Landsat
40 years of Earth Observation

Land Remote Sensing Data Access Workshop
March 13 & 14, 2012

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

Topics

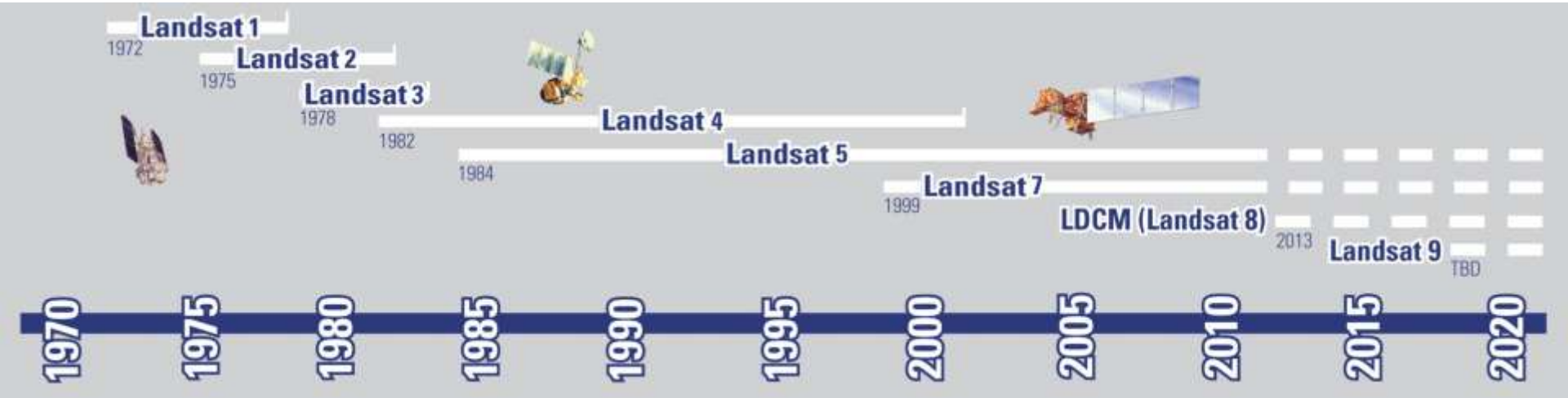
- **Current Landsat Missions**
  - Overview & History
  - Status of Current Missions
- **Data Acquisitions, Archive & Distribution**
  - Landsat Data Acquisitions
  - Ground Station Network
  - Landsat Global Archive Consolidation (LGAC)
  - Archive Statistics
  - Data Distribution Evolution

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

Landsat 5,
launched March 1, 1984

Landsat 7,
launched April 15, 1999

November 2011:
Imaging Operations Suspended
http://www.usgs.gov/newsroom/article.asp?ID=3109

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
May 31, 2003.

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.

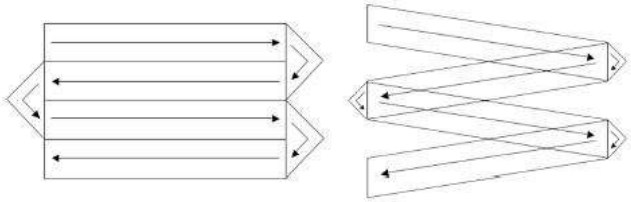


Fig. 1

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

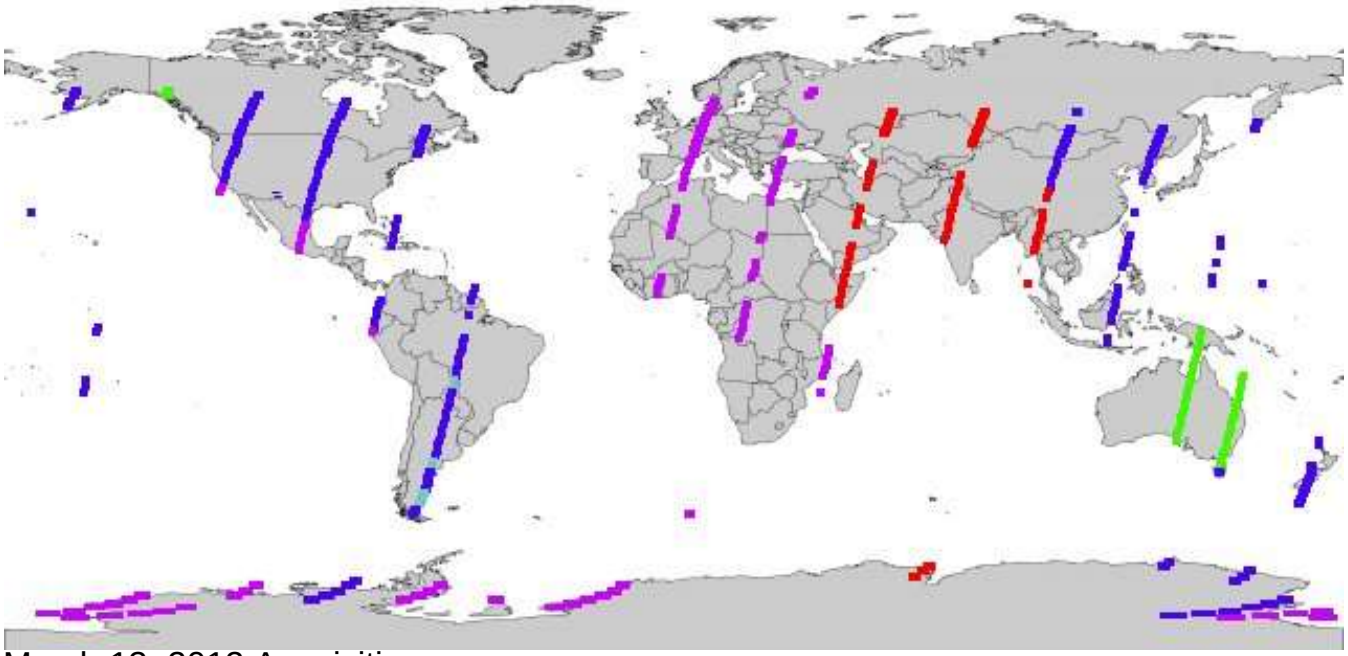
ETM+ Scan Line Corrector (SLC) cont.

