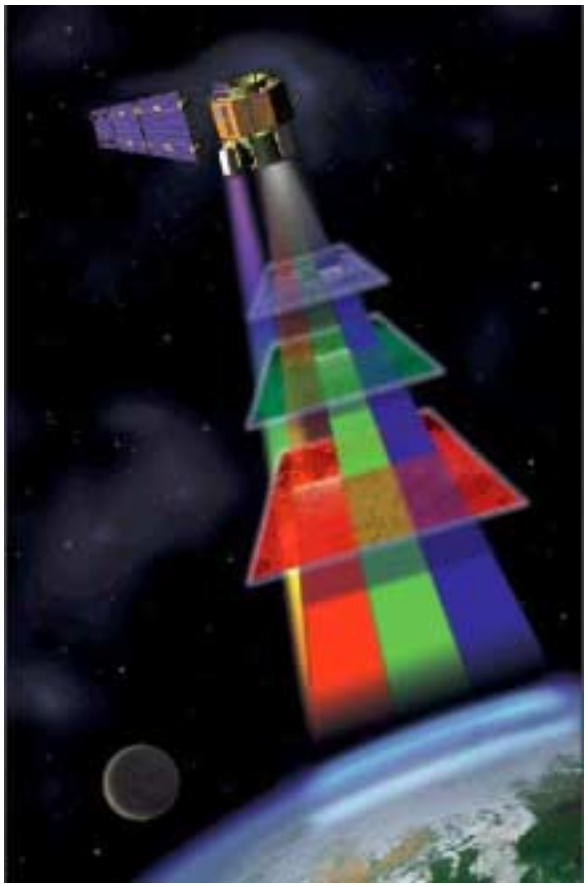
Overview of the Hyperion Imaging Spectrometer for the NASA EO-1 Mission



J. Pearlman, S. Carman, C. Segal,
P. Jarecke, and P. Barry, TRW
and
W. Browne, NASA GSFC

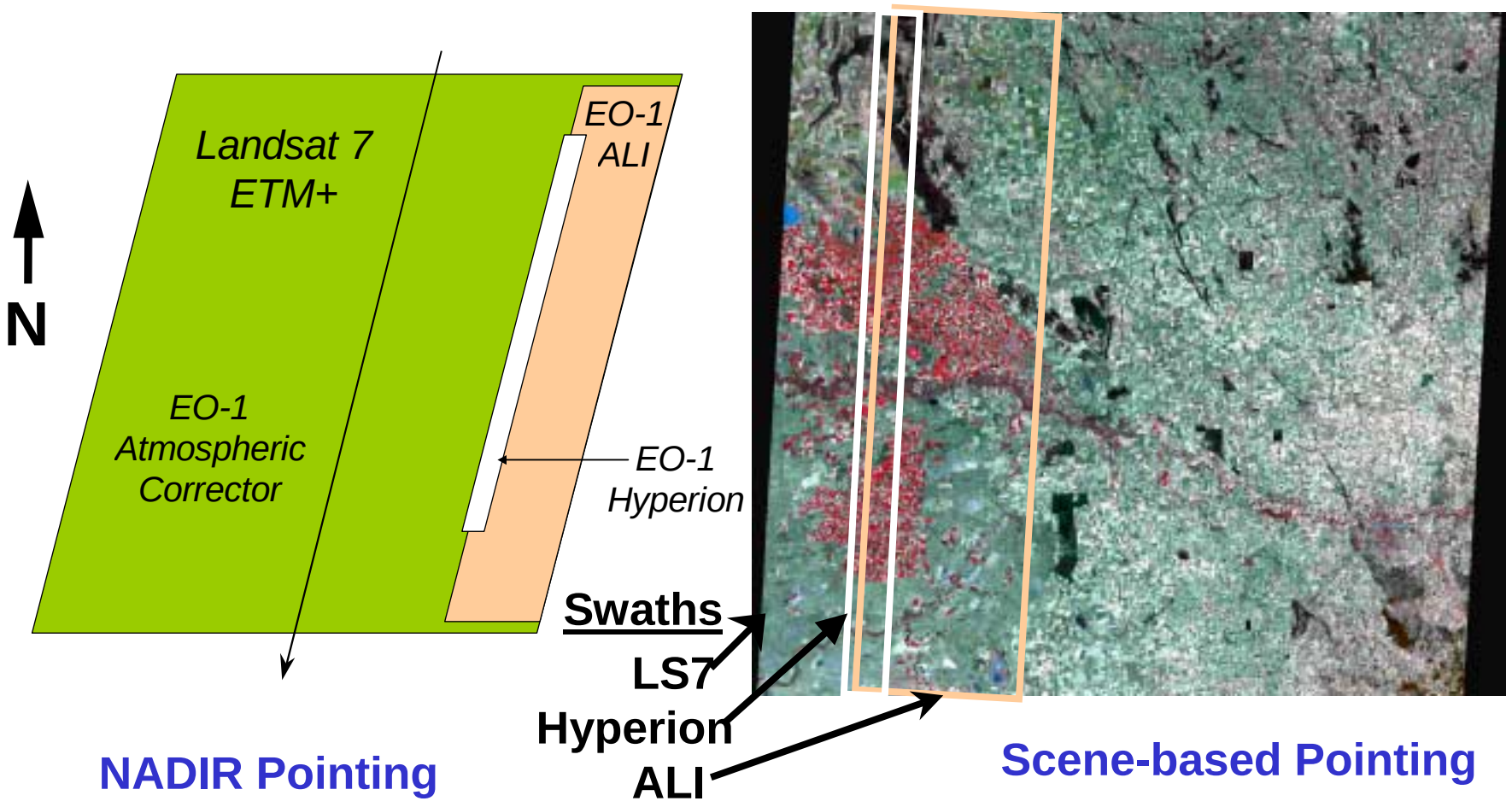
IGARSS 2001
JULY 9, 2001

Hyperion Imaging Spectrometer

Hyperion is a push-broom imager

- 220 10nm bands covering 400nm - 2500nm
- 6% absolute rad. accuracy
- Swath width of 7.5 km
- IFOV of 42.4 μradian
- GSD of 30 m
- 12-bit image data
- Orbit is 705km alt (16 day repeat)

EO-1 Sensor Swaths

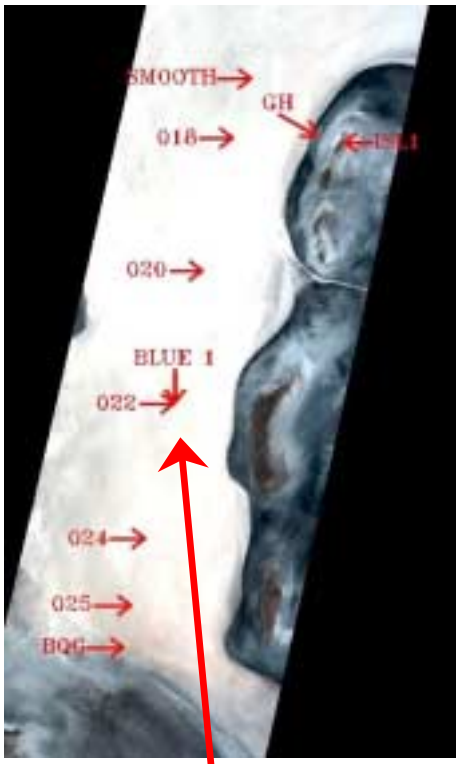


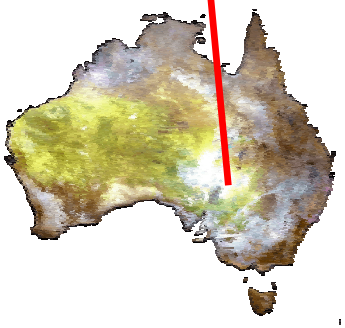
PERFORMANCE CHARACTERIZATION

A broad range of traditional and non-traditional techniques were used to characterize Hyperion

Desert Sites used for Vicarious Calibration

Lake Frome





RR Valley

Arizaro/Barreal Blanco

Out of this World Calibration

Hyperion image of the moon

Lunar image provides direct-viewing radiometric measurements for calibration without atmospheric effects.

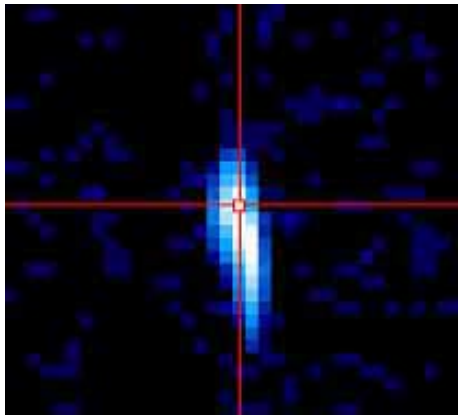
Issues of the lunar model and analysis techniques are being addressed

