USGS Report to the CEOS WGCV 36

May 13 – 17, 2013

Shanghai, China

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U.S. Department of the Interior

U.S. Geological Survey

LDCM Successful Lunch!

Contributors:

The slides in this presentation include contributions from a number of individuals in various organizations

- USGS/EROS LDCM Project
- NASA/GSFC LDCM Project
- Ball Aerospace & Technologies Corp (BATC, OLI builder)
- Orbital Sciences (LDCM spacecraft builder)
- …..

T-10 LDCM Launch Video

LDCM Launch Highlight Video Courtesy of ULA - http://www.ulalaunch.com/site/pages/News.shtml#/129/

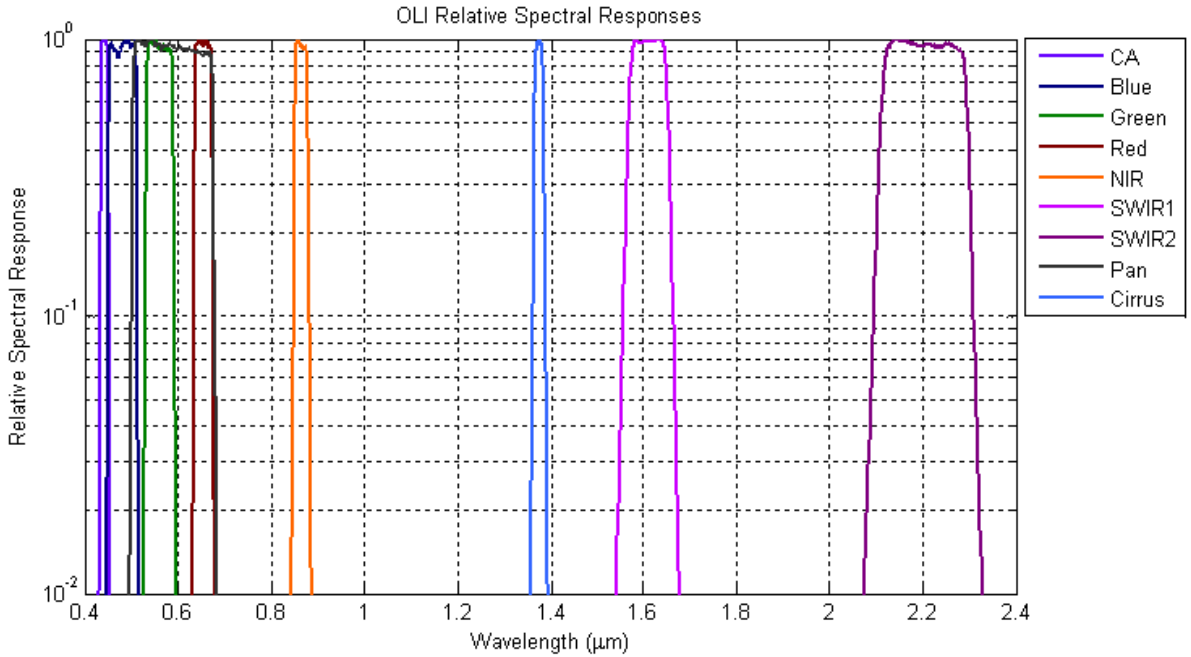
LDCM Spectral Bands

Landsat-7 Bands			LDCM Band Requirements			
			30 m Coastal/Aerosol	0.433 - 0.453	**(2)**	**Band 1**
Band 1	**30 m Blue**	0.450 - 0.515	**30 m Blue**	0.450 - 0.515		**Band 2**
Band 2	**30 m Green**	0.525 - 0.605	**30 m Green**	0.525 - 0.600		**Band 3**
Band 3	**30 m Red**	0.630 - 0.690	**30 m Red**	0.630 - 0.680		**Band 4**
Band 4	**30 m Near-IR**	0.775 - 0.900	**30 m Near-IR**	0.845 - 0.885	**(3)**	**Band 5**
Band 5	**30 m SWIR-1**	1.550 - 1.750	**30 m SWIR-1**	1.560 - 1.660	**(3)**	**Band 6**
Band 6	**60 m LWIR**	10.00 - 12.50	**120 m Thermal 1**	10.30 – 11.30	**(5)**	**Band 10**
			120 m Thermal 2	11.50 – 12.50	**(5)**	**Band 11**
Band 7	**30 m SWIR-2**	2.090 - 2.350	**30 m SWIR-2**	2.100 - 2.300	**(3)**	**Band 7**
Band 8	**15 m Pan**	0.520 - 0.900	**15 m Pan**	0.500 - 0.680	**(4)**	**Band 8**
			30 m Cirrus	1.360 - 1.390	**(1)**	**Band 9**

Explanation of Differences

1) Cirrus Band added in 2001 to detect cirrus contamination in other channels
2) Coastal Band added in 2001 at request of ocean color investigators requiring higher resolution of coastal waters relative to MODIS and SEAWifs
3) Bandwidth refinements made in all bands to avoid atmospheric absorption features
4) Panchromatic band narrowed to avoid crossing vegetation reflectance transition
5) Split-Window for atmospheric correction, actual pixel size ~100 meters

OLI Spectral Performance



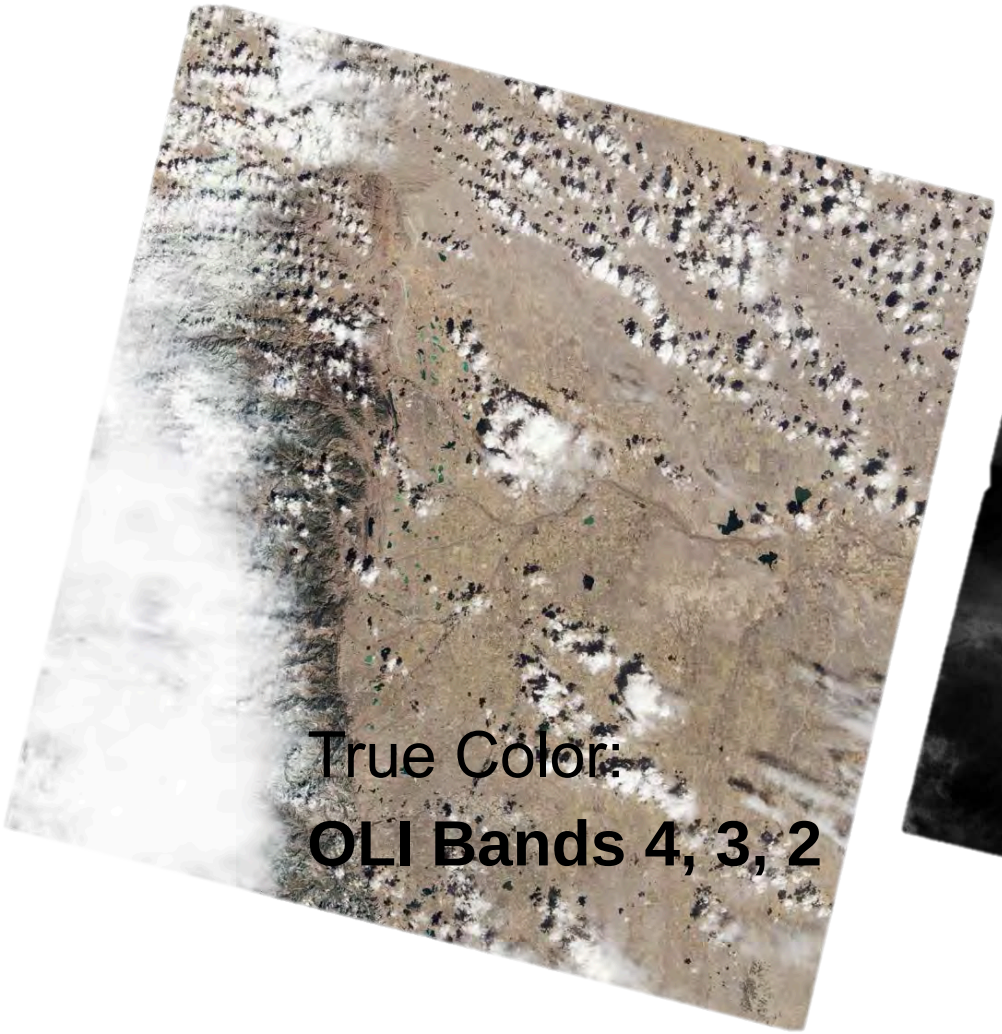
- **Spectral Performance**
  - Relative Spectral Responses have desired sharp bandpasses
  - Out-of-Band Response typically below 10^{-4}
  - **Only 4 pixels** have anomalous response (high Out-of-Band response in red)
  - Uniformity very good

