



USGS Update on Landsat and Sustainable Land Imaging

National Academies of Sciences,
Engineering and Medicine
Committee on Earth Sciences and Applications from
Space

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U.S. Geological Survey (USGS) – The Science Arm of Interior

Water Resources



Natural Hazards



Core Science Systems



Ecosystems



Energy and Minerals



- USGS is a primary Federal source of science-based information available to the public, providing data about ecosystem science, energy and mineral resources, natural hazards, water use and availability, and updated maps and Earth imagery
- USGS Earth observation systems: National Stream Gage Network, Global seismic monitoring system, Global volcano monitoring system, the Landsat series of satellites, airborne lidar, the National Hydrography Dataset, and many more.

Landsat 9 Launched from Vandenberg SFB on September 27, 2021

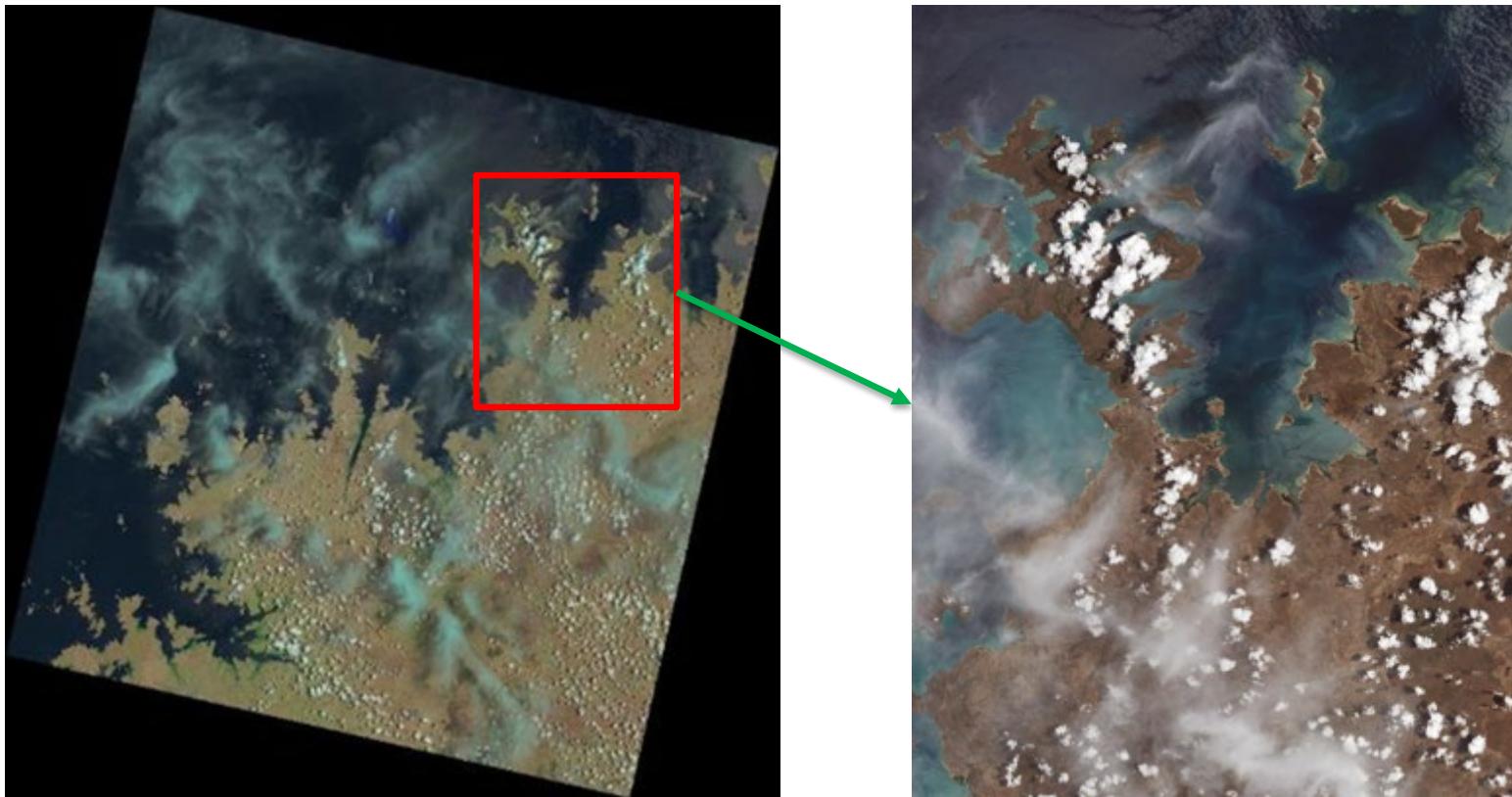
Landsat 9 Launch



Landsat 9
Observatory

Landsat 9 First Light Image

- ◆ Northern Australian Coast

