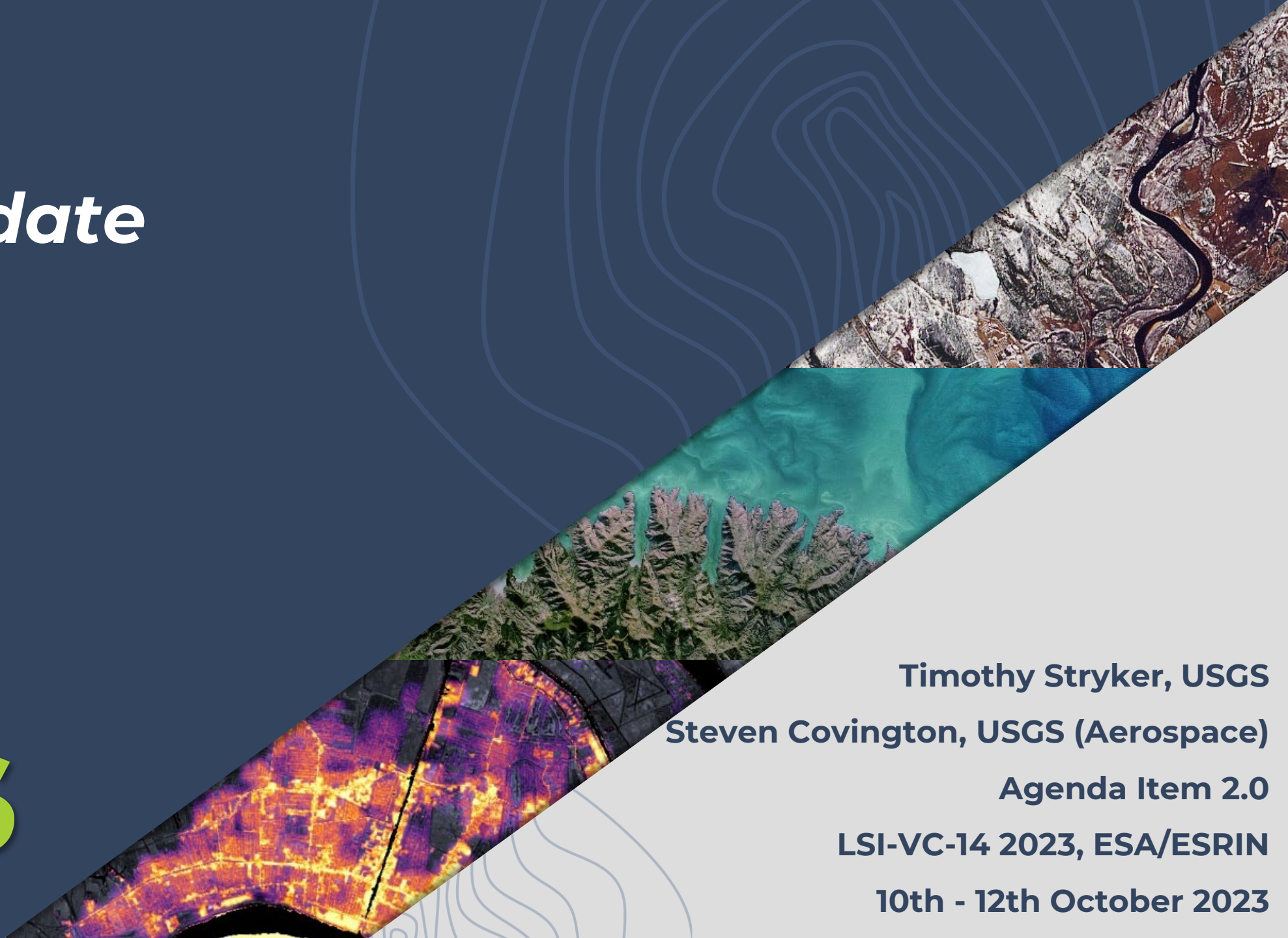
USGS Update



Timothy Stryker, USGS

Steven Covington, USGS (Aerospace)

Agenda Item 2.0

LSI-VC-14 2023, ESA/ESRIN

10th - 12th October 2023

CEOS

Committee on
Earth Observation Satellites

CEOS Analysis Ready Datasets

ceos.org/ard/index.html#datasets

CEOS Analysis-Ready Datasets

The following table summarises all of the satellite EO datasets that have been assessed as CEOS Analysis Ready Data (CEOS-ARD). DOI links are provided for access, along with links to further information, sample products, and the completed CEOS-ARD self-assessment and peer review outcome documents.

Product	CEOS-ARD Type	PFS Version	Agency	Mission(s)	Threshold Specification	Target Specification	Access (DOI)	Info	Self Assessment	Peer Review	Sample Products
ALOS-2 PALSAR-2 Global Mosaics (RTC)	Normalised Radar Backscatter	v5.5	JAXA	ALOS-2 PALSAR-2	100%	Not assessed	Link	Link	DOC	DOC	Link
ALOS-2 PALSAR-2 25m ScanSAR NRB	Normalised Radar Backscatter	v5.5	JAXA	ALOS-2 PALSAR-2	100%	Not assessed	Link	Link	DOC	DOC	Link
EnMAP	Surface Reflectance	v5.0	DLR	EnMAP	100%	Not assessed	TBA	Link	PDF	PDF	Link
Landsat Collection 2	Surface Reflectance	v5.0	USGS	Landsat 4, 5, 7, 8, 9	100%	81%	Landsat 4-5, 7, 8-9	Link	PDF	PDF	Link
Landsat Collection 2	Surface Temperature	v5.0	USGS	Landsat 4, 5, 7, 8, 9	100%	83%	Landsat 4-5, 7, 8-9	Link	PDF	PDF	Link
Landsat Collection 2 U.S. ARD	Surface Reflectance	v5.0	USGS	Landsat 4, 5, 7, 8, 9	100%	Not assessed	Link	Link	PDF	PDF	Link
Landsat Collection 2 U.S. ARD	Surface Temperature	v5.0	USGS	Landsat 4, 5, 7, 8, 9	100%	Not assessed	Link	Link	PDF	PDF	Link
PROBA-V L3 (0.1/0.333/1 km) TOC	Surface Reflectance	v5.0	VITO / ESA	PROBA-V	100%	Not assessed	Link	Link	PDF	PDF	Link
Sentinel-1 RTC	Normalised Radar Backscatter	v5.5	Sinergise & Digital Earth Africa	Sentinel-1 (A, B)	100%	Not assessed	Link	Link	PDF	PDF	Link
Sentinel-2 Level-2A	Surface Reflectance	v5.0	ESA	Sentinel-2A, 2B	100%	Not assessed	Link	Link	PDF	PDF	Link

Summary Self-Assessment
USGS Landsat Collection 1 (U.S. ARD) -> Collection 2
Surface Reflectance – CARD4L PFS v5.0

