USGS
science for a changing world

Landsat Collection 2

Landsat Collection 2 marks the second major reprocessing of the U.S. Geological Survey (USGS) Landsat archive. In 2016, the USGS formally reorganized the Landsat archive into a tiered collection inventory structure in recognition of the need for consistent Landsat 1–8 sensor data and in anticipation of future periodic reprocessing of the archive to reflect new sensor calibration and geolocation knowledge. Landsat Collections ensure that all Landsat Level-1 data are consistently calibrated and processed and retain traceability of data quality provenance.

Landsat Collection 2 introduces improvements that harness recent advancements in data processing, algorithm development, data access, and distribution capabilities. Collection 2 includes Landsat Level-1 data for all sensors (including Landsat 9, when launched) since 1972 and global Level-2 surface reflectance and surface temperature scene-based products for data acquired since 1982 starting with the Landsat Thematic Mapper (TM) sensor era (fig. 1).

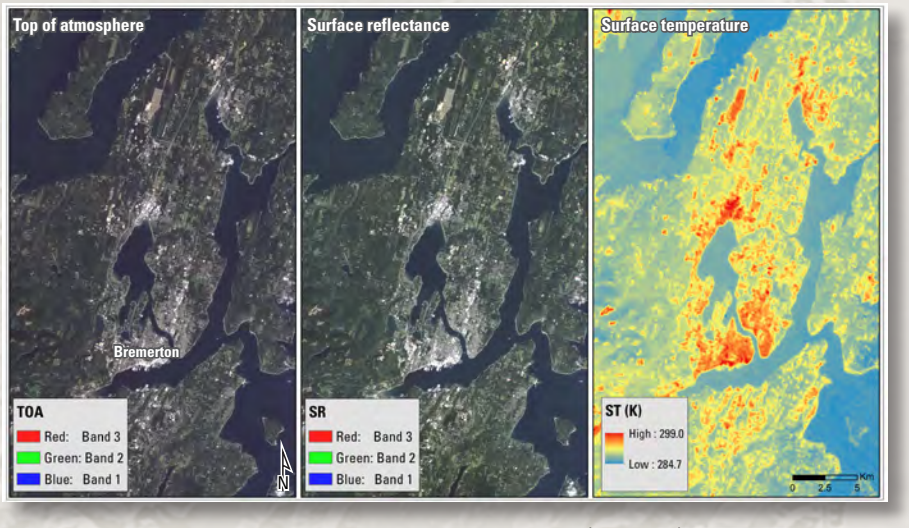


Figure 1. Landsat 5 Collection 2 Level-1 top of atmosphere (TOA; left). Corresponding Collection 2 Level-2 surface reflectance (SR; center) and surface temperature (ST [K]; right) images.

The primary improvements of Collection 2 data include

- rebaselining the Landsat 8 Operational Landsat Imager (OLI) Ground Control Points (GCPs) to the European Space Agency Copernicus Sentinel-2 Global Reference Image (GRI) to improve the interoperability of the global Landsat archive spatially and temporally;
- updating global digital elevation modeling sources; and
- improving accessibility from a commercial cloud-based environment.

Collection 2 Improvement Highlights

This section includes a high-level summary of the main improvements for Collection 2. For more detailed information, please visit the USGS Landsat Missions website (https://www.usgs.gov/core-science-systems/nli/landsat).

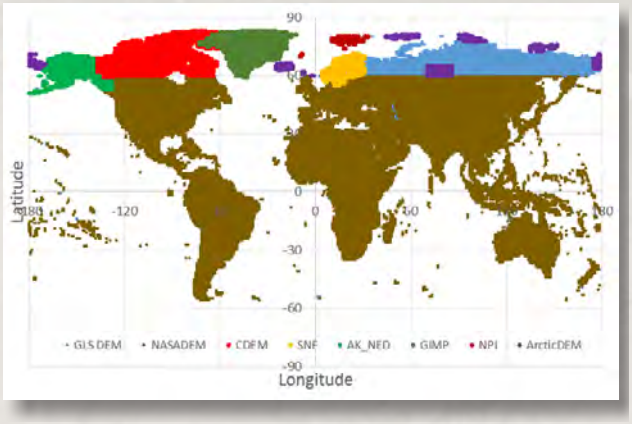
Geometric Accuracy

Rebaselining of Landsat 8 OLI GCPs to match the European Space Agency's Copernicus Sentinel-2 GRI improves the interoperability of the global Landsat Collection 2 inventory spatially and temporally with Europe's Copernicus Sentinel-2 missions.