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

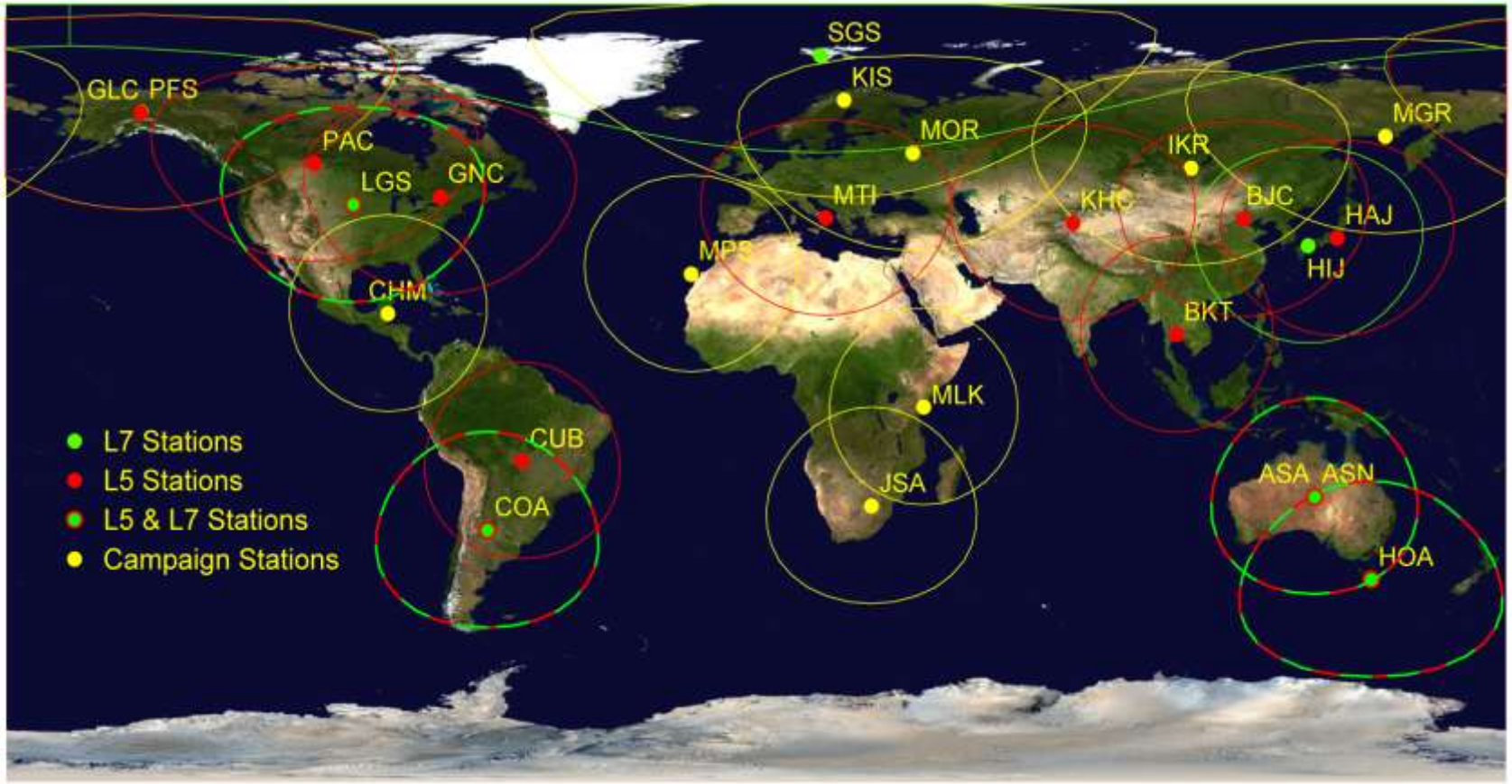


March 13, 2012 Acquisitions

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

Ground Station Network

Active Landsat Ground Stations



Where is all the Landsat 5 data?

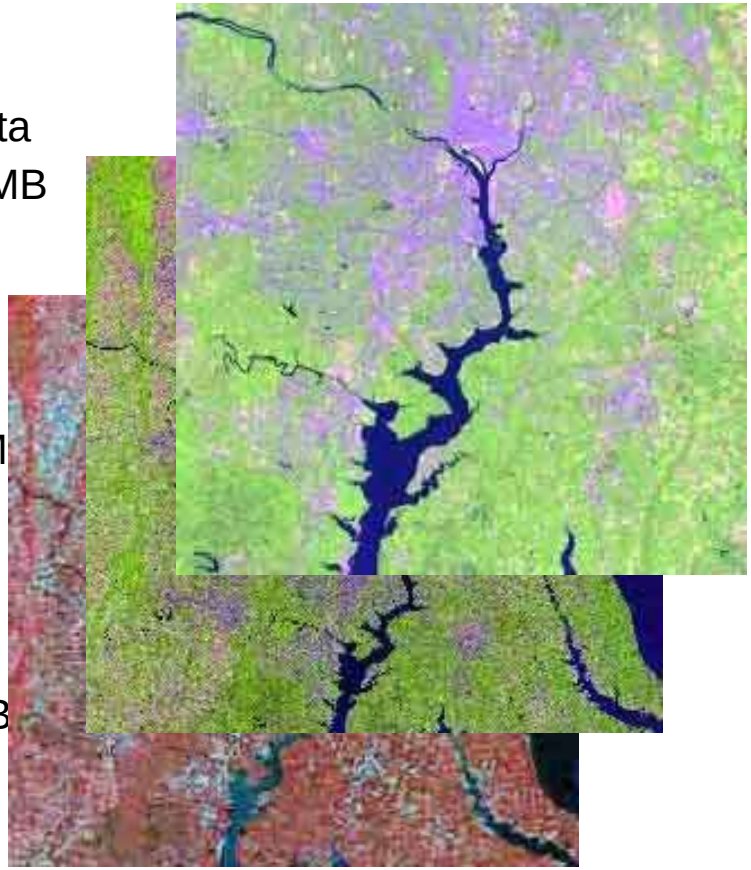
- Launch: March 1, 1984
- 1984: Privatization policy; Landsat data distribution given to commercial entity; costs of imagery increased and distribution was restricted.
- 1984-1999: many collections not made, esp. if no immediate buyer was waiting for the data
- 1987: Data recorder failed; only direct downlinks to ACTIVE ground stations
- 1992: Congress enacted the Land Remote Sensing Policy Act-instructed Landsat Program Management to build government-owned Landsat 7
- 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 M
- **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?

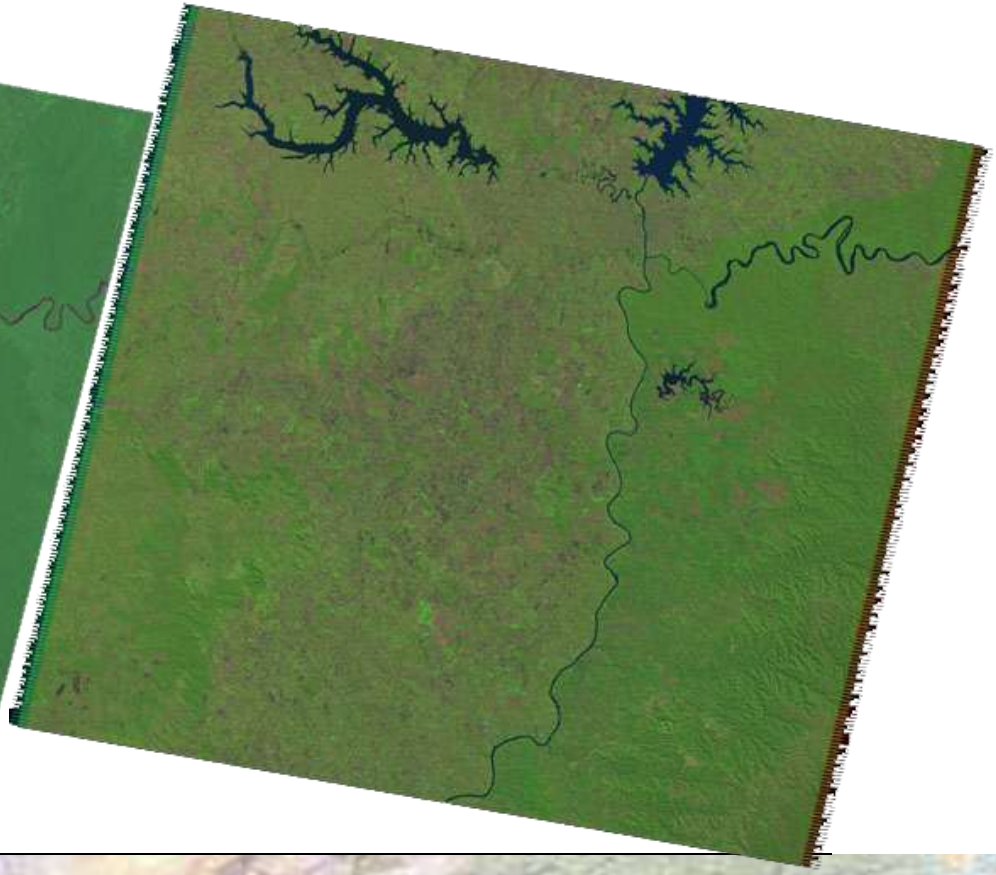
- Free data has broadened user base
  - Level 1 Product:
    - Large file size, multiple bands
    - Requires specialized software
- Less expertise in ‘remote sensing’
  - Already an expert in a different field
    - Educators, International users, News media
    - Existing users who want an image for display or presentation
- Reduces Barriers of knowledge, software, bandwidth