	Threshold	Target
1. General Metadata		
1.1 Traceability	Not required	No
1.2 Metadata Machine Readability	Yes	Yes
1.3 Data Collection Time	Yes	Yes
1.4 Geographical Area	Yes	Yes
1.5 Coordinate Reference System	Yes	Yes
1.6 Map Projection	Yes	Yes
1.7 Geometric Correction Methods	Not required	No -> Yes
1.8 Geometric Accuracy of the Data	Not required	No -> Yes
1.9 Instrument	Yes	No -> Yes
1.10 Spectral Bands	No -> Yes	No -> Yes
1.11 Sensor Calibration	Not required	Yes
1.12 Radiometric Accuracy	Not required	No -> Yes
1.13 Algorithms	Yes	No -> Yes
1.14 Ancillary Data	No -> Yes	No -> Yes
1.15 Processing Chain Provenance	Not required	No -> Yes
1.16 Data Access	No -> Yes	Yes
1.17 Overall Data Quality	Not required	Yes
2. Per-Pixel Metadata		
2.1 Metadata Machine Readability	Yes	Yes
2.2 No Data	Yes	Yes
2.3 Incomplete Testing	Yes	Yes
2.4 Saturation	Yes	Yes
2.5 Cloud	Yes	No -> Yes
2.6 Cloud Shadow	Yes	No -> Yes
2.7 Land/Water Mask	Not required	Yes
2.8 Snow/Ice Mask	Not required	No -> Yes
2.9 Terrain Shadow Mask	Not required	No
2.10 Terrain Occlusion	Not required	Yes
2.11 Solar and Viewing Geometry	No -> Yes	No
2.12 Terrain Illumination Correction	Not required	No
2.12 Aerosol Optical Depth Parameters	Not required	Yes
3. Radiometric and Atmospheric Corrections		
3.1 Measurement	Yes	No
3.2 Measurement Uncertainty	Not required	No
3.3 Measurement Normalization	Not required	Yes
3.4 Directional Atmospheric Scattering	No -> Yes	No -> Yes
3.5 Water Vapour Corrections	No -> Yes	No -> Yes
3.6 Ozone Corrections	Not required	No -> Yes
4. Geometric Corrections		
4.1 Geometric Correction	Yes	Yes

Table Key	
Threshold/Target Now Met in Collection 2	
Target Not Met	
Not assessable	

Summary Self-Assessment
USGS Landsat Collection 1 (U.S. ARD) -> Collection 2
Surface Temperature – CARD4L PFS v5.0

	Threshold	Target
1. General Metadata		
1.1 Traceability	Not required	Yes
1.2 Metadata Machine Readability	Yes	Yes
1.3 Data Collection Time	Yes	Yes
1.4 Geographical Area	Yes	Yes
1.5 Coordinate Reference System	Yes	Yes
1.6 Map Projection	Not required	Yes
1.7 Geometric Correction Methods	Not required	No -> Yes
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1.14 Ancillary Data	Yes	No -> Yes
1.15 Processing Chain Provenance	Not required	No -> Yes
1.16 Data Access	No -> Yes	Yes
1.17 Overall Data Quality	Not required	Yes
2. Per-Pixel Metadata		
2.1 Metadata Machine Readability	Yes	Yes
2.2 No Data	Yes	Yes
2.3 Incomplete Testing	No -> Yes	No -> Yes
2.4 Saturation	Yes	Yes
2.5 Cloud	Yes	No -> Yes
2.6 Cloud Shadow	Yes	No -> Yes
2.7 Snow/Ice Mask	Yes	No -> Yes
2.8 Solar and Viewing Geometry	Yes	No
3. Radiometric and Atmospheric Corrections		
3.1 Measurement	Yes	Yes
3.2 Corrections for Atmosphere and Emissivity	Yes	Yes
3.3 Measurement Uncertainty	Yes	Yes
4. Geometric Corrections		
4.1 Geometric Correction	Yes	Yes

Table Key	
Threshold/Target Now Met in Collection 2	
Target Not Met	
Not assessable	

Landsat Operations Status

Landsat 9 (2021 -)

Collecting more than 700 new scenes per day; full mission transitioned to USGS in 2022

Landsat 8 (2013 -)

Collecting more than 700 new scenes per day; watching potential solar array drive issue; longevity concerns

Landsat 7 (1999 -)

Lowered into storage orbit; awaiting NASA satellite rendezvous and refueling; still collecting new imagery

Earth Resources Observation and Science Center (EROS)