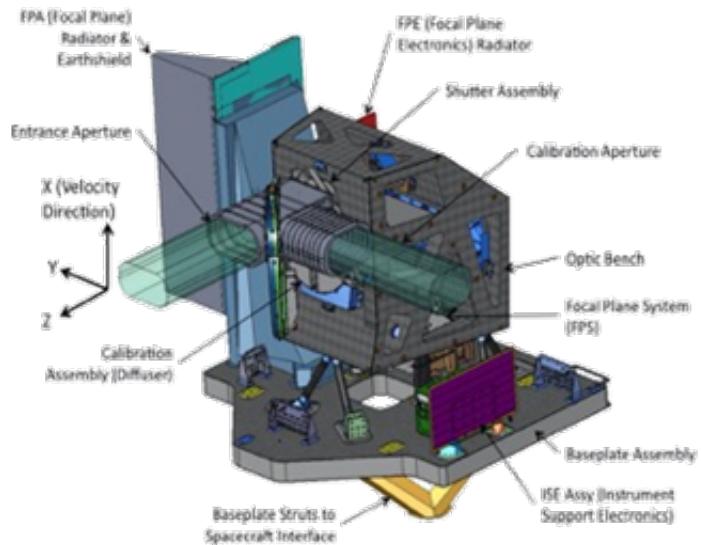




Landsat 9 Imaging Instruments

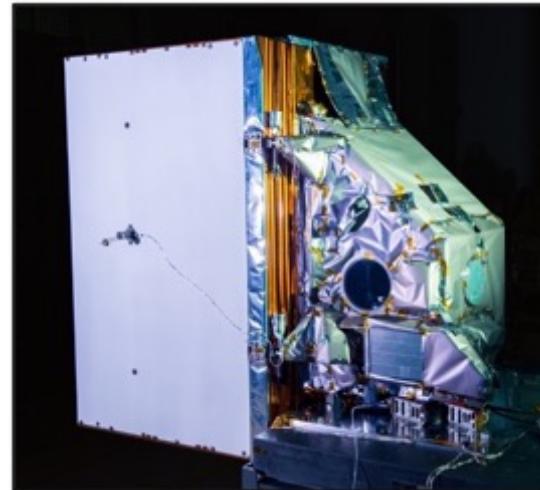
➤ Operational Land Imager 2 (OLI-2)

- ❑ Reflective band multispectral imager
- ❑ 8 VIS/NIR/SWIR bands w/ 30 m spatial resolution
- ❑ one panchromatic band w/ 15 m resolution
- ❑ Pushbroom sensor (Ball Aerospace)
 - » 4-mirror telescope
 - » Focal Plane Assembly (FPA) consisting of 14 sensor chip assemblies, passively cooled
- ❑ Absolute radiance uncertainty: <5%
- ❑ 6 on-board calibration sources: 3 stimulation lamps, 2 solar diffusors, and a shutter



➤ Thermal Infrared Sensor 2 (TIRS-2)

- ❑ Longwave imager for measuring surface temperature
- ❑ 2 spectral bands at 10.8 and 12 micrometers
- ❑ 100 m spatial resolution
- ❑ Pushbroom LWIR sensor (GSFC)
 - » 4-lens refractive telescope
 - » FPA consisting of three 2-d Quantum Well Infrared Photodetector (QWIP) sensor chip assemblies, mechanically cooled
- ❑ Absolute radiance uncertainty @ 300K <2%
- ❑ An on-board calibration source: a variable black body that can be set to different temperatures



