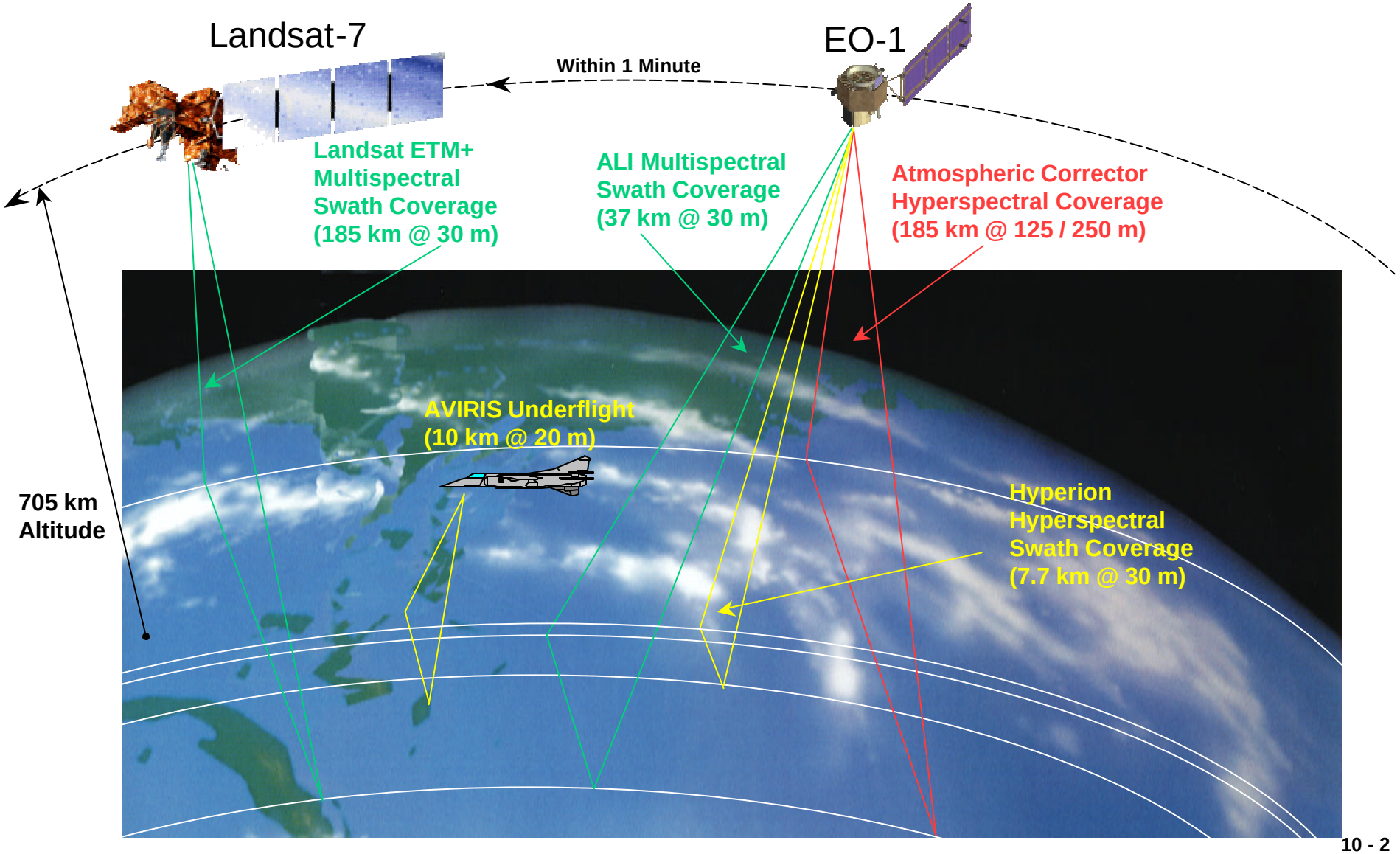
Nov. 28-29, 2001

Section 10

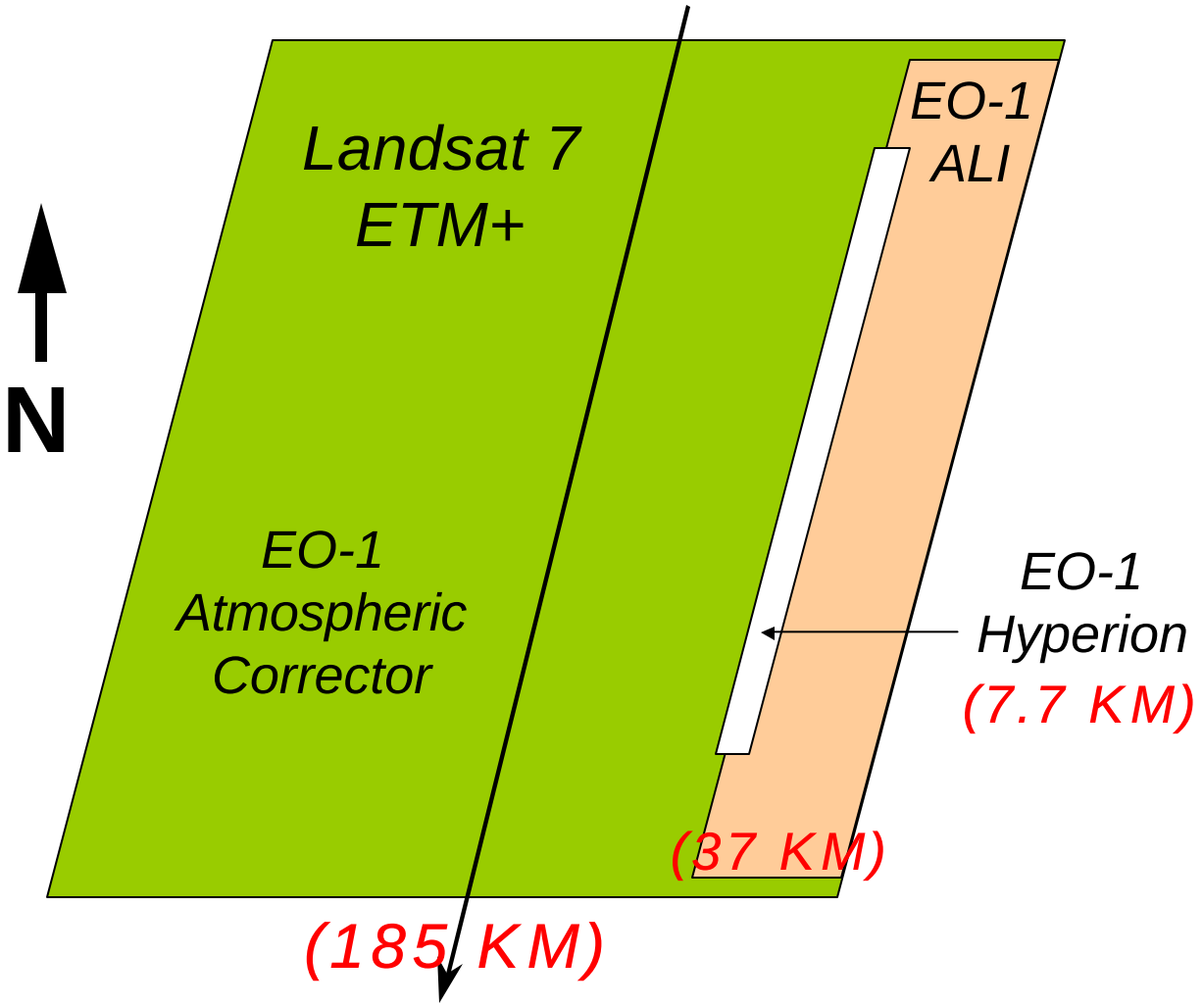
Comparison of ALI and Landsat Data Sets

Stephen G. Ungar
NASA GSFC Code 923

EO-1 and Landsat



EO-1 and Landsat 7 Descending Orbit Ground Tracks

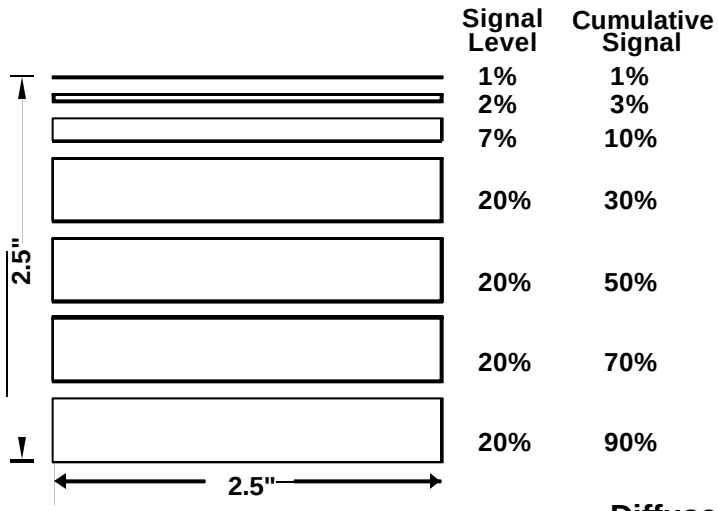


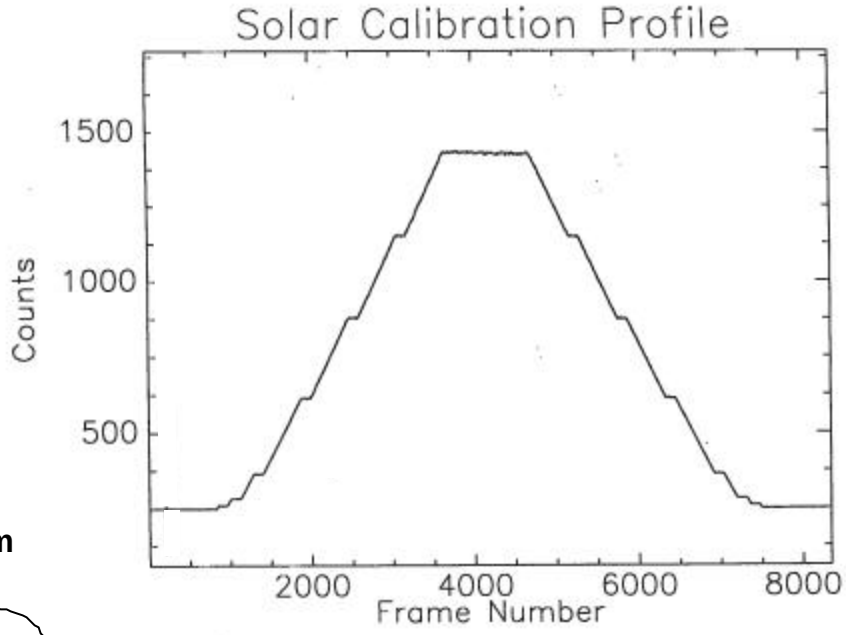
EO-1 Instrument Overviews

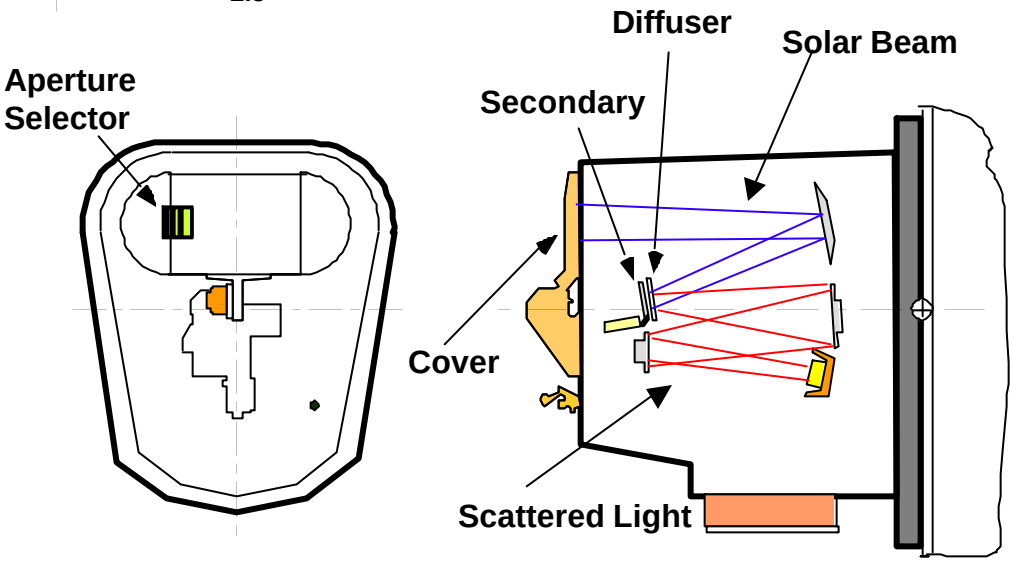
Parameters	Landsat 7 ETM+	EO-1 ALI	EO-1 HYPERION	EO-1 AC
Spectral Range	0.4 - 2.4 µm*	0.4 - 2.4 µm	0.4 - 2.5 µm	0.9 - 1.6 µm
Spatial Resolution	30 m	30 m	30 m	250 m
Swath Width	185 Km	37 Km	7.7 Km	185 Km
Spectral Resolution	Variable	Variable	10 nm	3 - 9 nm**
Spectral Coverage	Discrete	Discrete	Continuous	Continuous
Pan Band Resolution	15 m	10 m	N/A	N/A
Total Number of Bands	7	10	220	256

