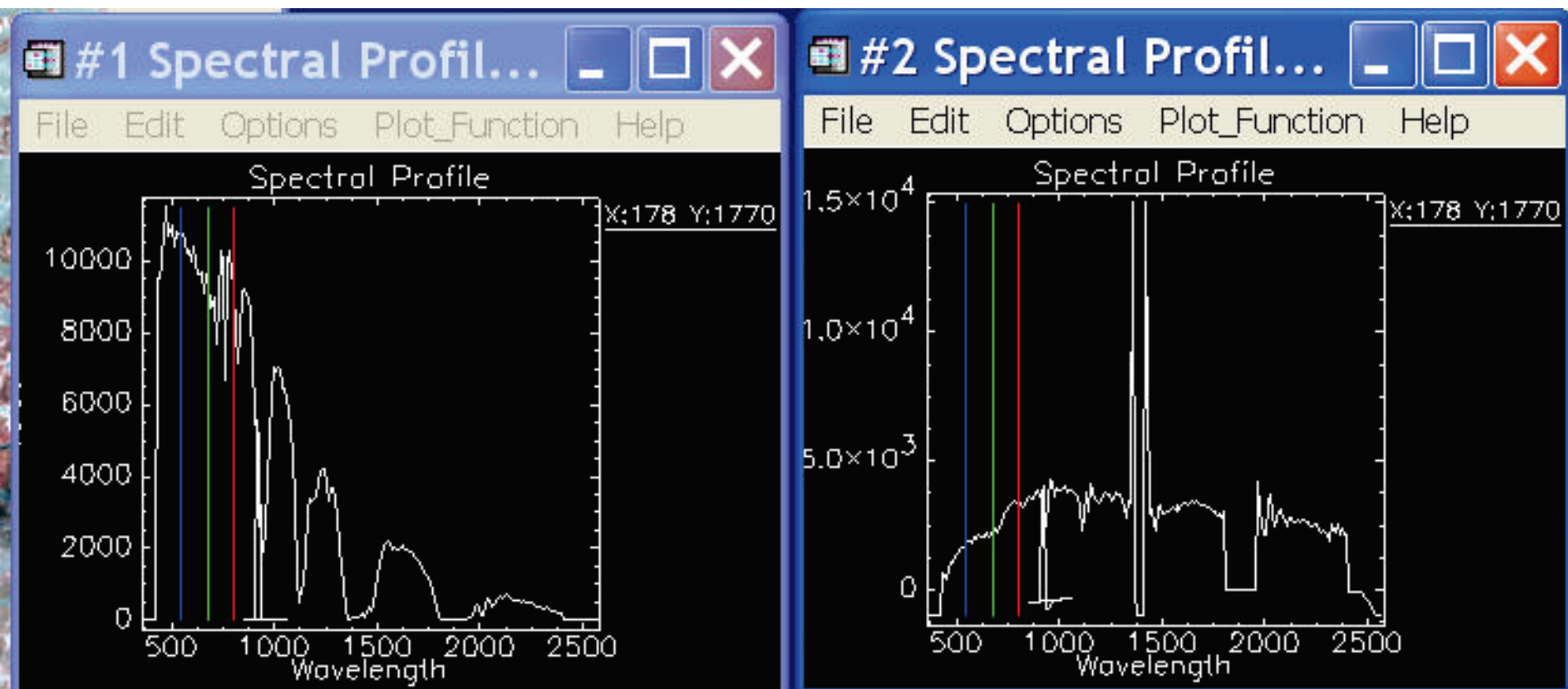
- **Recalibrate radiance**
- **conversion to reflectance**
- **bad band removal**
- **destreaking**
- **Georeferencing**

Original Hyperion radiance spectrum (right) with CSIRO* recalibration corrections applied (left)

