USGS Report to the CEOS WGCV 37

February 20, 2014

ESA/ESRIN, Frascati, Italy

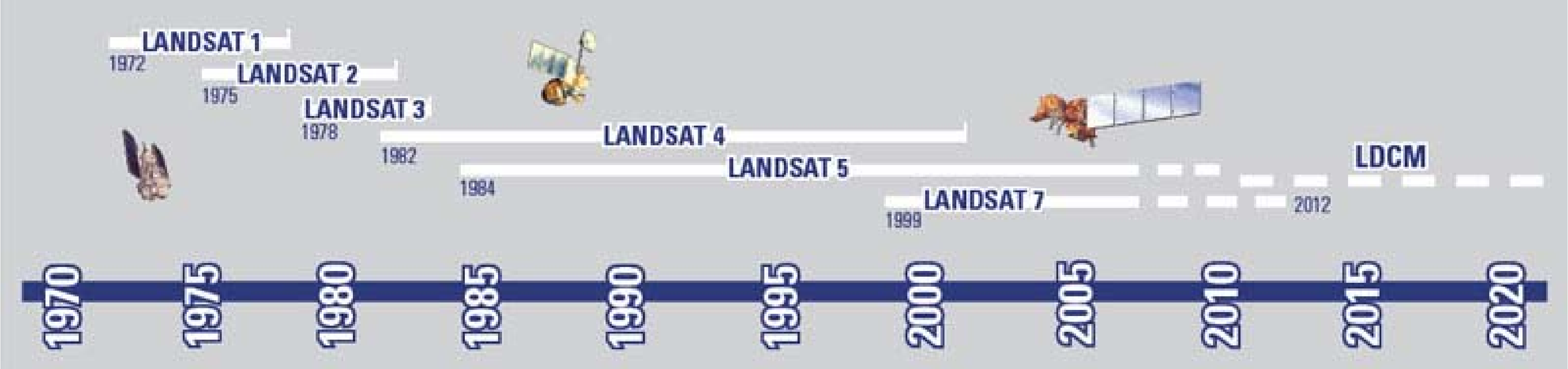
Greg Stensaas – USGS

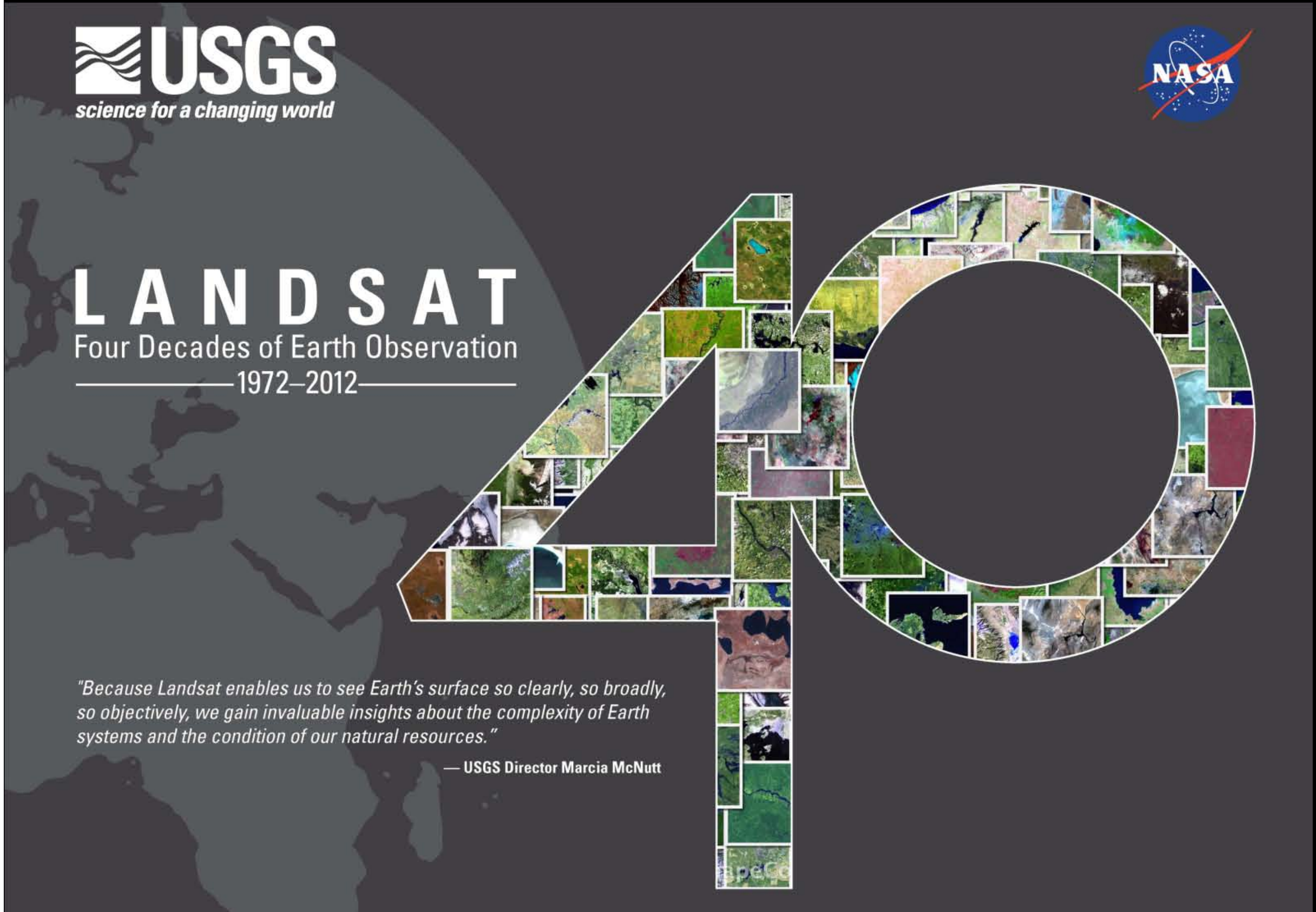
U.S. Department of the Interior

U.S. Geological Survey

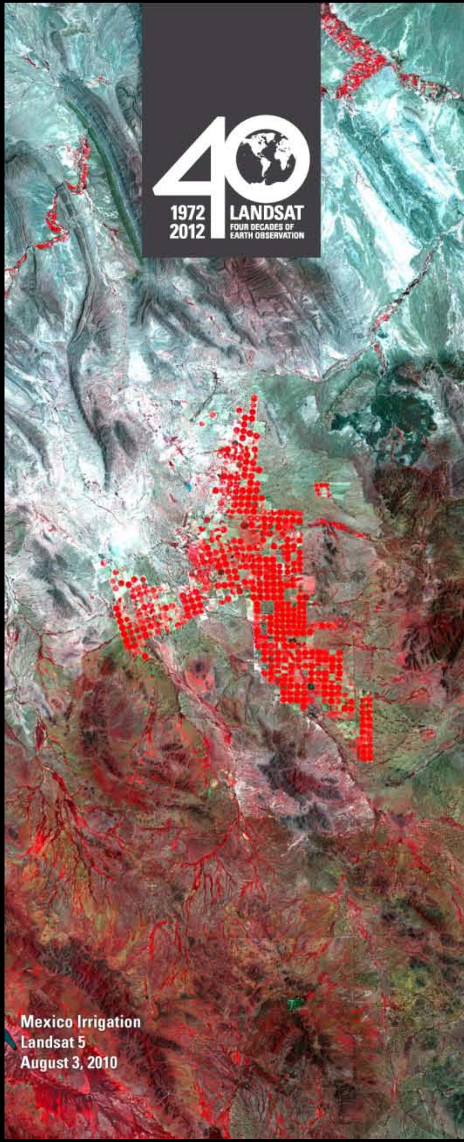
41+ Years of Continuous Landsat Global Land Observation

- **Landsat 1 was launched July 23, 1972 (MSS)**
- **Landsat 2 was launched January 22, 1975 (MSS)**
- **Landsat 3 was launched March 5, 1978 (MSS)**
- **Landsat 4 was launched July 16, 1982 (TM)**
- **Landsat 5 was launched March 1, 1984 (TM)**
- **Landsat 6 was launched October 5, 1993, but never reached orbit**
- **Landsat 7 was launched April 15, 1999, May 2003 SLC-Off (ETM+)**
- **Landsat 8 launched February 10, 2013 (OLI, TIRS)**



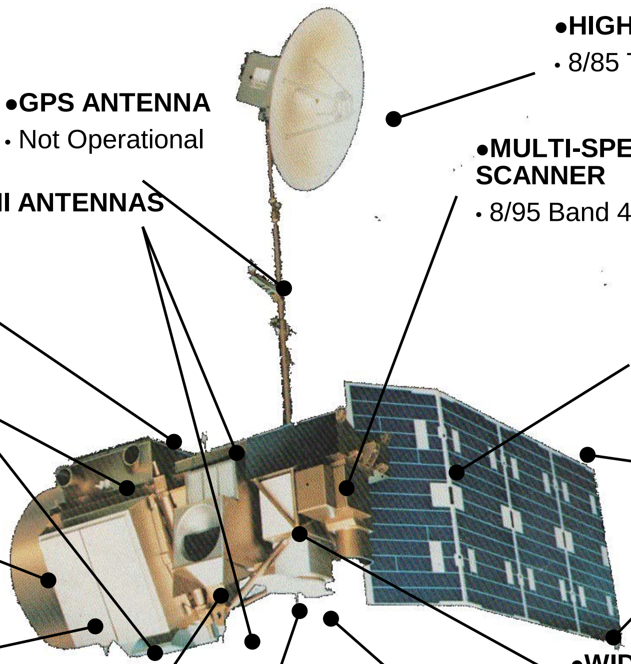


“EROS - Celebrating the Past, Looking to the Future
“40 Years of Service to the Planet” - August 9, 2013



"Hats off" to Landsat 5

≈ 29 years of on-orbit operations – Final command sent to Landsat 5: **June 5, 2013**



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Landsat 7 Spacecraft Status

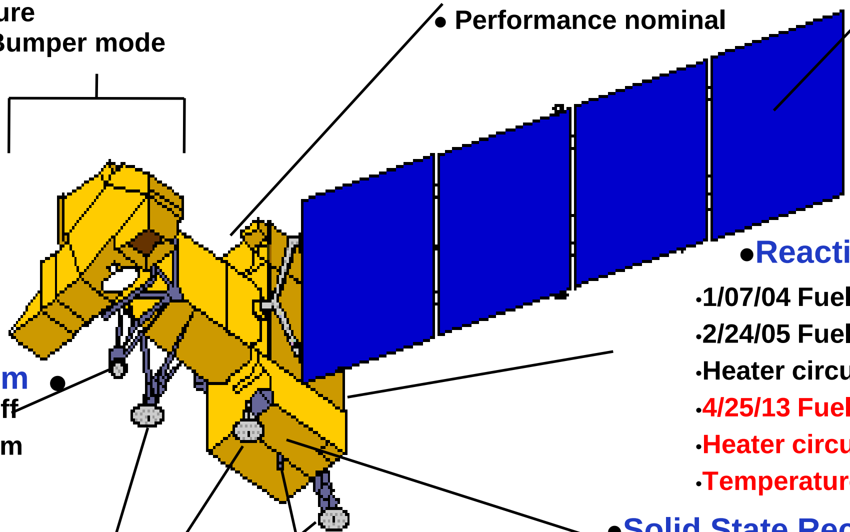
- Launched 15 Apr 1999
- > 14 years of on-orbit operations

Enhanced Thematic Mapper +
- 5/31/2003 SLC Failure
- 4/01/2007 SAM -> Bumper mode

Electrical Power System

Batteries:
- Performance nominal

Solar array:
- 5/14/2002 Circuit #14 Failure
- 5/16/2005 Circuit # 6 Failure
- 8/13/2008 Circuit #14 partial recovery
- 14 circuits remain operating
- no impact to ops



Reaction Control System
- 1/07/04 Fuel line #4 thermostat #1a failure
- 2/24/05 Fuel line #4 thermostat #1b failure; Primary
- Heater circuit disabled
- 4/25/13 Fuel line #2 thermostat 2a failure; Redundant
- Heater circuit disabled
- Temperature manually controlled

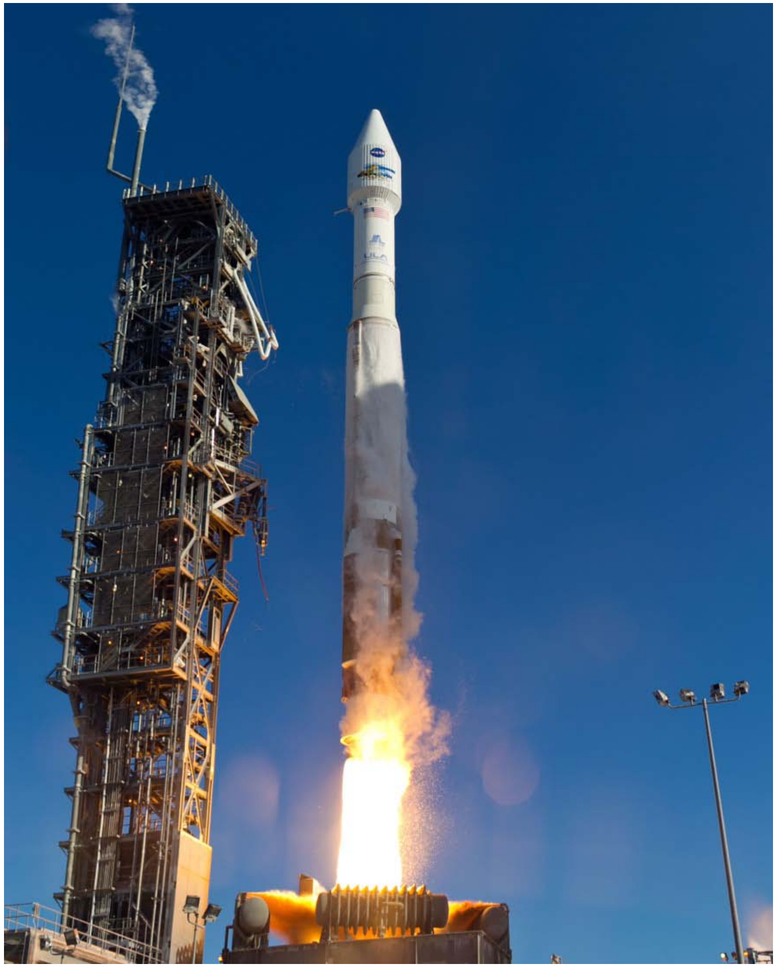
Attitude Control System
- 05/05/2004 Gyro 3 Shut Off
- Single gyro control system in development

Solid State Recorder
- 11/15/1999 SSR PWA #23 Loss
- 02/11/2001 SSR PWA #12 Loss
- 12/07/2005 SSR PWA #02 Loss
- 08/02/2006 SSR PWA #13 Loss
- 03/28/2008 SSR PWA #22 Loss
- 09/03/2008 SSR PWA #23 Recovered
- 10/12/2013 SSR PWA #11 Loss
- Each PWA is 4% loss of launch capacity
- Boards are likely recoverable

X-band System
- Performance nominal

S-band System
- Performance nominal

LDCM Launch – 1 year anniversary - 2/10/14

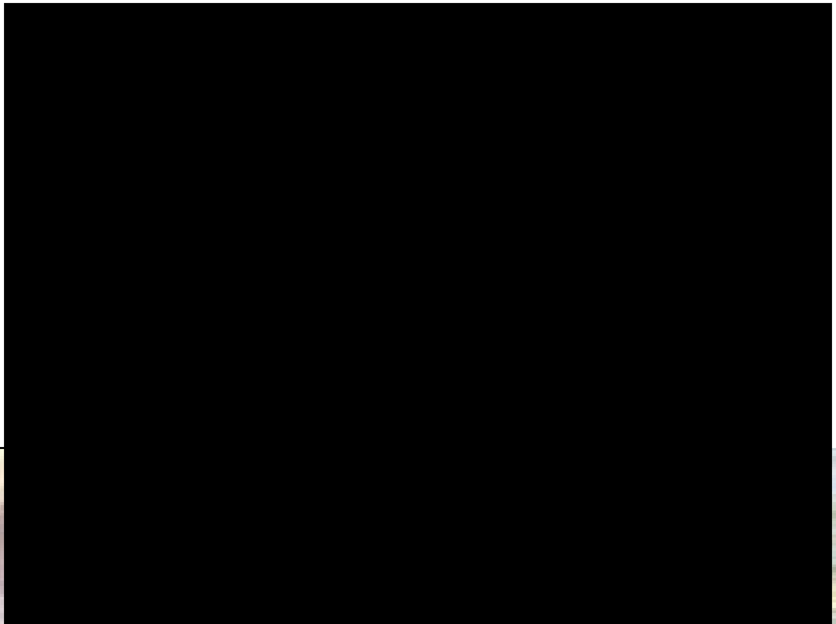


Contributors:

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

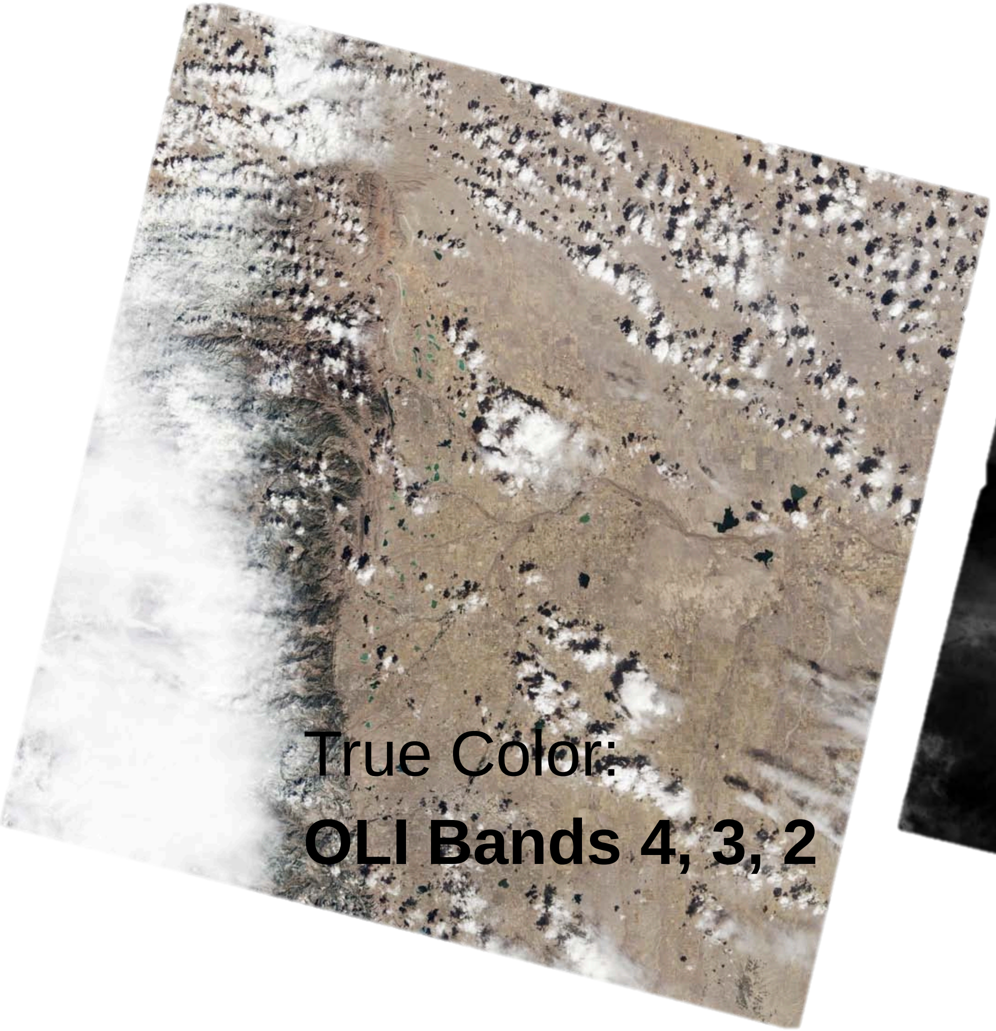


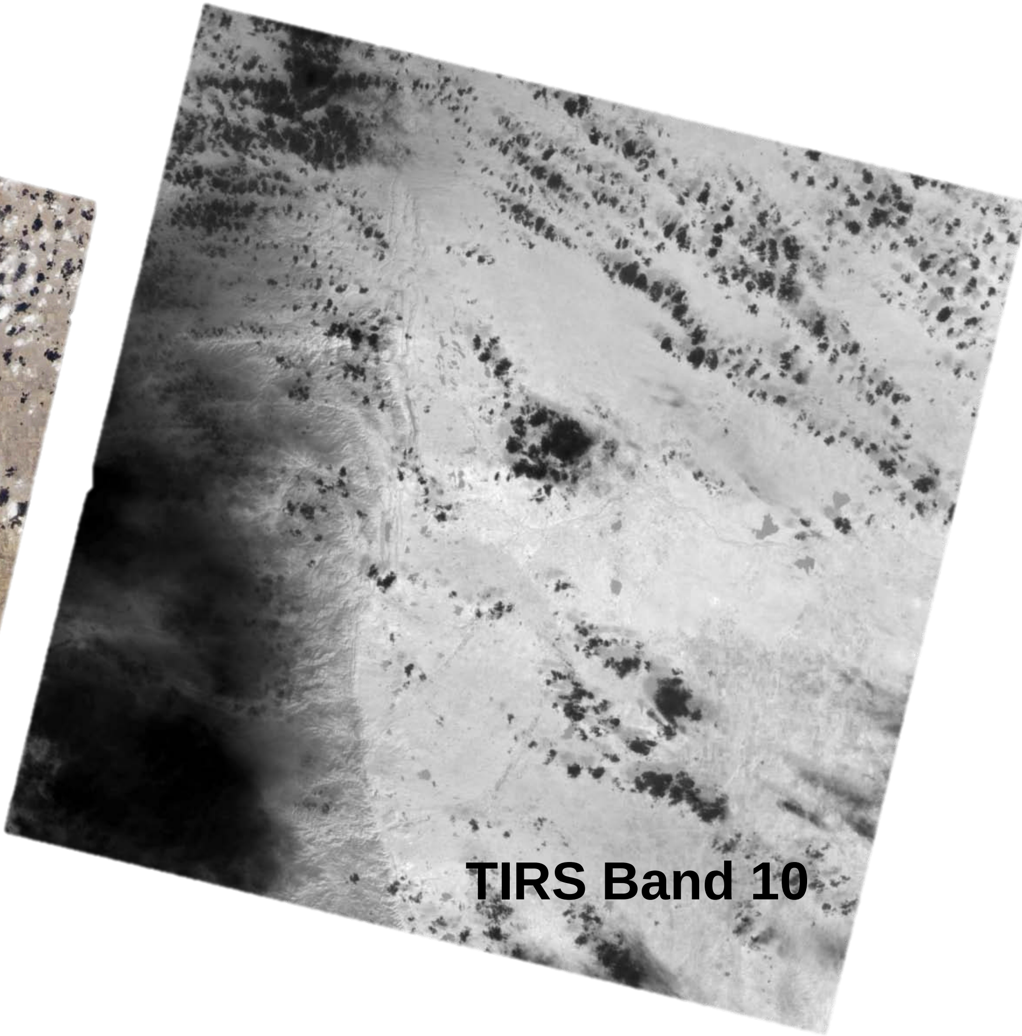
Landsat 8 Spacecraft Status

- Launched 10 Feb 2013
- > 1 years of on-orbit
- May 30, 2013 – USGS mission

- All systems good

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

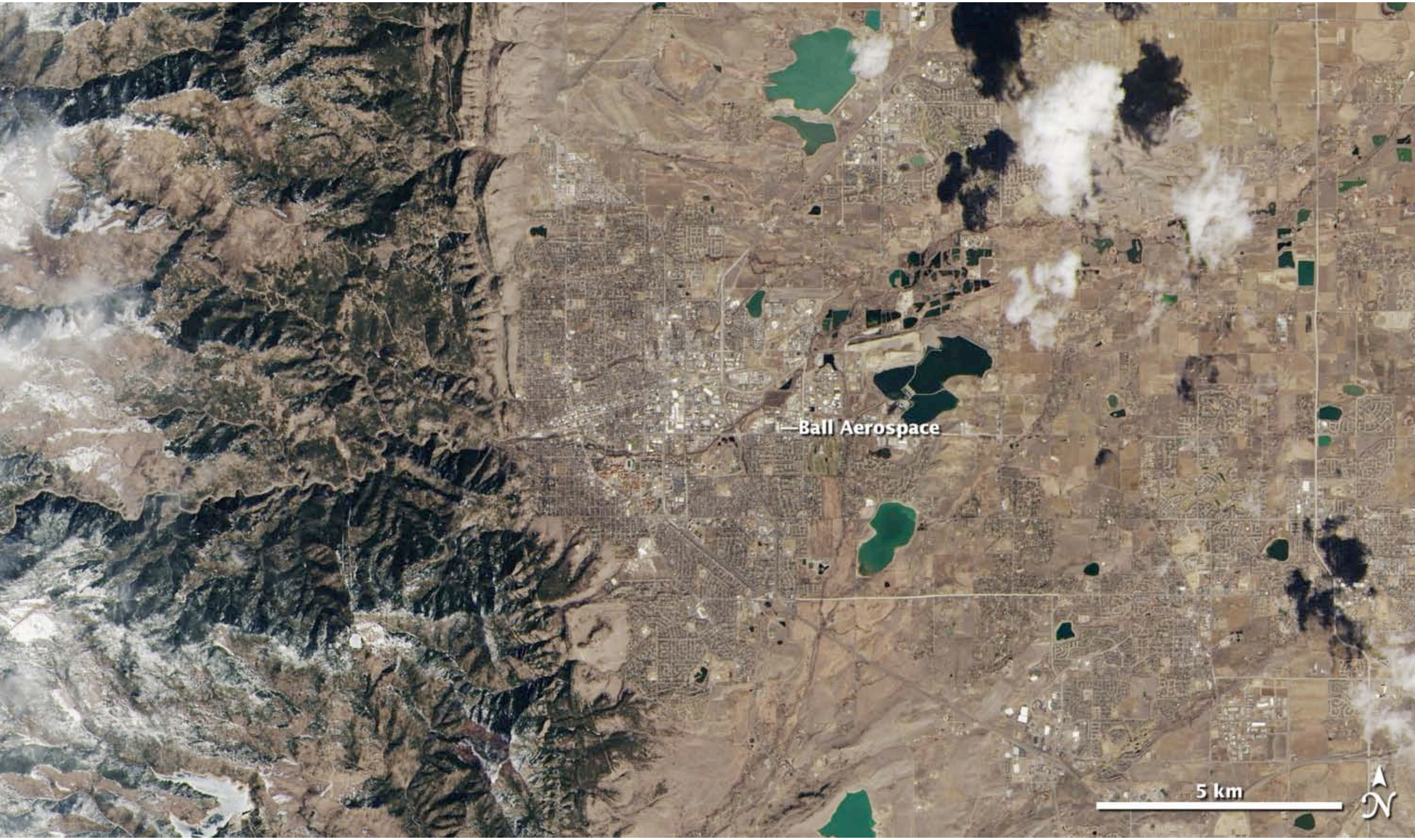




Path 33 / Row 32

Front Range of the Rockies in CO & WY

Boulder, CO: March 18, 2013



http://landsat.usgs.gov/

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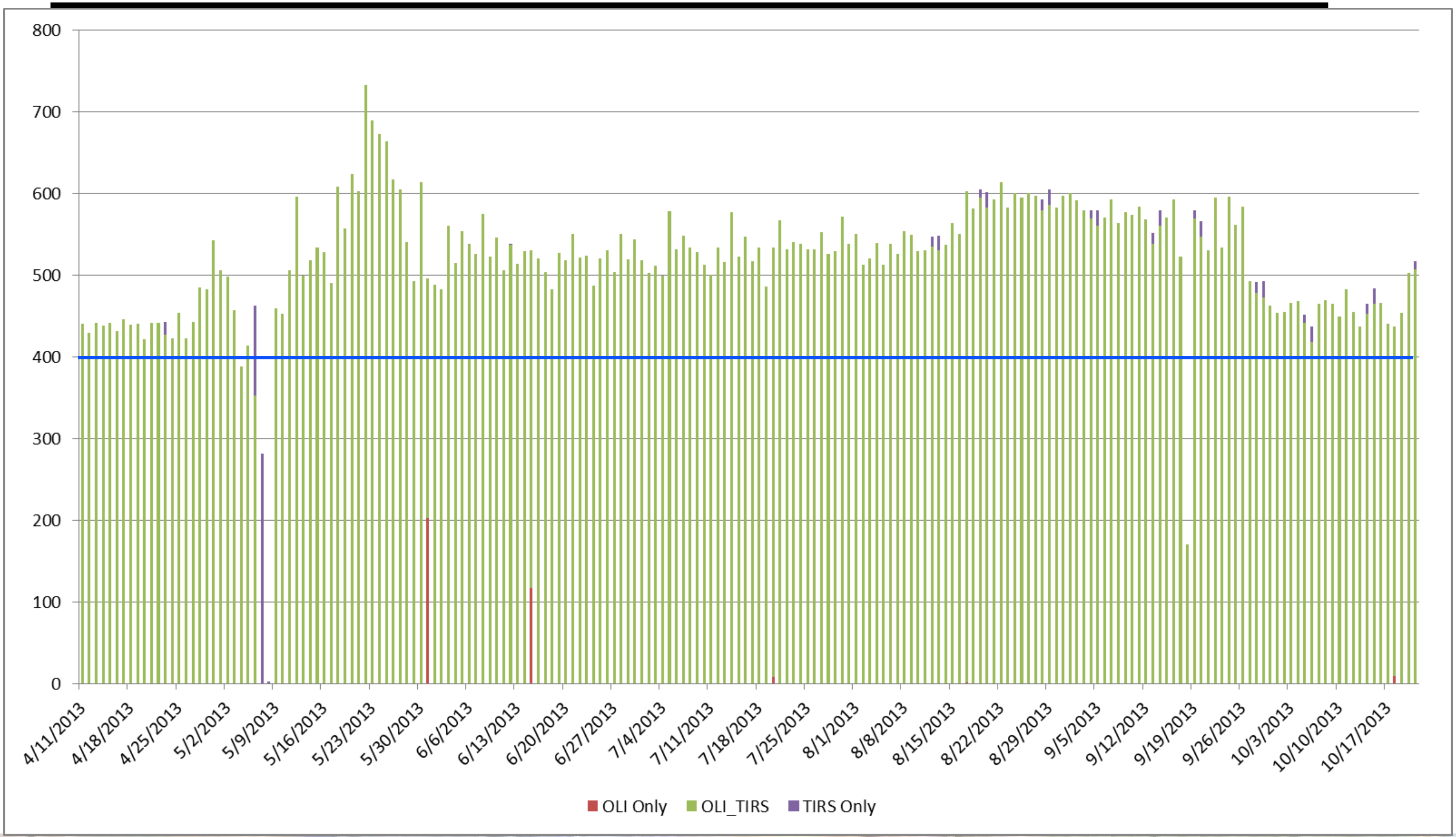
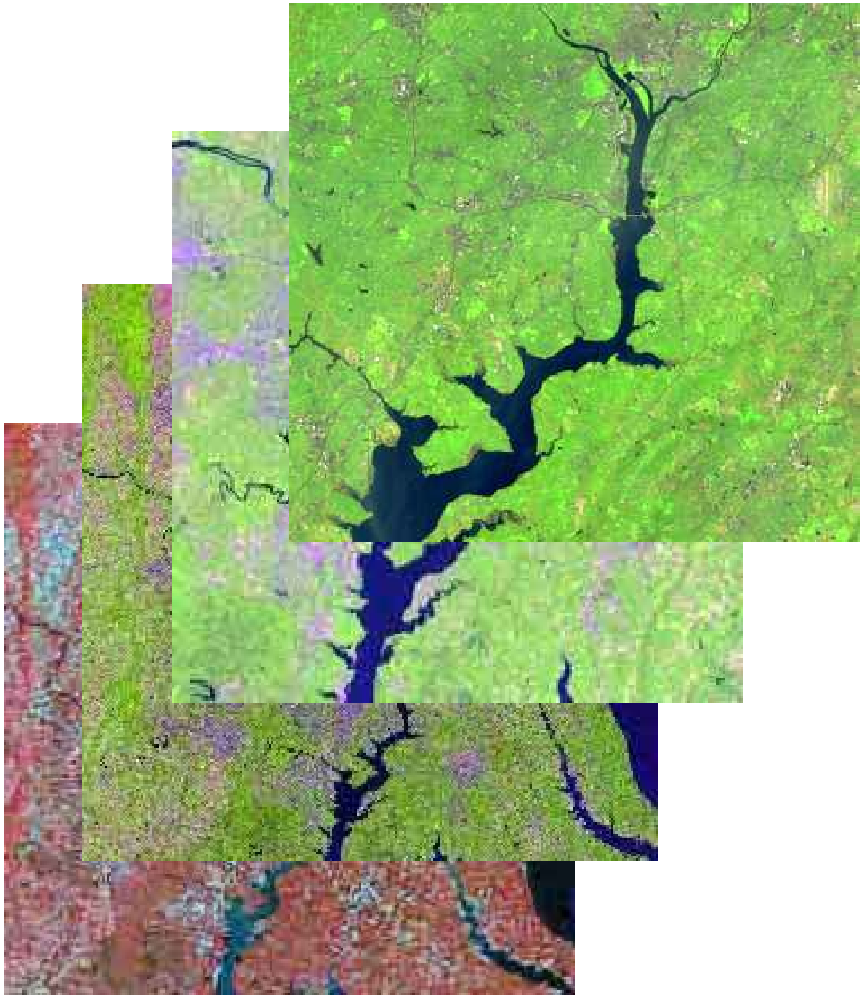
Landsat 8 Scenes Acquired per Day

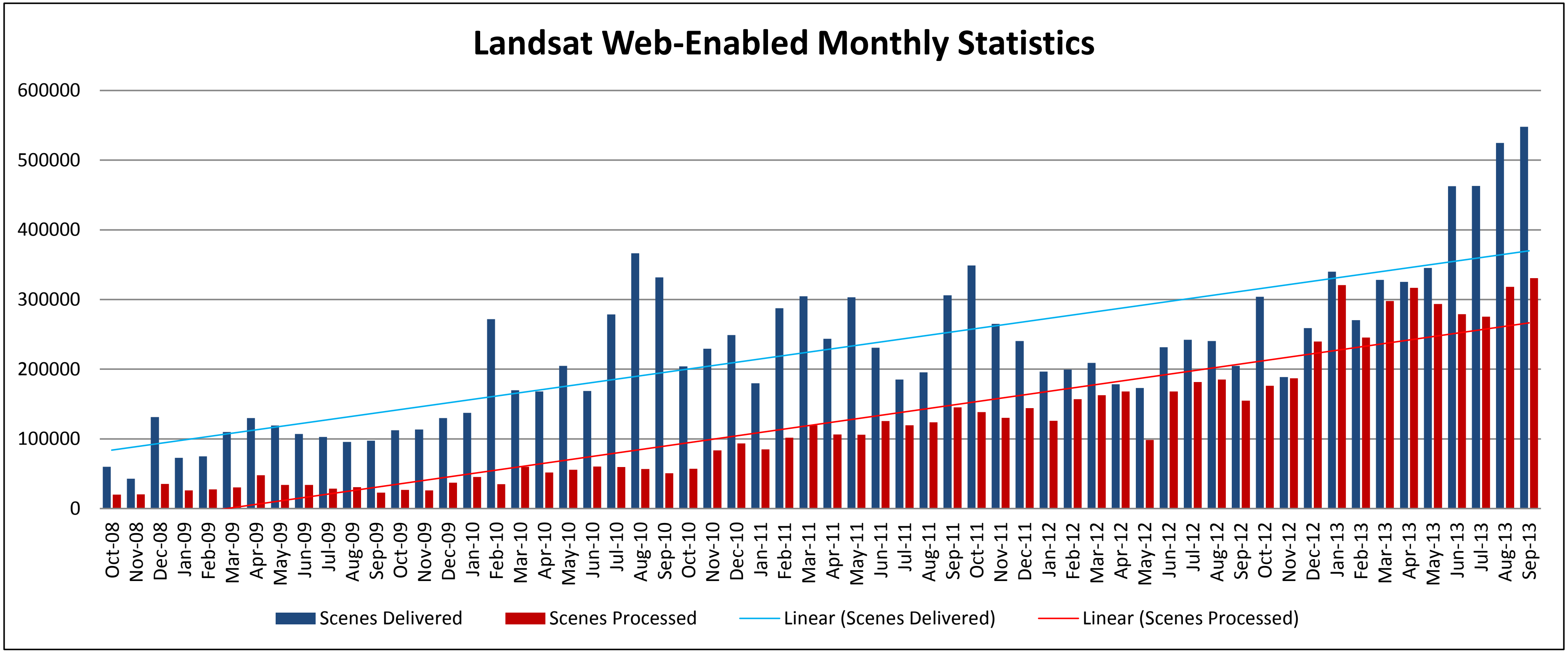


U.S. Landsat Archive Overview (October 17, 2013)

- **OLI-TIRS: Landsat 8**
  - **96,929** scenes
    - ~ 335 TB Raw and L0Ra Data
      average scene size 1813 MB
- **ETM+: Landsat 7**
  - **1,648,873** scenes
    - ~ 1,531 TB Raw and L0Ra Data
      average scene size 487 MB
- **TM: Landsat 4 & Landsat 5**
  - **1,770,791** scenes
    - ~ 888 TB Raw and L0Ra Data
      average scene size 263 MB
- **MSS: Landsat 1 through 5**
  - **1,142,352** scenes
    - ~ 69 TB Raw and L0Ra Data
      average scene size 32 MB
- **Total:**
  - **4,658,945** scenes
    - ~ 2,823 TB Raw and L0Ra Data



Monthly Downloads / Processed



•FY09 (Oct ‘08–Sep ‘09)
- Delivered: 1.14M
- Processed: 358K

•FY10 (Oct ‘09–Sep ‘10)
- Delivered: 2.45M
- Processed: 567K

•FY11 (Oct ‘10–Sep ‘11)
- Delivered: 2.92M
- Processed: 1.27M

•FY12 (Oct ‘11–Sep ‘12)
- Delivered: 2.73M
- Processed: 1.82M

•FY13 (Oct ‘12–Sep ‘13)
- Delivered: 4.36M
- Processed: 3.28M

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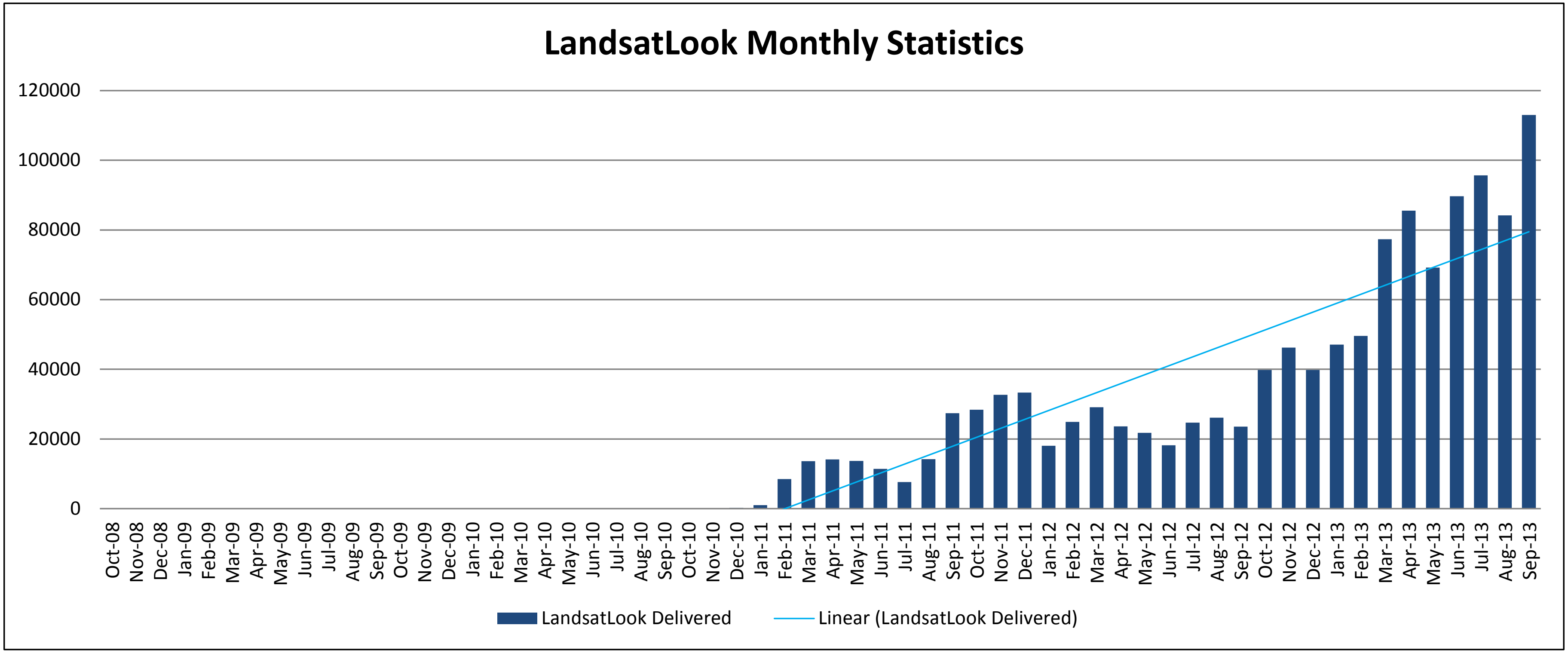
Full Resolution Browse Downloads



•FY11 (Oct ‘10–Sep ‘11)

- Delivered: 112K
-

•FY12 (Oct ‘11–Sep ‘12)

- Delivered: 304K

•FY13 (Oct ‘12–Sep ‘13)

- Delivered: 837K

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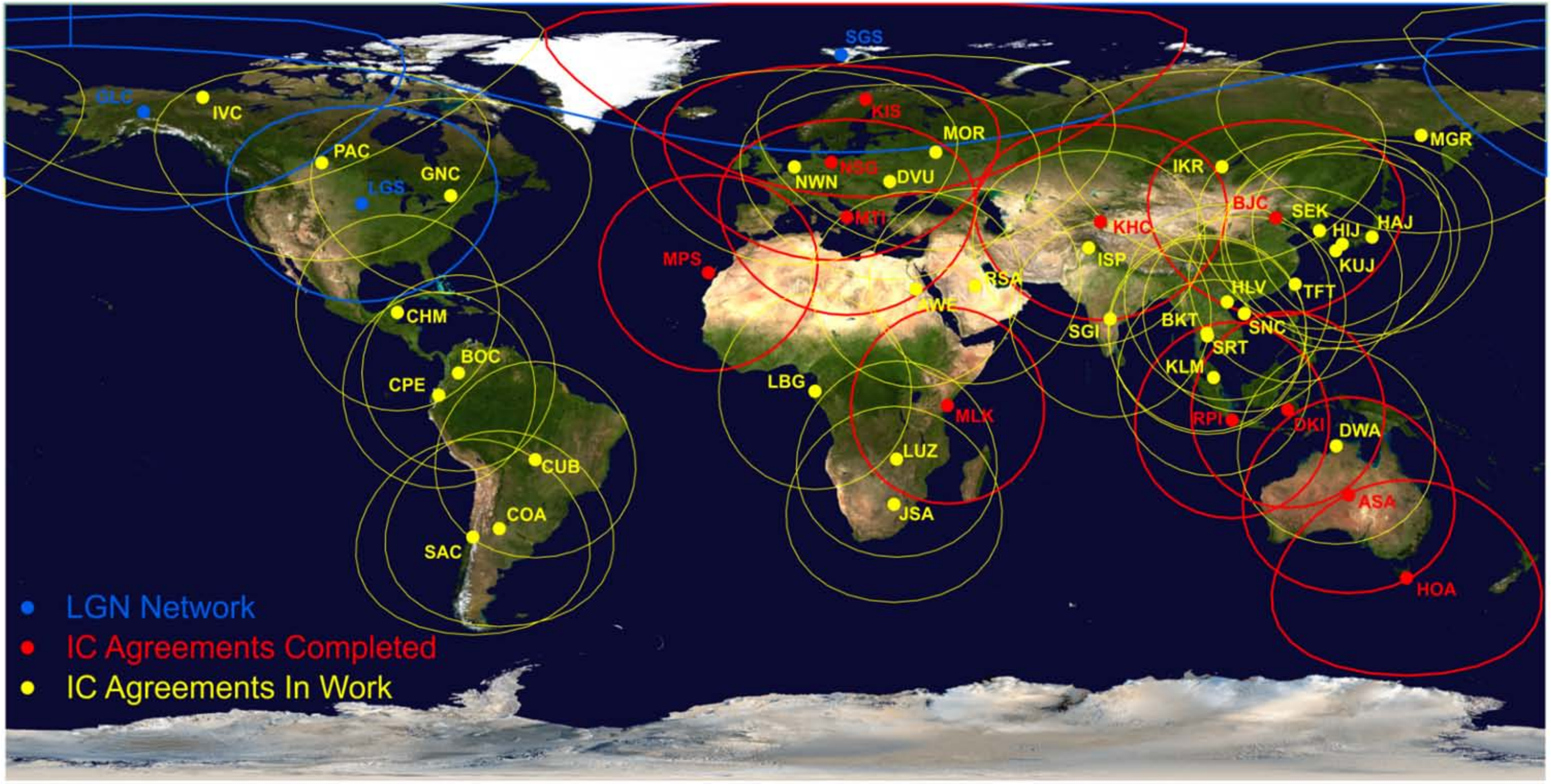
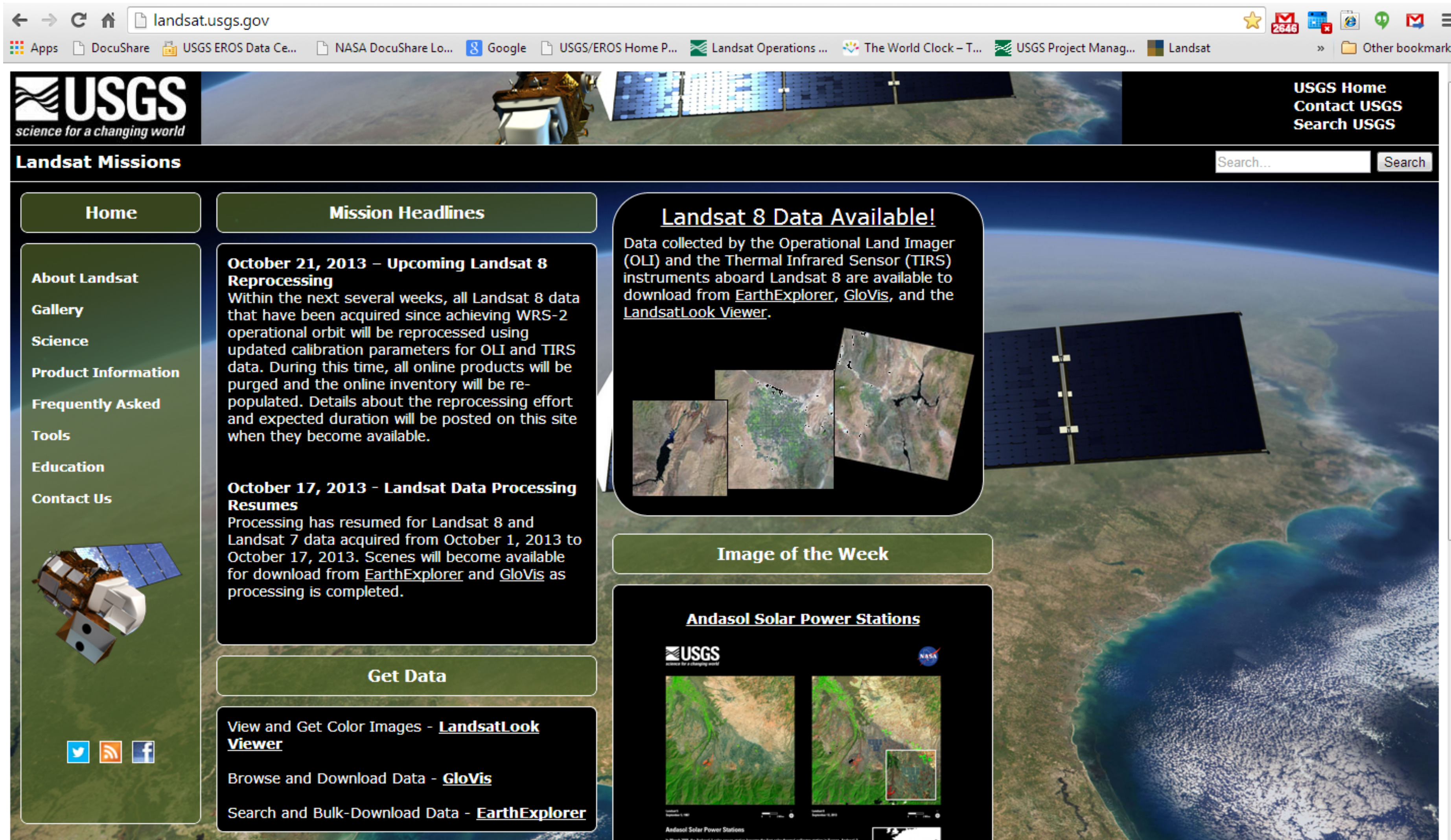
International Cooperator Network



Landsat Web Site

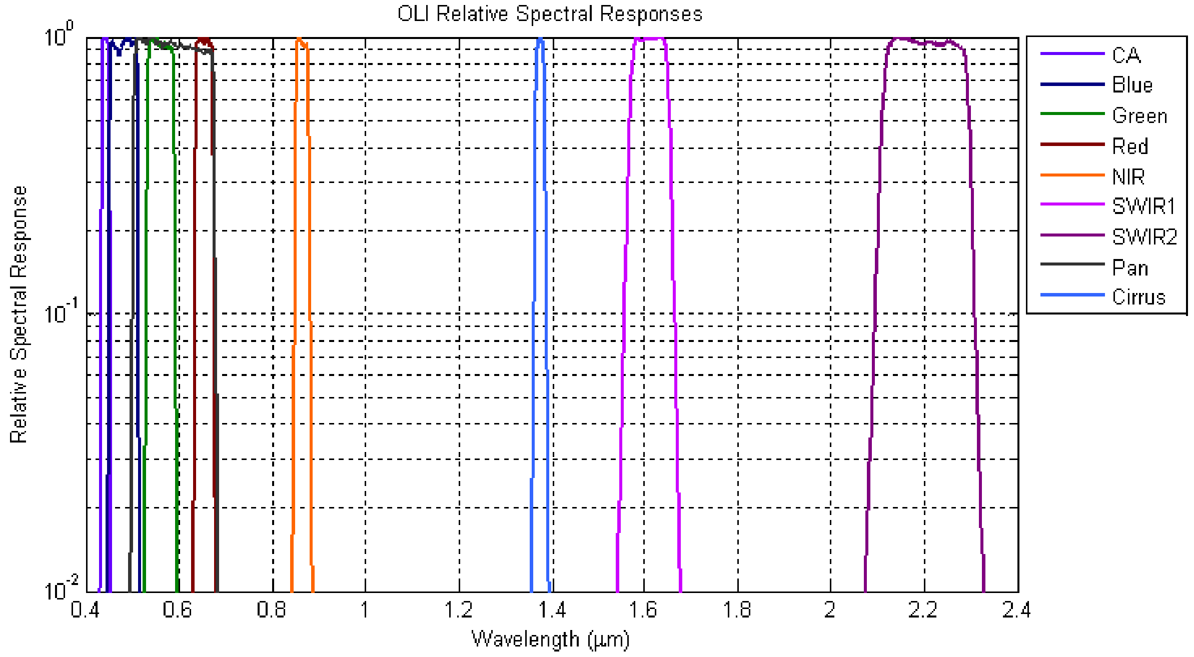
http://landsat.usgs.gov



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

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

L8 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 1 120 m Thermal 2	10.30 – 11.30 11.50 – 12.50	(5) (5)	Band 10 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