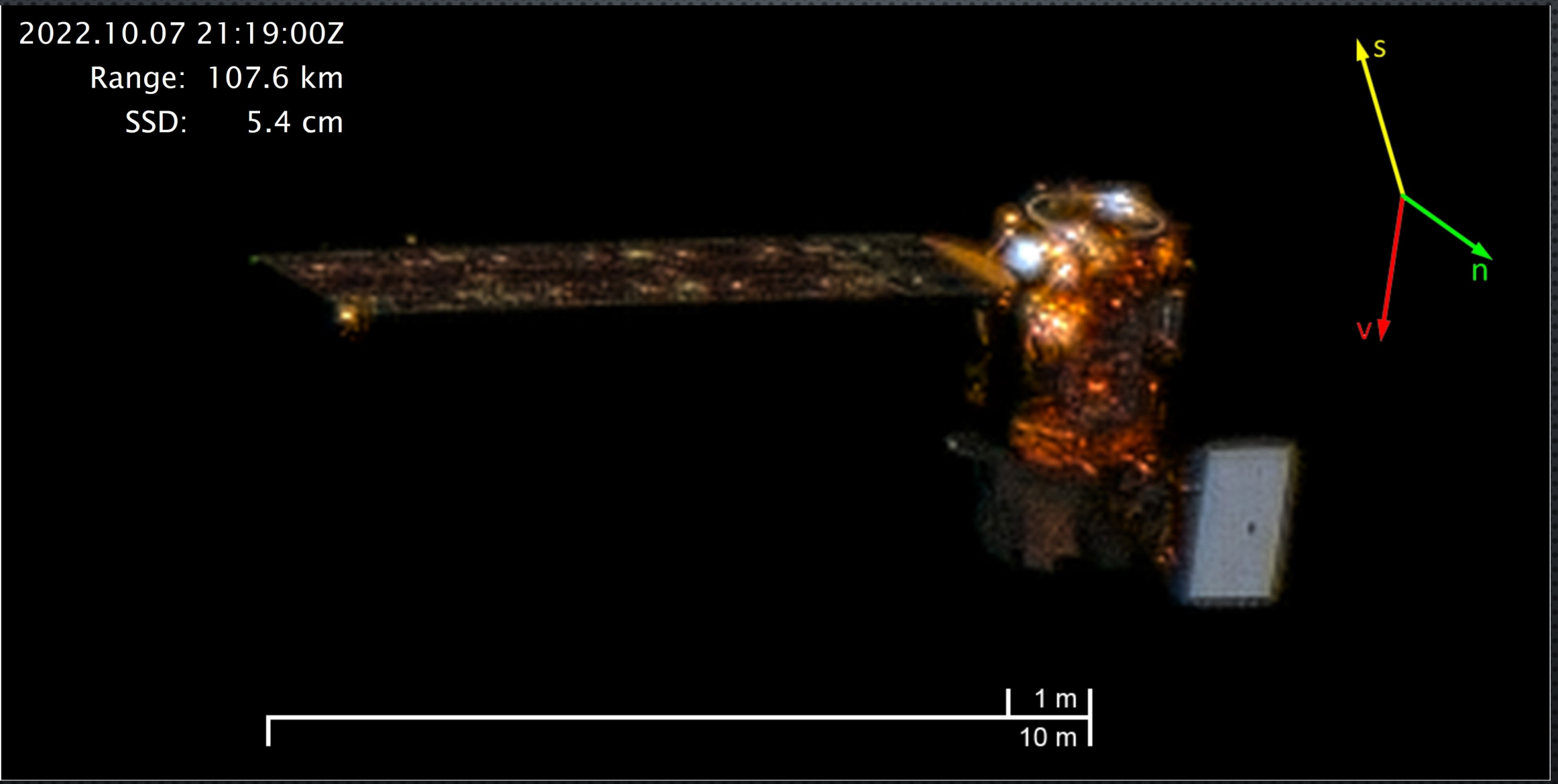
Landsat Archive Operations

Reprocessed Landsat "Collection 2" available on the Amazon Cloud.

On track for nearly **20 billion** user accesses this year!

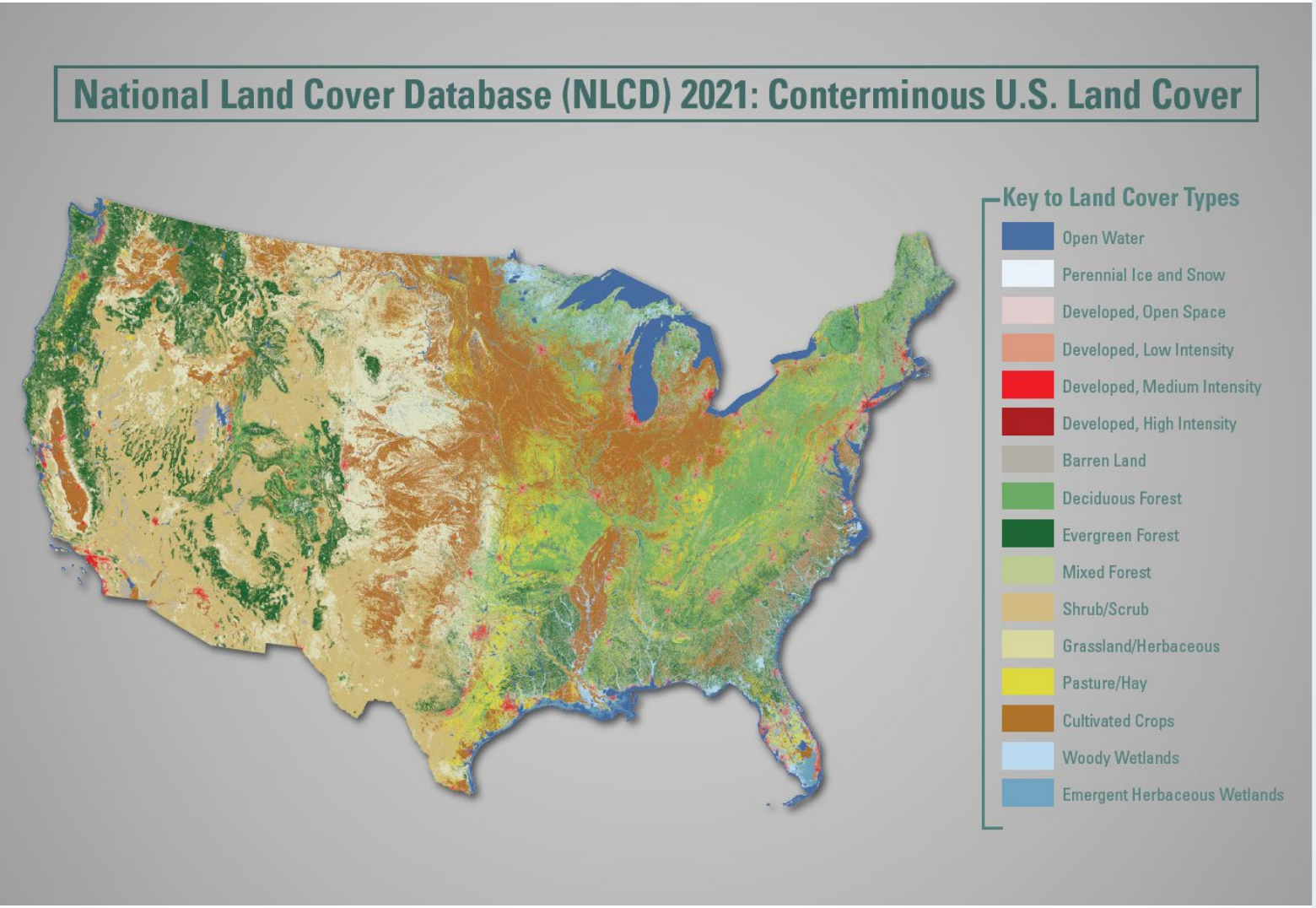
USGS

Image of Landsat 8 in Space



Courtesy: Maxar/WorldView 3

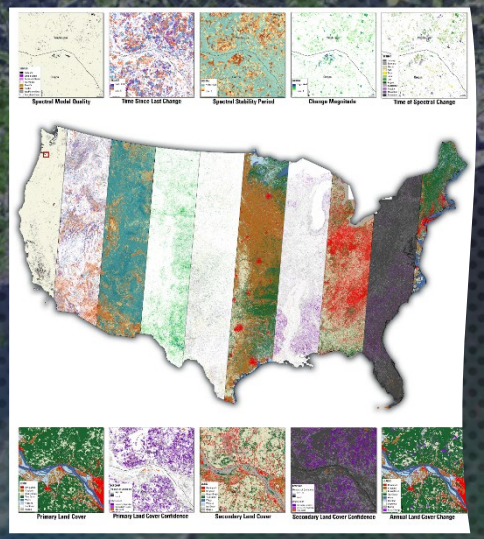
New National Land Cover Database Released!



National Land Cover Database (NLCD) 2021 Released!

