USGS and Landsat Update

Sarah J. Ryker
Deputy Associate Director for Climate and Land Use Change
U.S. Geological Survey

Copper River, Gulf of Alaska
Landsat 8 image
May 28, 2013

NRC Space Studies Board CESAS Meeting
March 3, 2014

USGS
science for a changing world

USGS Climate & Land Use Change Mission Area

"Land Use Change" 2014 budget and current activities:

- **Land Remote Sensing Program**
  - Known for the Landsat satellites
  - Developing new national-scale interpretive Landsat products
  - Responsible for studying users' land imaging requirements
  - Leads DOI's unmanned aerial systems development & technology transfer to resource management agencies
- **Land Change Science Program**
  - Known for the National Land Cover Database
  - Recent related products include 40-year land change trends data, future land change projected out to 2100, past land change "backcast" to 1940
- **National Biological Carbon Sequestration Assessment**
  - First of its kind assessment, based on Landsat data, biogeochemical modeling of carbon in vegetation and soil, and IPCC development scenarios
  - Being incorporated into decision tools for National Wildlife Refuge managers

A good time for the Landsat program

2012

- USGS and NASA celebrated Landsat's 40th anniversary

2013

- NASA launched Landsat 8 and handed operational control to USGS
- Administration recognized the value of Landsat and committed to a further 20 years of Landsat at both NASA and USGS

2014

- Congress supportive of Administration's direction; requested a plan within 120 days
- NASA, USGS working toward near- and long-term plans

Solving a 40-year problem

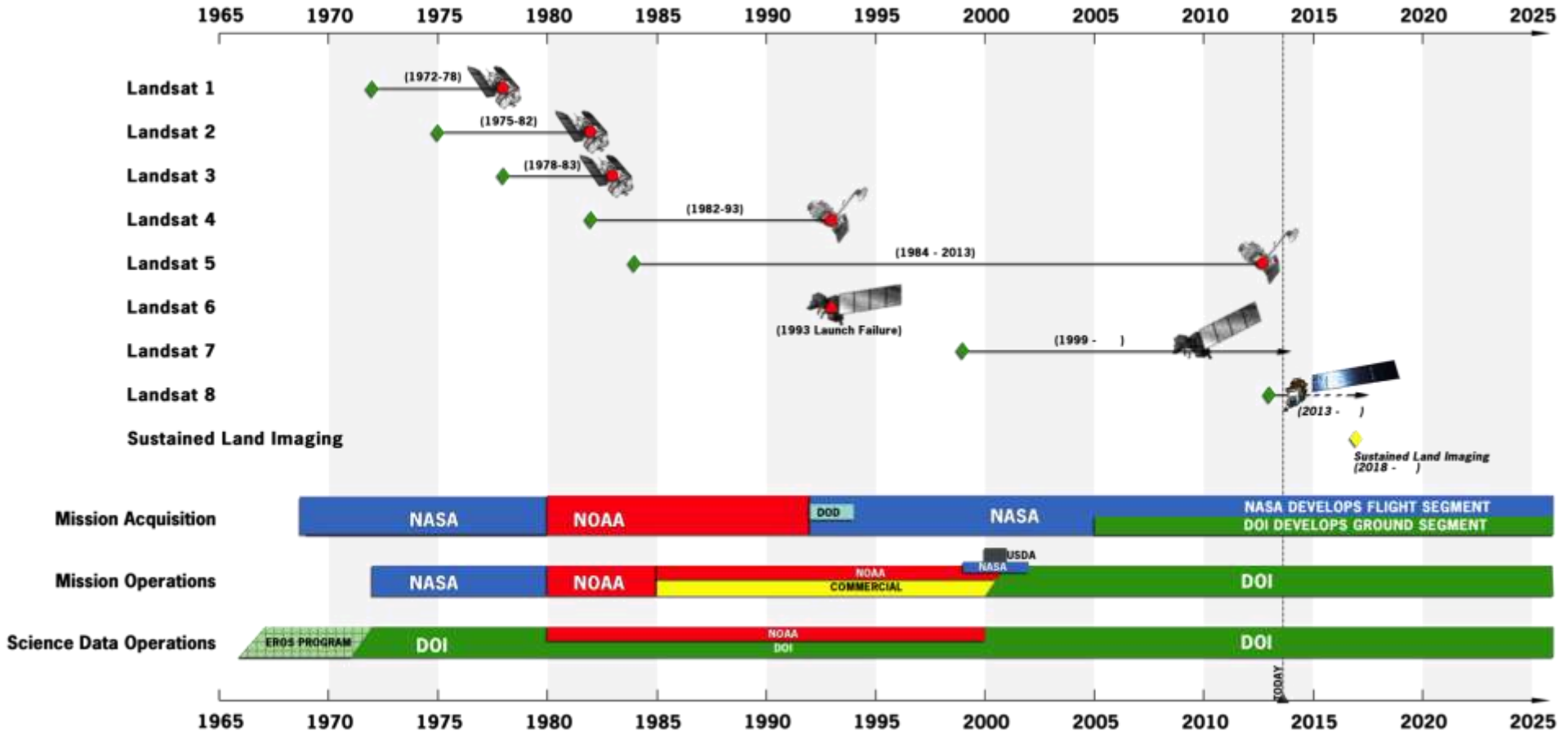
- We are on the verge of solving a decades-old budget problem.

