Landsat – Monitoring our Earth’s Condition for over 40 years

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Land Remote Sensing Program
USGS

ISPRS:Earth Observing Data and Tools for Health Studies
Arlington, VA
August 28, 2013
The Landsat Legacy:
Rooted in the USGS and the Department of the Interior

“... the time is now right and urgent to apply space technology towards the solution of many pressing natural resource problems being compounded by population and industrial growth.”

Interior Secretary Steward L. Udall, 1966
Landsat Supports Science

• Landsat provides a consistent, detailed, unbiased, unbroken record of the global land surface spanning 41 years

• The data are fundamental for:
  • mapping the pattern of cover across the landscape
  • monitoring land cover change over time
  • identifying the drivers of pattern and change
  • determining response and feedbacks to spatial and temporal variability, and
  • predicting response to an increasing population, growing economies, and changing climate

• Landsat-scale land-use research is essential to human adaptation to increasing pressure on our global resources
## Landsat Mission History and Payloads

<table>
<thead>
<tr>
<th>Mission</th>
<th>Launch</th>
<th>End of Imaging</th>
<th>Payload</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landsat 1</td>
<td>July 1972</td>
<td>January 1978</td>
<td>MSS</td>
</tr>
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<td>Landsat 2</td>
<td>January 1975</td>
<td>February 1982</td>
<td>MSS</td>
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<td>Landsat 3</td>
<td>March 1978</td>
<td>March 1983</td>
<td>MSS</td>
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<td>Landsat 4</td>
<td>July 1982</td>
<td>December 1993</td>
<td>MSS, TM</td>
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<td>Landsat 5</td>
<td>March 1984</td>
<td>November 2011</td>
<td>MSS, TM</td>
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<tr>
<td>Landsat 6</td>
<td>October 1993</td>
<td>[failed to achieve orbit]</td>
<td>ETM</td>
</tr>
<tr>
<td>Landsat 7</td>
<td>April 1999</td>
<td>--</td>
<td>ETM+</td>
</tr>
<tr>
<td>Landsat 8</td>
<td>February 2013</td>
<td>--</td>
<td>OLI, TIRS</td>
</tr>
</tbody>
</table>
Monitoring Urban Growth

Urban Growth of Las Vegas, Nevada

Critical Issues

- Water
- Economic Diversification
- Land Use
- Transportation
- Resource Conservation
- Public Health
Drought in the American Southwest

Elephant Butte Reservoir
Southern New Mexico

June 2, 1994  (source: Landsat 5)
Reservoir filled to approximately 89% of capacity

July 8, 2013  (source: Landsat 8)
Reservoir filled to approximately 3% of capacity
Green Dots represent locations of Coal Bed Natural Gas Wells
Powder River Basin - Wyoming

August 19, 2000 (source: Landsat 5)  

Courtesy of Dr. Ramesh Sivanpillai and Dr. Scott N. Miller (University of Wyoming)
Powder River Basin - Wyoming

August 21, 2009 (source: Landsat 5) 

Courtesy of Dr. Ramesh Sivanpillai and Dr. Scott N. Miller (University of Wyoming)
Landsat 8 Improvements

• More image data
  • 41 year record will extend to 45-50 years or more
  • At least 400 scenes/day vs. at least 250 scenes/day from Landsat 7
  • 100% of global data collected goes to the US archive each day
  • New images are available to users in less than 8 hours after acquisition
  • With Landsat 7, we have returned to an 8 day repeat cycle

• Better image data
  • 8 - 10x improvement in signal to noise ratios
  • 12 bit quantization permits improved measurement of subtle surface conditions and assessment of bright targets
  • Improved pixel geolocation (~ 12m )
  • Provides greater sensitivity to detect changes in surface properties

• New measurements – and new applications
  • Coastal blue 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 – more precise temperature measurements
OLI & TIRS Spectral Bands
This northern Australia tropical estuary was part of the first Landsat 8 image over Australia. The image combines the Red, Green and Deep Blue bands (RGB) for the water targets and SWIR, NIR and Green (RGB) for terrestrial areas.

Courtesy of Leo Lymburner, Geoscience Australia

Leo Lymburner, Geosciences Australia
Yosemite Fire, CA – August 2013 (pre-fire)

False Natural Color
(Bands 6,5,4)

August 15, 2013 (source: Landsat 8)

2km
Yosemite Fire, CA – August 2013

August 23, 2013 (source: Landsat 7)

False Natural Color
(Bands 5,4,3)
Yosemite Fire, CA – August 2013

Thermal IR
(Bands 10 and 11)

August 24, 2013 (source: Landsat 8)
Yosemite Fire, CA – August 2013

August 24, 2013 Landsat 8 image brought in to Google Earth (using Image Overlay tool)
Applications Development – Landsat 8 Prototype Surface Reflectance

• Top of the Atmosphere
• Surface Reflectance

From Eric Vermote, NASA GSFC - “...we we are going to be able to produce a great surface reflectance product given the radiometric performances (signal to noise) and the availability of extra and better band in the blue for aerosol retrieval over land.”
Detection of cirrus clouds using band 9 improves atmospheric correction of Landsat 8 multispectral data.
Web-Enabled Landsat 7 Data – 2003 - 2012