- Released July 31, 2023
- Product suite includes land cover, change, disturbance, and urban imperviousness at 30-meter spatial resolution
- Most widely used and cited national scale land cover data product for environmental monitoring, modeling, and land management
- NLCD 2021 characterizes land change from 2001 to 2021 *(Previous NLCDs: 2001, 2004, 2006, 2008, 2011, 2013, 2016, and 2019*)
- Moving towards the next-generation land cover and change product suite ***Land Cover Next (LC Next)***

National NLI Operational Science Products



Land Change Monitoring, Assessment and Projection (LCMAP)

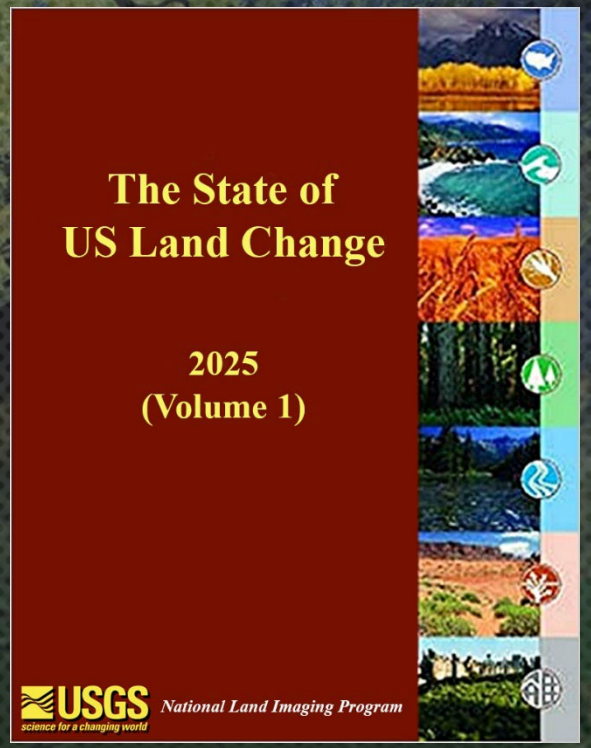
1985-2021

Focusing on change and trends

National Land Cover Database (NLCD)

2001, 2006, 2011, 2016, 2019, 2021 (release in July 2023)

Focusing on accurate thematic cover



Land Cover Next (LC Next)

1985-2024

2023 - Product Suite Definition

2024 - LC Next Product Release

Landsat-based land cover and change

Historical trends, current condition, drivers of change, future risks and vulnerabilities

USGS

Landsat Next – The Follow-on Mission to Landsat 9

- SLI Joint Steering Group in 2017 requested a NASA/USGS study to consider post-Landsat 9 options
- SLI Architecture Study Team completed detailed study in 2020
- SLI Joint Steering Group approved a *multi-element* architecture in 2020, including Landsat Next, and approved the Landsat Next "Triplets" mission concept in 2022
- NASA & USGS Landsat Next project teams on track for instrument award in early 2024, spacecraft bus award in late 2024, and launch projected for late 2030

"Superspectral" Landsat Next will provide a completely new next-generation Landsat, meeting the users' needs for richer spectral information and improved spatial and temporal resolution.

- **2024 is a critical year for LNext**

Landsat Next Requirements Meet Emerging Needs

The USGS spent several years engaging with the user community to develop and validate requirements and set priorities for Landsat Next to meet emerging needs:

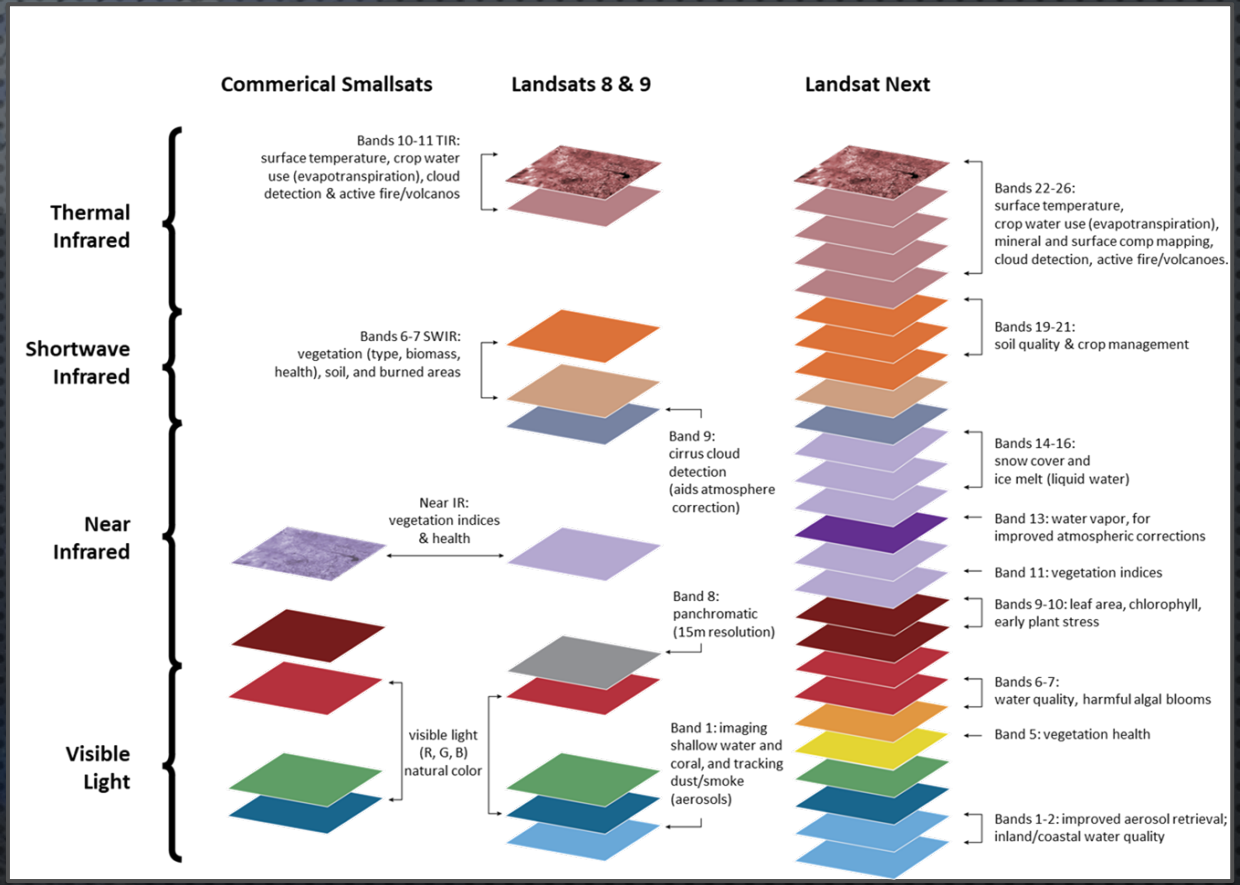
Improved revisit frequency to support applications which require ~weekly clear views, such as crop health & productivity, water quality, snow/ice state, wildfire

Higher spatial resolution (10-meter data vs 30-meter) to support monitoring of small agricultural fields, forest disturbance, urbanization, and other applications

Additional spectral bands to support emerging applications in water quality, snow hydrology, soil mapping, and other areas

Maintaining radiometric quality established by Landsat 8/9

Multi-spectral → Super-spectral



Landsat Next will provide more than *twice as many spectral bands* as Landsat 8/9, with *spatial resolution improved by a factor of 2*, and *significantly improved repeat coverage*