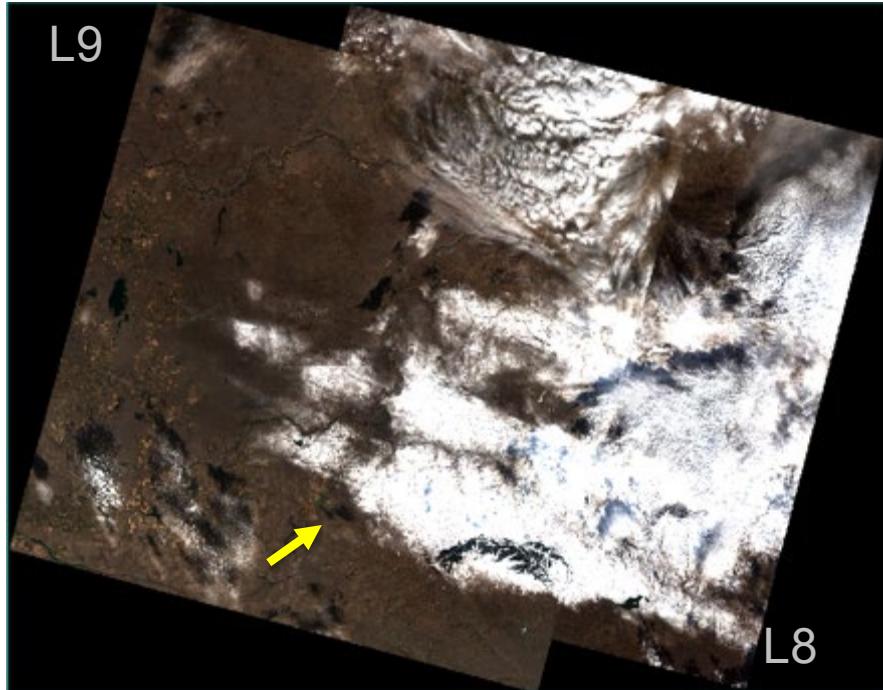
Vicarious Calibration (Underfly)

- As Landsat 9's orbit was increased to its operational/nominal orbit, there was a once in a mission lifetime opportunity where L9 was directly underneath L8, which allowed both missions to image the same area simultaneously.
- Field Teams from multiple countries and institutions were deployed to make the most of this opportunity



