

USGS Report to the CEOS WGCV 28th Meeting

Dates: February 26-29, 2008 Sanya, China

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Gyanesh Chander – SAIC/USGS**



Outline

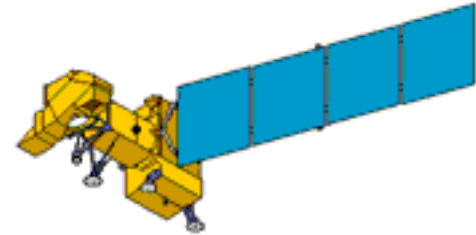
- **Landsat 5/7 Status**
- **Three principle initiatives in Land Remote Sensing (LRS)**
 - ◆ The Landsat Data Continuity Mission (LDCM)
 - ◆ The Landsat data gap and collaborations using other systems
 - ◆ The Future of Land Imaging (FLI)
- **World-wide test sites**

Landsat Mission Status

- **Landsat 7 - 15 April 1999 (~9 Years)**

- ◆ **Spacecraft**

- Gyro 3 Failure (Shut down May 5, 2004)
 - ◆ Working additional improvements for software gyro
- Other Spacecraft Issues (non-critical)
 - ◆ Solid State Recorder – 4 memory boards
 - ◆ Electrical Power Subsystem – shunt #14 and shunt #6
 - ◆ Fuel Line Thermostat



- ◆ **ETM+**

- Scan Line Corrector Failure (May 31, 2003)
- Bumper Mode Operations (April 1, 2007)

- **Landsat 5 – 1 March 1984 (~25 years)**

- ◆ **Spacecraft**

- Battery 2 Anomaly – Oct 2007
- Star Tracker Issue – June 2007
- Solar Array Drive - Fixed array operations – Aug 2006

- ◆ **TM**

- Functioning normally in bumper-mode



Landsat 7 ETM+ Calibration Update

- **Band-to-Band registration typically 0.05 pixels or better in line and scan direction (excluding band 6)**
- **Switch to bumper mode disrupted ETM+ sensor alignment calibration and degraded geodetic accuracy**
 - ◆ Pre-switch : 97% scenes better than 50 meters RMSE
 - ◆ Post-switch: 65% scenes better than 50 meters RMSE
- **Relative detector-to-detector normalization, i.e., striping less than $\pm 0.1\%$**
- **Absolute radiometric accuracy better than $\pm 5\%$ (reflective) and 1 K (thermal)**
- **Noise stable over mission life**
- **SLC failure had no significant impact on L7 ETM+ reflective band radiometry- continues to be excellent**

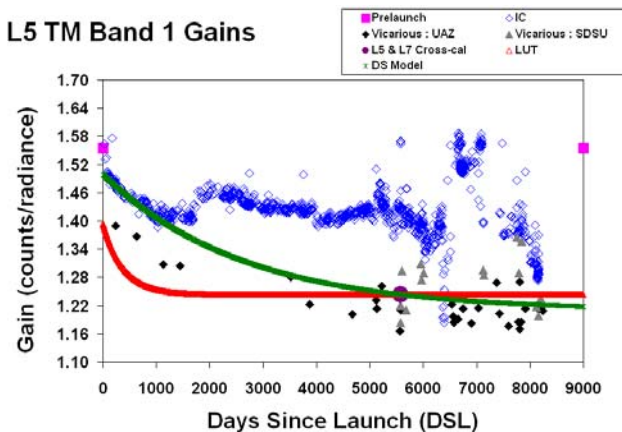
Landsat 5 TM Calibration Update

- **Within-band within-scene internal stability**
 - ◆ Scan-Correlated Shift (SCS) of up to 0.7 DN
 - Correctable with scan line-by-scan line background subtraction
 - ◆ Memory effect of up to 4 DN
 - Currently corrected in NLAPS processing
 - ◆ Some banding and striping issues remain to be resolved
- **Between-date stability**
 - ◆ Interference cycling from icing on B5 and B7
 - Correctable with IC processing or LUT that includes interference cycling
- **Radiometric calibration processing**
 - ◆ Uses Gain Calibration History stored in Look-Up Table
 - ◆ Extracts and applies biases on a scan line by scan line basis
 - ◆ Rescaled to Fixed Radiance Range (LMIN, LMAX)
 - ◆ Look-up Table revised April 2, 2007 to reflect revised trends from Sahara desert site data obtained from ESA

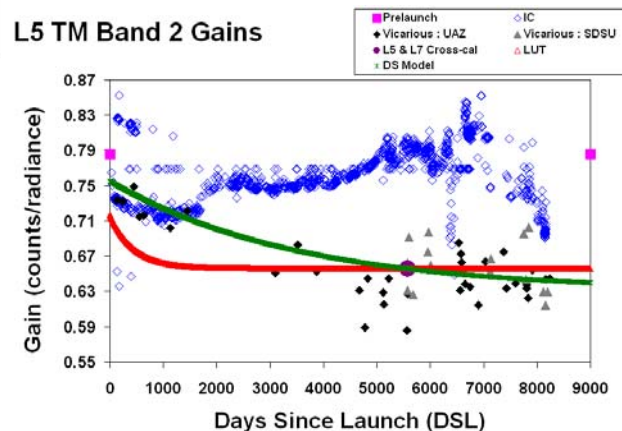
Comparison of L5 TM Radiometric Calibration Methods

(Pre-launch, IC, Vicarious, LUT03, LUT07)