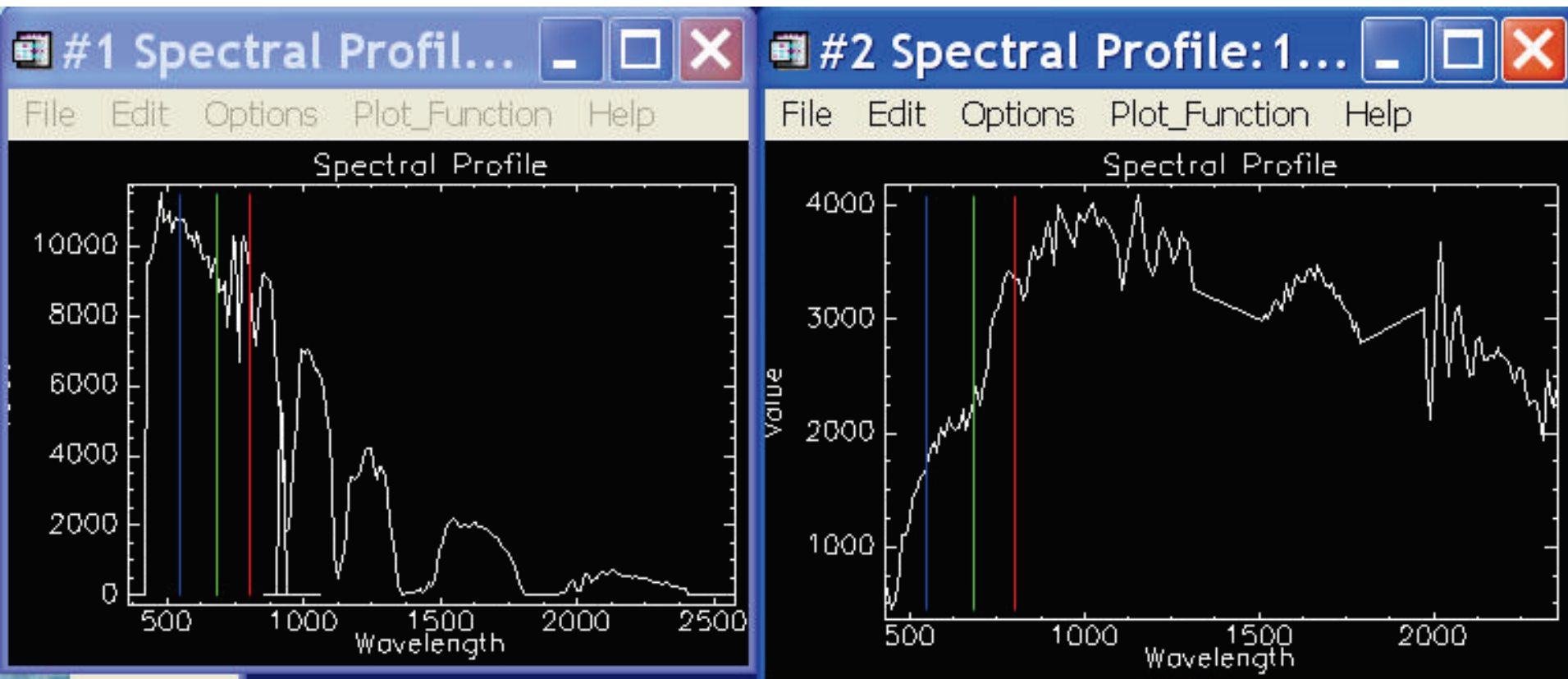


*Office of Space Science & Applications, Earth Observation Centre:
Drs. Bisun Datt and David Jupp

Recalibrated radiance data (left) converted to reflectance using ACORN software.