**** Excludes thermal channel***
***** 35/55 cm^{-1} constant resolution***

Solar Calibration







“First Light” image of Alaska

L7 PAN

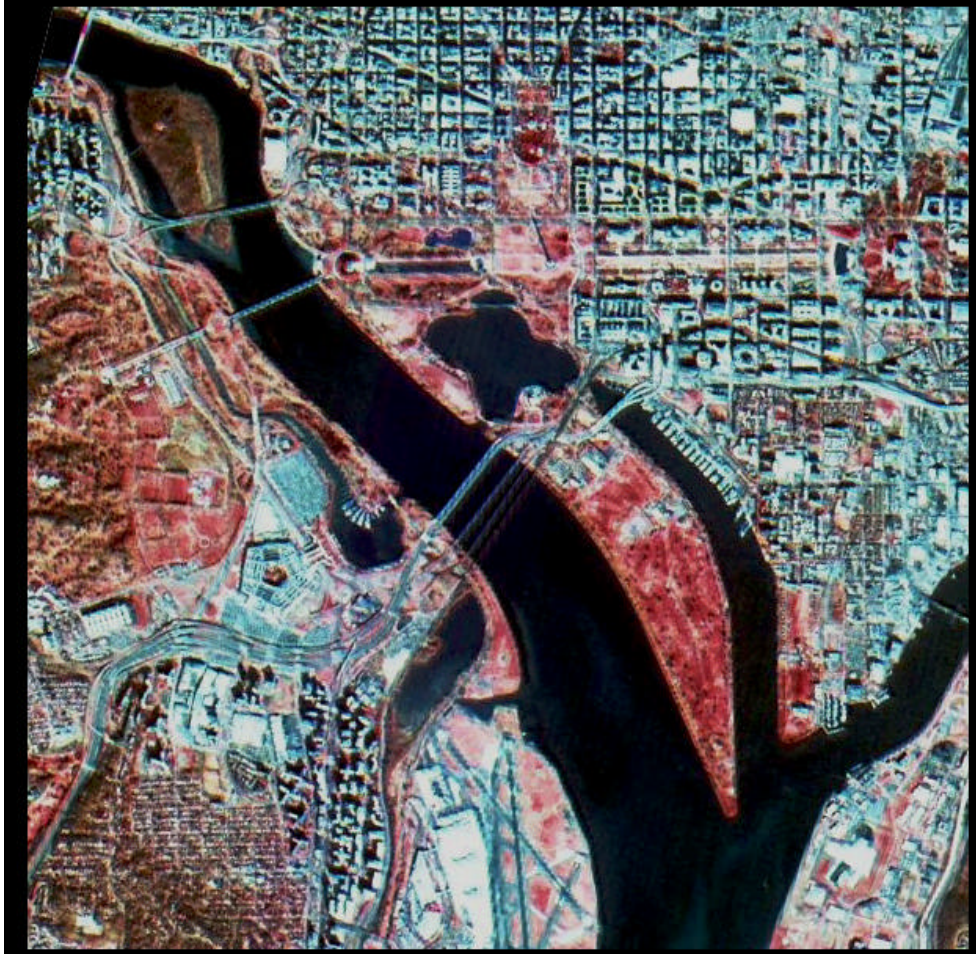
ALI PAN

Why is the ALI pan band better

- *Improved Radiometric resolution*
  - ***Superior signal-to-noise***
  - ***12-bit versus 8-bit representation of dynamic range***
- *Inherently higher contrast measurement*
  - ***ALI pan restricted to 480 – 690nm VIS spectral interval***
  - ***ETM+ spans vegetation transition rise (520 – 900nm)***
- *Smaller pixel size (IFOV)*
  - ***ALI pan IFOV is 10 meters***
  - ***ETM+ is nominally 15 meters (effectively 18 meters)***

ALI Pan Enhanced 4-3-2 Composite
Washington, DC - December 1, 2000

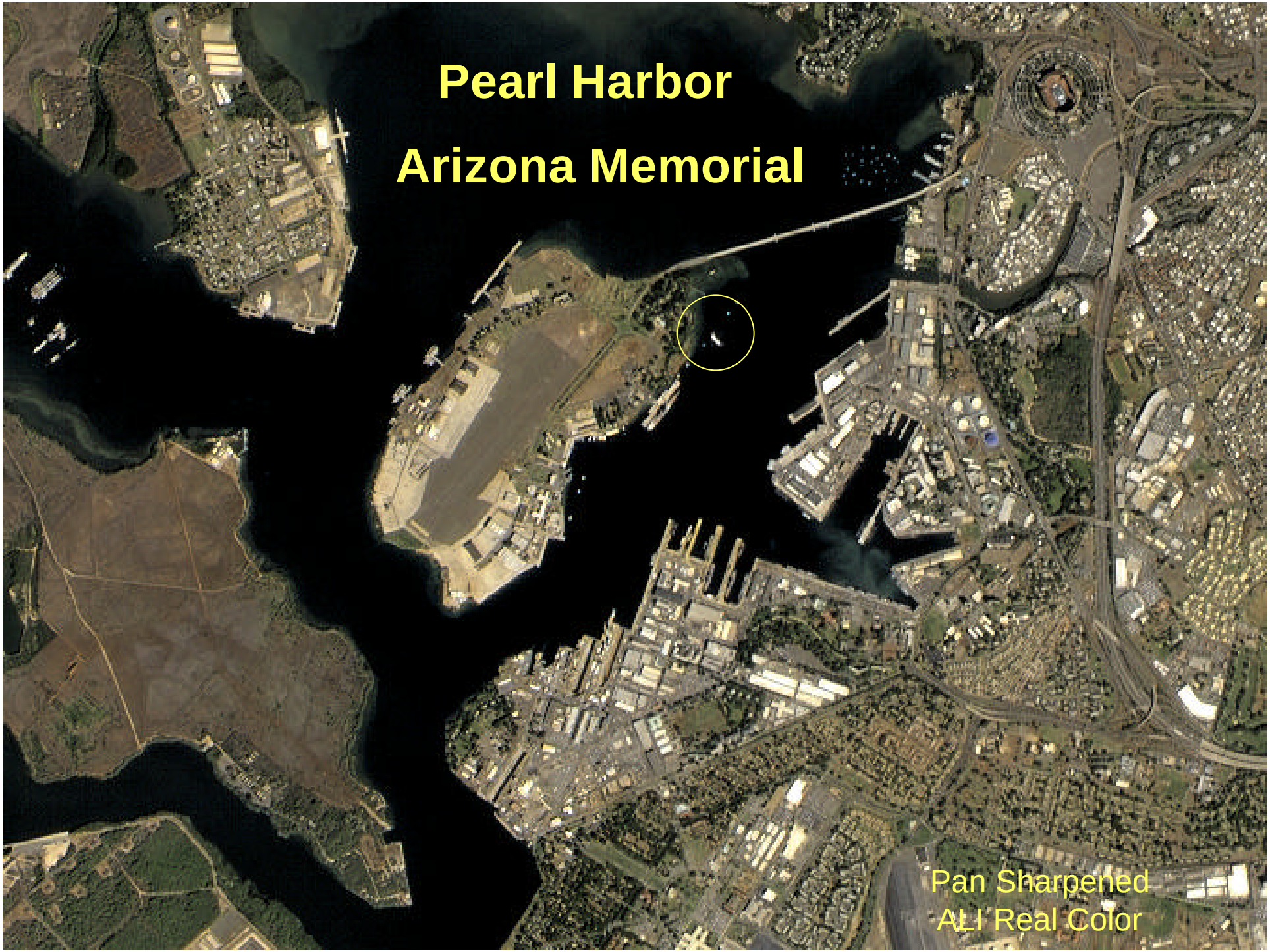
EO-1/ALI and IKONOS Comparison



ALI Pan Enhanced 4-3-2 Composite
Washington DC, December 1 ,2000

IKONOS MS 4-3-2 Composite
Washington DC, April 1, 2000

Pearl Harbor
Pan Sharpened
ALI Real Color


Pearl Harbor
Arizona Memorial
Pan Sharpened
ALI Real Color

Pearl Harbor
Pan Sharpened
ALI Real Color

Mount Etna - July 22, 2001

Earth Ob

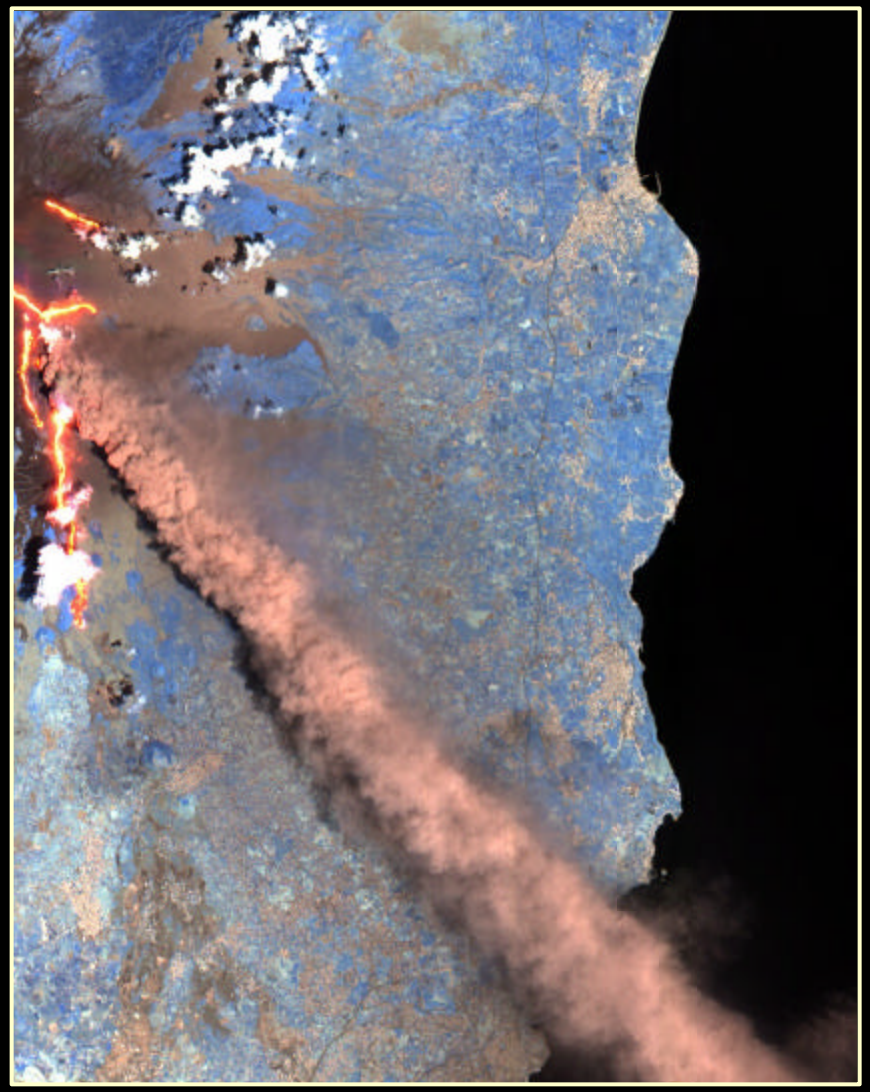
NASA

USGS

science for a changing world

ALI Pan Enhanced 3-2-1

EO-1 ALI Bands 7-5-5'



Earth Observing-1

Manhattan, New York - EO-1 ALI Pan Band

USGS science for a changing world

March 13, 2001

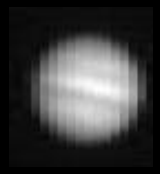
September 12, 2001

NYC – Sept. 12, 2001
EO-1/ALI Pan Enhanced
3-2-1 Color Composite

You can’t do that with EO-1!

(Views with the EO-1 ALI Pan band)

Full Moon



Jupiter

Half Moon

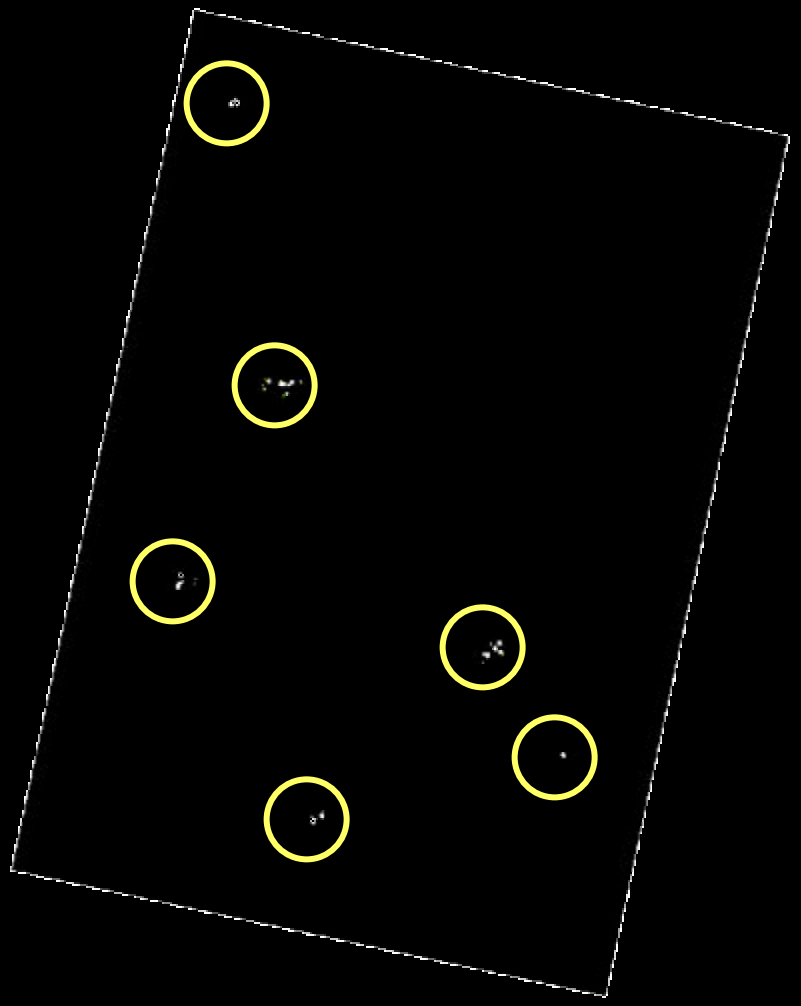
Venus

Saturn

You can’t do that with EO-1!