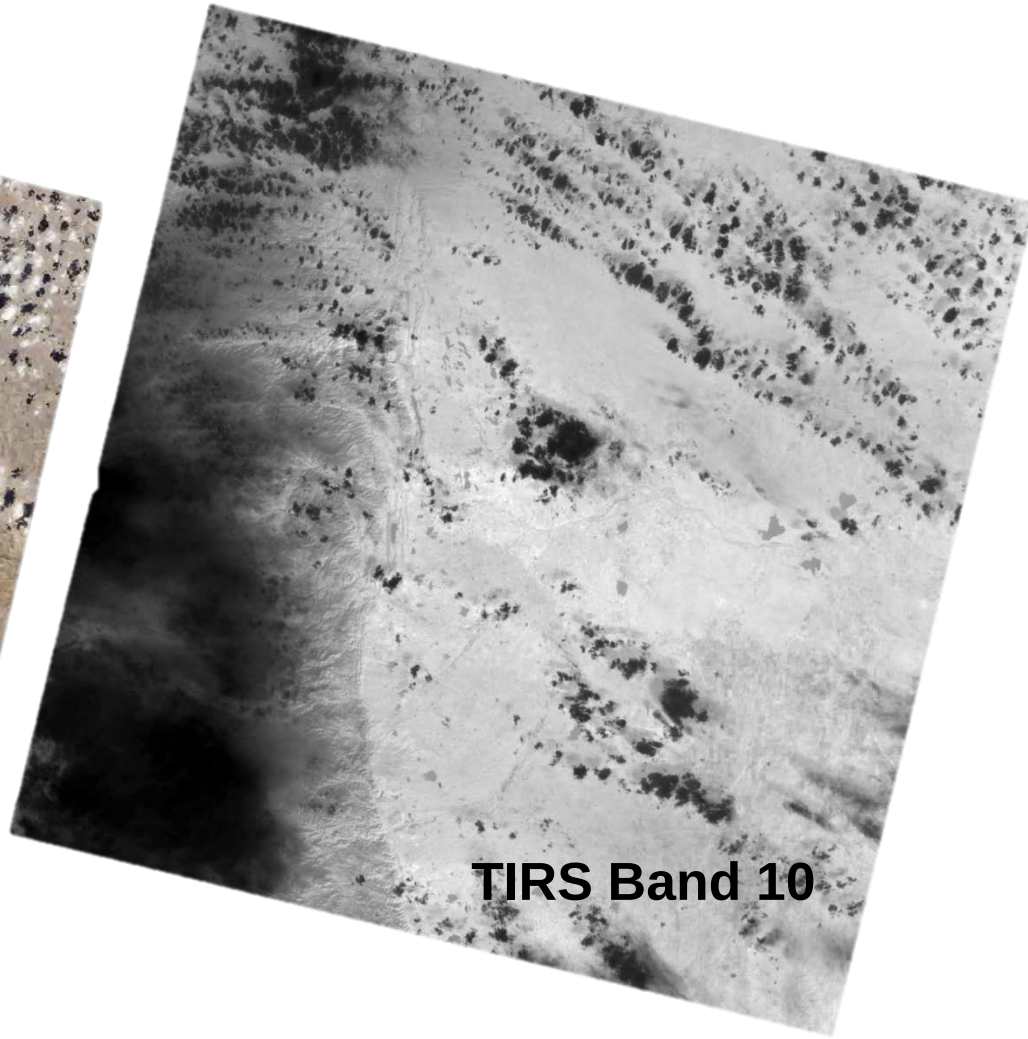
From BATC

LDCM Science Improvements

- **More image data –**
  - 40 year record is extended to 45-50 years, or more
  - 60% more coverage – 400 scenes/day vs. 250 scenes/day with L7
  - 100% of data collected goes to the US archive each day vs. ~40% with L7
- **Better image data – provides greater sensitivity to detect changes in surface properties**
  - 5x improvement in signal to noise ratios (SNR)
  - 12 bit quantization (256 vs 4096)
  - Improved cartographic accuracy due to advanced L8 geo-location capabilities
- **New measurements – and new applications**
  - Coastal aerosol band (0.433–0.453 μm) – detection of water column constituents (e.g., chlorophyll, suspended materials)
  - Cirrus band (1.360–1.390 μm) – improves overall image quality because of better cloud screening
  - Additional thermal band – improves accuracy and precision of temperature measurements