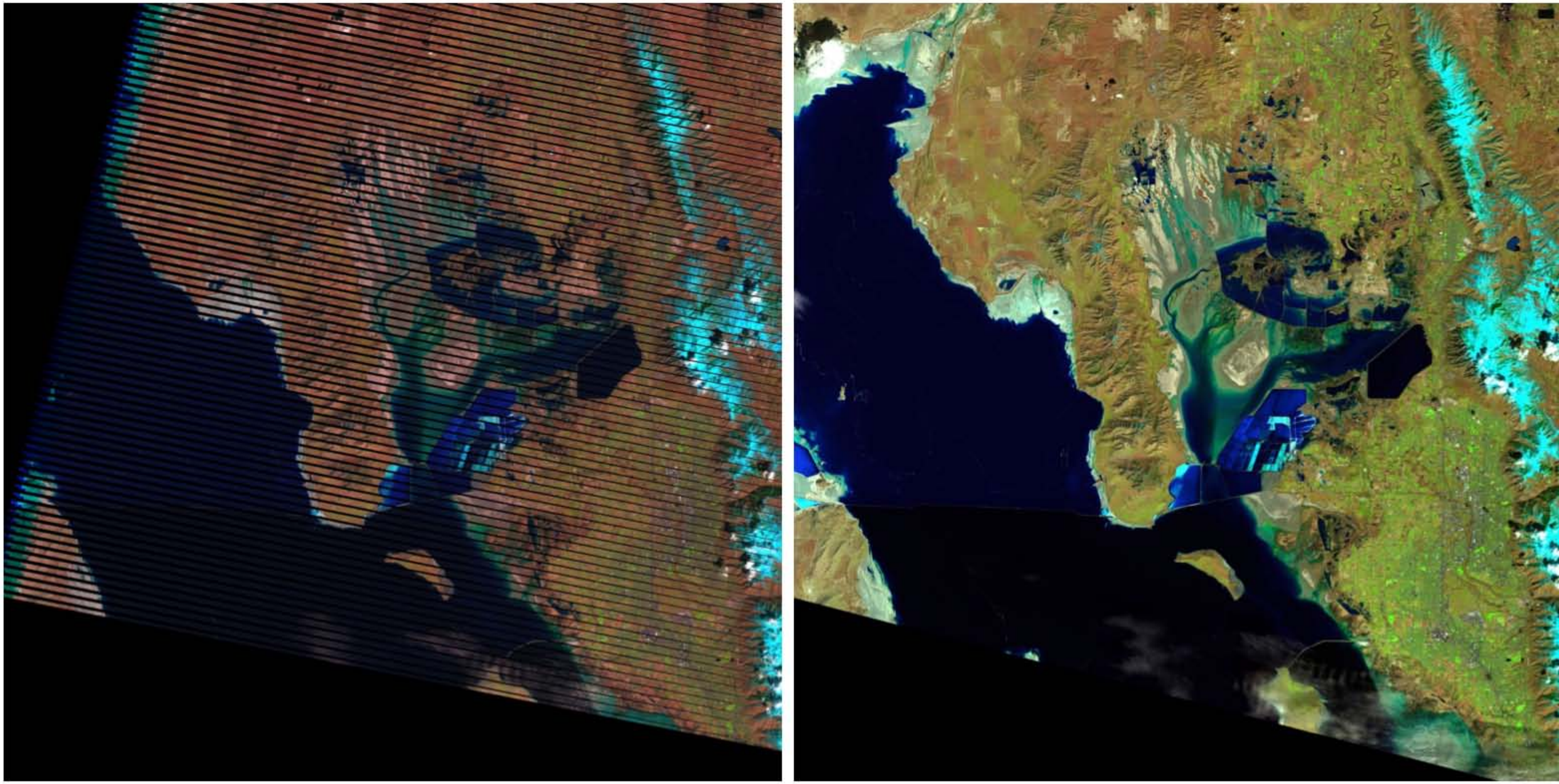
1) Cirrus Band added in 2001 to detect cirrus contamination in other channels
2) Coastal Band added in 2001 at request of ocean color investigators requiring higher resolution of coastal waters relative to MODIS and SEAWifs
3) Bandwidth refinements made in all bands to avoid atmospheric absorption features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

From Jim Irons

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

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

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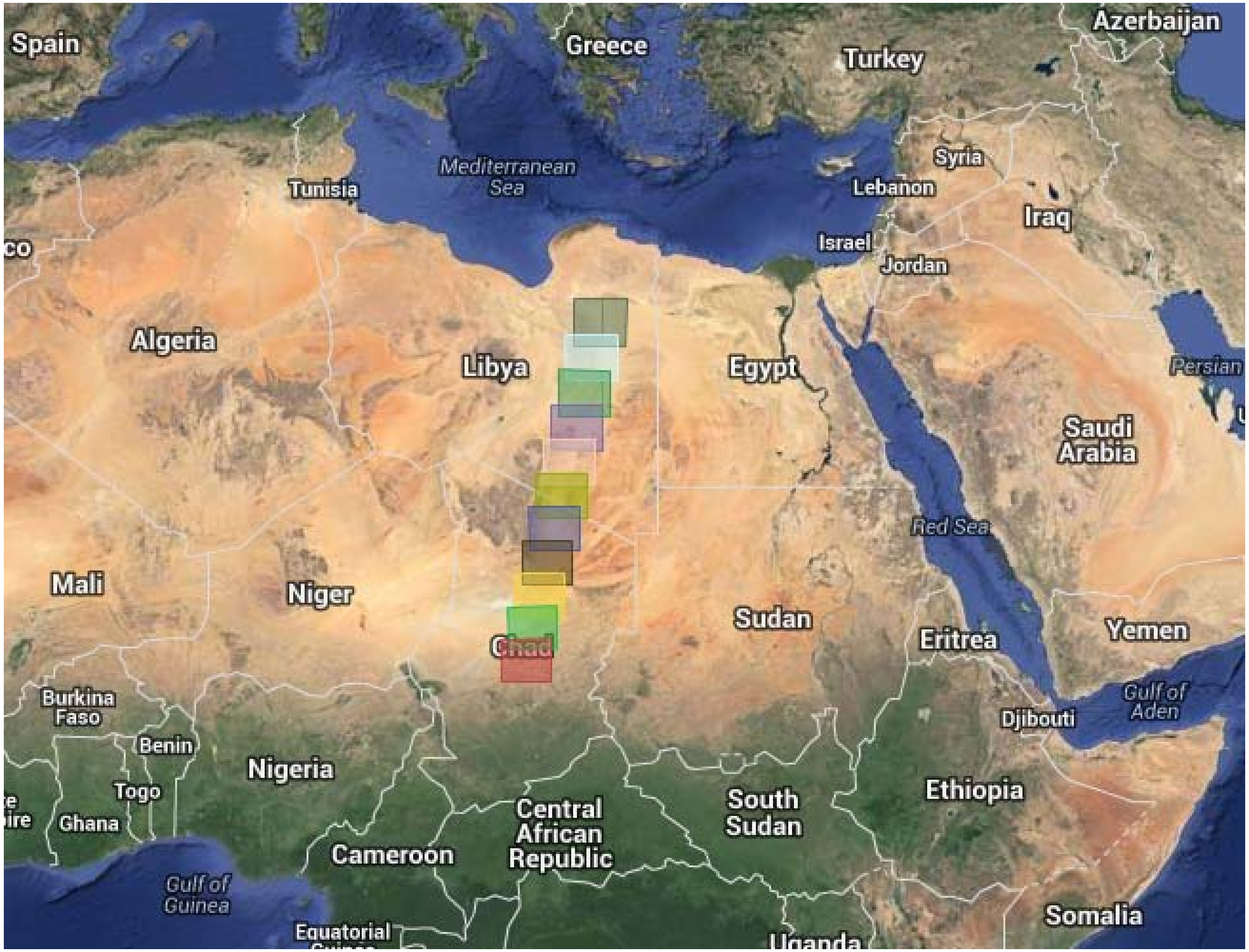
Locations of the scenes used



Ground Field Campaign

Atmospheric measurements collected coincident with sensor overpasses

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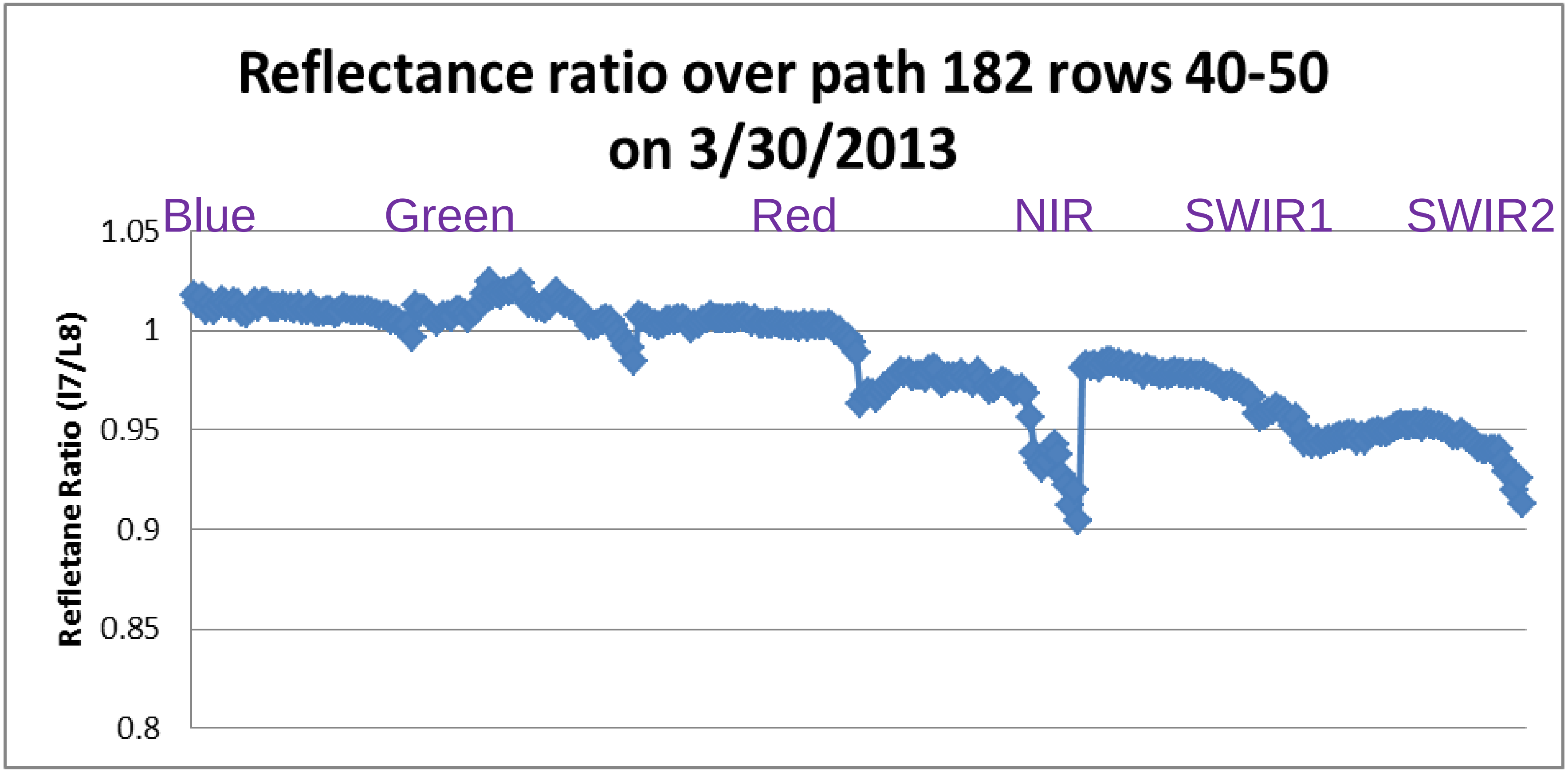
Ratio of L7/L8 TOA Reflectance



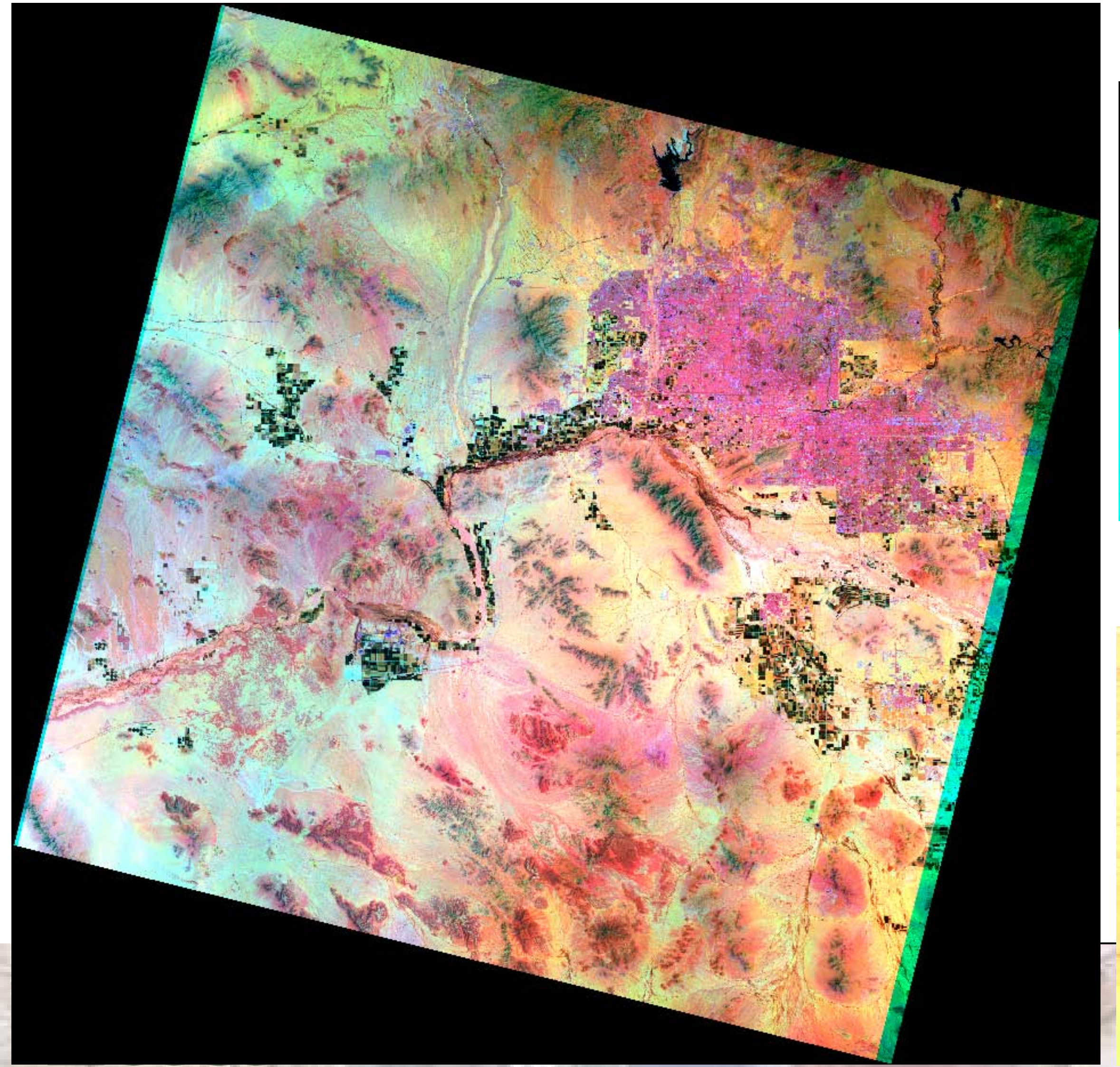
Haque, Micijevic, Morfitt, SGT, USGS Contract

TIRS-OLI Co-Alignment and Swath

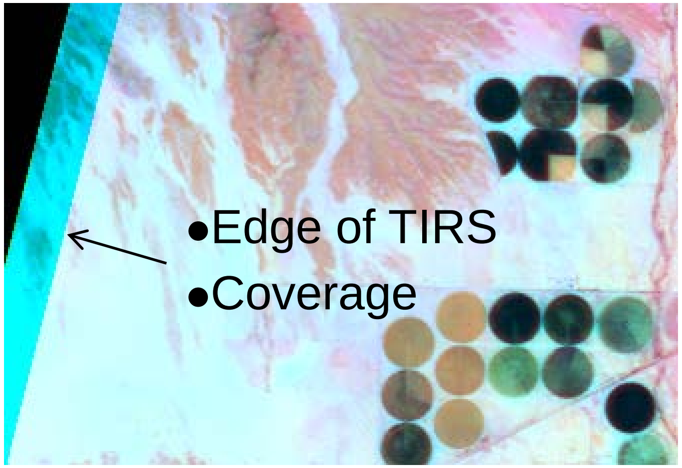
- **Coincident OLI and TIRS imagery demonstrates that the TIRS field of view is completely contained within the OLI field of view**
  - The TIRS FOV is more closely aligned (~700 meters) with the western (starboard side) edge of the OLI FOV
  - The OLI FOV extends ~3.3 km beyond the TIRS FOV on the eastern edge
- **Swath width measured at row 060 (equator):**
  - OLI: 190.2 km vs. 185 km requirement (KPR #5)
  - TIRS: 186.2 km vs. 185 km requirement
- **L8 yaw-steering compensates for Earth rotation and prevents SCA-to-SCA gaps (KPR #6)**
  - This makes the L8 scenes more rectangular (less Earth rotation skew) than heritage Landsat scenes

Full Scene Coverage for 037/037

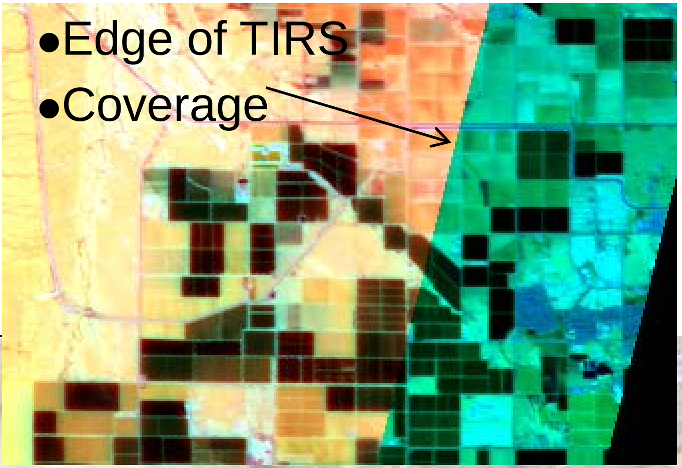
- Red = Band 10 (TIRS) : Green = Band 7 (OLI) : Blue = Band 1 (OLI)



- West Edge of Scene



- East Edge of Scene



OLI Band Registration Accuracy

- **Band registration accuracy was evaluated using cloud-free scenes of selected test sites**
  - Mainly desert sites are used
  - Data acquired between April 15, 2013 and December 1, 2013 (operational WRS-2 orbit)
- **Results from 350 OLI registration test scenes:**
  - 13 high-altitude Earth scenes used for cirrus band assessment
  - OLI band registration accuracy (worst band pair)
    - Line Direction: 3.90 meters LE90 (with cirrus)
    - Sample Direction: 3.98 meters LE90 (with cirrus)
    - Specification: 4.50 meters LE90
    - Line Direction: 3.26 meters LE90 (no cirrus) (KPR #7)
    - Sample Direction: 3.31 meters LE90 (no cirrus) (KPR #7)
    - Incentive Threshold: 3.80 meters LE90 (KPR #7)

TIRS Band Registration Accuracy

- **TIRS 10.8 μm to 12.0 μm band registration**
  - 146 TIRS test scenes acquired from 04/15/2013 to 11/27/2013
  - TIRS band registration accuracy
    - Line Direction: 10.7 meters LE90
    - Sample Direction: 8.9 meters LE90
    - Specification: 18.0 meters LE90
- **TIRS to OLI band registration**
  - 146 TIRS-to-OLI test scenes acquired from 04/15/2013 to 11/27/2013
  - TIRS-to-OLI band registration accuracy (worst band pair)
    - Line Direction: 22.2 meters LE90
    - Sample Direction: 20.5 meters LE90
    - Specification: 30.0 meters LE90
- **Recent CPF update should improve both TIRS band-to-band and TIRS-to-OLI registration**

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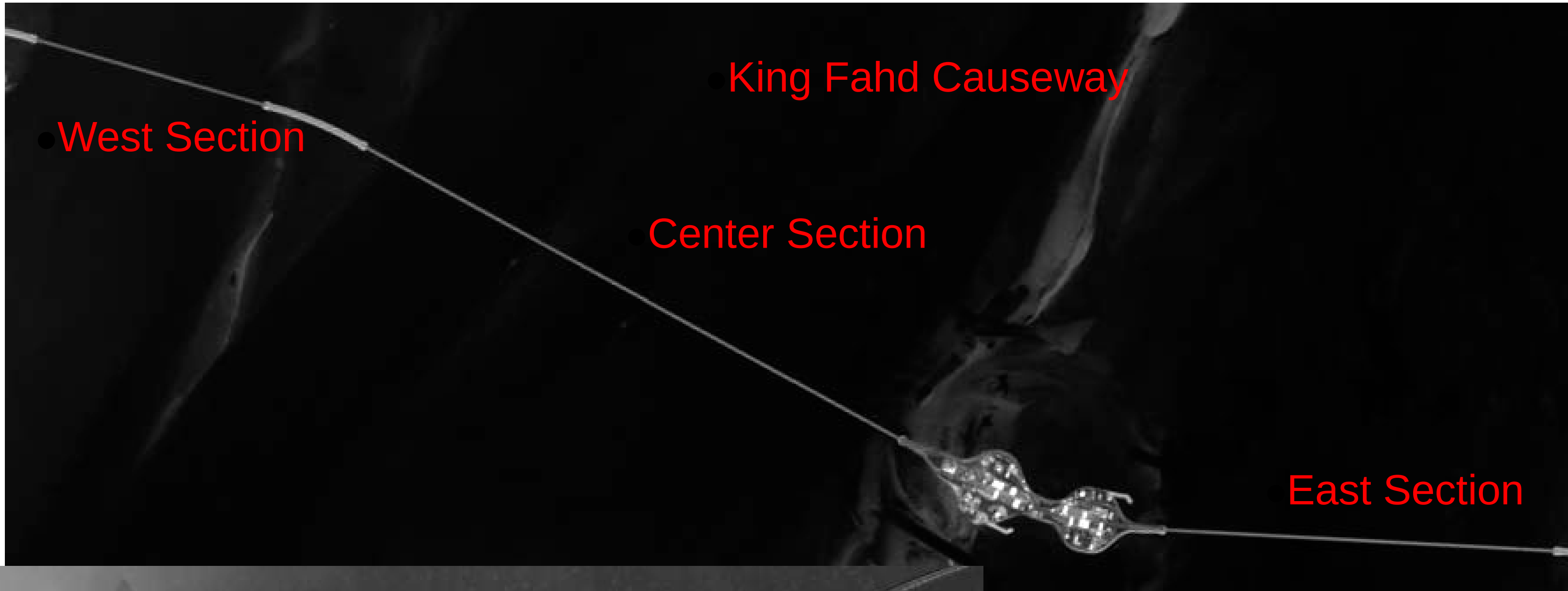
Geodetic Accuracy

- **Geodetic accuracy is evaluated by measuring the offsets between OLI L1G (systematic) images and ground control points (GCPs)**
  - Geometric supersites (DOQ/GPS control) and Global Land Survey anchor sites (NGA control) were used for geodetic accuracy characterization
- **OLI Geodetic Accuracy based upon 6952 characterization scenes acquired from WRS orbit and after OLI-to-ACS alignment cal**
  - Absolute Accuracy: 38.0 meters CE90
  - Specification: 65.0 meters CE90
  - Relative Accuracy: 20.2 meters CE90
  - Specification: 25.0 meters CE90

OLI Spatial Performance

- **Bridge targets are used to characterize the OLI system transfer function on-orbit**
  - Level 1R image samples are interleaved to construct oversampled bridge profiles
  - Transfer function parameters are varied to make the modeled bridge profile best fit the image profile
  - Best fit model is used to generate spatial parameters
- **Analysis of 101 bridge targets in 47 scenes indicates that OLI is meeting spatial edge slope and half edge extent requirements**
  - All bands well above minimum edge slope requirement (KPR #4)
  - Some bands are close to the upper limit set by the aliasing requirement
    - Both limits are shown on the following plot