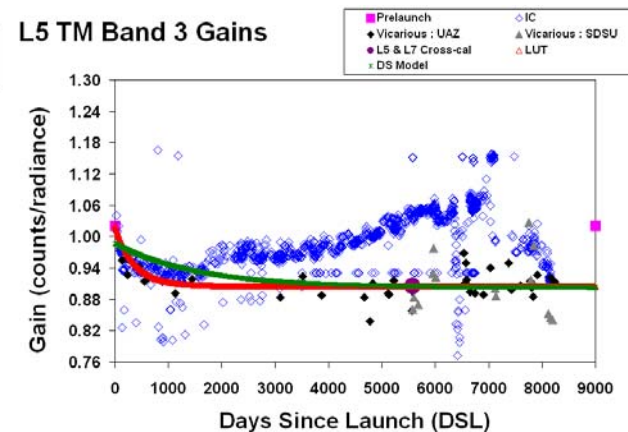
L5 TM Band 1 Gains



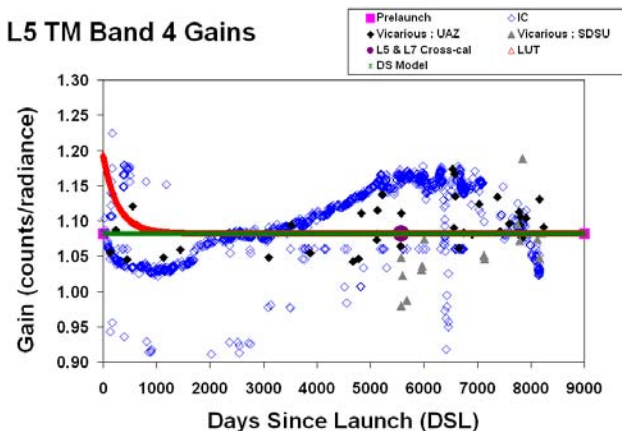
L5 TM Band 2 Gains



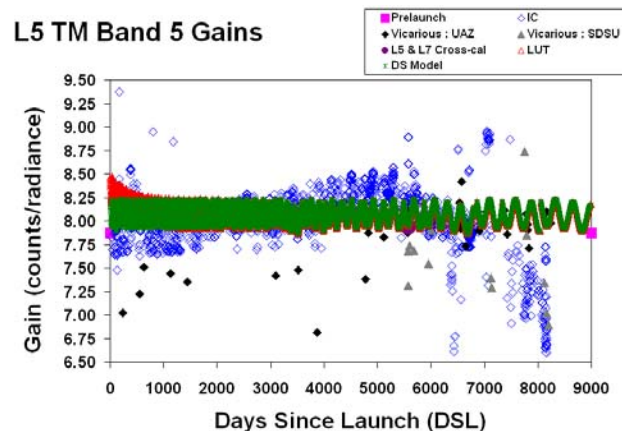
L5 TM Band 3 Gains



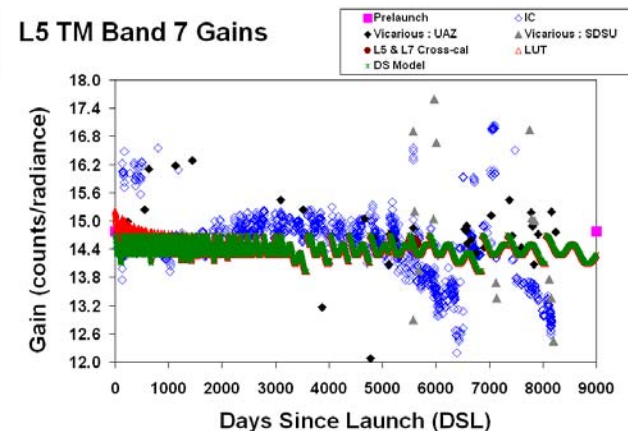
L5 TM Band 4 Gains



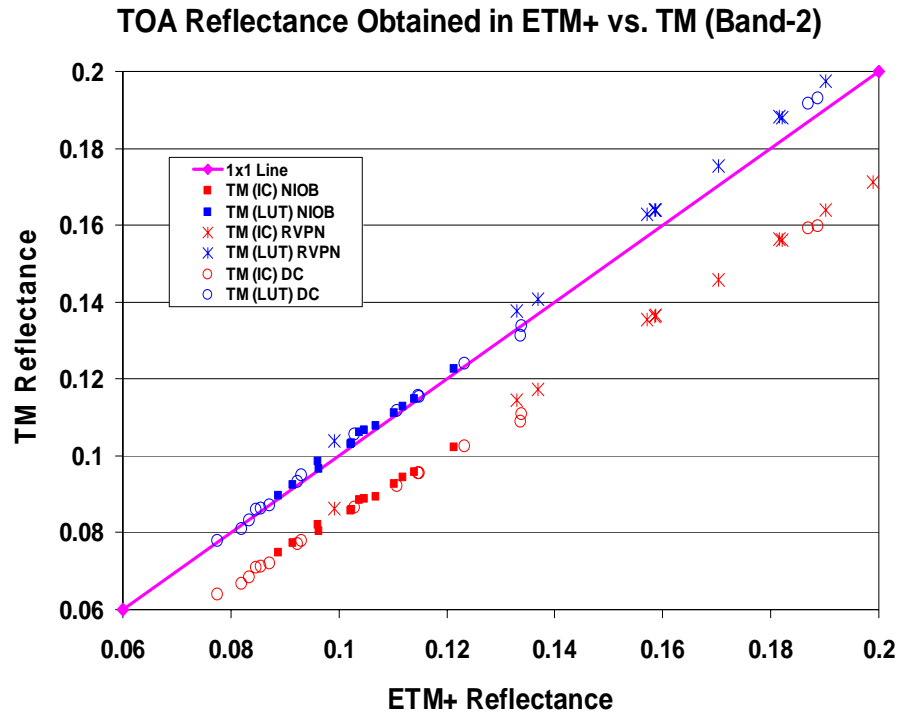
L5 TM Band 5 Gains



L5 TM Band 7 Gains

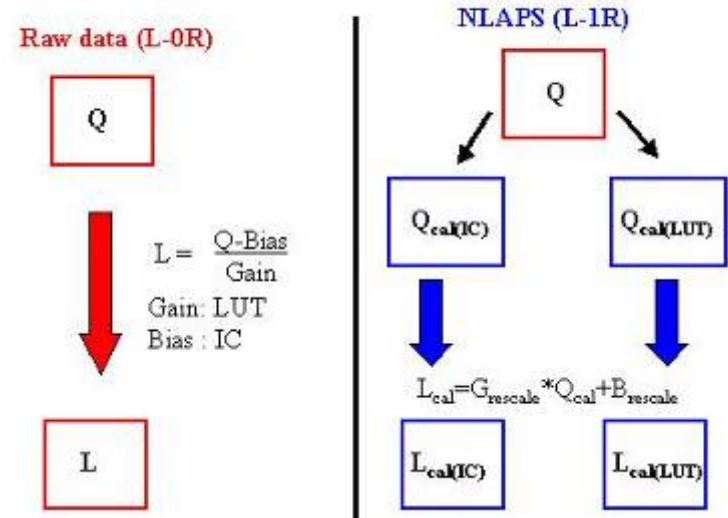


Improvement in absolute calibration accuracy of L5 TM with L7 ETM+ data

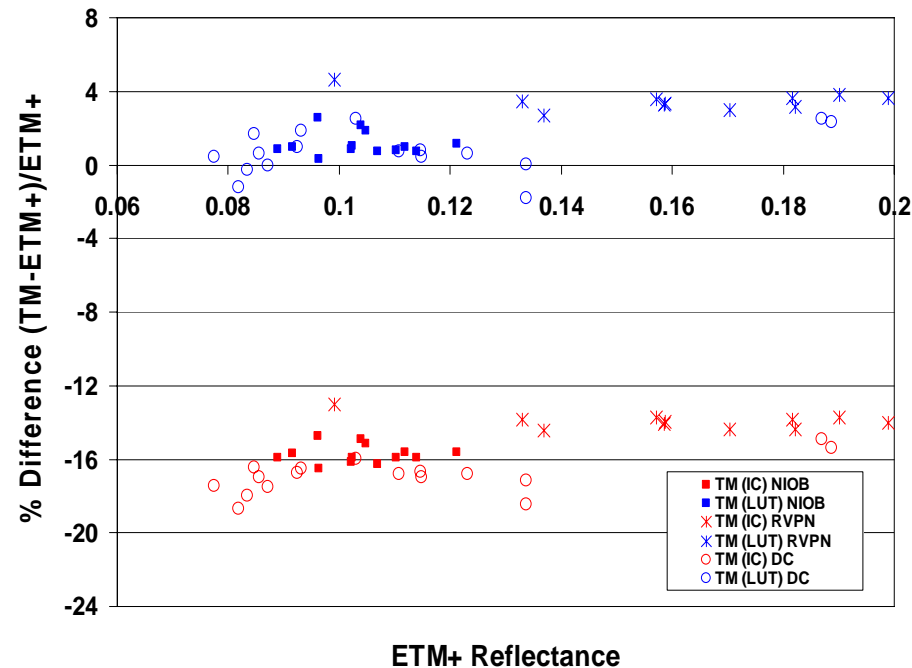


