



# USGS Report to the WGCV

CSSAR, Beijing, China  
15-17 October, 2003

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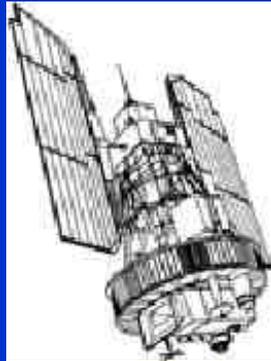
U.S. Geological Survey  
Land Report Sensing Program

# Items

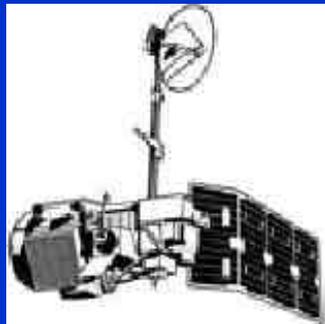
- WTF status (J. Morisette)
- Status of topographic projects (J.P. Muller)
- Status of principal missions
  - Landsat 5 TM
  - Landsat 7 ETM+
  - EO-1 ALI/Hyperion
  - Landsat Data Continuity Mission
- USGS C<sup>2</sup>V<sup>2</sup> project
- Other missions
  - ASTER
  - MODIS



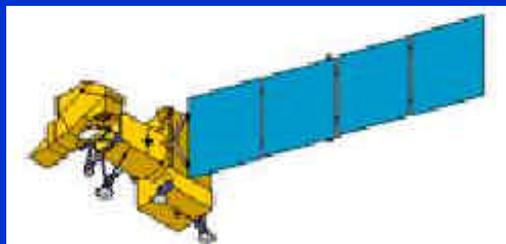
# Landsat Program History



Multi-Spectral  
Scanner (MSS)



Thematic Mapper  
(TM)



Enhanced  
Thematic  
Mapper  
Plus  
(ETM+)

- 1966 DOI Earth Resources Observation Systems Program initiated
- 1972 L1 launched (RBV/MSS)
- 1975 L2 launched (RBV/MSS)
- 1978 L3 launched (MSS)
  
- 1982 L4 launched (TM/MSS)
- 1984 L5 launched (TM/MSS)
- 1985 Commercial operator selected
  - Operate L4/5 & build/operate Landsat 6/7
- 1989 Commercial viability of L7 rejected (gov't continues to plan, launch operate)
  
- 1992 Land Remote Sensing Policy Act
  - Commercial operation of L4/5/6
  - NASA/DOD to build/operate Landsat 7
  - Landsat Program Management (LPM) Team
- 1993 Landsat 6 launch failure (ETM)
- 1994 LPM redefined (NASA/NOAA/USGS)
- 1998 Commercial Remote Sensing Policy Act
- 1999 L7 launched (ETM+)
- 2000 LPM redefined (NASA/USGS)
- 2000 L7 Flight operations assumed by USGS
- 2000 EO-1 Launched (ALI/Hyperion)
- 2001 L4/L5 returned to Govt.; L4 decommissioned
- 2001 EO-1 mission extended
- 2003 4 years of global L7 data acquisitions



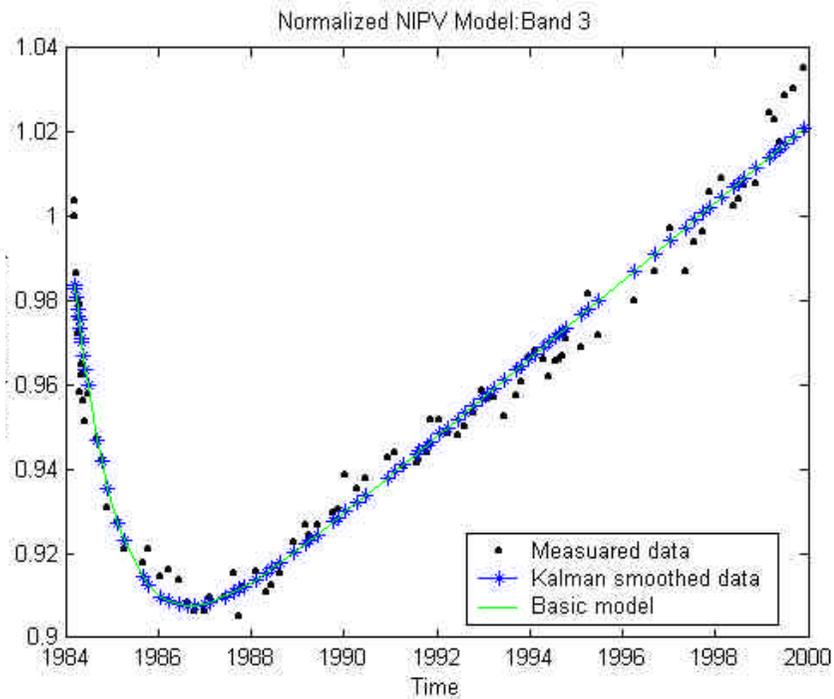
# Landsat 5 nearly 20 years after launch

- “Bumper mode” operational
  - Processing compensated for mirror synchronization problem
- S/C Operation:
  - Delta 1 & outgassing 11 Dec 2002, last one fall ‘03
  - WRS maintenance & solar drag delta through 2009
- “Incidents”
  - Failure of star tracker #1 in Aug, #2 operational
  - Intermittent failure of 2<sup>nd</sup> of two X-band transmitters
- Calibration issues (NLAPS)
  - IC lamps used prior to 5/5/03, assumed to be constant
  - New calibration from Helder’s L5 lifetime trending

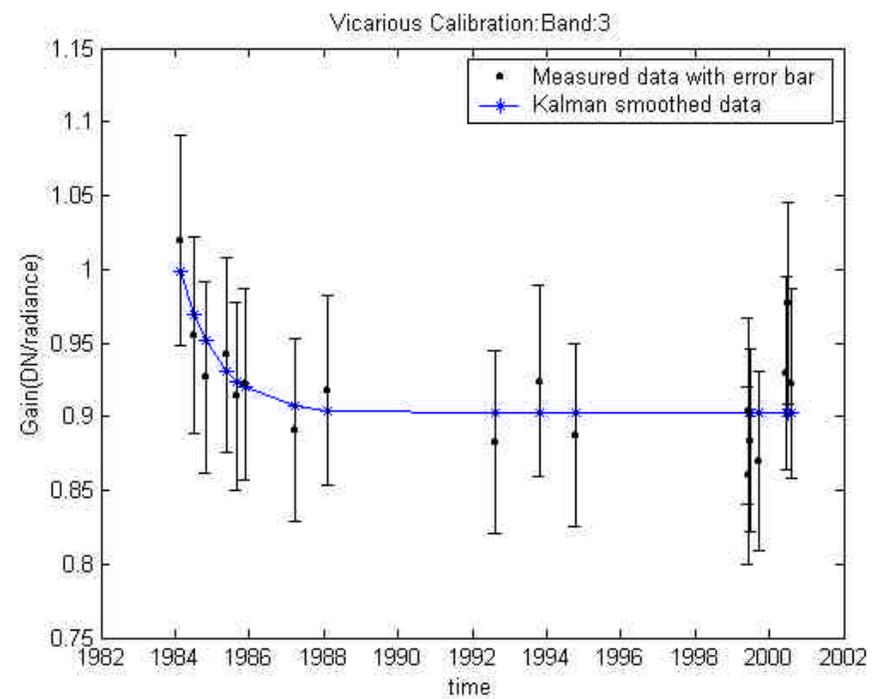


# Landsat 5 lifetime detector response

## Lamp Response



## Vicarious Calibration



Courtesy D. Helder, SDSU



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# L5 Spacecraft & MOC Status

- Attitude Control System - have 2 out of 2, need 1
- Gyros - have 3 out of 3, need 2.
- Reaction Wheels - have 4, need 3.
- Star Trackers - have 2 out of 2, need 1.
- Batteries – have 3 out of 3, need 2.
- Transponders – have 1 out of 2
- Image data Transmitters – have 1 out 4

- 11/92 Earth Sensor 1 failure
- 2/02 Earth Sensor 2 failure

- 3/84 Primary Thruster D failure
- Utilizing Current Mode Operations to increase Battery Longevity.