Digital Elevation Models

Collection 2 uses the 3-arc-second (90-meter) digital elevation modeling sources listed and illustrated below.

- Canadian Digital Elevation Model (CDEM) (updated)
- Global Land Survey Digital Elevation Model (GLS DEM)
- Greenland Mapping Project (GIMP) Digital Elevation Model
- NASA Shuttle Radar Topography Mission (NASADEM) (reprocessed)
- National Elevation Dataset for Alaska (AK_NED) (new)
- Norwegian Polar Institute (NPI) Elevation Data
- Sweden, Norway, and Finland (SNF) National Elevation Data
- WorldView-derived ArcticDEM



Collection 2 uses the 3-arc-second digital elevation modeling sources listed and shown on the map.

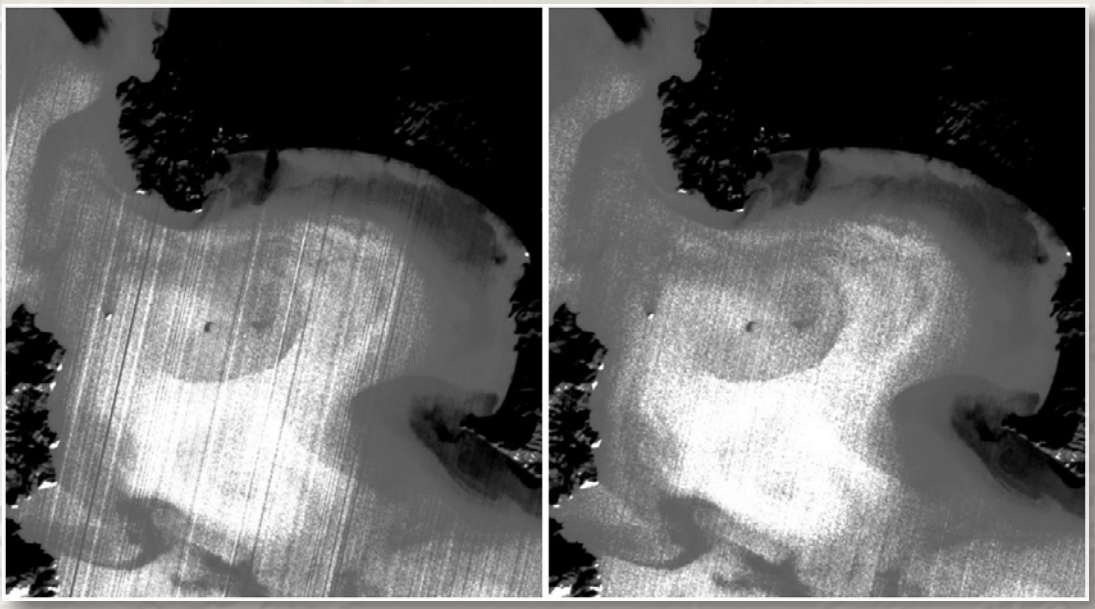


Figure 2. Example of a Landsat 8 Thermal Infrared Sensor Band 10 image with radiometric striping when processed into Collection 1 (left) and the visible reduction of striping in Collection 2 (right).

Radiometric Calibration

Several radiometric calibration improvements were made for Landsat 5 TM and Landsat 8 OLI data, including a correction for the Thermal Infrared Sensor (TIRS) striping effect (fig. 2).

Quality Assessment Bands

Collection 2 Level-1 calibrated data are delivered with a Pixel Quality Assessment Band and a Radiometric Saturation and Quality Assessment Band. Collection 2 Level-2 products include the Level-1 Quality Assessment (QA) Bands and a surface reflectance aerosol QA Band for Landsat 8, a surface reflectance cloud QA Band for Landsat 4–7, and a surface temperature QA Band to provide consistent QA information between Collection 2 products.