The percentage mean difference in reflectance measurements obtained from the L5 TM relative to ETM+ in **band-2** is reduced from about **15.6%** (using IC) to **1.8%** (using LUT)

NLAPS LUT Release Validation

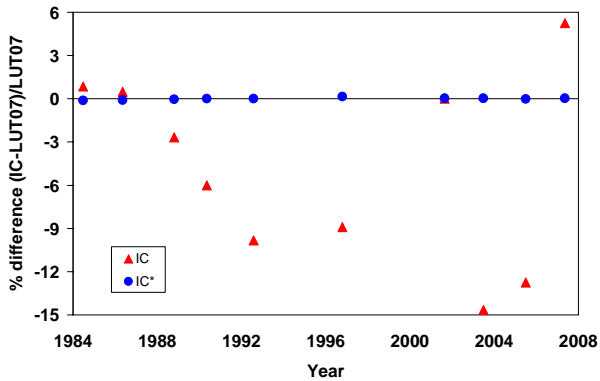


L5 TM % difference relative to L7 ETM+ (Band 2)

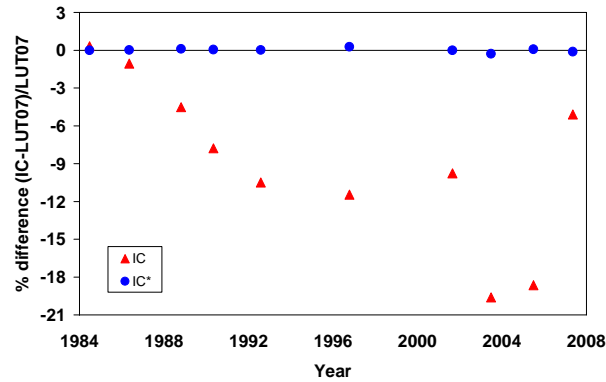


L5 TM Recalibration Procedure

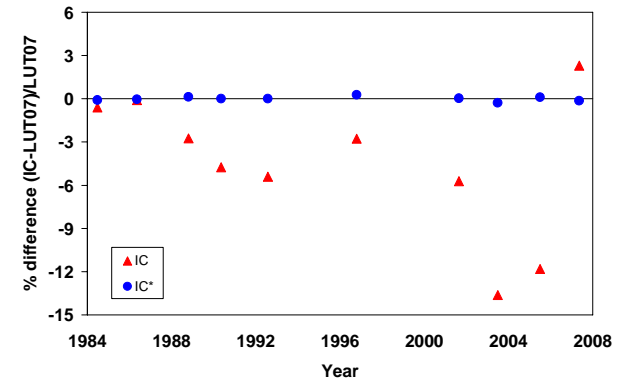
L5 TM Band 1 Recalibration (1984-2007)