March 18 – First day of Simultaneous OLI & TIRS Earth imaging





USGS

Path 33 / Row 32

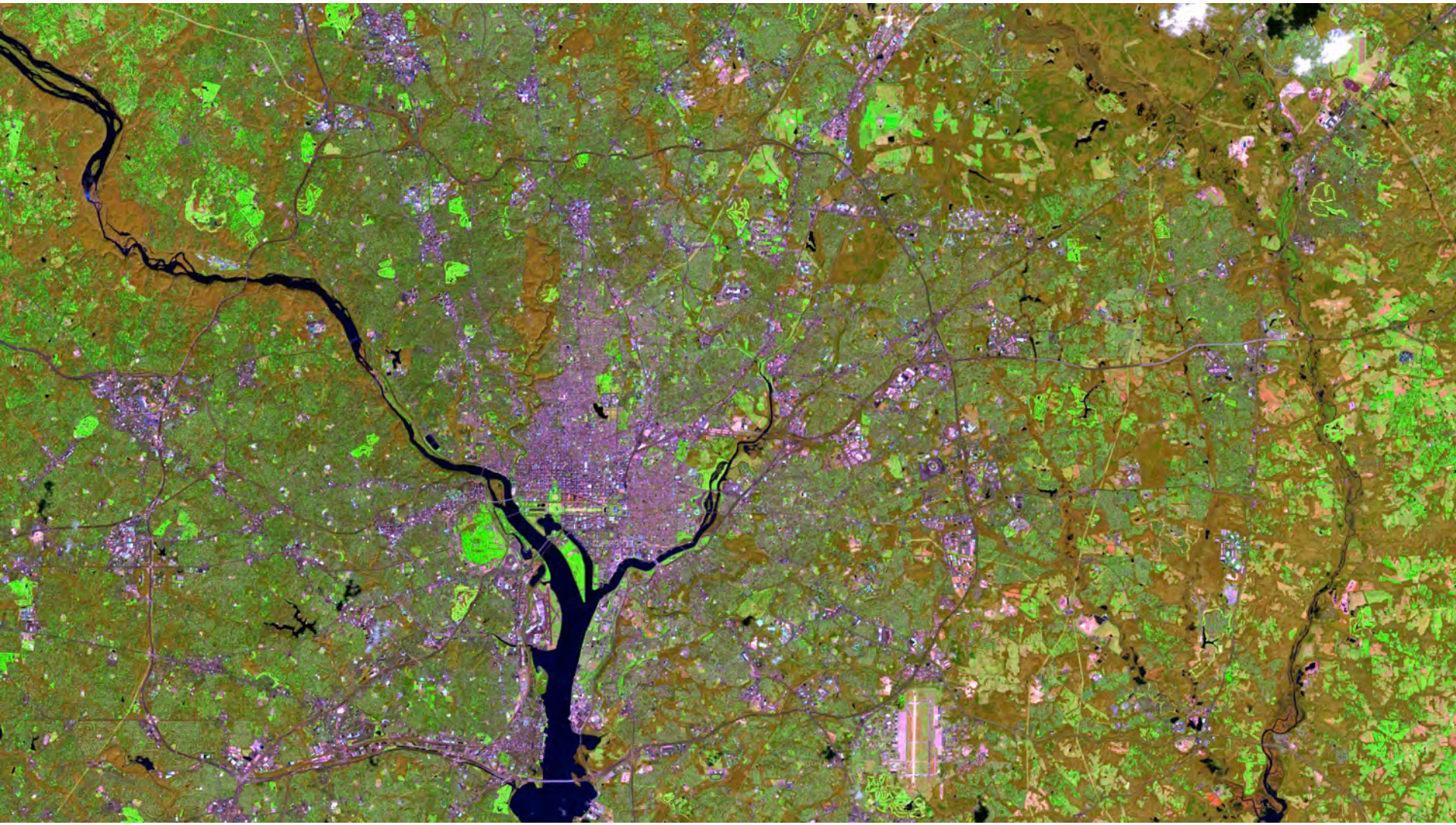
Front Range of the Rockies in CO & WY

Boulder, CO: March 18, 2013

USGS

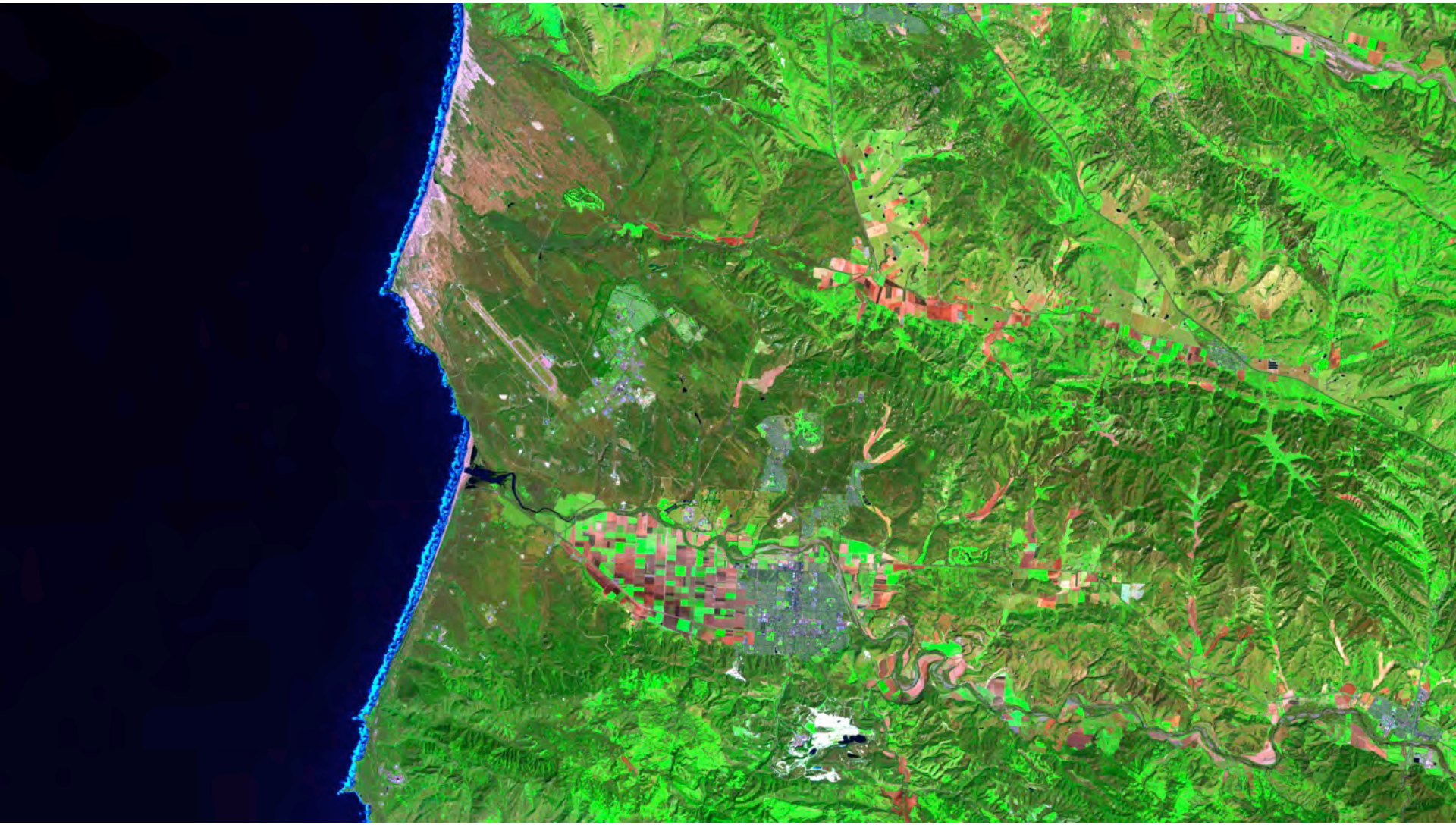
http://landsat.usgs.gov/

LDCM of Greenbelt/D.C. Area

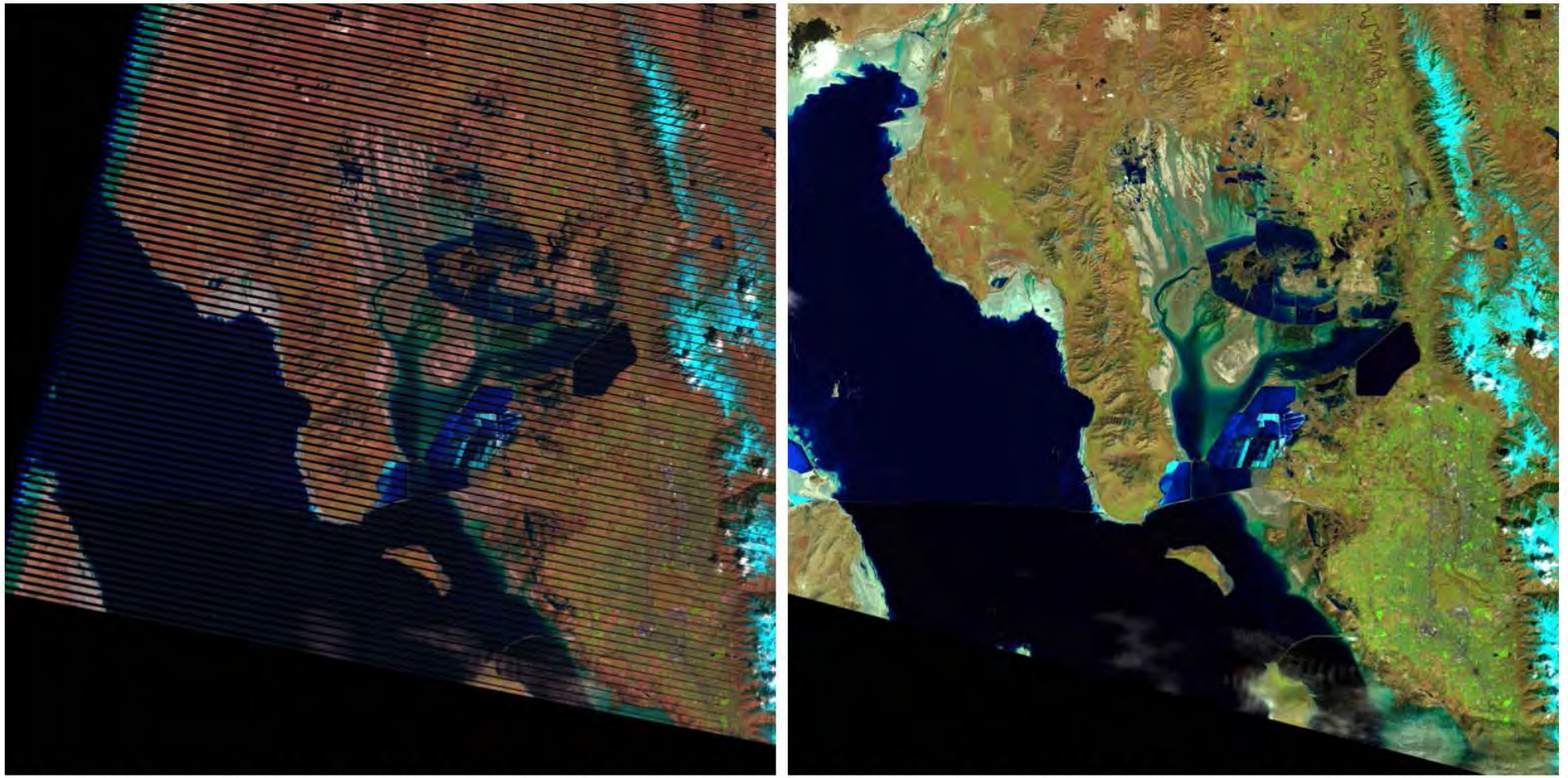


USGS

LDCM of Vandenberg Air force Base



Underfly of Landsat 7 – March 29, 2013



These images show a portion of the Great Salt Lake, Utah as seen by Landsat 7 (left), and LDCM/ Landsat 8 satellites (right). Both images were acquired on March 29, 2013.