(Views with the EO-1 ALI Pan band)

The Pleiades

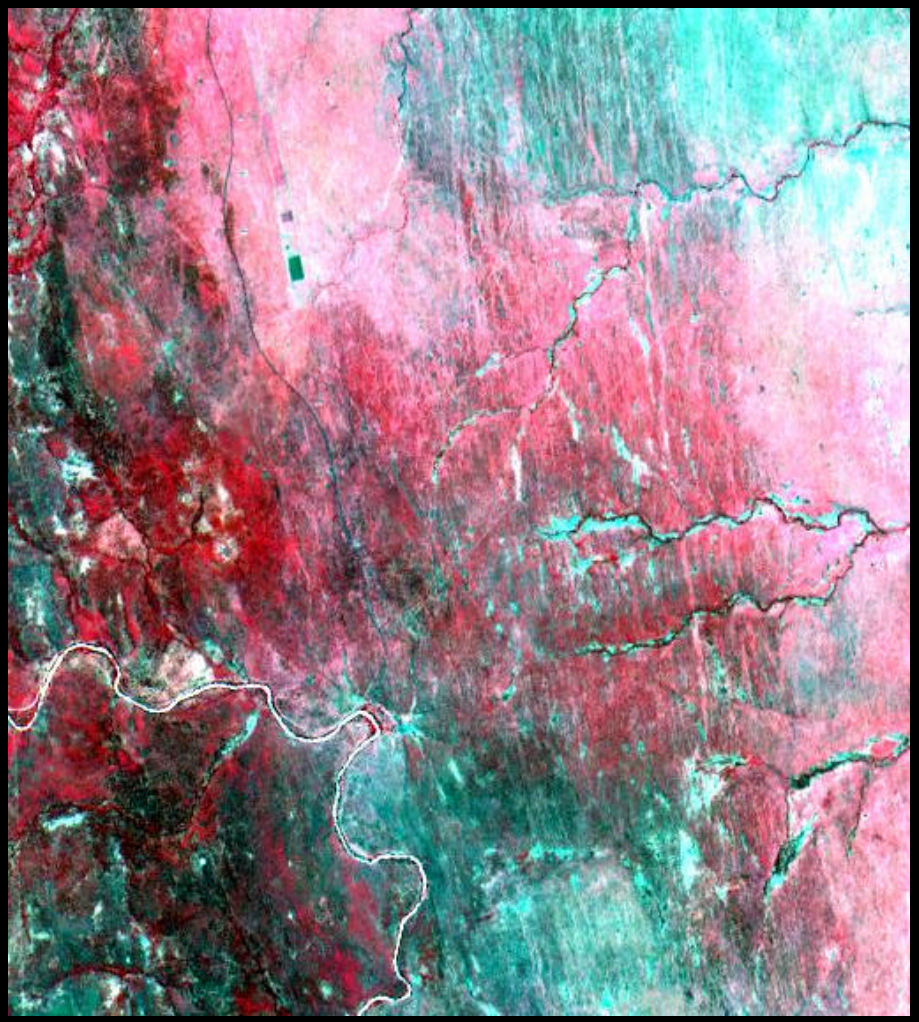


ALI detections

Kruger National Park, SA (R,G,B = 4,3,2)

Earth Observing-1

Landsat-7 ETM+

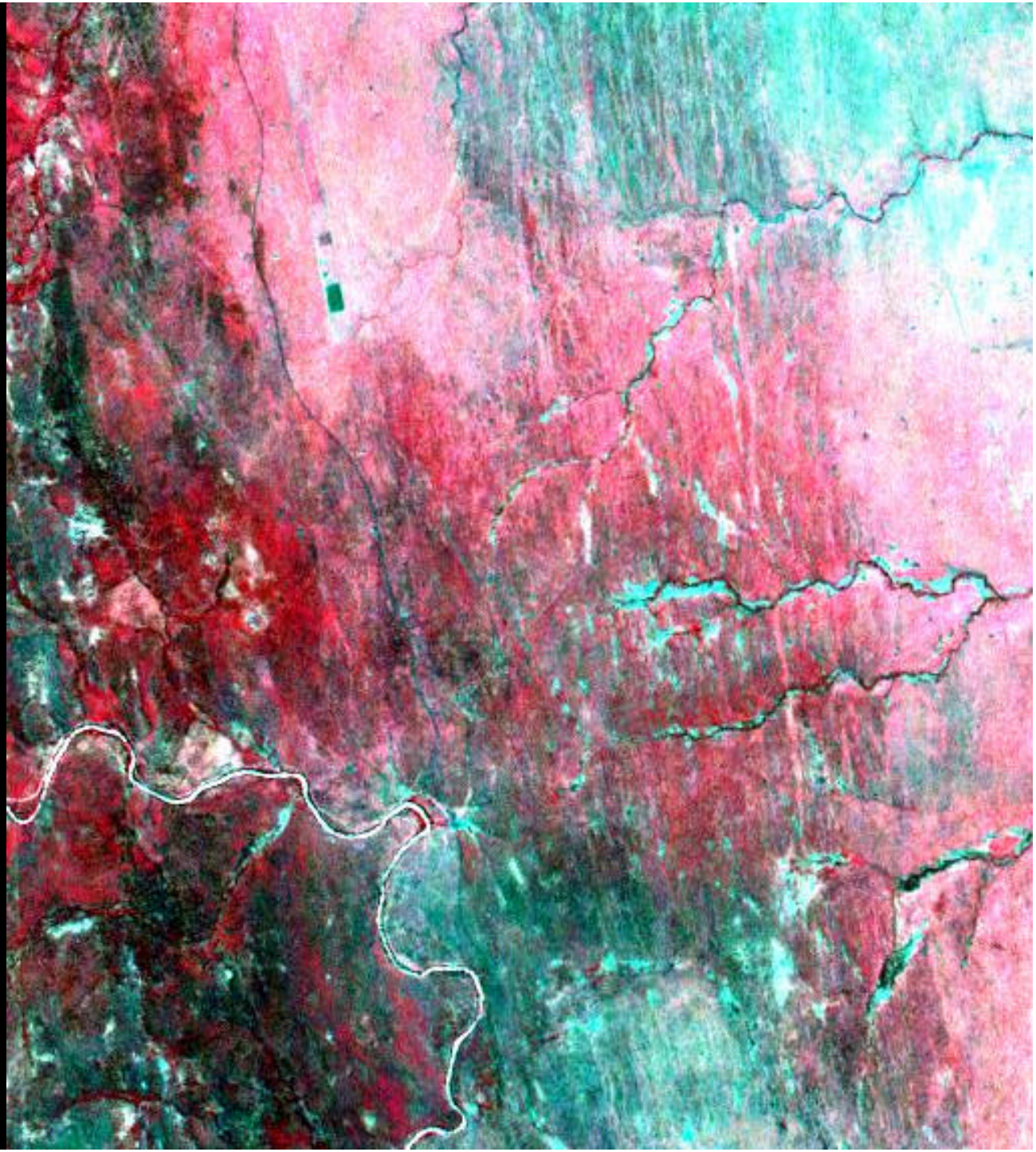


EO-1 ALI

Skukuza,
Kruger National Park
S. Africa

Landsat-7
ETM+

R,G,B = 4,3,2



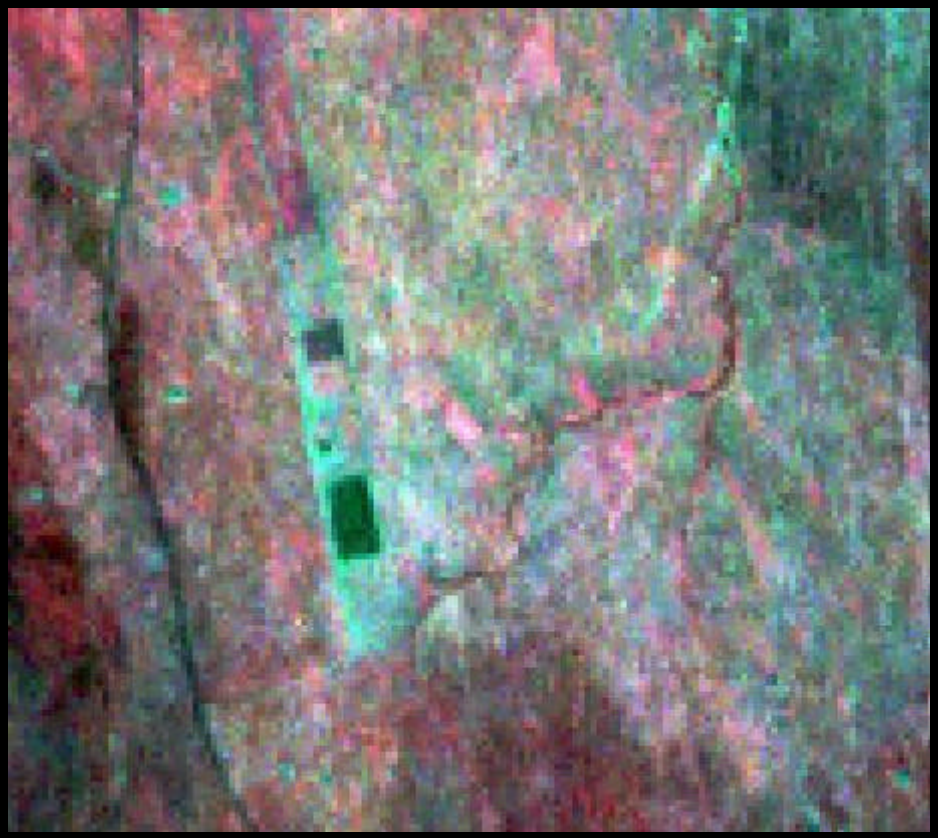
Skukuza,
Kruger National Park
S. Africa

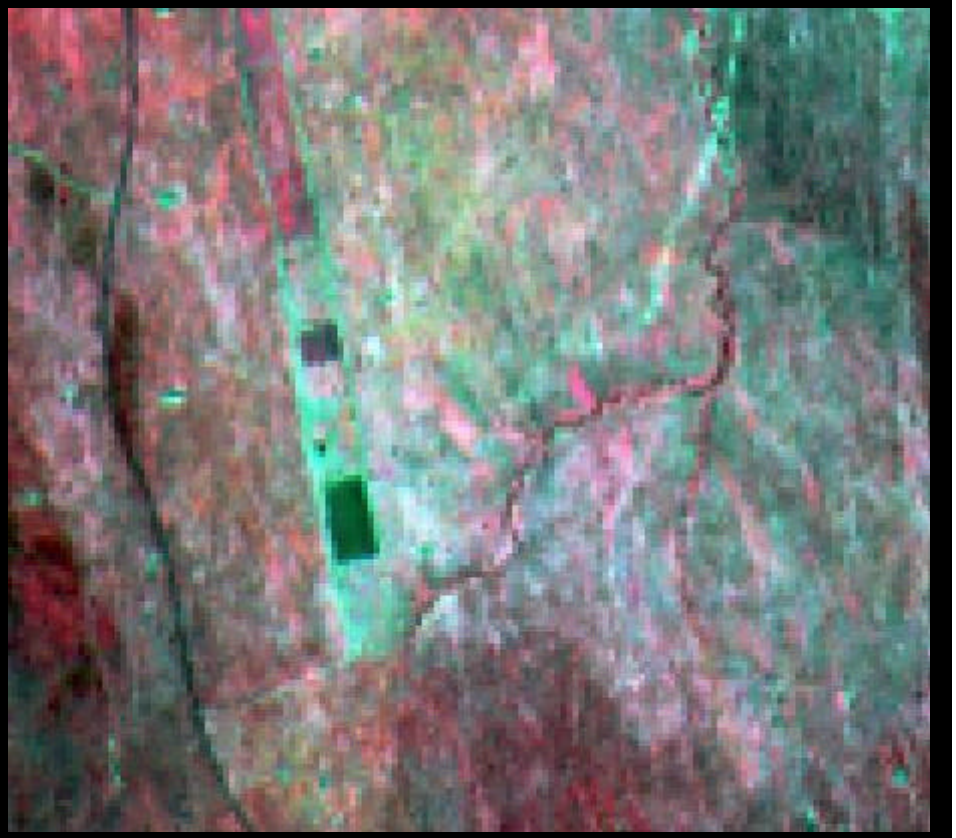
EO-1
ALI

R,G,B = 4,3,2

Kruger National Park, SA (R,G,B = 4,3,2)

