Landsat
40 years of Earth Observation
Land Remote Sensing Data Access Workshop
March 13 & 14, 2012
Topics

- **Current Landsat Missions**
  - Overview & History
  - Status of Current Missions

- **Data Acquisitions, Archive & Distribution**
  - Landsat Data Acquisitions
  - Ground Station Network
  - Landsat Global Archive Consolidation (LGAC)
  - Archive Statistics
  - Data Distribution Evolution
Topics (cont.)

- **Data Products**
  - Level 1 Data Product
  - LandsatLook Images
  - Global Land Survey

- **Using Landsat data**
  - Applications

- **LDCM Mission**
  - Mission Details
  - Mission Status
  - LDCM Data Product
Landsat Missions

- 40 years of Earth Observation 1972-2012
  - Landsats 1-3: Multispectral Scanner (MSS) primary sensor
  - Landsats 4-5: MSS & Thematic Mapper (TM)
  - Landsat 7: Enhanced Thematic Mapper Plus (ETM+)
  - LDCM (L8): Operational Land Imager (OLI), Thermal Infrared Sensor (TIRS)
  - Landsat 6?
Status of Current Missions

November 2011: Imaging Operations Suspended

May 2003: Scan Line Corrector (SLC) Failure
http://landsat.usgs.gov/using_Landsat_7_data.php
ETM+ Scan Line Corrector (SLC)

Scan Line Corrector (SLC) Failure

SLC compensates for the forward motion of the satellite.

Efforts to recover the SLC were not successful.

Without an operating SLC, the ETM+ line of sight now traces a zig-zag pattern along the satellite ground track.

Fig. 1
ETM+ Scan Line Corrector (SLC) cont.

- Impacts are most pronounced along the edge of the scene
- Gradually diminish toward the center
- The middle of the scene (approximately 22 kilometers) contains very little duplication or data loss
- Total loss of image data: approximately 20% over any given scene
- Maximum width of the data gaps along the edge is equivalent to one full scan line, or ~390 to 450 meters
- The precise location of the missing scan lines will vary from scene to scene
ETM+ Scan Line Corrector (SLC) cont.
ETM+ Scan Line Corrector (SLC) cont.

● How to fill the gaps?
  ◆ A number of methods have been established
    ● Display
    ● Scientific analysis

◆ http://landsat.usgs.gov/using_Landsat_7_data.php

● Gap Mask Files
  ◆ Help identify location of pixels affected, useful when using a L7 scene before May 2003, or L5 scene closest to date of SLC off scene to fill

● Gap Phase Estimator
  ◆ Calculates approximate area that will be filled if selected scenes are combined
Data Acquisition

- Landsat 7 ~300 scenes per day
- 185 km swath width
- 16 day revisit time on WRS-2

March 13, 2012 Acquisitions
Where is all the Landsat 5 data?

- Launch: March 1, 1984
- 1984: Privatization policy; Landsat data distribution given to commercial entity; costs of imagery increased and distribution was restricted.
- 1984-1999: many collections not made, esp. if no immediate buyer was waiting for the data
- 1987: Data recorder failed; only direct downlinks to ACTIVE ground stations
- 1994: Landsat 4 and 5 operations returned to US Government
- 2001: Commercial right to data relinquished; USGS pricing
Landsat Global Archive Consolidation (LGAC)

• Goal is to consolidate the entire Landsat archive
  ◆ 5 million scenes held internationally vs. 2 million in the USGS archive
    ● Over 750K scenes collected so far
  ◆ From current stations as well as historical stations
  ◆ Each station has data that will enhance the USGS archive
  ◆ Some data at risk due to aging media, storage imprudence
  ◆ Data format, processing methods
  ◆ Multi-year endeavor

• Enables scientific analysis of most complete time-series of images for global land change

• Provides data to global user community as standard product like current Landsat data from US archive
U.S. Landsat Archive Overview
(as of August 1, 2011)

- **ETM+: Landsat 7**
  - 1,153,059 scenes
  - ~1,071 TB Raw and L0Ra Data
    - average scene size 487 MB

- **TM: Landsat 4 & Landsat 5**
  - 1,150,074 scenes
  - ~576 TB Raw and L0Ra Data
    - average scene size 263 MB

- **MSS: Landsat 1 through 5**
  - 610,210 scenes
  - ~18 TB Raw and L0Ra Data
    - average scene size 32 MB

- **Total:**
  - 2,913,343 scenes
  - ~1,665 TB Raw and L0Ra Data
Data Distribution Evolution