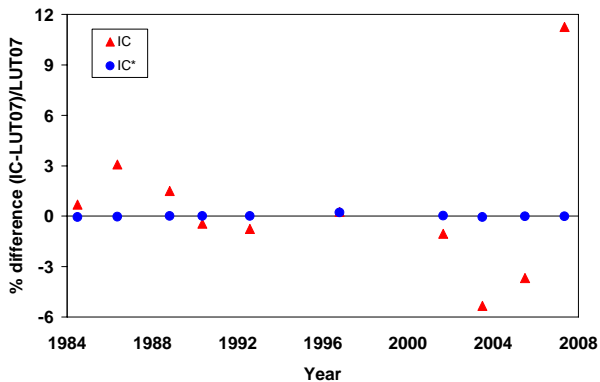
L5 TM Band 2 Recalibration (1984-2007)



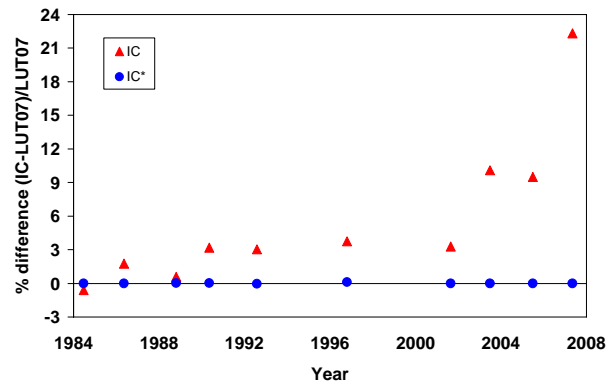
L5 TM Band 3 Recalibration (1984-2007)



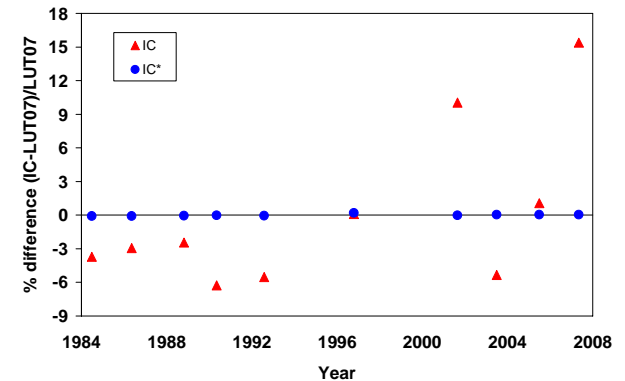
L5 TM Band 4 Recalibration (1984-2007)



L5 TM Band 5 Recalibration (1984-2007)



L5 TM Band 7 Recalibration (1984-2007)



Landsat Web-enabled Data Pilot

- **As of June 2007, the USGS web enabled release of Landsat 7 SLC-off image data of the United States through the Web**
 - ◆ US only – includes Alaska and Hawaii
 - ◆ L7 ETM+ SLC-off only – 2003 to present (and ongoing)
 - ◆ < 20% cloud cover
 - ◆ 9 quality
 - ◆ <http://glovis.usgs.gov/> or <http://earthexplorer.usgs.gov/>
- **Recipe recommended by LST for this Web-enabled LDCM pilot project and for Global Land Survey dataset**
 - ◆ Pixel size: 15m/30m/60m
 - ◆ Media type: Download (no cost), CD/DVD (\$50)
 - ◆ Product type: L1T (terrain-corrected)
 - ◆ Output format: GeoTIFF
 - ◆ Map projection: UTM
 - ◆ Orientation: North up
 - ◆ Resampling: Cubic convolution

Future plans for Landsat Data Availability

- **FY08**

- ◆ Expansion of Landsat 7 SLC-off Data
- ◆ Continued additions to MRLC dataset

- **FY09**

- ◆ Complete GLS2005
- ◆ Landsat 7 SLC-on data available
- ◆ Landsat 4/5 TM data available

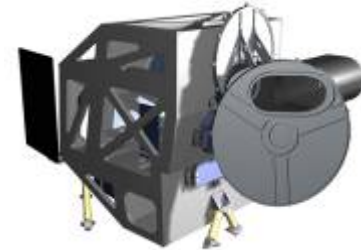
- **FY10**

- ◆ MSS data available

- **July 2011: Targeted LDCM launch readiness date;
Followed by 90 day on-orbit checkout and acceptance**

Current Project Status Operational Land Imager (OLI)

- Jan. 09, 2007 - NASA released Request For Proposals (RFP) for an Operational Land Imager (OLI)
- Proposals were received on Feb. 23, 2007
- OLI Contract Awarded to Ball Aerospace in July 2007
- Since Contract Award
 - ◆ Numerous subsystem peer reviews have been conducted
 - ◆ Completed successful Instrument Systems Requirements Review
 - ◆ Completed successful Instrument Integrated Baseline Review
 - Formally baselines the plan for building the instrument
 - ◆ Flight optics, filters, detectors, and optical bench in various phases of design and production
- **NASA successfully fended off a protest of the OLI award to Ball**
 - ◆ No impact OLI development schedule
- **On-going Requirements Optimization Exercise**
 - ◆ Maximize probability of maintaining 39 month OLI development schedule