Underfly Image Pairs

L9



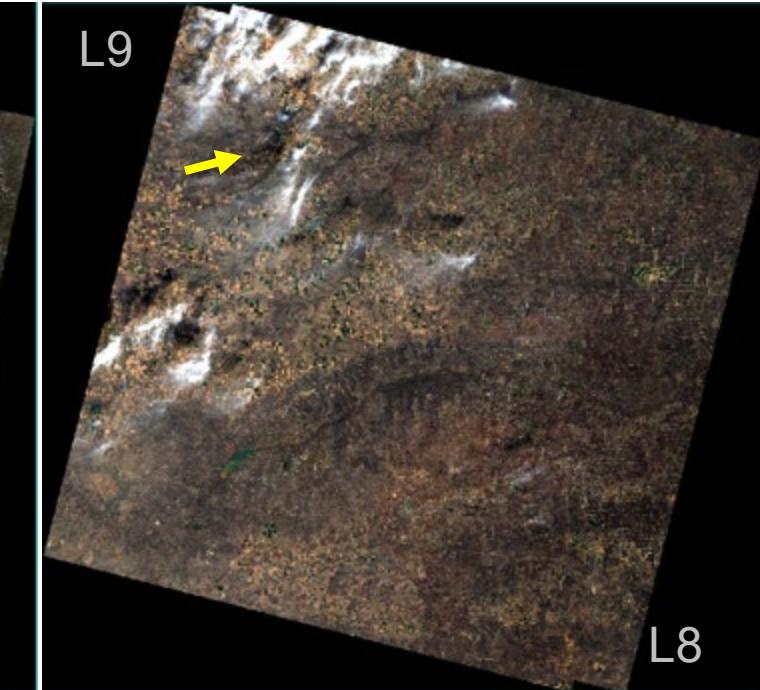
L8

L9



L8

L9



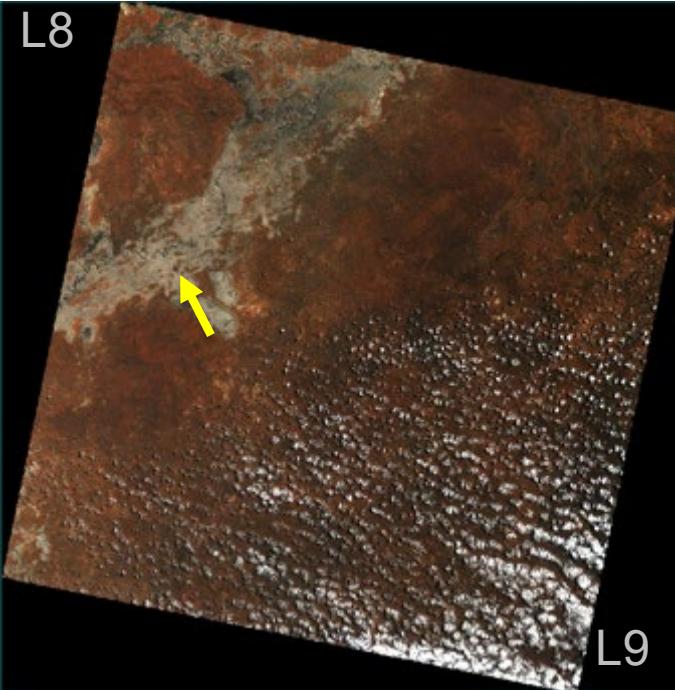
L8

Seven Persons (U of Lethbridge)
LC80390252021317LGN00
SCENE CENTER TIME: 18:11:57 UTC
LC90400252021317LGN00
SCENE CENTER TIME: 18:15:20 UTC

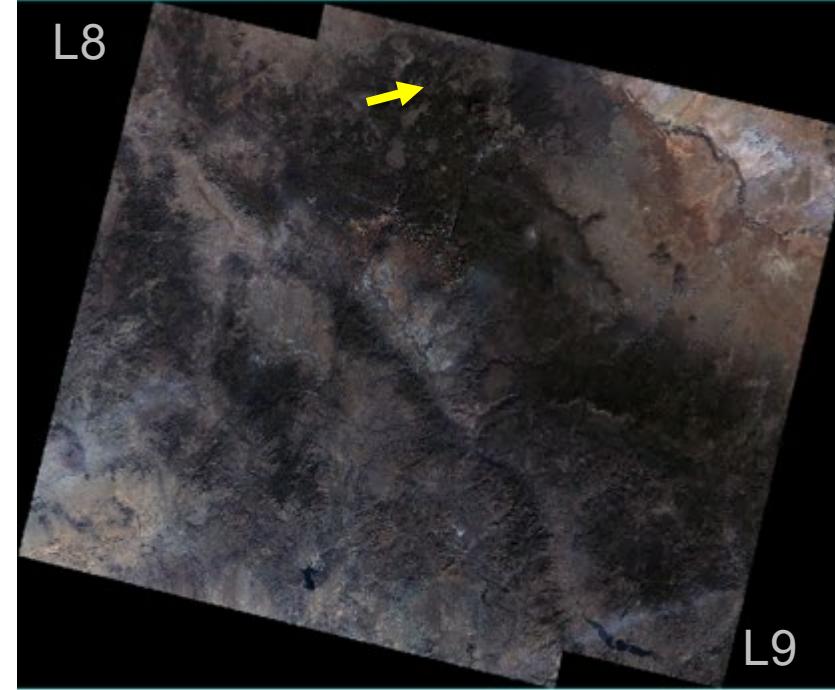
Ivanpah Playa, CA (U of Arizona)
LC80390352021317LGN00
SCENE CENTER TIME: 18:15:56 UTC
LC90400352021317LGN01
SCENE CENTER TIME: 18:19:18 UTC

Guymon, OK (USGS/EROS)
LC80300352021318LGN00
SCENE CENTER TIME: 17:20:18 UTC
LC90300342021318LGN00
SCENE CENTER TIME: 17:20:13 UTC

Underfly Image Pairs (Cont.)



Willcannia (Geoscience Australia)
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SCENE CENTER TIME: 00:14:34 UTC
LC90940822021319LGN00
SCENE CENTER TIME: 00:13:57 UTC