- 10/94 Power Supply 1 anomaly

▪ Not Operational

(2) OMNI ANTENNA

ACS MODULE

PROPULSION MODULE

POWER MODULE

THEMATIC MAPPER

WIDEBAND COMMUNICATIONS MODULE

HIGH GAIN ANTENNA

- 8/85 Transmitter A failure

MULTI- SPECTRAL SCANNER

- 8/95 Band 4 failure

SOLAR ARRAY PANELS

SUN SENSORS

S-BAND ANTENNA

X-BAND ANTENNA

- 8/87 Prime X-band failure (OCP)

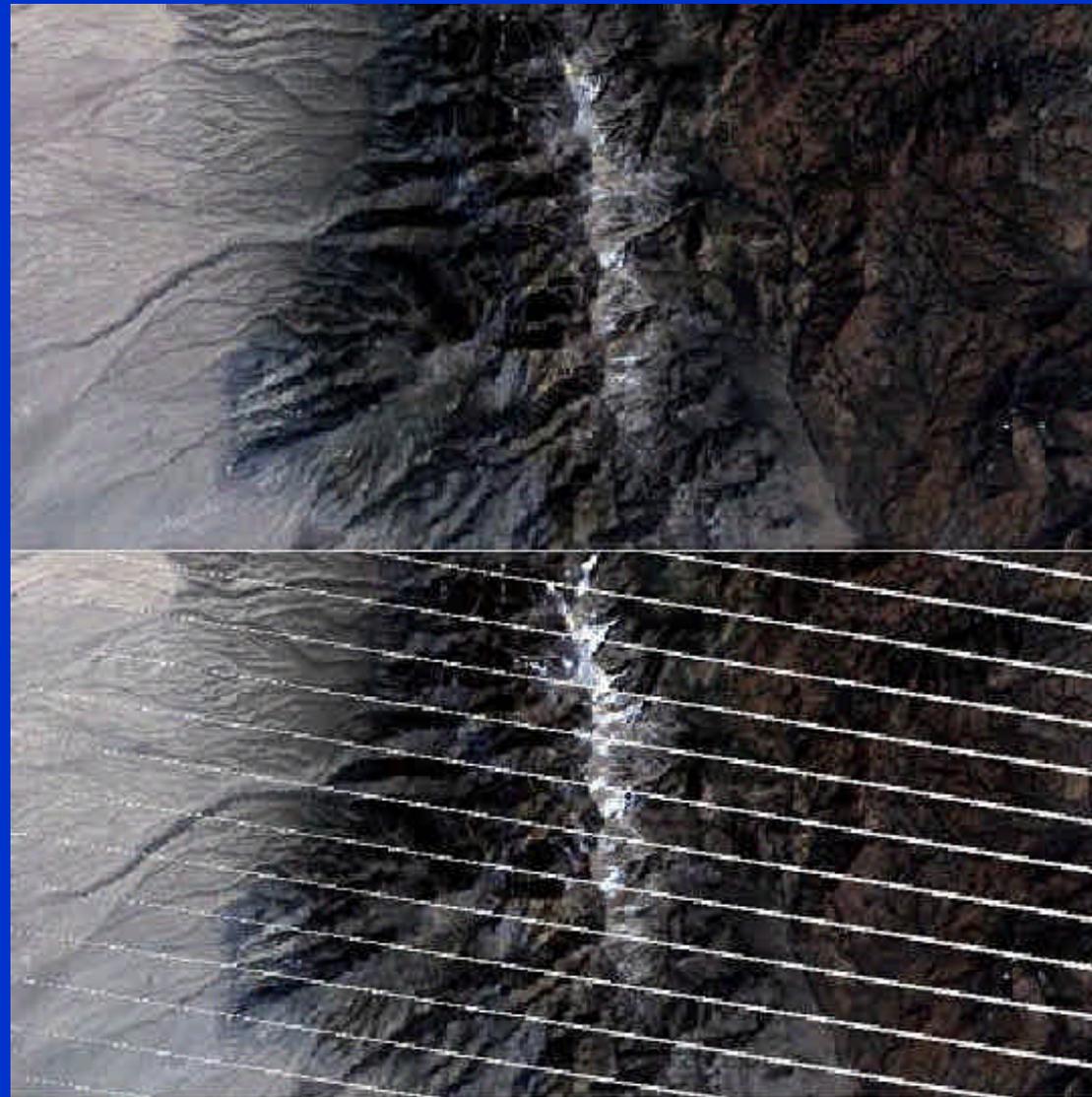
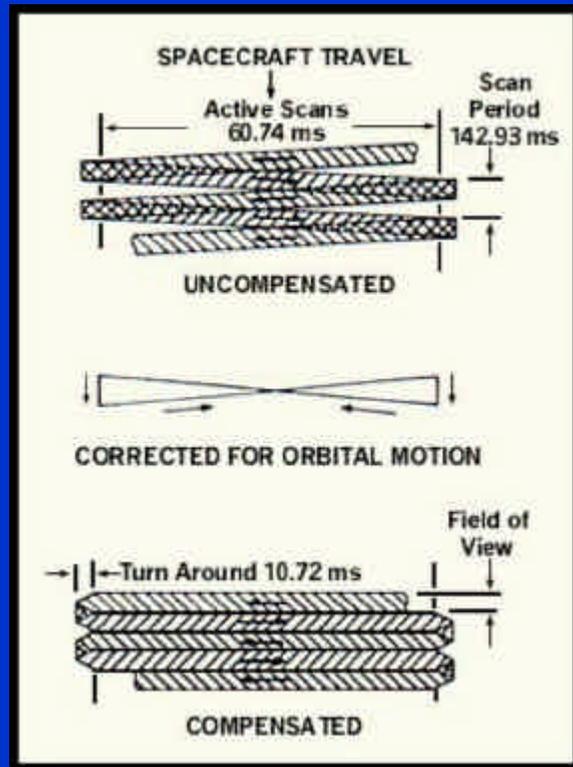


# Landsat 7 update

- Scan line corrector (SLC) failure 31 May '03
  - Fault tree testing of SLC model couldn't reproduce fault
  - Switch to backup electronics in Sept, fault persisted
  - Assumed to be mechanical failure, SLC switch off
  - Studies indicate "frozen" SLC
- SLC-off products
  - Data acquisition continued after 14 July '03
  - New processing includes updated SLC model
  - Updated products scheduled for release Nov '03
- Scientific usability study
  - "critical data source even in it's anomalous state"