OLI Specifications

Table 1. Required Spectral Bands and Spatial Resolution

#	Band	Minimum Lower Band Edge (nm)	Maximum Upper Band Edge (nm)	Center Wavelength (nm)	Maximum Spatial Resolution At Nadir (m)
1	Coastal /Aerosol	433	453	443	30
2	Blue	450	515	482	30
3	Green	525	600	562	30
4	Red	630	680	655	30
5	NIR	845	885	865	30
6	SWIR 1	1560	1660	1610	30
7	SWIR 2	2100	2300	2200	30
8	Panchromatic	500	680	590	15
9	Cirrus	1360	1390	1375	30

Landsat Science Team

- **USGS is co-chairing and funding the Landsat Science Team**
 - ◆ 1st Science Team meeting: January 9-11, 2007
 - ◆ 2nd Science Team meeting: June 12-14, 2007
 - ◆ 3rd Science Team meeting: January 8-10, 2008
- **The Science Team is funded to conduct research and provide feedback to the LDCM in several areas**
 - ◆ Applied research in natural resource monitoring and algorithm development
 - ◆ Participation in ground system requirements reviews
 - ◆ Definition of product specifications
 - ◆ Development of LTAP-8
 - ◆ Instrument Engineering
 - ◆ Communications and Outreach
 - ◆ Policy recommendations

USGS LDCM Science Office

- **Serves as a bridge between the user community (requirements) and engineering (systems development)**
- **Conducts applications research and algorithm development**
 - ◆ Land surface monitoring
 - ◆ Projections and resampling
 - ◆ Prototype products and metadata
 - ◆ Cloud cover assessment
 - ◆ Ancillary data required for LTAP-8 and product generation
- **Communications and Outreach**
 - ◆ Survey user requirements
 - ◆ Peer reviewed publications
 - ◆ Presentations at conferences and symposia
 - ◆ Participation in inter-agency working groups

Landsat Cross-calibration Activities

- **On-going Cross-calibration Activities**

- ◆ L7 ETM+ and L5 TM sensor
- ◆ L5 TM and L4 TM sensor
- ◆ L7 ETM+/L5 TM and EO-1 ALI sensor
- ◆ L7 ETM+/L5 TM and Terra MODIS sensor
- ◆ L7 ETM+/L5 TM and IRS-P6 AWiFS/LISS-III sensor
- ◆ L7 ETM+/L5 TM and CBERS-2 CCD sensor
- ◆ L7 ETM+/L5 TM and ALOS AVNIR-2 sensor

- **Planned Cross-calibration Activities**

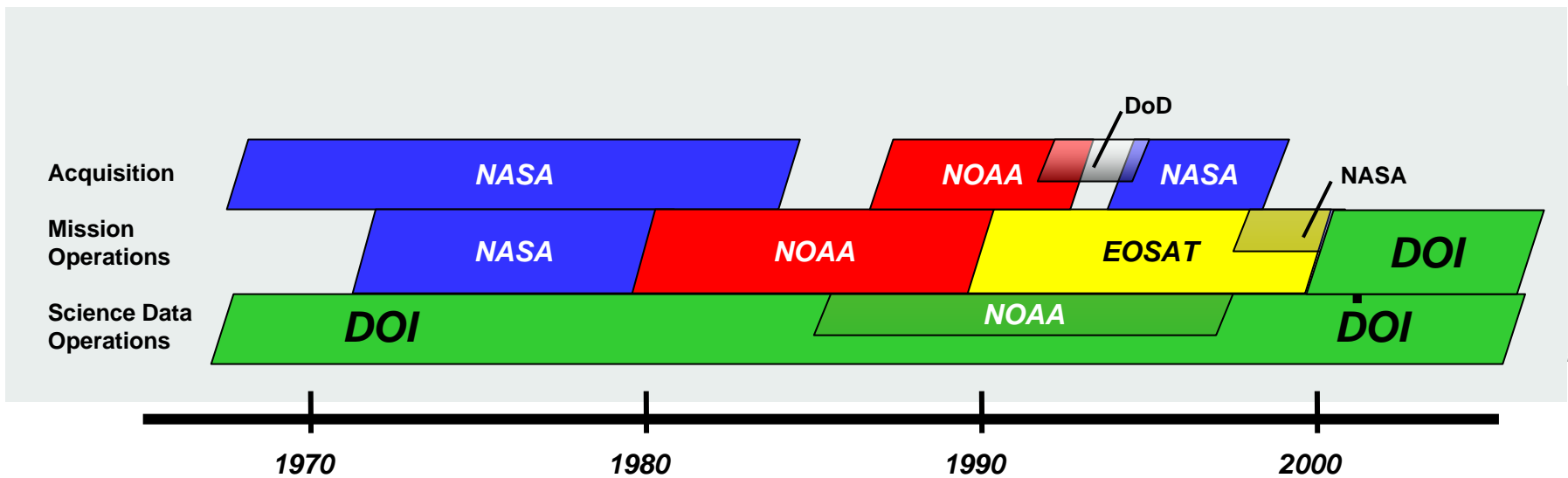
- ◆ L7 ETM+/L5 TM with: CBERS-2B, ENVISAT MERIS, AVHRR MetOP, THEOS, DMC, Beijing1, Topsat, Cartosat-2, ResourceSat, RapidEye, Worldview, GEOEYE, SPOT

- **Presentations at Joint Agency Commercial Imagery Evaluation (JACIE) Workshop, 25-27 March 2008**

- ◆ <http://www.usm.edu/ncpc/jacie/>

The Issue

- No long-term U.S. commitment for providing Landsat-like data
- No U.S. commercial alternative
- No resources to sustain an operational land imaging program for the U.S



National Land Imaging Program

A PLAN FOR A U.S. NATIONAL LAND IMAGING PROGRAM



Future of Land Imaging
Interagency
Working Group

In December 2005, the President's Science Advisor stated: "It remains the goal of the U.S. Government to transition the Landsat program from a series of independently planned missions to a sustained operational program..."