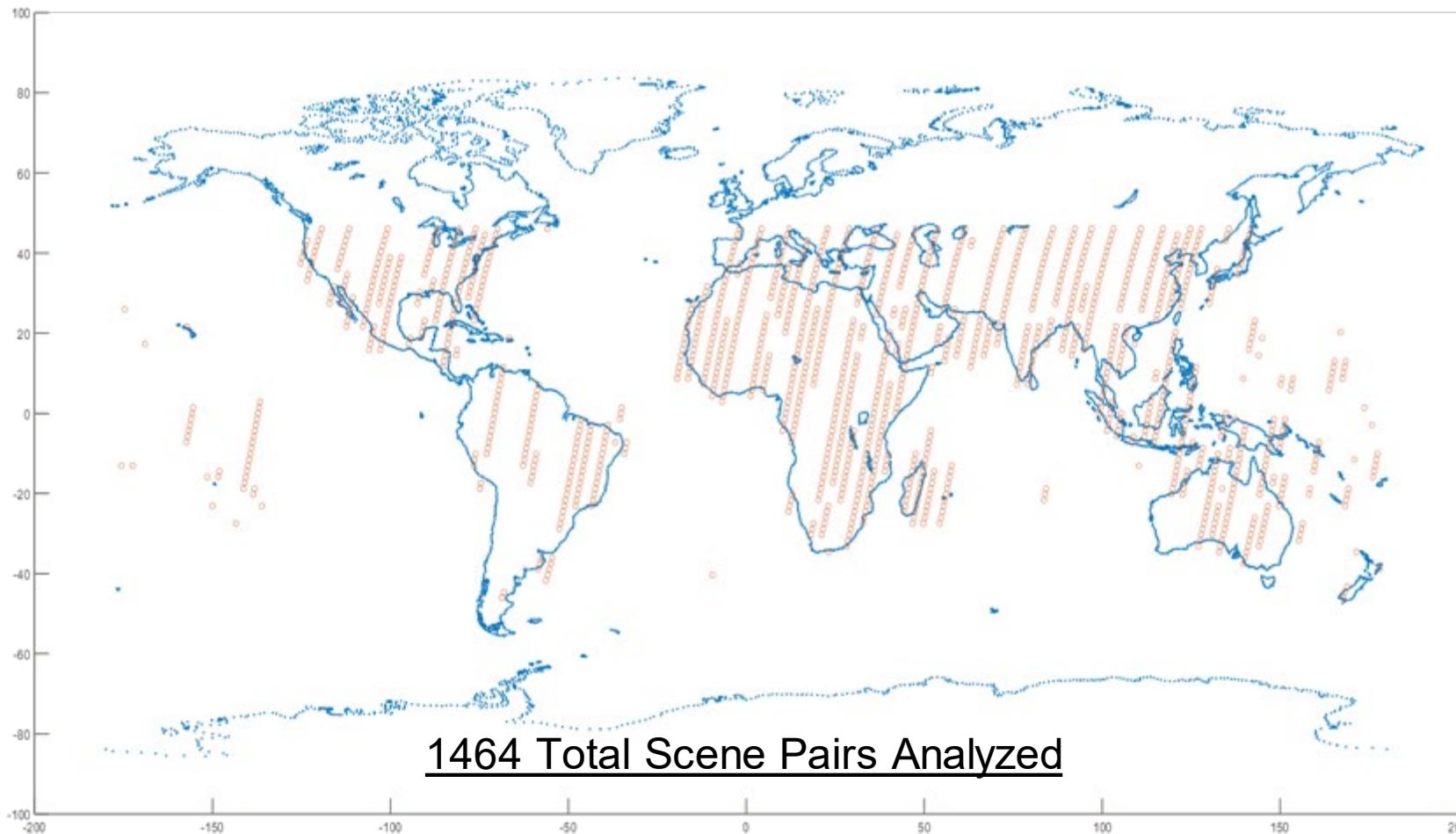


Coconino, AZ (USGS/EROS)
LC80370362021319LGN00
SCENE CENTER TIME: 18:03:57 UTC
LC90370362021319LGN01
SCENE CENTER TIME: 18:00:57 UTC



Jockey Ridge, NC (RIT)
LC80140342021318LGN00
SCENE CENTER TIME: 15:40:01 UTC
LC90140342021318LGN01
SCENE CENTER TIME: 15:41:32 UTC

Landsat 9 vs Landsat 8 (Global Underfly)



- ◆ Ensuring L9 and L8 produce consistent imagery
- ◆ Global comparison of all coincident L9/L8 image pairs during the underfly
 - ◆ Low Sun Elevation scenes were not used, and cloudy scenes were avoided

Landsat Operations Status

Landsat 9 (2021 -)



Landsat 8 (2013 -)

Collecting up to 740 new scenes per day; night and off-nadir imaging of volcano and fire imaging.

Landsat 7 (1999 - 2022)

Collecting about 470 new scenes per day; latest fuel estimate projects operations into 2022.



Earth Resources Observation and Science Center (EROS)

Landsat Archive Operations

10 million unique Landsat scenes available in the near 50-year archive, with well over 100 million downloads since Landsat data become freely available in 2008.