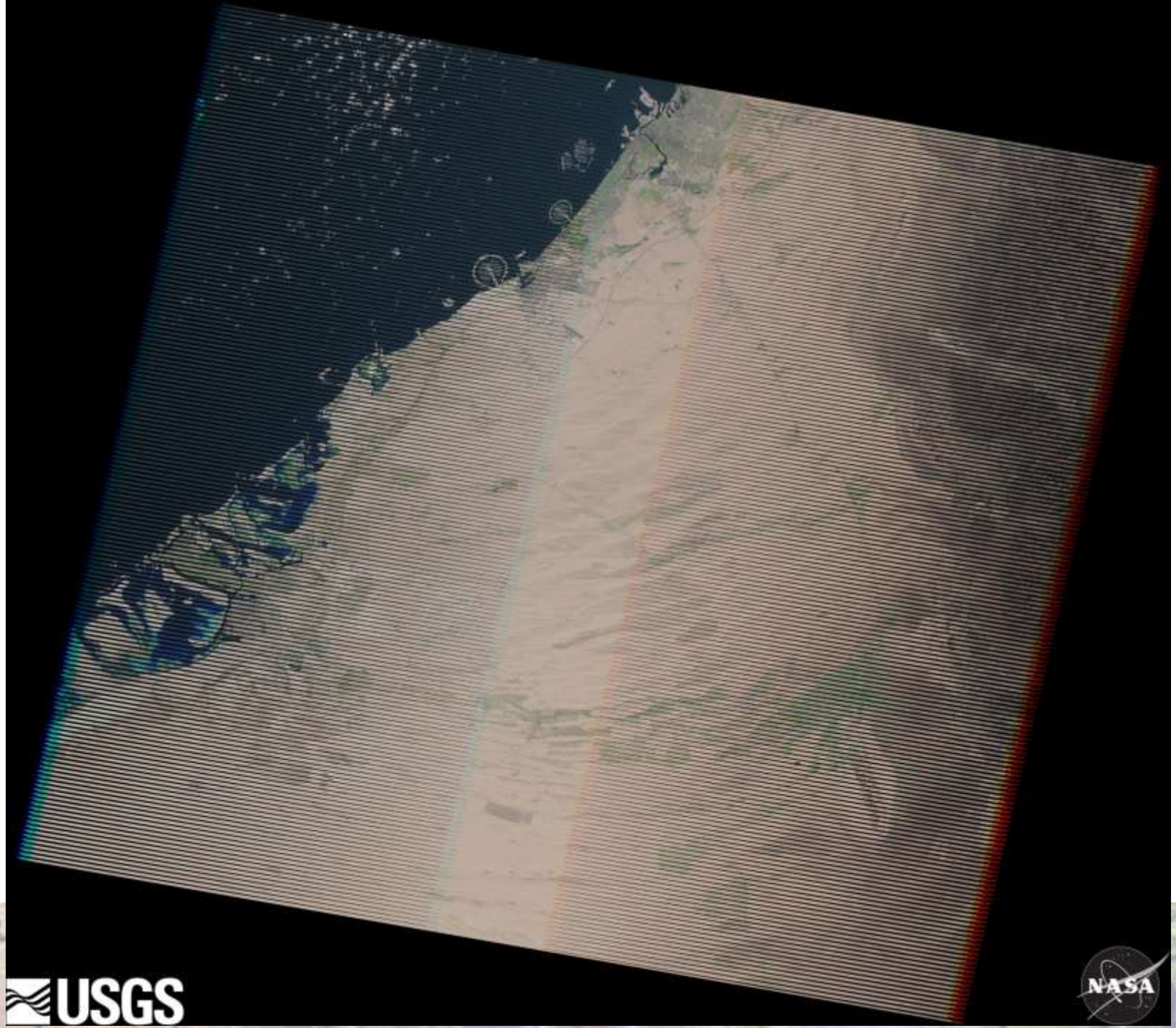
http://landsat.usgs.gov/LandsatLookImages.php
http://pubs.usgs.gov/fs/2011/3153/pdf/fs2011-3153.pdf