courtesy of P. Barry & H. Kieffer

Special targets for characterization

Searchlights
-California

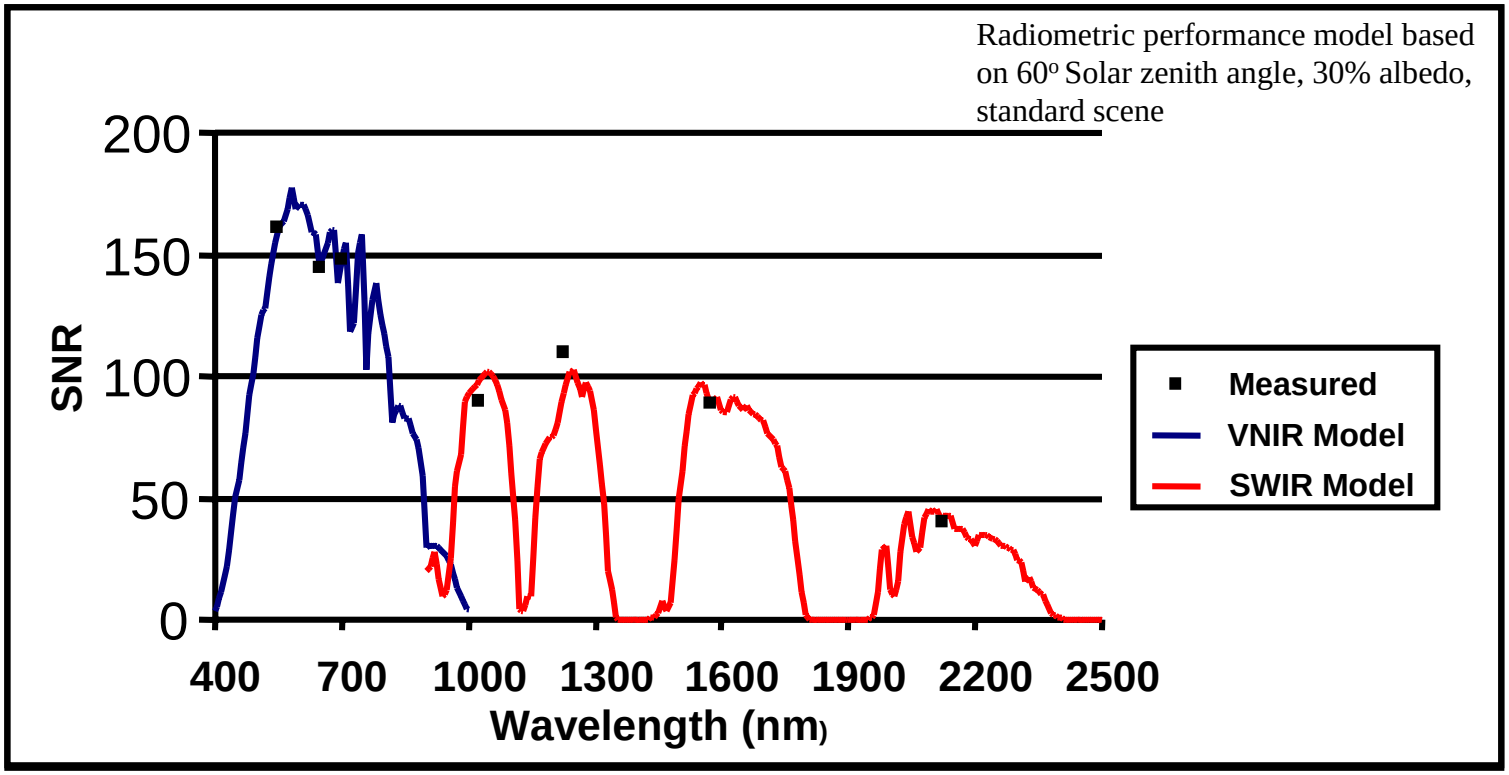
Planets
-Venus



90 deg
Yaw

Gas Flares
-Moomba

Hyperion SNR



Hyperion Measured SNR						
550 nm	650 nm	700 nm	1025 nm	1225 nm	1575 nm	2125 nm
161	144	147	90	110	89	40

Hyperion Characteristics

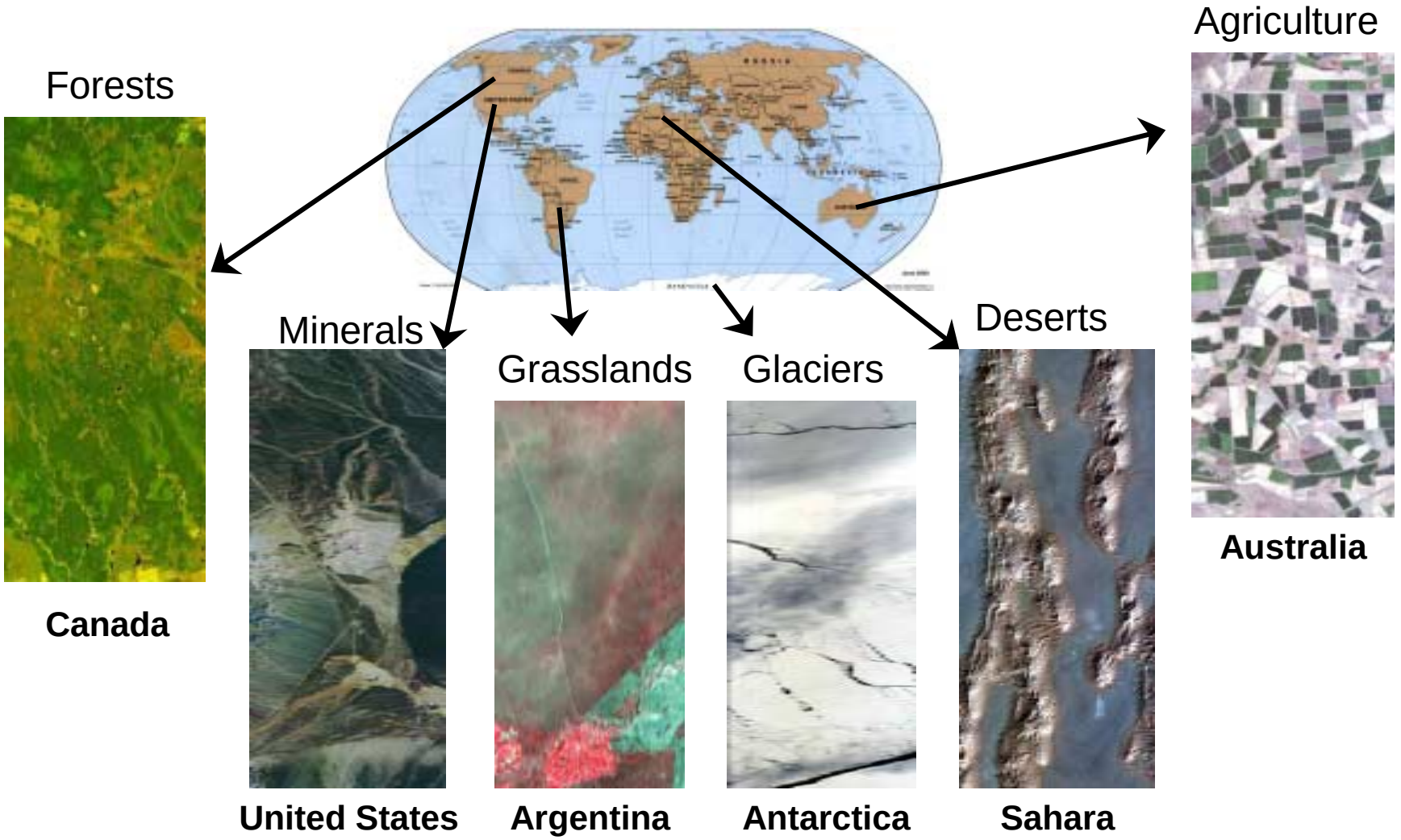
Characteristic	Pre-launch Cal	On-orbit Cal
GSD (m)	29.88	30.38
Swath (km)	7.5	7.75
No. of Spectral Channels	220	200 (L1 data)
VNIR SNR (550-700nm)	144-161	140-190
SWIR SNR (~1225nm)	110	96
SWIR SNR (~2125nm)	40	38
VNIR X-trk Spec. Error	2.8nm@655nm	2.2nm
SWIR X-trk Spec. Error	0.6nm@1700nm	0.58
Spatial Co-Reg: VNIR	18% @ Pix #126	*
Spatial Co-Reg: SWIR	21% @ Pix #131	*
Abs. Radiometry(1Sigma)	<6%	3.40%
VNIR MTF @ 630nm	0.22-0.28	0.23-0.27
SWIR MTF @ 1650nm	0.25-0.27	0.28
VNIR Bandwidth (nm)	10.19-10.21	*
SWIR Bandwidth (nm)	10.08-10.09	*

*** Consistent with Pre-Launch Calibration or not measured**

APPLICATIONS

Evaluating space-based hyperspectral imaging

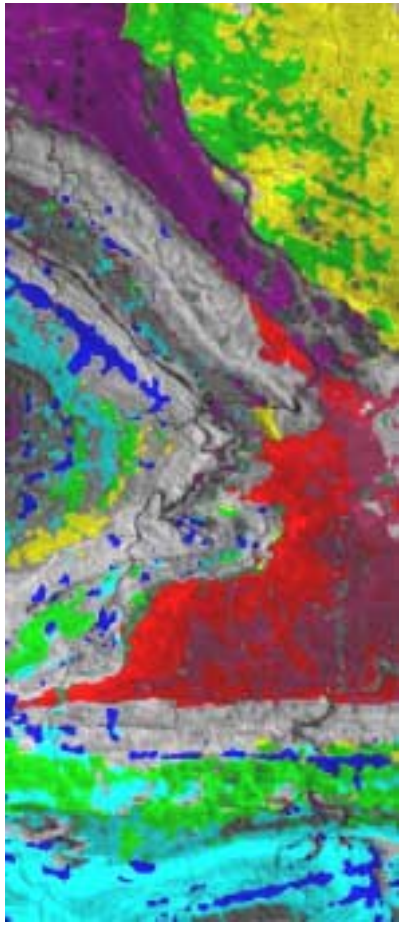
Hyperion addresses a broad range of issues and world-wide sites