Bahrain and China Bridge Targets -



- Panchromatic Band Images
- Single Span Bridges

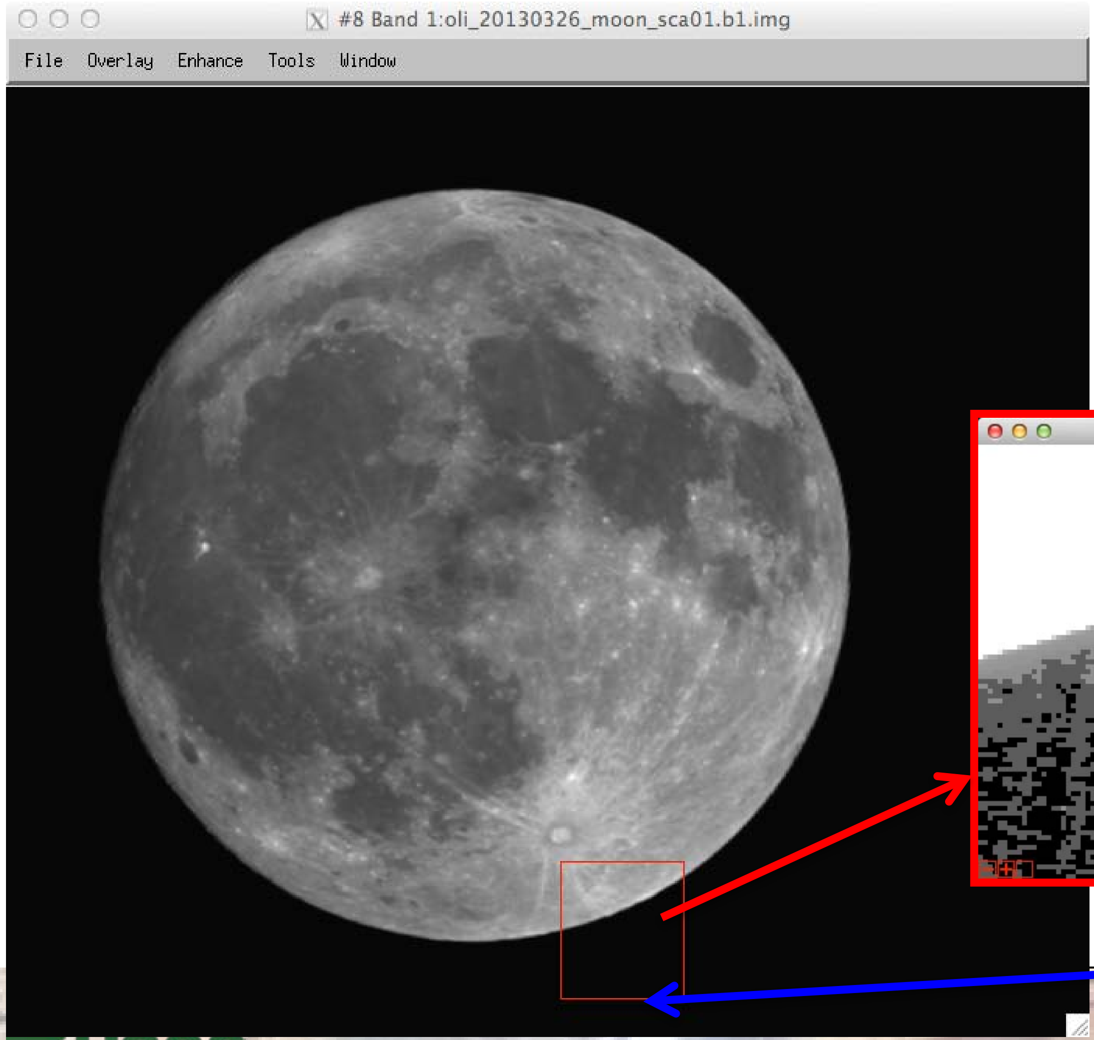
L8 Performance Summary

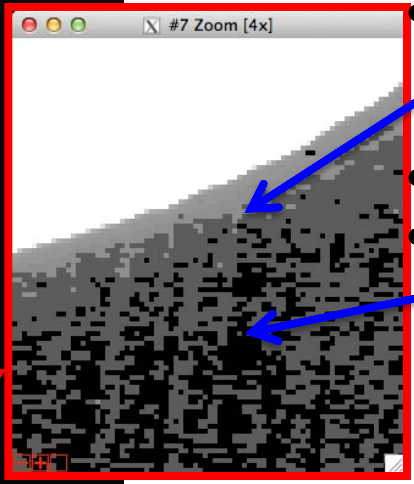
- **Landsat 8 on-orbit geometric performance is excellent and meets all requirements**

Requirement	Measured Value	Required Value	Units	Margin
OLI Swath	190.2	>185	kilometers	2.8%
OLI MS Ground Sample Distance	29.934	<30	meters	0.2%
OLI Pan Ground Sample Distance	14.932	<15	meters	0.5%
OLI Band Registration Accuracy (all bands)	3.98	<4.5	meters (LE90)	11.6%
OLI Band Registration Accuracy (no cirrus)	3.33	<4.5	meters (LE90)	26.1%
Absolute Geodetic Accuracy	38.0	<65	meters (CE90)	41.5%
Relative Geodetic Accuracy	20.2	<25	meters (CE90)	19.1%
Geometric (L1T) Accuracy	11.4	<12	meters (CE90)	5.0%
OLI Edge Slope	0.03054	>0.027	1/meters	13.1%
TIRS Swath	186.2	>185	kilometers	0.6%
TIRS Ground Sample Distance	103.424	<120	meters	13.8%
TIRS Band Registration Accuracy	10.7	<18	meters (LE90)	40.6%
TIRS-to-OLI Registration Accuracy	22.2	<30	meters (LE90)	26.1%

Lunar calibration with L-8

- Lunar image CA band





- @5 pixels from edge
- 0.53% of lunar signal
- @15 pixels from edge
- 0.25% of lunar signal
- @ >30 pixels from edge
- 0.14%

- From Raviv Levy

Landsat-8 Calibration

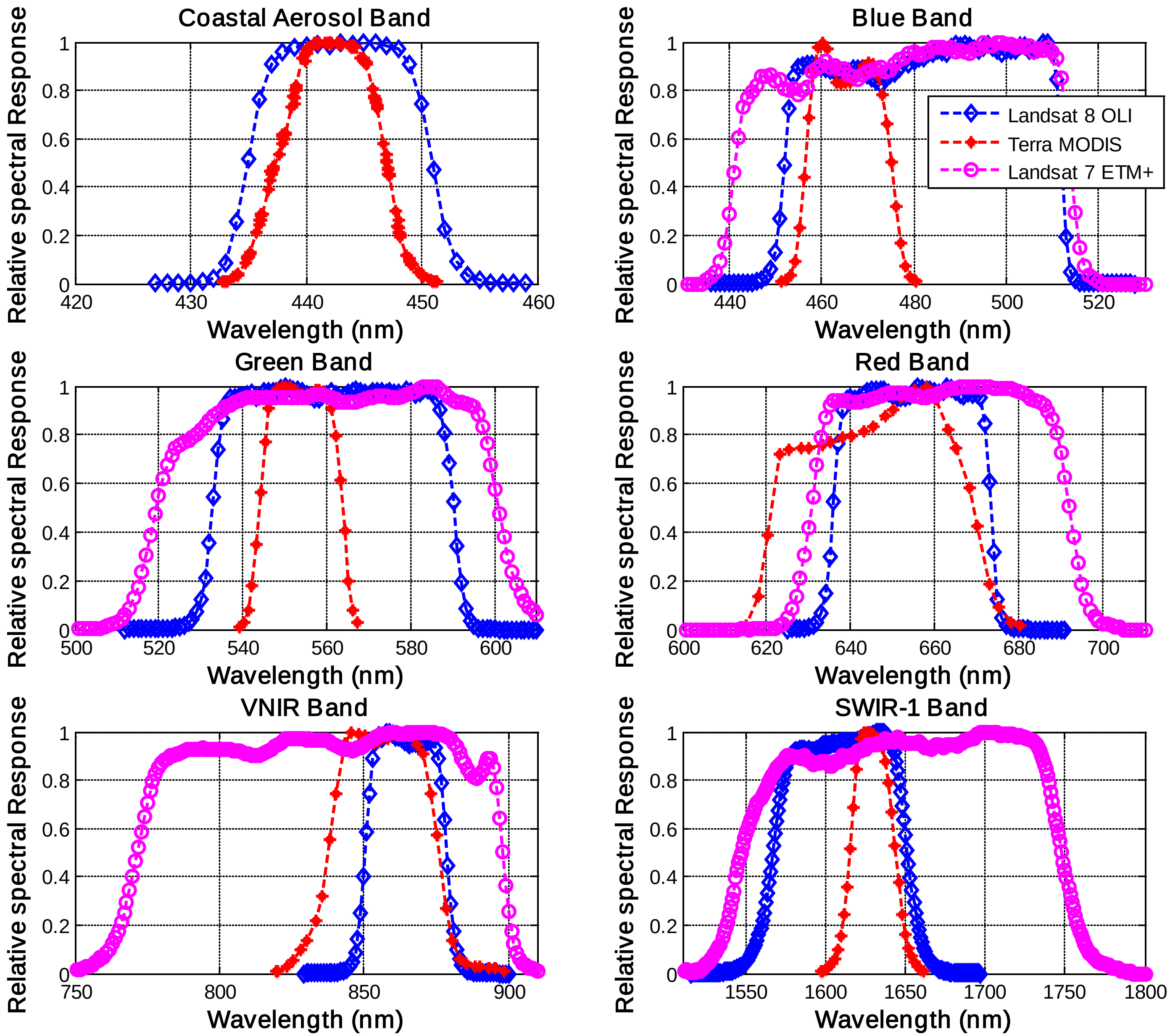
- **Operational Land Imager (OLI) Operating exceptionally 1 year after launch.**
  - The calibration team has made an overall improvement to the radiometry (color fidelity) of the OLI sensor's bands to resolve discrepancies in Landsat 8 images of dark, uniform areas such as large expanses of water.
- **Thermal Infrared Sensor (TIRS) acquires two infrared bands. Both are being affected to different degrees, by a stray light problem.**
  - Light from outside the area we are looking at is getting into the telescope-it's being reflected from something in the sensor itself-which is causing 'ghosting' in the images,
  - To fix the problem, the calibration and instrument teams are scanning the moon, which is a very bright object with a very dark background, to try to find out exactly where the stray light is coming from.
  - Then build a filter to remove the ghosts from the images

Landsat 8 Reprocessing

- **Landsat 8 Reprocessing on February 3, 2014**
- **The entire Landsat 8 archive will be cleared from the online cache and reprocessed to take advantage of calibration improvements identified during its first year of operation.**
  - Data is available and on demand data is continuing. Reprocessing is expected to take approximately 50 days.
- **Corrections to all calibration parameter file updates since launch both the OLI and TIRS.**
  - Improved OLI reflectance conversion coefficients for the cirrus band;
  - Improved OLI radiance conversion coefficients for all bands;
  - Refined OLI detector linearization to decrease striping;
  - a radiometric offset correction for both TIRS bands;
  - Slight improvement to the geolocation of the TIRS data.

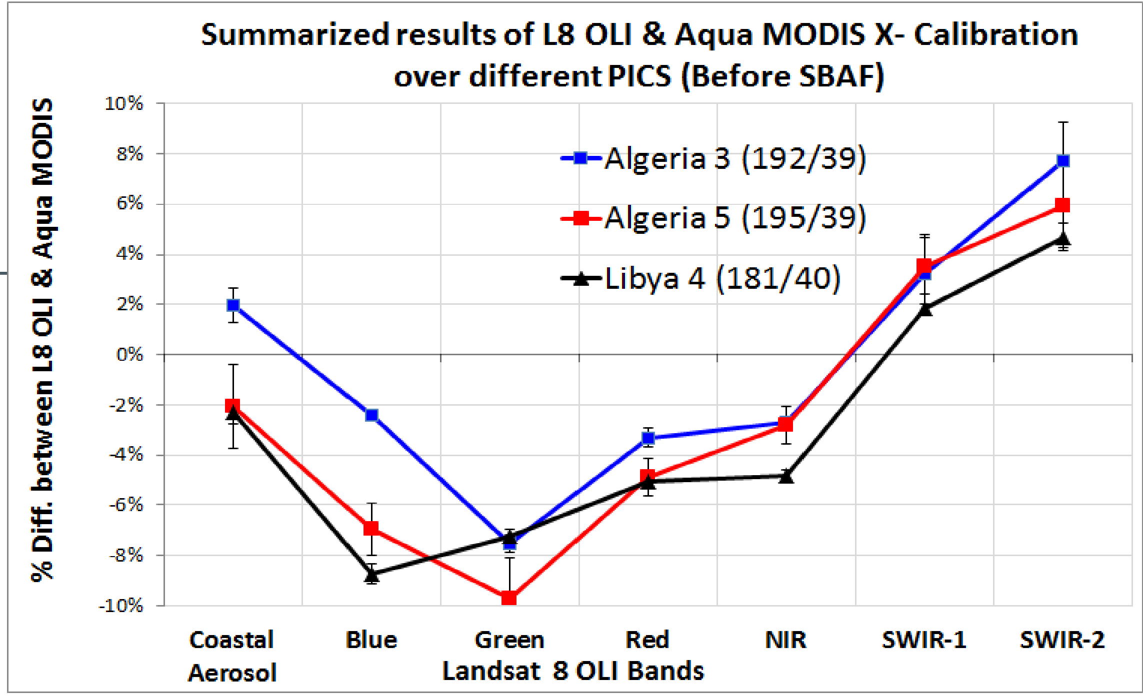
Landsat MODIS Spectral Band Comparison

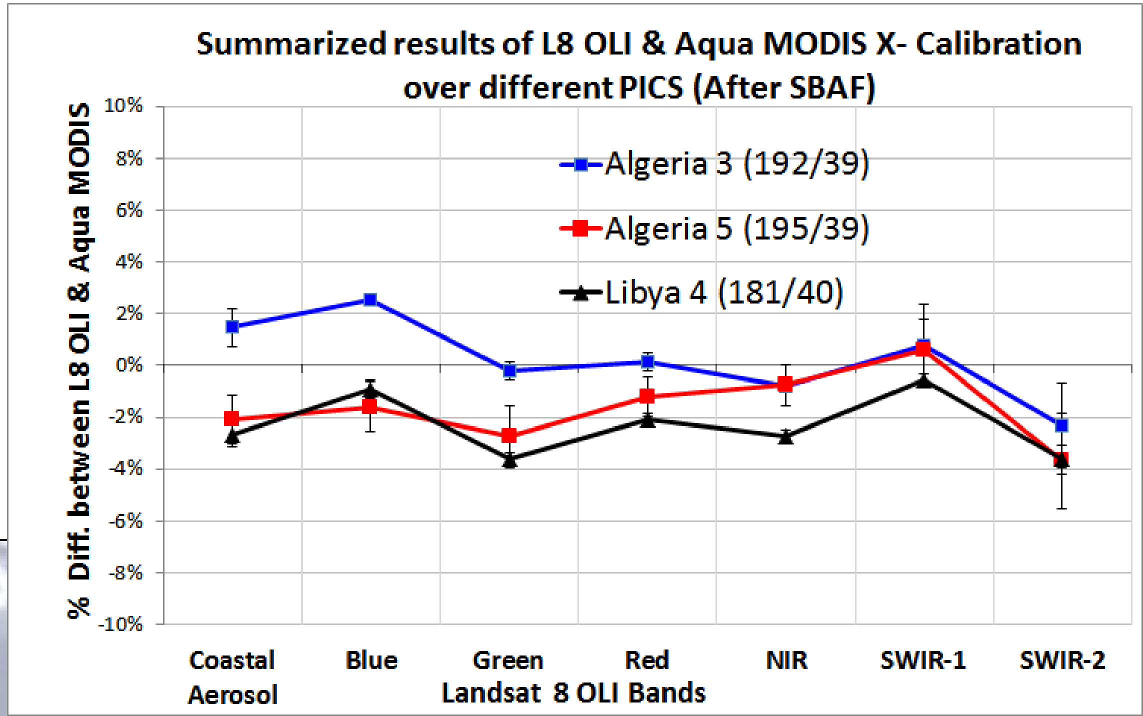
- In general, ETM+ has the wider bandpass compared to analogous OLI and Aqua MODIS bands.
- The L8 OLI NIR band is very similar to MODIS



Landsat OLI - MODIS AQUA

- Comparison shows that
  - OLI is reporting higher value of TOA reflectances in visible-NIR bands than Aqua
  - The scenario is reverse in the two SWIR channels
  - After adjusting for the spectral differences, the agreement between two sensors is within ±2% for deep blue-SWIR-1
  - The highest difference is in SWIR-2 bands ,~3% where there is minimum spectral overlap)
- The effect of off-nadir Aqua acquisitions on the comparisons is yet to be investigated.





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SDSU 3M SITE 2013 Landsat Data Collections

- L7:
  Fair, fair, fair, fair, fair
- L8: OLI:
  Fair, good, fair+, fair+, fair, fair-, good

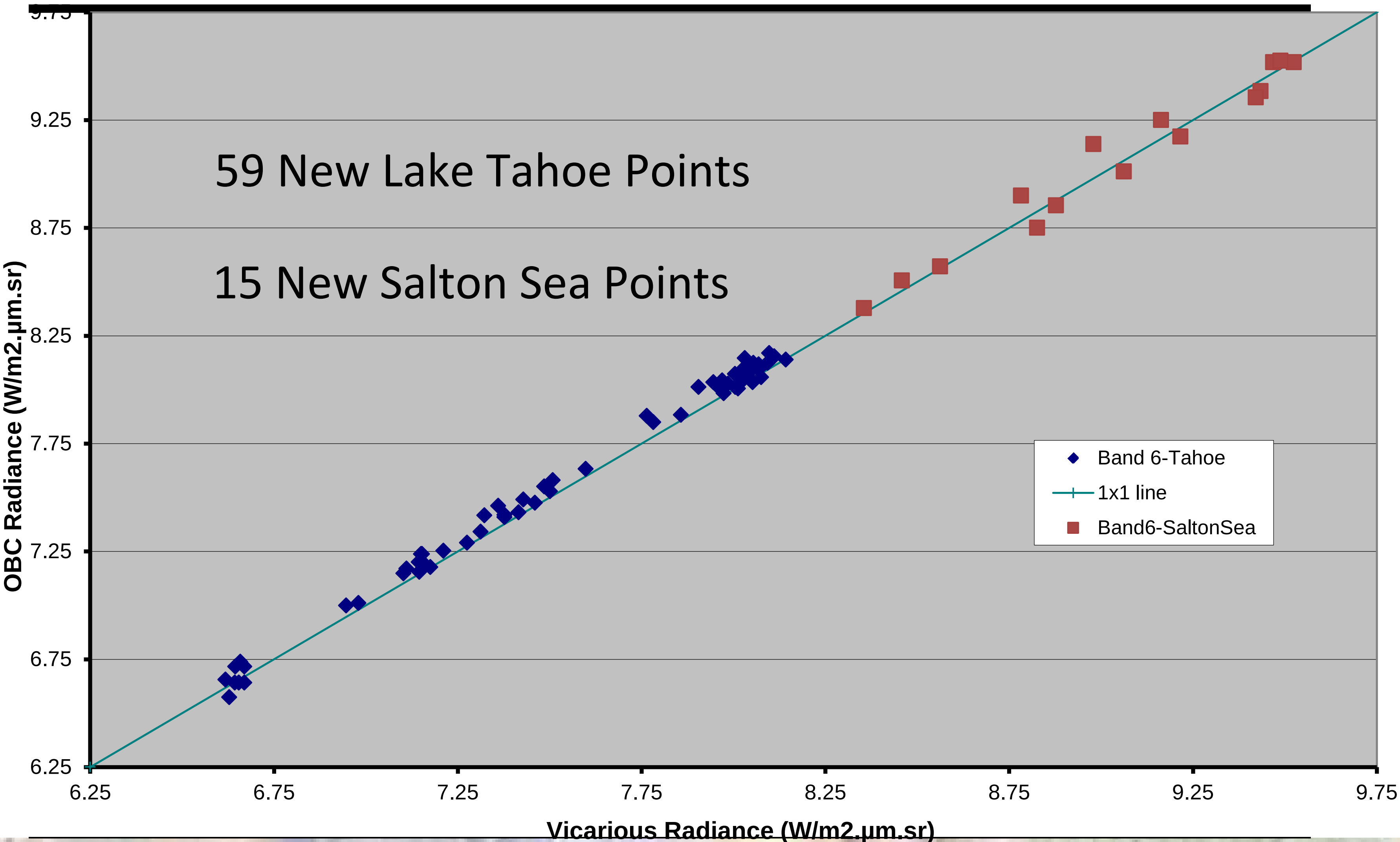
- **ETM+: 5 fair**
- **OLI: 5 fair, 2 good**

30-March	Underfly L7 & L8	Fair
Month of April	Landsats	clouds (cold and wet)
Month of May	Landsats	clouds (cold and wet)
25-May	Landsat 8	clouds
2-June	Landsat 7	fair
10-June	**Landsat 8**	**Good**
18-Jun	Landsat 7	cumulus at overpass
26-Jun	Landsat 8	clouds
4-Jul	Landsat 7	fair (hazy from smoke)
12-Jul	Landsat 8	fair +
20-Jul	Landsat 7	clouds at overpass
28-Jul	**Landsat 8**	**Cloud at overpass**
5-Aug	Landsat 7	clouds at overpass
13-Aug	Landsat 8	fair+
21-Aug	Landsat 7	clouds no deploy
29-Aug	Landsat 8	fair
6-Sep	Landsat 7	fair
14-Sep	Landsat 8	clouds
22-Sept	**Landsat 7**	**Fair**
30-Sept	Landsat 8	fair-
8-Oct	Landsat 7	major cirrus all a.m.
16-Oct	**Landsat 8**	**Good**
24-Oct	Landsat 7	clouds no deploy

USGS

SDSU; David Aaron, Larry Leigh, Morakot Kaewmanee, Ryan Hahn

Landsat 7, Channel 6 Vicarious and OBC Thermal Infrared Derived Radiances at Lake Tahoe and Salton Sea, NEW DATA!



•Simon J. Hook, Robert Radocinski, William Johnson, Julia Barsi, Brian Markham

In Flight Validation of the Landsat 7 Thermal Channel Using Automated Validation Sites at Lake Tahoe CA/NV and Salton Sea CA

- **L7 thermal band data demonstrated to be within ± 0.8K each year from 2001-2013**
- **Overall data show small –ve bias (-0.33K). L7 is warm!**
- **Now most of data re-processed see clear gain effect –we over-corrected**
- **Lack of nighttime data in early years affects the trend.**
- **Note: The 2010 files contain data processed with the current calibration and should not be combined with the other data. As I get time, I will be reprocessing older data and scenes will move from the older file (2001) to the new file but until then the older file is just a reference for the calibration error that we corrected for in 2010..”**
- **All data now processed with Jan2010cal**

USGS

Multiple Landsat Science team meetings since launch

Landsat Science Team : 2012-2017

The team members, affiliations, and research and applications emphases are:

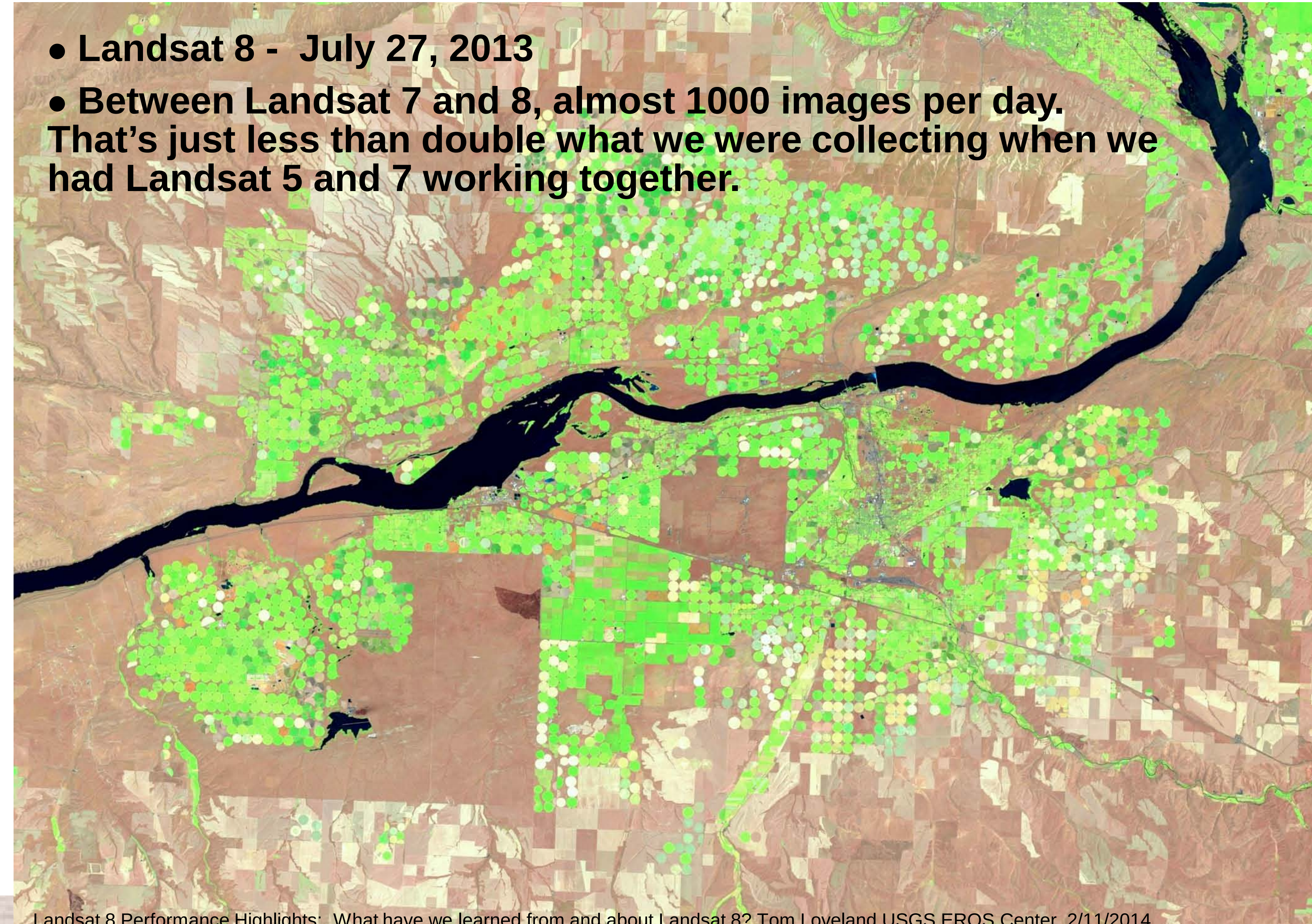
- Developing and enhancing Landsat derived evapotranspiration and surface energy products; Dr. Richard Allen, University of Idaho; Dr. Ayse Kilic, University of Nebraska; Dr. Justin Huntington, Desert Research Institute
- Mapping vegetation phenology, water use and drought at high spatiotemporal resolution fusing multi-band and multi-platform satellite imagery, Dr. Martha Anderson, USDA Agricultural Research Service; Dr. Feng Gao, USDA Agricultural Research Service
- Understanding the global land-use marketplace ,Dr. Alan Belward, European Commission Joint Research Centre
- Ecological Applications of Landsat Data in the Context of US Forest Service Science and Operational Needs, Dr. Warren Cohen, USDA Forest Service
- Landsat data continuity: advanced radiometric characterization and product development, Dr. Dennis Helder, South Dakota State University
- Integrating Field-Level Biophysical Metrics Derived from Landsat Science Products into a National Agricultural Data Warehouse, Dr. Jim Hipple, USDA Risk Management Agency
- Synergies between future Landsat and European satellite missions for better understanding coupled human-environment systems, Dr. Patrick Hostert, Humboldt University of Berlin
- Operational monitoring of US croplands with Landsat 8, Mr. David Johnson, USDA National Agricultural Statistical Service
- Using time-series approaches to improve Landsat's characterization of land surface dynamics, Dr. Robert Kennedy, Boston University
- Multi-temporal Analysis of biophysical parameters derived from the Landsat Series of satellites, Dr. Leo Lymburner, Geoscience Australia