LandsatLook Images

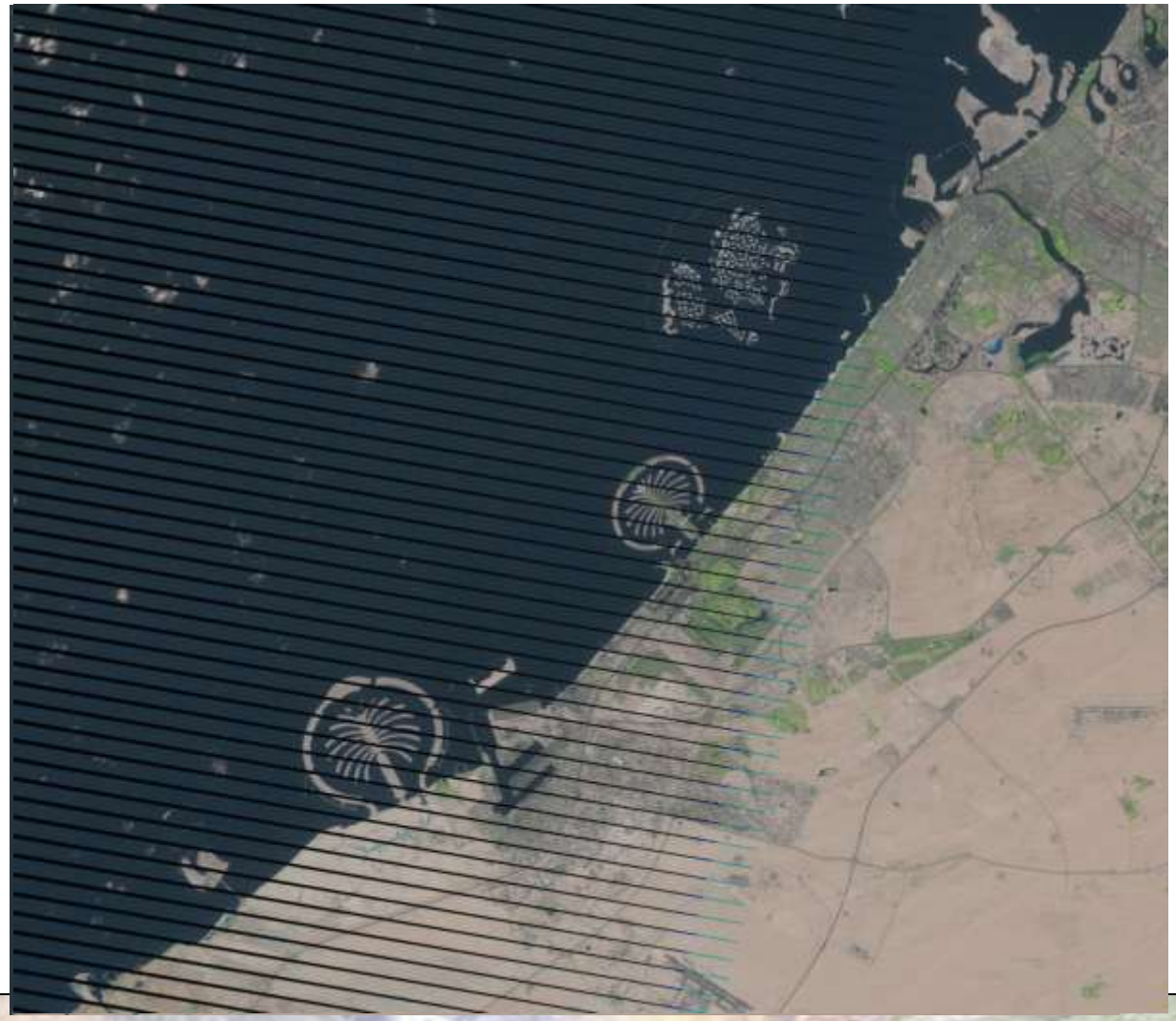
Landsat 1: 23 Feb 1973
Bands 241

Landsat 5: 13 Jun 2005
Bands 543



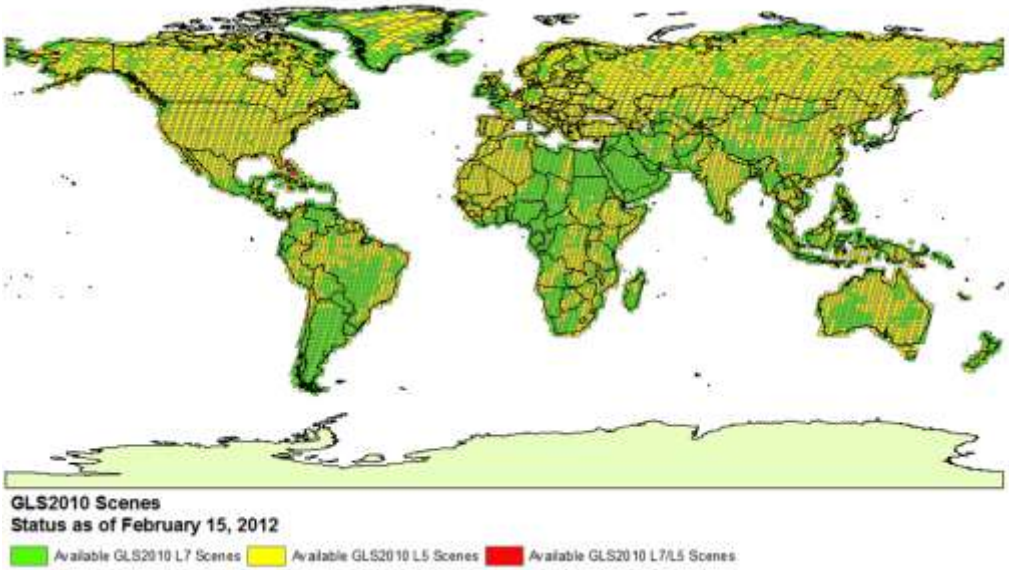

USGS
NASA

LandsatLook images comparing 1999-2011



Global Land Surveys

- **USGS/NASA collaboration effort**
- **Orthorectified, global dataset**
  - Cloud-free Landsat imagery
  - Centered on 1975, 1990, and 2000, 2005 2010 epochs
  - Support numerous science studies and mapping applications