- “Web-enabled” data became available in early 2009
  - Prior to ‘no-charge’ downloadable data:
    - ~25,000 scenes were sold in biggest year
  - After web-enabled data became available:
    - 29,500 scenes were downloaded on biggest DAY

- Over 7 MILLION Landsat scenes have been downloaded since data became “available for download at no charge”
Landsat Level 1 Data Product

- Landsat Level 1 product
  - Processed to best correction possible: L1T, L1GT, or L1G
  - GeoTIFF output format
  - Cubic Convolution (CC) resampling method
  - 30-meter (TM, ETM+) and 60-meter (MSS) pixel size (reflective bands)
  - Universal Transverse Mercator (UTM) map projection (Polar Stereographic projection for Antarctica)
  - WGS-84 Datum
  - MAP (North-up) image orientation

- Each downloaded .tar.gz file contains:
  - TIFF data files
  - Metadata files
  - GVERIFY files (TM & MSS) and Gap-Mask files (L7 ETM+)

http://landsat.usgs.gov/Landsat_Processing_Details.php
LandsatLook Images

- Full resolution JPEG images
- “Natural-color 3-band image
  - 5,4,3 for TM & ETM+  2,4,1 for MSS
- Thermal 1-band image
  - Not available for MSS
- Geographic bundle
  - Natural, thermal, and geographic reference files
    - (GDAL XML) and ESRI™ World Files
- Top of Atmosphere reflectance values
  - Uses stretch (gamma = 2)
Why LandsatLook Images?

- Free data has broadened user base
  - Level 1 Product:
    - Large file size, multiple bands
    - Requires specialized software

- Less expertise in ‘remote sensing’
  - Already an expert in a different field
    - Educators, International users, News media
    - Existing users who want an image for display or presentation

- Reduces Barriers of knowledge, software, bandwidth

http://landsat.usgs.gov/LandsatLookImages.php
LandsatLook Images

Landsat 1: 23 Feb 1973
Bands 241

Landsat 5: 13 Jun 2005
Bands 543
LandsatLook images comparing 1999-2011
Global Land Surveys

- USGS/NASA collaboration effort
- Orthorectified, global dataset
  - Cloud-free Landsat imagery
  - Support numerous science studies and mapping applications

http://landsat.usgs.gov/science_GLS.php
Using Landsat Data Products

- Geography & Mapping
- Water Quality & Coastal Studies
- Land Use & Land Change
- Agriculture
- Resource Management

- Government
- Commercial
- Civilian
- Military
- Education
- Outreach
Aid in Emergency Response
Provide Insight into Broad Patterns
Landsat Data Continuity Mission (LDCM)

- Projected Launch January 2013
  - Launch Site: Vandenberg Air Force Base
  - Launch Vehicle: Atlas 5
  - Design Life: 5 years

- Two sensors – pushbroom scanners
  - Operational Land Imager (OLI)
    - 8 spectral bands: 30 meters
    - 1 panchromatic band: 15 meters
  - Thermal Infrared Sensor (TIRS)
    - 2 longwave bands: 100 meters

- Will acquire ~400 scenes per day
LDCM Sensors
LDCM Sensors
LDCM Data Product

- Will be consistent with current standard data products:

  **Processing:** Level 1 T- Terrain Corrected

  **Pixel Size:**
  - OLI multispectral bands: 30-meters
  - OLI panchromatic band: 15-meters
  - TIRS bands: resampled to 30 meters to match OLI Multispectral bands

  **Data Characteristics:**
  - GeoTIFF data format
  - Cubic Convolution (CC) resampling
  - North Up (MAP) orientation
  - Universal Transverse Mercator (UTM) map projection (Polar Stereographic for Antarctica)
  - World Geodetic System (WGS) 84 datum
  - 12 meter circular error, 90% confidence global accuracy for OLI
  - 41 meter circular error, 90% confidence global accuracy for TIRS
  - 16-bit pixel values

  **Data Delivery:** HTTP Download
LDCM Data Product, cont.

• LDCM Product files will include:
  ◆ TIFF image files: 9 shortwave + 2 thermal
  ◆ Metadata files
  ◆ Quality assurance band file
    • Detection of clouds, water, and snow

  ◆ Addition of 2 multispectral bands
    • Band 1 “Ultra-blue” - Coastal, Aerosol
    • Band 9 – Cirrus cloud detection
Landsat 7 Bands to LDCM Bands

More information

- [http://ldcm.nasa.gov](http://ldcm.nasa.gov)
- Follow on Twitter: @USGSLandsat
- Facebook: [http://facebook.com/NASA.Landsat](http://facebook.com/NASA.Landsat)

Questions?
- landsat@usgs.gov