http://landsat.usgs.gov/LDCM_Underfly_with_Landsat_7.php

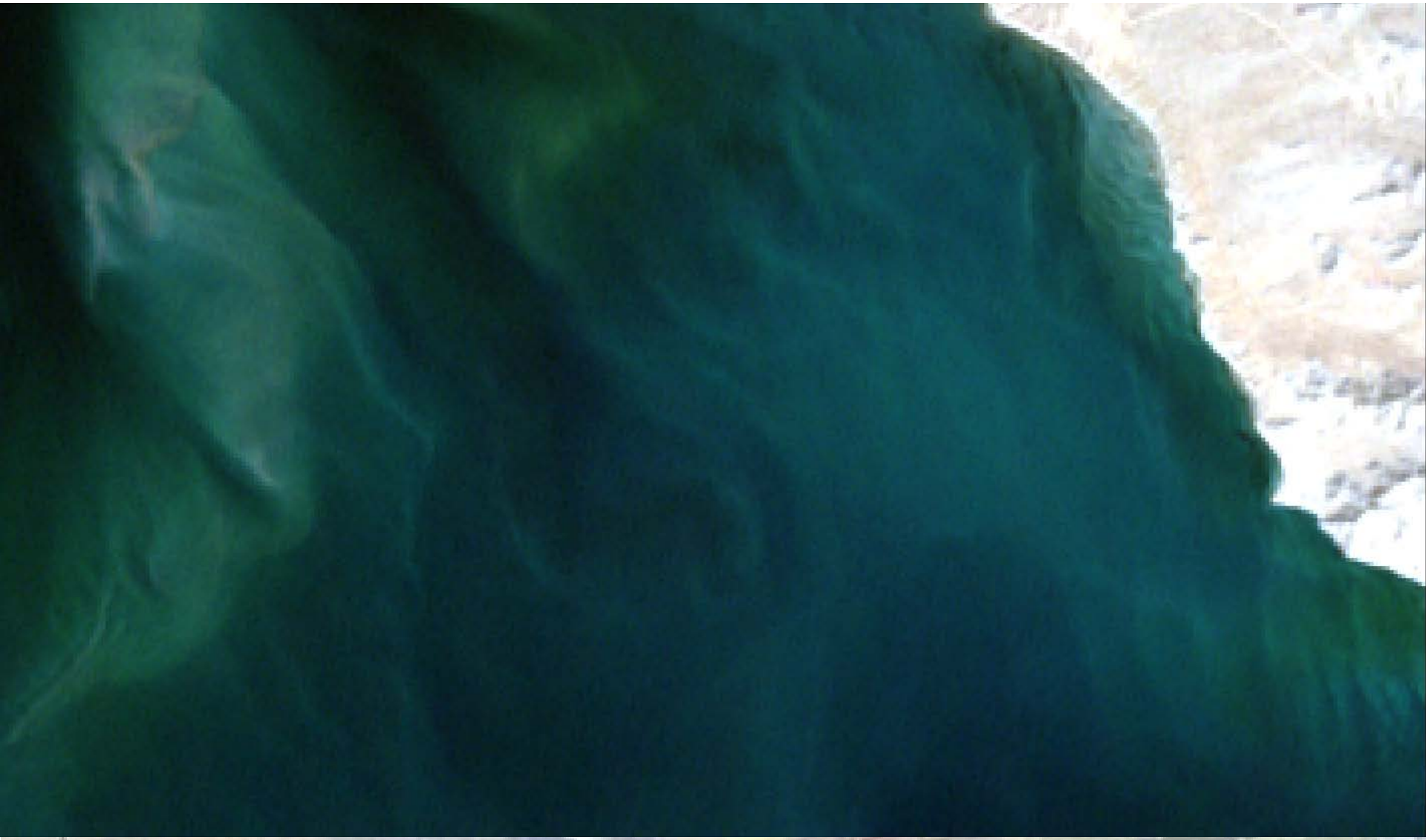
Tandem Collection (LDCM and L7)

- **Tandem collections of western US by OLI and ETM+ allowed for cross-comparison of the two**
- **Joint campaign between Univ. of Arizona and GSFC**
  - Jeff Czapla-Myers lead UofA investigator with help from Nik Anderson
  - Joel McCorkel lead GSFC investigator with help from Jason Hair, Don Jennings, and Kurt Thome
- **Test sites collected were Ivanpah and Railroad Valley**
- **Reflectance-based approach used by both groups**
  - Field spectrometer measurements referenced to white panel
  - Atmospheric measurements for atmospheric correction

Ground Field Campaign

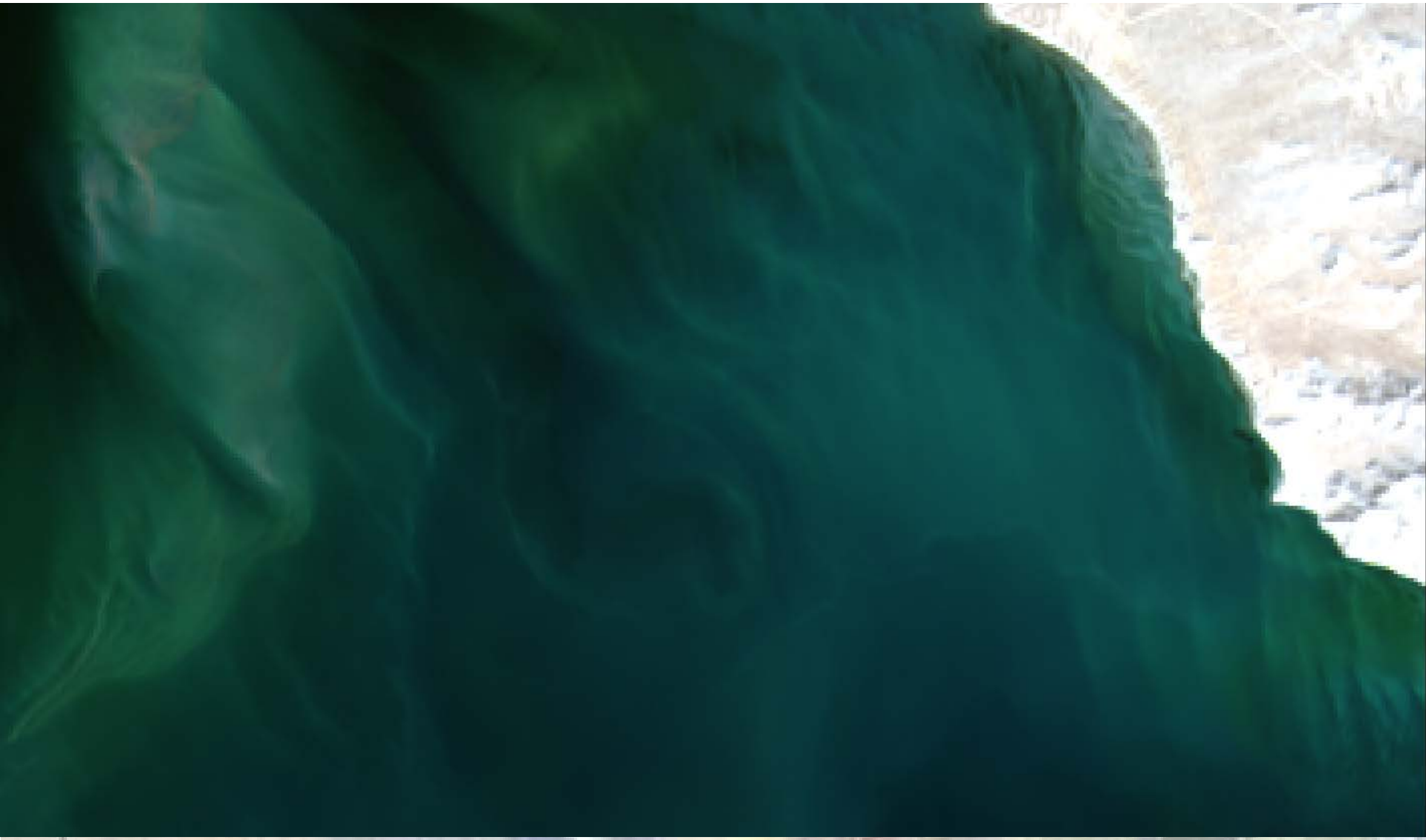
Atmospheric measurements collected coincident with sensor overpasses

L7 ETM+ Natural Color (3,2,1)



From Pat Scaramuzza, EROS

LDCM OLI Natural Color (4,3,2)



From Pat Scaramuzza, EROS

L7 ETM+ Natural Color

From Pat Scaramuzza, EROS

LDCM OLI Natural Color

From Pat Scaramuzza, EROS

First OLI Lunar Images
Pan Band

From Lawrence Ong

LDCM Standard Level-1T Products

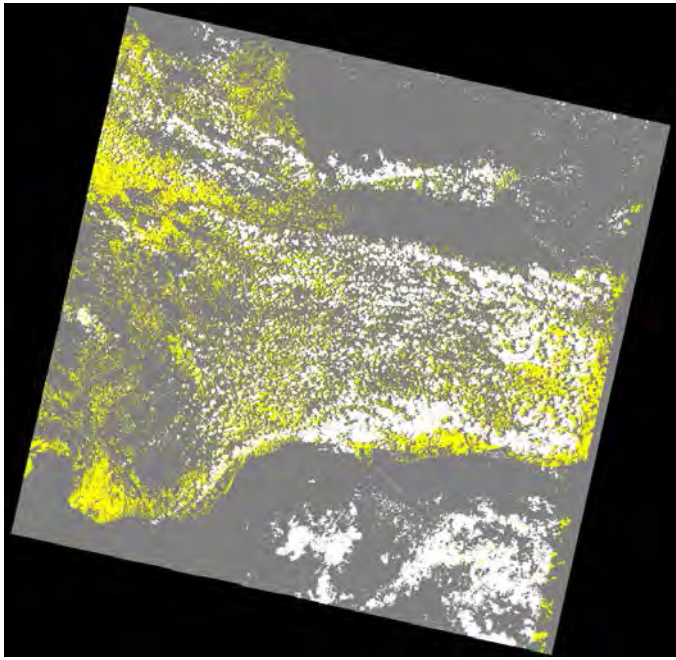
- LDCM standard Level-1 data products will be consistent with heritage Landsat product specifications.
- OLI and TIRS data will be co-registered via a ground control library to provide a common geodetic reference base and distributed as a combined product
- Browse imagery (full- and reduced-resolution) is generated from Level 1 data
- Metadata will include gain and offsets to convert OLI and TIRS data to at-sensor radiance, and to convert OLI data to at-sensor reflectance

Pixel size:	15m/30m/30m
Media type:	FTP
Product type:	Level-1T (precision, terrain correction)
Output format:	GeoTIFF
Map projection:	UTM (Polar Stereographic for Antarctica)
Datum:	WGS84
Orientation:	North up
Resampling:	Cubic convolution
Accuracy:	OLI 12m circular error, 90% confidence
	TIRS 41m circular error, 90% confidence