In 2007, The Department of Interior accepted the role of leading the National Land Imaging Program (NLIP)

Future of Land Imaging Interagency Working Group (FLI IWG) guidance

- Why does the U.S. need moderate-resolution land imagery?
- What are the key societal benefits of moderate resolution land imaging?
- What are the options for acquiring these capabilities or data?
- How should U.S. land imaging be managed and governed?



Catalog of World-wide Test Sites for Sensor Characterization

- **The layout is set up to help the user quickly locate the needed information available on the site**
 - ◆ Drop-down menus list locations so the user may go straight to a specific site
 - ◆ A map with clickable links provides another way to go to sites
 - ◆ The maps include a world map, where the user selects a continent, and a map of each major continent
- **Each of the calibration site pages contains the same fields for easy review**
 - ◆ These fields include location, terrain elevation, center latitude/longitude, WRS-2 path/row, size of usable area, owner, researcher, purpose, description, support data, suitability, and limitations
- **Other features include**
 - ◆ a small image of the globe depicting the position of the site
 - ◆ satellite images of the test site
 - ◆ previous/next button
 - ◆ sample Landsat images and Google KMZ files



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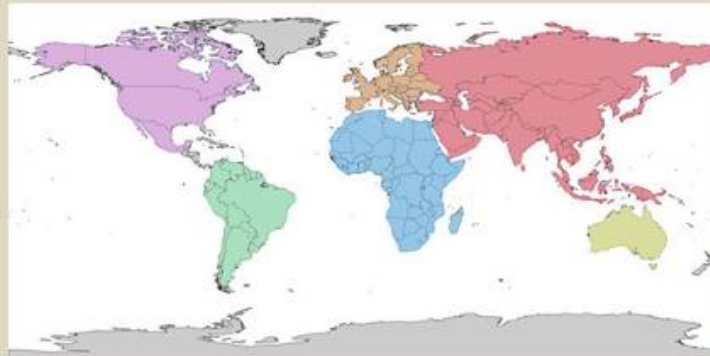
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Test Site Catalog

Catalog of World-wide Test Sites for Sensor Characterization

In an era when the number of Earth-observing satellites is rapidly growing and measurements from these sensors are used to answer increasingly urgent global issues, it is imperative that scientists and decision-makers rely on the accuracy of Earth-observing data products. The characterization and calibration of these sensors are vital to achieve an integrated Global Earth Observation System of Systems (GEOSS) for coordinated and sustained observations of Earth. The U.S. Geological Survey (USGS), as a supporting member of Committee on Earth Observation Satellites (CEOS) and GEOSS, worked with partners around the world to establish an online Catalog of prime candidate world-wide test sites for the post-launch characterization and calibration of space-based optical imaging sensors. The online Catalog provides easy public web site access to this vital information for the global community. Through greater access to and understanding of these vital test sites and their use, the validity and utility of information gained from Earth remote sensing will continue to improve.
([Additional Information](#))

Contact Information: Gyanesh Chander gchander@usgs.gov or Gregory L. Stensaas stensaas@usgs.gov



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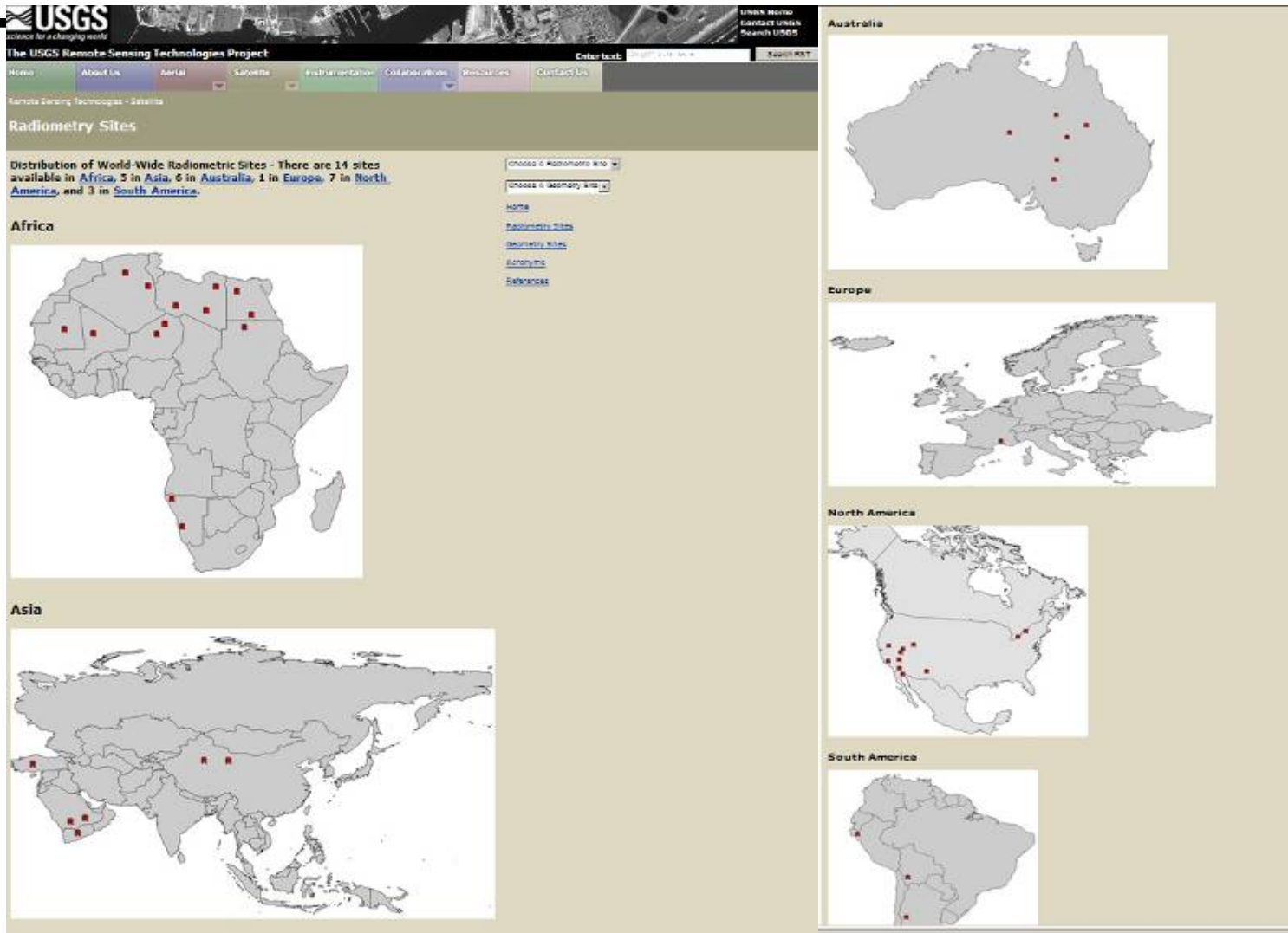
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Radiometry Sites