Hyperion Maps Mt. Fitton Geology

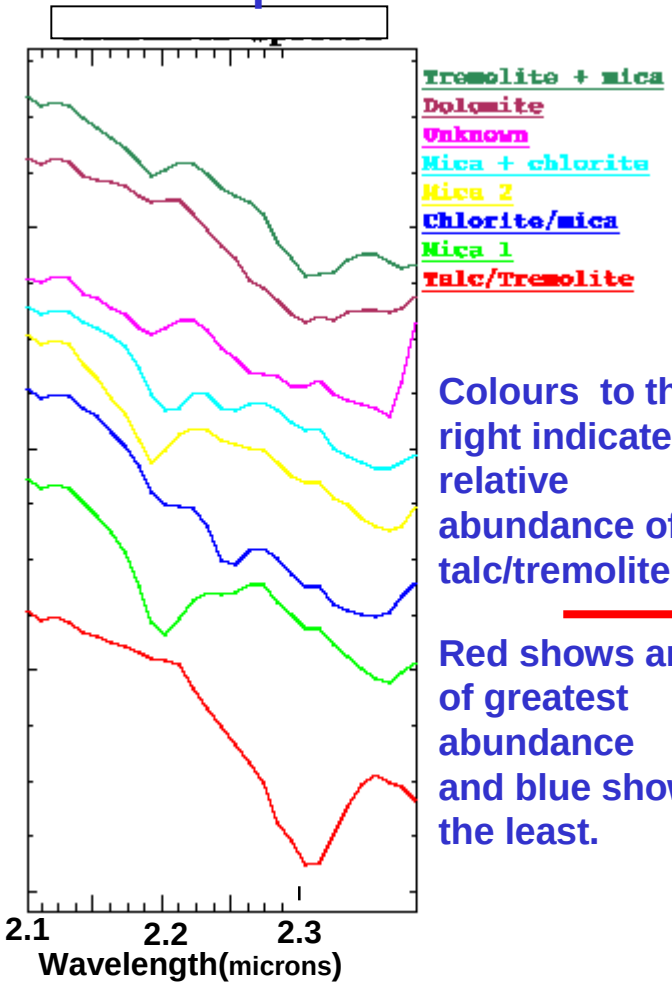
Automatic mineral mapping algorithm creates, in 30 seconds, a quick-look mineral map (left & centre). More precise detail is on right. (Courtesy of CSIRO Australia)

Mineral Map



Colours of spectra match the thematic image to left.

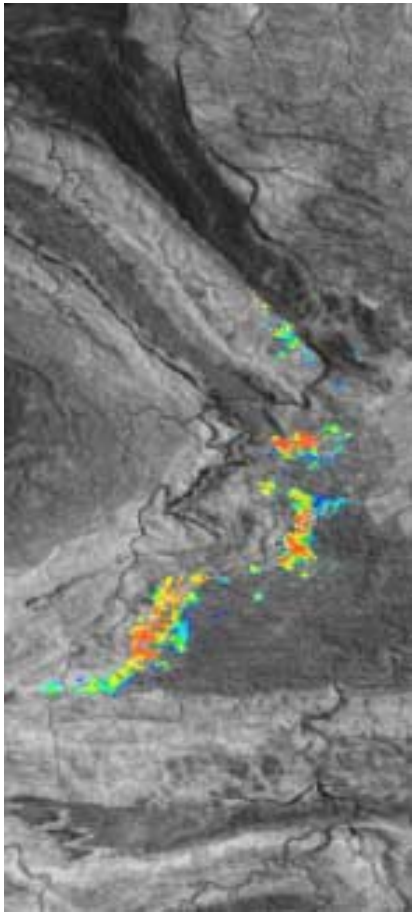
Mineral Spectra



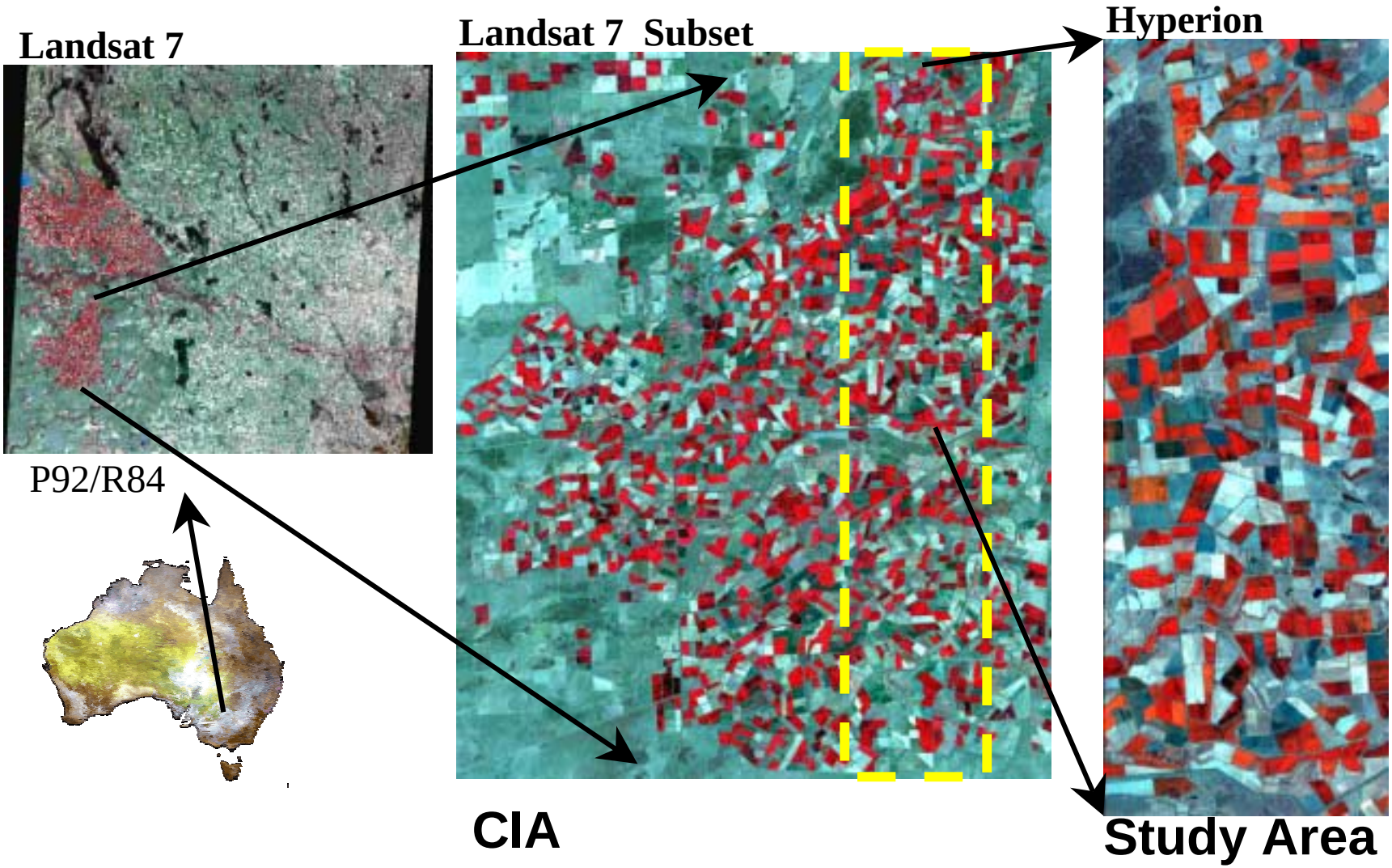
Colours to the right indicate the relative abundance of talc/tremolite .

Red shows areas of greatest abundance and blue shows the least.