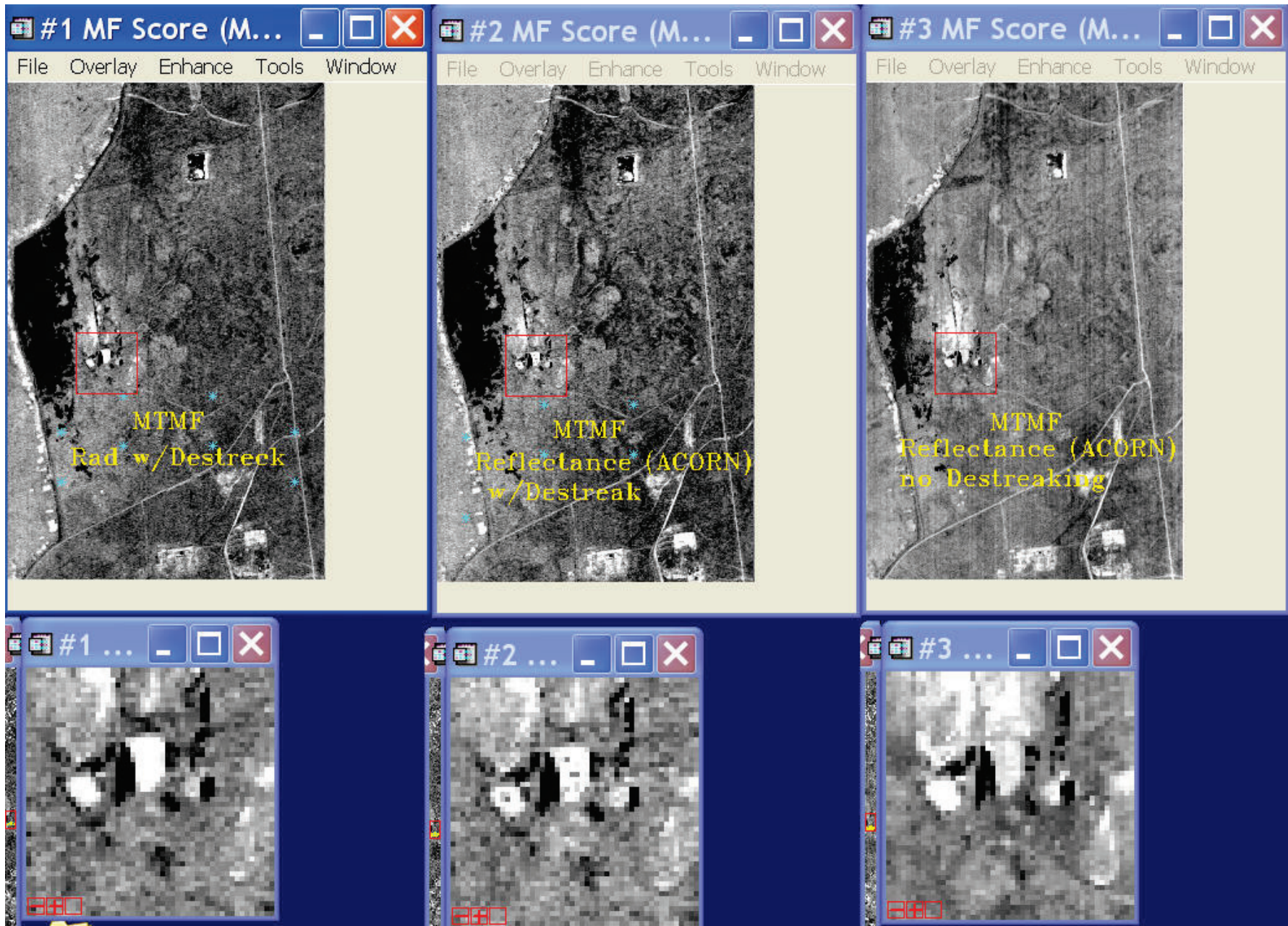


Bad Band Removal



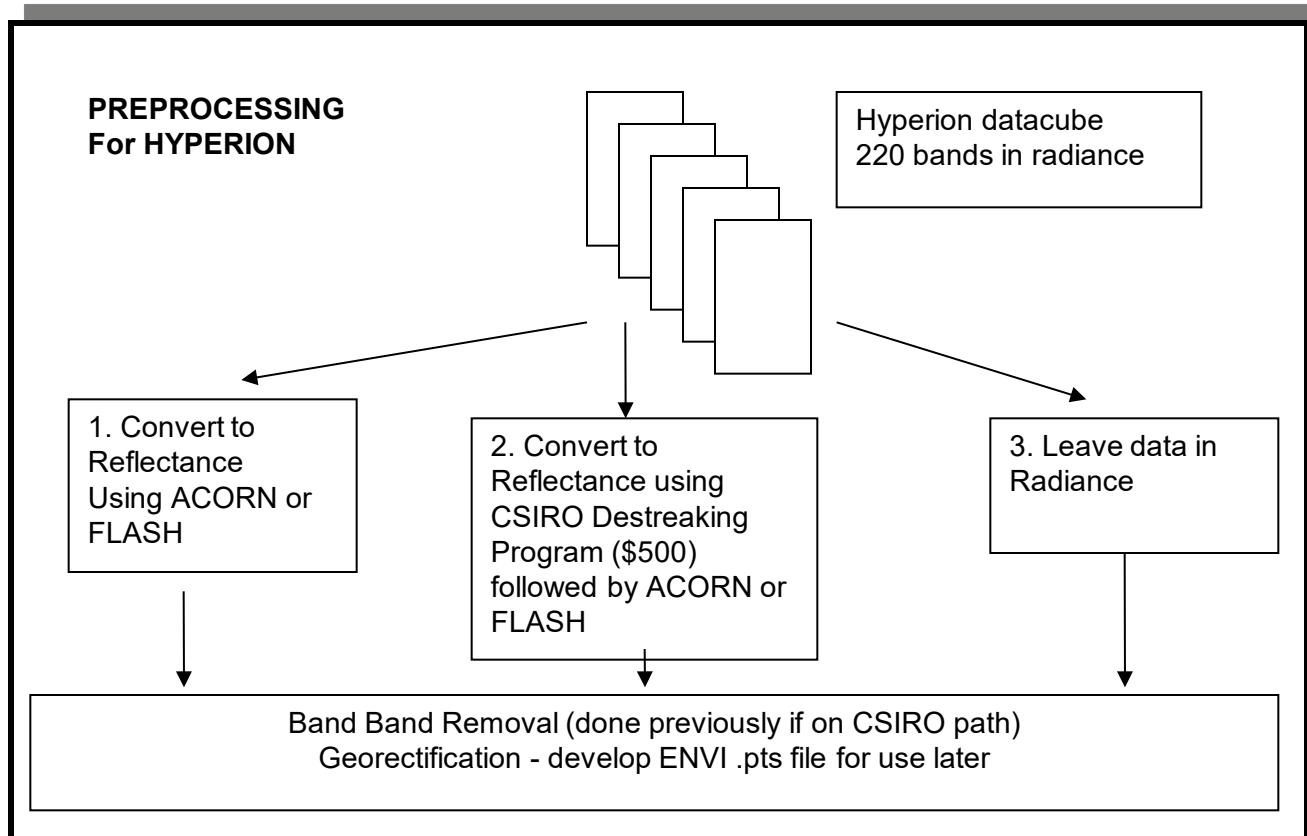
Recalibrated radiance data (left) with bad bands removed in reflectance data (right)