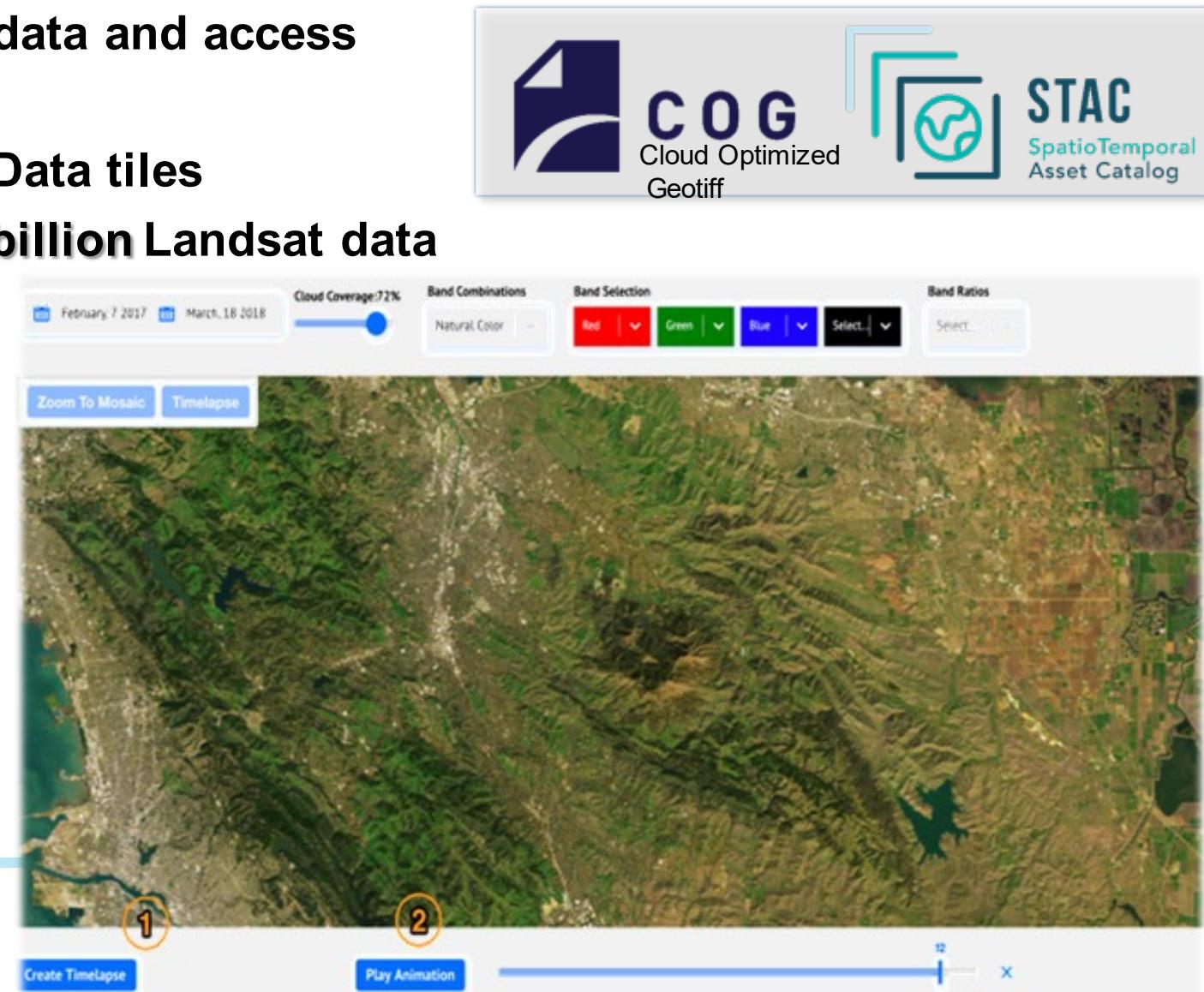
New “Collection 2” now available on the Amazon Cloud.

Landsat Collection 2 Released in the Commercial Cloud – May 2021

- Improved radiometry, geometry, metadata and access
- New tools for search and discovery
- Direct access to U.S. Analysis Ready Data tiles
- Since May, there have been over one billion Landsat data accesses made by users in the Cloud



More Landsat data products have been accessed directly from the Commercial Cloud in the last six months than in the entire combined 50-year history of the Landsat program!