- The Landsat satellites provide extraordinary value to the Nation's Earth science, natural resource management, and economy, but have never had solid budgetary footing. As each satellite ages, its successor is funded on a one-time emergency basis.

- There is currently support from the Administration and bipartisan support within the Congress for making the program "operational", with the successful NASA/USGS partnership maintained. The 2014 direction to develop a long-term plan is an excellent step forward.

- Landsat 8 has bought the program some time, restoring 8-day repeat data collection just after Landsat 5 was decommissioned. The biggest immediate concern is a near-term replacement for Landsat 7, which has only a few years of fuel left.

USGS/NASA Landsat partnership since 1966



NASA/USGS Landsat roles

NASA

- Develops sensors, satellites, and launches land imaging space systems
- Co-chairs USGS-funded Landsat Science Team
- Conducts research using Landsat data

USGS

- Documents users' needs for data
- Funds and co-chairs Landsat Science Team
- Develops ground systems for space systems
- Operates satellites
- Collects, processes, archives and disseminates data
  - Establishes global data acquisition strategy
  - Coordinates international partner ground receiving station network
  - Distributes data and information products at no charge
- Conducts research using Landsat data, including developing new interpretive products and applications

Landsat status

Two satellites on orbit:

- Landsat 7 launched in 1999
  - Could last through 2017, though well past its design life and with several failed parts
- Landsat 8 launched in 2013
  - Has a 5-year design life and 10 years of fuel

With 2 satellites on orbit, USGS provides data every 8 days for any location on the land surface

- In 2012, USGS & NASA found that two-thirds of user applications require 8-day repeat data collection. Requirements pilot study (2013) confirms this finding.

USGS
science for a changing world

Landsat status

Landsat 8

- USGS assumed operational responsibility from NASA on May 30, 2013
- Collecting over 500 new scenes per day
- Restored 8-day revisit cycle lost when Landsat 5 was decommissioned
- Improvements: better signal-to-noise, new bands (coastal blue, cirrus, thermal)
    - Better resolution of snow and ice-covered regions
    - Detection of water column constituents
    - Better cloud screening
    - More precise temperature measurements

Landsat 7

- Collecting more than 400 new scenes per day
- About 22% of pixels are missing per scene (faulty scan-line corrector)
- Sufficient fuel for a few more years of operation; limited subsystem redundancy

Landsat-based Information Products

- Standard orthorectified L1T calibrated radiance Landsat products
- LandsatLook (full-resolution JPEGs)
- New TM/ETM+ surface reflectance climate data record (CDR) product
- New OLI surface temperature CDR in development
- Surface Water Extent, Burned Area Extent available soon for evaluation
- Snow-covered area available late this year

USGS
science for a changing world

Landsat 8, one year post-launch

USGS science for a changing world

USGS Home
Contact USGS
Search USGS

Landsat 8 Celebrates First Year of Success

« Previous Next »
Email/Print

CATEGORIES: FEATURED
POSTED ON FEBRUARY 11, 2014 AT 12:06 PM BY: JON CAMPBELL, 703-648-4180, JONCAMPBELL@USGS.GOV

One year ago, on February 11, 2013, delegations from around the world watched tensely as NASA launched the Landsat 8 Earth observing satellite from Vandenberg Air Force Base in California. Landsat 8 is the latest success in a decades-long NASA and U.S. Geological Survey partnership that has provided a continuous record of change across Earth's land surfaces since 1972.

Orbiting 440 miles above Earth, Landsat satellites document natural processes such as volcanic eruptions, glacial retreat, floods, and forest fires, and human processes such as urban expansion, crop irrigation, and forest clear-cutting. Since 2008, all Landsat data are freely available to anyone on Earth.