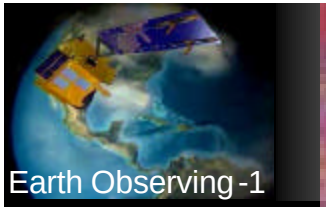
Earth Observing-1



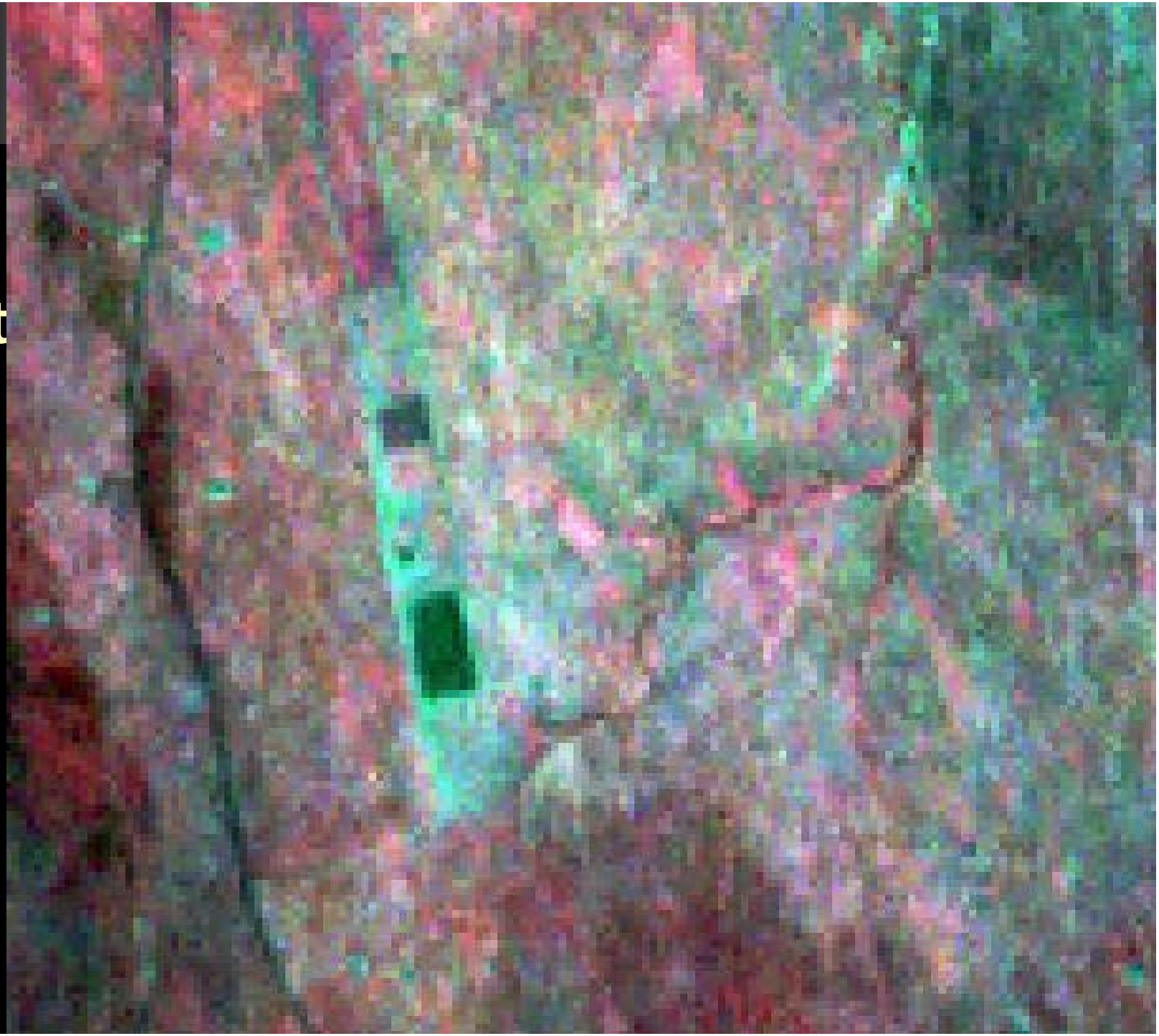


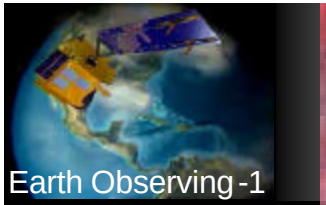
Landsat-7 ETM+

EO-1 ALI



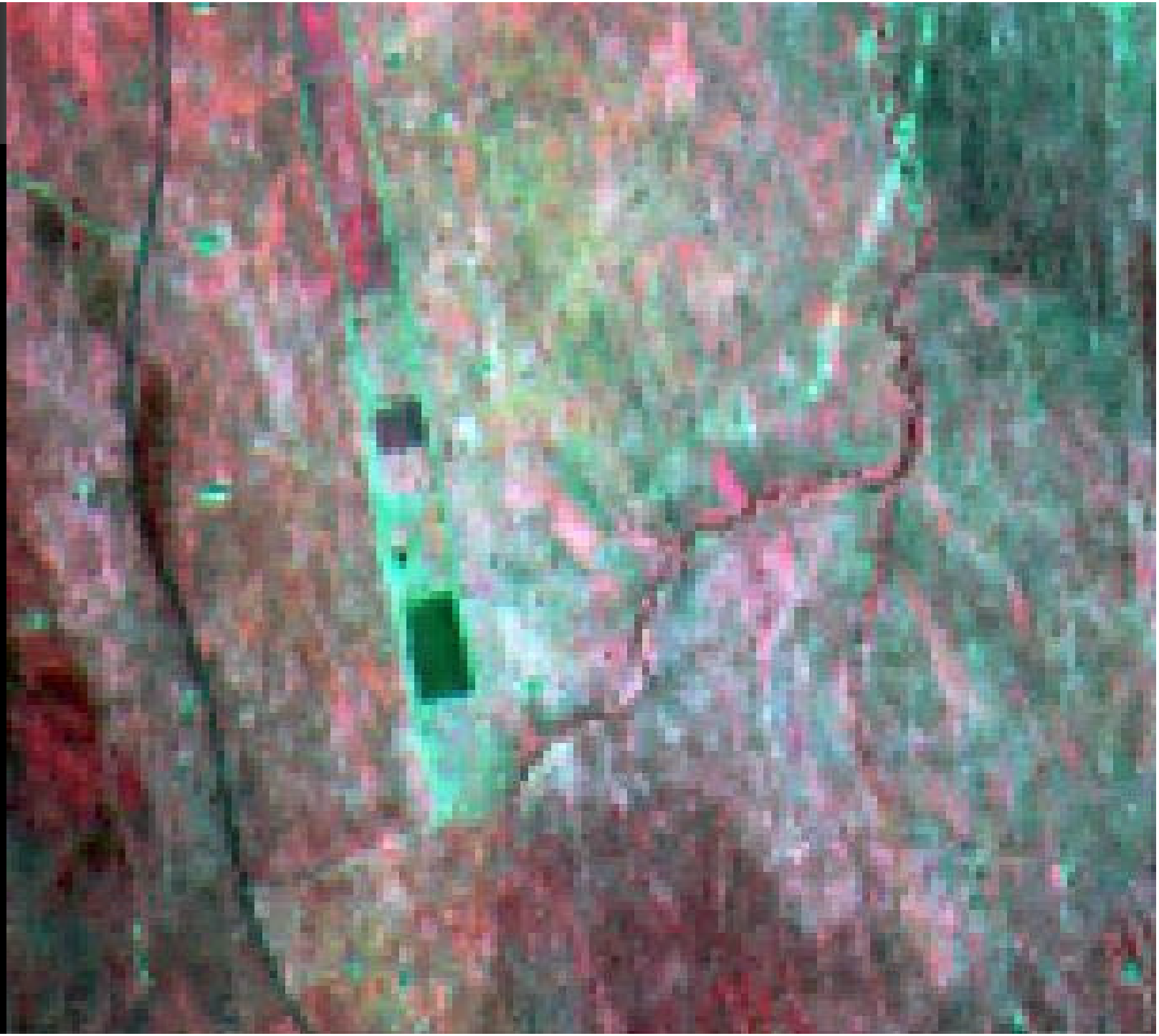
Landsat ETM+





EO-1

ALI



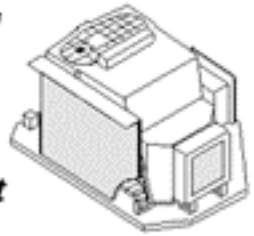
Comparison of ALI and Landsat 7 ETM+

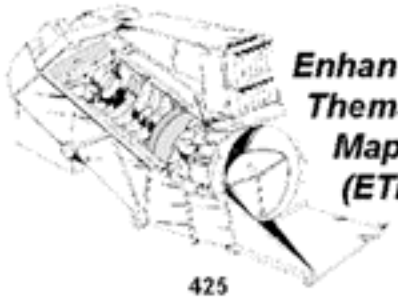
- ***Physical Specifications***
- ***Spectral Bands***
- ***Radiometric Performance***
- ***Geometric Performance***

Physical Specifications

EO-1/Landsat Instrument Comparison

ALI Based Concept for Future Landsat Instrument





Enhanced Thematic Mapper (ETM+)

100	Mass (kg)	425
100	Power (W)	545
0.2	Size (m^3)	1.4
10	VNIR / SWIR Bands	7
6200	Detectors Per Band	16
None	Thermal Bands	1
300	Data Rate (Mbps)	150
10	Pan Resolution (m)	15
4x	Relative SNR	1x

Spectral Bands

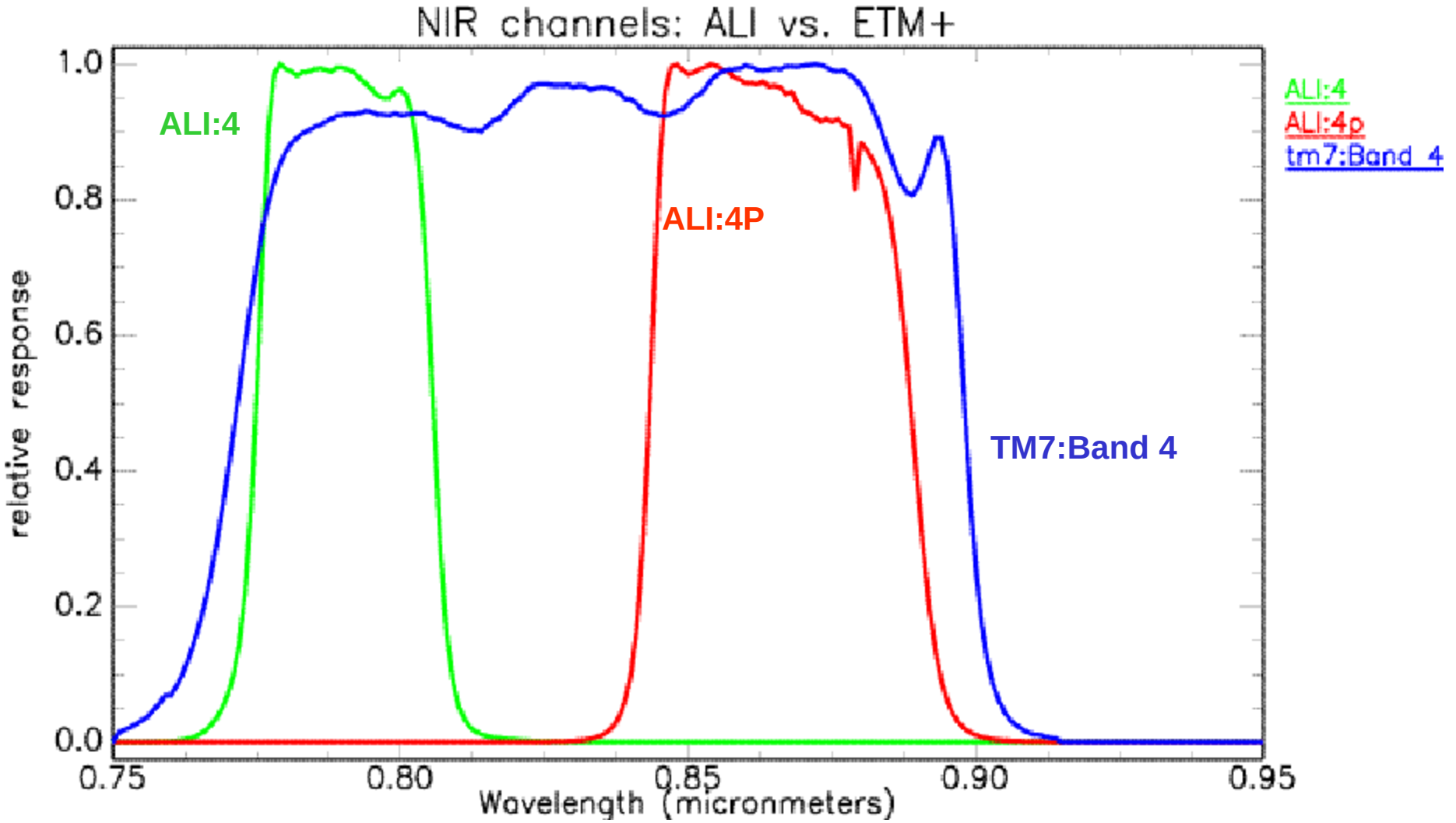
EO-1 ALI Spectral Coverage

Band	Wavelength (μm)	Ground Sample Distance (m)
Pan	0.48 - 0.69	10
MS-1'	0.433 - 0.453	30
MS-1	0.45 - 0.515	30
MS-2	0.525 - 0.605	30
MS-3	0.63 - 0.69	30
MS-4	0.775 - 0.805	30
MS-4'	0.845 - 0.89	30
MS-5'	1.2 - 1.3	30
MS-5	1.55 - 1.75	30
MS-7	2.08 - 2.35	30