Destreaking Options - *CSIRO* algorithms

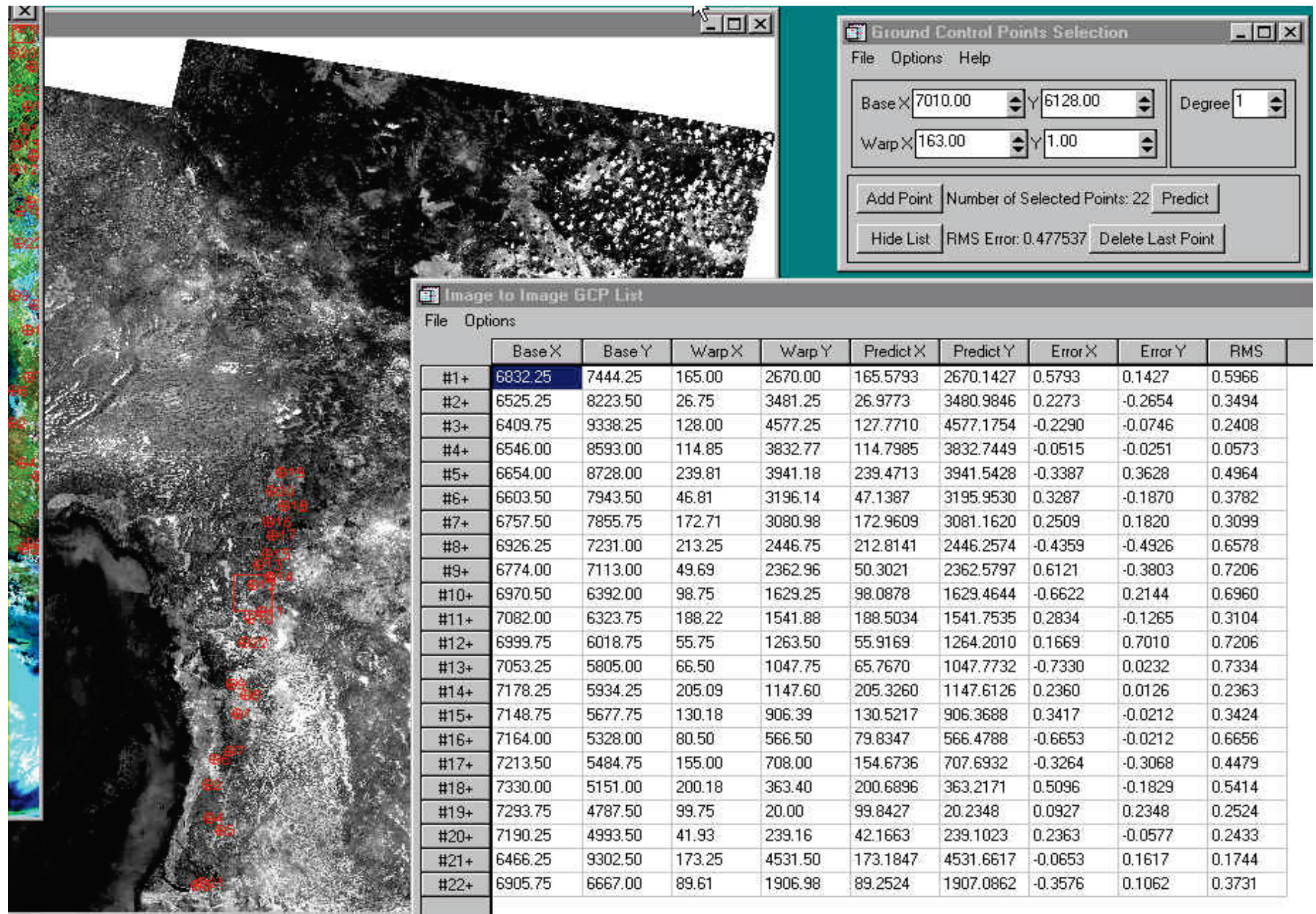


Our Team Followed Three Preprocessing Paths

- each path has a value for mapping



GeoReferencing Hyperion to TM7 - *RMS error <1.2 pixel*



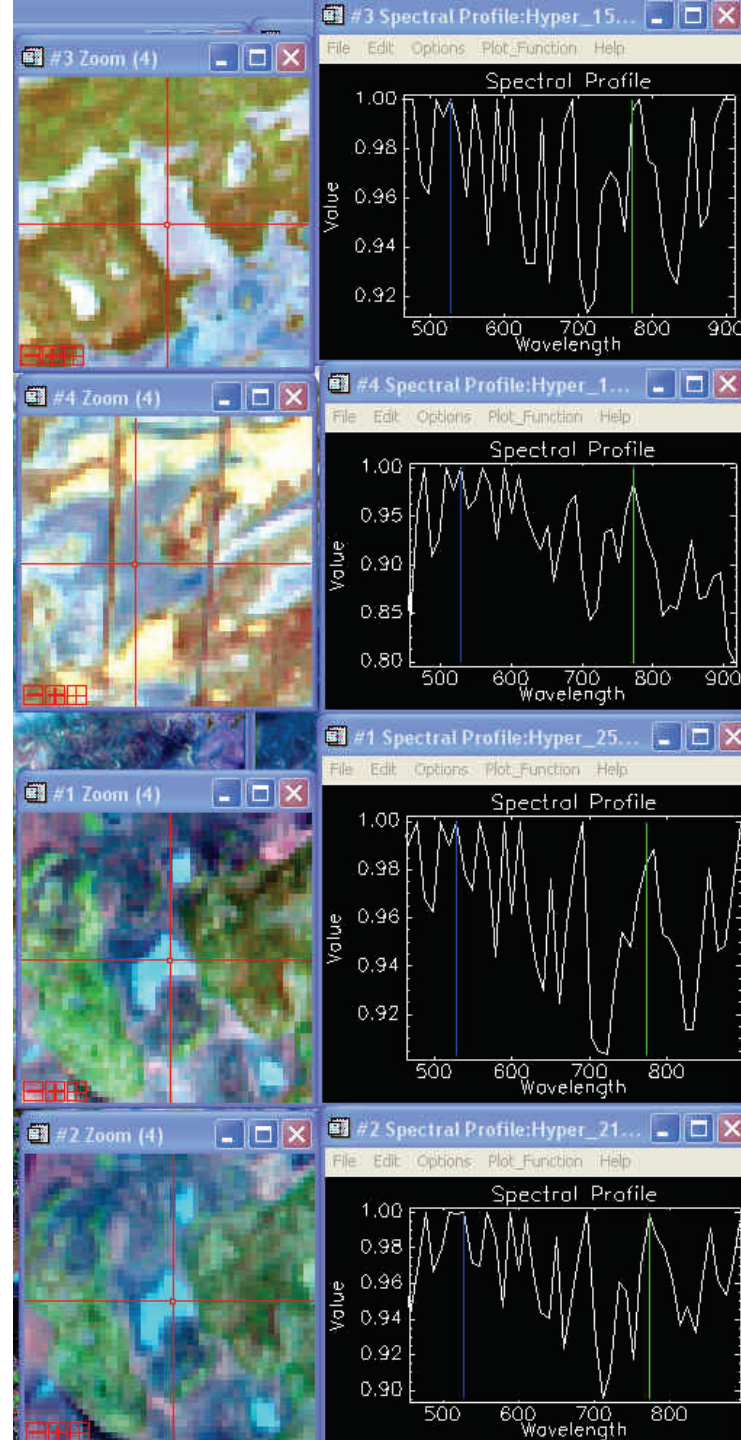
Some Processing Results & Issues

- **Spectral stability**
 - evaluated between different orbital strips
 - evaluated within an orbital strip
 - Hyperion signatures extrapolated to same-day Advanced Land Imager (ALI) & other Landsat TM7
- **Change detection with overlapping strips acquired at different times**
- **Vegetation and Land Use/Land Cover**
 - field training sites correlated with spectral patterns
 - Vegetation Vigor mapped with NDVI

Playas as imaged by Hyperion VNIR sensor at different times

- 6 June
- 20 June
- 10 Sep
- 2 Aug

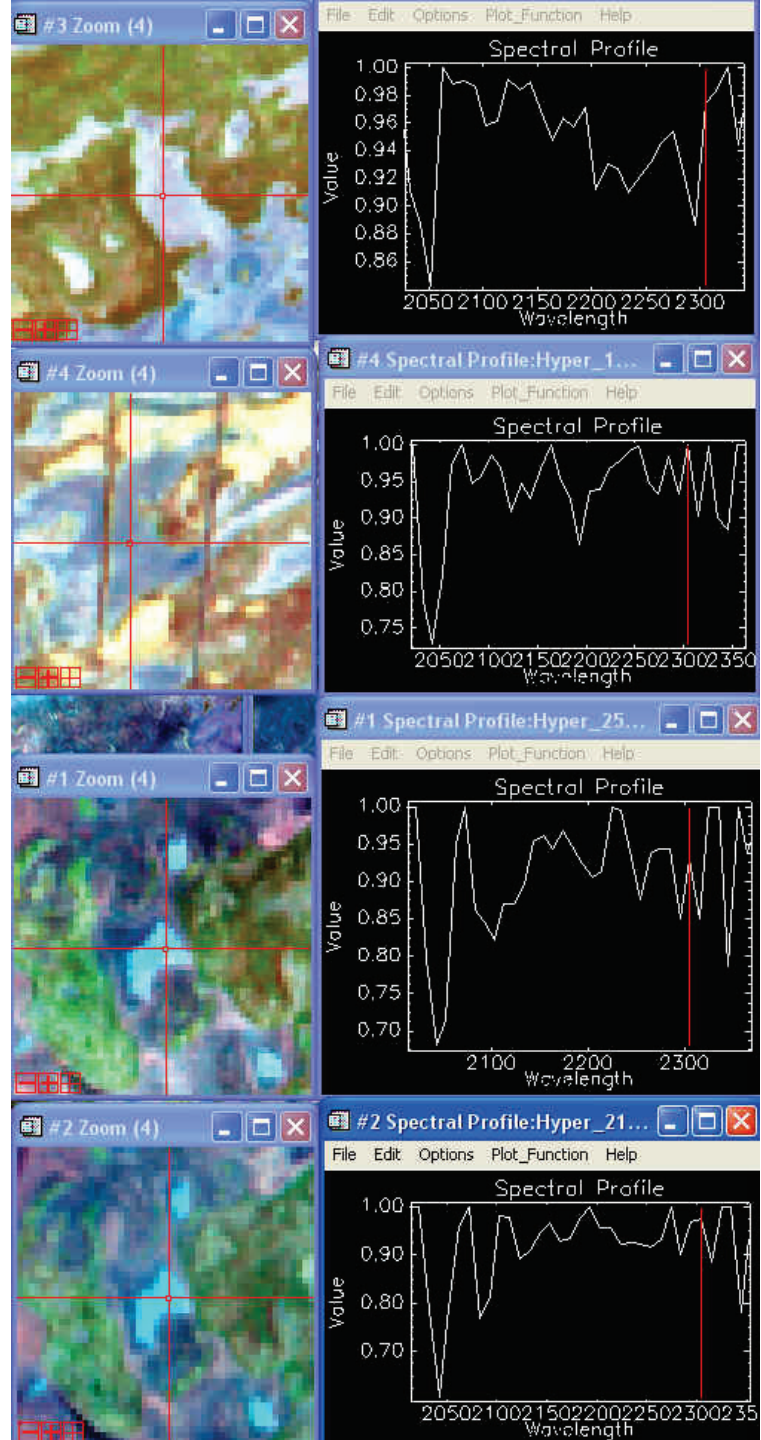
***VNIR spectral pattern
was consistent
between different
images - essential for
using Hyperion for
mapping vegetation
and moisture content.***