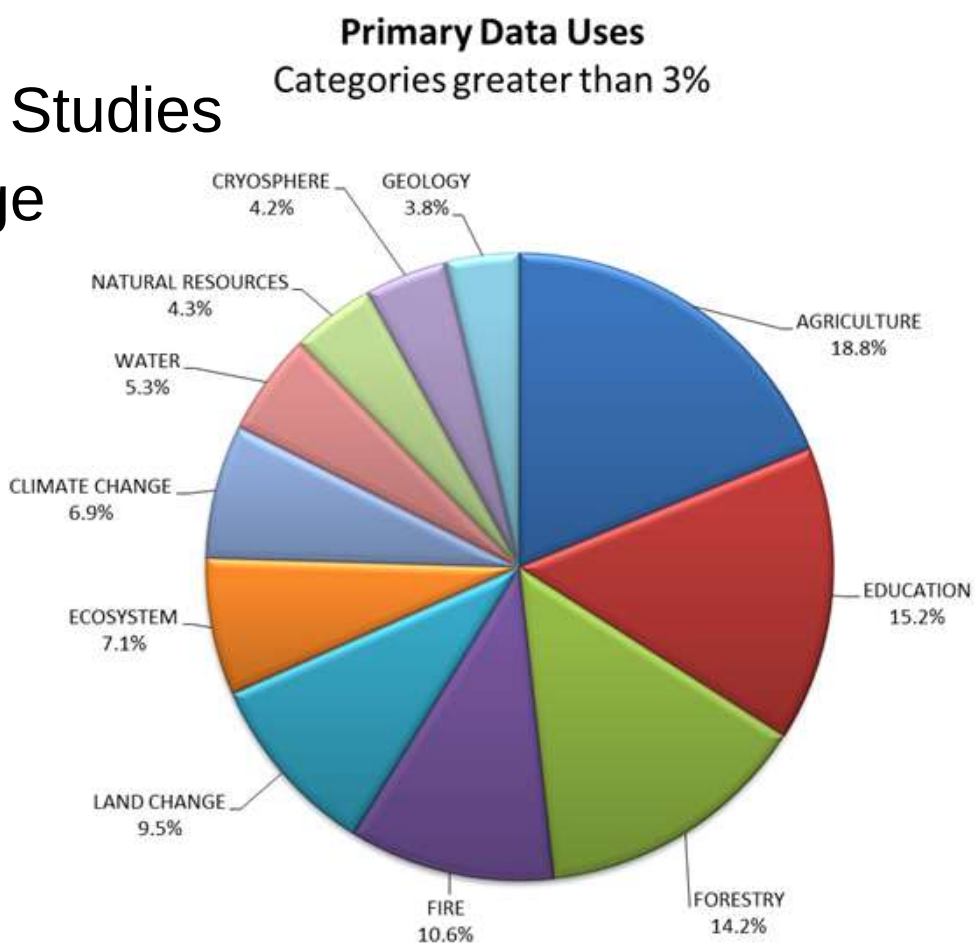


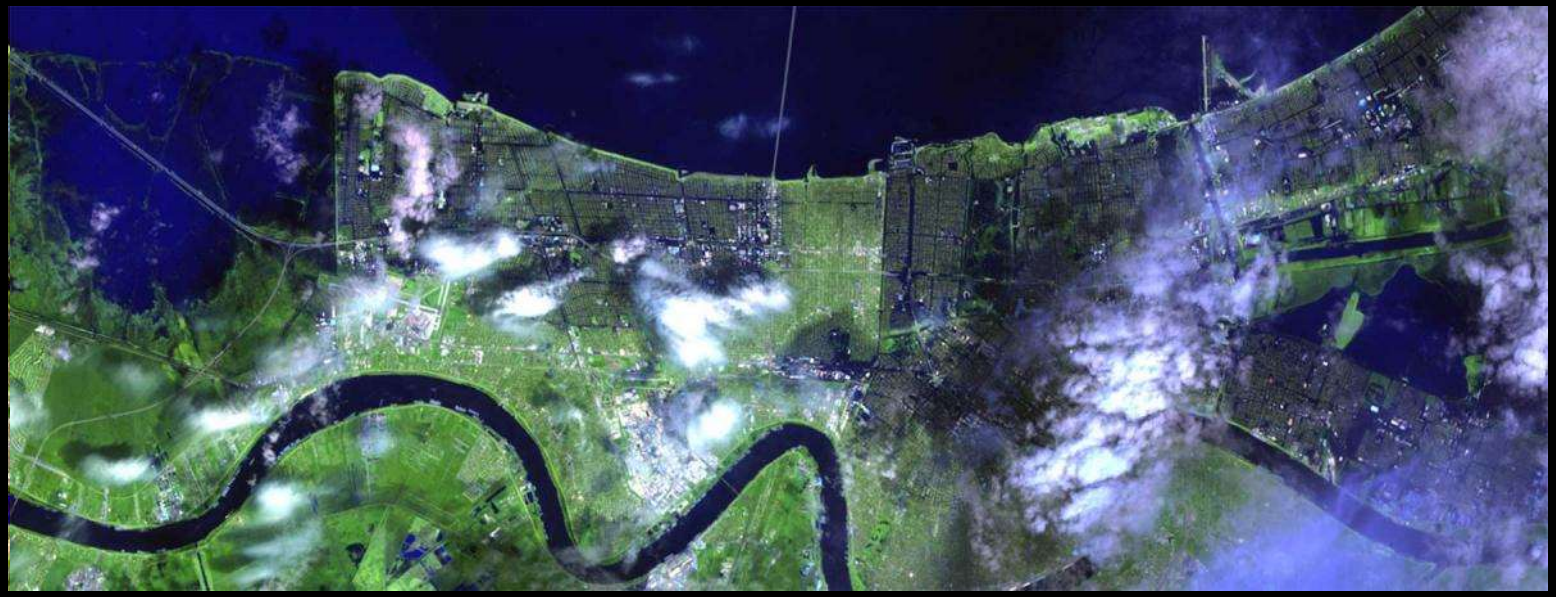
http://landsat.usgs.gov/science_GLS.php

Using Landsat Data Products

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

  - Government
  - Commercial
  - Civilian
  - Military
  - Education
  - Outreach





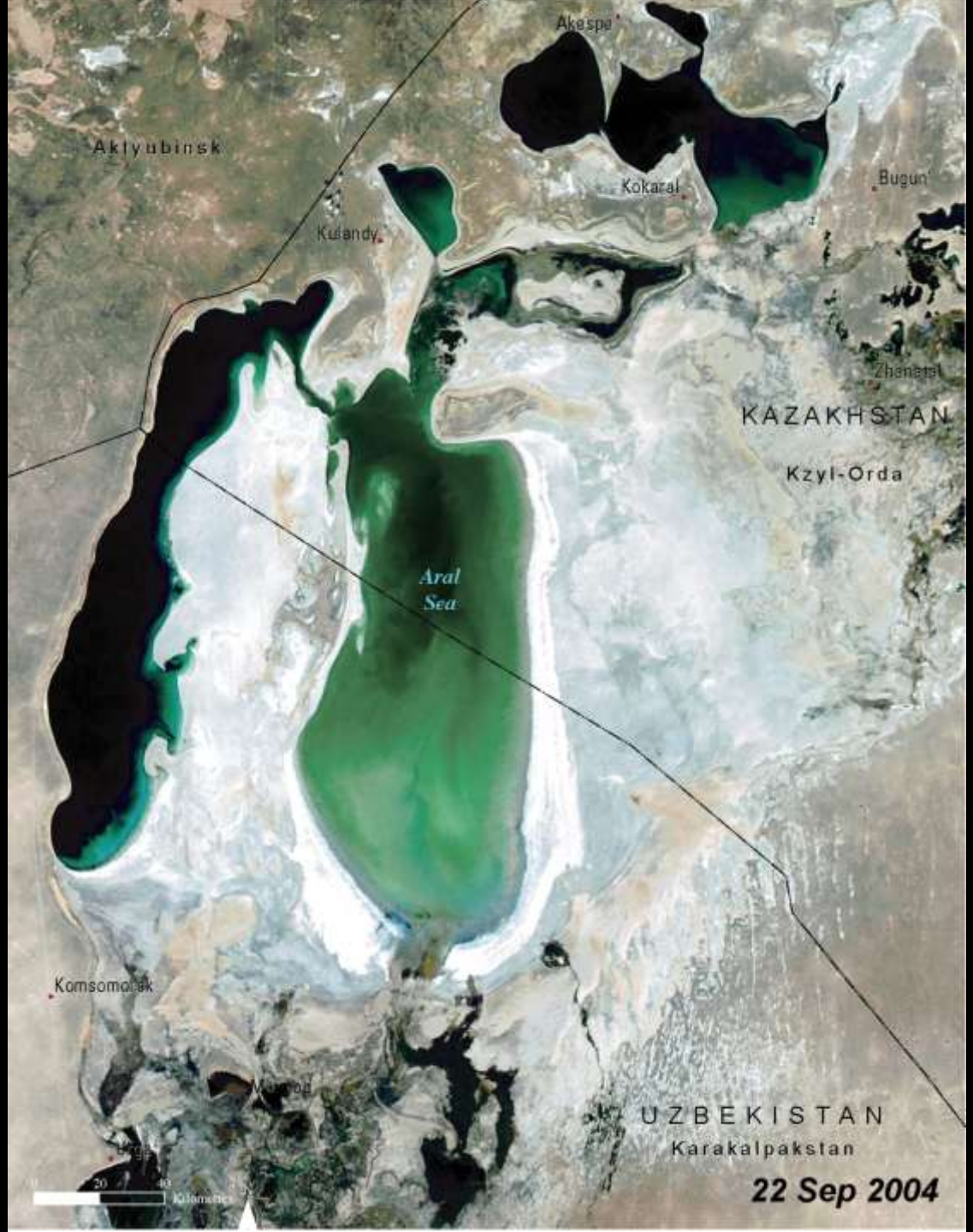
Aid in Emergency Response

USGS