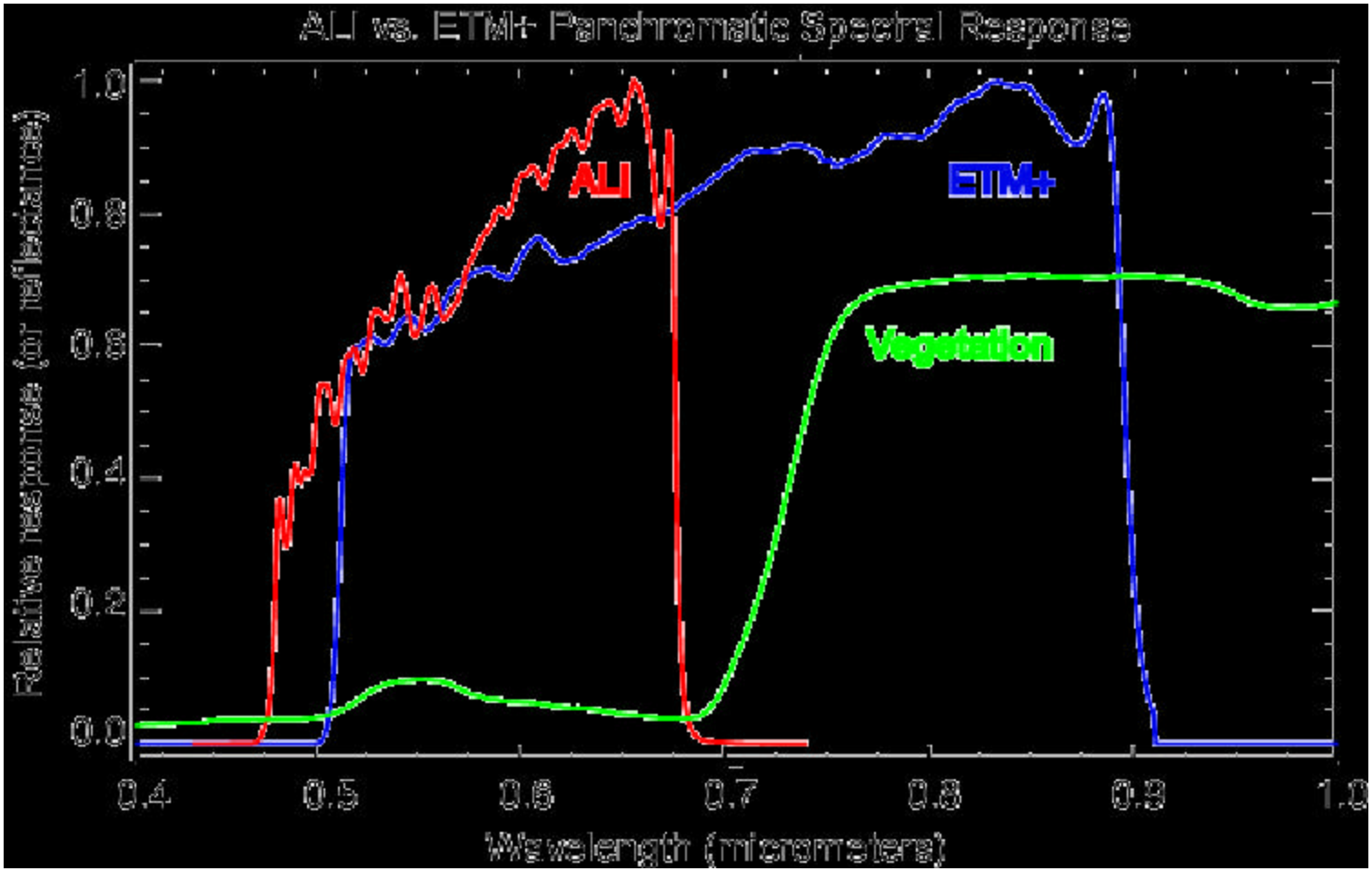
Spectral Bands (con't)

- ***ETM+ Heritage Bands***
  - ***ETM+ panchromatic band extends into the NIR***
  - ***ALI panchromatic band cuts off in the red***
  - ***ETM+ NIR band 4 split into ALI bands 4 and 4'***
- ***ALI "Prime" Bands***
  - ***1' - "deep" blue (atmospheric correction, oceanography)***
  - ***4/4' - modified NIR (less sensitive to water vapor)***
  - ***5' - SWIR 1 - vegetation mapping applications***

NIR spectral response

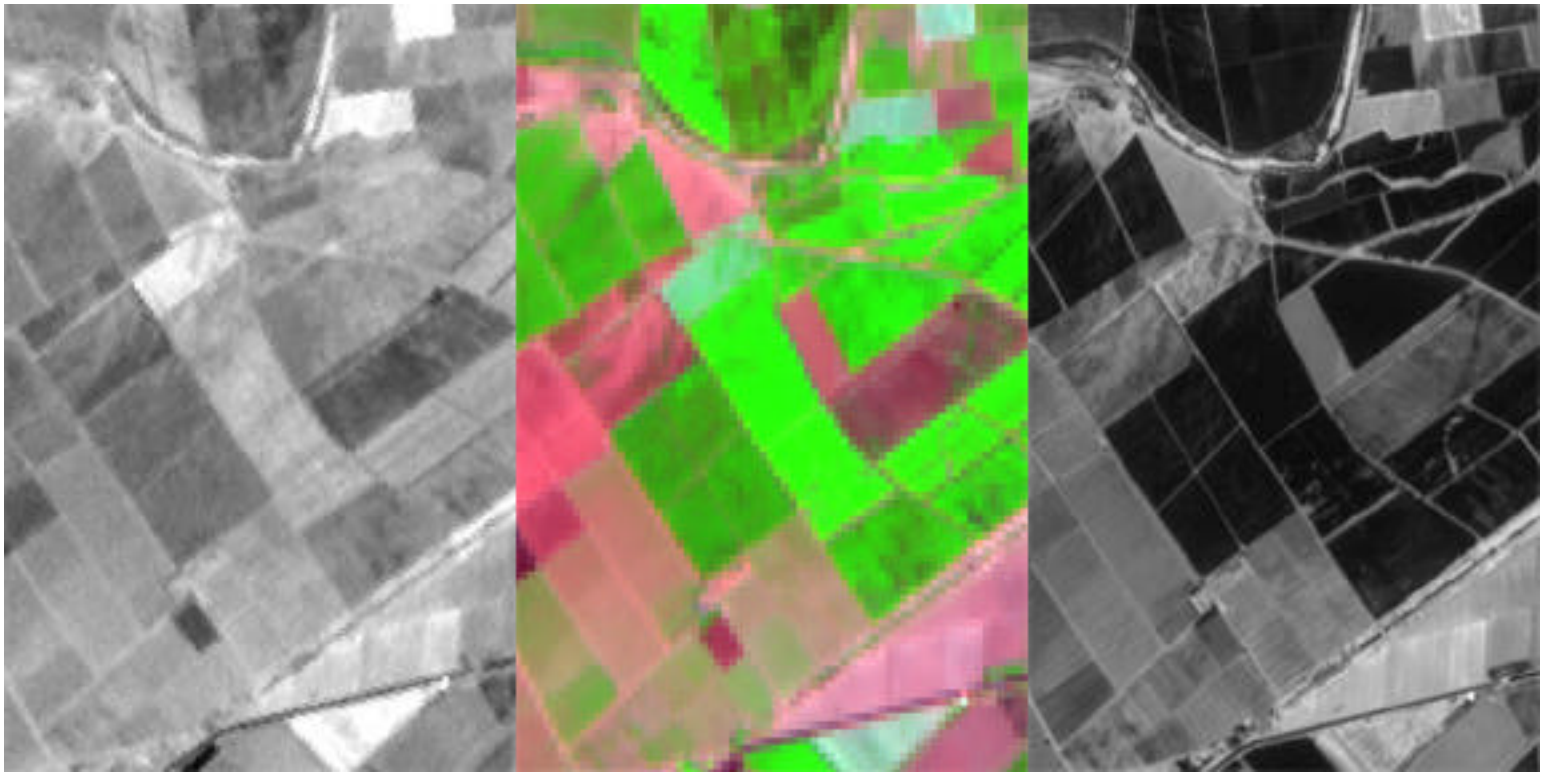


Pan band spectral response



Pan band spectral response

California Test Site (day 206)