Detailed Talc-Tremolite Map

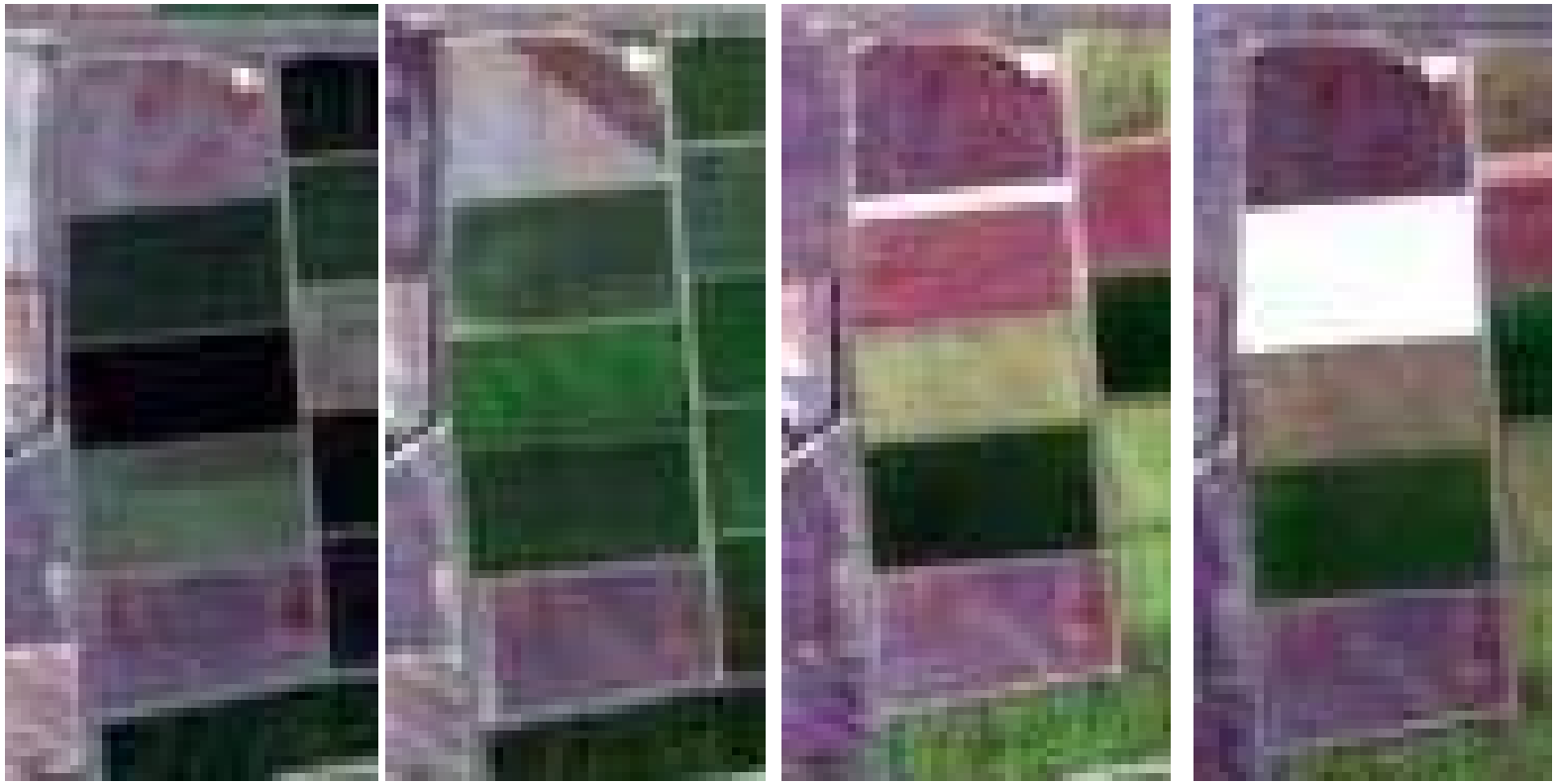


Landsat and EO-1 Images



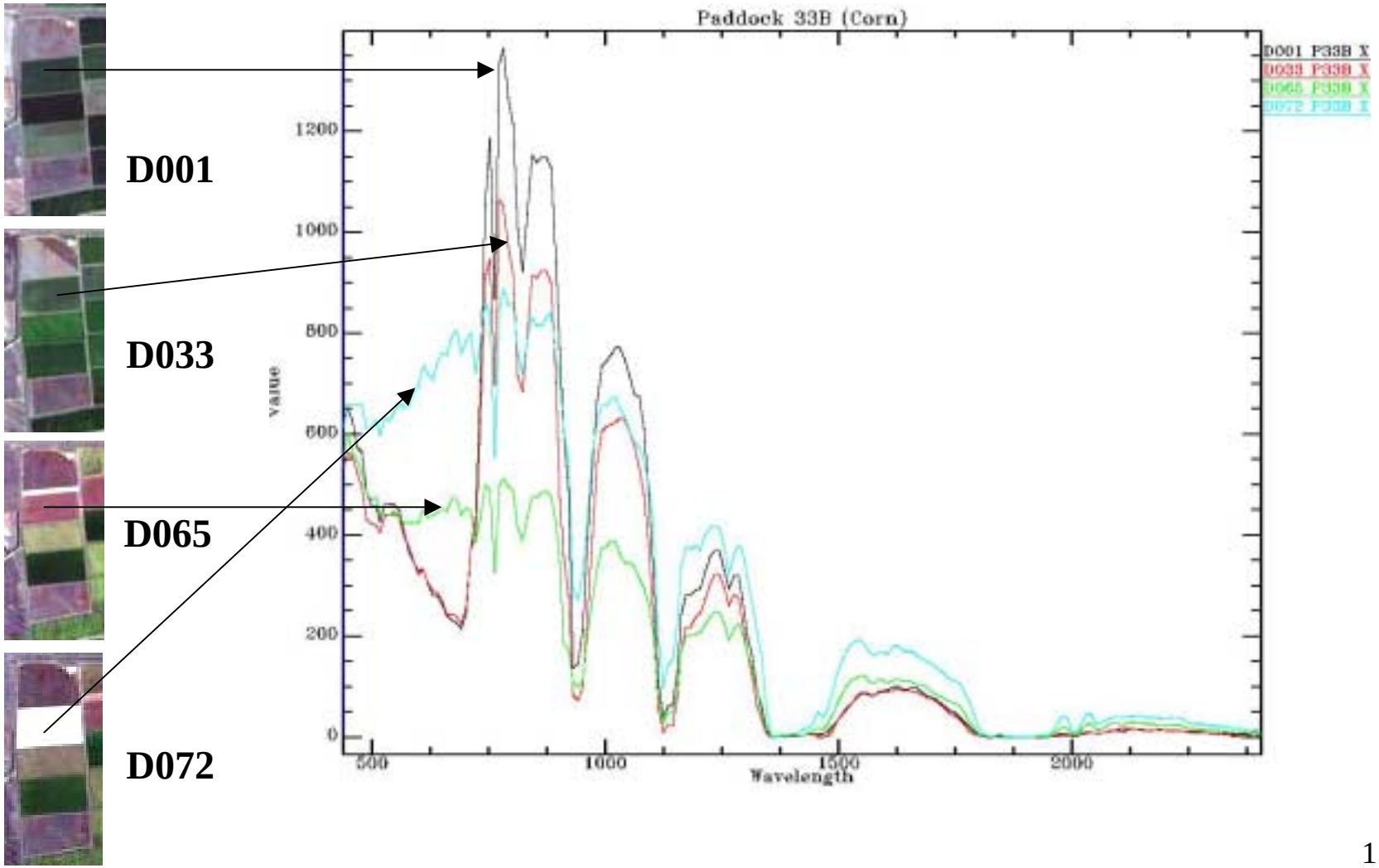
Temporal Sequence of Hyperion Images

Coleambally Irrigation Area



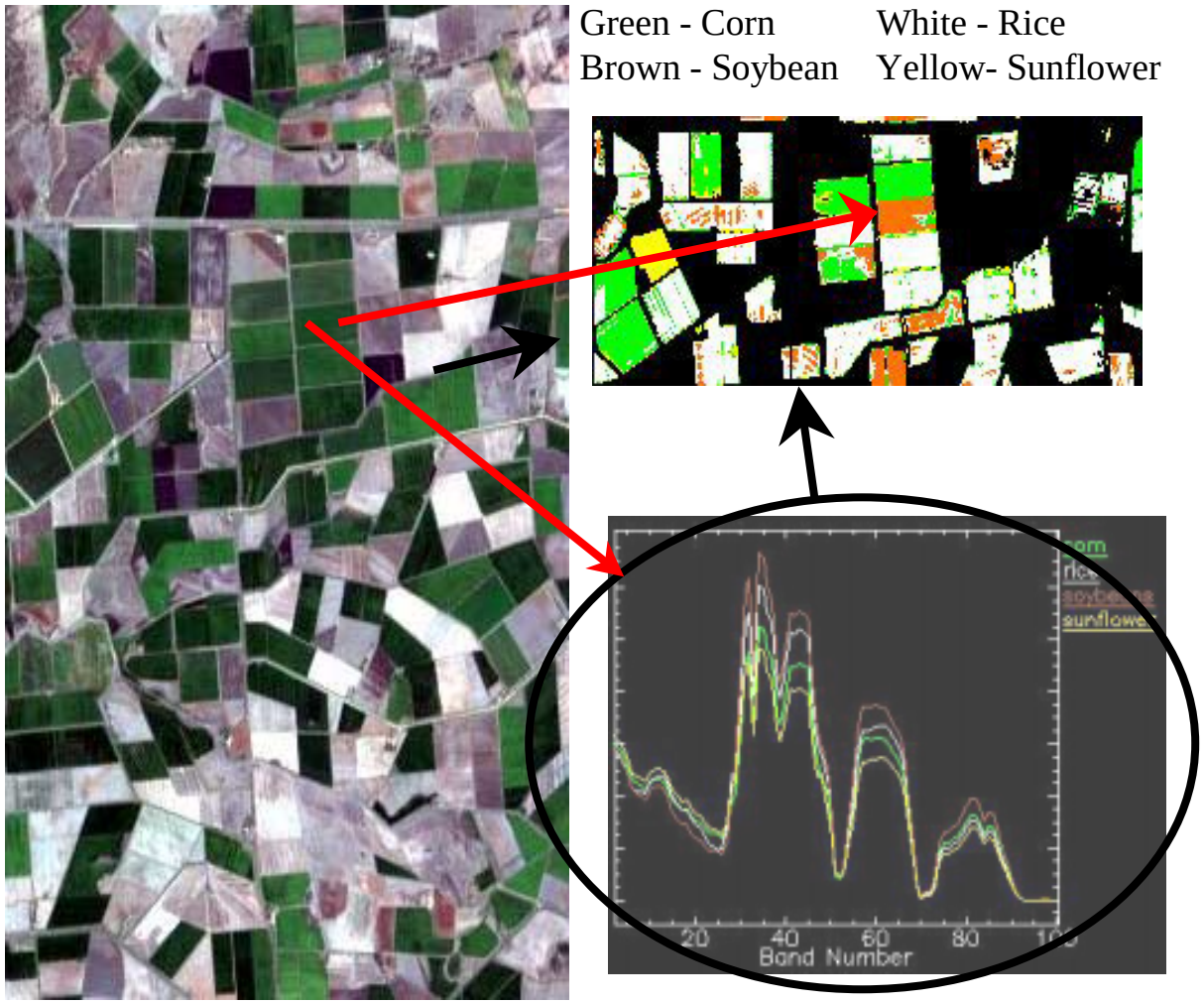
Julian calendar days of 2001

Time Sequence of Corn
(Paddock 33B)