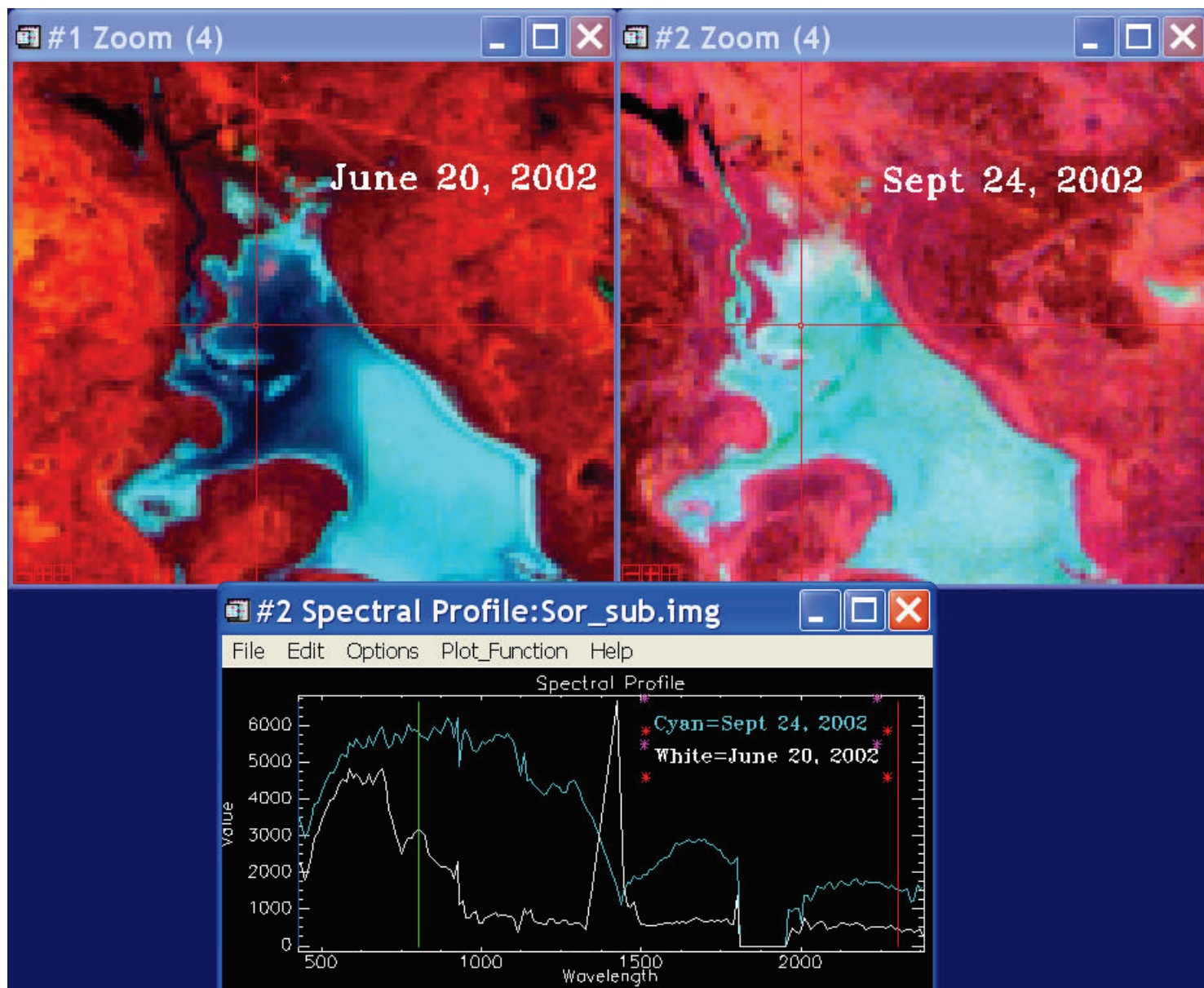
Playas as imaged by Hyperion SWIR sensor at different times