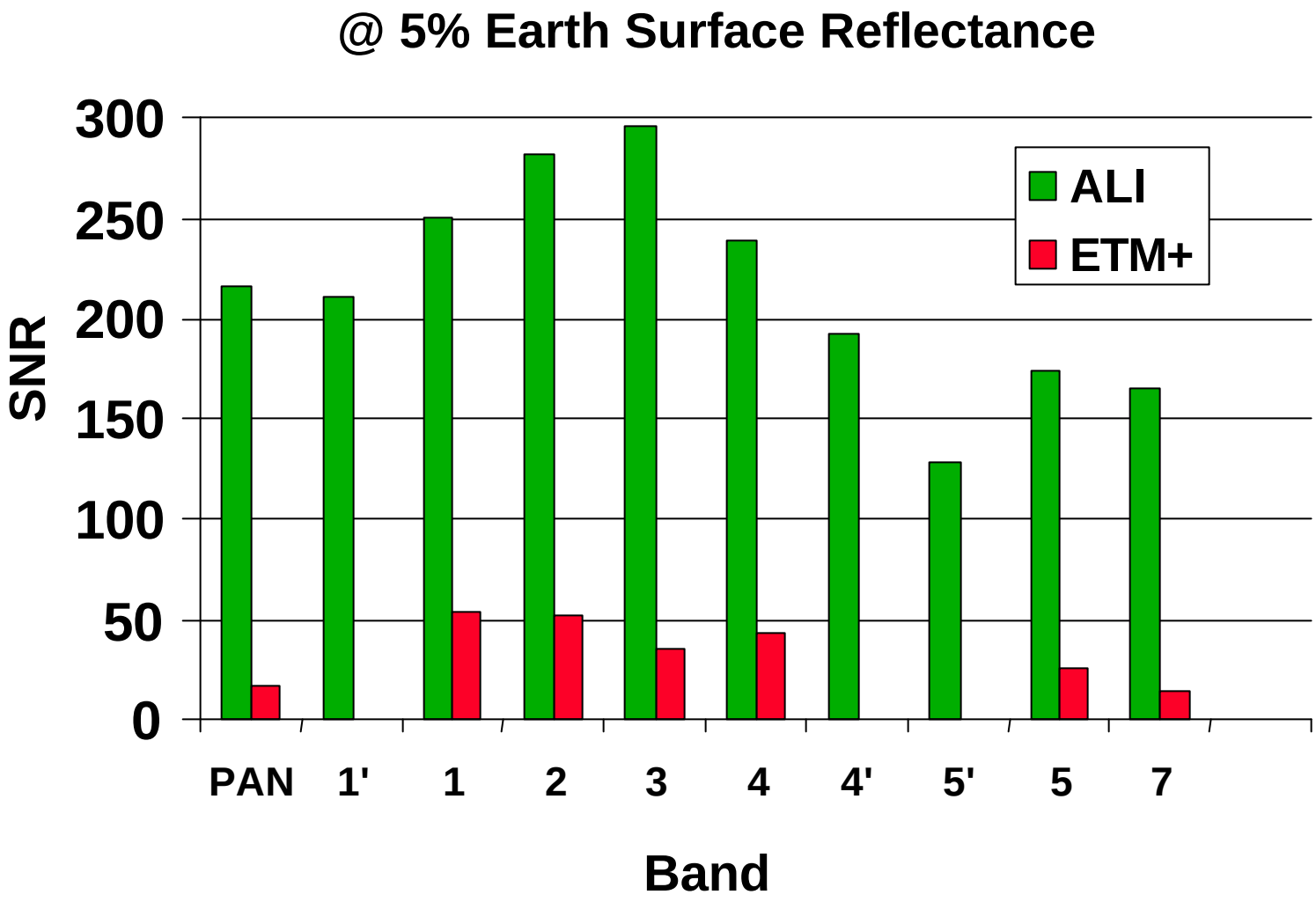


ETM+ ETM+ bands 5,4,3 ALI

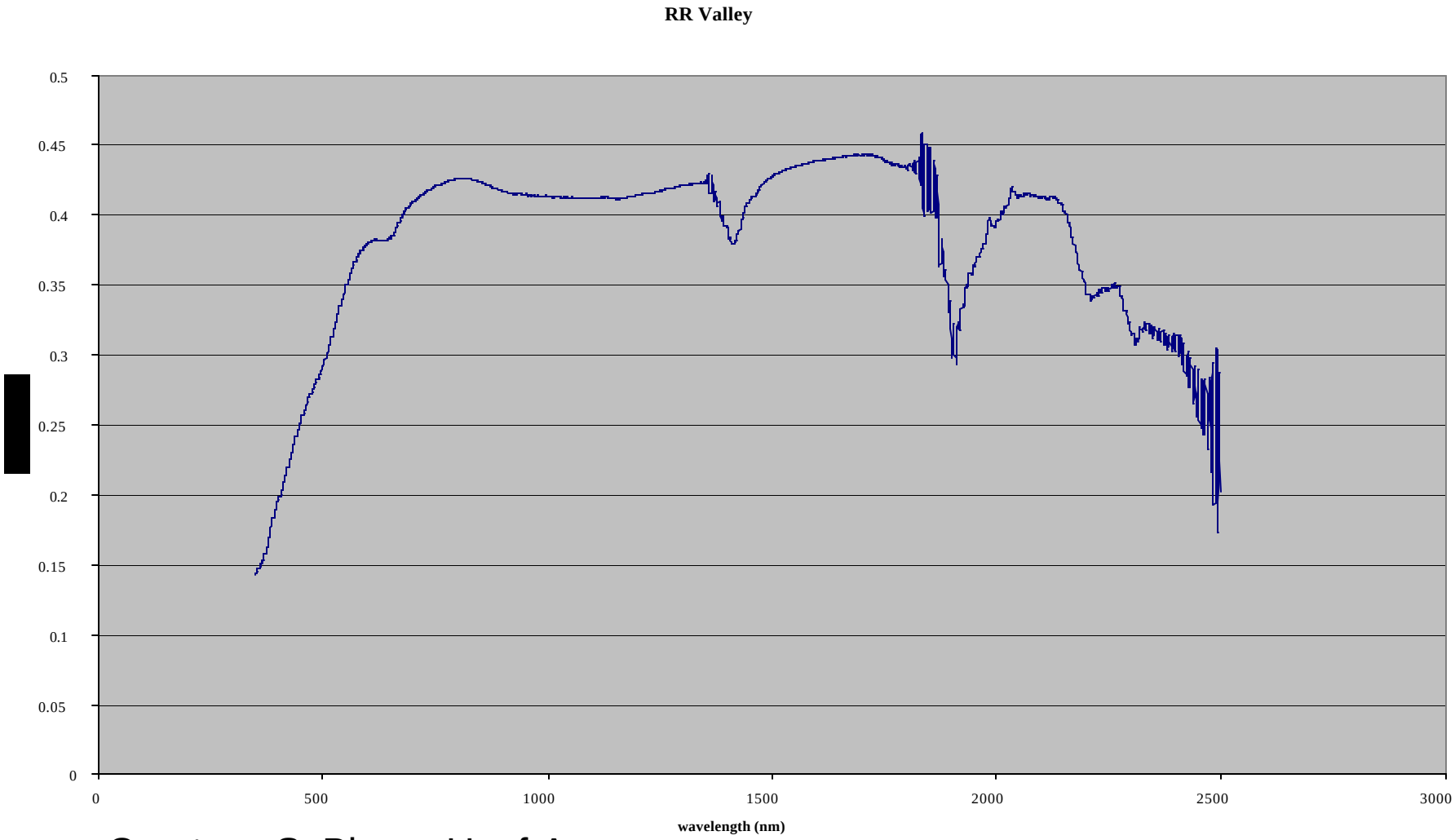
Radiometric Performance

- ***ALI: high signal-to-noise***
  - ***Improved sensitivity range w/o saturation***
  - ***Improved low-light response***
- ***On-board calibration***
  - ***L7: FASC, PASC***
  - ***ALI: solar diffuser***
- ***Ground-based calibration (U. Az.)***

Radiometric Performance
Prelaunch SNR

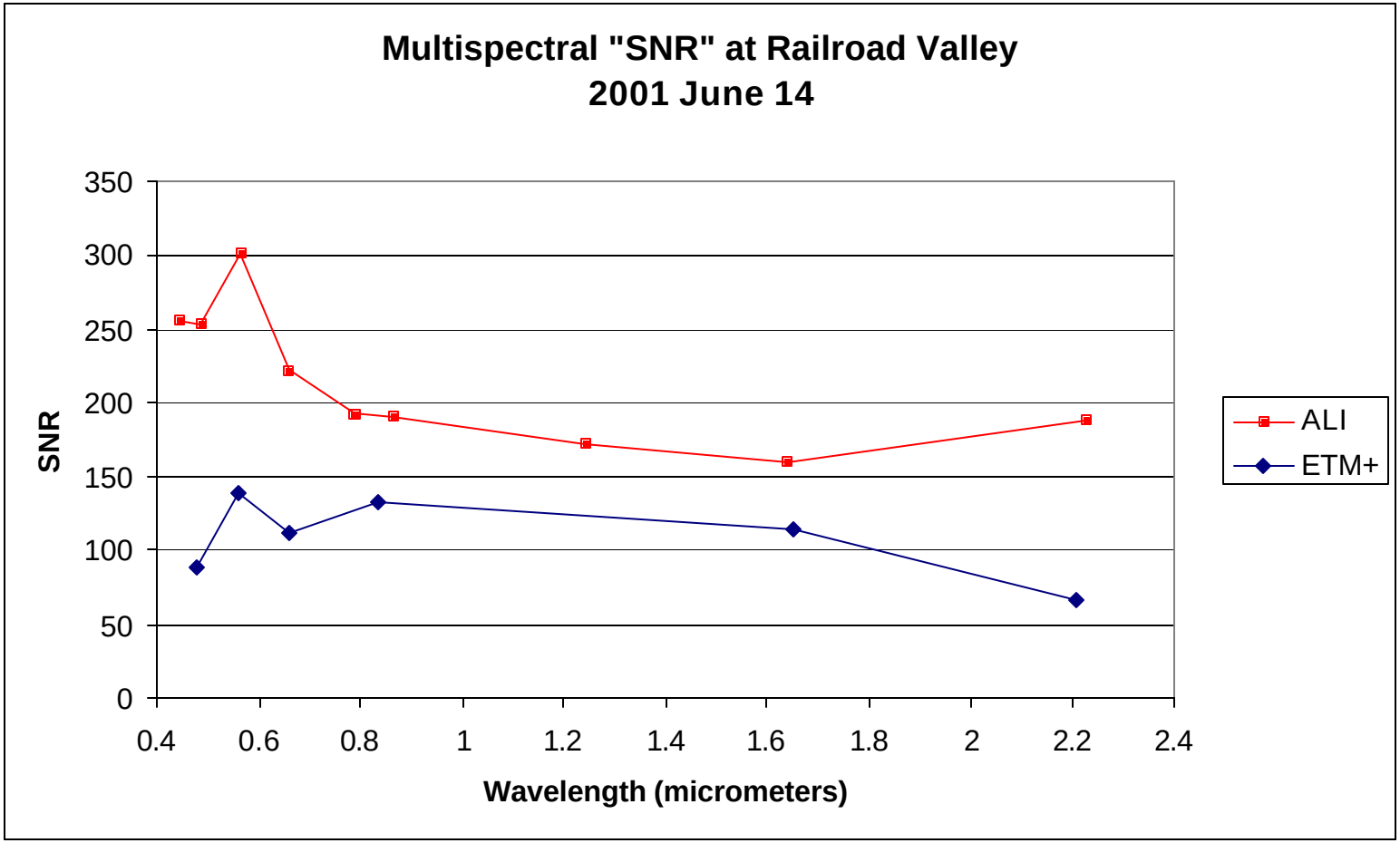


Radiometric Performance RR Valley Calibration Site



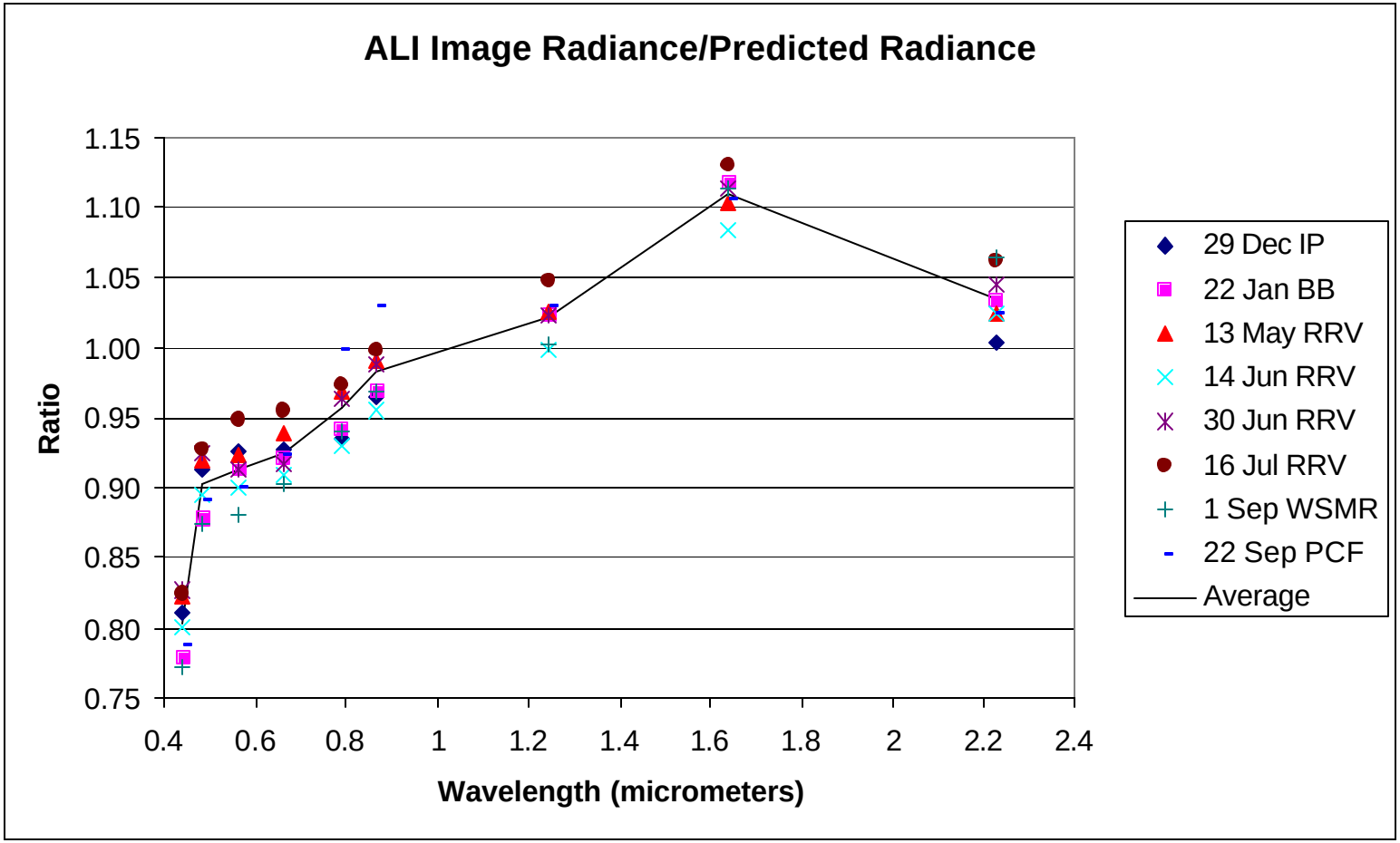
Courtesy S. Biggar U. of Az

Radiometric Performance On-Orbit SNR



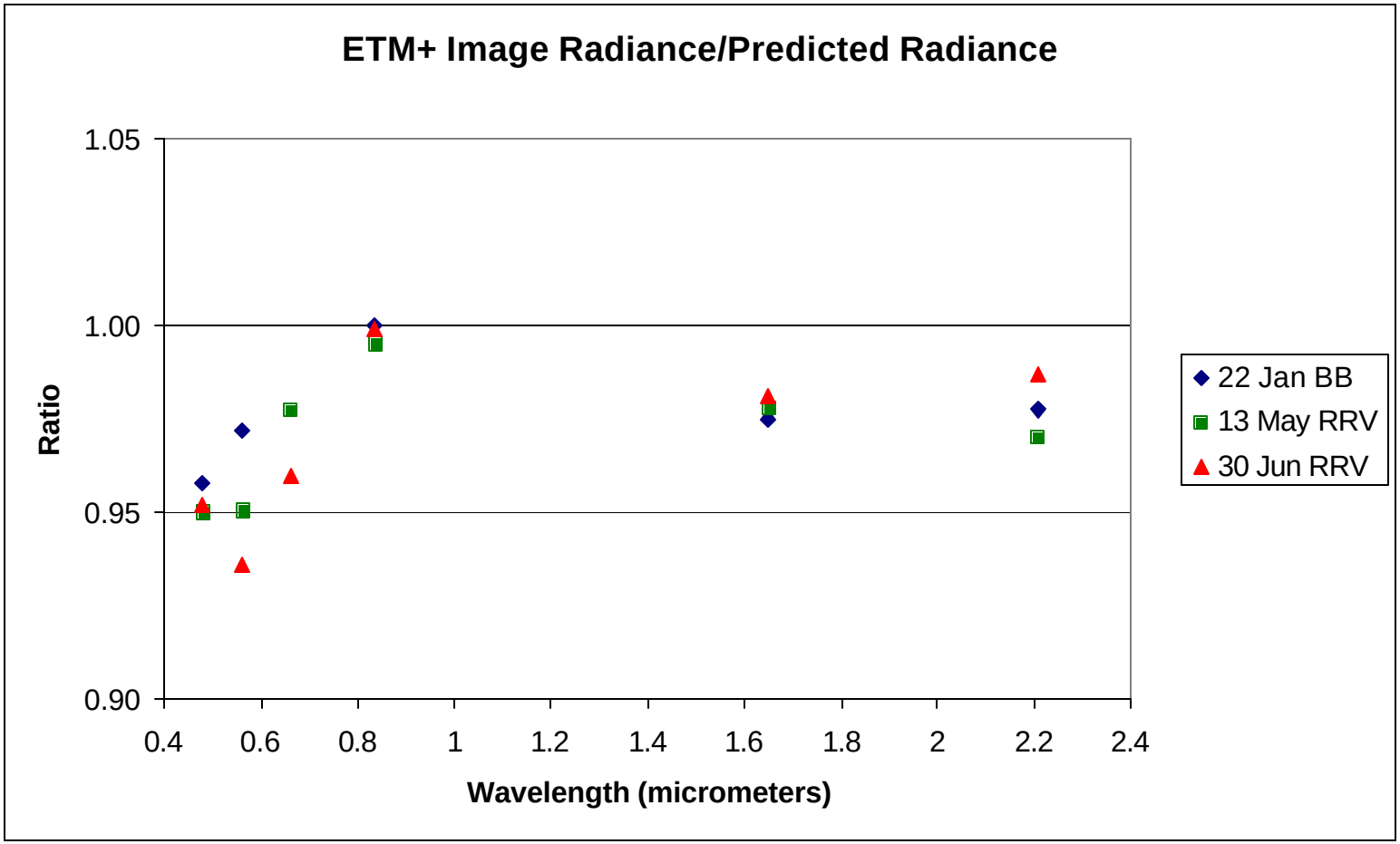
Courtesy S. Biggar U. of Az

Radiometric Performance ALI vs. Ground



Courtesy S. Biggar U. of Az

Radiometric Performance ETM+ vs. Ground



Courtesy S. Biggar U. of Az

ALI spatial response (U. AZ)