NASA Landsat Science

Article Archive
Did You Know?
Image Galleries

Celebrating Landsat 8's First Year in Orbit

Feb 27, 2014 • [Source: NASA Science Visualization Studio] On Feb. 11, 2013, Landsat 8 launched into Earth orbit, riding on rocket. Weighing in at 6,133 pounds, Landsat 8 is the eigth satellite in the long-running Landsat program, jointly managed by U.S. Geological Survey.

Bipartisan pride in Landsat 8

- "Data produced by Landsat plays a vital role in managing America's natural resources and the industries and jobs that rely on those resources," said **Senator Barbara Mikulski of Maryland**, Chairwoman of the Senate Appropriations Committee that funds NASA and USGS. "It was Landsat that brought home the severity of Midwest floods in the 1990s, and it has helped identify periods of severe drought that were so devastating to our farmers and foresters. My hat goes off to NASA's Goddard Space Flight Center that has played a key role in building each of the Landsat satellites, including Landsat 8, improving each satellite with the latest technology and help us better understand planet Earth."

- "For over forty years, the Landsat Program has provided a valuable stream of image data of the Earth's landscape. The newly activated Landsat 8 satellite continues this mission, sending images to the USGS Earth Resources Observation and Science (EROS) Center near Sioux Falls, S.D.," said **Senator John Thune of South Dakota**. "The land and water resource data from Landsat 8 is a great asset to agricultural producers and others in both the public and private sectors. I salute the professionals at NASA and USGS who have worked to make this resource available for decades, and into the future."

USGS
science for a changing world

New Landsat 8 capabilities

Spectral band improvements

- Landsat 7 has 8 spectral bands (3 VIS, 1 NIR, 2 SWIR, 1 TIR, and pan band)
- Landsat 8 has 11 spectral bands (4 VIS, 1 NIR, 3 SWIR, 2 TIR, and a pan band)
  - New VIS “coastal aerosol” band allows detection of water column constituents (e.g., chlorophyll, suspended materials, etc.)
  - New SWIR “cirrus” band improves overall image quality because of better cloud screening
  - Addition of a 2nd thermal band improves the accuracy and precision of temperature measurement (though TIR resolution decreases from 60m to 100m)
  - Changes in panchromatic band spectral range will increase the overall use of this band for image sharpening and other applications.

Detection, quantification, and mapping of surface (land and water) characteristics have improved because of:

- 5x improvement of signal-to-noise ratios of spectral measurements
- 12 bit quantization of spectral signals (Landsat 7 was 8 bit)

Early results from the Landsat Science Team

Landsat Science Team

- Funded by USGS; co-chaired by USGS and NASA
- Recognized national and international leaders in land remote sensing
- Plays a key role in evaluating the new Landsat 8 data and ensuring that the Landsat 8 mission is successfully integrated with past, present, and future remotely sensed data for the purpose of observing national and global environmental systems

Examples of Landsat Science Team projects

- Operational monitoring of U.S. croplands with Landsat 8
- Using time-series approaches to improve Landsat's characterization of land surface dynamics
- Use of Landsat 8 for monitoring fresh and coastal water
- Ecological disturbance monitoring using Landsat time series data