NASA/DOI Sustainable Land Imaging (SLI) Program

- SLI is a multi-decadal program that provides users worldwide with high-quality, space-borne global, land-imaging measurements compatible with the existing nearly 50-year Landsat record
 - Addresses near-and longer-term issues of continuity risk
 - Leverages government, commercial and international capabilities
- Top-level Agency Roles and Responsibilities
 - NASA maintains responsibility for development, launch, on-orbit checkout & commissioning of space systems
 - DOI responsible for developing & maintaining associated ground systems (satellite operation & mission data systems), operating on-orbit spacecraft, and collecting, archiving, processing and distributing SLI data to users
- SLI Joint Steering Group (JSG):
 - Top-level board to integrate SLI program efforts
 - Forum to enable overall program strategy generation and approval, as well as coordination of NASA/DOI engagement & advocacy strategies with external stakeholders, including Executive and Legislative branches, on issues of budget and policy.
 - Includes Interior Assistant Secretary Trujillo, Associate Administrator Zurbuchen, David Applegate, the Associate Director for Natural Hazards Exercising the Delegated Authority of the Director, USGS, and NASA Earth Science Division Director St. Germain

Landsat Next

- **Landsat Next:** Under the SLI agreement, the U.S. intends to implement a robust spaceborne, land imaging system to ensure continued collection of data for processing into useful and efficient information products for use by the wide range of interested science communities.
- **Mission Concept:** Collection of “superspectral” land observations featuring both richer spectral information and higher spatial resolution than Landsat 8 and 9 with improved temporal frequency.
- **Requirements:** Reflect the needs of users for:
 - **Improved temporal revisit** for monitoring dynamic land and water surfaces such as vegetation crop phenology, burn severity, water use and quality, coastal and wetland change, glacier and ice sheet dynamics.
 - **Improved spatial resolution** for agricultural monitoring, ecological monitoring, urban studies, water resources management and other applications.
 - **Synergy with European Sentinel-2 bands** allowing easier merging of information products.
 - **Improved spectral resolution** to support new and evolving applications, including surface water quality, cryospheric science, geology, and agricultural applications including crop water consumption.
 - **Preservation of heritage performance:** spatial, geometric, radiometric, and Signal-to-Noise Ratio (SNR).

Landsat Next Comparison with Commercial, Landsat 8/9

Commercial Smallsts	Landsats 8 & 9	Landsat Next	Landsat Next Science/Applications Benefit	Enhancement
Thermal Infrared	Bands 10-11 TIR: surface temperature, crop water use (evapotranspiration), cloud detection & active fire/volcanos		Bands 22-26: surface temperature, crop water use (evapotranspiration), mineral and surface comp mapping, cloud detection, active fire/volcanoes.	Acquires 26 spectral bands, more than twice the number acquired by Landsat 8/9
Shortwave Infrared	Bands 6-7 SWIR: vegetation (type, biomass, health), soil, and burned areas		Bands 19-21: soil quality & crop management	
Near Infrared	Near IR: vegetation indices & health		Bands 14-16: snow cover and ice melt (liquid water) Band 13: water vapor, for improved atmospheric corrections Band 11: vegetation indices Bands 9-10: leaf area, chlorophyll, early plant stress	Improves spatial resolution to 10, 20, or 60 meters for all bands
Visible Light	visible light (R, G, B) natural color		Bands 6-7: water quality, harmful algal blooms Band 5: vegetation health Bands 1-2: improved aerosol retrieval; inland/coastal water quality	Doubles the acquisition frequency to all land/coastal areas every 6 days
<p><i>Landsat Next enhancements improve our understanding of global environmental change</i></p>				