- 6 June
- 20 June
- 10 Sep
- 2 Aug

***SWIR spectral pattern
was reasonably
consistent between
different images -
mapping results were
closely evaluated***



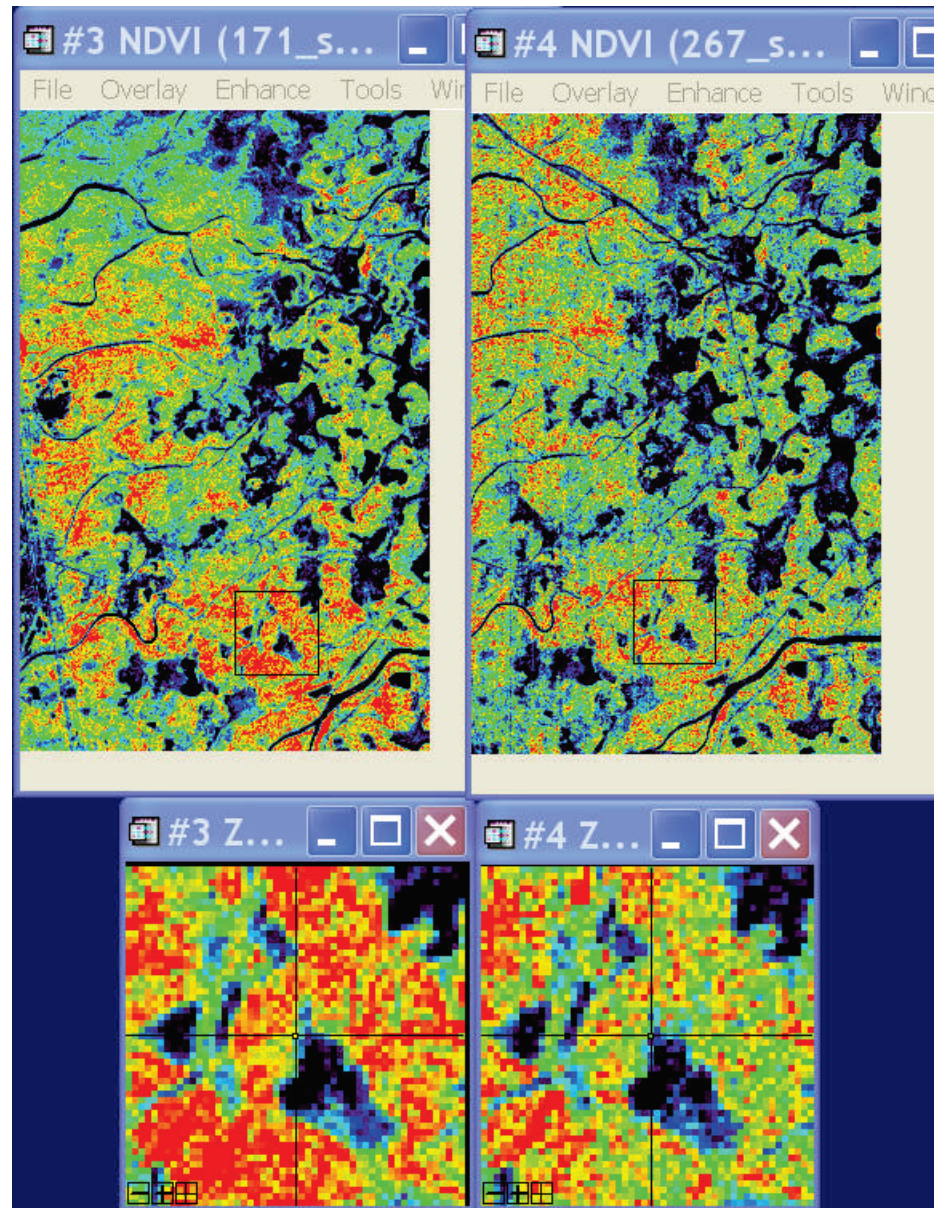
Change Detection - *moisture content*

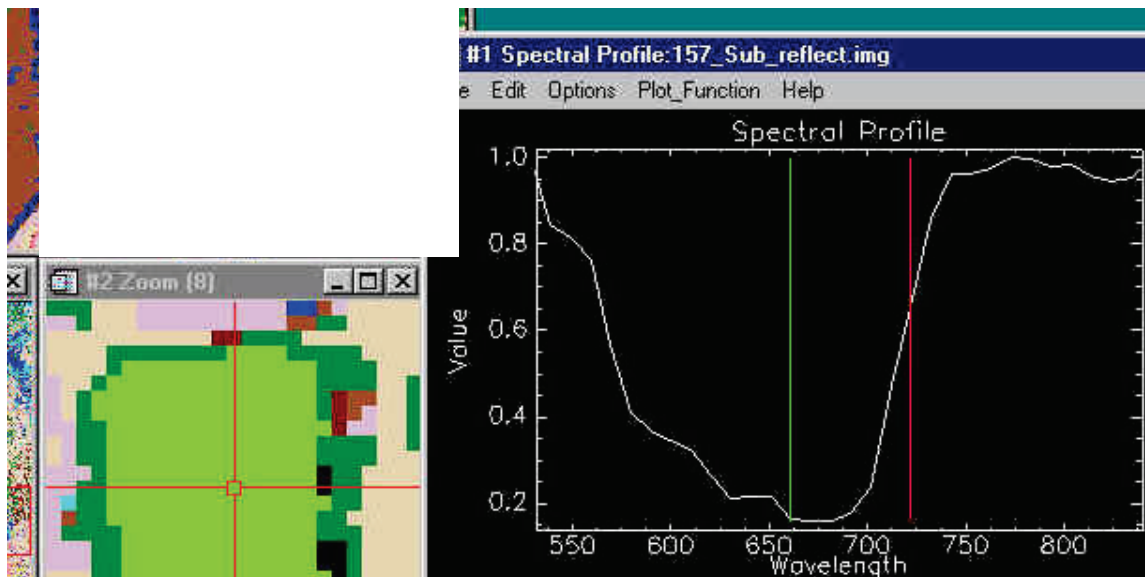


**Vegetation Vigor
changed as the
summer progresses
and the soils dry out
as imaged with
Hyperion**

**20 June (left)
compared with
24 September**

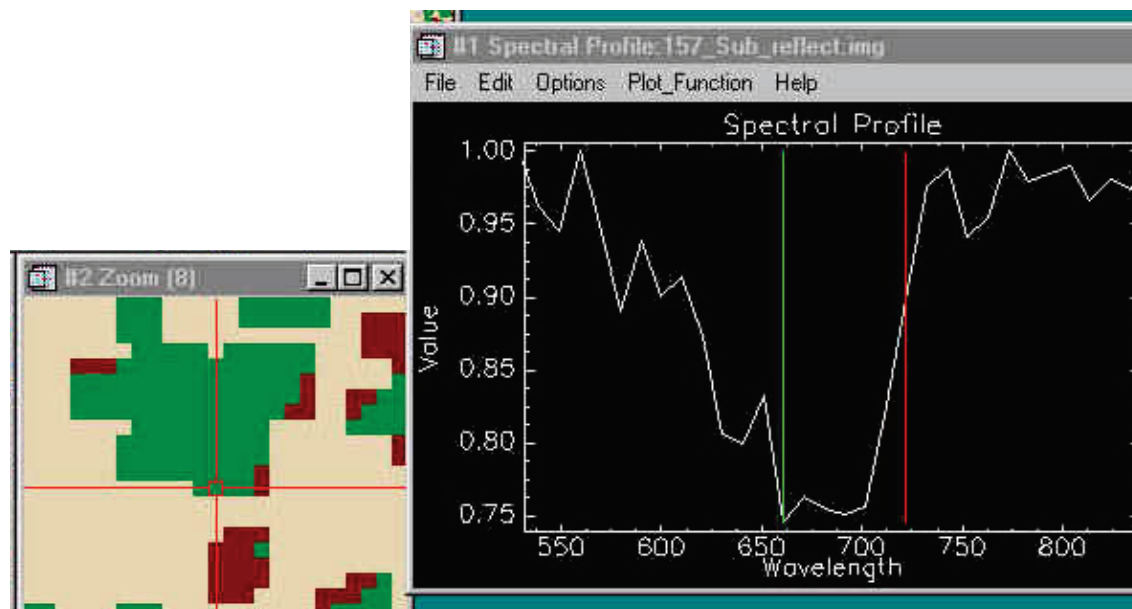
***Patterns stable and
reasonable between
different orbital strips***