Quality Assessment Band A file that contains quality statistics from the image data and cloud mask for the scene

Bit	Description	Bit	Description
0	Designated Fill	8	Vegetation Confidence
1	Dropped Frame	9	
2	Terrain Occlusion	10	Snow/Ice Confidence
3	Artifact (Reserved)	11	
4	Water Confidence	12	Cirrus Confidence
5		13	
6	Cloud Shadow (reserved)	14	Cloud Confidence
7		15	

Bit	Description
0	Designated
1	Dropped Frame
2	Terrain Occlusion
3	Water**
4	Vegetation**
5	Snow/Ice**
6	Cirrus**
7	Cloud**



Quality Assessment Band (8-bit)

- 16-bit QB rolls off of the Online Cache with the L1 Product
- 8-bit QB available with the Full Resolution Browse

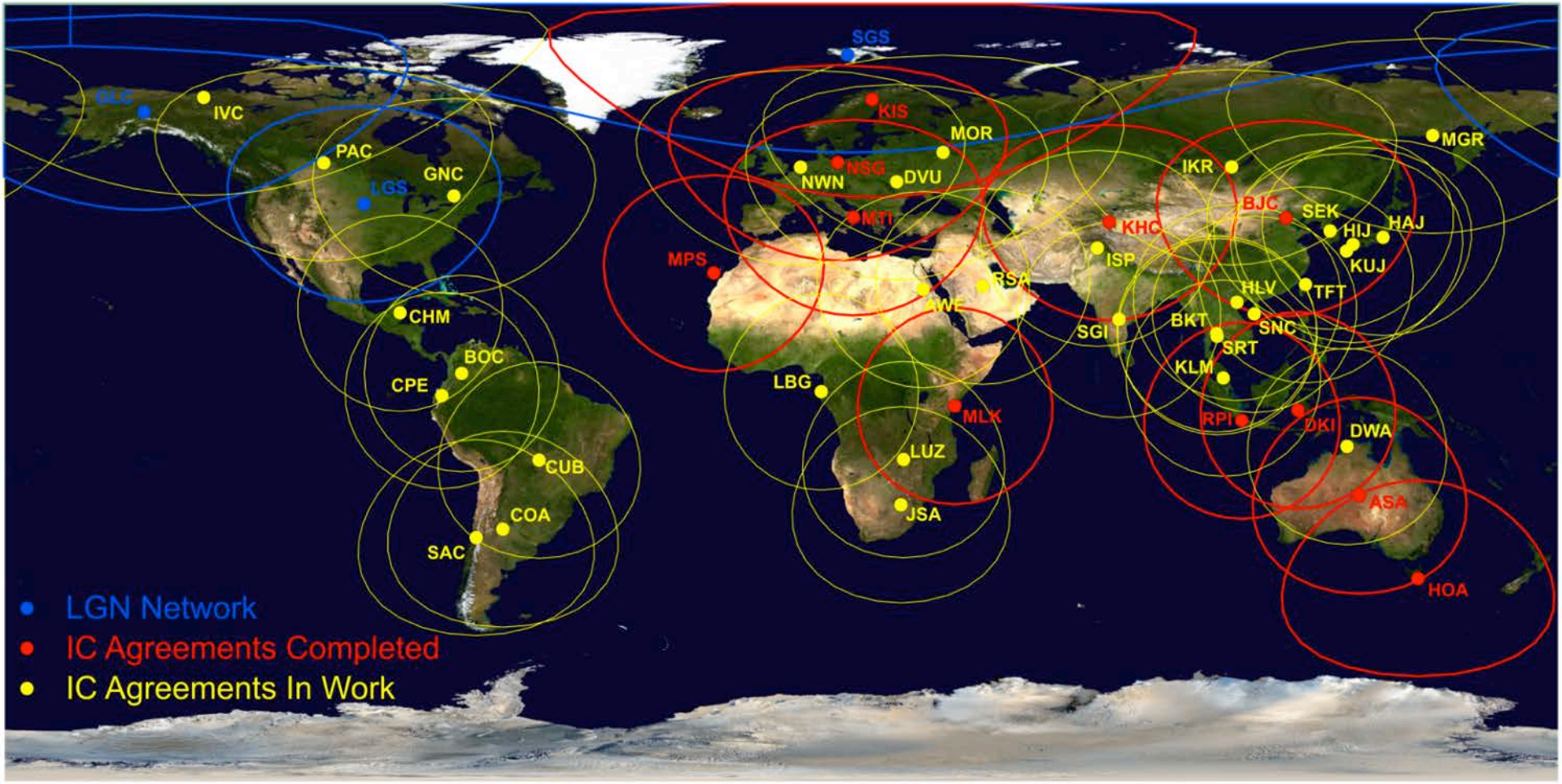
At-launch bits

**- Set for highest Confidence Level (11)

Confidence Levels
00 = none or unset
01 = 0-33% confidence
10 = 34-66% confidence
11 = 67-100% confidence

- The QB looks like any other band file and is a 16-bit image with the same dimensions as the L1T scene.
- The bits are assigned to various processing artifacts that are identified in the L1 processing.

Potential LDCM International Cooperators



LDCM Milestones

http://landsat.usgs.gov/

http://www.nasa.gov/landsat

• **LDCM Launch**	**February 11**
• **First Light Images**	**March 18**
• **Underfly of Landsat 7**	**March 29-30**
• **LDCM on WRS-2**	**April 14**
• **On-orbit Acceptance Review @ GSFC**	**May 14**
• **Post-Launch Assessment Review @ EROS**	**May 29**
• **Mission Transition Review @ EROS**	**May 30**
◆ LDCM renamed Landsat 8	
• **Full Release of Landsat 8 Data Products!**	**May 30**

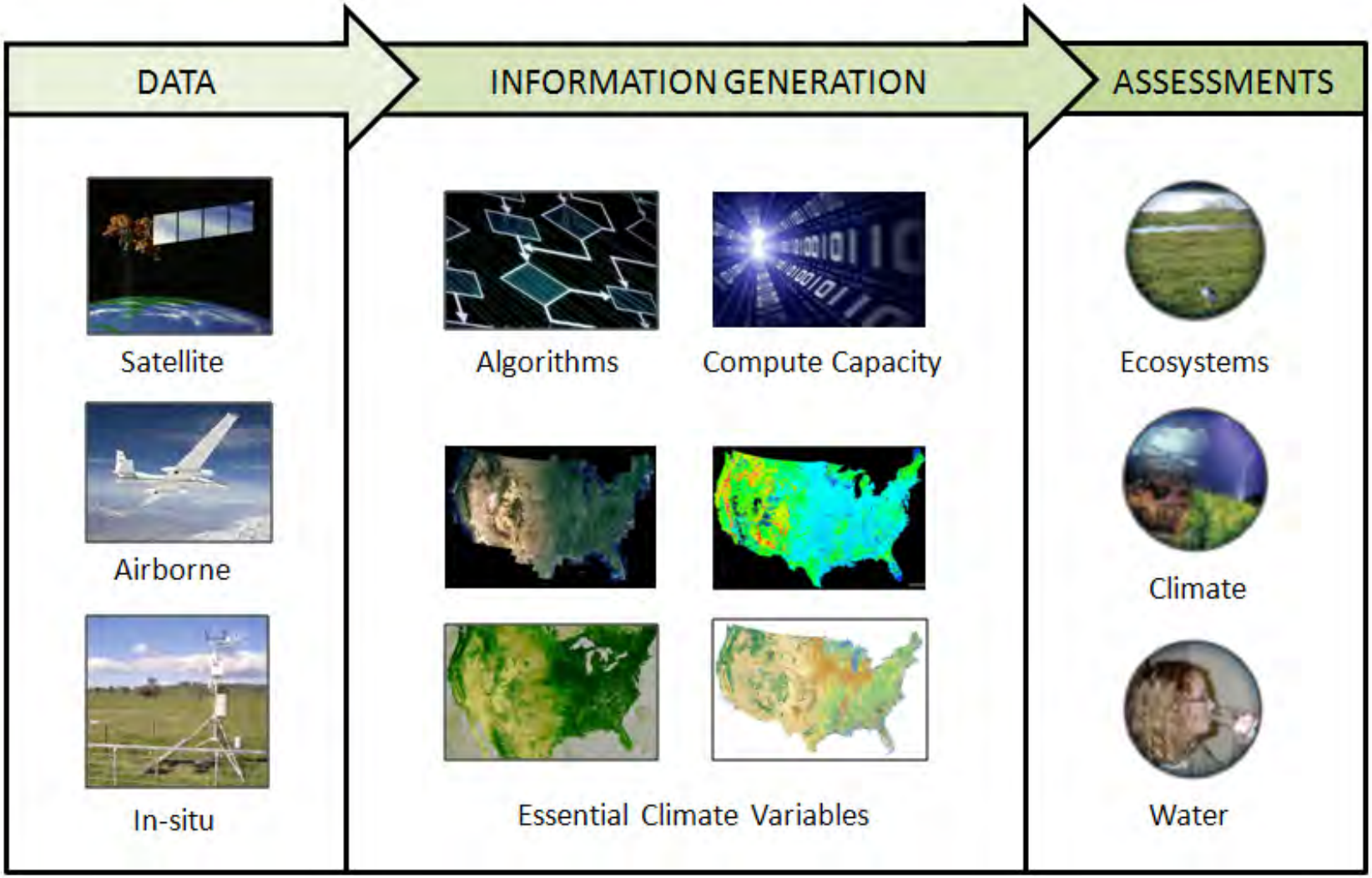
LDCM Summary

- **Successful Launch!**
- The sample data is now available: http://landsat.usgs.gov/
- All the LDCM data will be released on May 30, 2013
- Standard Level-1T products will be spatially and geometrically consistent with historical Landsat data
- In-flight performance monitoring will ensure maintenance of instrument calibration
- Sign-up for the Landsat newsletter to get timely information and updates http://landsat.usgs.gov/about_Landsat_Updates.php