Driving Applications for Landsat Next

Societal Benefit Area	Application	Science Benefits from Landsat Next
Agriculture	U.S and global agricultural monitoring	Landsat Next will allow USDA Foreign Agricultural Service (FAS), Farm Service Agency (FSA) and National Agricultural Statistics Service (NASS) more precise observation of crop emergence.
	Crop residue monitoring/soil conservation	Landsat Next observations in the early growing season can allow USDA Natural Resources Conservation Service to detect cover crop and crop residue for soil conservation at the field-scale.
Forestry	Forest health monitoring	Landsat Next will aid USFS, BIA, BLM, FWS, NPS and USGS in the detection and identification of insect/disease agents for forest health monitoring, since symptoms are often seasonal and transient.
Water Resources	Evapotranspiration and water use	Landsat Next frequent observations of evapotranspiration (ET) are needed for field-scale ET estimates and continuous water use monitoring operationally by BOR, USGS, FAS, NASS and Western States.
Water Quality	HAB detection and monitoring	The new targeted spectral bands for water quality provided by Landsat Next will enable detection of specific organisms that cause harmful blooms.
Cryosphere	Snow/water availability	Higher temporal frequency and new targeted spectral measurement capabilities of Landsat Next will reduce cloud cover contamination while increasing detection.
Public Health	Monitoring urban heat islands	Landsat Next can help capture more frequent, intense, and longer heat waves as climate change indicators.
Wildfire	Pre- and post-fire assessment	Landsat Next higher temporal revisit is needed to capture the onset of more frequent wildfires and provide immediate post-fire response.

LNext
Landsat Next

Temporal Coverage Impacts of Landsat Next on Agency Needs

USGS

	Climate		Landsat Heritage		Landsat Next
Science Applications and Agencies for User Needs Satisfaction	Climate Indicators	Critical Measures	L8+L9		Triplets
			8-day Revisit	16-day Revisit	6-day Revisit
Agriculture & Forestry (FAS, FSA, NASS, NRCS, RMA, USFS, BIA, BLM, FWS, NPS, USGS, EPA, USAID, NASA, DOE)	**ST, LC**	**CT, CY, LAI, VC**			
Emergency/Disasters (USGS, OSMRE, BOEM, BSEE, USFS, NOAA, USAID, NIH, FEMA, NASA, DOE)		**AF, VA, SWE, OSE**			
Public health/Water Quality (USGS, NPS, EPA, NOAA, NIH, NASA)	**ST**	**UHI, WQWC**			
Water resources monitoring (BOR, USGS, FAS, NASS, NASA, DOE)	**ST**	**ET, WQWC**			
Wildfire Response and Assessment (BIA, BLM, FWS, NPS, USGS, USFS, NRCS, NASA)	**ST, LC**	**BABS, VC, LULC**			
Cryosphere (BOR, USGS, NRCS, NOAA, NASA, DOE)	**ST, GLI**	**GLI, SCE, SGS**			
Ecosystems/Land Use (USDA, DOI, EPA, NOAA, USAID, FEMA, NASA, DOE)	**ST, LC**	**fPAR, LULC, VC**			

ST – Surface Temperature
LC – Land Carbon
GLI – Glacier & Ice Sheets

CT – Crop Type
CY – Crop Yield
LAI – Leaf Area Index
VC – Vegetation Condition
BABS – Burned Area/Burn Severity
AF - Active Fires
VA – Volcanic Activity
SWE – Surface Water Extent

OSE – Oil Spill Extent
UHI – Urban Heat Island
WQWC – Water Quality/Water Chemistry
ET – Evapotranspiration
LULC – Land Use/Land Cover
SCE – Snow Cover Extent
SGS – Snow Grain Size
fPAR - Photosynthetically Active Radiation

Reflects varying spatial and spectral capabilities

GREEN = > 2/3 of user revisit needs met
YELLOW = 1/3 – 2/3 met
RED = < 1/3 met

Key to Agencies

FAS: Foreign Agriculture Service
FSA: Farm Service Agency
NASS: National Agricultural Statistics Service
NRCS: Natural Resources Conservation Service
RMA: Risk Management Agency
USFS: U.S. Forest Service
BIA: Bureau of Indian Affairs
BLM: Bureau of Land Management
FWS: U.S. Fish and Wildlife Service
NPS: National Park Service
USGS: U.S. Geological Survey
EPA: Environmental Protection Agency
USAID: U.S. Agency for International Development
NASA: National Aeronautics & Space Administration
DOE: Department of Energy
OSMRE: Office of Surface Mining Reclamation and Enforcement
BOEM: Bureau of Ocean Energy Management
BSEE: Bureau of Safety and Environmental Enforcement
NOAA: National Oceans and Atmospheric Administration
NIH: National Institutes of Health
FEMA: Federal Emergency Management Agency
BOR: Bureau of Reclamation
USDA: U.S. Department of Agriculture
DOI: Department of the Interior

USGS Landsat Next Responsibilities

- Mission Partner with NASA
  - USGS jointly supports project management, mission engineering, science, calibration and validation, IT security, and operations readiness activities.
- Landsat Next Ground Segment
  - Mission Operations Center (MOC)
    - Facility and requisite capability, functionality, and automation to perform constellation operations of Landsat Next.
    - Flight Operations Team (FOT) to perform command and control, health and safety, mission planning, orbit maintenance, and trending and analyses.
  - Ground Network Element (GN)
    - Landsat Ground Network stations provide command and telemetry link between the MOC and the constellation satellites via S-Band and science data return receipt via Ka-band.
  - Data Processing and Archive System (DPAS)
    - Provides data ingest, storage and archive, image assessment, product generation, and data access and distribution.
    - DPAS facility at USGS EROS Center.

The increasing demands on the USGS Landsat Next ground system development require additional resources beyond the current NLI program baseline in order to keep pace with NASA on the multi-year development