On-line Catalogue Example: Railroad Valley Playa, North America

Site Location: Railroad Valley Playa

Radiometric [PREV](#) [NEXT](#)


Location (City, State, Country):	Ely, Nevada, USA, North America
Altitude above sea level (meters):	1435
Center Latitude, Longitude (Degrees):	+38.5, -113.69
Landsat WRS-2 Path/Row:	40 / 33
Size of Usable Area (km):	10 x 10
Owner:	Bureau of Land Management (BLM)
Researcher:	Dr. Kurtis J. Thome Email Researcher

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19 May 2003




Site Location

[Download LT ETM+ GeoTIF Data](#)
[Download Google Earth KML File](#)

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Purpose:	Radiometric, vicarious calibration test site, with large homogenous regions
Description:	Dry-lake plays, spatially homogeneous, consisting of compacted clay-rich lacustrine deposits forming a relatively smooth surface compared to most land covers, although it has a lower spatial uniformity compared to the Ivanpah and Lunar Lake sites. The surface composition is comparable to those of Ivanpah and Lunar Lake; however, all three sites suffer from the presence of iron absorption (Fe3+) in the visible part of the spectrum, characteristic of plays in this region of the US. Google Earth: Slightly patchy (in colour and intensity) across the plays.
Support Data:	Strong linear road features and oil drilling structures (no lat/long. available)
Suitability:	Recommended for 15m GSD and larger, VisibleUV to SWIR, Solar reflective and emissive, sub-meter to 2km GSD
Limitations:	Soft surface composition, spatial and spectral variation, possible hot spot effects, periodic snow and water, cloud cover increases in winter, remote location for ground-based studies


Railroad Valley Playa

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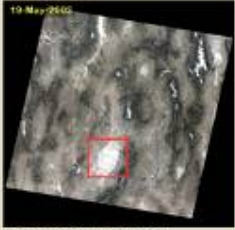
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19 May 2003



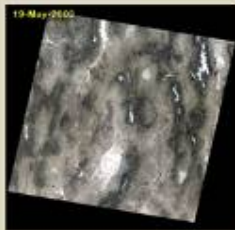
ETM+ Bands 321 Zoomed

19 May 2003




ETM+ Bands 321 Site Parameters

19 May 2003




ETM+ Bands 321

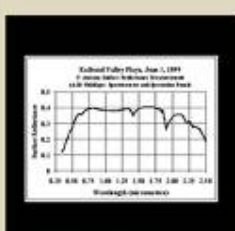
Google Earth Zoomed



Ground Picture 1



Ground Picture 2



Railroad Valley Reflectance

On-line Catalogue Example: Libya 4, Africa

Site Location: Libya 4

Radiometric



Location (City, State, Country):	Libya, Africa
Altitude above sea level (meters):	118
Center Latitude, Longitude (Degrees):	+28.55, +23.39
Landsat WRS-2 Path/Row:	181/40
Size of Usable Area (km):	75x75
Owner:	Unavailable
Researcher:	Henry Patrice Email Researcher



[Download L7 ETM+ GeoTiff Data](#)
[Download Google Earth KMZ File](#)

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Purpose:	TBD
Description:	South-west quadrant of Landsat WRS-2 181/40. Used by CNES (100x100 km) - smaller area would be better. Google Earth: Dunes at multiple scales, but large usable areas of 75 km x 75 km or more, especially north-west of centre coordinates. The surface varies slightly in intensity and colour across the area.
Support Data:	TBD
Suitability:	TBD
Limitations:	TBD

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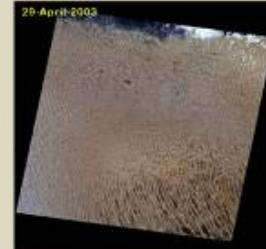
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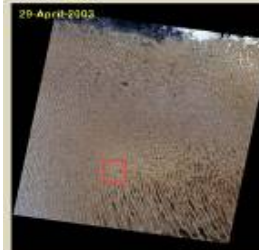
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ETM+ Bands 321 Zoomed



ETM+ Bands 321



ETM+ Bands 321 Site Parameters



Google Earth Ground Picture

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On-line Catalogue Example: Dunhuang, Asia