USGS
science for a changing world

Landsat 8 data improving land cover classification

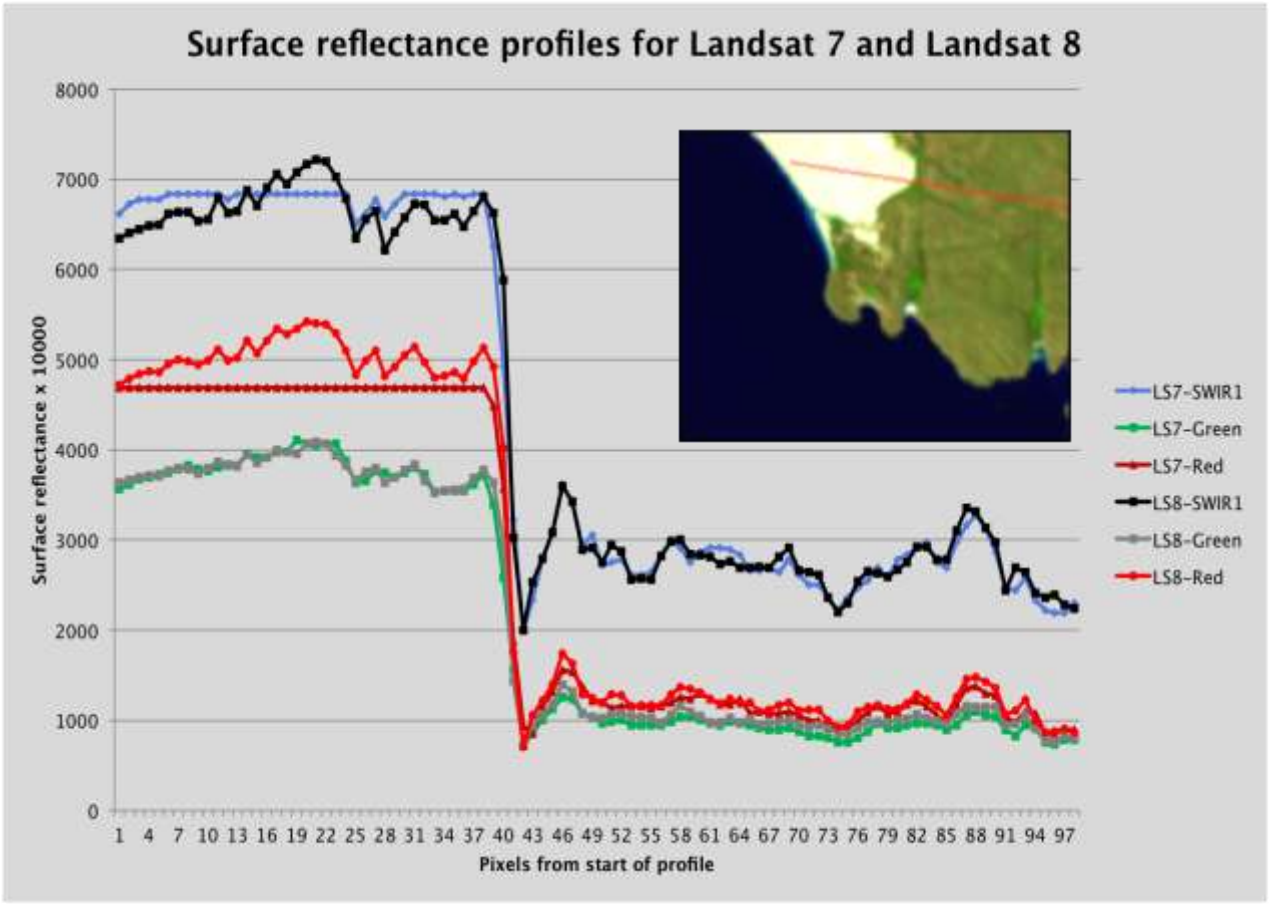
Landsat 8 FCC **Landsat 7 LC** **Landsat 8 LC**

In classification tests over New Orleans and Boston, Landsat 8's land cover results were 20% better than Landsat 7's.