# Landsat 7 ETM+ SLC Issue

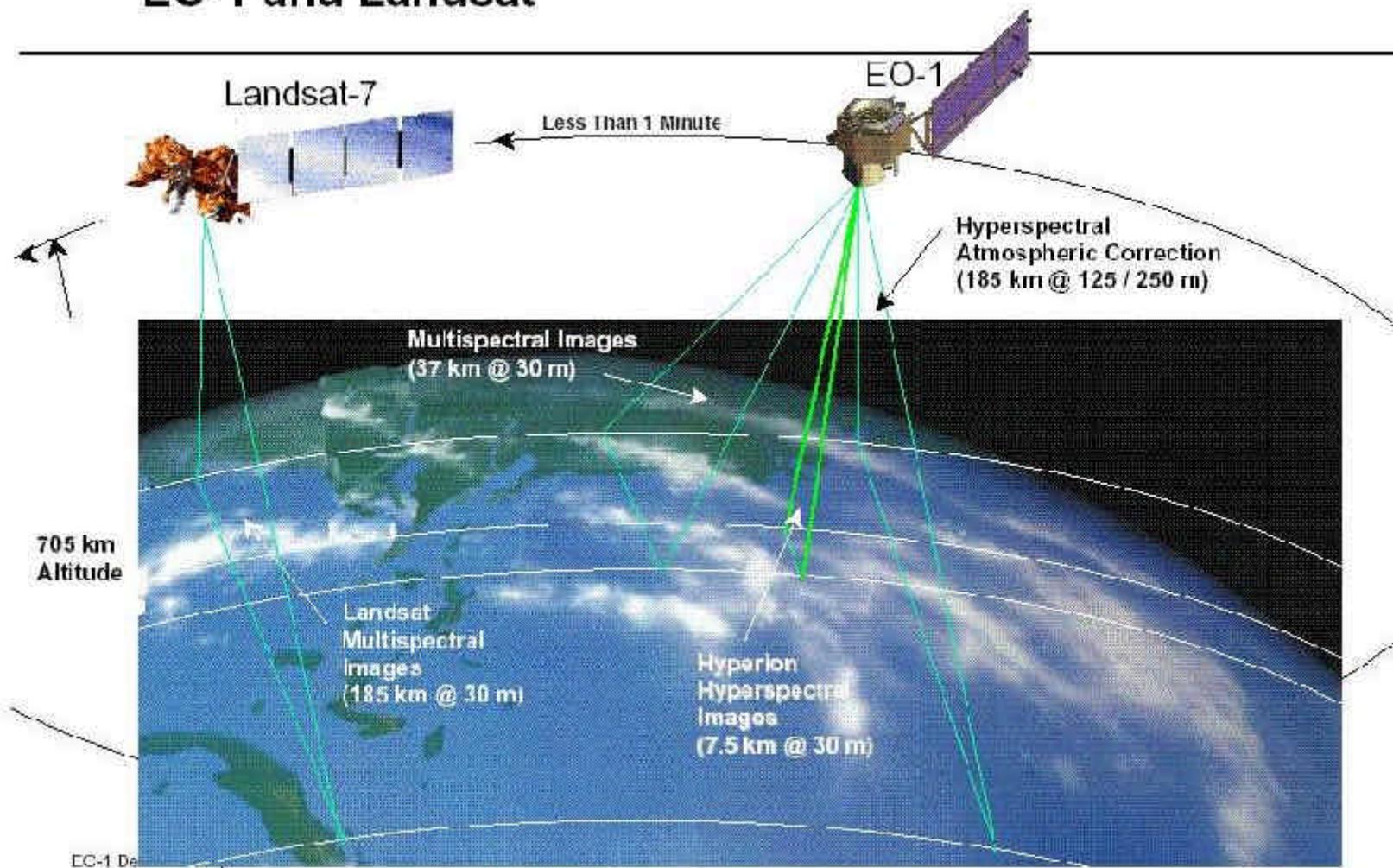


# EO-1 Status

- EO-1 began as a 1-year technology-demonstration mission ending on November 20, 2001
  - Technology flight validation was highly successful
  - Satellite is fully operational – with three imaging sensors
    - Advanced Land Imager (ALI), Hyperion, Atmospheric Corrector (AC)
- NASA and USGS entered into a joint partnership for an extended mission in December 2001
  - Over 16,000 Level 0 archived scenes collected to date (Hyperion and ALI)
  - High continued interest by science, government, and industry
  - Extended mission is based on cost reimbursable model i.e., must be self-sustainable through product sales



## EO-1 and Landsat

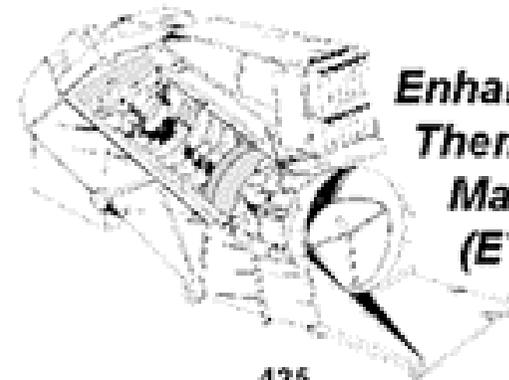
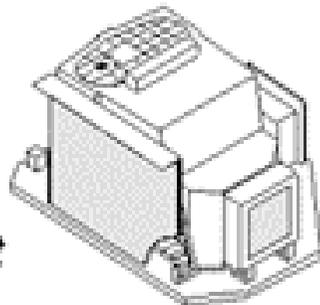


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# EO-1 Physical Specifications