Provide Insight into Broad Patterns

Pine Island Glacier – January 2011 – January 2012

USGS

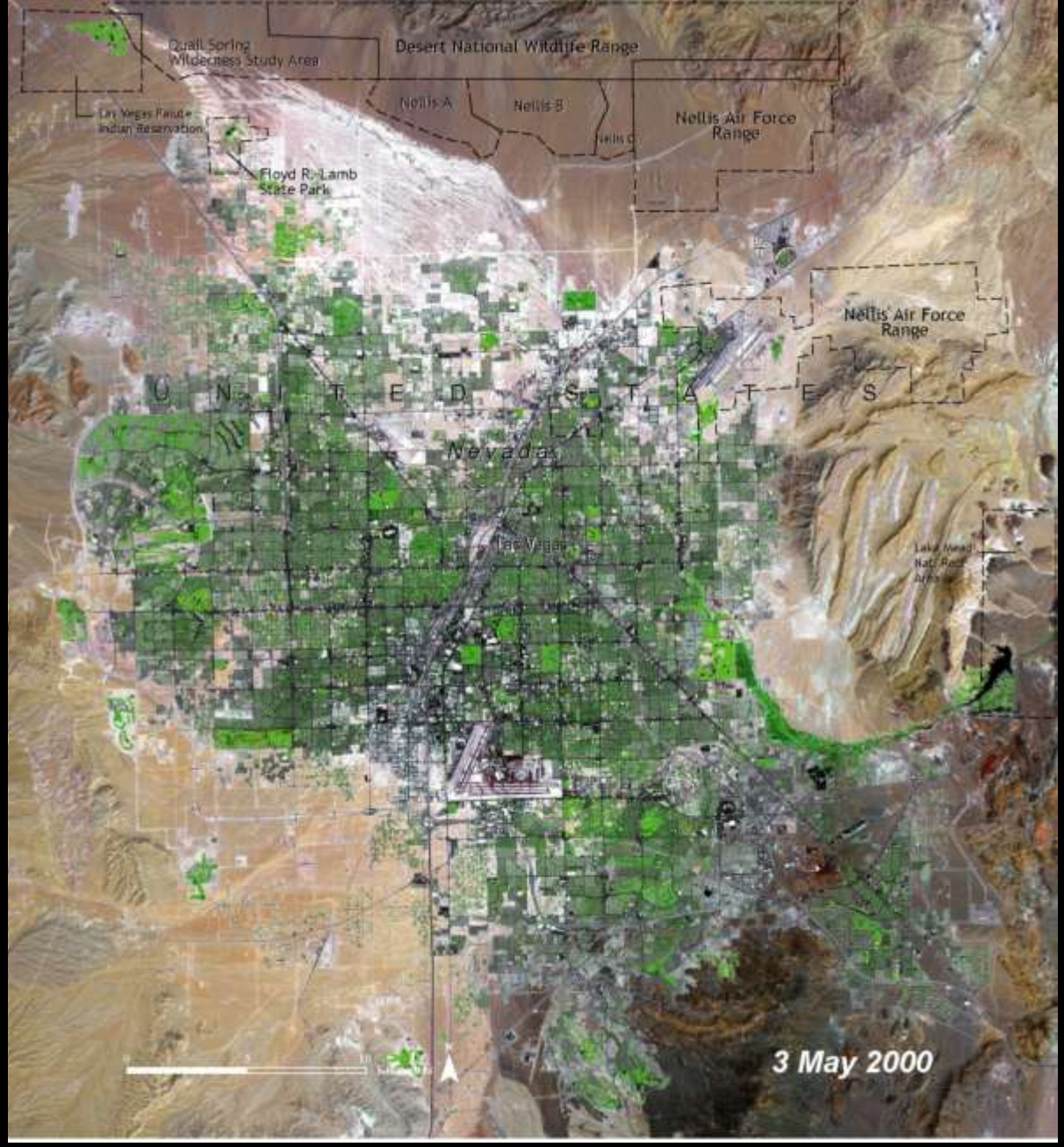

Akespe
Aktyubinsk
Kokaral
Bugun'
Kulandy
Zhanatal
KAZAKHSTAN
Kzyl-Orda
Aral
Sea
Komsomolsk
UZBEKISTAN
Karakalpakstan
22 Sep 2004

USGS

San Ramon
Rio San Pedro
Los Cajas
B O L I V I A
Grande (Guapay)
La Esperanza
Santa Cruz
Cotoca
Santa Cruz
6 May 2003