USGS

Landsat Science Team : 2012-2017

- Absolute radiometric and climate variable intercalibration of Earth observing sensors, Dr. Joel McCorkel, NASA Goddard Space Flight Center
- Continuity of the Web Enabled Landsat Data (WELD) Product Record in the LDCM Era, Dr. David Roy, South Dakota State University
- North American Land Surface Albedo and Nearshore Shallow Bottom Properties from Landsat and MODIS/VIIR, Dr. Crystal Schaaf, University of Massachusetts, Boston
- Cryospheric Applications of the Landsat Data Continuity Mission (Landsat 8), Dr. Ted Scambos, University of Colorado
- The Use of LDCM for the Monitoring of Fresh and Coastal Water, Dr. John Schott, Rochester Institute of Technology
- Developing Decadal High Resolution Global Lake Products from LDCM and Landsat, Dr. Yongwei Sheng, University of California, Los Angeles
- Development of Landsat surface reflectance Climate Data Records, Drs. Eric Vermote and Christopher Justice, University of Maryland
- Ecological Disturbance Monitoring using Landsat Time Series Data, Dr. Jim Vogelmann, U.S. Geological Survey
- Better Use of the Landsat Temporal Domain: Monitoring Land Cover Type, Condition and Change, Dr. Curtis Woodcock, Boston University
- Integrating the past, present, and future of Landsat, Dr. Mike Wulder, Canadian Forest Service
- Making Multitemporal Work, Dr. Randolph Wynne, Virginia Tech

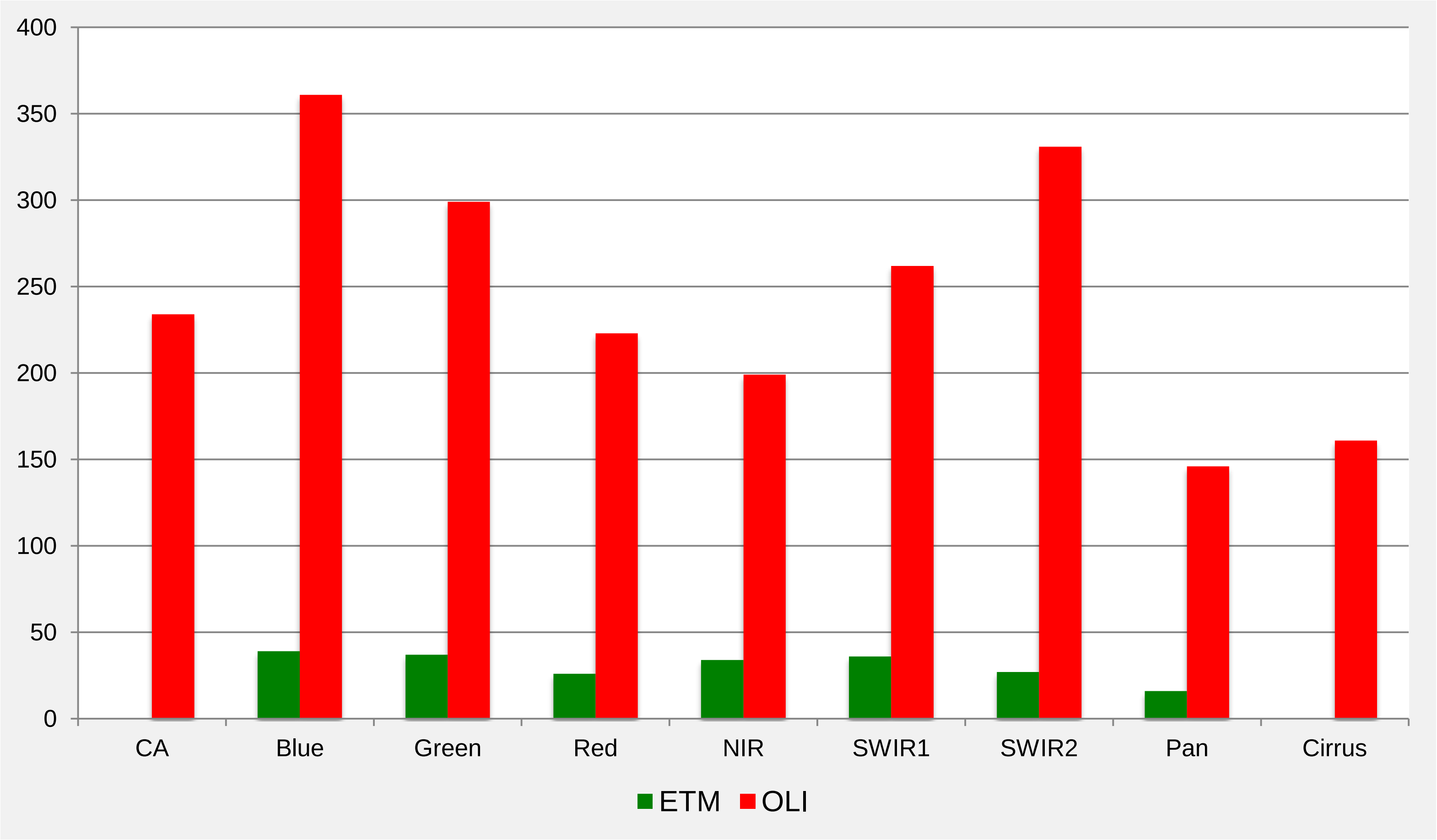
- **Landsat 8 - July 27, 2013**
- **Between Landsat 7 and 8, almost 1000 images per day. That's just less than double what we were collecting when we had Landsat 5 and 7 working together.**



Landsat 8 Performance Highlights: What have we learned from and about Landsat 8? Tom Loveland USGS EROS Center, 2/11/2014

USGS

Landsat 8 Signal-to-Noise

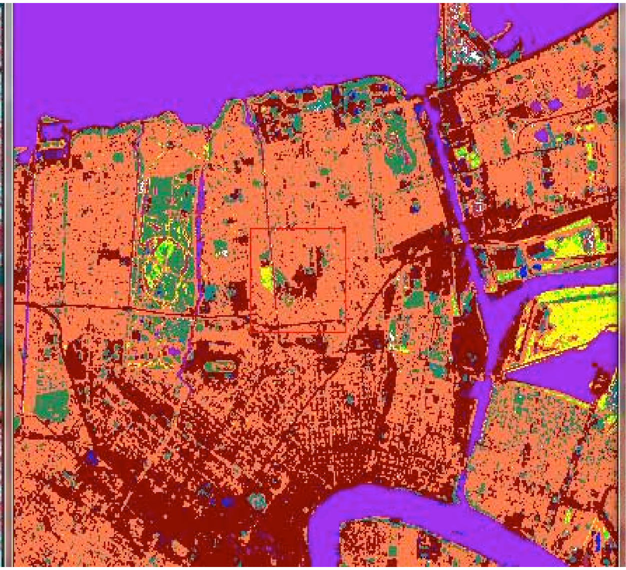


Improved SNR allows the more accurate detection and characterization of subtle land and water conditions.

USGS

Landsat 8 data are improving land cover classification

Landsat 8 FCC

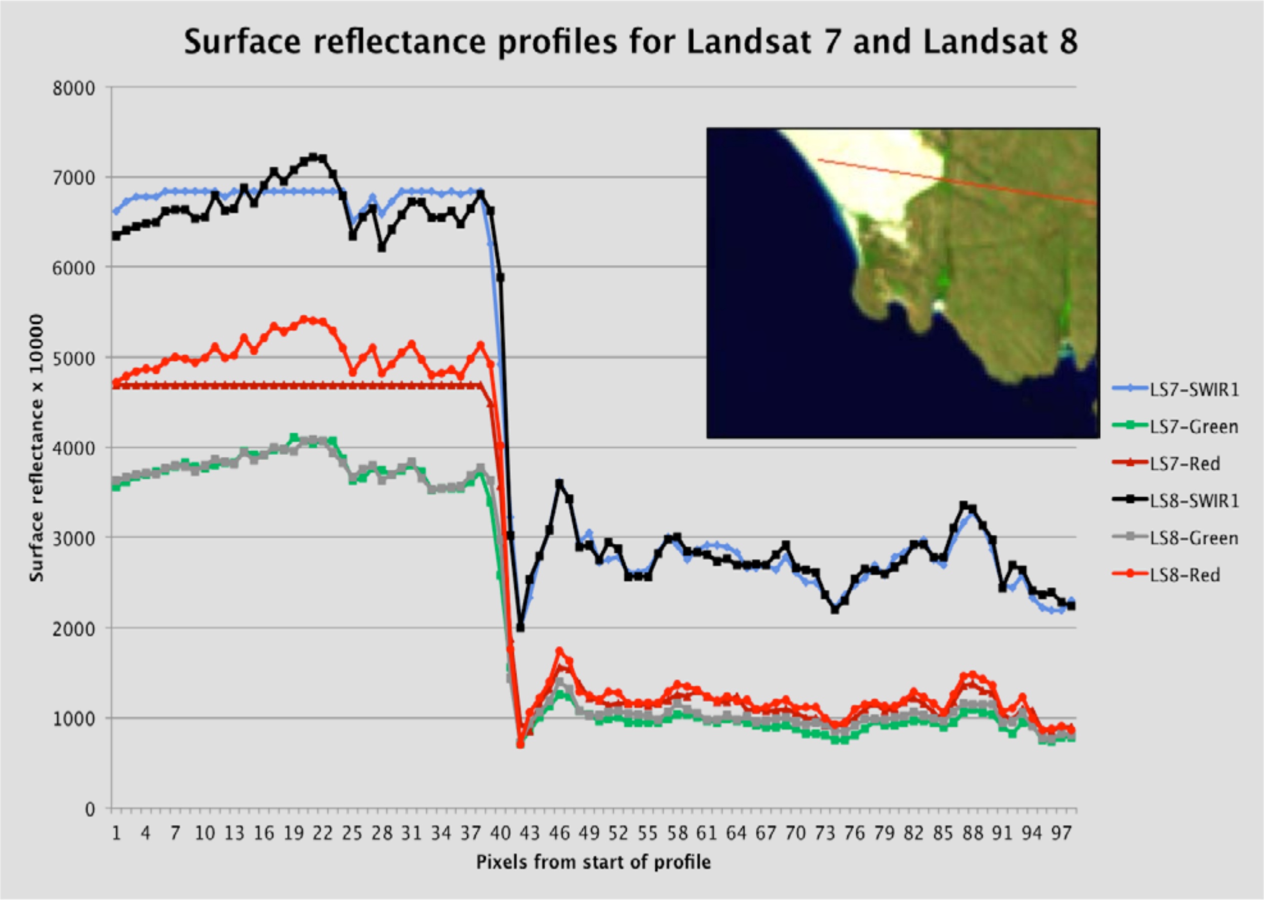


Landsat 7 LC

Landsat 8 LC

In classification tests over New Orleans and Boston, Landsat 8 land cover results were 19.5% better than Landsat 7.

Landsat 8's 12-bit quantization eliminates bright target saturation

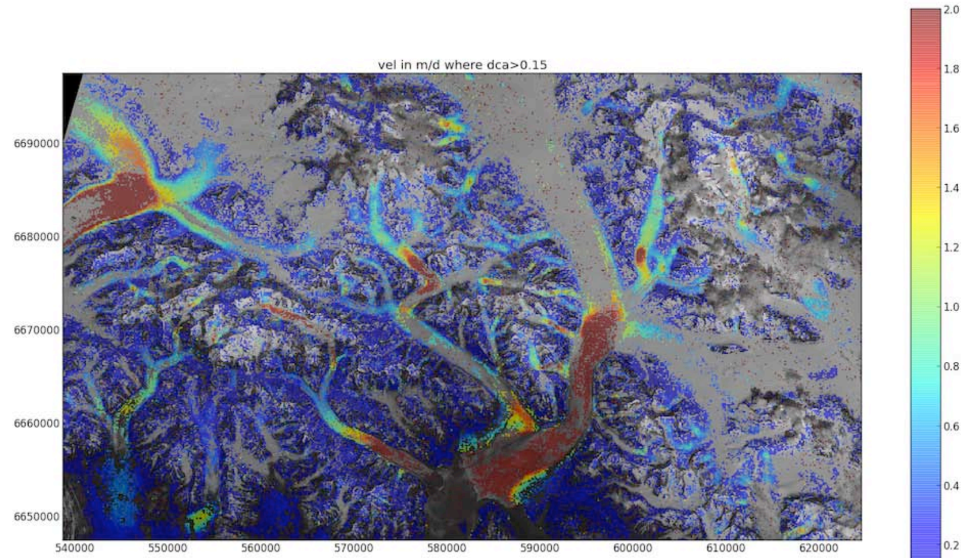


•

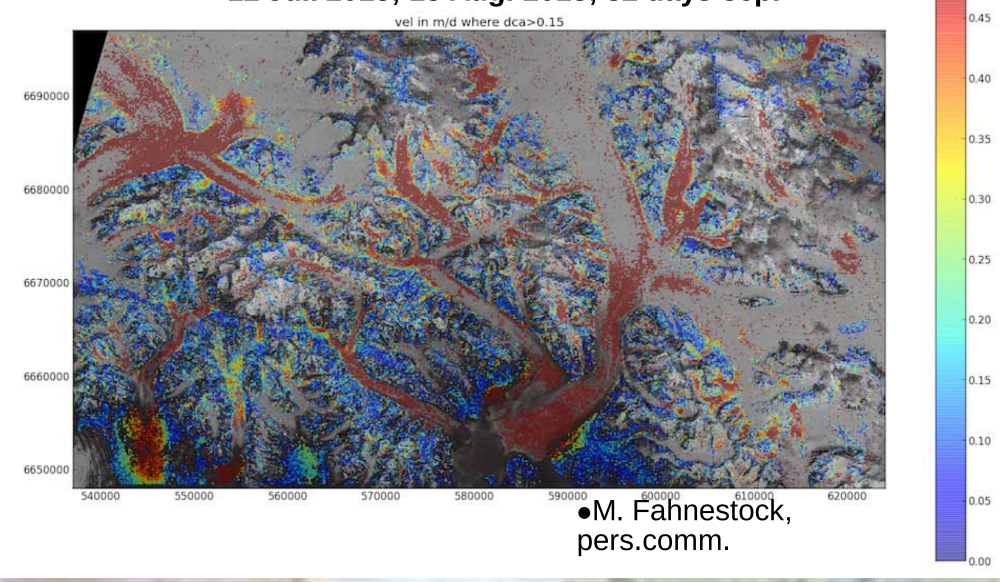
Improved Landsat 8 geodetic control allows accurate measurement of ice motion

- The high precision of L8 scene geo-location, as well as the improved radiometric fidelity, is enabling accurate measurement of glacial ice motion.

- Using pairs of Landsat 8 panchromatic bands, 0.3 pixels (about 5 meters) of ice motion were detected over a 32 day period in the summer of 2013.



- **Hubbard Glacier, Alaska P61 R018**
- **12 Jul. 2013; 13 Aug. 2013; 32 days sep.**



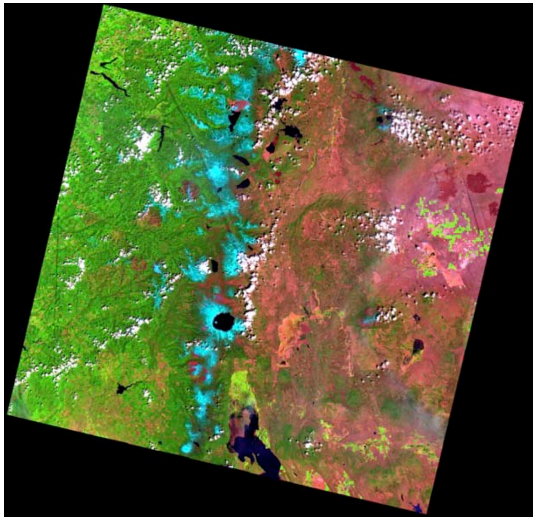
- M. Fahnestock, pers.comm.

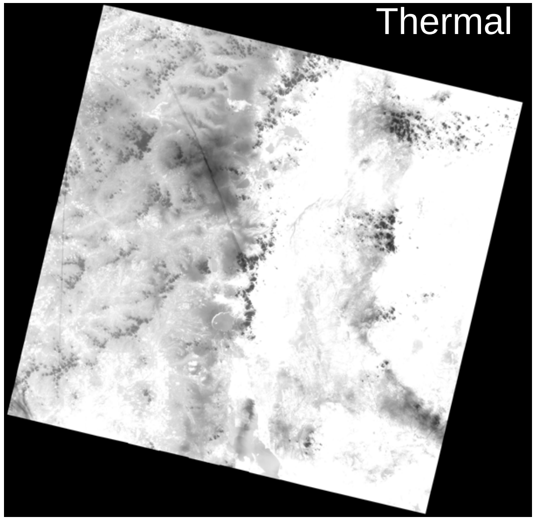
USGS

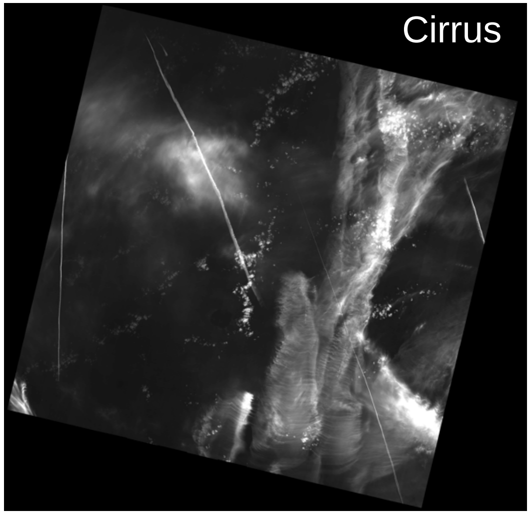
Coast aerosol band and improved radiometry benefits water quality studies

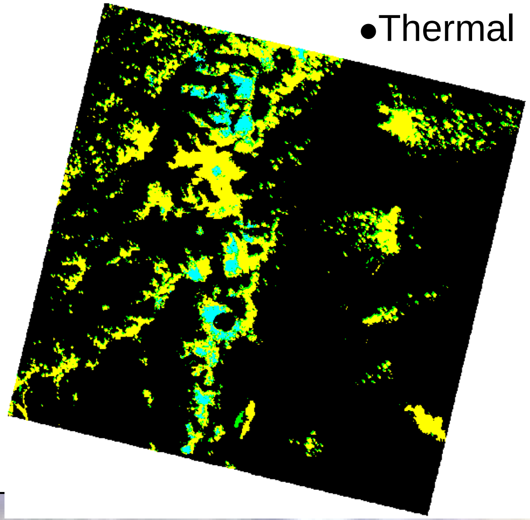
- Analysis by John Schott, RIT, demonstrates that Landsat 8 performance is sufficient to measure chlorophyll, colored dissolved organic material, and suspended materials in near shore areas.

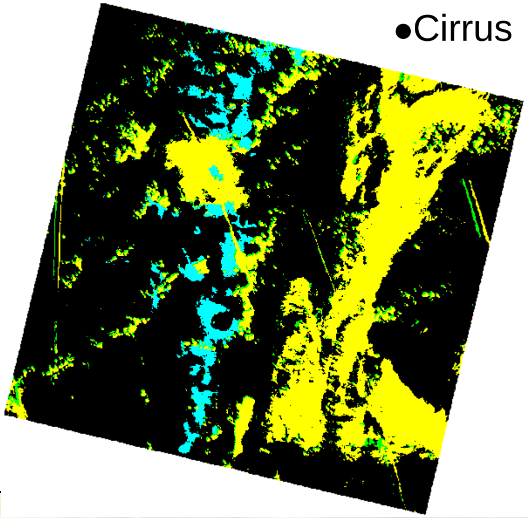
Landsat 8's cirrus band improves cloud detection











USGS

•Zhe Zhu

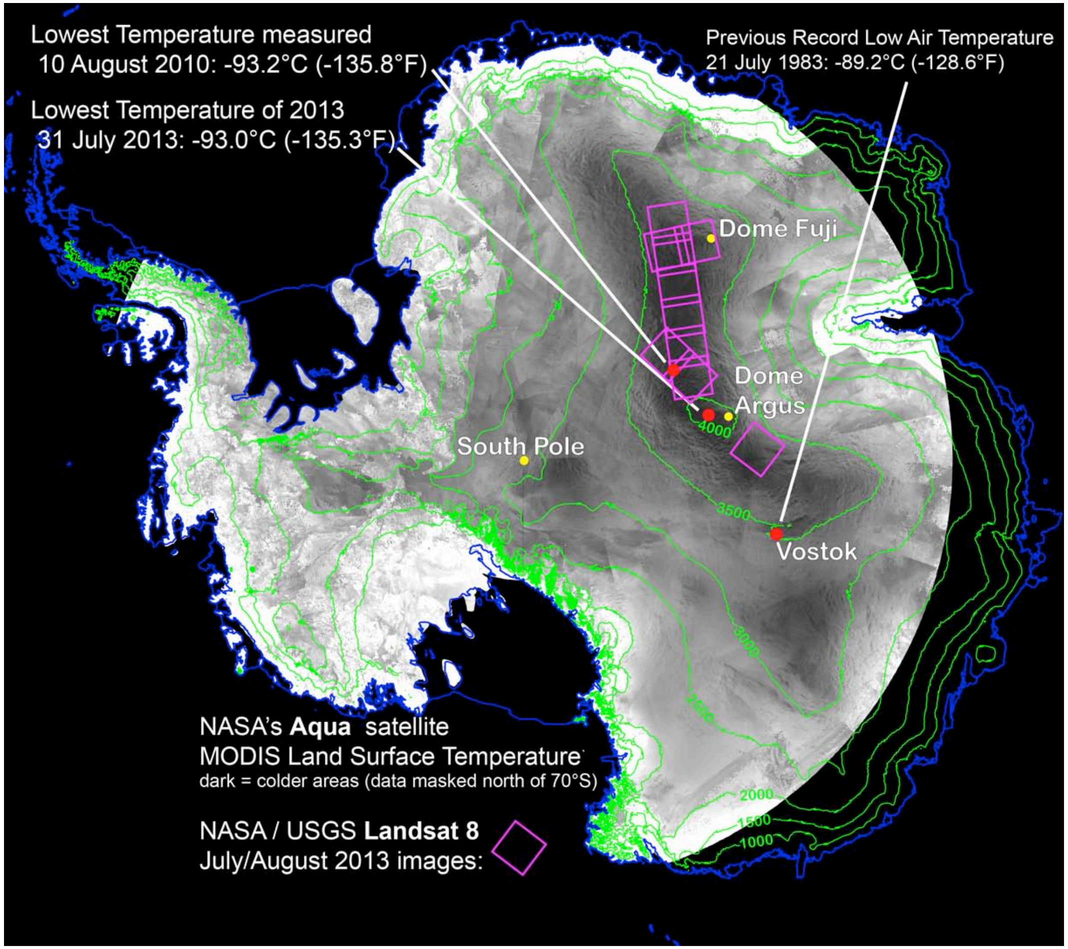
BOSTON UNIVERSITY

Landsat 8 measures the coldest place on Earth

- Temperatures from −134 to −137 F in a 1,000-kilometer long swath on the highest section of the East Antarctic ice divide.

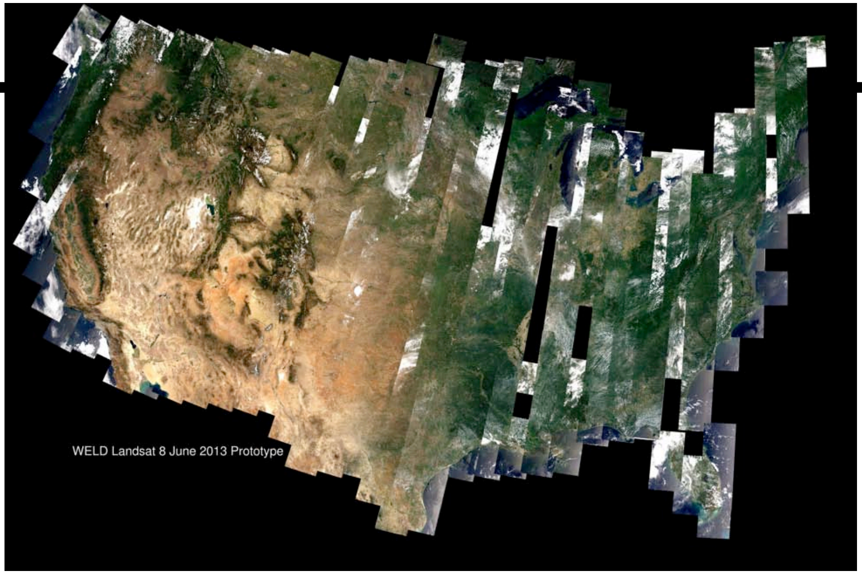
- The measurements were made between 2003-2013 by MODIS and during the 2013 Southern Hemisphere winter by Landsat 8.

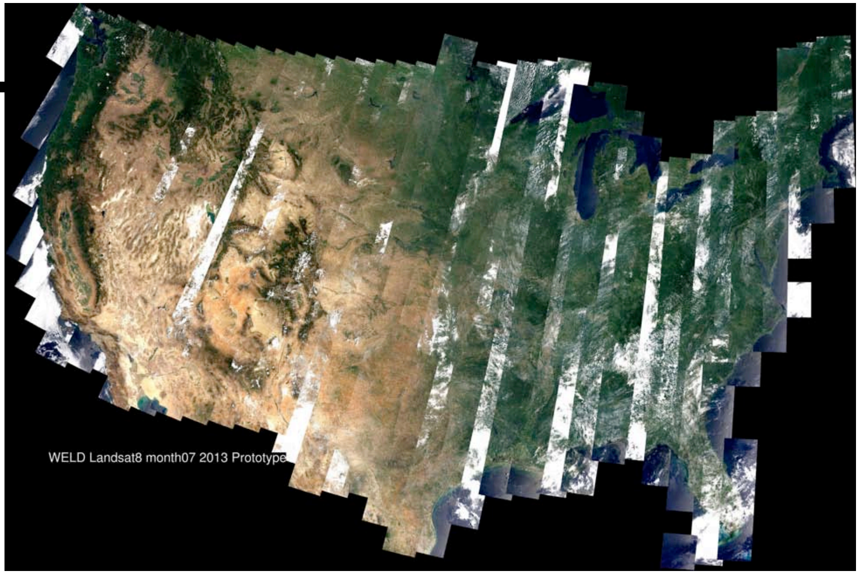
- "Landsat 8 is still a new sensor, but preliminary work shows its ability to map the cold pockets in detail," Scambos said. "It's showing how even small hummocks stick up through the cold air."