## *EO-1/Landsat Instrument Comparison*

**ALI Based  
Concept  
for Future  
Landsat  
Instrument**



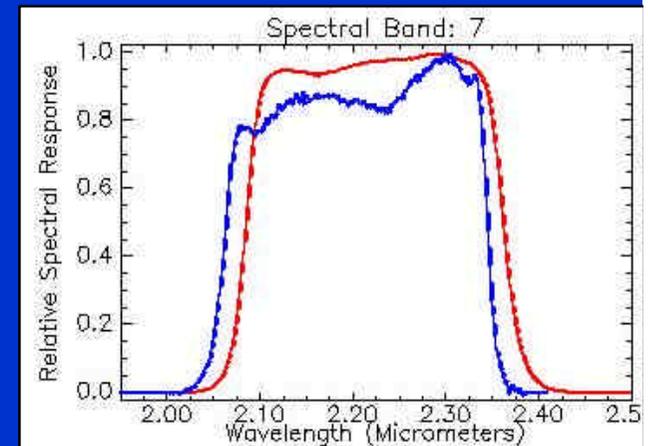
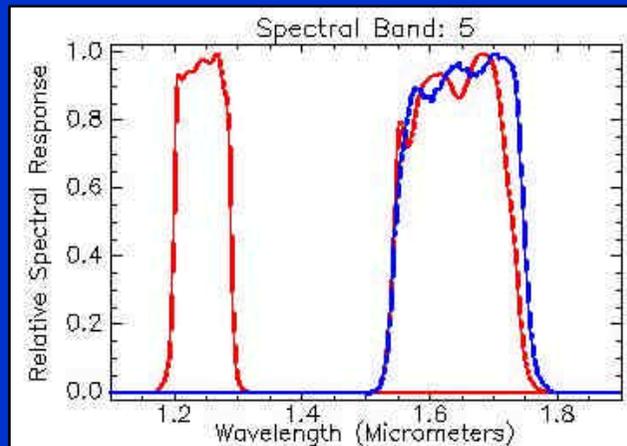
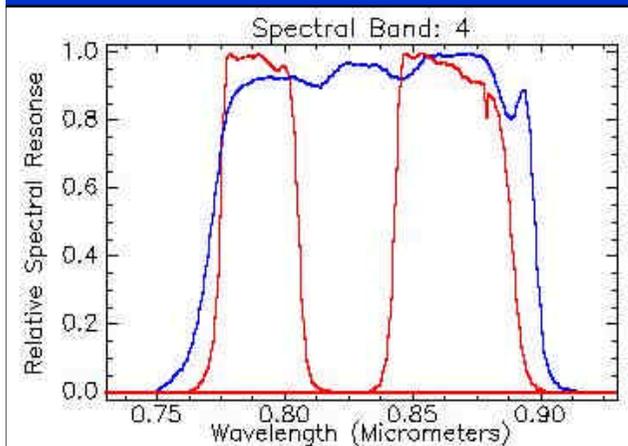
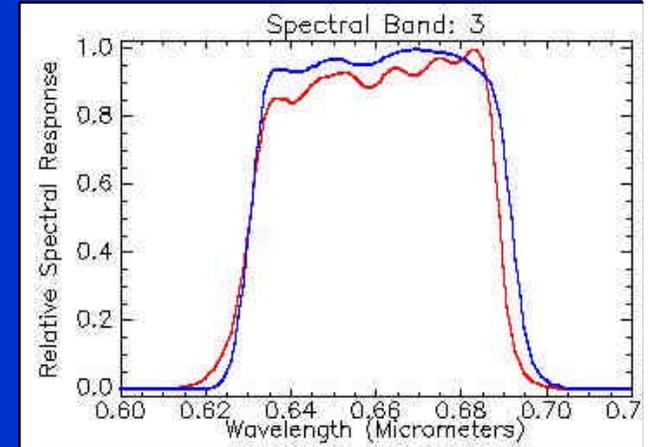
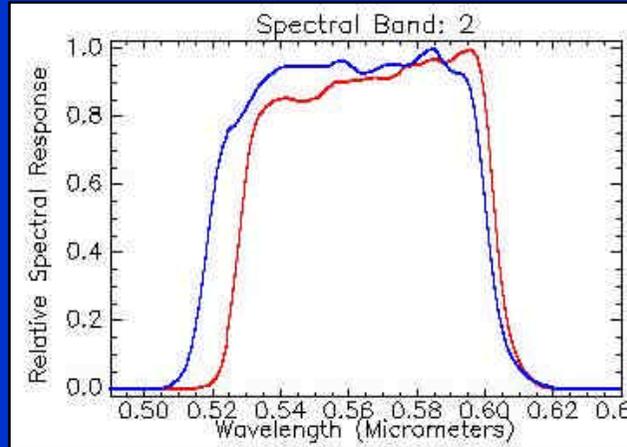
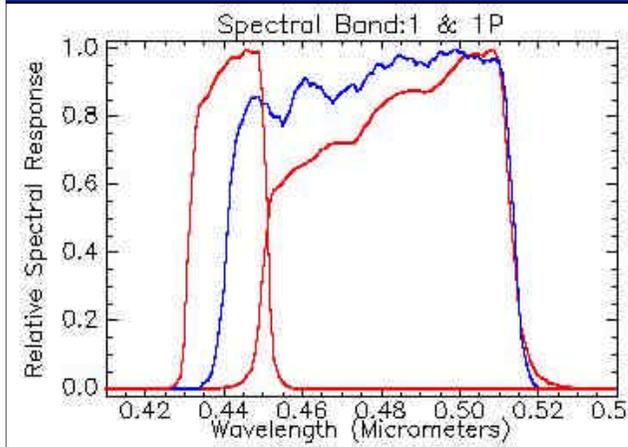
**Enhanced  
Thematic  
Mapper  
(ETM+)**

100	Mass (kg)	425
100	Power (W)	545
0.2	Size (m <sup>2</sup> )	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



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# Relative Spectral Response (RSR) Profiles



ALI (red)

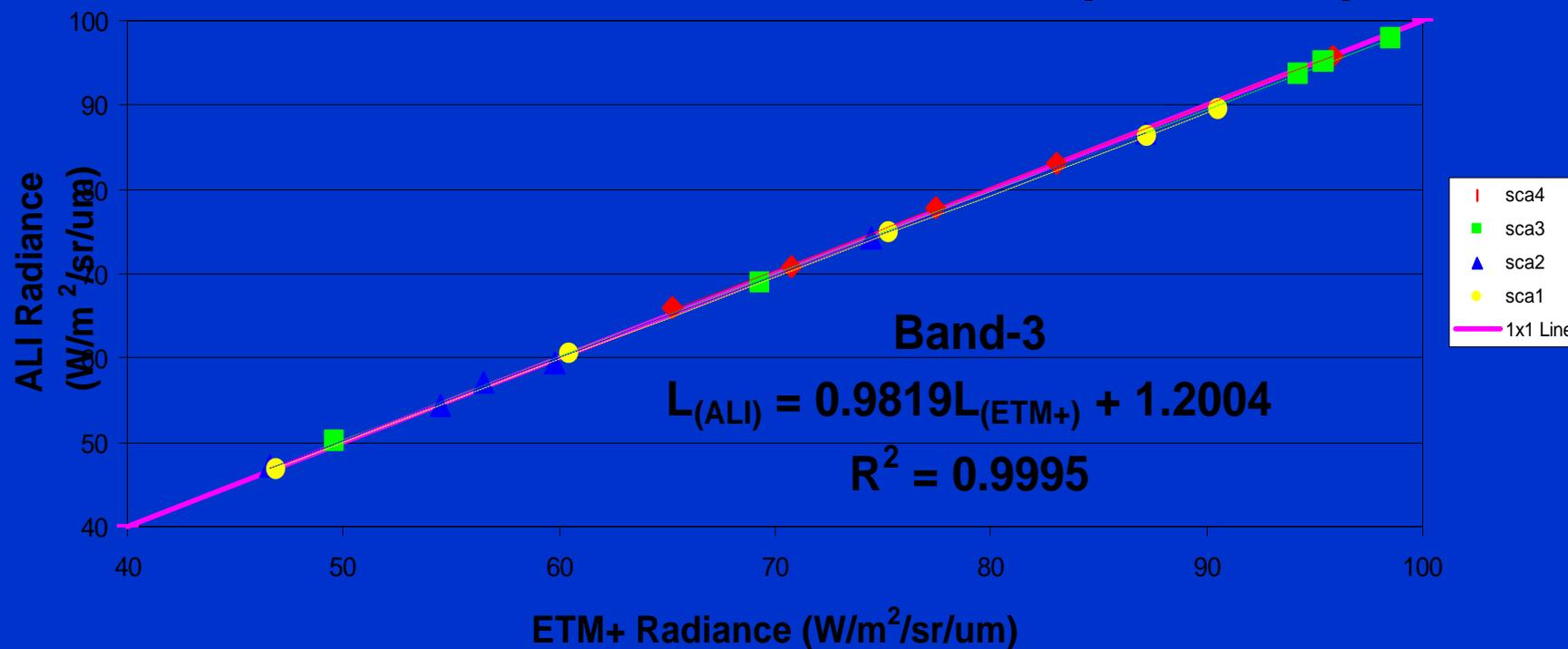
ETM+ (blue)