USGS

Landsat Next Summary

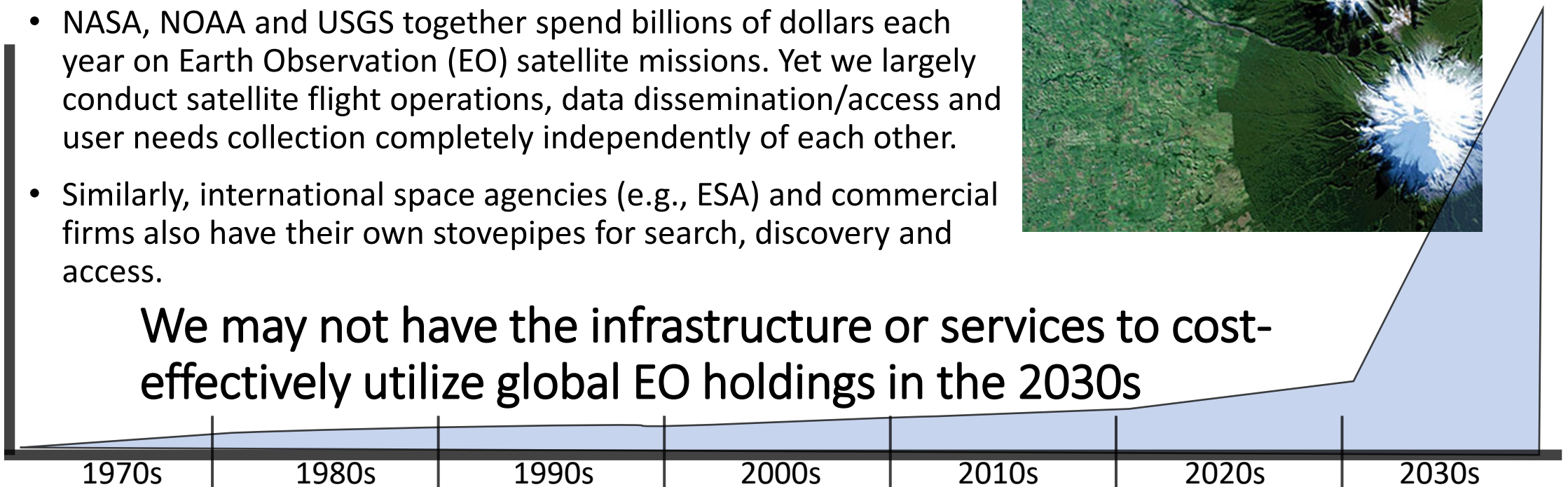
- **Landsat Next will continue and improve the 50-year Landsat data record**
  - Relied upon by Federal/State/Tribal/local government, commercial, industrial, educational communities
  - Landsat is the most widely used land remote sensing data source within Federal civil agencies
  - Commercial data providers need Landsat's rigorous calibration standards to build/improve products
- **Provides a completely new and improved Landsat for the next generation**
  - Much better spatial resolution (10 meter), twice as many spectral bands (new ones for agriculture, water use, HABs, mineral mapping, volcanos), and improved revisit (6-day) while retaining continuity
  - Ensures projected climate change impacts on the land can be rigorously monitored & assessed
- **Continues substantial economic benefits to the U.S. economy (~$2 billion/year)**
  - Much like GPS and weather data, Landsat data are used every day to help us better understand our dynamic planet – and to continue tracking the effects of global climate change
  - Information from Landsat contributes to day-to-day decisions on land, water, and resource use that protect life and property; safeguard the environment; advance science, technology and education; support climate resiliency; and grow the U.S. economy

Landsat Next ensures future generations will continue to reap the benefits of the Landsat series of measurements-- trusted scientific data enabling a myriad of research and operational applications.

USGS and US Civil Space Have a Big Data Problem

- Current USGS Landsat archive is 20PB (NASA's archive ≈ 125PB)
- By 2030, the USGS Landsat archive will have grown to 35PB (NASA's archive ≈ 325PB)
- In 2031, one year after LNext operations begins, the USGS Landsat archive will be close to 50PB
- NASA, NOAA and USGS together spend billions of dollars each year on Earth Observation (EO) satellite missions. Yet we largely conduct satellite flight operations, data dissemination/access and user needs collection completely independently of each other.
- Similarly, international space agencies (e.g., ESA) and commercial firms also have their own stovepipes for search, discovery and access.

We may not have the infrastructure or services to cost-effectively utilize global EO holdings in the 2030s



2030 Challenge

Remove Stovepipes: A new collaborative framework of U.S. Civil (NASA-NOAA-USGS) Earth Observation could truly integrate satellite-based Earth Observation (EO) activities and products, benefitting science and operational users of the data, and potentially realizing operational efficiencies and cost savings.

Consolidate Functional Infrastructure and Services: Arrive at a robust, shared architecture and service suite that potentially reduces cost for collection, archiving, processing and dissemination of respective agency products. Improve search and discovery functionality across Federal civil holdings, improve interoperability of federal civil products and services, enhance ability to process and exploit data in a cloud environment, and facilitate concurrent access to Federal, commercial, and foreign EO holdings.

Start Now: The three agencies need to work together to develop this shared architecture concept, define relevant synergies and use cases, and explore options that efficiently meet stakeholder and user needs into the future. An integrated U.S. architecture beginning in the 2030 timeframe would provide sufficient time for the agencies to plan for its implementation while not disrupting current missions and projects.

Ubiquitous Cloud Access and Services Across the U.S. Archive of Earth Observations

NASA “Landsat’s Next Chapter” Video https://svs.gsfc.nasa.gov/14262

Thank You!

Timothy Stryker & Steven Covington
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U.S. Geological Survey
U.S. Department of the Interior
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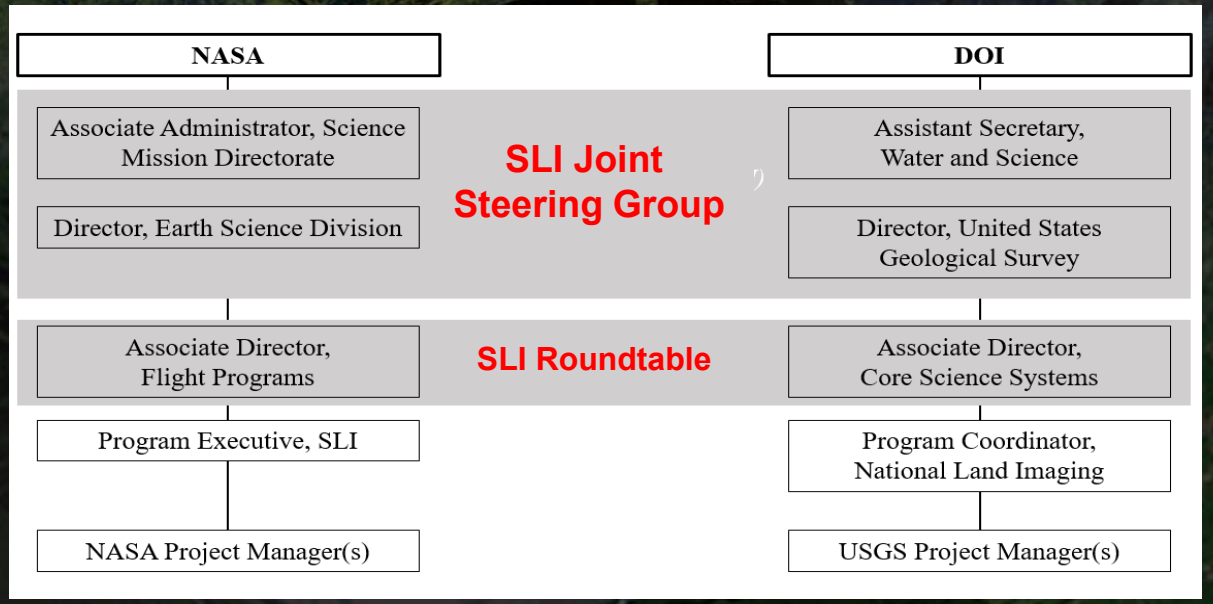
scovington@contractor.usgs.gov