Curtis Woodcock, Boston University

BOSTON UNIVERSITY

12-bit quantization eliminates bright target saturation



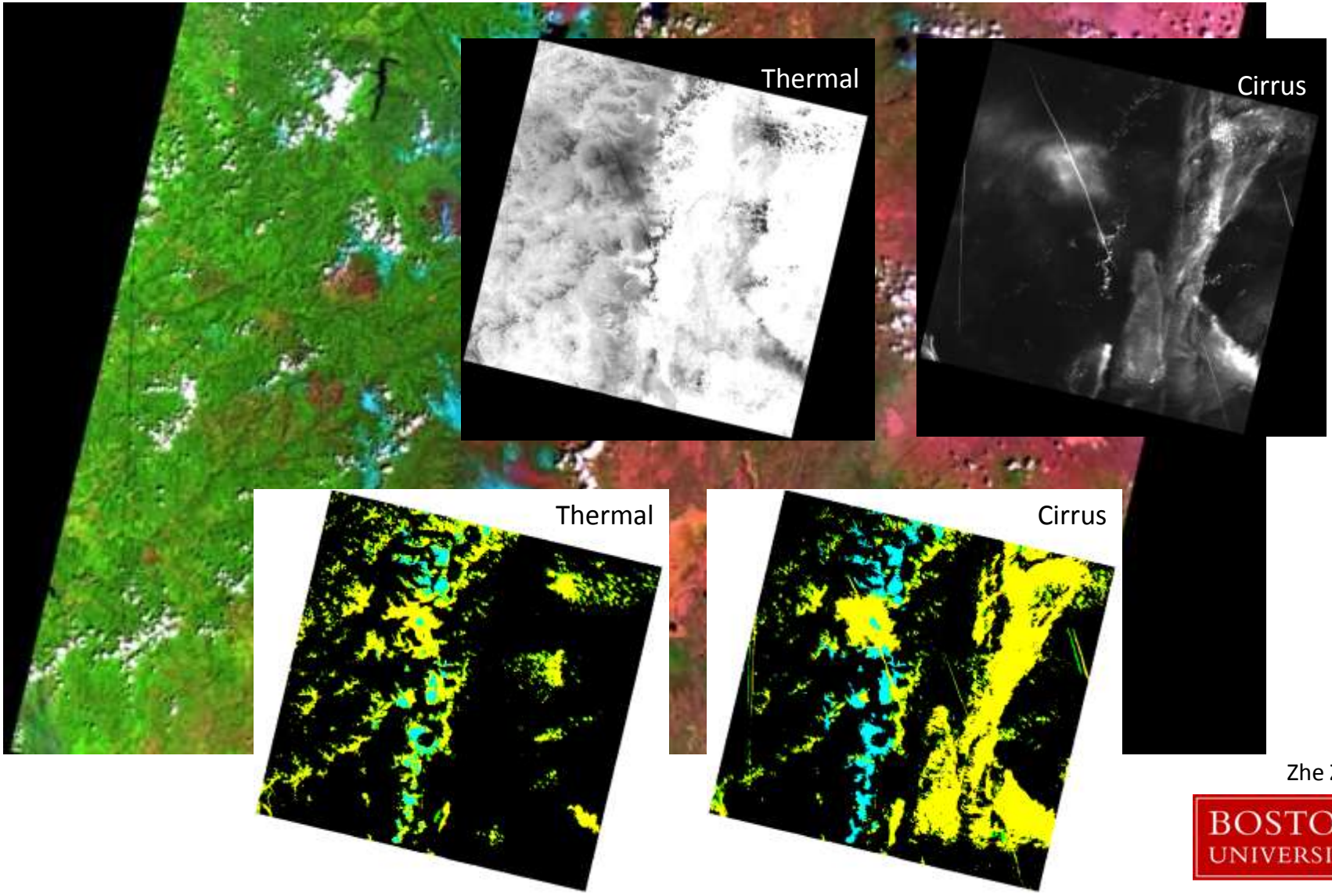
Leo Lymburner, Geosciences Australia

Landsat 1-7 signal saturation that affected the ability to detect subtle changes in bright surfaces is no longer an issue. This is improving the characterization of snow- and ice-covered regions, and detection and mapping of land degradation or improvement in the extensive Australian outback.

New coastal band and improved radiometry benefit 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.