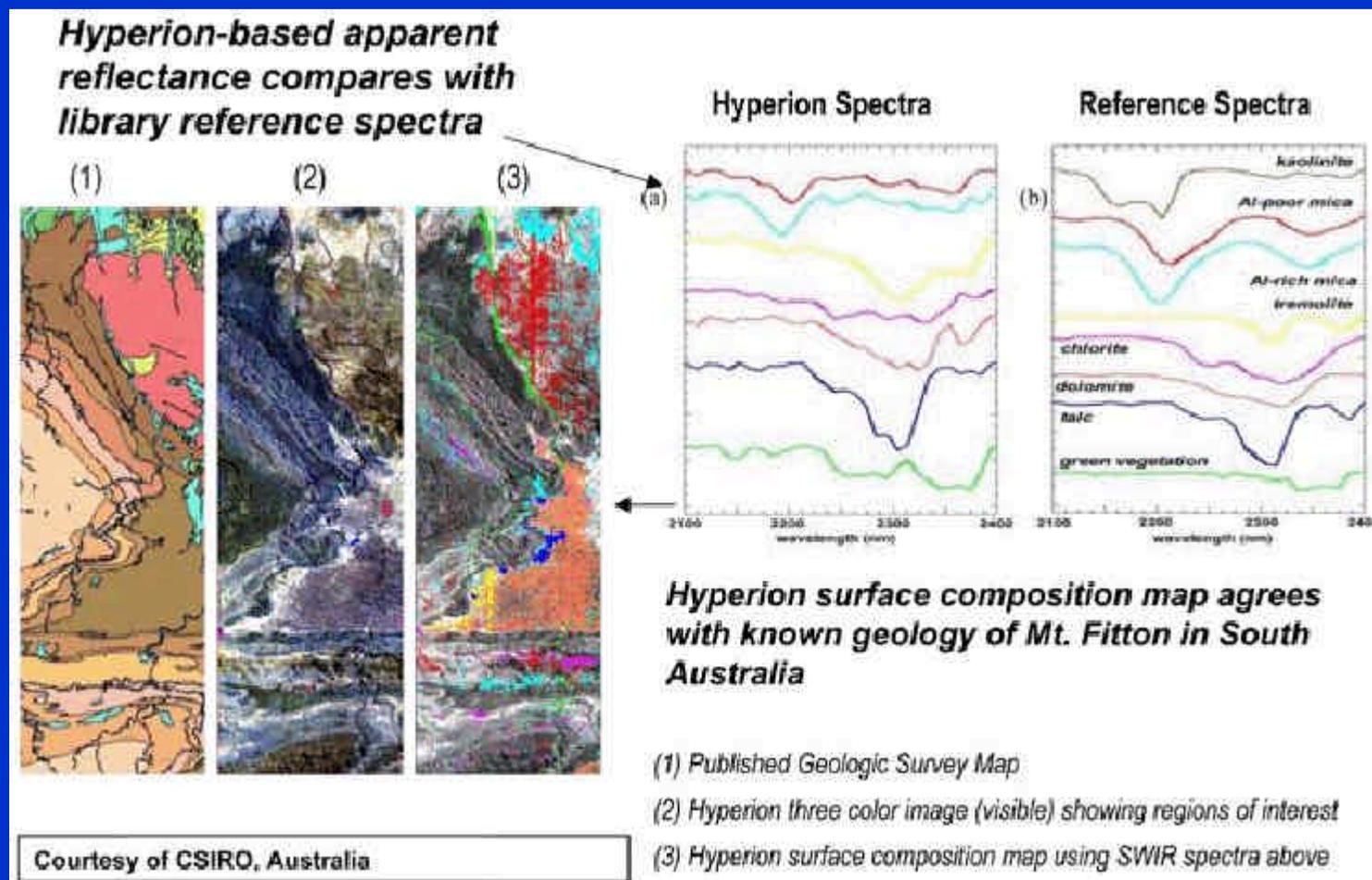
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# Cross Calibration: ALI to ETM+