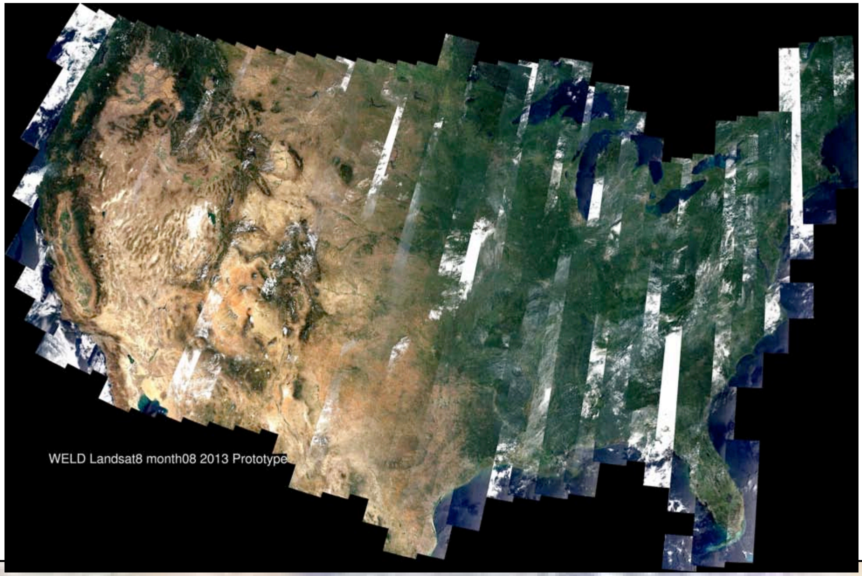


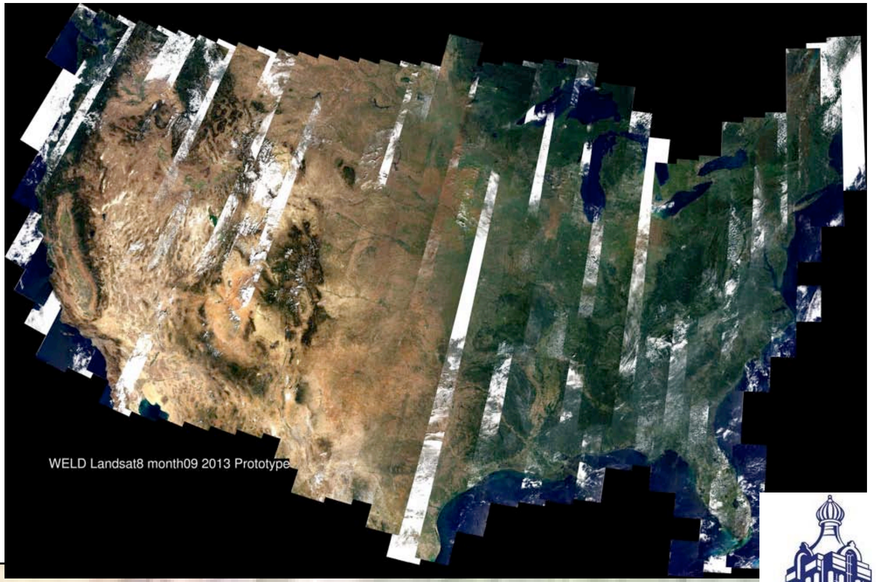
(Ted Scambos, U of Colorado)

Landsat 8 Web-Enabled Landsat Data







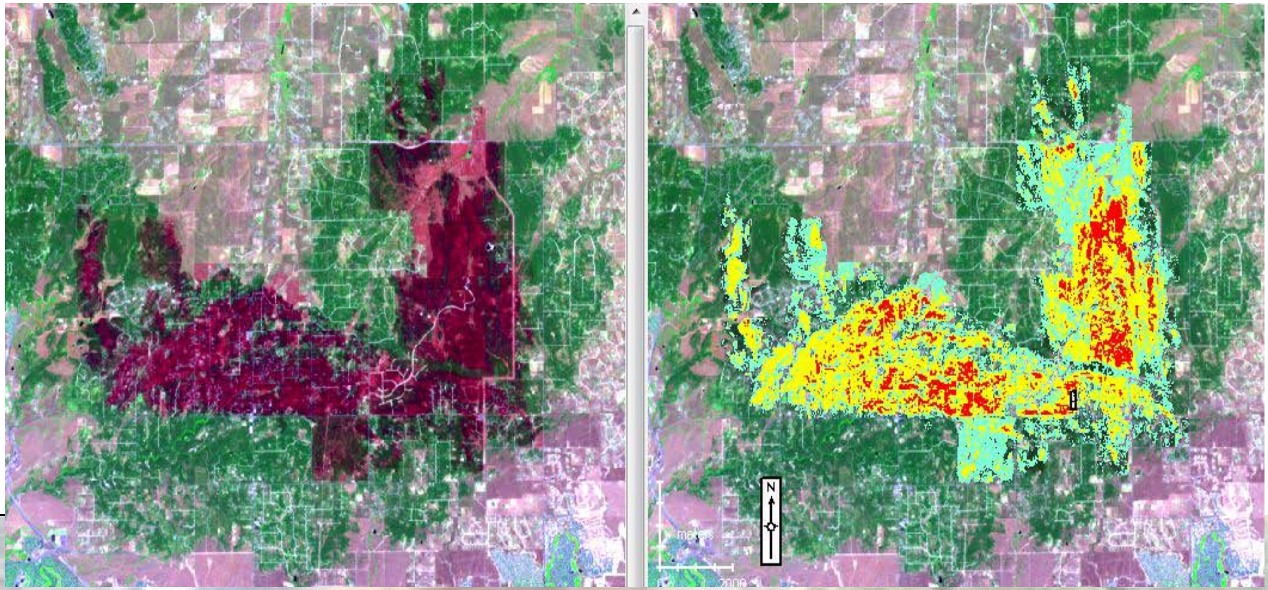


David Roy, SDSU

EROS science and applications using Landsat 8

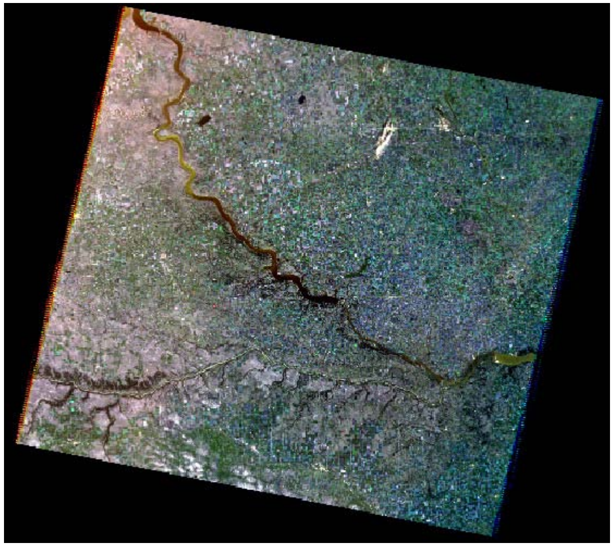
- More than 5500 Landsat 8 scenes used for 2013 LandFire update
- Used in 2013 Monitoring Trends in Burn Severity project
- Providing NLCD with improved shrub land maps
- Early use of Landsat 8 data in WaterSMART indicates improved quality and accuracy of evapotranspiration

Black Forest Fire, Colorado Springs: Courtesy of Randy McKinley, USGS EROS

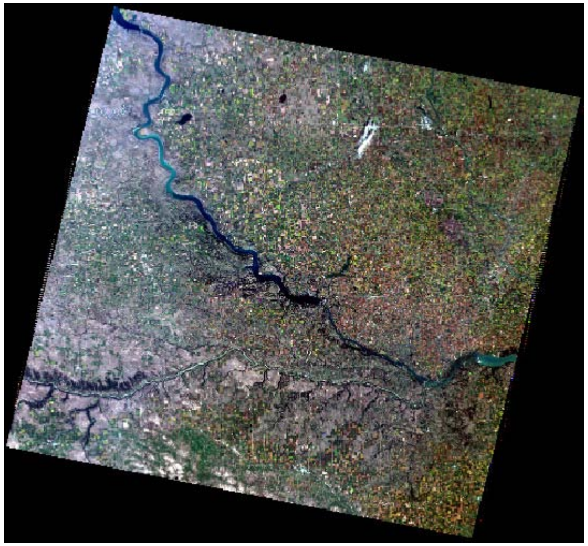


Prescriptive Levels of Processing

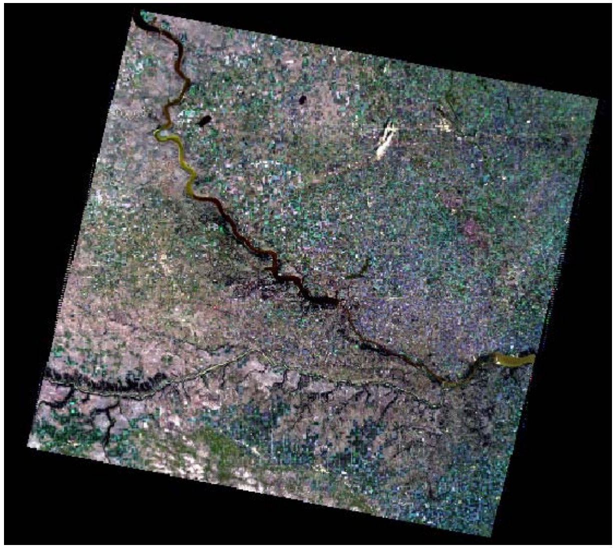
Provide users with the product most suitable to their needs



Scaled DNs



TOA Reflectance



Surface Reflectance

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

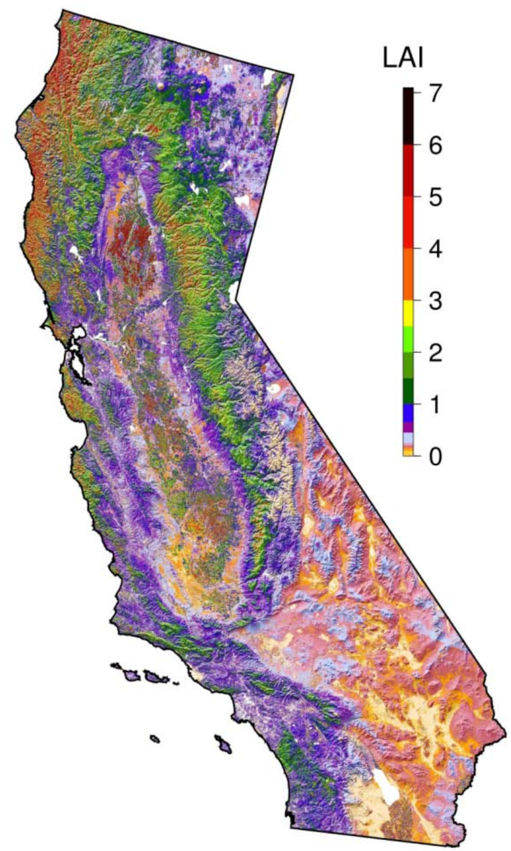
http://earthexplorer.usgs.gov

Moving from Data to Information

L1T At-sensor Radiance (FCDR)

Surface Reflectance (TCDR)

Leaf Area Index (ECV)



(Nemani, NASA)

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)

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]

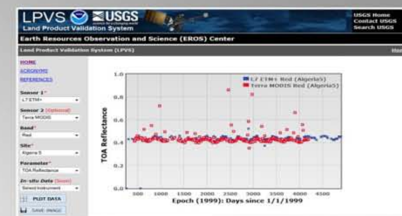
[1]National Oceanic and Atmospheric Administration (NOAA) National Environmental Satellite, Data, and Information Service (NESDIS) visiting scientist at U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD 57198 U.S.A.
[2]Technical Support Services Contract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



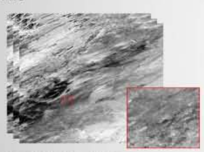
https://calval.cr.usgs.gov/lpvs/ajax.php

INPUT: Multiple Satellite Products

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

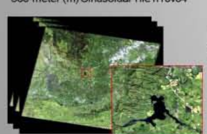
Terra MODIS

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

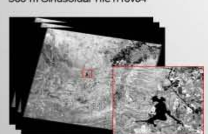


MOD13A1 16-Day NDVI
500-m Sinusoidal Tile h10v04

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

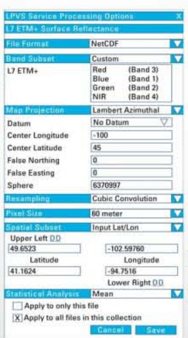
SERVICE PROCESSING OPTIONS

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

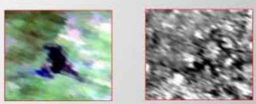
6 Pixel Size
- 30-meter
- 60-meter
- 120-meter
- 250-meter
- 370-meter
- 500-meter
- 740-meter
- 1000-meter
- 2000-meter

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

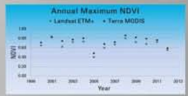
OUTPUT: Processed Products with Statistics

MODIS tile reprojected, resampled, and subset to match Landsat scene extent.

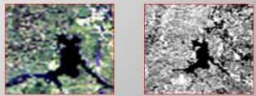
MODIS tile reprojected to Lambert Azimuthal and resampled to 250-m.



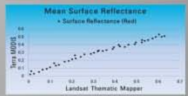
MODIS Surface Reflectance (left) and NDVI (right) reprojected, resampled, and subset to area of interest over Angostura Reservoir near Hot Springs, SD (Lambert Azimuthal, 250-m).



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.

Cross-calibration of Landsat with multiple satellites

Remote Sensing Technologies

understanding the technologies needed to sense our world

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 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

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

March 23-27, 2014, Louisville, Kentucky

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

National Aeronautics and Space Administration
Goddard Space Flight Center

Search

Flight Projects | Sciences and Exploration

Sustainable Land Imaging Architecture Study

Sustainable Land Imaging Users Forum

Time: 1:00 - 4:15 p.m. EST
Date: Wednesday, December 4, 2013
Location: NASA Goddard Visitors Center Auditorium, 8800 Greenbelt Rd., Greenbelt, Md., 20771.

- **Register for this Event**
  Capacity Note: Onsite-attendance will be limited by seating capacity to 124.

On December 4, the U.S. Geological Survey (USGS) and NASA will host an event in which leadership from both agencies will provide details about how user needs will be assessed to help inform NASA's Sustainable Land Imaging Program. User requirements are a critical source of information used as input to help inform the design and implementation of future spaceborne systems intended to provide global, continuous Landsat-quality visible to shortwave infrared and thermal infrared measurements for at least the next 25 years. The USGS has been developing a structured methodology for acquiring, cataloging, maintaining and evaluating user requirements for Earth observations through its Land Remote Sensing Program, which manages the USGS contributions to the joint efforts of USGS and NASA for the Landsat program. The Users Forum will feature the methodologies and approaches the USGS is utilizing to acquire and evaluate user requirements and will present some findings and evaluations that can be applied to design considerations for the development of the future architecture. The forum will include presentation of methods and preliminary findings, and will offer opportunities for feedback with regard to the approach and requirements gathered to date. The requirements component will be described in the context of our upcoming planning timeline and identify opportunities and processes for providing input into our planning. This is a notice of a meeting, not a solicitation of any kind.

WebEX and Conference Call In Information

Topic : (100) USGS User Requirements Forum (100)
Date : Wednesday, December 4, 2013
Time : 12:45 pm, Eastern Standard Time (New York, GMT-05:00)
Meeting number : 714 481 217
Meeting password : (This meeting does not require a password.)

- **Join the meeting**

Users Forum Documents

- **Sustainable Land Imaging Users Forum : Operational Uses of Landsat Data** ***[J. Dwyer, 12.04.2013]***
- **Sustainable Land Imaging Architecture Study Team User Forum Panel Session**
- **Application Requirements Worksheet (.pdf) | (.xlsx)**

Request for Information

- **Get Information on RFI**

FAQ

- **Frequently Asked Questions**

Reference Documents

- **Industry & Partner Day Presentations** ***[9.18.2013]***
- **Landsat and Beyond: Sustaining and Enhancing the Nation's Land Imaging Program**

Related Links

USGS

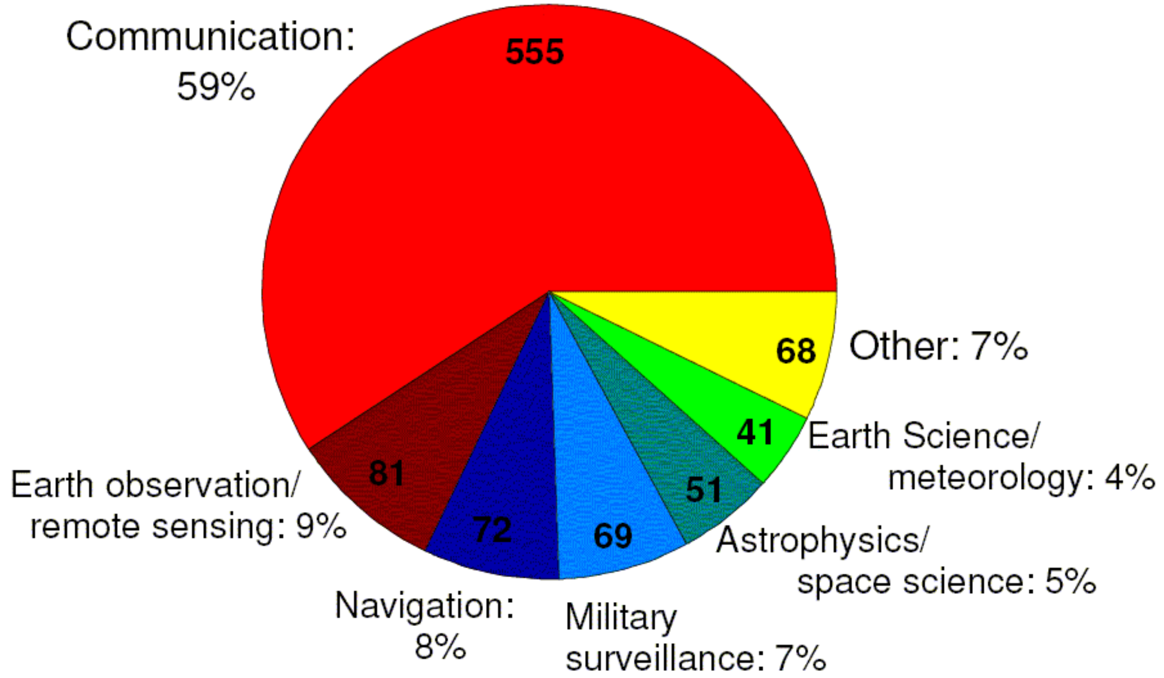
http://espd.gsfc.nasa.gov/landimagingstudy/

Multiple Earth Observation (EO) Satellites

• The Number of EO Satellites is Growing

- There are 80+ RS satellites in orbit now; so much data
- Sensor and processing capabilities are continually improving
- How well do they work and do they meet user requirements?
- UAS and Aerial remote sensing systems growing just as fast

• "Over the next decade more than 280 Earth-observation-satellite systems are expected to be launched into orbit"
– *Aviation Week & Space Technology*



•*Current Satellites in Orbit*

USGS

Many EO Systems

- http://www.eohandbook.com/
- List of EO systems and search database

- Agency Current and Future Missions

Agency	Country	Agency Website	# Missions	# Instruments
ASI	Italy	click here	13 - timeline	16
BELSPO	Belgium	click here	1 - timeline	-
CAST	China	click here	12 - timeline	36
CDTI	Spain	click here	3 - timeline	3
CNES	France	click here	26 - timeline	32
CONAE	Argentina	click here	9 - timeline	21
CRESDA	China	click here	8 - timeline	6
CSA	Canada	click here	15 - timeline	13
CSIRO	Australia	click here	-	2
DLR	Germany	click here	10 - timeline	8
EC	Europe	click here	14 - timeline	8
ESA	Europe	click here	37 - timeline	38
EUMETSAT	Europe	click here	23 - timeline	22
GISTDA	Thailand	click here	1 - timeline	2
INPE	Brazil	click here	5 - timeline	6
ISRO	India	click here	26 - timeline	32
JAXA	Japan	click here	14 - timeline	13
JMA	Japan	click here	4 - timeline	7
KARI	Korea	click here	7 - timeline	9
METI	Japan	click here	1 - timeline	2
NASA	U.S.A.	click here	48 - timeline	83
NASRDA	Nigeria	click here	2 - timeline	2
NOAA	U.S.A.	click here	35 - timeline	49
NRSCC	China	click here	17 - timeline	20
NSAU	Ukraine	click here	1 - timeline	5
NSC	Norway	click here	4 - timeline	2
NSMC-CMA	China	click here	17 - timeline	22
ROSHYDROMET	Russia	click here	17 - timeline	28
ROSKOSMOS	Russia	click here	17 - timeline	33
SANSA	South Africa	click here	-	-
SNSB	Sweden	click here	1 - timeline	3
TUBITAK	Turkey	click here	1 - timeline	2
UKSA	United Kingdom	click here	2 - timeline	4
USGS	U.S.A.	click here	2 - timeline	3
Total Intruments				532

USGS

Moderate Resolution Satellite Imagery

•UK DMC-2
(22m)

•Chinese BeijingSat
(32m)

•Canadian RapidEye
(5m)

•Indian LISS-4
(5.8m)

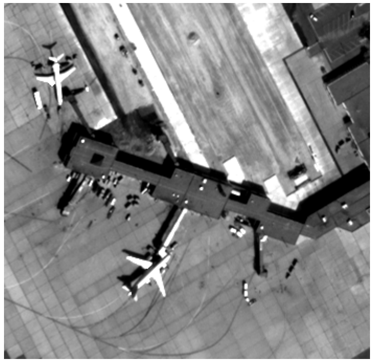
•US Landsat-8
(30m)

•Imagery over Sioux Falls SD Test Range & Airport

•(Image Credit to each satellite operator)

USGS

High Resolution Satellite Imagery

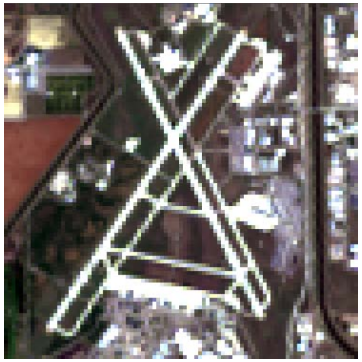


•US WorldView-1 (0.6m) image of the city of Sioux Falls, SD airport

•Canadian RapidEye-3 (5m) image of the city of Sioux Falls, SD airport

•French Pleaides-1a (0.5m) image of the city of Sioux Falls, SD airport

•Vietnam VNREDSat-1 (2.5m) image of the city of Melbourne, Australia

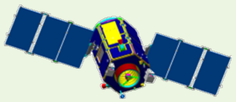
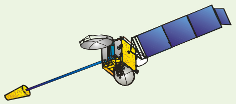


•US Landsat-8 (30m) for resolution comparison

•(Image Credit to each satellite operator)

Space Program in KARI

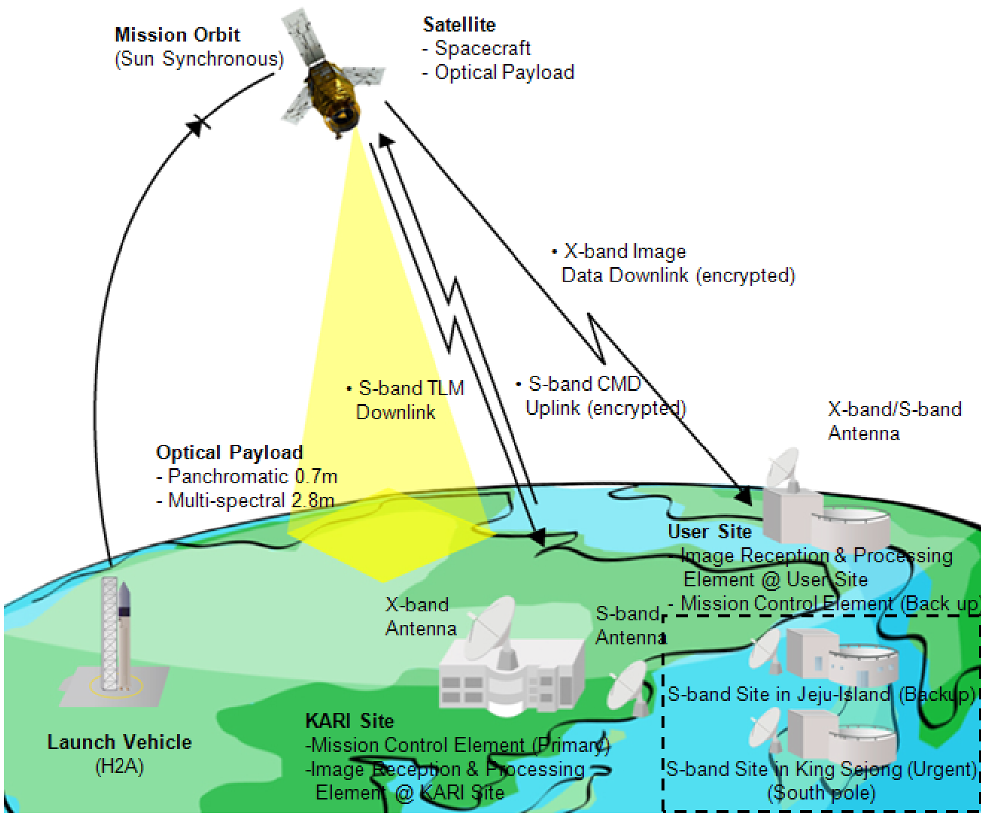
- Korea Aerospace Research Institute (KARI) - Government Funded Space Research Institute from 1989. **Dr. DongHan Lee at USGS EROS for 1 year.**