New cirrus band improves cloud detection



Zhe Zhu

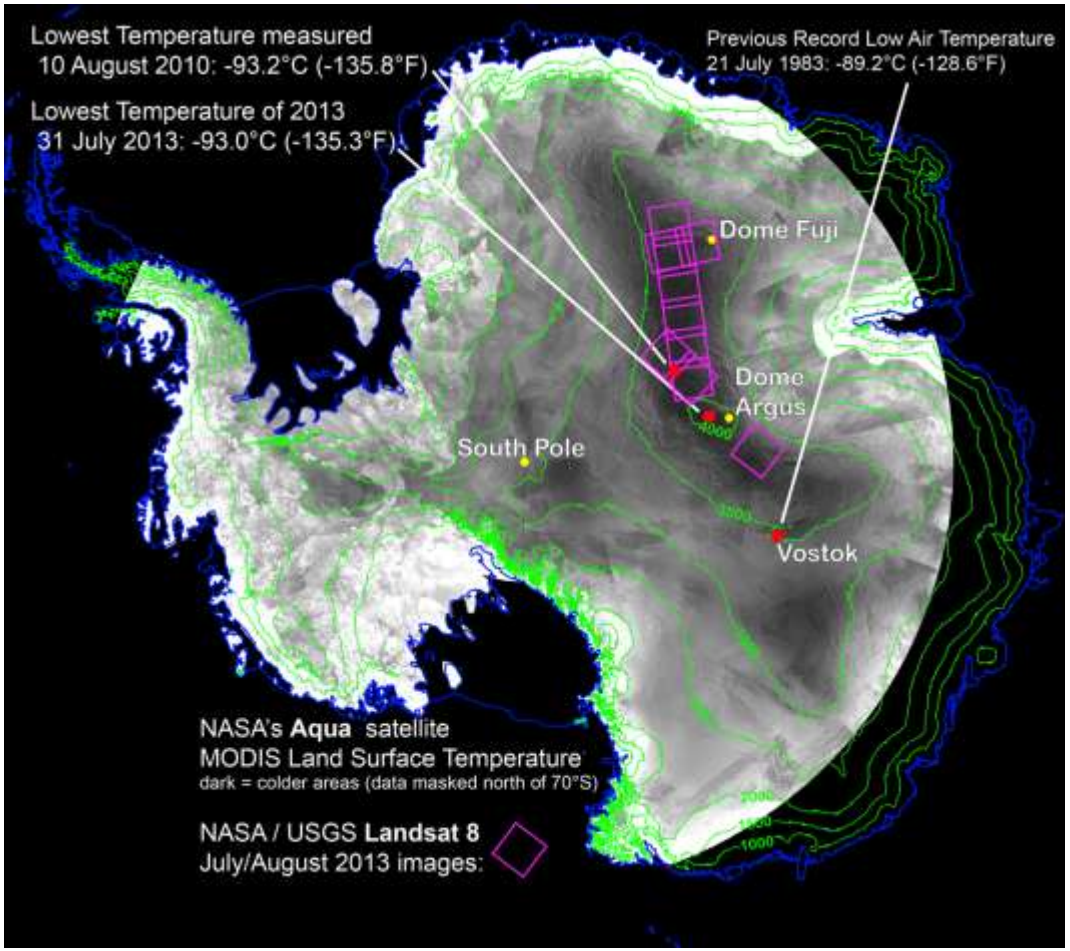
BOSTON UNIVERSITY

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)

Boulder

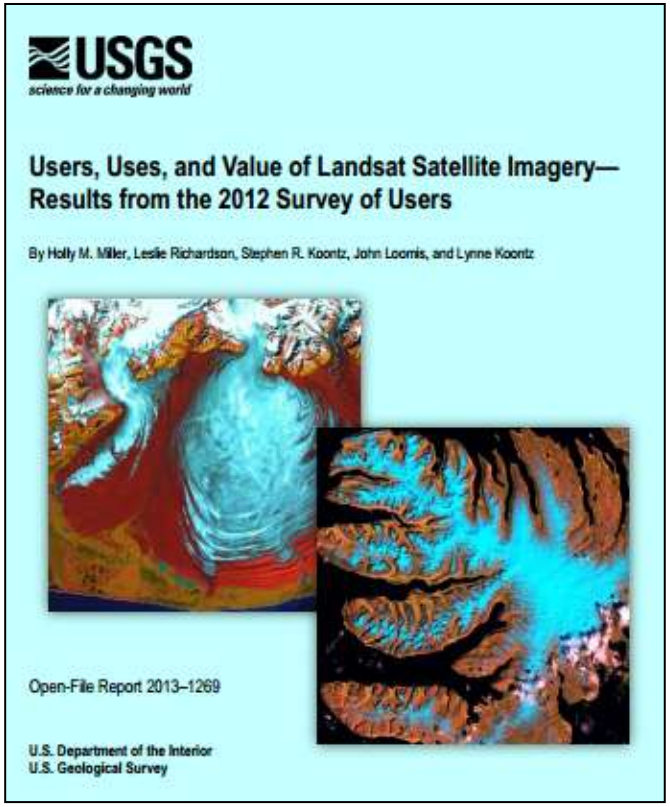
Studying Land Imaging Users

Landsat User Survey (2013)

- Conservatively estimated Landsat's value to U.S. users at $1.8B/year (not including value from redistributed data or value-added products)
- Depending on definitions, 1/3 of users classified themselves as "operational". Operational users were also most dependent on Landsat.
- 1/4 of users relied completely on Landsat. For 3/4 of users, Landsat was the major data source but they used a mix of satellite imagery. If Landsat imagery were no longer available, 62% would need to discontinue some of their work.