Landsat Next Current and Near-term Activities

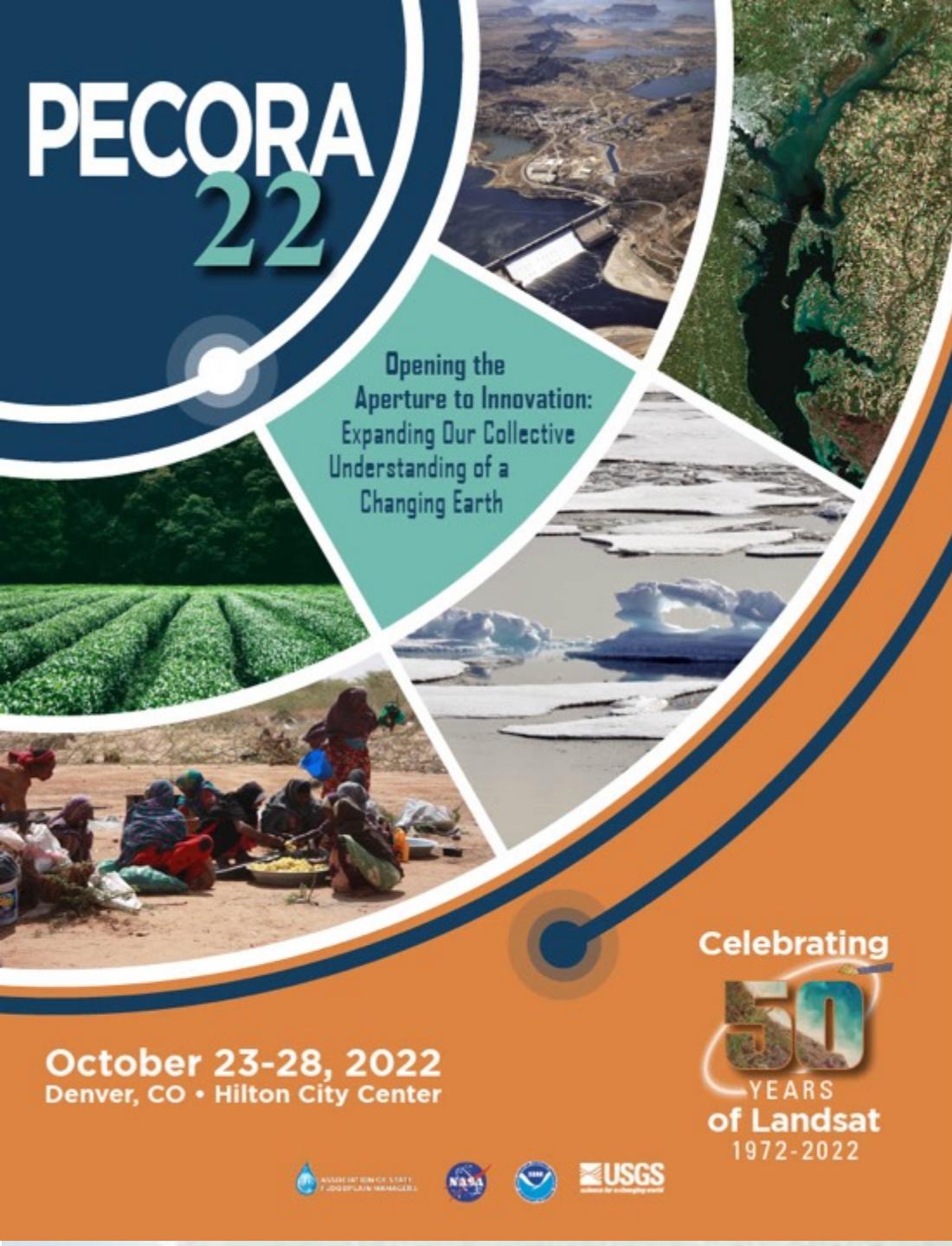
- **NASA and USGS are working together to determine the Landsat Next mission concept**
 - NASA/USGS Landsat Next Project Teams have been working together for well over a year
 - Three Requests for Information released (Science Requirements/instrument concept/mission architecture, Instrument, Payload Interface/Data Storage)
 - Multiple space architectures considered
 - Ground system studies and architecture trades in progress
- **Target Launch Readiness Date: Late 2020s**
- **NASA Mission Concept Review (MCR) and Key Decision Point A for approval to proceed scheduled for 2022**

National Space Council Meeting - December 1, 2021

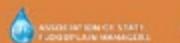
- Convened by Vice President Harris at the U.S. Institute of Peace
- Announced new **Executive Order** renewing the Council; adds Interior, Agriculture, Labor, Education, and the National Climate Advisor
- Released **Space Priorities Framework** synchronizing civil, commercial and national security space communities:



"The United States will advance the development and use of space-based Earth observation capabilities that support action on climate change..."



October 23-28, 2022
Denver, CO • Hilton City Center



PECORA-22: October 23-28, 2022

Denver, Colorado



- Our flagship land-imaging satellite applications conference, and a longstanding USGS-NASA partnership
- Highlights Landsat's 50th anniversary
- Conference will feature Landsat 9, Landsat Next and the many innovative developments in government and commercial land-imaging programs
- Website: pecora22.org