Metadata Files

There are several enhancements and changes between Collection 1 and Collection 2 Level-1 product metadata. Collection 2 products add an extensible markup language file to the Material Template Library file. The metadata files facilitate consistency, machine-to-machine scripting, and rapid querying of the USGS Landsat Collection inventory. There are also changes to the metadata fields visible on EarthExplorer and its associated applications.

Cloud Optimized File Format

Landsat Collection 2 data are provided in a Cloud Optimized Georeferenced (COG) Tagged Image File Format. COGs are an extension of the current Georeferenced Tagged Image File Format, which improves access to geospatial datasets in a cloud-based environment by allowing users to request an entire product bundle (all bands) or only a subset of bands.

Collection Tier Structure

Collection 2 maintains the use of a tiered inventory structure for the Level-1 product (table 1). The purpose of the collection tier structure is to

- ensure consistent Landsat processing, traceability, and known data quality provenance;
- provide Real-Time (RT) data within 12 hours of acquisition in support of the International Charter to help mitigate the effects of disasters on human life and property;
- contain the highest quality Landsat Level-1 calibrated data ever created; and
- support data stacking and time-series analysis at the pixel scale.

A typical Landsat Collection 2 product generation timeline is illustrated below. Landsat 7 and Landsat 8 Level-1 RT use products are available for download within 4–6 hours after acquisition. For Landsat 7, the timeframe from acquisition to Tier 1 or Tier 2 takes about 24–26 days to allow for application of the refined bumper mode parameters to Level-1 RT scenes. For Landsat 8, it takes about 14–16 days to process to a Tier 1 or Tier 2 product while refined TIRS instrument line of sight model parameters are applied to RT scenes.

Level 2 surface reflectance and surface temperature products are typically available within 24 hours after a scene has been processed into Tier 1 or Tier 2 for both instruments. The National Aeronautics and Space Administration's Goddard Earth Observing System Model Version 5 Forward Processing for Instrument Teams (GEOS–5 FP–IT) Atmospheric Assimilation Products are used for Level-2 product generation.

Upon launch and on-orbit checkout, Landsat 9 will deliver Collection 2 Level-1 Tier 1 or Tier 2 scenes within 4–6 hours of acquisition and a Level-2 surface reflectance and surface temperature product within 3 days of acquisition (fig. 3). Landsat 9 will also use the GEOS–5 FP–IT atmospheric auxiliary data product for Level-2 product generation.

Table 1. Side-by-side comparison of improvements from Collection 1 to Collection 2 (green cells). To access the comprehensive list of Collection 2 improvements, please visit https://www.usgs.gov/media/files/landsat-collection-1-vs-collection-2-summary.

[U.S., United States; ARD, Analysis Ready Data; L2PGS, Landsat 2 Product Generation System; OLI, Operational Land Imager; DEM, Digital Elevation Model; NASADEM, NASA Shuttle Radar Topography Mission; NED, National Elevation Dataset; CDEM, Canadian Digital Elevation Model; SNF, Sweden, Norway, and Finland; NPI, Norwegian Polar Institute; GIMP, Greenland Mapping Project; RAMP, Radarsat Antarctic Mapping Project; TIRS, Thermal Infrared Sensor; N/A, not applicable; LEDAPS, Landsat Ecosystem Disturbance Adaptive Processing System; TM, Thematic Mapper; ETM+, Enhanced Thematic Mapper Plus; LaSRC, Land Surface Reflectance Code]

