

LANDSAT COLLECTIONS

Overview

The Landsat Program, presently administered by the United States Geological Survey (USGS) and the National Aeronautics and Space Administration (NASA), provides the longest continuous remotely sensed record of the Earth's surface. Since ERTS-1 (Landsat 1) was launched on July 23, 1972, Landsat data have become valued throughout the world as an integral element that supports the understanding of scientific issues related to land cover, land use, and natural resources.

While the Landsat Program offers a continuous record of imagery, there are differences among the various satellites and sensors that pose challenges when comparing images and conducting time-series analyses. Therefore, to account for these radiometric and geometric differences and to enable improved analyses, the USGS reorganized the Landsat data archive into a tiered collection structure. This tiered collection structure was developed to provide a consistent archive of known data quality.

Landsat Satellites and Sensors

Table 1. Landsat satellite and sensor characteristics.

| SATELLITE | SENSOR(S)* | SPATIAL RESOLUTION | NUMBER OF BANDS | ALTITUDE | EQUATORIAL CROSSING TIME |
|------------------------|--------------|--------------------------------------|-------------------|----------|--------------------------|
| Landsat 1 | RBV/MSS | 80 m ¹ | 3 cameras/4 bands | 917 km | 9:30 AM |
| Landsat 2 | RBV/MSS | 80 m ¹ | 3 cameras/4 bands | 917 km | 9:45 AM |
| Landsat 3 | RBV/MSS | 80 m ¹ | 3 cameras/4 bands | 917 km | 9:30 AM |
| Landsat 4 | MSS/TM | 80 m ¹ /30 m ² | 4 bands/7 bands | 705 km | 9:45 AM |
| Landsat 5 | MSS/TM | 80 m ¹ /30 m ² | 4 bands/7 bands | 705 km | 9:45 AM |
| Landsat 6 ³ | ETM | 30 m ⁴ | 8 bands | n/a | n/a |
| Landsat 7 | ETM+ | 30 m ⁴ | 8 bands | 705 km | 10:00 AM |
| Landsat 8 | OLI/TIRS | 30 m ⁵ /100 m | 9 bands/2 bands | 705 km | 10:00 AM |
| Landsat 9 | OLI-2/TIRS-2 | 30 m ⁵ /100 m | 9 bands/2 bands | 705 km | 10:00 AM |

* RBV = Return Beam Vidicon, MSS = Multispectral Scanner, TM = Thematic Mapper, ETM = Enhanced Thematic Mapper, ETM+ = Enhanced Thematic Mapper Plus, OLI = Operational Land Imager, TIRS = Thermal Infrared Sensor, OLI-2 = Operational Land Imager 2, TIRS-2 = Thermal Infrared Sensor 2

¹ MSS data were processed to 60-meter pixel size

² Band 6 of TM is a thermal band (120 meter resolution)

³ Landsat 6 failed to reach orbit

⁴ Band 6 of ETM/ETM+ is a thermal band (120 meter resolution), Band 8 is a panchromatic band (15 meter resolution)

⁵ Band 8 of OLI/OLI-2 is a panchromatic band (15 meter resolution)