USGS science for a changing world

BACKUP SLIDES

Landsat NASA/Interior Partnership: Sustainable Land Imaging (SLI)

- Joint program by which NASA & DOI/USGS implement new Landsat missions
- NASA develops space & launch segments
- DOI/USGS collects user needs, develops & maintains ground systems to collect, archive, process & distribute SLI data to users; operates on-orbit spacecraft
- Governed by SLI Joint Steering Group (JSG)
  - Top-level board to integrate SLI program efforts
  - Co-Chairs: DOI Principal Deputy Assistant Secretary for Water & Science (Mr. Michael Brain) and NASA Associate Administrator for Science (Dr. Nicola Fox)



NASA/DOI Interagency Agreement for Collaboration on SLI Projects (2021)

NASA and Interior/USGS SLI Partnership is Developing Landsat Next

USGS

Multi-Decadal Sustainable Land Imaging Program

Partnership between DOI/USGS and NASA to ensure sustained access to high-quality, global, land-imaging measurements compatible with the existing 50-year Landsat record for research and operational users

First Phase of SLI

Landsat 9

Second Phase of SLI

Landsat Next

Commercial/Interagency/ International Partnerships

SLI Technology Development and Infusion (NASA) (USGS)

User Needs Development (USGS)

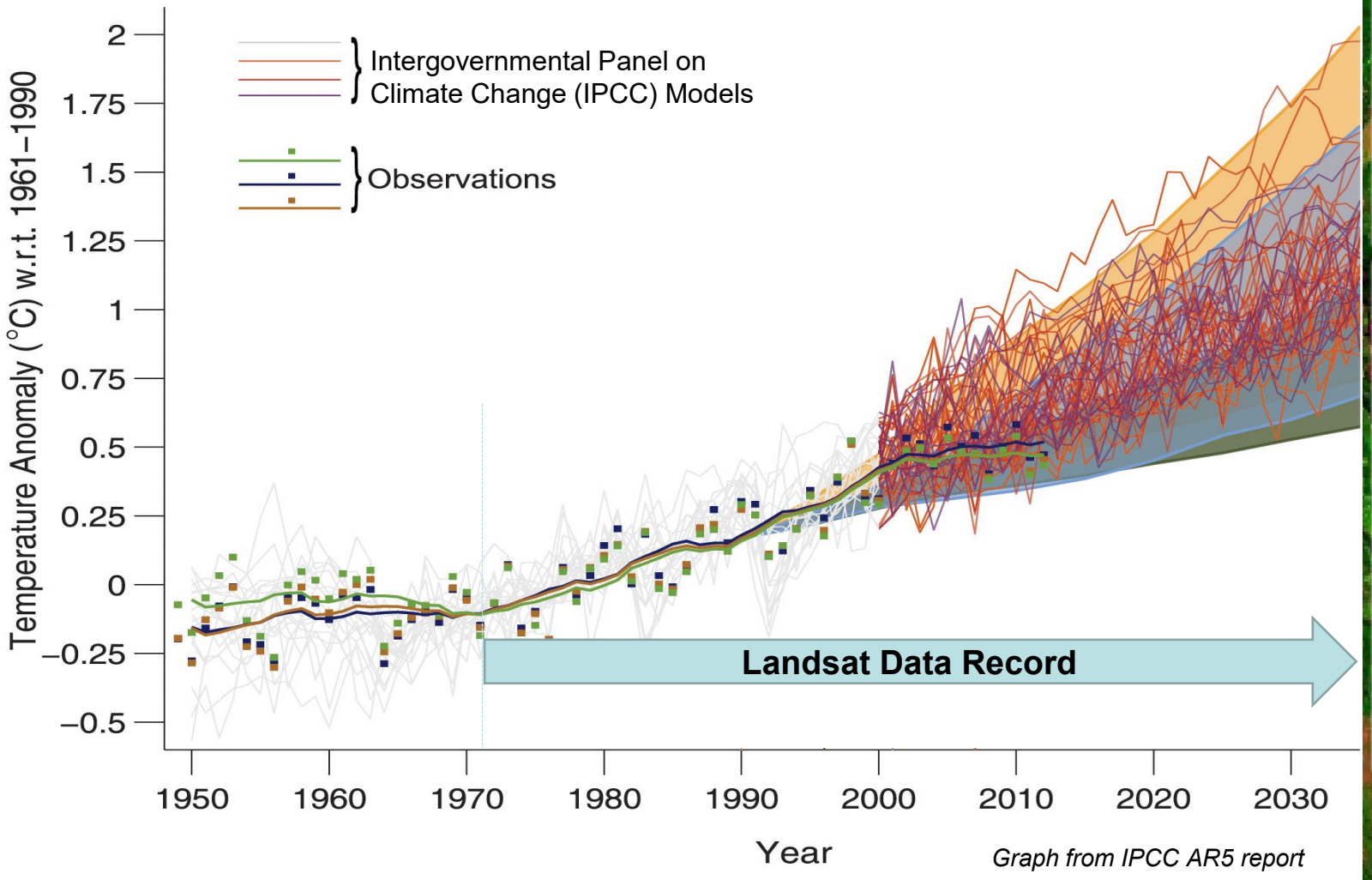
JSG=Joint Steering Group Meeting

Status of Landsat 8

- Landsat 8 is fully operational 9 years after its launch (2013)
  - Risk Class ‘B’ mission with a 5-year design life (TIRS instrument is Risk Class C, with a 3-year design)
- Landsat 8 has experienced issues with its Thermal Infrared Sensor (TIRS)
  - Stray light design issue; two failures of the scene select mirror encoder system; operational workarounds in place
- Landsat 8 Solar Array Drive Assembly (SADA) longevity is in question
  - Joint Polar Satellite System SADA life-test unit failed catastrophically at equivalent of 12 years of operation
  - Same unit as used on both Landsat 8 and pre-launch Landsat 9; replaced L9 SADA had same issue
  - Landsat 8 SADA will reach 12 years of operation in 2025
- The Aerospace Corporation survey found that, on average, Class B missions survive approximately 12-15 years, and Class C missions 7-9 years
  - Landsat 8 will reach 15 years in 2028; TIRS already at 9 years
- Loss of Landsat 8 would reduce revisit to 16 days; significant impact to many user applications
  - Evapotranspiration, critical for water management; Climate change and Cryospheric science, Fire monitoring
  - Sentinel-2 can mitigate, but lack of concurrent thermal imagery hampers continuity of observations

USGS NASA

Landsat & Climate Change



Graph from IPCC AR5 report

"As the longest-running continuous satellite image dataset for land processes, Landsat data provide unparalleled witness to the enormous changes occurring on Earth since 1972."
(Kennedy, et al., Environmental Research Letters, 2014)