Type	Collection 1		Collection 2		
	Level 1 (Landsat 1–8)	Level 2 (U.S. ARD; Landsat 4–8)	Level 1 (Landsat 1–8 [Landsat 9])	Level 2 (Landsat 4–8 [Landsat 9])	Level 2 (U.S. ARD; Landsat 4–8 [Landsat 9])
Supporting software					
Processing software	Landsat Product Generation	L2PGS BRIDGE R0.8.x	Landsat Product Generation System (LPGS) R15.x		
Geometry					
Coverage	Global	U.S.	Global	Global[1]	U.S.
Geometric	Global Land Survey (GLS) 2000		Landsat 8 OLI Harmonized with Sentinel-2 Global Reference Image (GRI)		
Digital elevation	GLS DEM		GLS DEM/NASADEM/Alaska NED/CDEM/SNF/NPI/GIMP/ArcticDEM/RAMP		
Precision	Baseline		Improved usage of Ground Control Points (GCPs) to produce more		
Radiometry					
Solar/sensor viewing angle information	Angle Coefficient File	None (per-pixel correction already applied)	Angle Coefficient File + Band 4 Solar/Sensor Angle Bands	None (per-pixel correction already applied)	
TIRS Post-Stray Light Correction Adjustment (L8 only)	None		Post-Stray Light Residual Bias Applied	Post-Stray Light Residual Bias Applied	
Atmospheric correction/Level 2					
Surface Reflectance Algorithm Version	N/A	LEDAPS v3.2.1 (TM/ETM+) LaSRC v1.3.0 (OLI/TIRS)	N/A	LEDAPS v3.4.0 (TM/ETM+) LaSRC v1.4.1 (OLI/TIRS)	
Surface Temperature Algorithm Version	N/A	Landsat Single-Channel Surface Temperature v1.3.0	N/A	Landsat Single-Channel Surface Temperature v1.3.0	
Surface Reflectance Fill Value	N/A	−9999	N/A	0	
Surface Temperature Fill Value	N/A	−9999	N/A	0	
Data Type/Scaling Factor (Surface Reflectance)	N/A	Signed 16-bit integer 0.0001 (no offset)	N/A	Unsigned 16-bit integer 0.0000275 + −0.2	
Data Type/Scaling Factor (Surface Reflectance)	N/A	Signed 16-bit integer 0.1 (no offset)	N/A	Unsigned 16-bit integer 0.00341802 + 149.0	
L7 ETM+ Surface Temperature Band	N/A	Band 6L only	N/A	Bands 6L and 6H combined (6H if unsaturated, 6L otherwise)	

[1]Global Level-2 products are only produced where solar angle constraints are met and atmospheric auxiliary data are available.