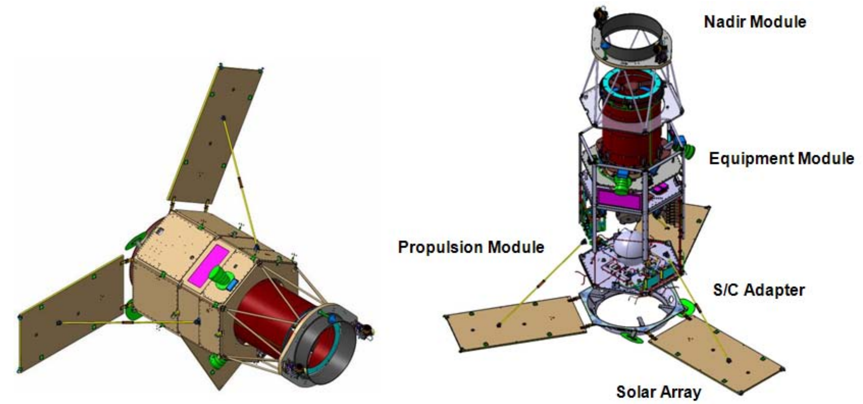
	KOMPSAT-1	KOMPSAT-2	KOMPSAT-3	KOMPSAT-5	COMS	KOMPSAT-3A
						
Payload	EOC, OSMI	MSC	**AEISS**	COSI	MI, GOCI	KISS
	Visual	Visual	**Visual**	SAR-X	Meteorology	Visual+MWIR
Launch	1999~2008	2006~	**2012.5~**	2013.7~	2010~	2014
Performance	6.6m (EOC) 1km (OSMI)	1m, 4m 10bit	**0.7m, 2.4m 14bit**	1m, 3m X-band	500m	0.55m, 2.2m 5.5m (MWIR)
Image mode	Strip	Strip	**Spot, Strip, Wide**	HR, Strip, Wide		Spot, Strip, Wide
Swath	15km	15km	**15km**	15km	2,500km	15km
Orbit	Geo-sync	Geo-sync	**Geo-sync**	Geo-sync	Geo-Station	Geo-Sync

KOMPSAT-6 (SAR) & COMS-2 will be developed by KARI after KOMPSAT-5 & COMS

USGS

KOMPSAT-3 Overview





System Attributes	Requirement
Design lifetime	4 years
Operation frequency	X-band
Ground Sample Distance (GSD)	**PAN : 0.7 m @ altitude 685 km(nadir)** **MS : 2.8 m @ altitude 685 km(nadir)**
Spectral Band	PAN : 450 ~ 900 nm MS1 (Blue): 450 ~ 520nm MS2 (Green): 520 ~ 600nm MS3 (Red): 630 ~ 690nm MS4 (NIR): 760 ~ 900nm
Swath Width	PAN : 15 km, MS: 15 km @ nadir
Duty Cycle	10% per orbit (50 minutes per day)
Modulation Transfer Function (MTF)	System MTF at Nyquist fr. for PAN : 8% System MTF at Nyquist fr. for MS : 12% (at strip imaging mode)
Data Storage	512 Gbits
Compression	JPEG2000-like
Radiometric Resolution	14 bits
CCD	64 TDI Pushbroom

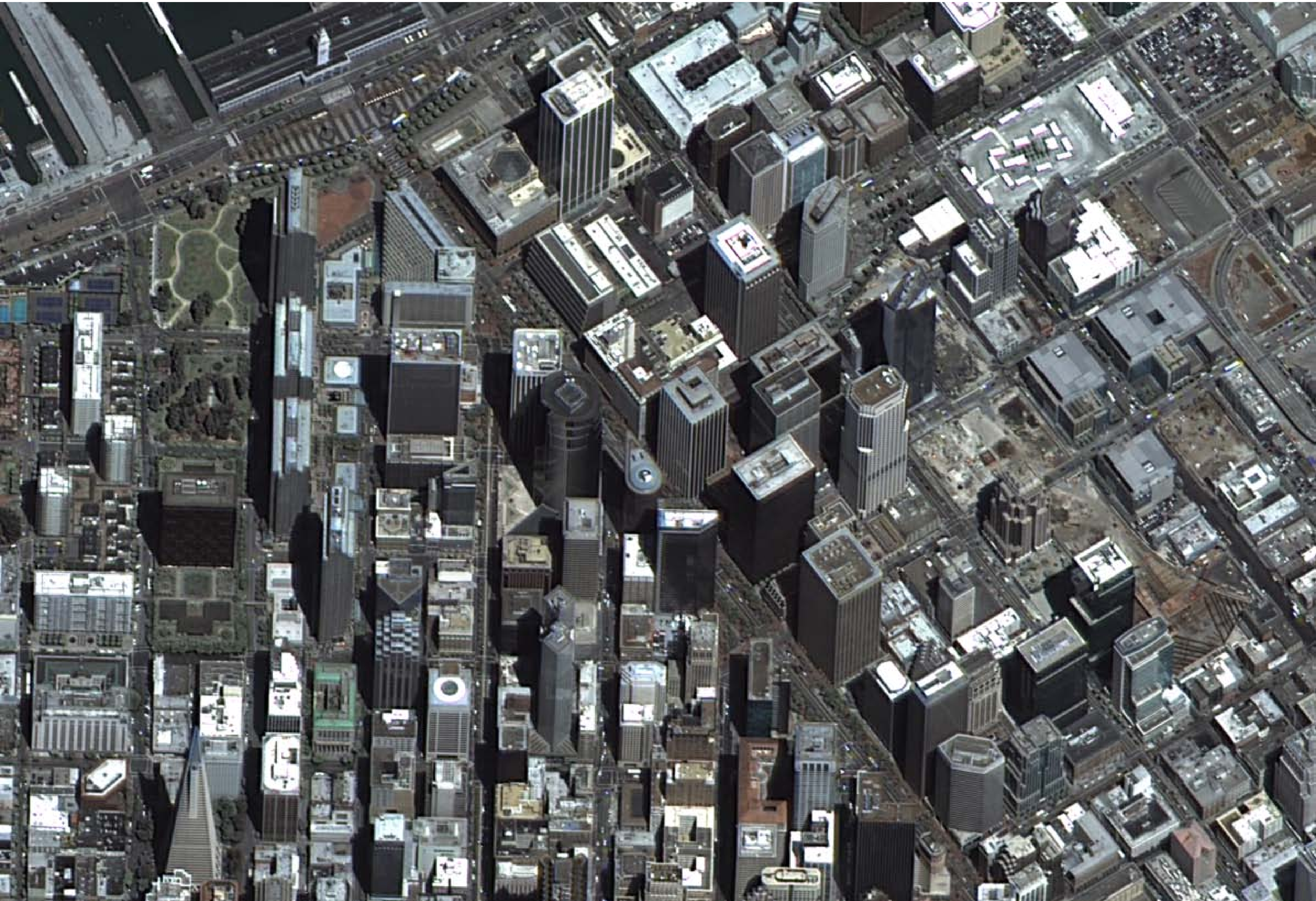
Parameters	Value
Nominal Orbit Altitude at the Equator	685.13km (Sun synchronous orbit)
Inclination	98.13°
Mean Local Time of Ascending Node	13:30
repeat ground track	409 orbit per 28 day
Imaging mode	Strip, S-Stereo, Multi-P, Wide

KOMPSAT-3 Product's Quality

Item		Strip		Multi & One pass stereo		Remark
		Level1R (Basic)	Level1G (Standard)	Level1R (Basic)	Level1G (Standard)	
GSD		PAN:0.7m, MS:2.8m (Nadir)				
Pointing Accuracy (Targeting Accuracy)		1200m (3 sigma)				
Location Accuracy		285m CE90 70m CE90 (Opt.)	< 70m CE90		< 70m CE90	With POD & PAD data after 1 day
Radiometric Accuracy	Dynamic range	14bit (0~16383)				
	SNR	> 200				
	MTF (Before / After MTFC)	8~10% / 13~20% (PAN) 19% (MS)*		8~10% / 13~20% (PAN) Less than 19% (MS)*		
Length distortion		< 2 pixel				
Registration Accuracy		0.5pixel 2σ (only MS)	0.5pixel 2σ	0.5pixel 2σ (only MS)	0.5pixel 2σ	
Mapping (Ortho.)					1 : 5,000	
Imaging mode		Strip, Multi-point, Single pass Stereo, Wide area (#)				

- (*) No MTFC on MS
- (#) Quality on Wide area imaging can't be guaranteed.
- (#) Quality on Short term Multi-point imaging can't be able to complied with the qualities in the table.

KOMPSAT-3, San Francisco (with initiai. MTFC before Cal/Val), 2012.08.10



SPOT6 Image data Information

Draft Preliminary information, for March JACIE Workshop

Product Level	GSD		Band	MTFC (XML)	Compress (XML)	Comment
	Document (XML)	Image data				
Pueblo	(P) 2.10m x 2.20m (M) 8.40m x 8.80m	(P) 1.51m x 1.49m (M) 6.00m x 6.00m	PAN MS1, MS2, MS3, MS4	(P) True (M) False	Lossless	Ortho Bundle GeoTIFF
Sioux Falls	(P) 2.11m x 2.24m (M) 8.44m x 8.96m	(P) 1.51m x 1.50 m (M) 6.00m x 6.00m	PAN MS1, MS2, MS3, MS4	(P) True (M) False	Lossless	Ortho Bundle GeoTIFF
Sioux Falls	2.11m x 2.24m	1.12m x 1.54m	PAN+MS1 PAN+MS2 PAN+MS3 PAN+MS4	(P) True (M) False	Lossless	Ortho PAN-sharpened 4-Band GeoTIFF

Band Combination products	Image files (*)	Number of band
Panchromatic (Black and White, 1.5m)	1	1
Pan-sharpened 3-Band (Natural Color, 1.5m)	1	3
Pan-sharpened 3-Band (False Color, 1.5m)	1	3
Pan-sharpened 4-Band (Color, 1.5m)	1	4
Multispectral 4-Band (Color, 6m)	1	4
Bundle (Panchromatic, 1.5m + 4-Band Color, 6m)	1 + 1	1 + 4

(*) Regardless of tiling

TABLE 13: NUMBER OF IMAGE FILES AND OF BANDS PER PRODUCT TYPE

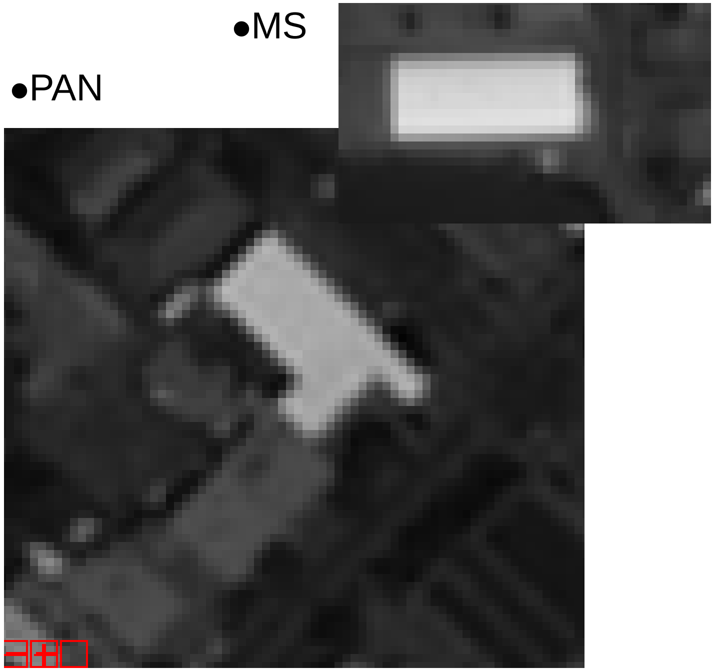
SNR (Pueblo)

Draft Preliminary information, for March JACIE Workshop

- Bright Size of ROI: 24 x 8 (22 x 5)

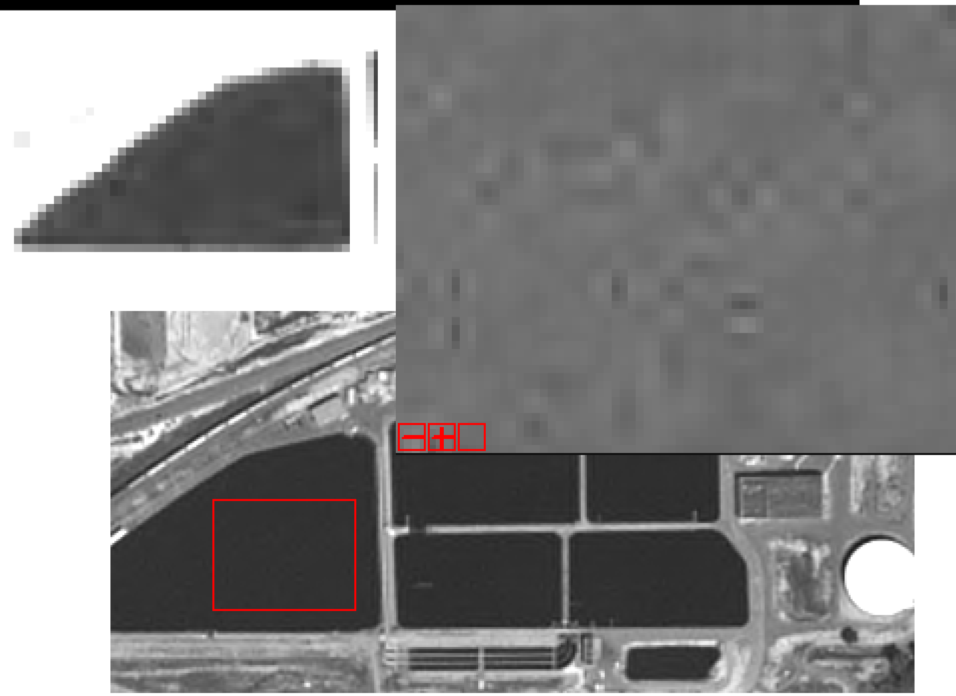
●MS

●PAN



Band	Min	Max	Mean	Std. Dev.
PAN	2659	2855	2719.43	38.83
MS1	2601	2766	2709.88	43.42
MS2	2595	2747	2686.10	43.40
MS3	2287	2422	2367.70	35.78
MS4	2507	2676	2607.23	44.81

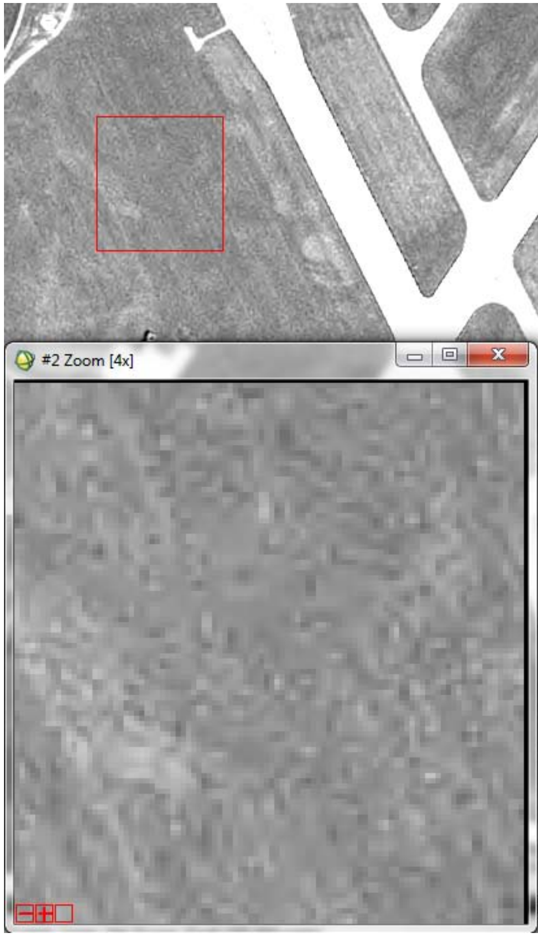
- Dark Size of ROI: 72 x 57 (17 x 10)



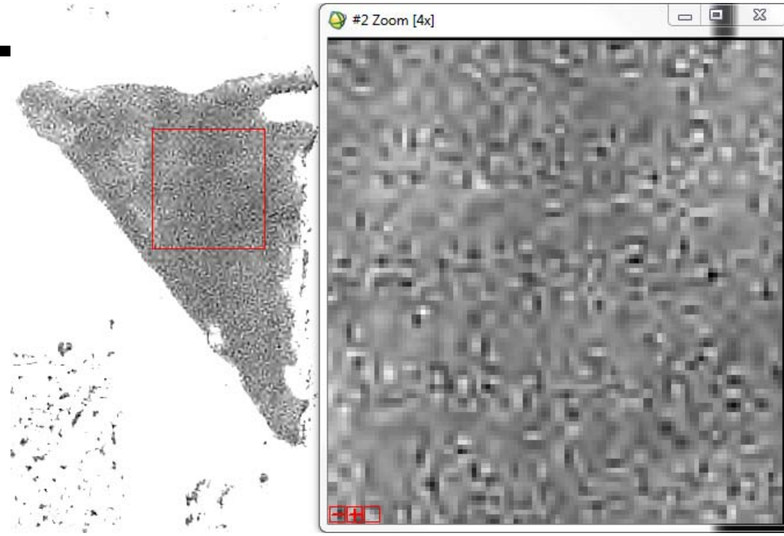
Band	Min	Max	Mean	Std. Dev.
PAN	208	255	233.66	4.09
MS1	161	175	168.75	2.48
MS2	274	286	278.04	2.24
MS3	360	375	366.89	2.19
MS4	103	124	109.11	3.28

Smoothing & Granulating noise (K3)

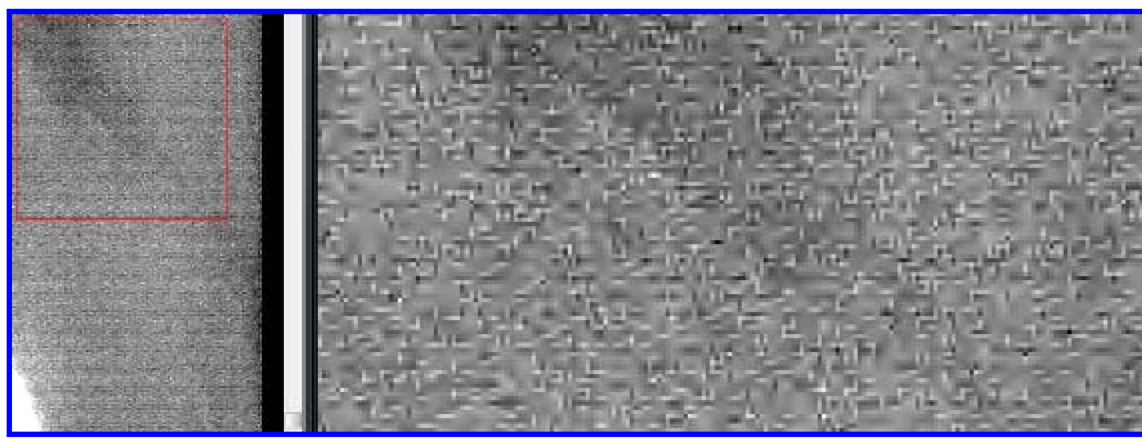
Draft Preliminary information, for March JACIE Workshop



●SPOT6, PAN



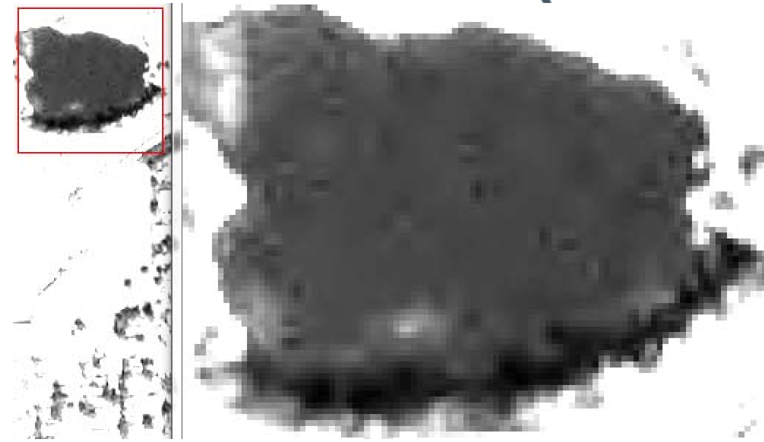
●SPOT6, PAN



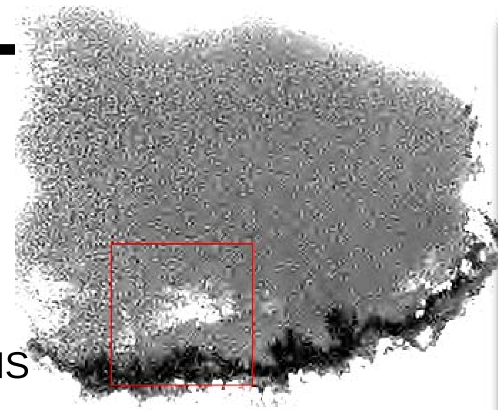
●KOMPSAT-3, PAN (5.5)

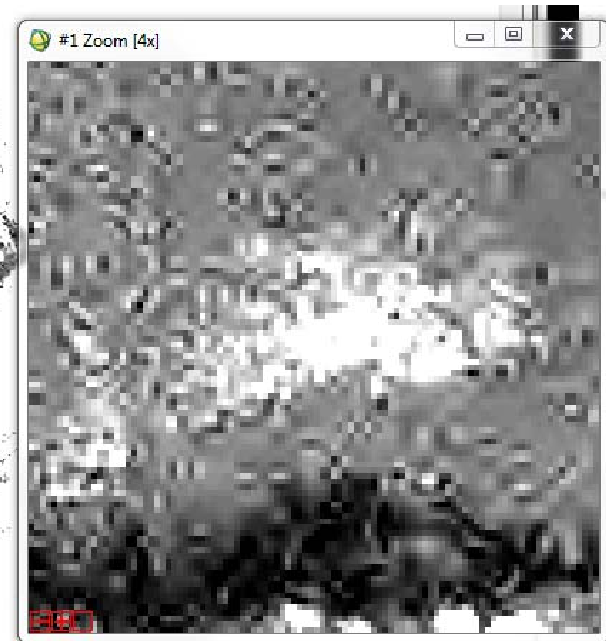
- Smoothing & Granulating noise are same.

Pleiades-1B (LOSSLESS in Metadata)

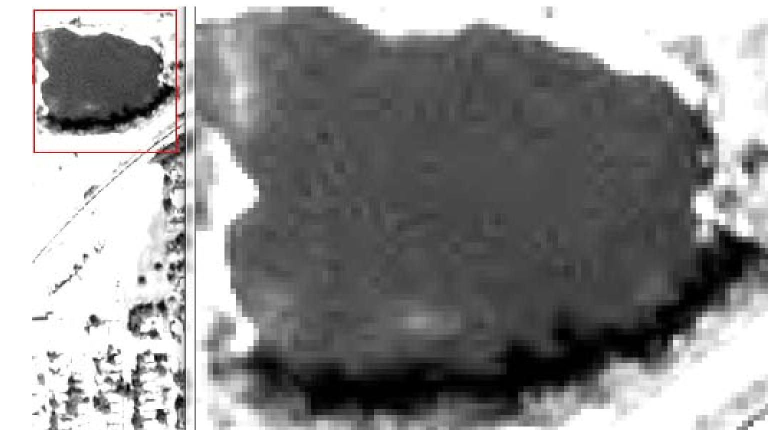


●PAN, Sioux Falls



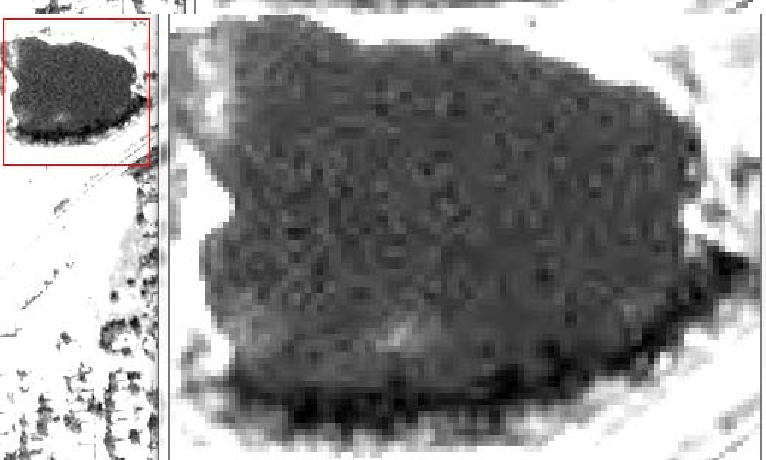


●MS 1

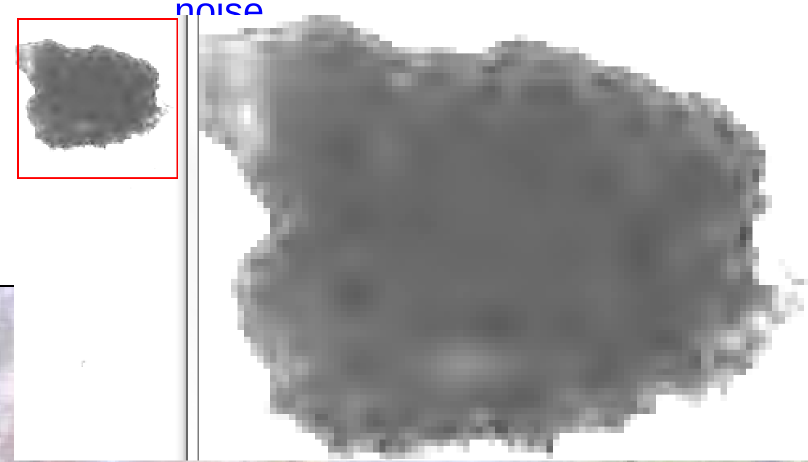


●MS 2

- Smoothing & Granulating noise
- There is little compression noise



●MS 3



●MS 4

Calibrated Imagery Comparison LANDSAT and WorldView-2

DigitalGlobe

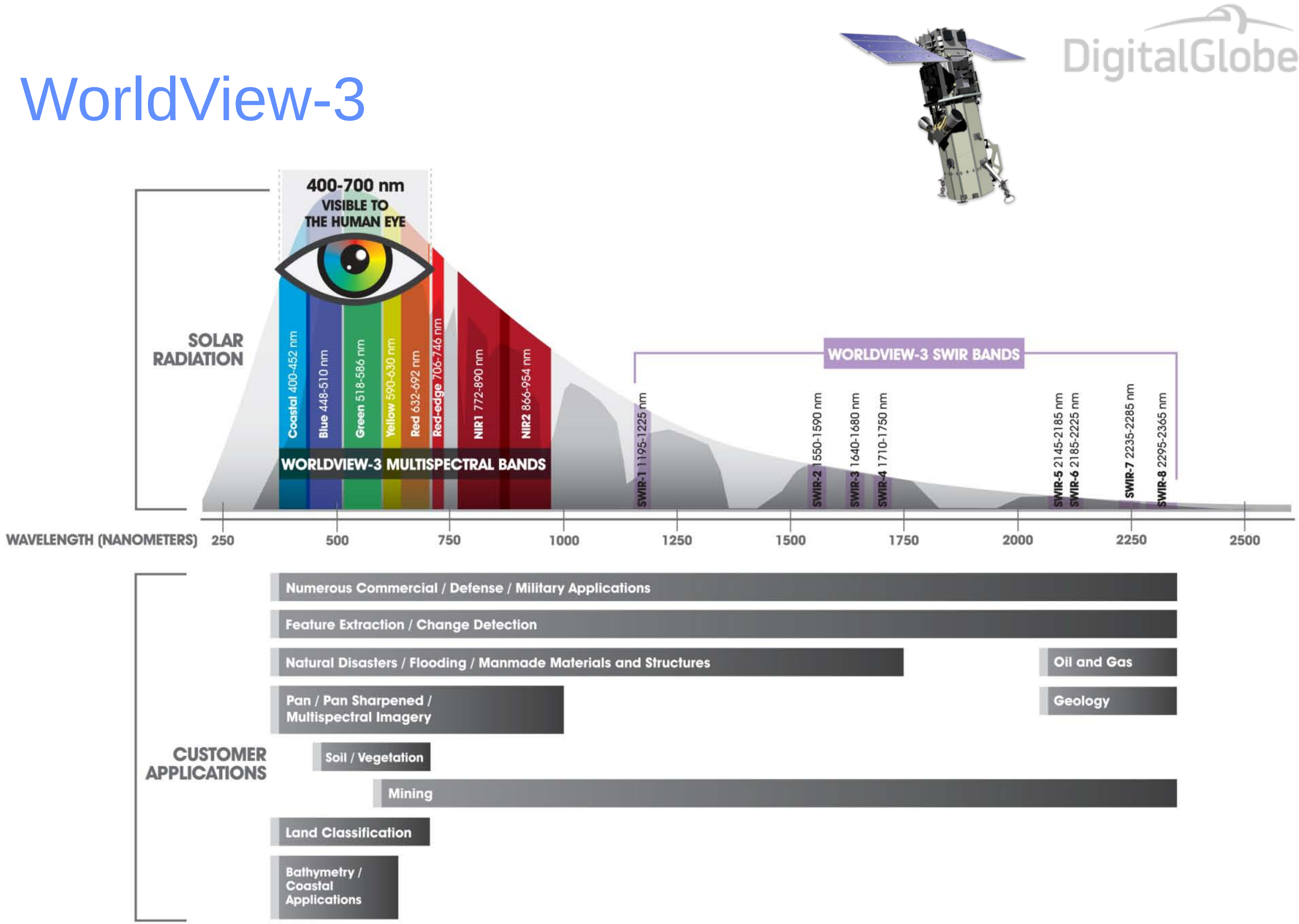
●Moving thought different zoom levels over the same region Landsat imagery shows similar surface candidate areas to WorldView-2 yet Landsat loses definition quickly when moving to a closer scale.