- WELD provides seamless Landsat 7 ETM+ mosaics for Conterminous US and Alaska
- Developed by David Roy, South Dakota State University

http://landsat.usgs.gov/WELD.php
Free, Web-Enabled Landsat Data
Each downloaded scene covers over 12K square miles

A New Era in Utilization of Land Satellite Imagery

Free data policy
October 1, 2008

Primary Landsat Data Usages
(10/01/2012 through 05/31/2013)

- Fire science/management: 17.1%
- Land use/land cover change: 22.7%
- Education: university/college: 11.0%
- Education: K-12: 0.2%
- Energy/metals/minerals exploration/extract/development: 0.2%
- Urban planning and development: 0.0%
- Engineering/construction/surveying: 0.3%
- Software development: 0.3%
- Other Use: 1.2%
- Agriculture for feeding: 7.5%
- Forest science/management: 8.0%
- Ecological/ecosystem science/monitoring: 8.3%
- Water resources: 4.3%
- Climate science/change: 4.4%
- Agricultural management/production/conservation: 3.1%
- Geology: 3.1%
- Biodiversity conservation: 1.6%
- Engineering/construction/surveying: 0.5%
- Environmental regulation: 0.9%
- Urbanization: 0.3%
- Fish and wildlife science/management: 0.3%
- Coastal science/monitoring/management: 1.4%
- Emergency/disaster management: 1.4%

In Millions of Scenes Downloaded

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

10/1/07 2/1/08 6/1/08 10/1/08 2/1/09 6/1/09 10/1/09 2/1/10 6/1/10 10/1/10 2/1/11 6/1/11 10/1/11 2/1/12 6/1/12 10/1/12 2/1/13 6/1/13

USGS
Understanding User Requirements

- Mission Areas
- Goals
- Strategies
- Mission Service Areas
- SBA
- Sub-Area
- Sub-Sub-Area
- Key Objective
- Key Products/Services
  - EO Datasets
  - Intermed Products
  - Models
  - Direct Observations
  - Observing Systems

- Key Products/Services provide a consistent and enduring component that can be mapped/remapped to any value tree:
  - Organizational
  - SBA
  - Other
Value Tree Example – DOI BOR

- DOI Mission Area
  - Sustainably manage energy, water, and natural resources

- DOI Goal
  - Manage water for the 21st Century

- DOI Strategy
  - Conserve Water

Bureau of Reclamation (BOR) Mission Service Area

- BOR Key Products/Services
  - EO datasets, intermediate products, and models used to generate BOR’s key products/services

- Consumptive Water Use Assessments
  - EO Datasets
  - Intermed Products
  - Models
  - Direct Observations
  - Observing Systems

- Riparian Vegetation Mapping
  - EO Datasets
  - Intermed Products
  - Models
  - Direct Observations
  - Observing Systems

- Support to Reservoir Water Operations
  - EO Datasets
  - Intermed Products
  - Models
  - Direct Observations
  - Observing Systems

USGS
National Land Imaging Requirements Approach

- **Performance/ Satisfaction Scale**
  - Basis for standardized product from each group elicited

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
<th>Requirements</th>
</tr>
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<tbody>
<tr>
<td>100</td>
<td>Ideal</td>
<td>Meets all requirements and exceeds some</td>
</tr>
<tr>
<td>90</td>
<td>Fully Satisfied</td>
<td>Meets all requirements</td>
</tr>
<tr>
<td>80</td>
<td>Good</td>
<td>Meets all major requirements with minor limitations</td>
</tr>
<tr>
<td>70</td>
<td>Fair</td>
<td>Meets most major requirements, with significant limitations</td>
</tr>
<tr>
<td>60</td>
<td>Poor</td>
<td>Fails to meet many major requirements, but provides some value</td>
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<tr>
<td>50</td>
<td></td>
<td></td>
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<tr>
<td>40</td>
<td>Very Poor</td>
<td>Fails to meet most major requirements, but provides minor value</td>
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<tr>
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<tr>
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<tr>
<td>10</td>
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<td></td>
</tr>
<tr>
<td>1</td>
<td>No Capability</td>
<td>Provides no value</td>
</tr>
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</table>
Some Useful Links

• USGS Landsat Web Site: [http://landsat.usgs.gov](http://landsat.usgs.gov)

• Sources of USGS satellite data
  • Earth Explorer: [http://earthexplorer.usgs.gov](http://earthexplorer.usgs.gov)
  • GloVis: [http://glovis.usgs.gov](http://glovis.usgs.gov)
  • LandsatLook Viewer: [http://landsatlook.usgs.gov](http://landsatlook.usgs.gov)

• Landsat 8 (LDCM) Orbit YouTube: [http://www.youtube.com/watch?v=iGoD5ZOPizc](http://www.youtube.com/watch?v=iGoD5ZOPizc)

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