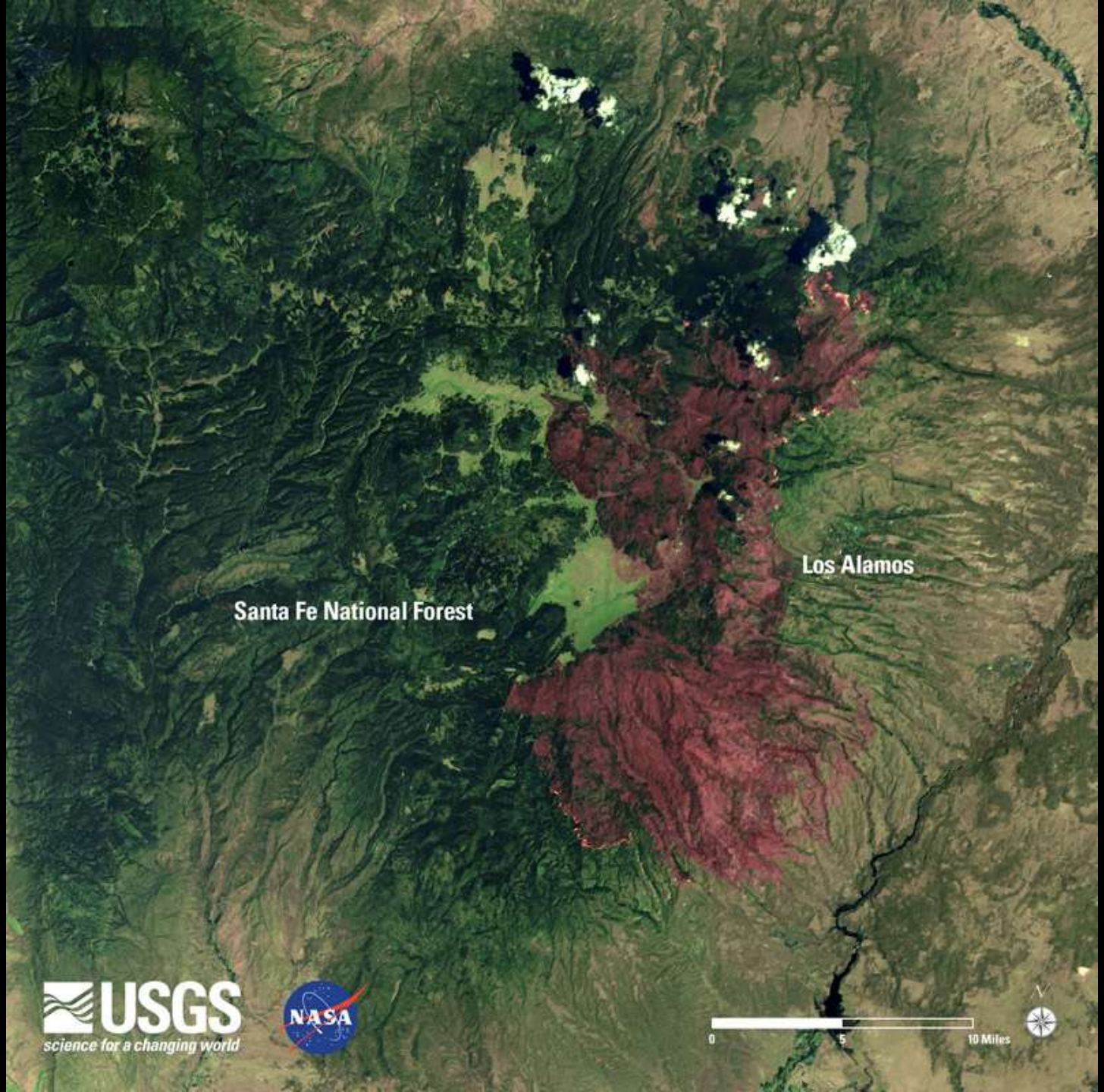
USGS

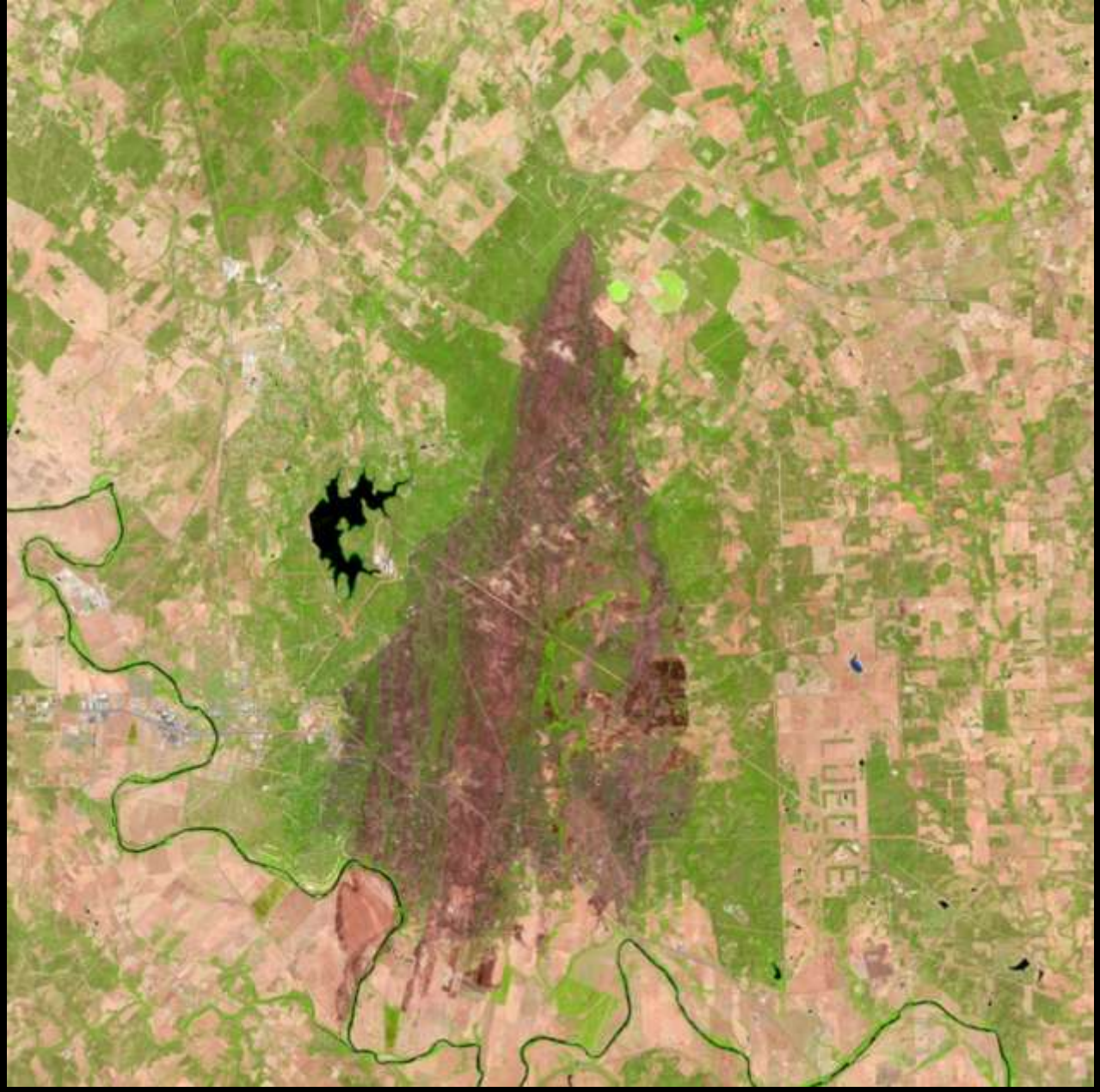
CAESARS PALACE
CELINE DION


Quail Spring
Wilderness Study Area
Desert National Wildlife Range
Nellis A
Nellis B
Nellis C
Nellis Air Force
Range
Las Vegas Paiute
Indian Reservation
Floyd R. Lamb
State Park
Nellis Air Force
Range
U N I T E D S T A T E S
Nevada
Las Vegas
3 May 2000