Global Climate Observing System

Domain	Subdomain	Essential Climate Variable
Atmospheric (over land, sea and ice)	Surface	Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed/direction, Water vapour
	Upper Air	Earth radiation budget, Upper-air temperature, Wind speed and direction, Water vapour, Cloud properties.
	Composition	Carbon dioxide, Methane, Ozone, Other long-lived long lived greenhouse gases, Aerosol properties
Oceanic	Surface	Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Current, Ocean color, Carbon dioxide partial pressure.
	Subsurface	Temperature, Salinity, Current, Nutrients, Carbon, Ocean tracers, Phytoplankton.
Terrestrial	River discharge, Water use, Ground water, Lakes, Snow cover, Glaciers and ice caps, Permafrost and seasonally-frozen ground, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (fAPAR), Leaf area index (LAI), Above ground biomass, Fire disturbance, Soil moisture, Soil carbon, Ice sheets.	

Conceptual Framework



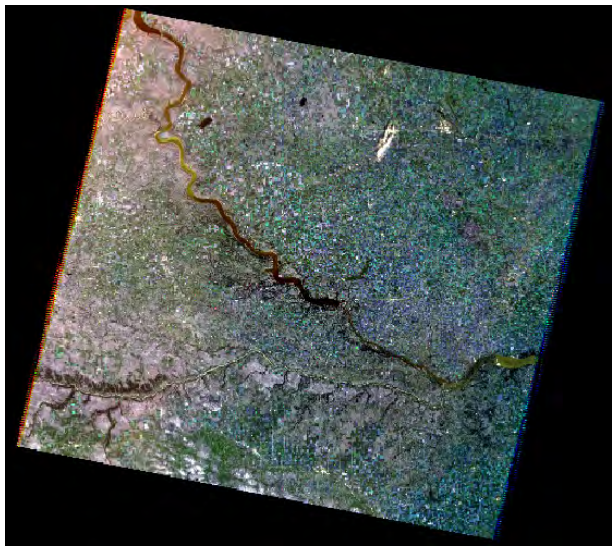
USGS CDR & ECV Development

- **Climate Data Records (CDRs)**
  - Surface Reflectance (NASA GSFC/USGS EROS)
  - Surface Temperature (NASA GSFC/USGS EROS/RIT/JPL)

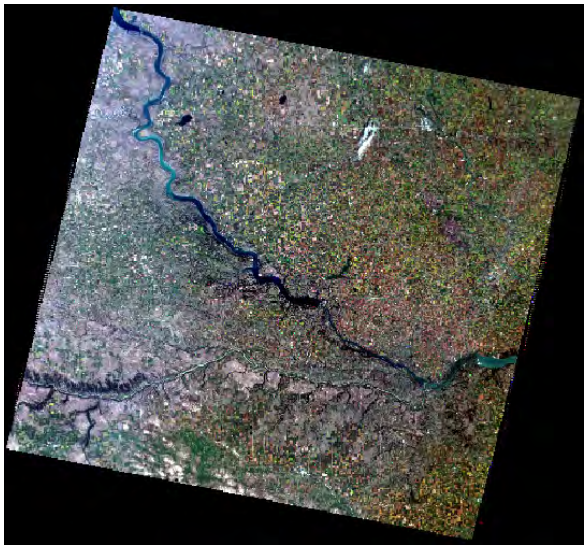
- **Essential Climate Variables (ECVs)**
  - Global 30m Land Cover (Chandra Giri/EROS)
  - Burned Area (Susan Stitt & Todd Hawbaker/GESC)
  - Snow Covered Area (Dave Selkowitz/AGSC)
  - Surface Water Extent (John Jones/EGSC, Mike Starbuck/EROS)
  - Leaf Area Index Validation (Carol Mladinich/GESC)
  - Above Ground Biomass (Dennis Dye/WGSC, Jason Stoker/EROS)

Prescriptive Levels of Processing

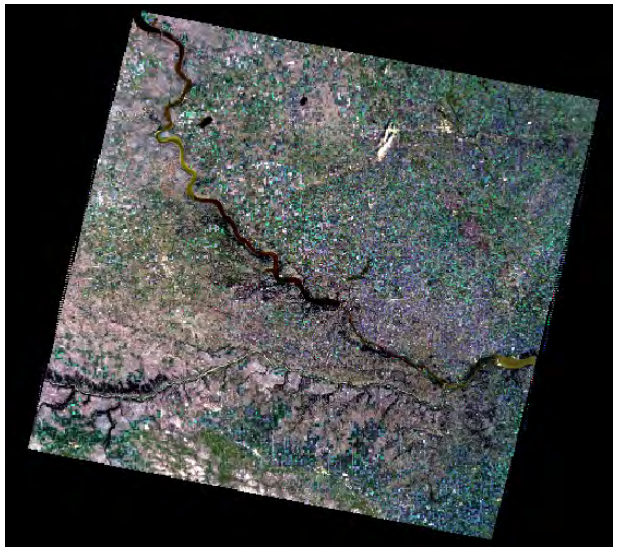
Provide users with the product most suitable to their needs



Scaled DNs



TOA Reflectance



Surface Reflectance

On-demand surface reflectance products will be available through Earth Explorer

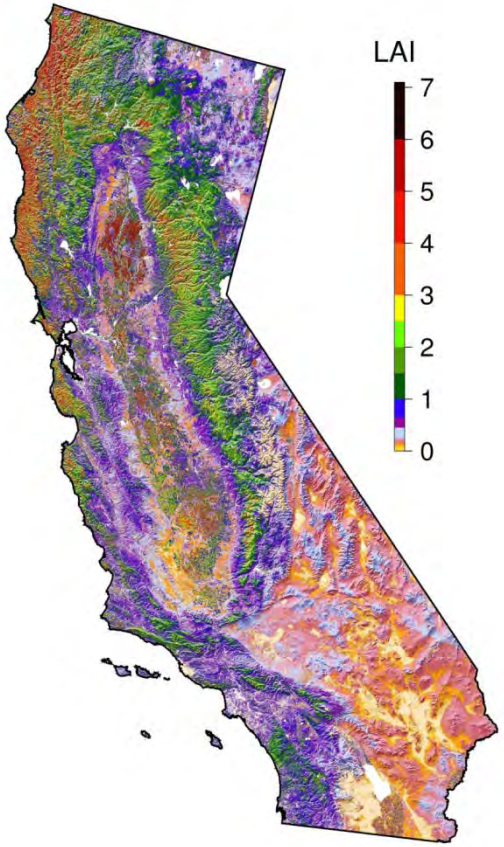
http://earthexplorer.usgs.gov

Moving from Data to Information

L1T At-sensor Radiance (FCDR)

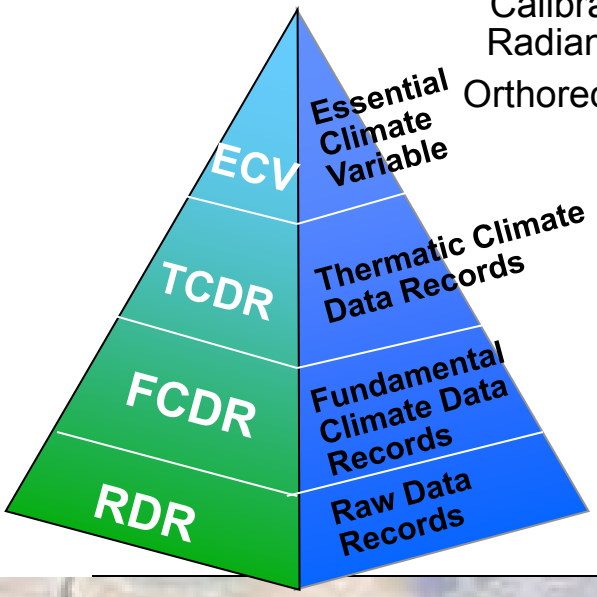
Surface Reflectance (TCDR)