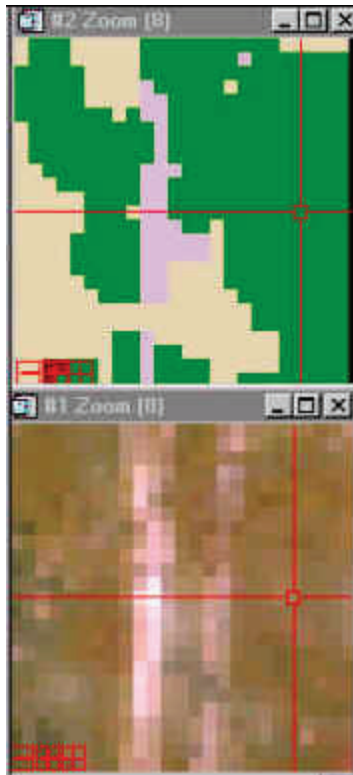




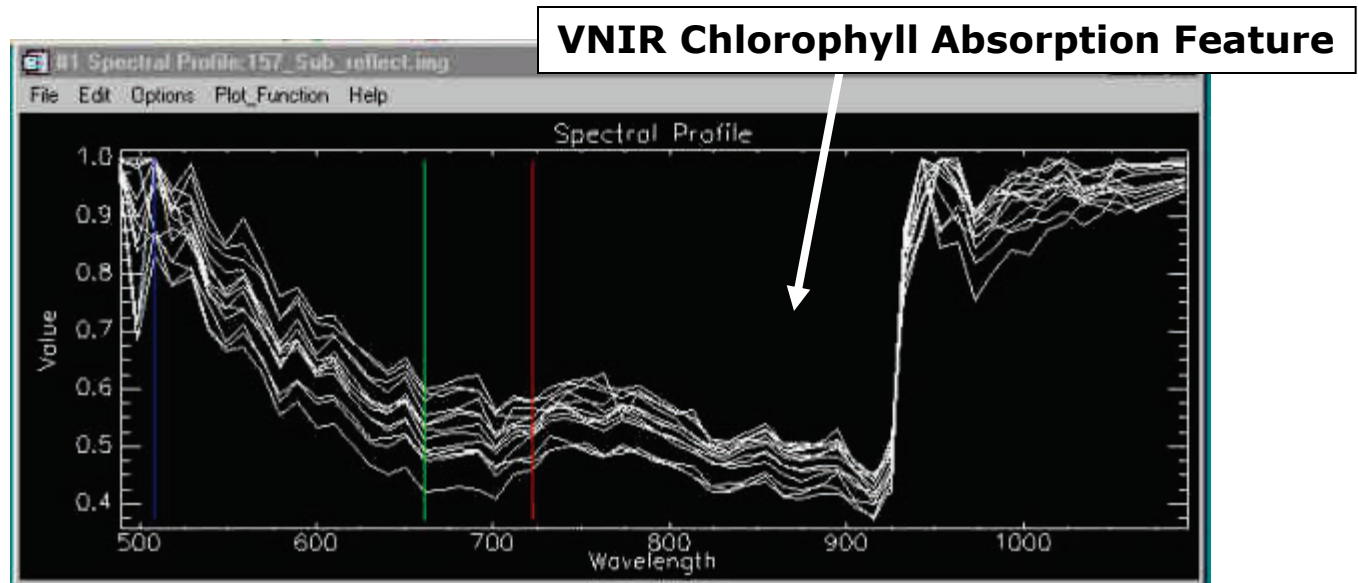
**Pixel of Vigorous
Vegetation as
Recorded by
Hyperion:
Chlorophyll
Absorption
Feature & Red
Edge**

**Pixel of
Less Vigorous
Vegetation from
Land Use/land Cover
Map**

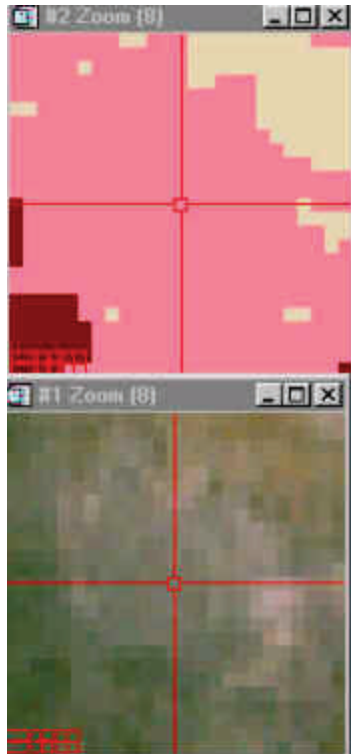




Vegetation interpreted to be Saltwort in comprehensive land use/land cover classification map shows consistent VNIR spectral pattern. Enables extrapolation to multispectral, same-day ALI that covers a much larger area.