## ALI vs. ETM+ Radiance (Band-3)



# EO-1 Hyperion

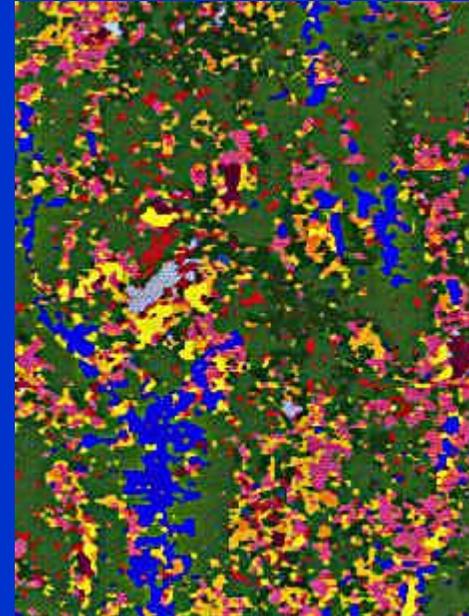


# EO-1 Hyperion: Forestry

## Landsat Analysis



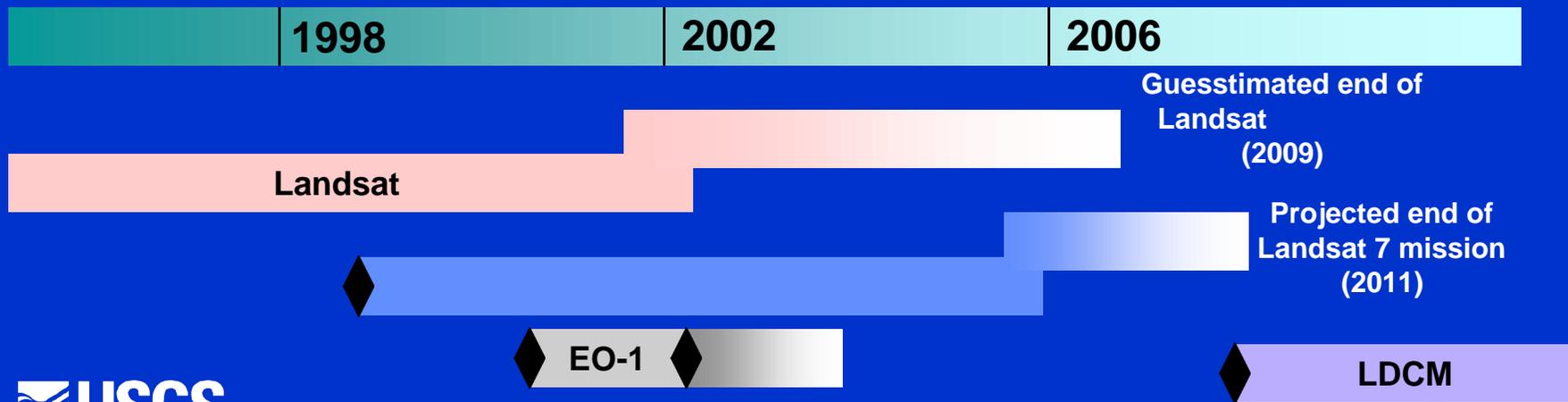
## Hyperspectral Analysis



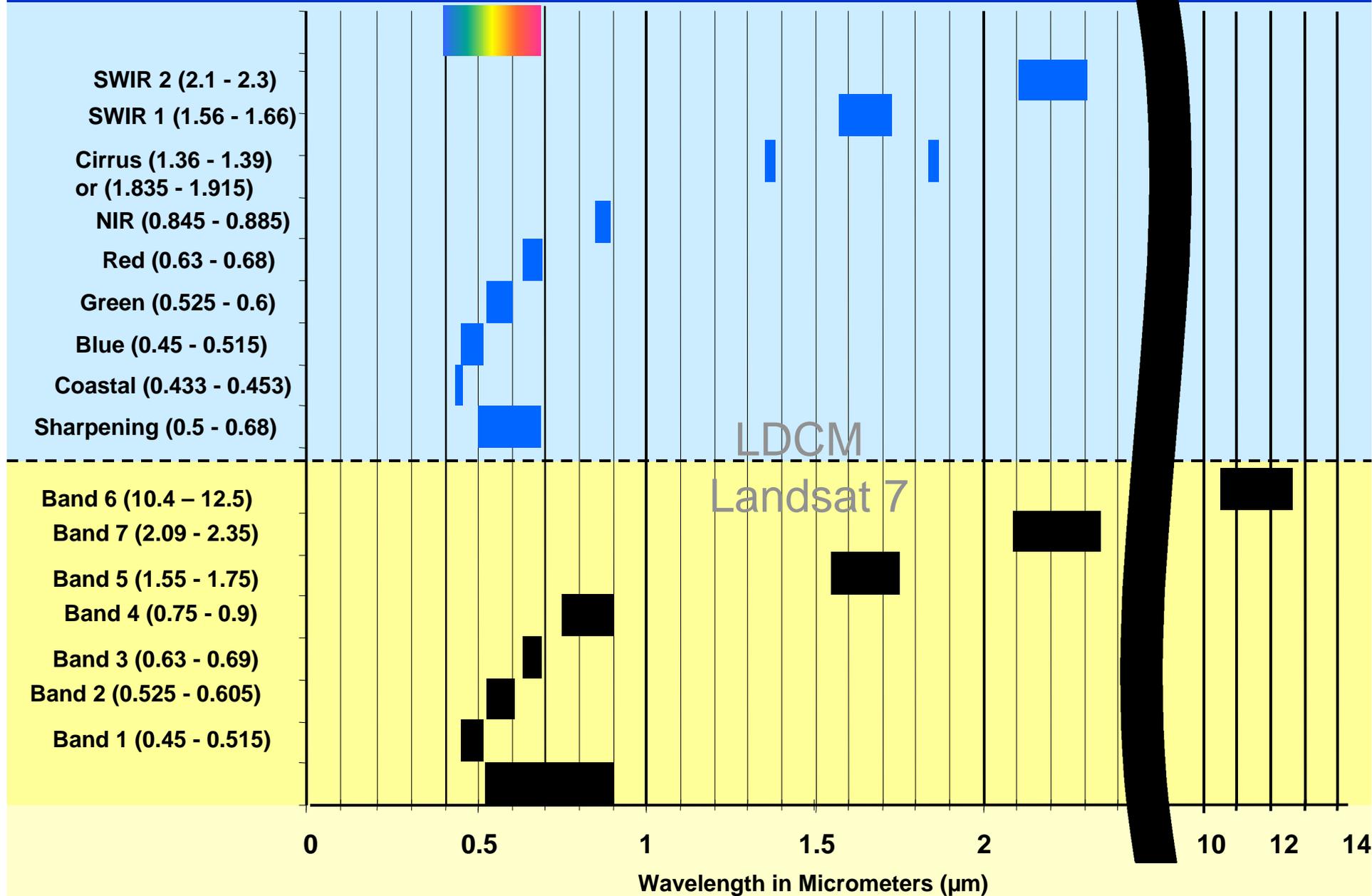
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Courtesy Mary Martin, U. New Hampshire

# Data Continuity Mission



# Landsat 7 vs. LDCM Band Comparison



# LDCM News

- LDCM program underway since June 1999
- Formulation phase awarded March 2002
  - “Study phase” for various technical and trade studies
  - Two bidders selected: Digital Globe and Resource 21
  - Culminated in preliminary system design
- Implementation phase proposals received Feb 2003
  - Final design, fabrication, launch, and checkout
  - On-orbit data delivery
  - Solicitation cancelled Sept. 2003
  - Next phase: international collaboration for Landsat Data Continuity
- USGS/NASA will continue LDCM data preparatory studies using ALI candidate technology
  - Evaluate ALI performance
  - Simulate “fully populated” ALI focal plane



# LDCM: What's Next?

- **Gov't given 4 options by 1992 Law:**
  - Private sector funding and management
  - U.S. Government-private sector cooperative effort
  - International consortium
  - U.S. Government funding and management
- **Options 1 & 2 now found unacceptable**
  - Pursuing Option 3 now
  - Option 4 remains if all else fails
- **Gov't Remains Committed to Continuity of Landsat-type Data!**



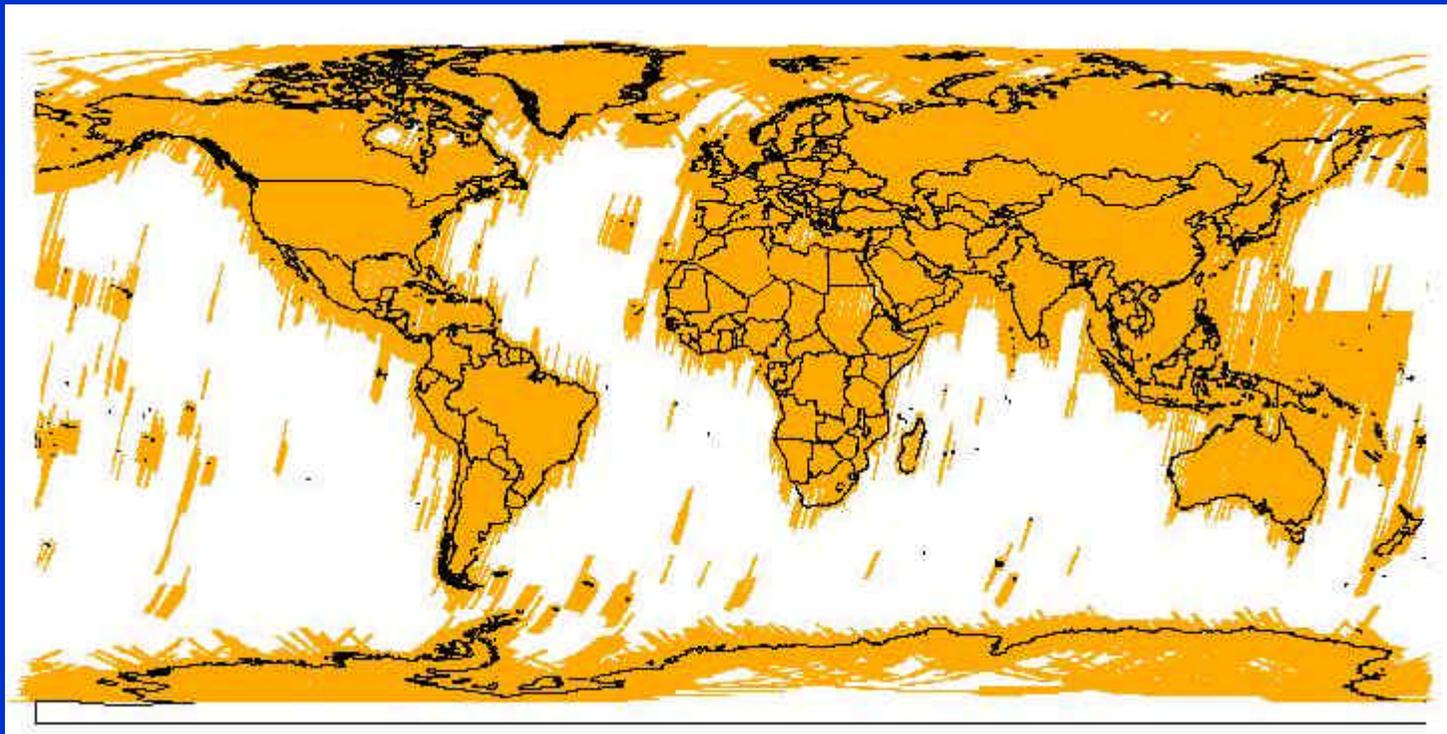
# USGS C<sup>2</sup>V<sup>2</sup> Effort