Leaf Area Index (ECV)



(Nemani, NASA)

Operationally Processing Data Into Information



Validation
Evaluation

Raw Sensor Data

Fundamental Climate Data Record

Calibrated Radiances
Orthorectified

Assimilation And Modeling

Radiative transfer modeling
Product-specific algorithms

Thematic Climate Data Record

Surface reflectance
Surface temperature

Essential Climate Variable

Albedo
Land cover
LAI
Surface water
Snow/ice
Fire disturbance

A Land Product Validation System (LPVS) for enhanced data access, retrieval, and analysis of satellite land data products

Kevin Gallo[1], Calli Jenkerson[2], Greg Stensaas[3], Gyanesh Chander[2], John Dwyer[3], and Ryan Longhenry[3]

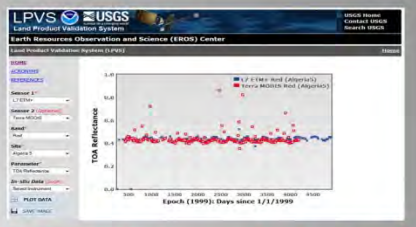
[1]National Oceanic and Atmospheric Administration (NOAA) National Environmental Satellite, Data, and Information Service (NESDIS) visiting scientist at U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD 57198 U.S.A.
[2]Technical Support Services Contract at USGS EROS Center, Sioux Falls, SD 57198 U.S.A.
[3]USGS EROS Center, Sioux Falls, SD 57198 U.S.A.

The National Oceanic and Atmospheric Administration (NOAA) and the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center are collaborating on the development of a Land Product Validation System (LPVS) that will facilitate the application of multi-satellite and in-situ data for characterization and validation of land products (e.g., surface reflectance, normalized difference vegetation index (NDVI), and land surface temperature) derived from satellite sensors. Developed for evaluation of Geostationary Operational Environmental Satellite – R Series (GOES-R) and Joint Polar Satellite System (JPSS) products, LPVS will provide capabilities for cross-comparisons between multiple data sets. Data and products from satellites such as the USGS Landsat 8, the European Space Agency (ESA) Sentinel series of satellites, and other moderate to high spatial resolution sensors, will be added to LPVS when available.

The LPVS includes data inventory, access, and analysis functions that will allow data from multiple archive facilities to be easily identified, retrieved, co-registered, and compared statistically through a single interface. This functionality is evolving through a recently completed prototype phase (September 2012) towards a beta operational phase (September 2013) that will transition to full operations in late 2014.

http://landsat.usgs.gov/LPVS.php

http://lpvsexplorer.cr.usgs.gov/



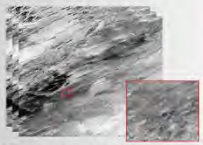
https://calval.cr.usgs.gov/lpvs/ajax.php

INPUT: Multiple Satellite Products

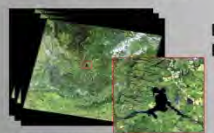
Time Series over Angostura Reservoir near Hot Springs, SD
Southern Black Hills

Terra MODIS

MOD09GA Daily Surface Reflectance
500-meter (m) Sinusoidal Tile h10v04

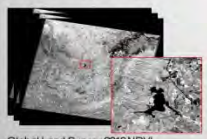


MOD13A1 16-Day NDVI
500-m Sinusoidal Tile h10v04



Landsat ETM+

Global Land Survey 2010 Surface Reflectance
30-m Universal Transverse Mercator (UTM)
Path 33 / Row 30



Global Land Survey 2010 NDVI
30-m UTM
Path 33 / Row 30

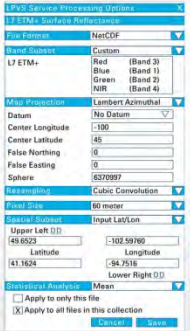
SERVICE PROCESSING OPTIONS

1 File Format
Geotiff
HDF4
HDF5
NetCDF
Binary
ASCII

2 Band Subsets
Specific to Product

3 Map Projection
UTM
Albers
Alaska Albers
Lambert Azimuthal
Geographic

4 Resampling
Nearest Neighbor
Bilinear
Interpolation
Cubic Convolution



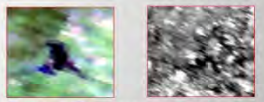
5 Spatial Subset
Input Lat/Lon

6 Pixel Size
30-meter
60-meter
120-meter
250-meter
370-meter
500-meter
740-meter
1000-meter
2000-meter

7 Statistical Analysis
Single Sensor
Multiple Sensors
Single Product
Multiple Products
Mean
Standard Deviation
Maximum
Minimum
Root Mean Square Error

OUTPUT: Processed Products with Statistics

MODIS tile reprojected to Lambert Azimuthal and resampled to 250-m.



MODIS Surface Reflectance (left) and NDVI (right) reprojected, resampled, and subset to area of interest over Angostura Reservoir near Hot Springs, SD (Lambert Azimuthal, 250-m).

Comparative plot of maximum NDVI per year for Landsat Enhanced Thematic Mapper Plus (ETM+) and Terra MODIS.

Landsat Surface Reflectance (left) and NDVI (right) reprojected, resampled, and subset to area of interest over Angostura Reservoir near Hot Springs, SD (Lambert Azimuthal, 250-m).

Landsat ETM+ (x) and Terra MODIS (y) red surface reflectance values plotted for statistical comparison.

The LPVS will serve as a much needed tool for intercomparison of products from multiple satellites, including Landsat and MODIS as represented here, and for GOES-R ABI, JPSS VIIRS, and Landsat 8 Operational Land Imager (OLI) as those data become available. LPVS is planning to add in-situ collections to its inventory as well, further enhancing its capability to provide data stacks and statistics from a single system for comparative analyses. Please visit the Web interfaces mentioned above for additional information and direct access to the LPVS.

Remote Sensing Technologies

understanding the technologies needed to sense our world

Search

Joint Agency Commercial Imagery Evaluation (JACIE)

The growing number of commercial sources for remotely sensed data offers users more choices than ever before. The key to using data from these new sources is understanding their characteristics and capabilities, and the quality of the data they produce.

The Joint Agency Commercial Imagery Evaluation (JACIE) program was formed to leverage Federal agencies' resources for the characterization of commercial remote sensing data and to share those results across the Federal Government and beyond. Consisting of representatives from the U.S. Geological Survey (USGS), the National Aeronautics and Space Administration (NASA), the National Geospatial-Intelligence Agency (NGA), and the U.S. Department of Agriculture (USDA), the JACIE team performs product analysis of commercial and other remote sensing data and information products, providing earth scientists and other users with awareness and independent verification of commercial imagery data quality.

The JACIE team provides independent characterizations of delivered image and image-derived end products. Each team member agency brings their resources and strengths to this task, providing Federal users in-depth assessments of commercial imagery quality. JACIE team efforts have been instrumental in several improvements to commercial image product quality and have enhanced working relationships between government and the commercial remote sensing industry.

Results of JACIE evaluations are presented at the annual JACIE Civil Commercial Imagery Evaluation Workshop.

JACIE Civil Commercial Imagery Evaluation Workshop: http://calval.cr.usgs.gov/jacie/

March 23-27, 2014, Louisville, Kentucky

April 16-18, 2013, St. Louis, Missouri

April 17 – 19, 2012, Fairfax, Virginia

JACIE 2012

Proceedings From Previous JACIE Workshops

- November 8-10, 2004
- March 14-16, 2006
- March 20-22, 2007
- March 25-27, 2008
- March 31 – April 2, 2009
- March 16 – 18, 2010
- March 29 – 31, 2011

RECENT NEWS

- USGS National Test Ranges
- JACIE 2012
- RST Project supports global quality standards for earth observation data
- IEEE TGRS Special Issue on "Inter-Calibration of Satellite Instruments"
- USGS Announces "No USGS Digital Camera Certification Requirement"
- USGS Will Continue to Provide Film Camera Calibration Services
- USGS RST ASPRS 2010 Paper Featured by GISCafe
- Joint Agency Commercial Imagery Evaluation (JACIE) Workshop Agenda
- Successful GSICS Working Group Meeting in Daejeon, South Korea
- 15th Annual NASA LCLUC Science Team Meeting