- ***Image based evaluation***
- ***Linear targets***
- ***Sensor intercomparison***
  - ***ALI to ETM+***
  - ***ALI to high spatial resolution sensors***
    - *IKONOS (MS and pan)*
    - *ADAR (aircraft sensor)*

LSF extraction

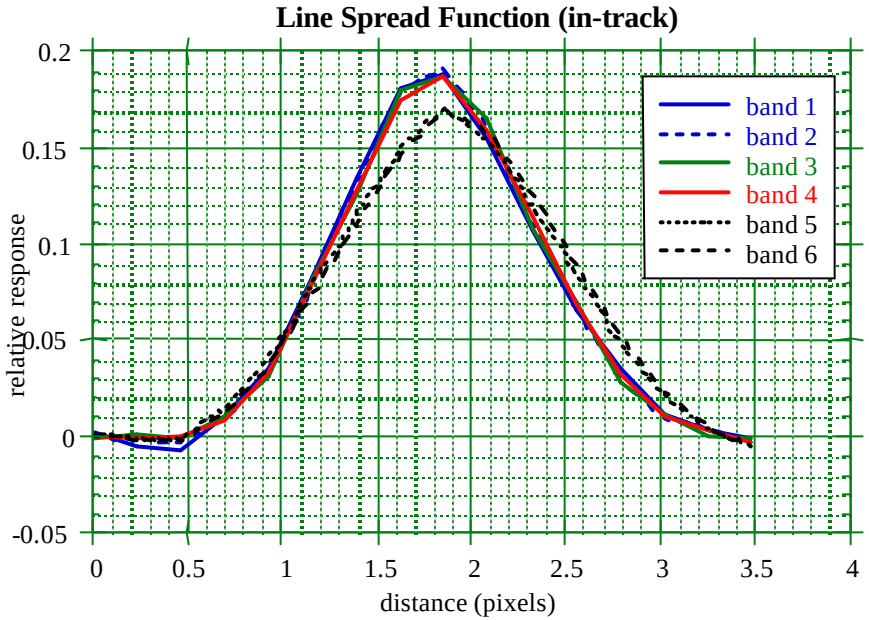
- extract multiple profiles across field berms
- shift profiles to align maxima and average
- average profile = subpixel-sampled Line Spread Function (LSF) in orthogonal direction
- in-track and cross-track

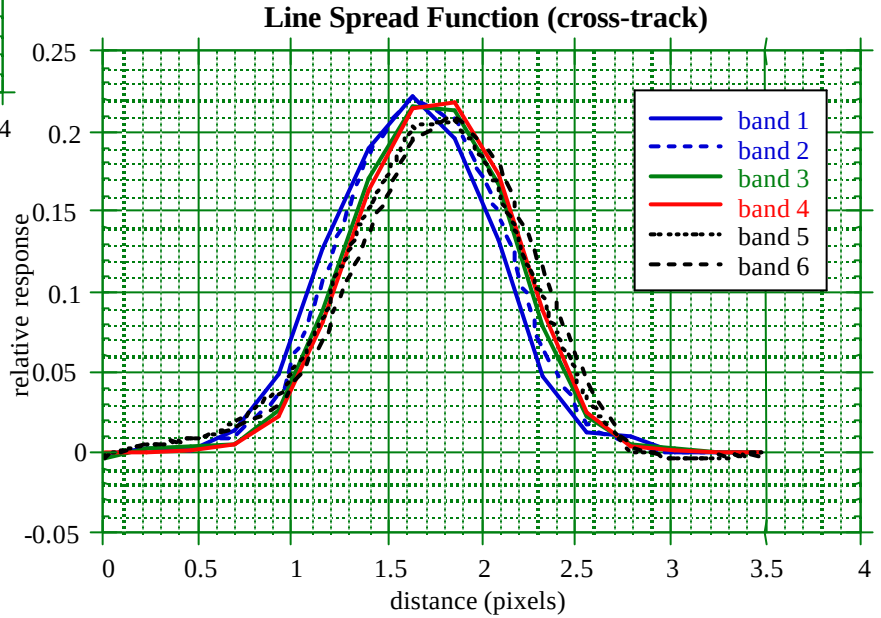
- subpixel interval = tan(13.08° inclination angle) = 0.23 ALI pixels
- berm width about 7-8m = 0.25 ALI pixels (measured from Ikonos image)

- Fourier transform of LSF = Modulation Transfer Function (MTF)

Courtesy S. Biggar U. of Az

ALI LSFs (bands 1 - 6)

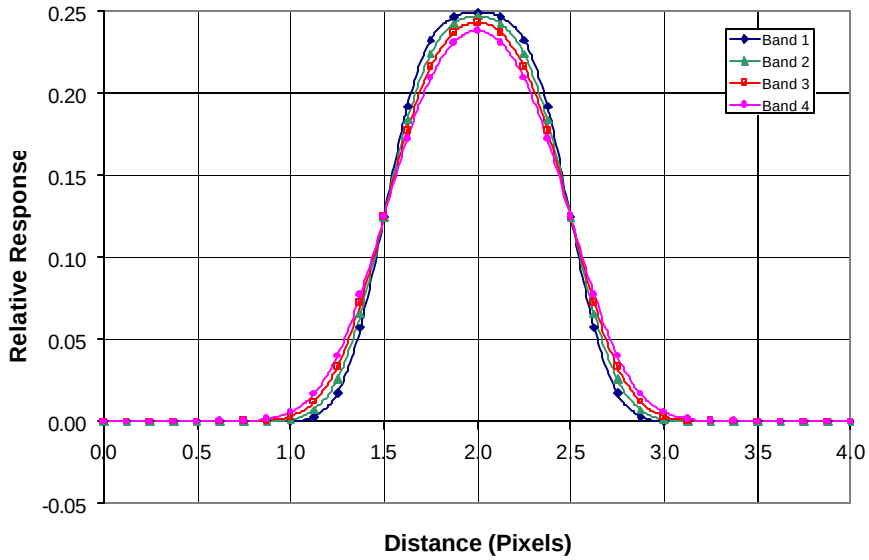




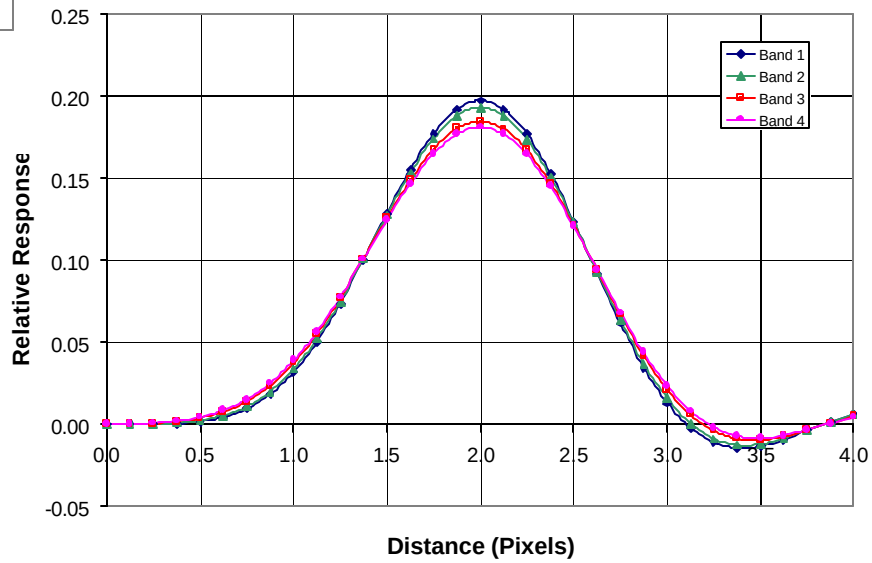
Courtesy S. Biggar U. of Az

ETM+ LSF (Bands 1-4)

ETM+ LSF (In-Track)



ETM+ LSF (Cross-Track)



ALI Radiometric Artifacts

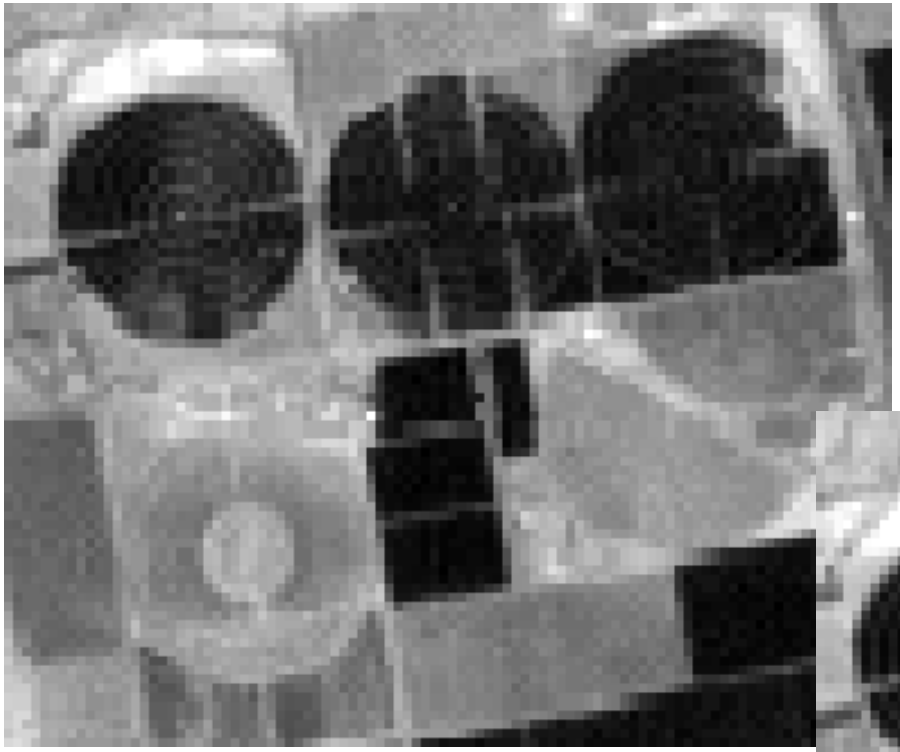
- ***Leaky Pixel: correctable***
- ***Residual Striping: relative gain correction under development***
- ***Stray light: quantifiable, but not correctable***

Geometric performance

- ***ALI: no moving parts to degrade over time (e.g., ETM+ "bumper wear")***
- ***Small inter-SCA misalignment correctable***
- ***Phased array X-band antenna affords stable imaging platform (unlike gimbaled antenna)***
- ***Terrain effects on band registration and SCA-to-SCA registration***