"The US Global Change Research Program identified Landsat as a critical observatory for climate and environmental change research due to the unbroken length of the Landsat record and its ability to monitor remote regions with surface features such as glaciers, rainforests, permafrost, and coral reefs."
(CRS Report on Landsat 9 and the Future of the Sustainable Land Imaging Program)

Landsat Data Record coincides with dramatic global temperature changes; sustaining it will ensure continued tracking of future global changes

USGS NASA

Recent Landsat Advisory Group (LAG) Findings

2021 LAG paper: Revisiting the Land Remote Sensing Policy Act of 1992

- ***"While some worried that free Landsat data would interfere with the private sector, the opposite has often been the case. Free availability of Landsat data has allowed the number of users and applications for land remote sensing to increase significantly, thus massively expanding the potential market for commercial remote sensing data. Users may experiment with relatively low-resolution Landsat data before turning to commercial providers for more precise imagery. Commercial entities use Landsat data to calibrate their own instruments and sometimes offer products that fuse their commercial data with free government data."***

2020 LAG paper: Landsat Data: Community Standard for Data Calibration

- ***"The Landsat program continues to be a spectacular value proposition: it unlocks $3.45B in benefits for its users every year, is the foundation upon which commercial missions are modelled against, and, most importantly, provides humanity our longest continuous high resolution historical record of the earth's surface since 1972."***
- ***"[Planet] Dove imagery that is collected near-simultaneously with trusted reference missions like Landsat is then automatically and continuously leveraged to bring all the Dove images to geometric and radiometric alignment with the Landsat calibration standard."***

Note: The Landsat Advisory Group provides advice to the Federal Government on the Landsat Program, and includes representatives of commercial Earth observation companies.
https://www.fgdc.gov/ngac/meetings/april-2021/ngac-paper-revisiting-the-land-remote-sensing.pdf
https://www.fgdc.gov/ngac/meetings/october-2020/ngac-paper-landsat-data-community-standard-for.pdf

What is Landsat?

The world's longest continuously operated land remote sensing satellite series and most widely used and cited land remote sensing data set, helping us understand and manage natural and human-induced landscape change via a multitude of land, water, and natural resource management applications.

Common Uses of Landsat data by Federal Agencies, States, and the private sector:

- Agriculture and Forestry
- Regional Land Use Planning
- Land Use/Land Cover
- Fire/Disaster Management
- Energy and Mineral Mapping
- Water Quality and Resources
- Global Change Science
- Flood Management
- National Security
- Ecosystem Monitoring
- Famine Early Warning
- Carbon Assessment
- Drought Monitoring
- Transportation Planning
- Calibration/Validation

Multi-spectral coverage in VNIR-SWIR-TIR**
-> to map surface composition & temperature

15 / 30 / 100 meter spatial resolution
-> to resolve human-scale land dynamics

16-day revisit frequency (8-days w/ two satellites)
-> global, seasonal coverage

Broad area collection => 12,000+ square miles per image
-> 1500 images/day = 22 million square miles/day

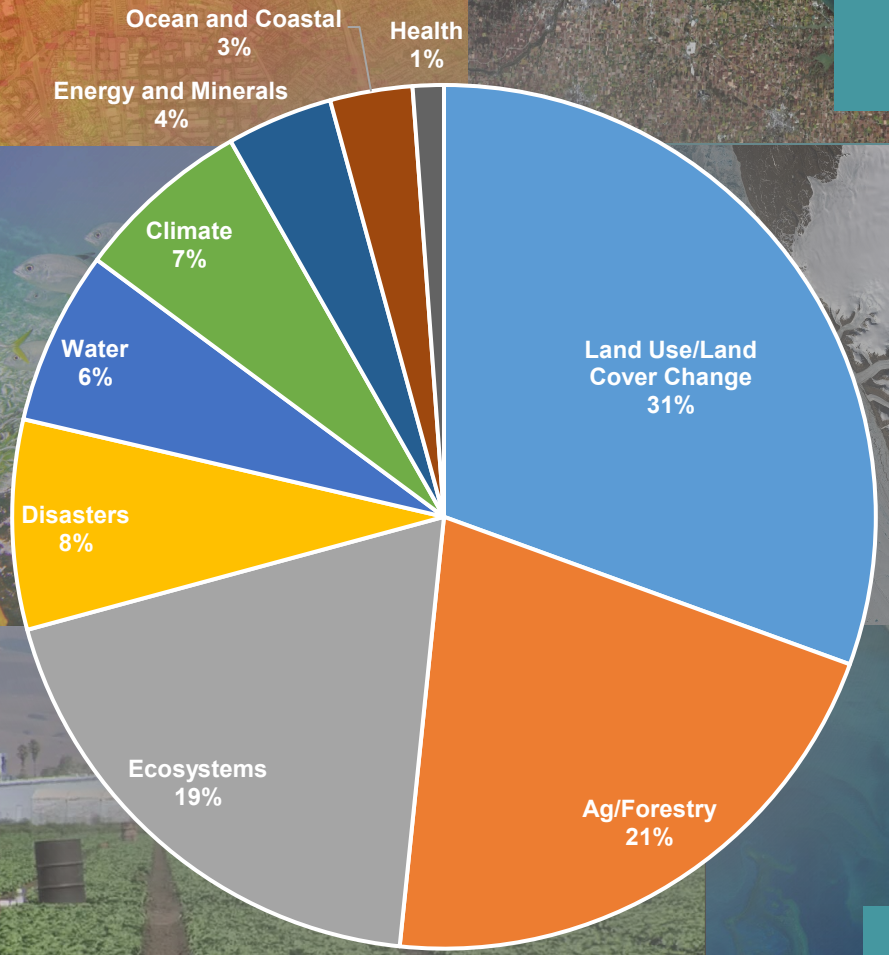
Highly calibrated "science quality" data
-> to resolve long-term trends & retrieve biophysical variables

Free and Open Data policy since 2008
-> 100 million products distributed and 4 billion data accesses via Commercial Cloud in the last year alone

USGS NASA

***VNIR: Visible Near-Infrared SWIR: Shortwave Infrared TIR: Thermal Infrared*

Landsat Applications



Landsat is the single most-used land imaging data set by U.S. Federal users and the 2nd highest in societal benefit impact (behind GPS) of 1300 Earth observation systems

- Federal Agencies (e.g. DOI, USDA, EPA, NASA, DOD, NOAA, State, USAID)
- State Agencies (planning, natural resources, Transportation)
- University Researchers and Educators
- International Organizations (e.g., UN agencies, GEO)
- Non Governmental Organizations (e.g., The Nature Conservancy, World Resources Institute, World Wildlife Fund, Resources for the Future)
- Commercial (e.g., Exxon-Mobil, MapBox, Descartes Labs, Esri, Gallo, Harris Corp, ITT, MDA Federal)
- Foreign space agencies
- U.S. and foreign commercial satellite operators
- Cloud Service Providers (e.g. Amazon Web Services, Google Earth Engine)
- General Public

Supports Federal, state, local, tribal, academic, commercial, non-profit, and international use

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