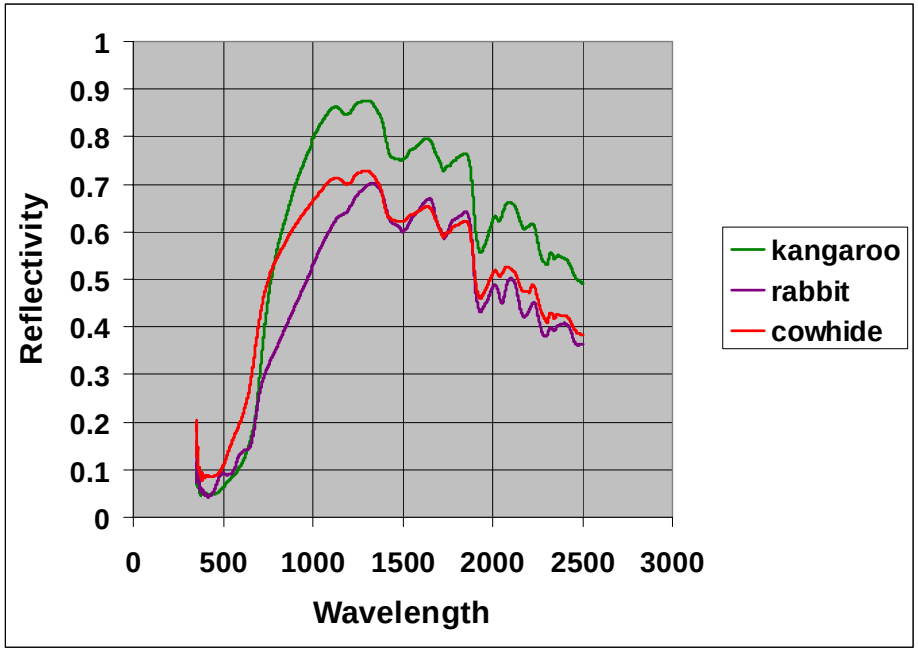
Work in Process

- **Recent data release**
- **Atmospheric Correction**
- **Space-ground data comparisons**
- **Inter-instrument comparisons**
- **Science Validation**



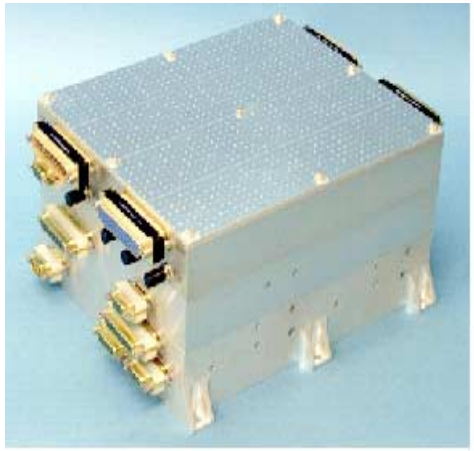
Ground Data Teams

Long Term Directions



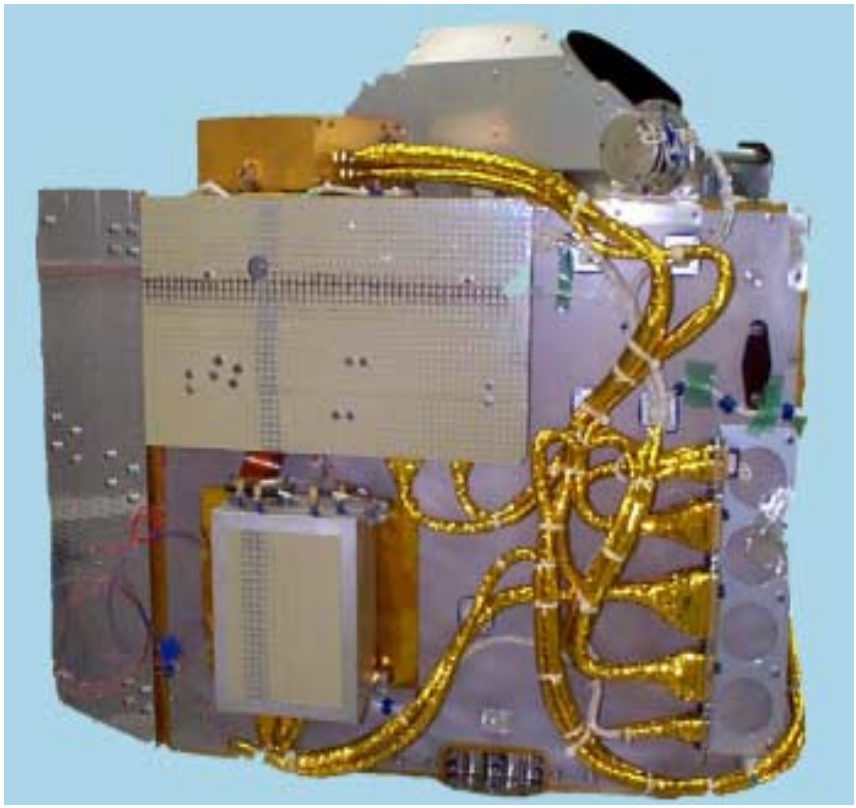
Backup

Hyperion Subassemblies

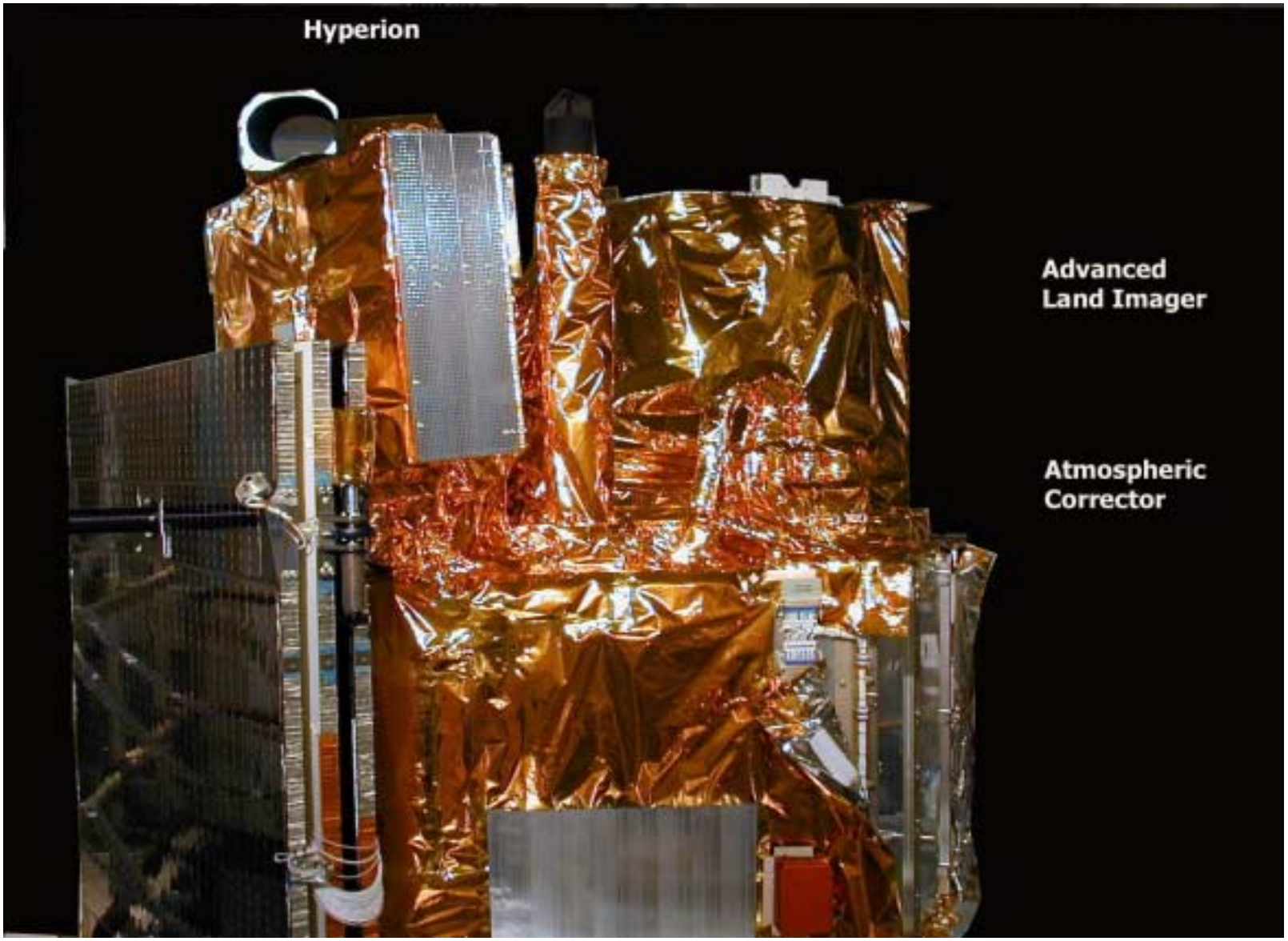


Hyperion Electronics Assembly (HEA)

Cryocooler Electronics Assembly (CEA)