●Landsat
●WorldView-2

USGS

●Courtesy Digital Global JACIE 2013

WorldView-3



USGS

●Courtesy Digital Global JACIE 2013

National Land Imaging Requirements (NLIR) Project

- **USGS started NLIR in 2012**
- **Joint effort with NOAA**
- **Two components:**
  - System Development:
    - Earth Observation Requirements Evaluation System (EORES)
    - Repository for requirements and capabilities information
    - Analytical tools
    - Joint development with NOAA TPIO (Atmosphere & Ocean)
  - User Requirements Collection:
    - All land imaging needs
    - Repeatable and transparent process
    - Traceability of requirements to organizational goals and objectives

Earth Observation Requirements Evaluation System (EORES) and User Requirements Elicitation

Input Sources

- SMEs
- Elicitations
- Analysts
- Observation Requirements
- Observing Systems
- Value Tree Information

Graphical User Interface (GUI)

Next Generation CasaNOSA:

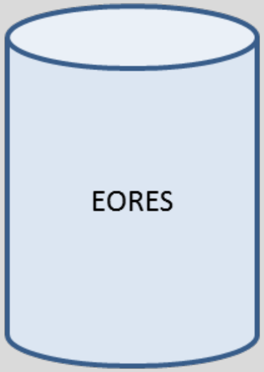
- CORL
- NOSA
- CasRT
- Versioning
- Value Tree Information (VTI), GIS, Archive, SME / Bulk Upload, Off-line Processing

Middleware (MW)

Tools:

- Pushing data to the database
- Pulling data from the database
- Miscellaneous functionality not performed in GUI

Central Repository (CR)



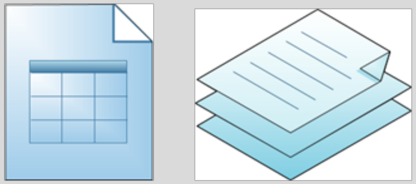
Next Generation Database:

- CORL
- NOSA
- CasRT
- Value Tree Information
- DMS and ABD

Database Functionality:

- Create / Ingest
- Browse
- Maintain
- Export
- Query
- Archive and Versioning

Exports and Reports



Export Functionality:

- PALMA
- Analysis Tools

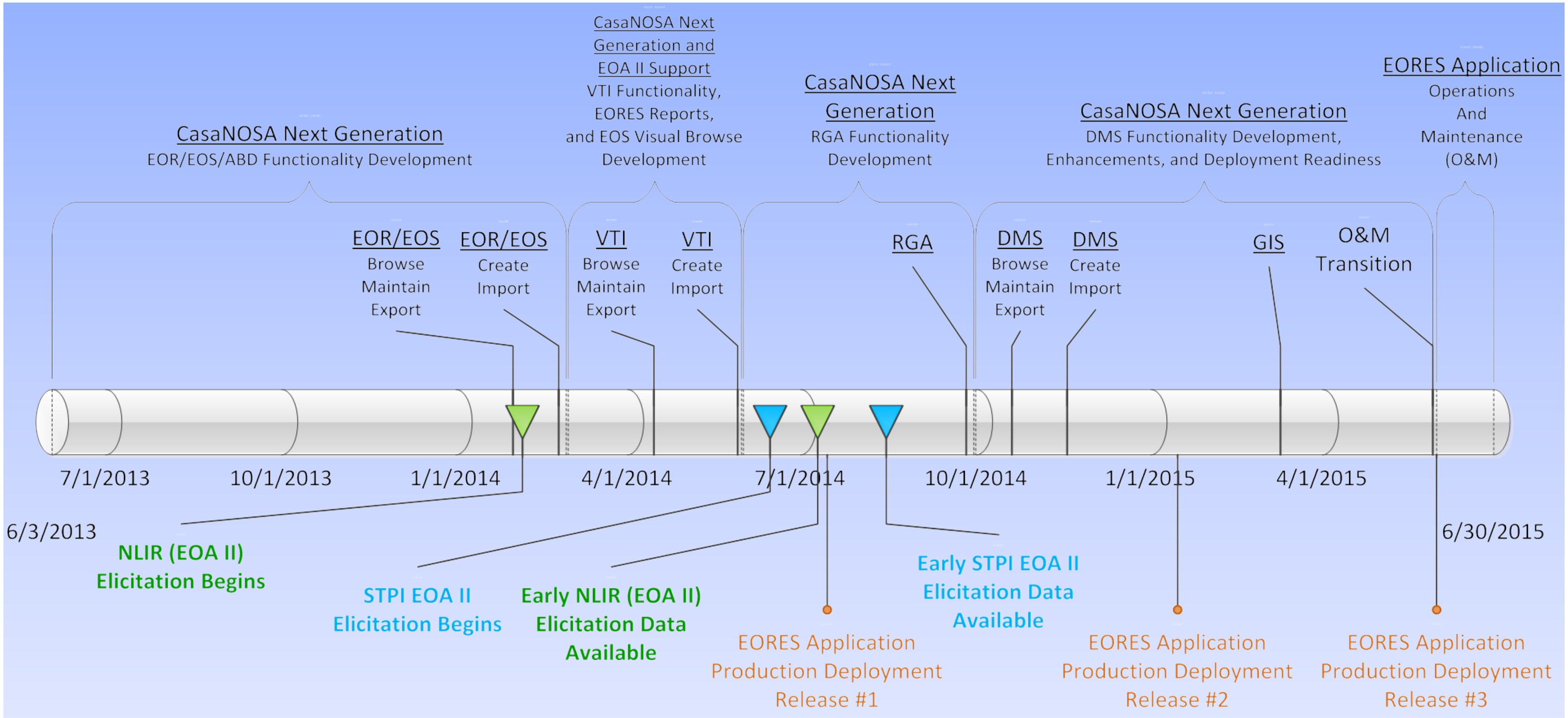
Reports Functionality:

- Observing Requirements
- Observing Systems
- Value Tree Information (VTI)
- Requirements Gap Analysis (RGA)
- "What-If" Analysis
- Database data integrity
- Other reporting as needed.

Visualization and Analysis

Pivot Viewer, Map Viewer, Other Websites, PALMA, Geospatial Analysis Tools, CasRT, Other Analysis Tools

NLIR Schedule



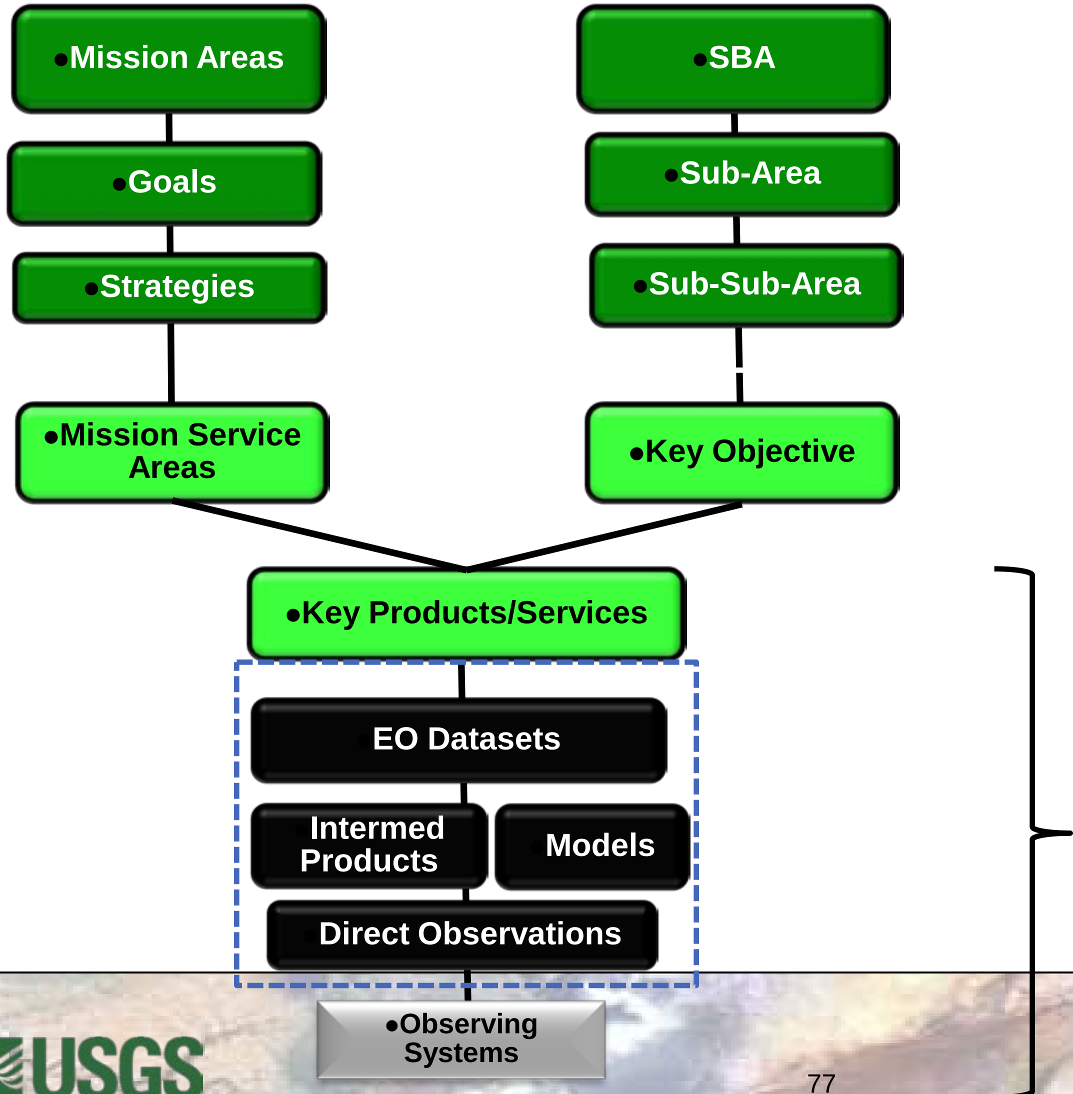
Legend

EOR – Earth Observation Requirements
EOS – Earth Observing Systems
ABD – Administrative and Business Data
VTI – Value Tree Information

RGA – Requirements Gap Assessment
DMS – Data Management Systems
GIS – Geographic Information System

USGS

Organizational vs Societal Benefit Area Value Trees



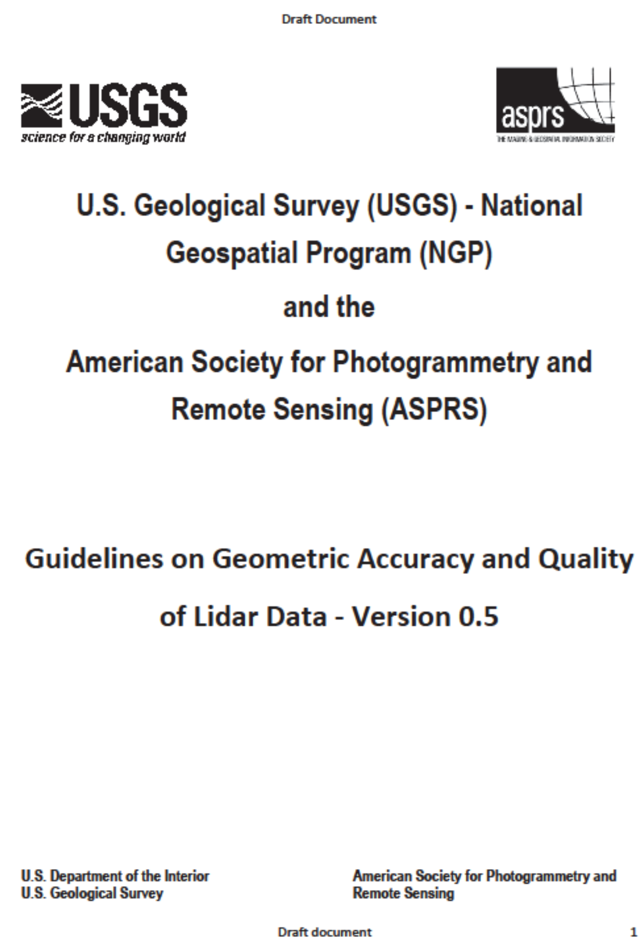
•Key Products/ Services provide a consistent and enduring component that can be mapped/ remapped to any value tree:

- Organizational
- SBA
- Other

Lidar Data Quality

- **LiDAR Data Quality Measures Software Development and Testing**
  - Provide ASPRS community Automated software and documentation to measure internal x,y,z accuracy
  - Focusing on internal LiDAR swath data quality prior to the data production phases
  - Key to development of future 3DEP specification including LiDAR swath quality measures and thresholds

- **LiDAR External Absolute Data Quality Control Procedures and Testing**
  - Provide ground control targets and process to measure and provide absolute x,y,z accuracy with data
  - Test with USGS Liaisons and ASPRS opportunities
  - Provide recommendations in USGS ASPRS LiDAR Quality Guideline


Draft Document

USGS science for a changing world

asprs

U.S. Geological Survey (USGS) - National Geospatial Program (NGP)

and the

American Society for Photogrammetry and Remote Sensing (ASPRS)

Guidelines on Geometric Accuracy and Quality of Lidar Data - Version 0.5

U.S. Department of the Interior
U.S. Geological Survey

American Society for Photogrammetry and Remote Sensing

Draft document 1

Guidelines and Standards

- **ISO -19159 - Geographic information - Calibration and validation of remote sensing imagery sensors and data** **http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=32577**
  - This International Specification defines the calibration and validation of identified airborne and space borne remote sensing imagery sensors and data.
  - The term calibration refers to geometry and radiometry, and includes the instrument calibration in a laboratory as well as in-situ calibration methods.
  - The validation methods are split into process- and product-validation, and include the prerequisites for installing a validation environment.
- **ISO -19157 - Geographic information -- Data quality** **http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=32575**
  - This Technical Specification defines a set of measures for the data quality sub-elements identified in ISO 19113 Geographic information - Quality principles.
  - The measures will be applicable when evaluating the quality of geographic datasets and assessing their fitness for their intended purpose. Multiple measures will be defined for each data quality sub-element, and the choice of which to use will depend on the type of the data and its intended purpose.

Summary & USGS Key Involvement

- **USGS has extensive internal capabilities and leads a number of national and international calibration partnership and activities**
- **Continue GEOSS Quality Assurance Strategy & QA4EO**
- **Strong interest in continuing to support Landsat Cross-calibration activities with CEOS partners**
- **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
  - Continue to support CEOS WGCV subgroups
- **Working to establish an operational Landsat program**

USGS

Suggestions for WGCV

- **Land Information products are way of the future**
  - Land Product Validation becoming more important
  - LPVS integration into CWIC/COVE
  - Allow for cal/val science open data policy via CWIC
  - World DEM purchase as CEOS/GEO baseline
  - Work more with WGISS, Climate, Capacity Building
  - Integrate key CEOS tasks and VC efforts into cal val
  - Continue to pursue calibration sites for visible and IR systems
  - Integrate the LPV SG efforts and test sites into a recommended collection and automated process
  - Principle CEOS member told they were not allowed to participate in LPV meeting, Why?

Big Time for USGS - 2013

- **LDCM launched** — **Feb 10, 2013**
- **Underfly of Landsat 7** — **March 29-30, 2013**
- **LDCM on WRS-2** — **April 14, 2013**
- **On-orbit Acceptance Review @ GSFC** — **May 14, 2013**
- **Post-Launch Assessment Review @ EROS** — **May 29, 2013**
- **Mission Transition Review @ EROS** — **May 30, 2013**
  - LDCM renamed Landsat 8
  - Full Release of Landsat 8 Data Products!
- **L-5 celebrated 29+ years**
  - Final command sent to Landsat 5 — **June 5, 2013**
- **L-7 - 14 years, remaining approx. 2 years**
- **Sustainable Land Imaging Report** — **August 2014**

USGS

SNR (Pueblo)

$$SNR = \frac{DN\_Difference}{(Std\_Dark + Std\_Bright)/2}$$

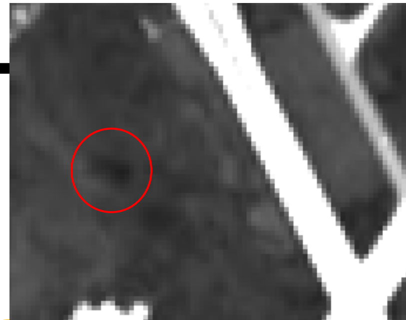
Band	Bright		Dark		SNR
	Mean	Std.Dev	Mean	Std.Dev	
PAN	2719.43	38.83	233.66	4.09	> 115.83
MS1	2709.88	43.42	168.75	2.48	> 110.72
MS2	2686.10	43.40	278.04	2.24	> 105.52
MS3	2367.70	35.78	366.89	2.19	> 105.39
MS4	2607.23	44.81	109.11	3.28	> 103.89

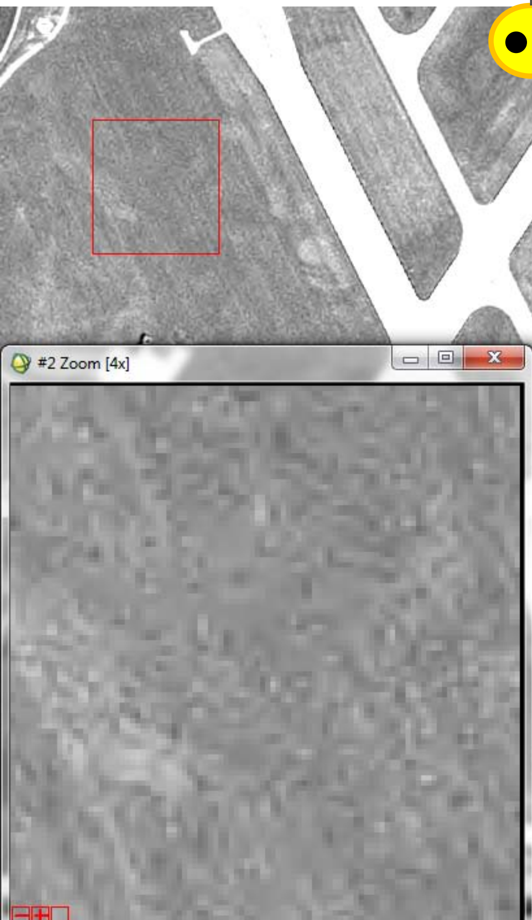
- Bright area and Dark area is not perfectly uniform, and It is difficult to find out a bright uniform area.
  - ✓ It makes lower SNR.
- There is a Compression noise.
  - ✓ It may make bigger SNR.

Smoothing & Granulating noise

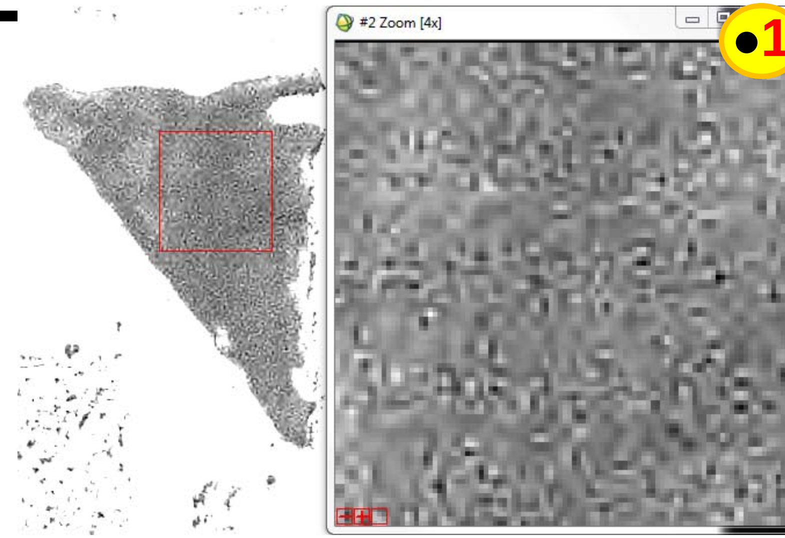
Draft Preliminary information, for March JACIE Workshop

- MS1

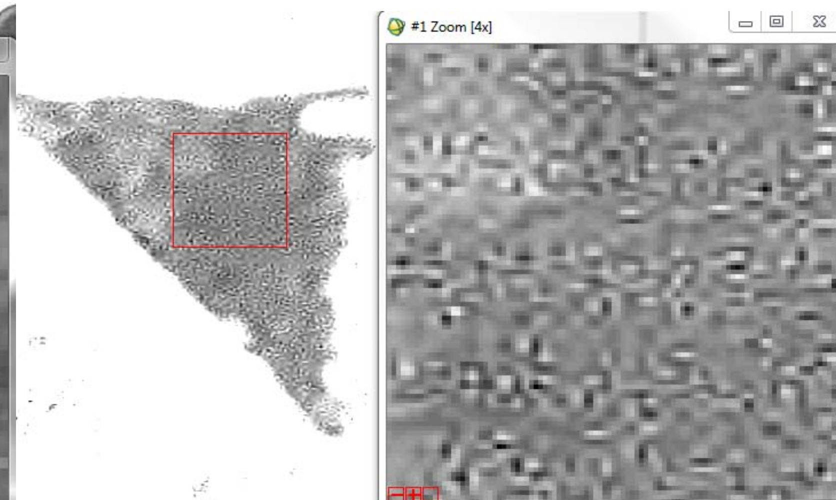




- PAN
- PAN sharpened (MS1)

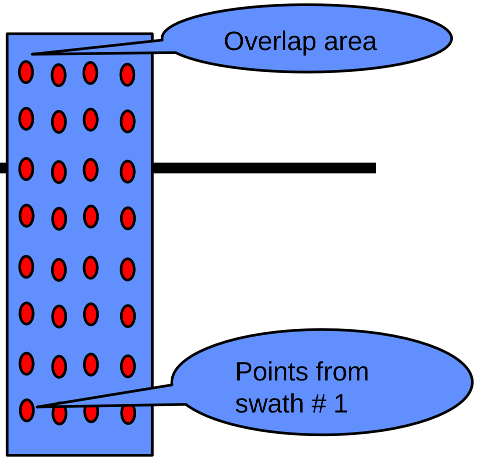


- PAN



- PAN sharpened (MS1)

DQM Research Software



- **Determines overlap region**
  - Uniformly steps through overlap region
  - Selects points from swath # 1 at regular intervals
  - Only last returns used
- **For every point in selected in swath # 1:**
- **Selects 50-100 nearest points in swath # 2**
- **Determine Delaunay neighbors**
- **Use Eigenvalue/eigenvector to determine plane equations**