Site Location: Dunhuang Choose A Radiometric Site


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Location (City, State, Country):	Dunhuang, Gobi Desert, Gansu Province, China, Asia
Altitude above sea level (meters):	1220
Center Latitude, Longitude (Degrees):	+40.13, +94.34
Landsat WRS-2 Path/Row:	137 / 32
Size of Usable Area (km):	25 x 25
Owner:	Unavailable
Researcher:	Unavailable

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15-Oct-2002




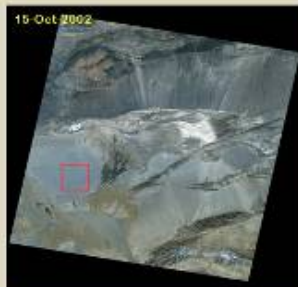

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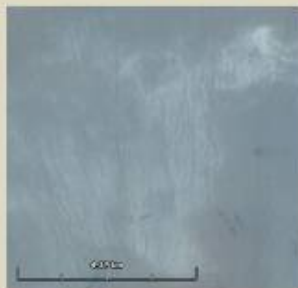
Purpose:	TBD
Description:	Located in the Gobi desert in north-west China, about 35 km west of the city of Dunhuang (Gansu Province). The calibration area is situated on a stabilised alluvial fan. The area used for vicarious calibration measurements is approximately 400 m x 400 m in the centre of the fan and the surface comprises cemented gravels, with no vegetation. Sources of meteorological data for the site include the Dunhuang PAM automated weather station, which is part of the Asian Automatic Weather Station Network. Atmospheric aerosols over the site are typical of a rural continental location, although some larger particles were observed, possibly influx from the sand dunes to the north-west. Sandstorms affect the site on around 8 days per annum and atmospheric dust is a significant factor on around 60 days per annum. (Source: Network for Calibration and Validation of Earth Observation (NCAVEO) web site. http://www.ncaveo.ac.uk/calibration/radiometry/in-flight/dunhuang). AERONET site. Google Earth: Looks very uniform in intensity and colour, especially in Google Maps satellite imagery, which shows more detail.
Support Data:	TBD
Suitability:	TBD
Limitations:	TBD

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15-Oct-2002 15 Oct 2002 Choose A Geometry Site


ETM+ Bands 321 Zoomed **ETM+ Bands 321 Site Parameters**

ETM+ Bands 321 **Google Earth Zoomed**

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Acronyms

ELM	Bureau of Land Management
CEOS	Committee on Earth Observation Satellites
CNES	Centre National d'Etudes spatiales (French)
DOI	Department of Interior
DOQQ	Digital Orthorectified Quarter Quad
EROS	Earth Resources Observation and Science
ETM+	Enhanced Thematic Mapper Plus
G	Geometric Site
GEOSS	Global Earth Observation System of Systems
L7	Landsat 7
NASA	National Aeronautics And Space Administration
NIR	Near Infrared
R	Radiometric Site
SAIC	Science Application International Corporation
SWIR	Short Wave Infrared
TBD	To Be Determined
USGS	United States Geological Survey
VNIR	Visible to Near Infrared
WGCV	Working Group for Calibration and Validation
WRS	Worldwide Reference System

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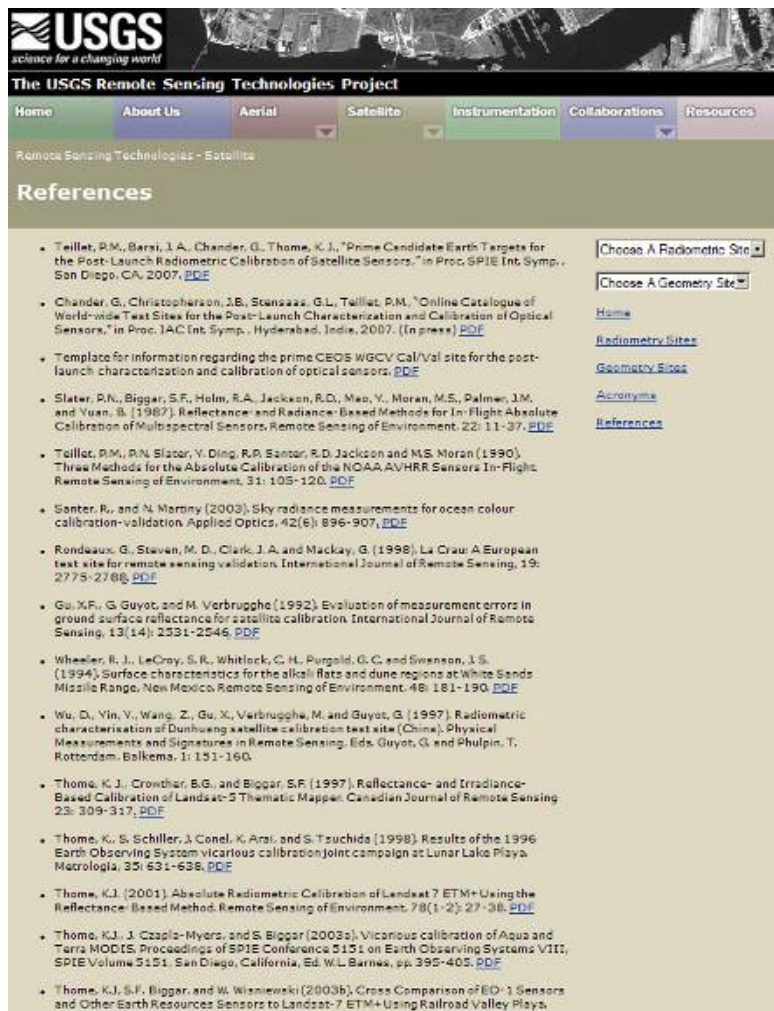
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