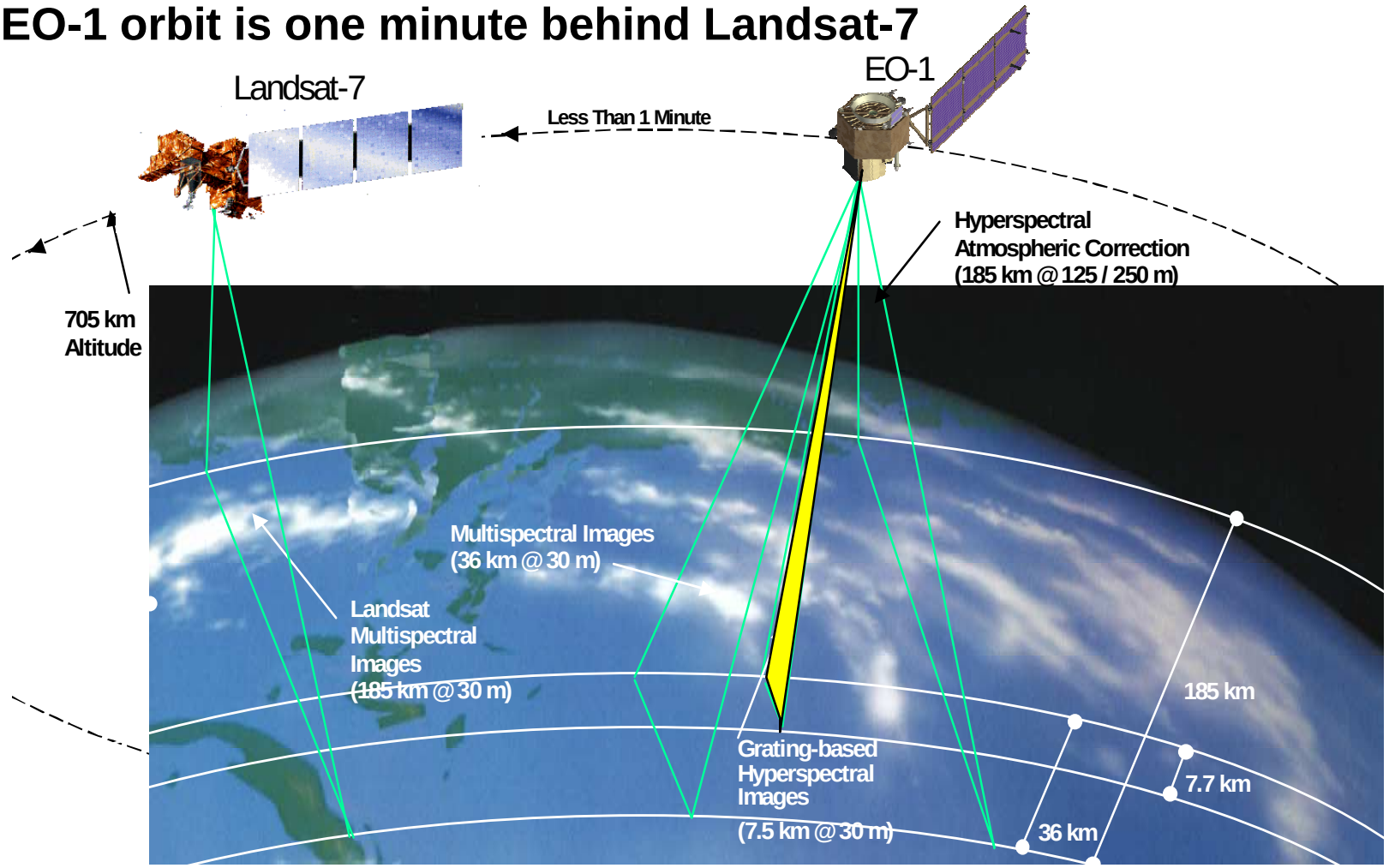


Hyperion Sensor Assembly (HSA)


Hyperion
Advanced
Land Imager
Atmospheric
Corrector

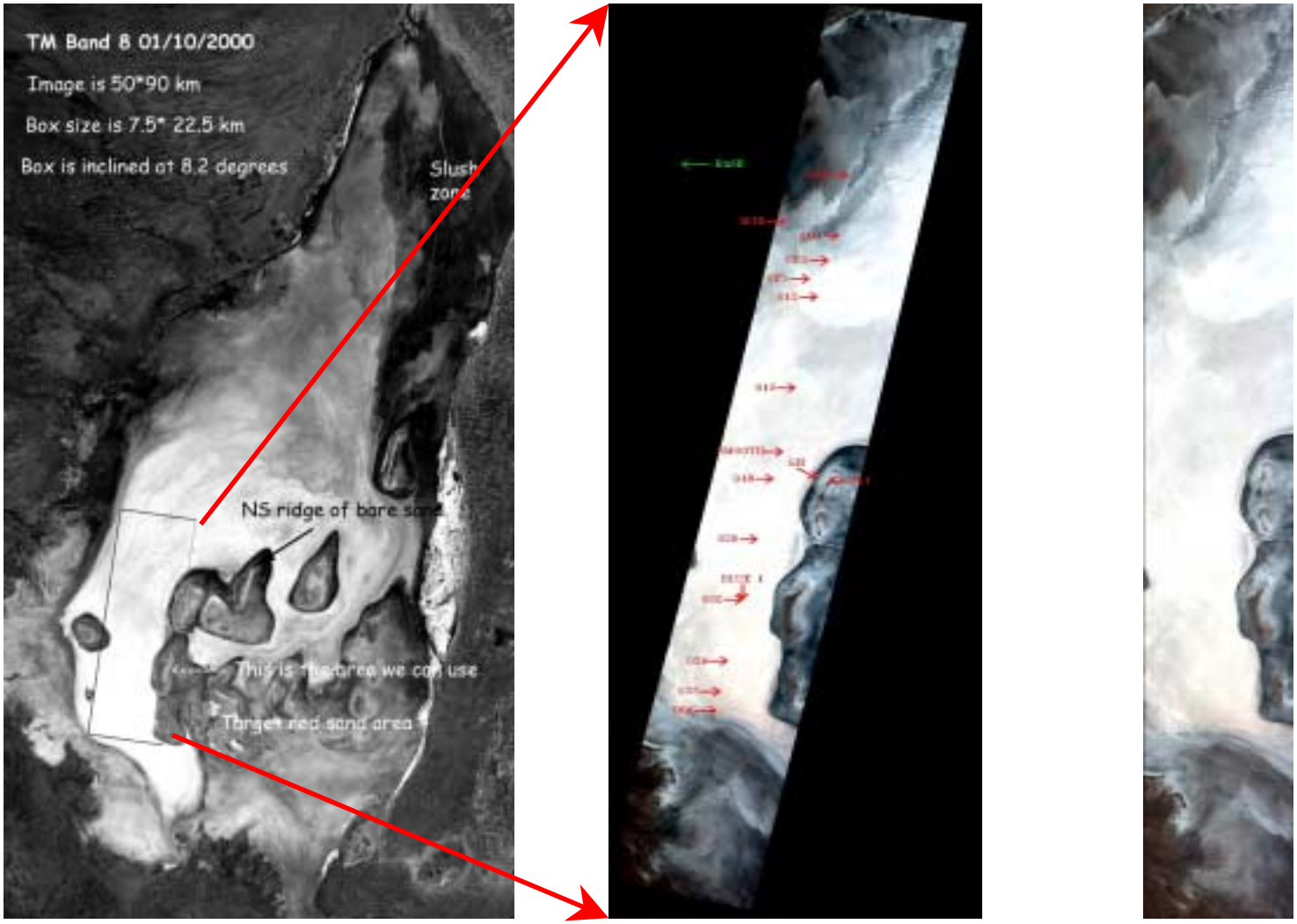
EO-1 Orbit

- **EO-1 Spacecraft launched November 21, 2000 from Vandenberg Air Force Base**
- **EO-1 orbit is one minute behind Landsat-7**