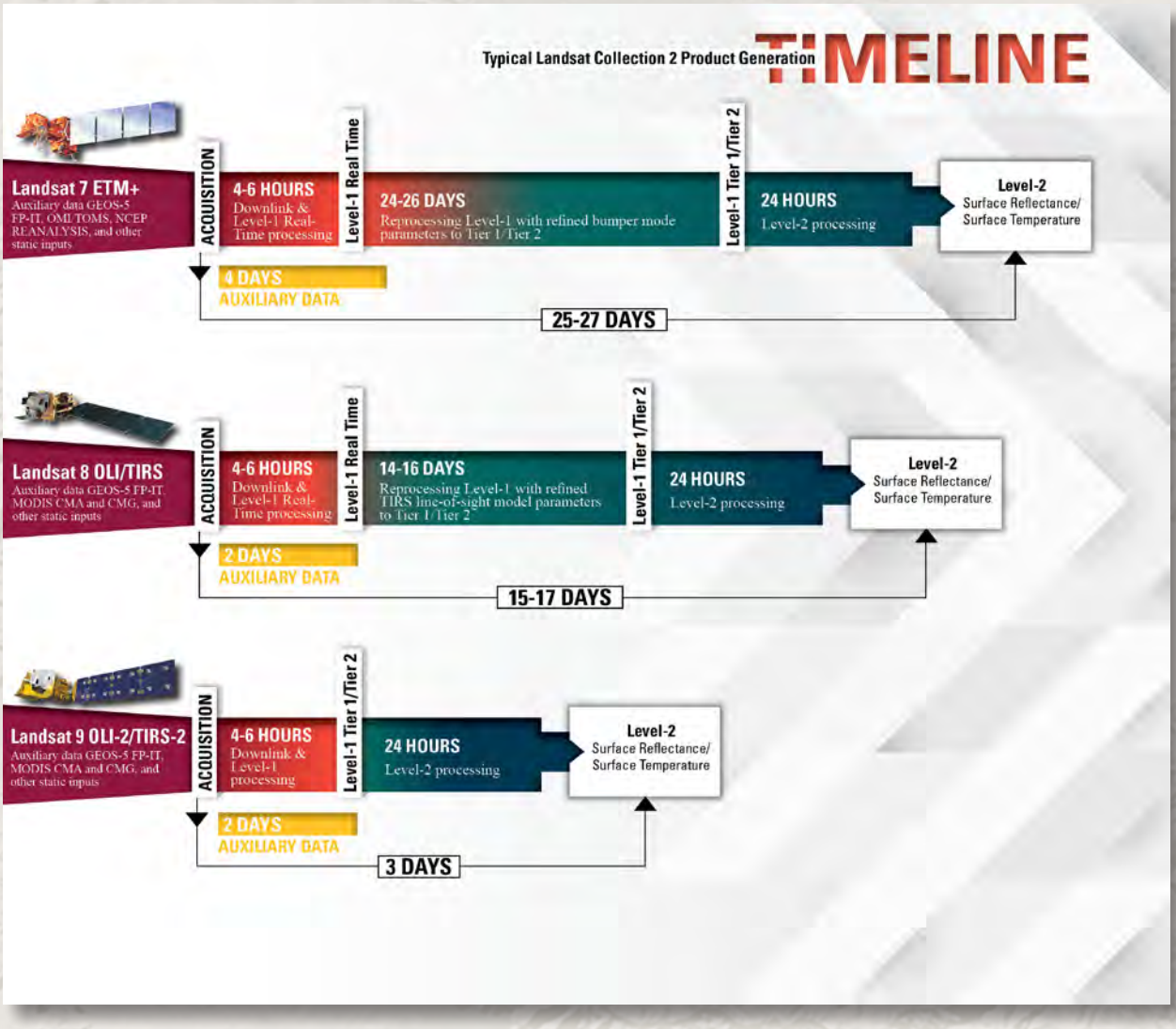


Figure 3. Typical Landsat 7–9 Collection 2 product generation timeline. [ETM+, Enhanced Thematic Mapper Plus; GEOS-5 FP-IT, Goddard Earth Observing System Model Version 5 Forward Processing for Instrument Teams; OMI/TOMS, Ozone Monitoring Instrument/Total Ozone Mapping Spectrometer; NCEP, National Center for Environmental Prediction; OLI, Operational Land Imager; TIRS, Thermal Infrared Sensor; MODIS, Moderate Resolution Imaging Spectroradiometer; CMA, Climate Modeling Grid Aerosol; CMG, Climate Modeling Grid]

Data Access

Landsat Collection 2 data are available for download from the USGS EarthExplorer. The USGS Landsat no-cost open access data policy remains intact since its inception in 2008. Collection 2 data are also available through direct commercial cloud access. Users wanting to engage direct cloud access and deploy their own algorithms on the Collection 2 products may incur fees.

For additional information or to learn more about Landsat Collection 2, please visit the Landsat Missions website at https://www.usgs.gov/core-science-systems/nli/landsat/landsat-collection-2.

Visit https://www.usgs.gov for more information about the USGS and https://www.usgs.gov/core-science-systems/national-land-imaging-program for specifics about the National Land Imaging Program.

For more information and to ask questions about Landsat operations, products, and data access, please contact:

Customer Services
U.S. Geological Survey
Earth Resources Observation and Science (EROS) Center
47914 252nd Street
Sioux Falls, SD 57198

Phone: 605–594–6151 or 1–800–252–4547
Email: custserv@usgs.gov
Twitter: @USGSLandsat
Instagram: https://www.instagram.com/usgslandsat/
Facebook: https://www.facebook.com/USGSLandsatProgram/
Publishing support provided by the Rolla and Sacramento Publishing Service Centers

ISSN 2327-6932 (online)
ISSN 2327-6916 (print)
https://doi.org/10.3133/fs20213002