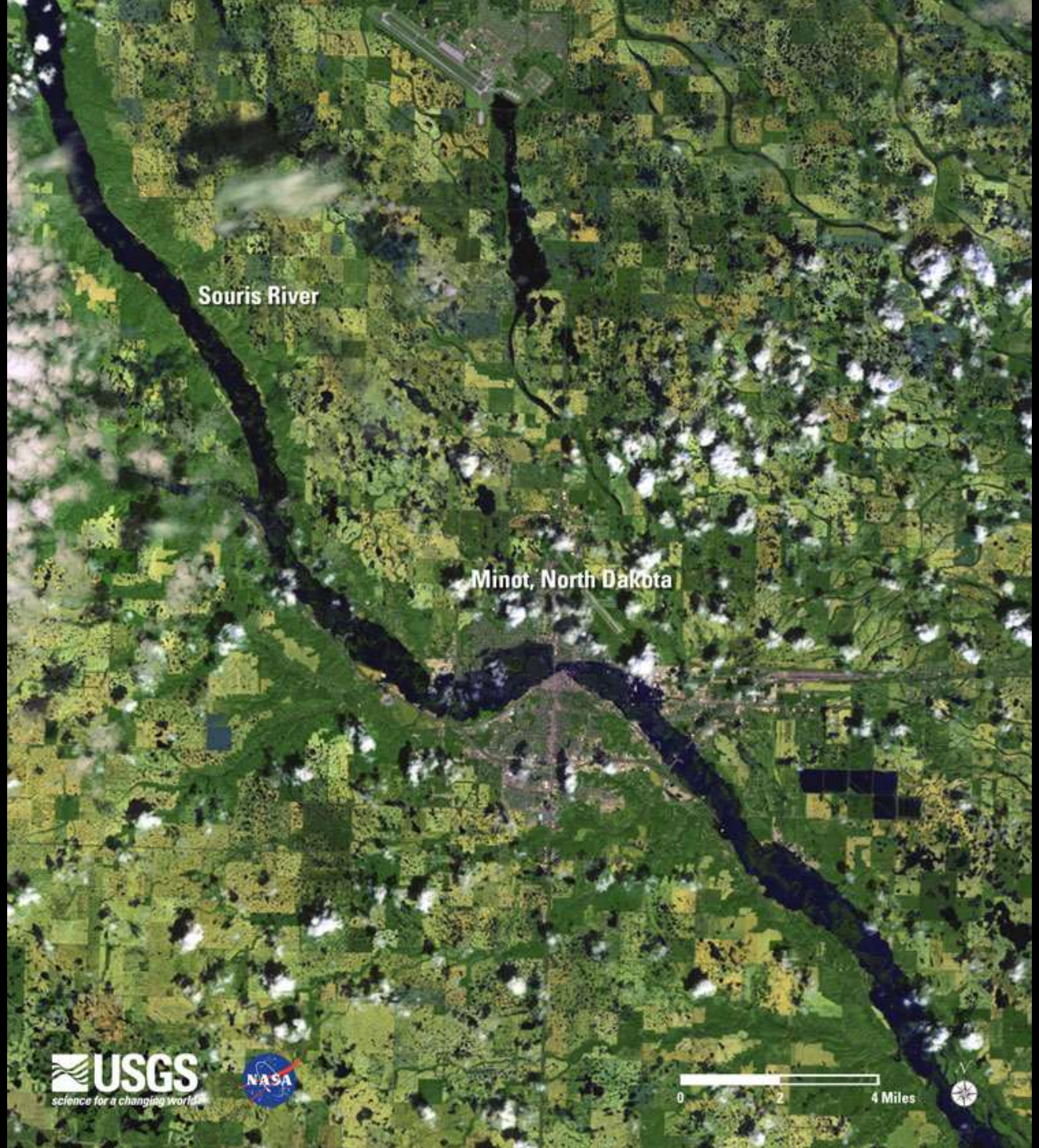
USGS

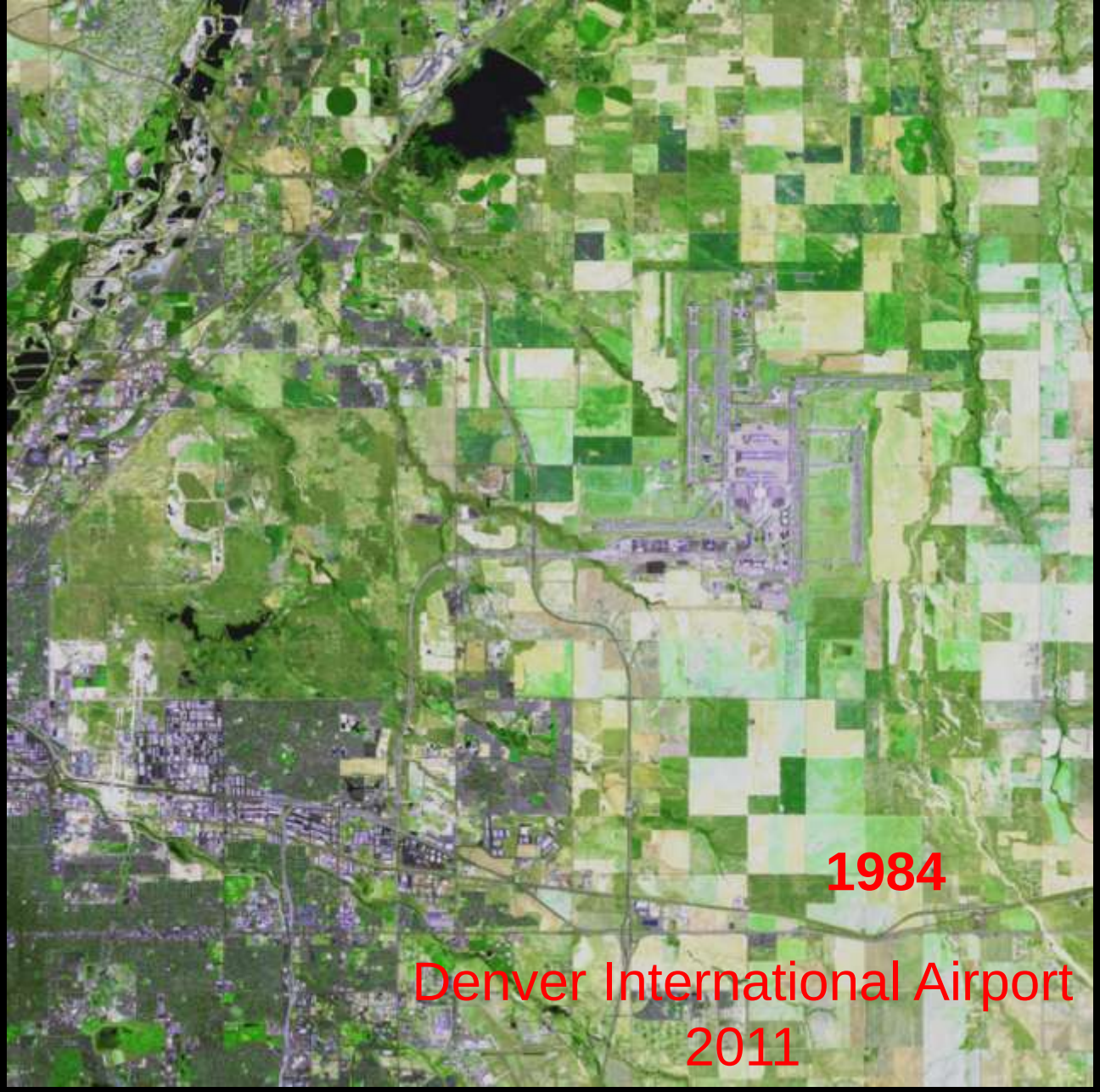
Courtesy: BBC News


Los Alamos
Santa Fe National Forest
USGS
science for a changing world
NASA
0
5
10 Miles
N



USGS


Souris River
Minot, North Dakota
USGS
science for a changing world
NASA
0
2
4 Miles



USGS

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

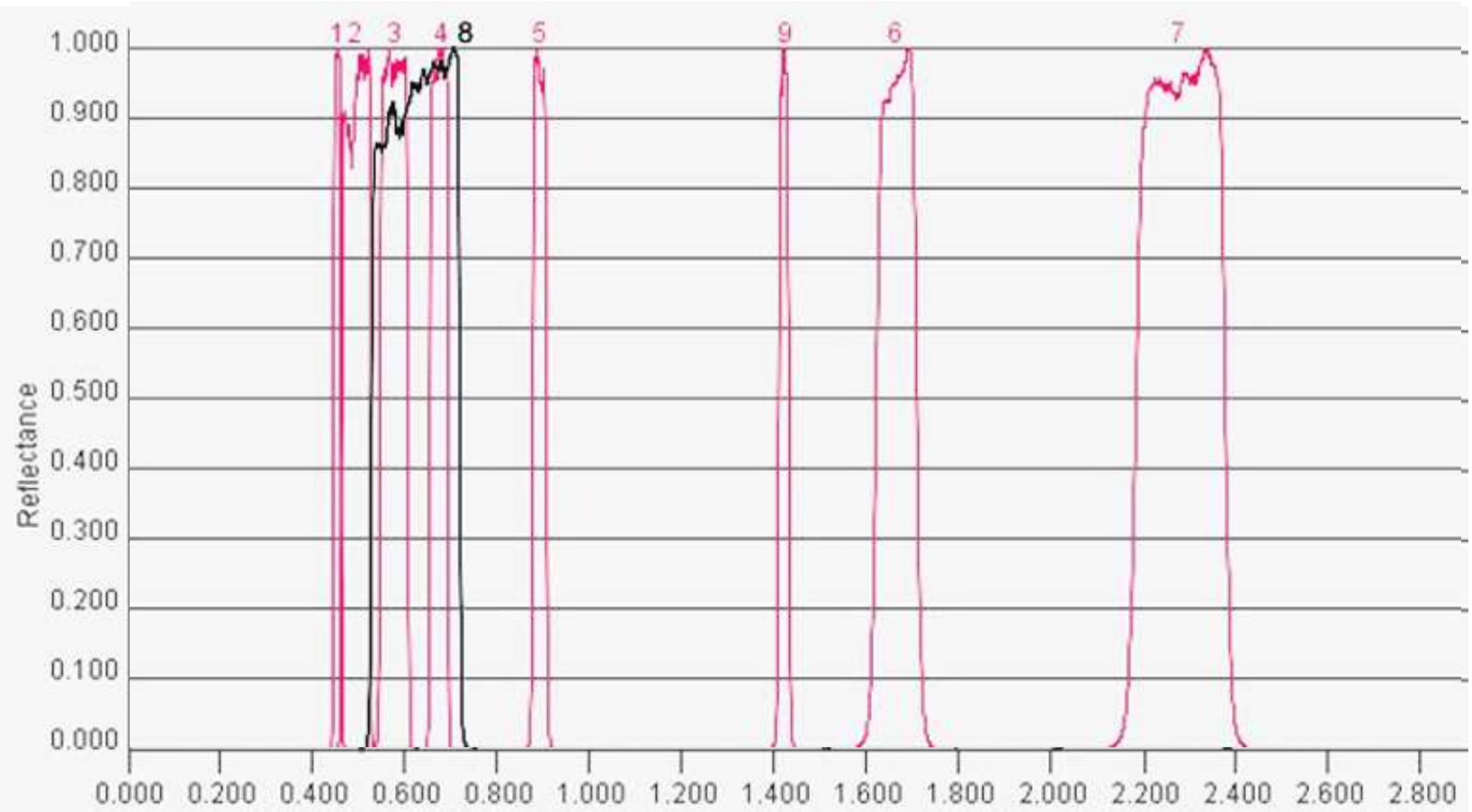
- Will be consistent with current standard data products:

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



http://landsat.usgs.gov/band_designations_landsat_satellites.php
http://landsat.usgs.gov/tools_viewer.php

More information

- http://landsat.usgs.gov/
- http://ldcm.nasa.gov
- Follow on Twitter : @USGSLandsat
- Facebook: http://facebook.com/NASA.Landsat
- Using Landsat 7 data: http://landsat.usgs.gov/using_Landsat_7_data.php

- Questions?
  - landsat@usgs.gov