## Remote Sensing Characterization Project

- Coordination of USGS resources for instrument characterization, calibration, verification, validation (C<sup>2</sup>V<sup>2</sup>) projects across USGS
  - Science activities (Satellites, ROLO, Spectroscopy Lab etc.)
  - Operational mapping programs (camera certification, image product acceptance criteria)
- Planning for development and integration of a consolidated, coordinated C<sup>2</sup>V<sup>2</sup> effort for current and future satellite and airborne sensors
- Coordinate cal/val activities between the USGS and other Federal agencies, academic institutions, commercial and international organizations (**commitment to CEOS/WGCV**)
- Project Lead: Gregory Stensaas ([stensaas@usgs.gov](mailto:stensaas@usgs.gov))



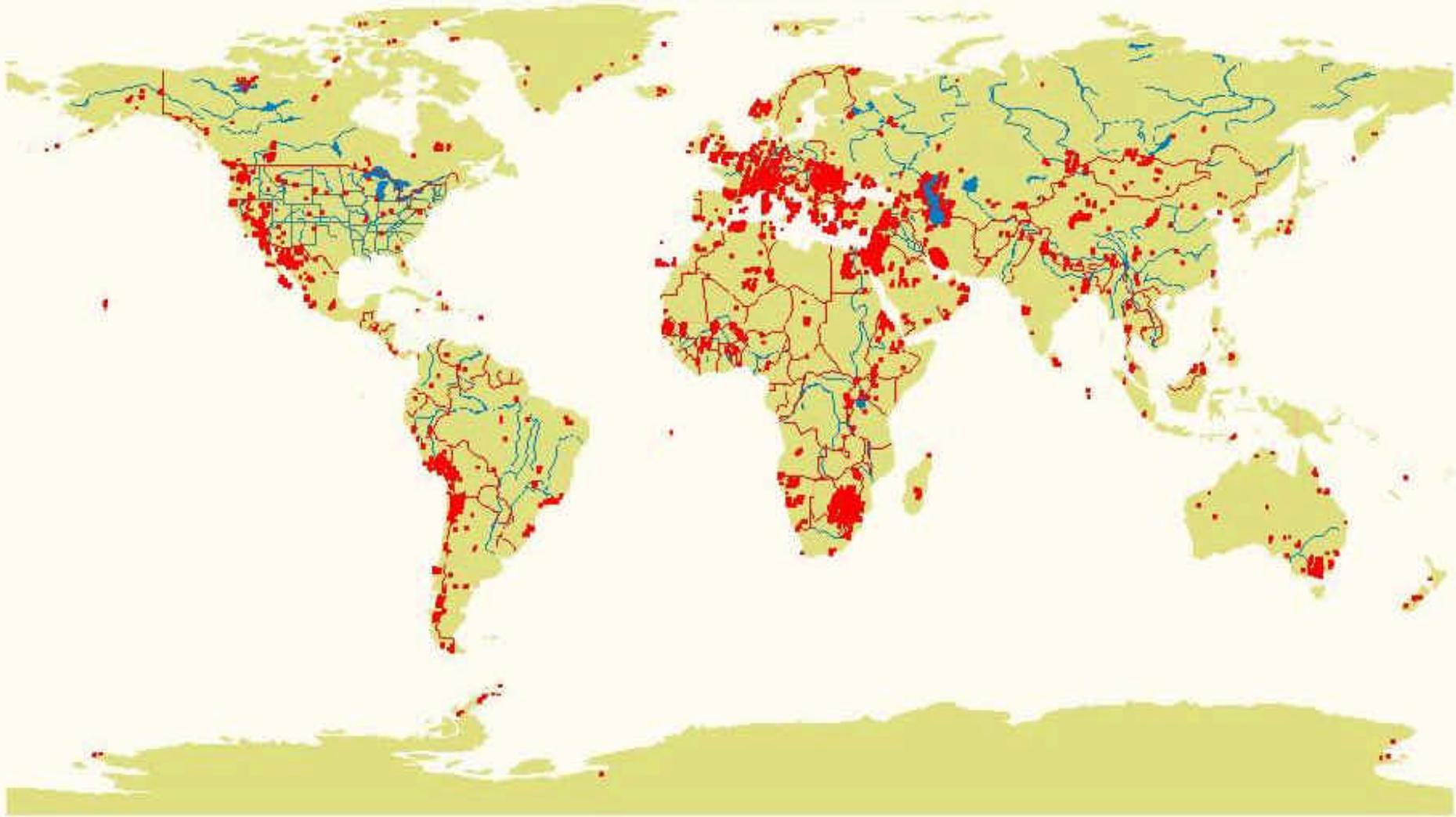
# Coverage of ASTER Stereo Acquisitions



# ASTER DEM Coverage (Sep 24, 2003)

WGCV Beijing, 15-17 October, 2003

ASTER DEM Coverage as of September 24, 2003 (3118 DEMs)



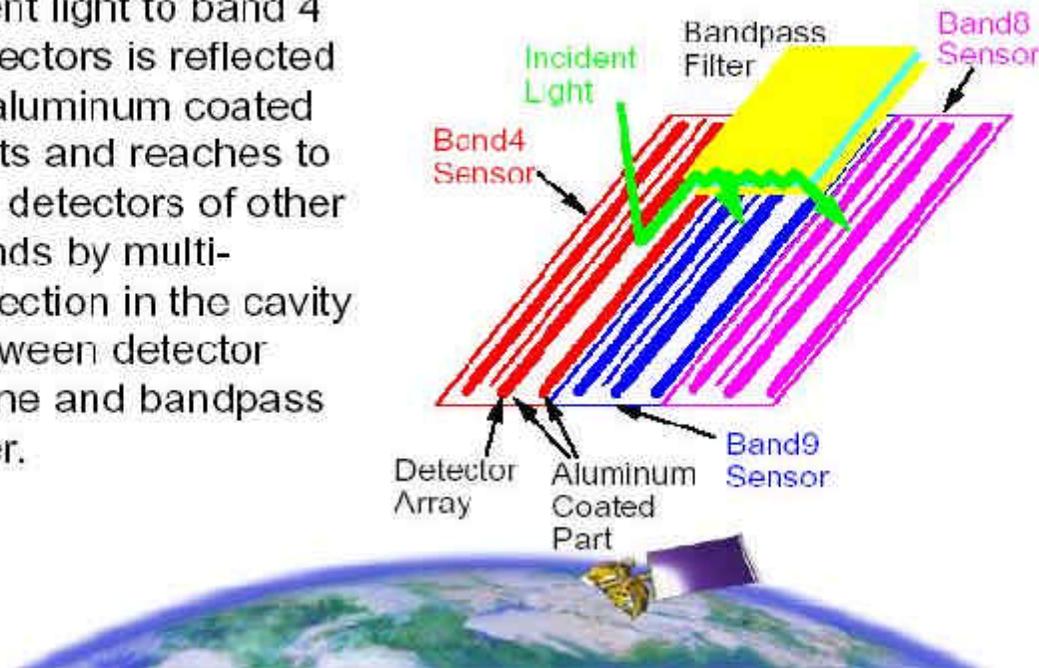
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# SWIR Cross-talk Problem

Stray light reflects from backside of filters to adjacent detectors. Most pronounced for Band 4 contaminating Bands 5 and 9

## Crosstalk Mechanism

Incident light to band 4 detectors is reflected at aluminum coated parts and reaches to the detectors of other bands by multi-reflection in the cavity between detector plane and bandpass filter.