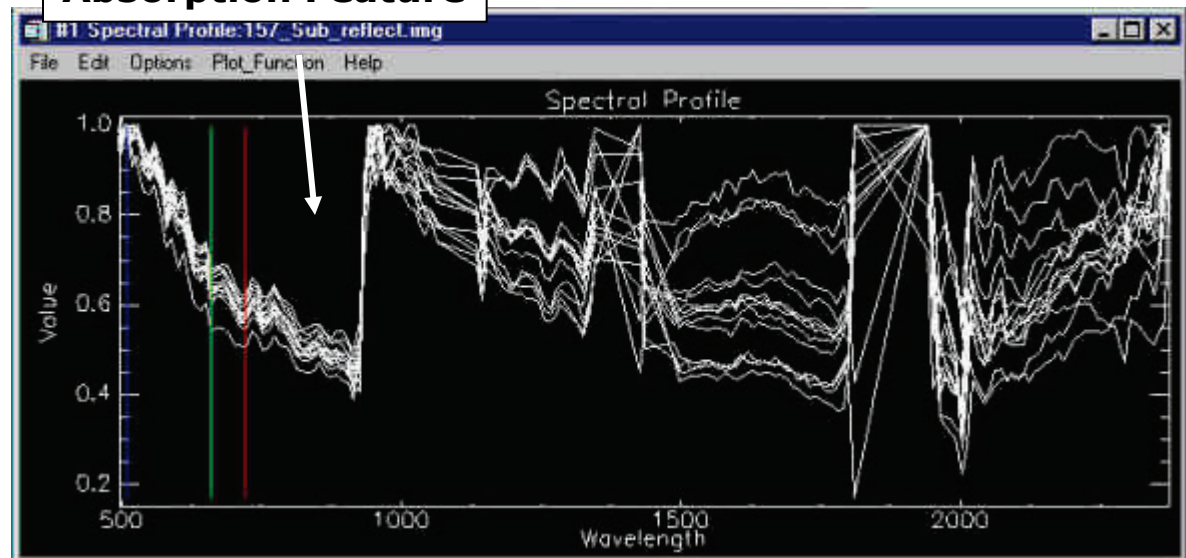


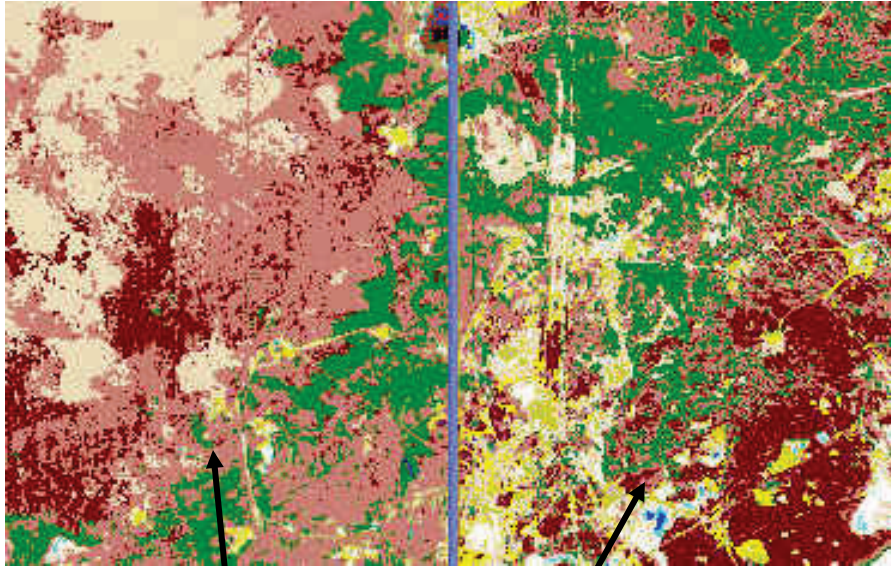
Vegetated pixels in Hyperion had consistent VNIR but erratic SWIR spectral patterns. Had to rely on same-day ALI.



VNIR Chlorophyll Absorption Feature

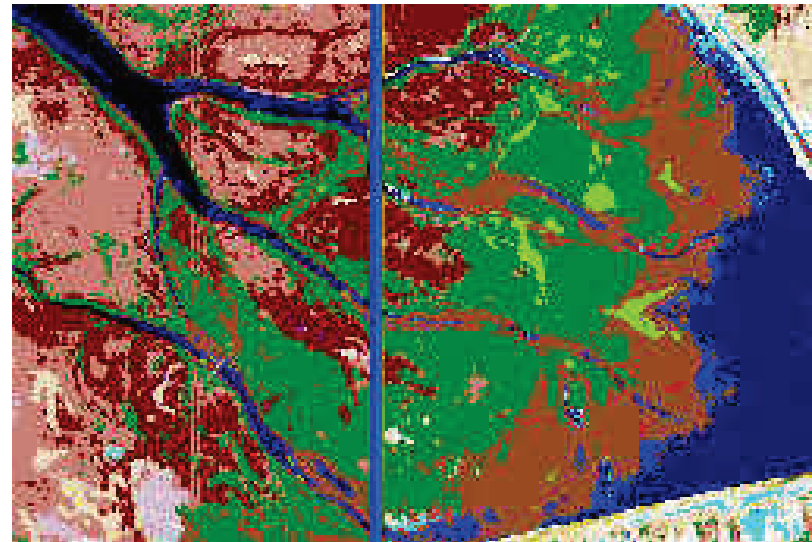
← **SWIR** →





**Hyperion had
consistent spectral
character for soils,
vegetation, water,
and infrastructure on
imagery acquired at
different times**

**Land Use/Land Cover
spectral classifications
from Hyperion, based
on 2 orbital strips -
acquired 2 weeks apart.
Signatures extrapolated
to same-day ALI**



Right side 2 weeks later
than Left Side

Summary

- **The aggressive acquisition program was a success**
- **No visual degradation with off-nadir imagery**
- **Building a consistent SWIR Spectral Library was an issue**
- **Preprocessing (conversion, bad bands, destreaking, etc.) used 3 paths**
- **Reliable mapping required:**
 - **training sites,**
 - **analyst adjustments for changing environmental conditions through the season,**
 - **regional, same-time, multispectral imagery such as Advanced Land Imager, Landsat TM7, or ASTER to provide a geographically consistent framework**