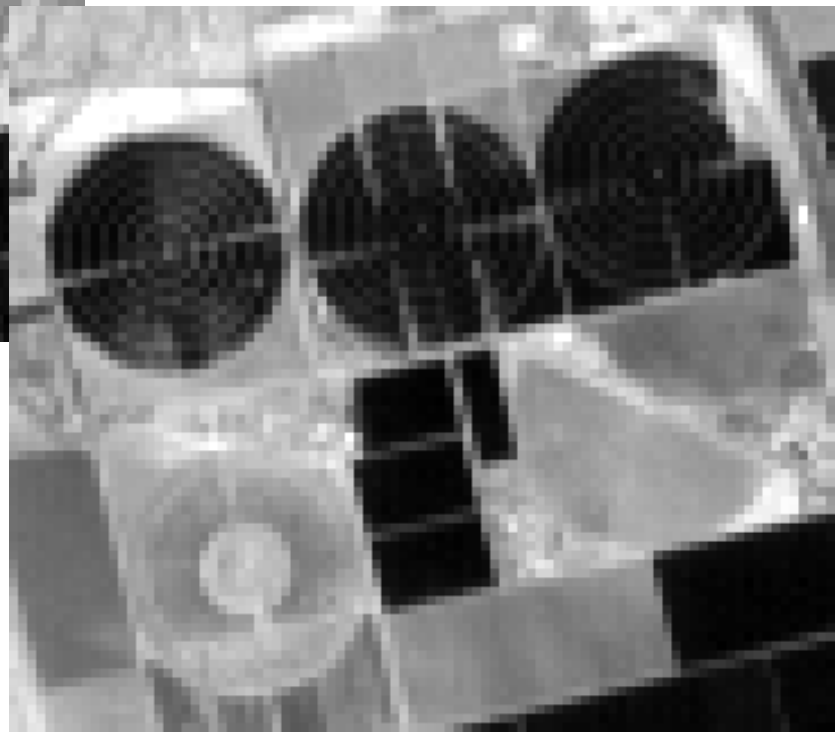
ALI versus ETM local geometry

Maricopa July 27, 2001 (DOY208)



ETM
L1G
band 1

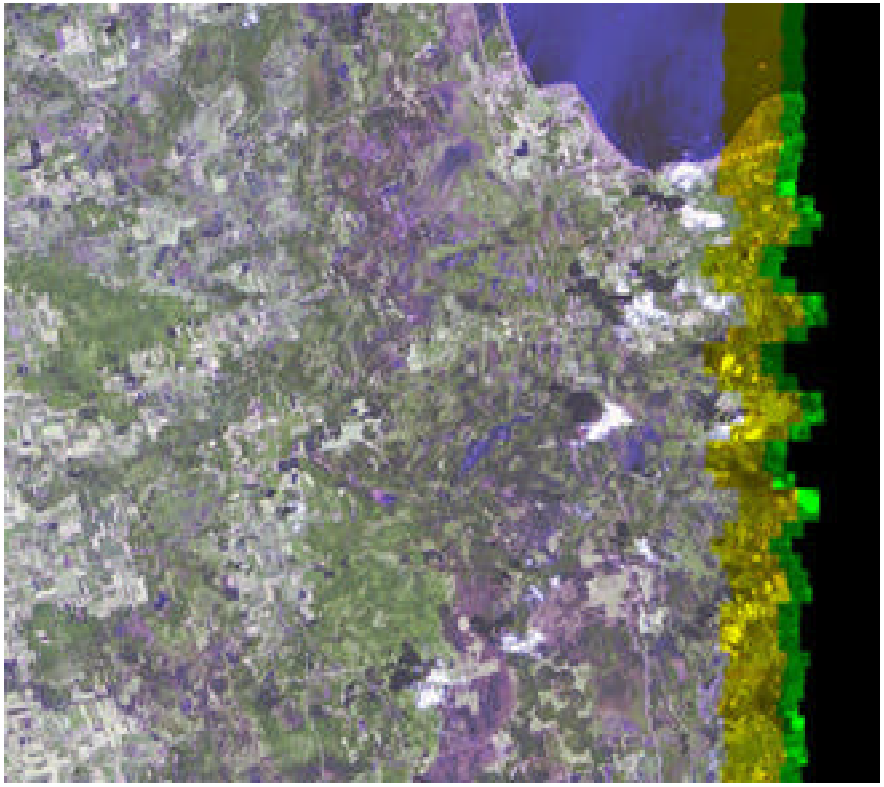
ALI
L1R
band 2

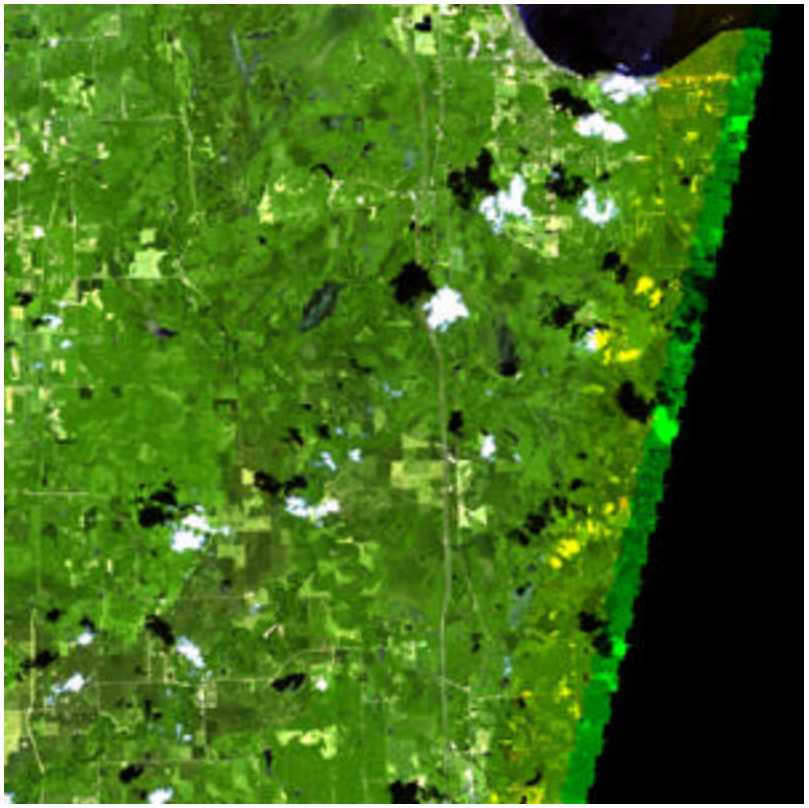


Courtesy S. Biggar U. of Az

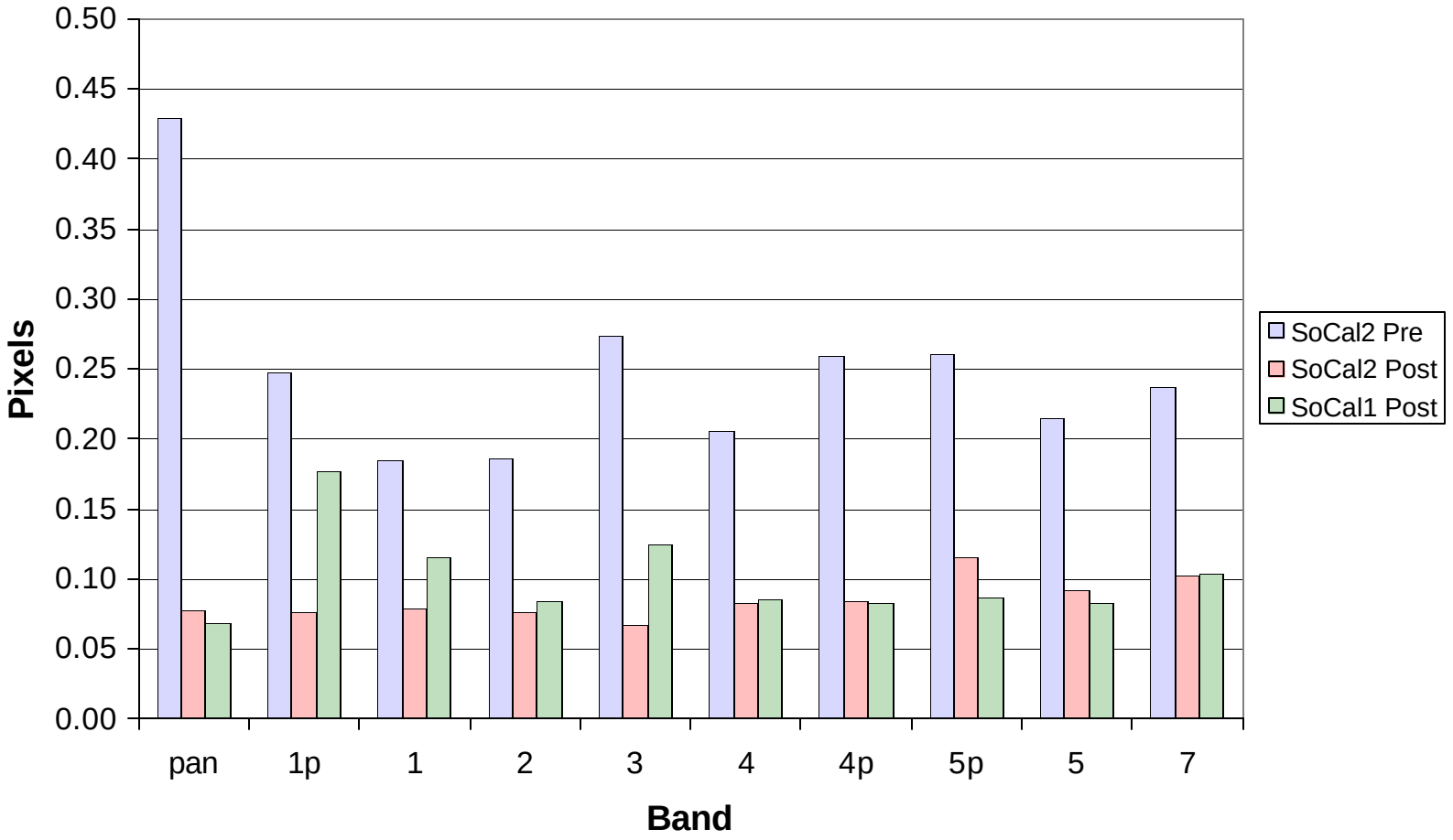
Geometry: effects of Landsat 7 gimbaled antennae

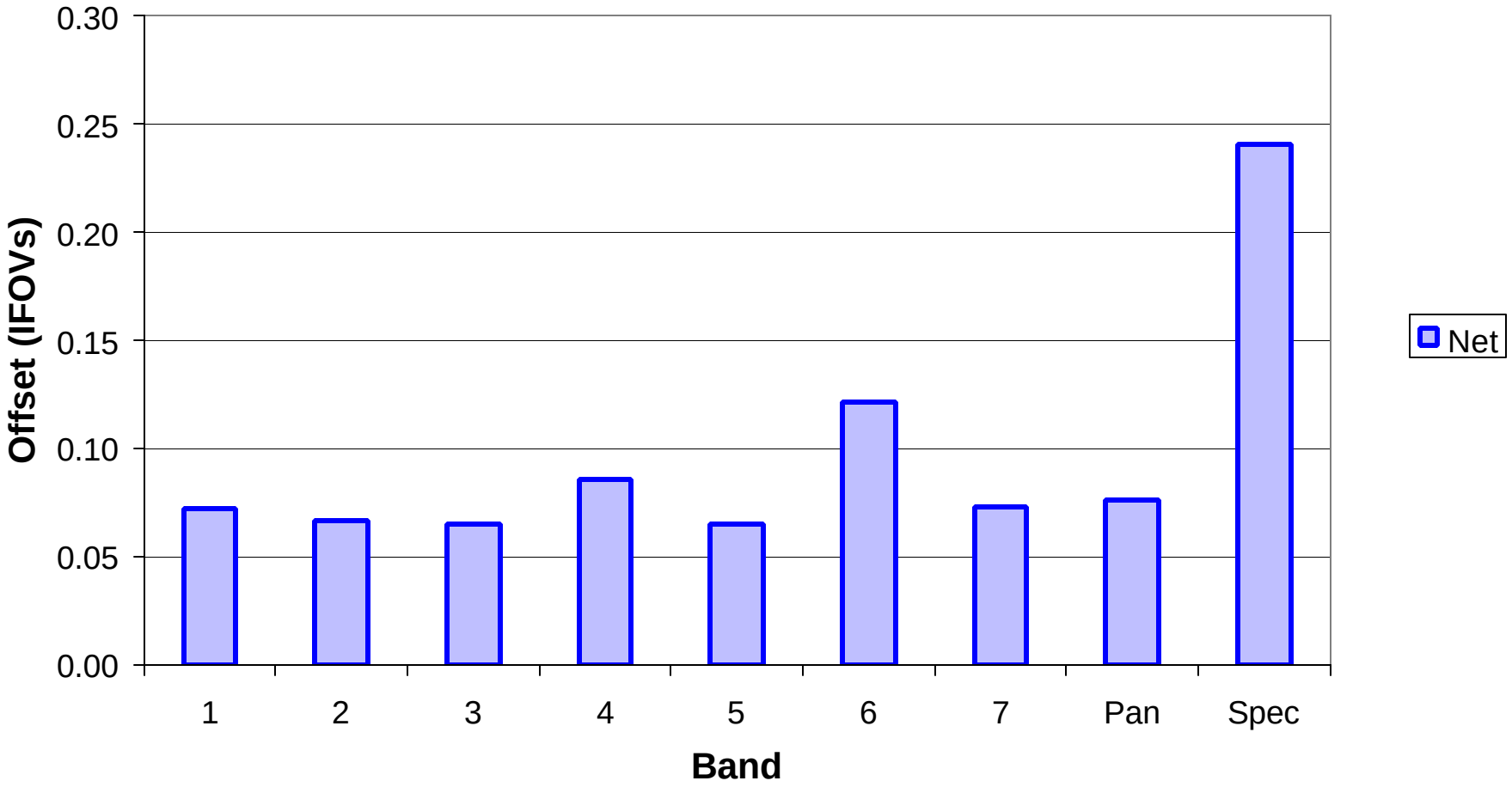
Uncorrected L0 Data ***Corrected L1 Data***





ALI interband registration



ETM+ interband registration

Band Average RMS Registration
Operational Period Calibration