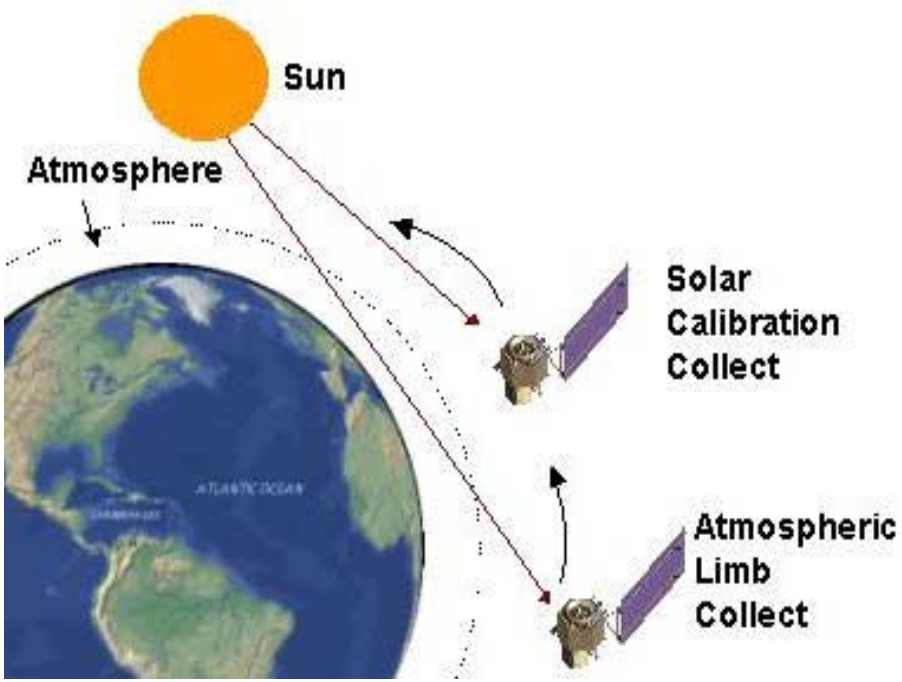
Extensive Pre-flight Calibration

Lake Frome Calibration Site



Hyperion Spectral Calibration –

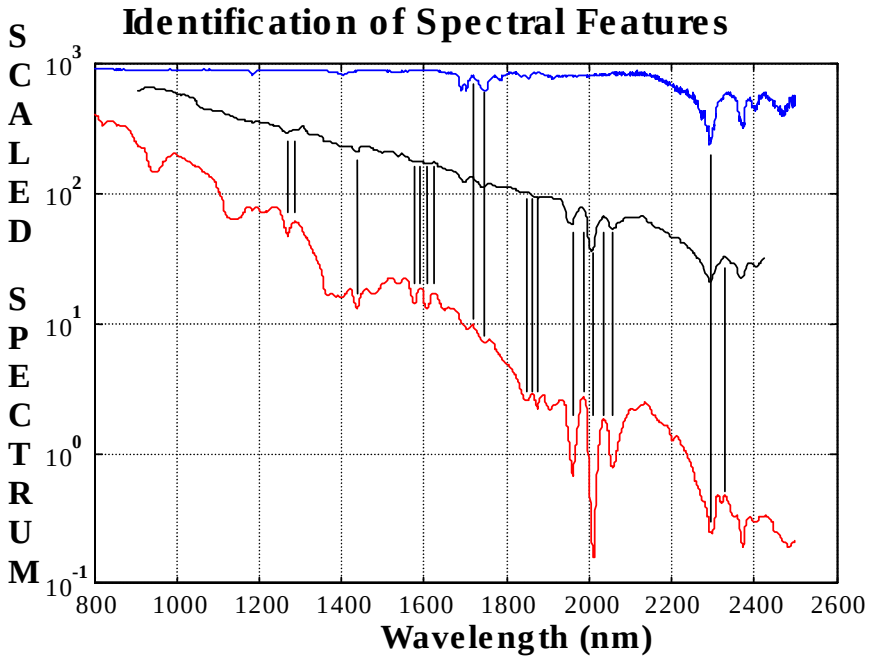
atmospheric absorption lines



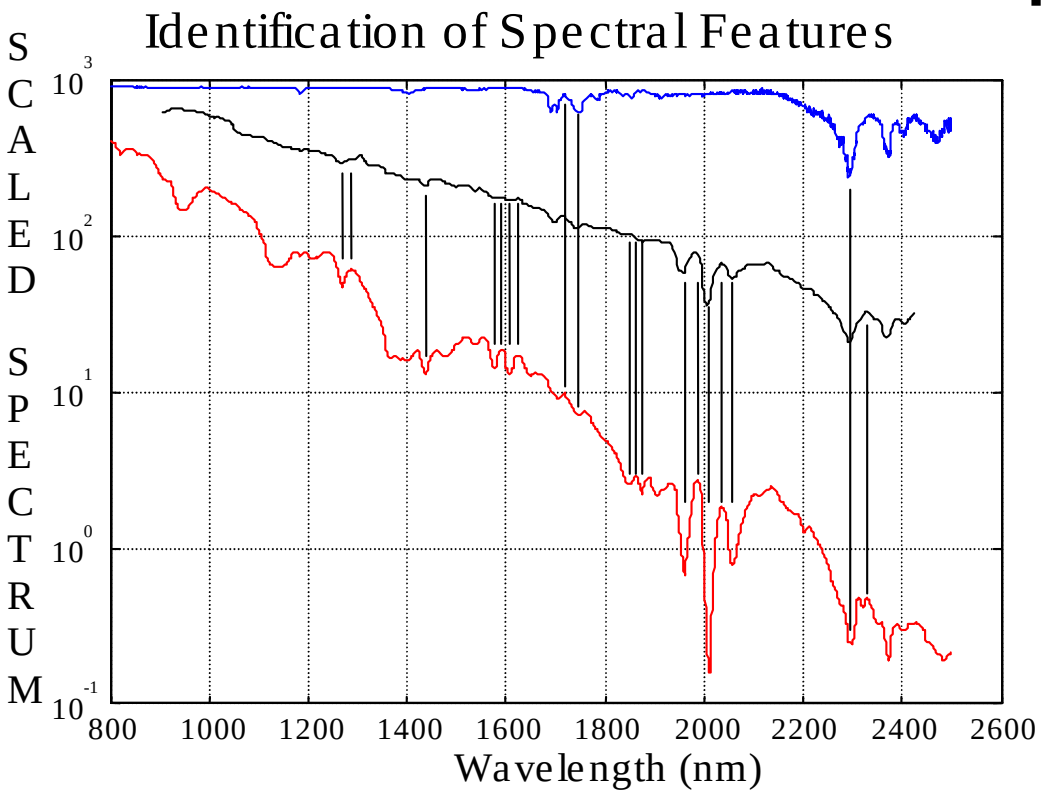
Hyperion Spectra – red

Atmospheric Reference – black

Diffuse Reflectance of cover – blue



Spectral Calibration –SWIR



Hyperion Spectra – red

Atmospheric Reference – black

Diffuse Reflectance of cover – blue

Process:

1.) Create Pseudo-Hyperion Spectra from reference: Modtran-3 for atmosphere, and Cary 5 & FTS measurements for diffuse reflectance of the cover

2.) Correlate Spectral Features: band number units of Hyperion max/min correlated with reference wavelength of max/min

3.) Calculate Band to Wavelength map: apply low order polynomial to fit the data over the entire SWIR regime

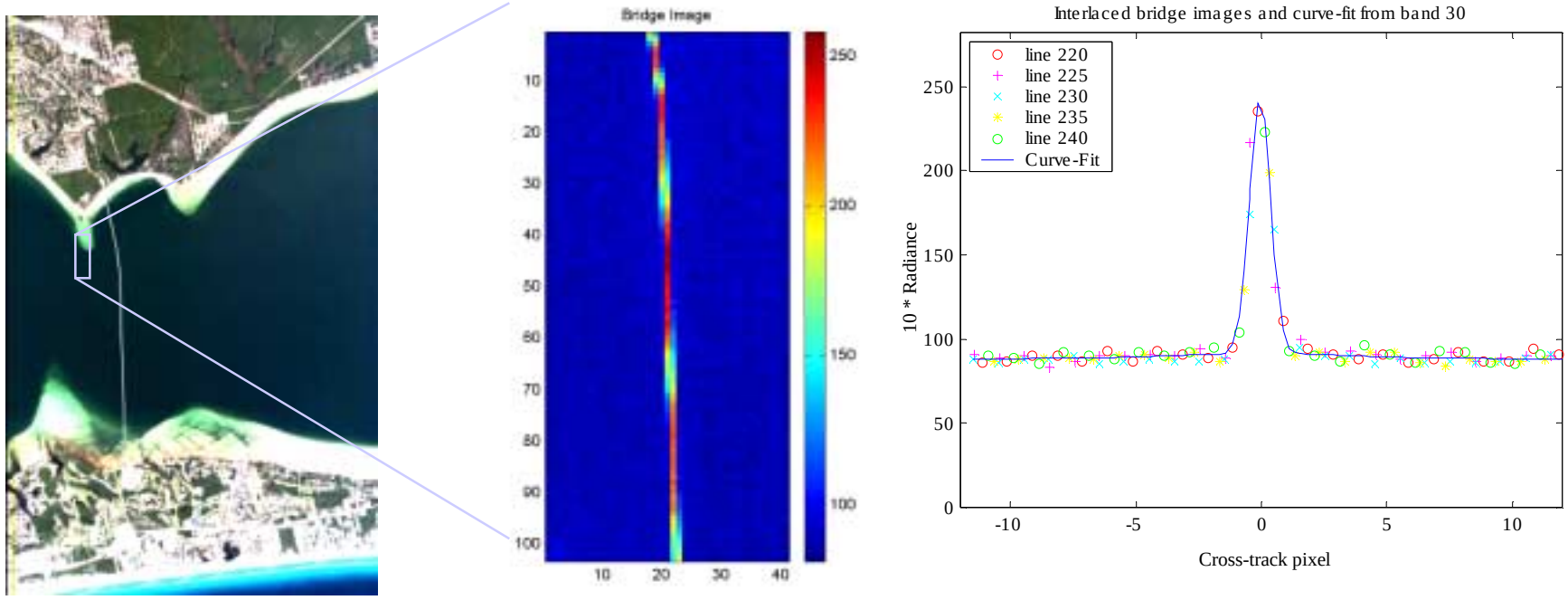
MTF Approach

- **Calculate cross-track and in-track MTF using a step response and impulse response example**

- **Results of on-orbit analysis give good agreement with the pre-launch laboratory measurements**