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National Aeronautics and  
Space Administration  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, California



# Summary of Proposed ASTER Processing Enhancements

Problem	Cause	User impact	JPL Status of correction	
Geolocation coordinate	Incorrect calculation of earth rotation	GIS errors of 0-200m daytime; 0-700m nighttime	Coding complete	
Geolocation coordinate	No correction for surface above sea-level	GIS errors of 0-500 m	Coding complete	
SWIR cross-talk	Stray light from band 4 to bands 5&9	Reflectance spectra cannot be easily matched to library curves.	Coding complete; will be in next L2 product software delivery to DAAC	
TIR calibration updates	Only periodic update of values, while instrument changes continuously	Temperature product drifts out of spec 1-2C after 3-6 months; error can propagate to emissivity product	Algorithm coded.	
VNIR-SWIR radiometry	Vicarious calibration results are not used to update values in Japan	Disagreement between ASTER and Landsat/MODIS of 6-12% in VNIR, 5+% in SWIR	<b>Not yet coded</b>	



## ASTER Radiometric & Geometric Correction Strategy

- Correct calculation of earth rotation to be incorporated into future Level-1A to -1B code
- Correction for surface above sea-level and Correct calculation of earth rotation to be incorporated into code for processing from JPL ASTER Web site
- SWIR cross-talk correction to be incorporated into LP DAAC Level-2 (On-demand) processing code
  - Correct calculation of earth rotation, surface above sea-level may also be incorporated into Level-2 processing

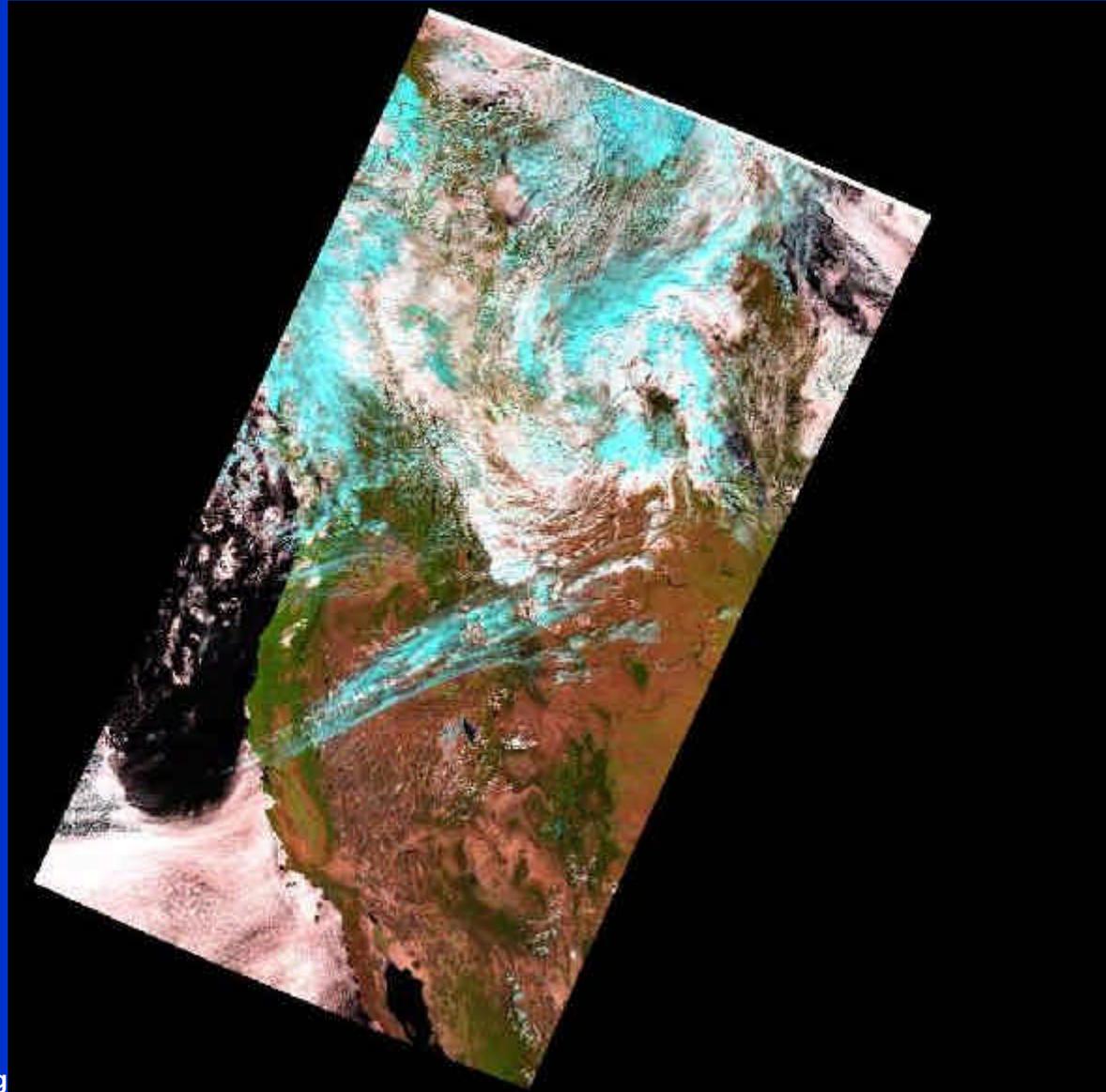


# MODIS Direct Broadcast Data Reception & Products

- MODIS Direct Broadcast (MDB) website at <http://modisdb.usgs.gov/>
- Dataset and band information
  - Acquisition maps
  - Jpegs of recent acquisitions
  - Frequently Asked Questions (FAQs)
  - Gallery of unique MDB images
- Daily MDB NDVI composite of the United States (using a daily incremented 7-day composite window?)
- Two methods of downloading these data
  - full composite from our retrieval site as described on the MDB website
  - download user-specified areas of interest from SDDS at <http://seamless.usgs.gov/>
- Updated the Perl script on our retrieval site ([edc.usgs.gov/modisdata/](http://edc.usgs.gov/modisdata/)), useful in automating your MODIS DB downloads



# Example of Daily Browse Product from USGS EDC MODIS Direct Broadcast Reception



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# USGS websites

## ■ Landsat 5 & 7

- <http://landsat7.usgs.gov> (mission description, status)

## ■ EO-1

- <http://eo1.usgs.gov> (data products)
- <http://eo1.gsfc.nasa.gov> (mission & payload information)

## ■ General data access

- <http://lpdaac.usgs.gov> (MODIS, ASTER)
- <http://earthexplorer.usgs.gov> (remote sensing & other geospatial)
- <http://glovis.usgs.gov> (java-based browsing tool)
- <http://seamless.usgs.gov> (DEMs, digital cartography, land cover, etc.)