Requirements analysis (2012, 2013, ongoing)

- 2/3 of applications require 8-day repeat (crop productivity, fire assessment, flood monitoring, irrigation management, etc)
- 1/3 of applications require thermal data



Direction: operationalizing interpretive products

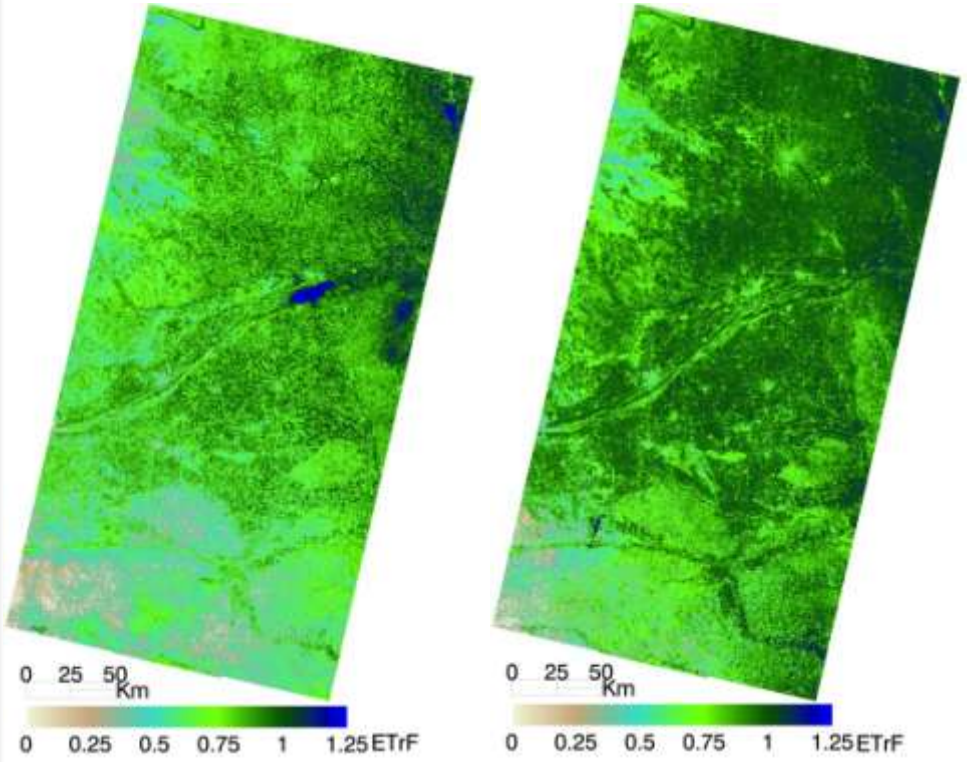
- "Operationalize" decision support applications developed by the Landsat Science Team

- Develop new Landsat-based national-scale analyses useful to natural resource managers and the climate monitoring community*
  - Surface reflectance
  - Land surface temperature
  - Wildfire burned area extent
  - Surface water extent
  - Snow covered area

* Some products can be updated every 8 days, in near-real-time

Evapotranspiration (from Landsat 8, July 2013)

Evapotranspiration (from Landsat 8, Aug 2013)



Nebraska's Central Platte Natural Resources District uses Landsat-based estimates of water use to manage the Ogallala Aquifer. (METRIC model pioneered by the Idaho Department of Water Resources, University of Idaho, and Landsat Science Team.)

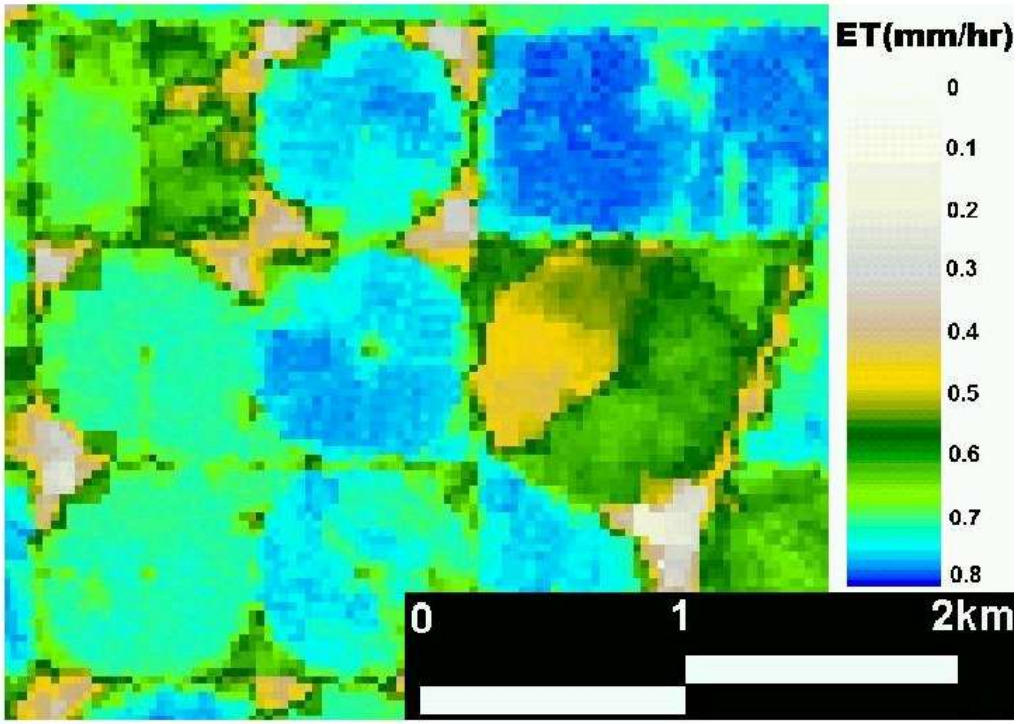
States & growers monitor field-by-field water use