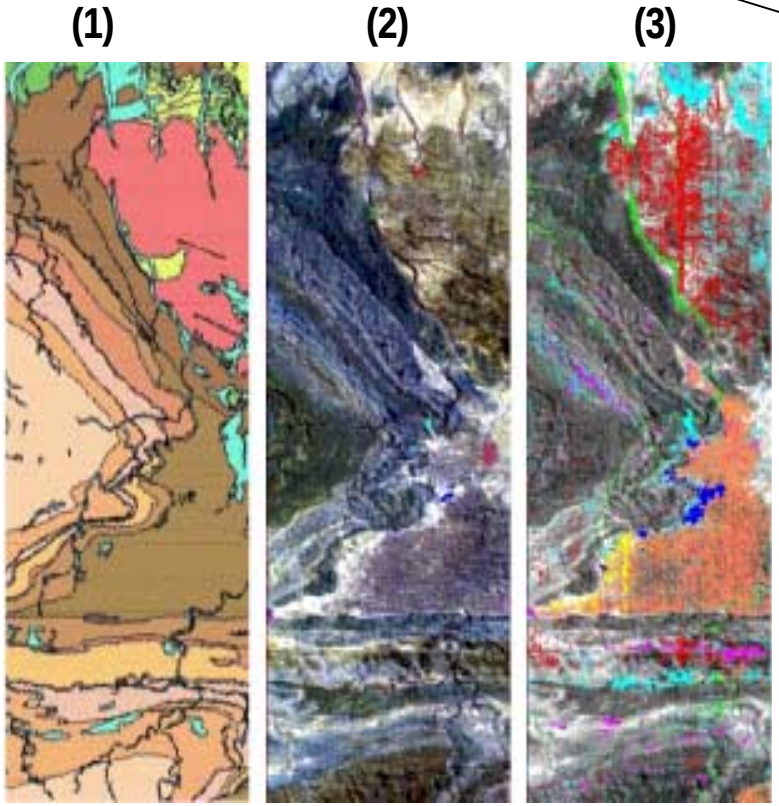
Example: Cross-track MTF

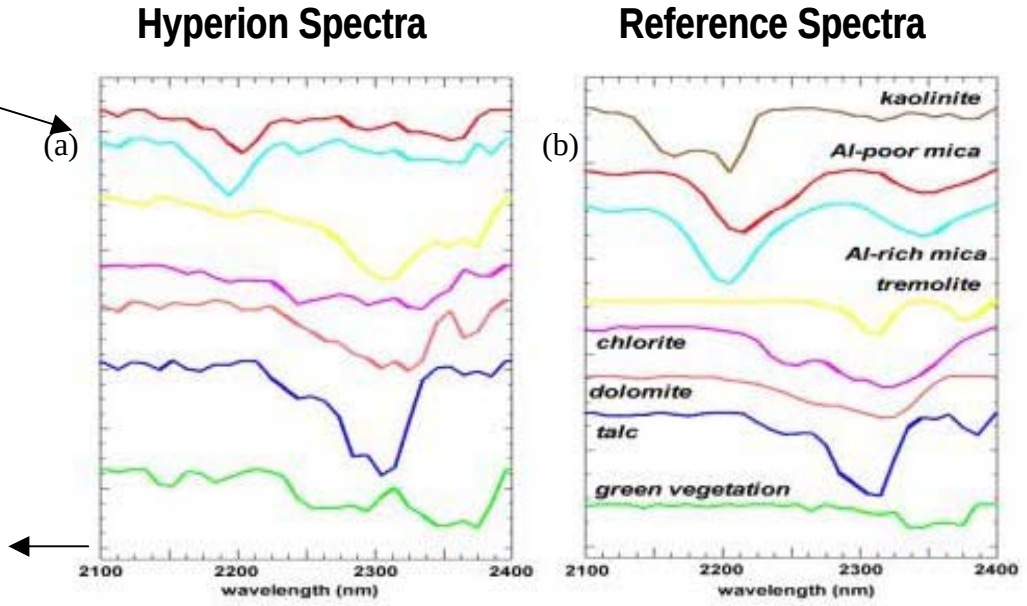
- Scene is Port Eglin from Dec 24, 2000. Bridge is the Mid-bay bridge . Bridge width is 13.02 meters.
- Bridge angle to the S/C direction is small so every 5th line is used to develop the high resolution bridge image.
- MTF result at Nyquist is between 0.39 to 0.42 while the pre-flight measurement was 0.42.



Hyperion Maps Mt. Fitton Geology

Hyperion-based apparent reflectance compares with library 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 (visible) showing regions of interest

(3) Hyperion surface composition map using SWIR spectra above

Courtesy of CSIRO, Australia

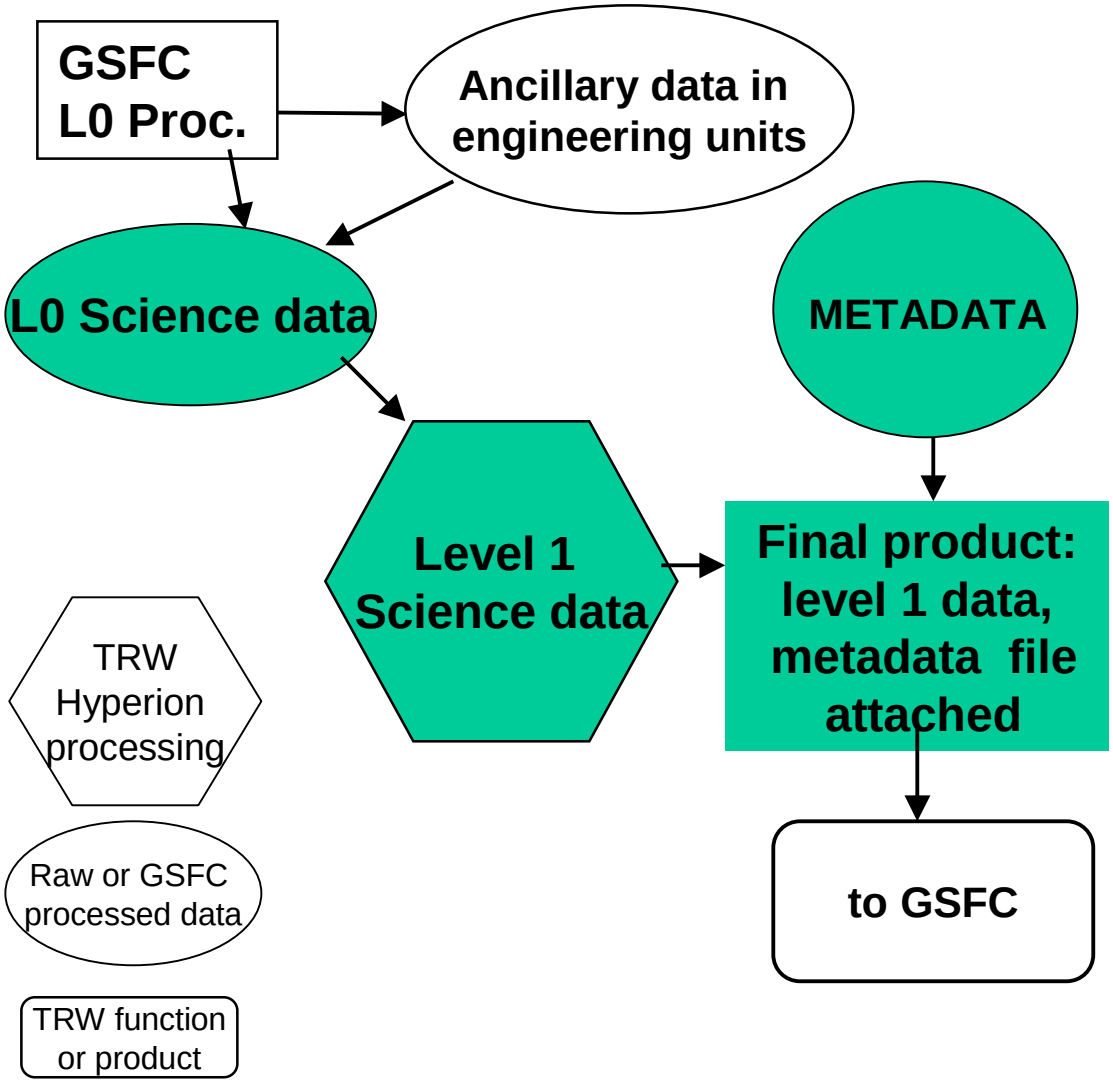
VNIR/SWIR Repeatability

- **Solar Calibration demonstrates good pixel-to-pixel repeatability**
  - **VNIR is highly repeatable - <0.05% variation**
  - **SWIR is repeatable - <0.75% variation**

- **Spectral Calibration indicates stability based on comparisons of Pre-launch and On-Orbit measurements**

DATA CHARACTERISTICS

Hyperion Data Flow



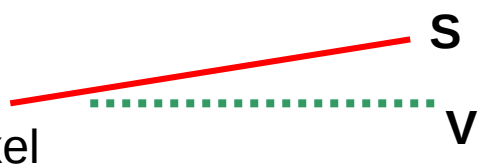
Science Data: Level 0 or Level 1 (radiometrically corrected) data products with VNIR and SWIR data frames combined. Includes solar, lunar calibrations, earth images, dark and light calibrations

Metadata: Data about the science data. Information to support higher level processing, e.g., pre-flight characterization data

Ancillary Data: Supporting data derived from spacecraft telemetry during image collection

Hyperion Data - Comments

Level 1 data: 438-926nm and 892-2406nm
Bands 9-57 and 75 - 225;
SWIR is West of VNIR and rotated CCW by one pixel



Band	Center(nm)	FWHM(nm)	
50	**854.66**	**11.27**	VNIR
51	**864.83**	**11.27**	
52	**875**	**11.28**	
53	**885.17**	**11.29**	
54	**895.34**	**11.3**	
55	**905.51**	**11.31**	
56	**915.68**	**11.31**	
57	**925.85**	**11.31**	
58	936.02	11.31	
59	946.19	11.31	
71	852	11.17	SWIR
72	862.09	11.17	
73	872.18	11.17	
74	882.27	11.17	
75	**892.35**	**11.17**	
76	**902.44**	**11.17**	
77	**912.53**	**11.17**	
78	**922.62**	**11.17**	
79	**932.72**	**11.17**	
80	**942.81**	**11.17**