BROWSE ARCHIVES

January 2012

BROWSE CATEGORIES

- About Us
- Aerial
- Highlights
- JACIE
- News
- Reports
- Satellite

IEEE TRANSACTIONS ON

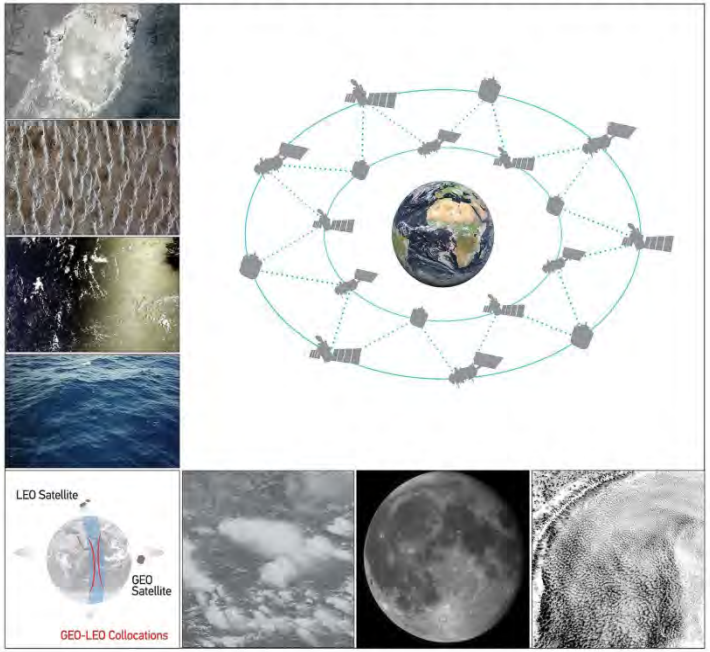
GEOSCIENCE AND REMOTE SENSING

A PUBLICATION OF THE IEEE GEOSCIENCE AND REMOTE SENSING SOCIETY

MARCH 2013 VOLUME 51 NUMBER 3 IGRSD2 (ISSN 0196-2892)

PART I OF TWO PARTS

SPECIAL ISSUE ON INTERCALIBRATION OF SATELLITE INSTRUMENTS



(Top and bottom corner) Symbolic global network of Earth observing satellites connected by intercalibration and schematic illustration of the GEO and polar LEO satellites and distribution of their collocated observations. (Left column and bottom row) Examples of natural targets used as calibration references.

- This special issue focuses on how intercalibration and comparison between sensors can provide an effective and convenient means of verifying their postlaunch performance and correcting their measurement differences

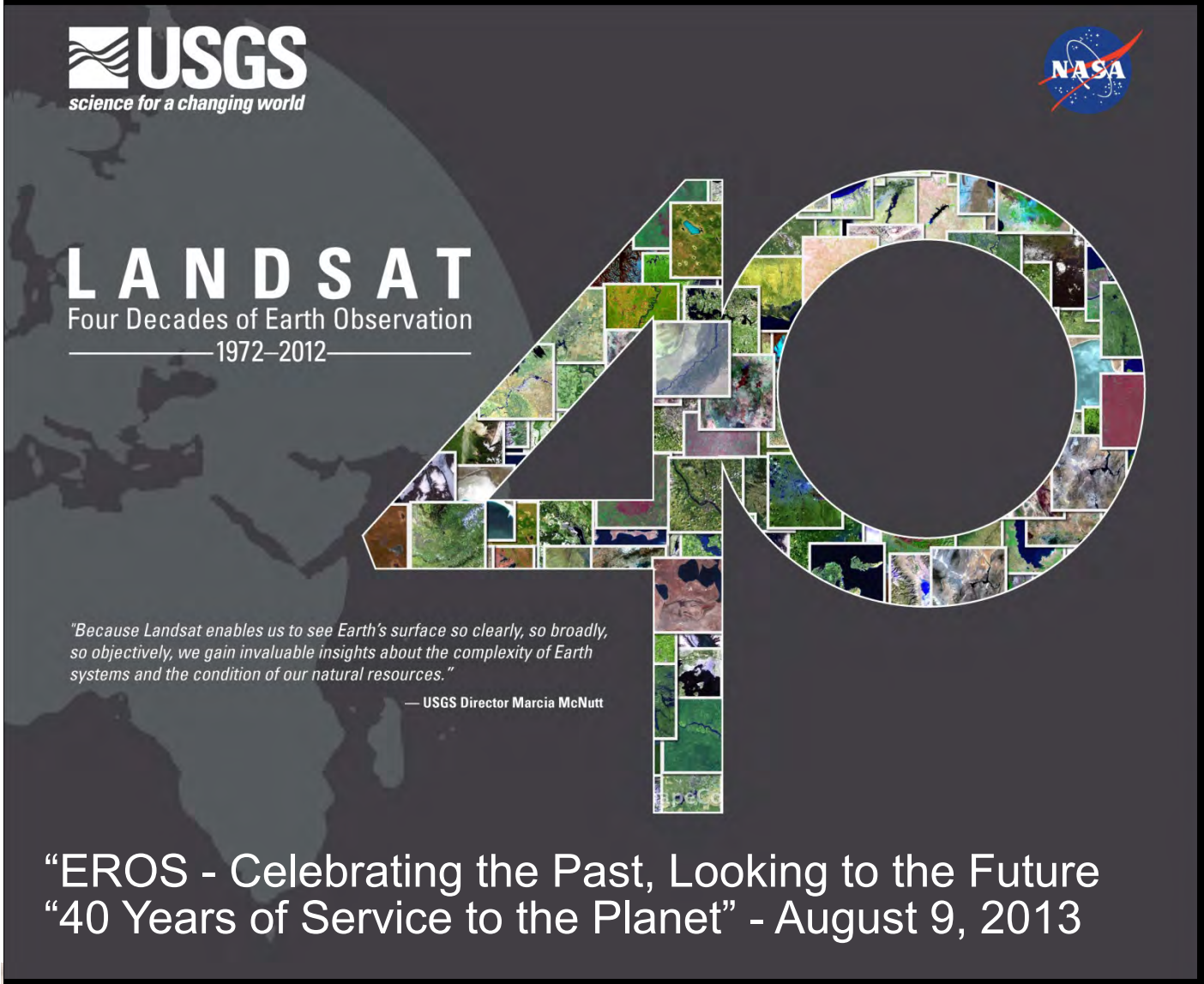
- The papers contained within this special issue include topics that explore PICS, SNO and other ray-matching comparisons, lunar and stellar observations, DCC, LWC, Rayleigh scattering, and sunglint

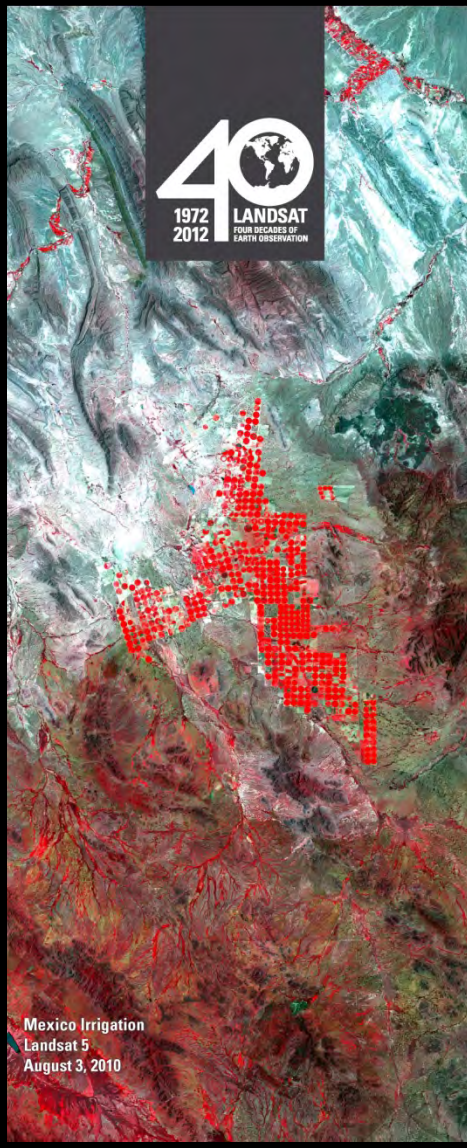
- The goal of this special issue is to capture the state-of-the-art methodologies and results from intercalibration of satellite instruments, including full end-to-end uncertainty analysis

- There are 40 papers published in this issue. You'll see a number of contributions from the GSICS and CEOS community. Several of these are being published with Open Access, so you can download them freely!

- This 500-page special issue will become a reference anthology for the remote sensing community

Available online through the IEEE Xplore website at http://ieeexplore.ieee.org/xpl/tocresult.jsp?isnumber=6469257&punumber=36





"EROS - Celebrating the Past, Looking to the Future
"40 Years of Service to the Planet" - August 9, 2013

Summary & USGS Key Involvement

- **USGS has extensive internal capabilities and leads a number of national and international calibration partnership and activities**
- **Lead a number of GEOSS Quality Assurance Strategy sub-tasks**
- **Continuing Landsat Cross-calibration Activities**
  - On-going Cross-calibration Activities:
    - IRS-P6 AWiFS/LISS-III, CBERS-2/B CCD, ALOS AVNIR-2, UK DMC-1/2, RapidEye Constellation, SPOT, Worldview, MODIS, ALI, THEOS MS sensors
  - Planned Cross-calibration Activities
    - Landsat TM/ETM+ with: LDCM, Sentinel, ENVISAT MERIS, AVHRR MetOP, Cartosat-2, ResourceSat-2, CBERS-3, etc.
- **Landsat archive and open data policy has enabled growth and innovation in use and applications of land remote sensing data**
- **Land Information products are way of the future**
  - Land Product Validation becoming more important
- **Working to establish an operational Landsat program**