- Water rights regulation and administration are critically tied to identification and quantification of water consumption on a field-by-field basis

  - *Allen, R.G. "The Need to Continue High Resolution Thermal Imagery …"*

- Quantification of water use from Landsat using thermal data is the only way to independently and consistently measure water use on a field-by-field basis

  - *Morse, A., and R.G. Allen. "Water and the Critical Need for a Thermal Band on Landsat"*



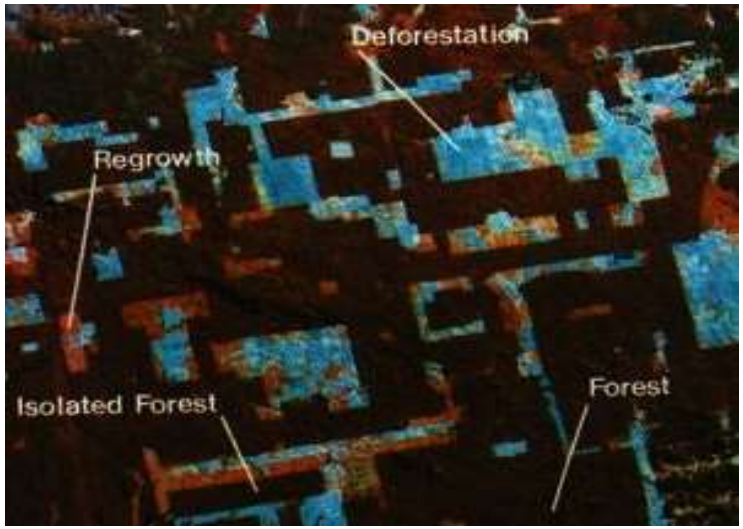
Evapotranspiration at time of Landsat overpass
Oakley Fan, Idaho, July 7, 1989

Continuity in action

Landsat satellite data first quantified Amazonian deforestation (1978-1988)

- Demonstrated contributions of local land uses to global change
- Changed Earth scientists' & public's understanding of role of forest practices in global change
- Demonstrated use of objective satellite record
- Increased transparency of land use policy outcomes

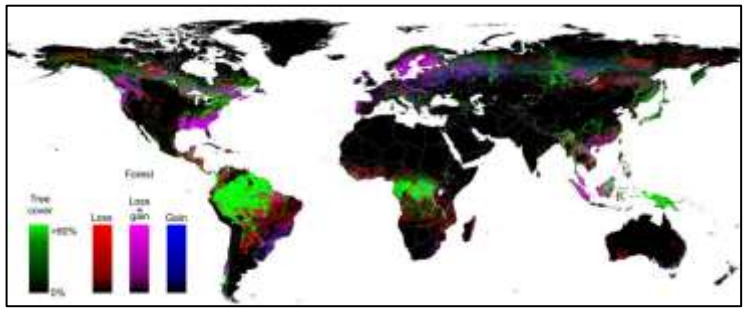
(Skole and Tucker, 1993, *Science*)



Landsat satellite data first quantified <u>global</u> forest change (2000-2012)

- Leveraged new computing technologies and 2008 Landsat free data policy

(Hansen et al., 2013, *Science*)



What supports these studies

- Long-term continuity and Long Term Acquisition Plans
  - Consistent global coverage, including remote locations.
- Free data policy
  - Hansen et al. used >654,000 Landsat scenes. Would have cost ~$392M without the free data policy.
- All Landsat data orthorectified and calibrated to a common radiometric standard
  - Permits comparison across the 41+ year instrument record.
  - Supports measurement of gradual, fine-scale shifts in ecosystem characteristics over a long period, whether due to climate or disturbance.

USGS