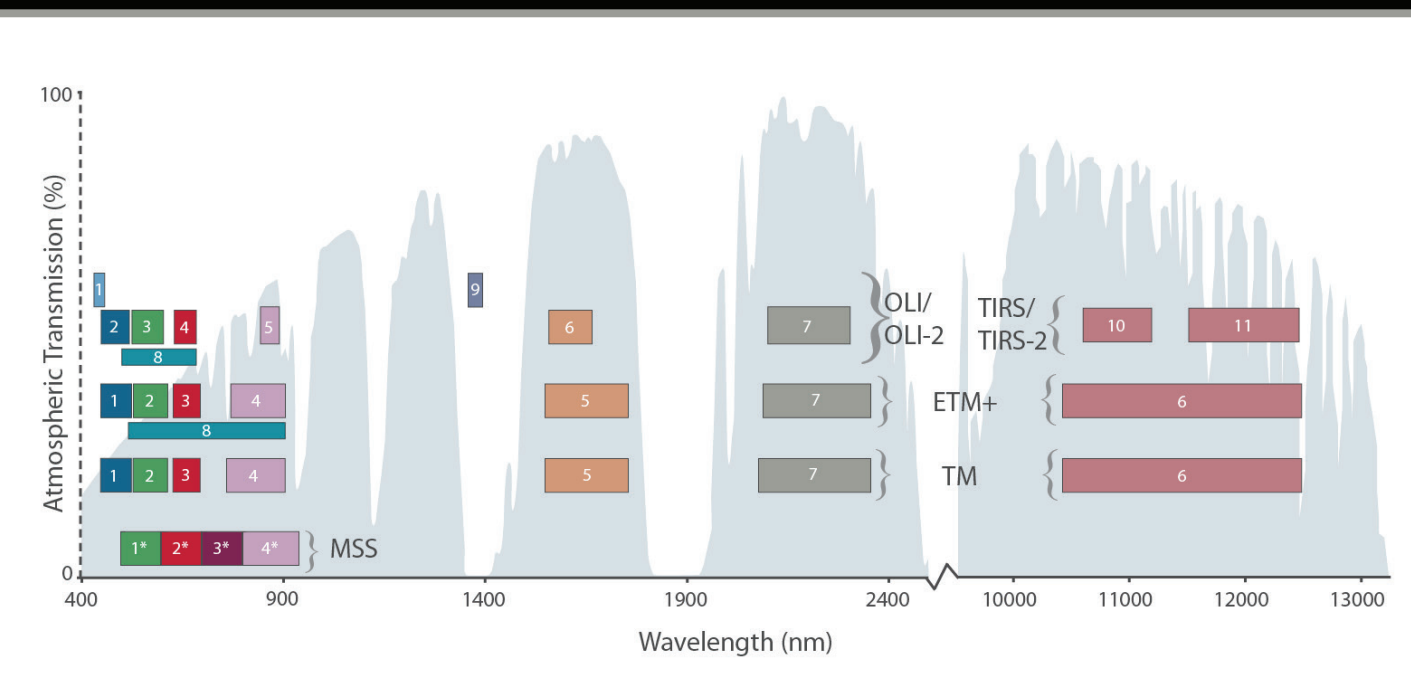


Figure 1. Spectral band comparison for the different Landsat sensors. Image credit: USGS/NASA.

* MSS Bands 1-4 were known as bands 4-7, respectively, on Landsat 1-3.

Landsat Collection 1

Landsat Collection 1 represents the first tiered collection management structure for Landsat data products. It contains data acquired since 1972 from Landsat 1-5 Multispectral Scanner (MSS), Landsat 4-5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Landsat 8 Operational Land Imager (OLI)/Thermal Infrared Sensor (TIRS) instruments. Collection 1 processing began in August 2016 and continued until May 2018 when all archived Landsat data were processed. This collection marked a significant change in the management of the data archive by ensuring consistent quality through time and across all sensors. Some of the improvements made during Collection 1 processing include the development of:

- Landsat Product Identifiers
- Solar and sensor coefficient files
- Payload correction data for Landsat 4-5
- Geometric accuracy files for Landsat 1-5
- New and updated quality assessment bands
- Improved cloud cover algorithms and estimates
- Landsat 8 TIRS stray light correction algorithm
- Calibration parameter files

| LANDSAT PRODUCT IDENTIFIER | |
|----------------------------|----------|
| LC | TX |
| XXXX | YYYYMMDD |
| XXXX | YYYYMMDD |
| XXXX | CC |
| XXXX | TX |

L = Landsat
X = Sensor (C=OLI/TIRS, O=OLI, T=TIRS, E=ETM+, T=TM, M=MSS)
SS = Satellite (01=Landsat 1, 02=Landsat 2, 03=Landsat 3, etc.)
LLLL = Processing Correction Level (L1TP, L1GT, L1GS)
PPP = WRS/WRS-2 Path
RRR = WRS/WRS-2 Row
YYYYMMDD = Date of Acquisition
yyyymmdd = Date of Processing
CC = Collection Number (01, 02)
TX = Collection Category (RT=Real Time, T1=Tier 1, T2=Tier 2)

EXAMPLES

LC08_L1GT_029030_20151209_20160131_01_RT
LT04_L1GS_017036_19821115_20160315_01_T2

Figure 2. Landsat Product Identifier (i.e. file naming convention).

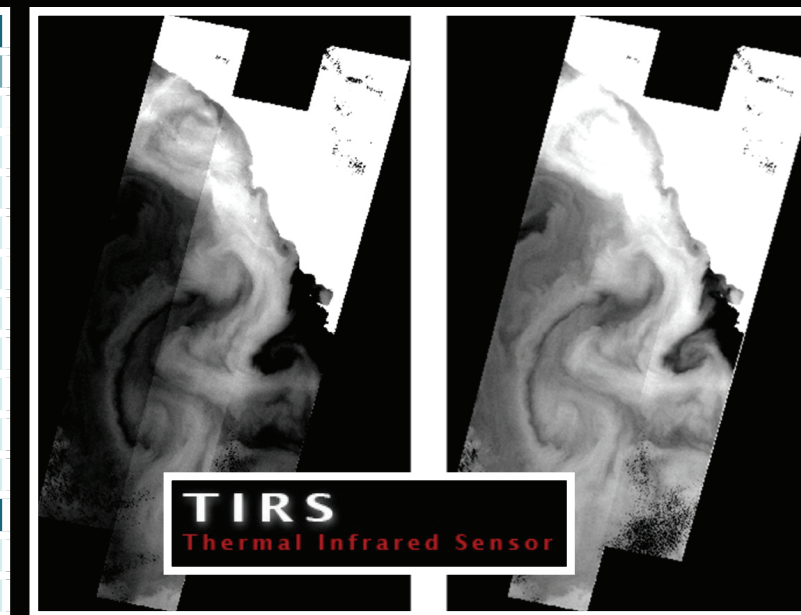


Figure 3. Landsat 8 TIRS Band 10 image before (left) and after (right) stray light correction. Credit: Gerace and Montanaro, 2017.

For more information on Landsat Collections (Fact Sheet 2018-3049):

For more information on Landsat Collection 2 (Fact Sheet 2021-3002):

Landsat Collection 2

Collection 2 marks the second major reprocessing of the Landsat archive. Collection 2 was initiated in early 2020 and released in December 2020. By the end of 2021, Collection 1 processing will cease and all new Landsat acquisition will be processed into the Collection 2 inventory structure. The Collection 2 processing resulted in several data product improvements that harness recent advancements in data processing, algorithm development, and data access and distribution capabilities. The primary improvements include:

- Improved geometric accuracy
- Consistent quality assessment bands
- Updated digital elevation modeling sources
- Updated and consistent metadata files
- Improved radiometric calibration
- Cloud optimized file format

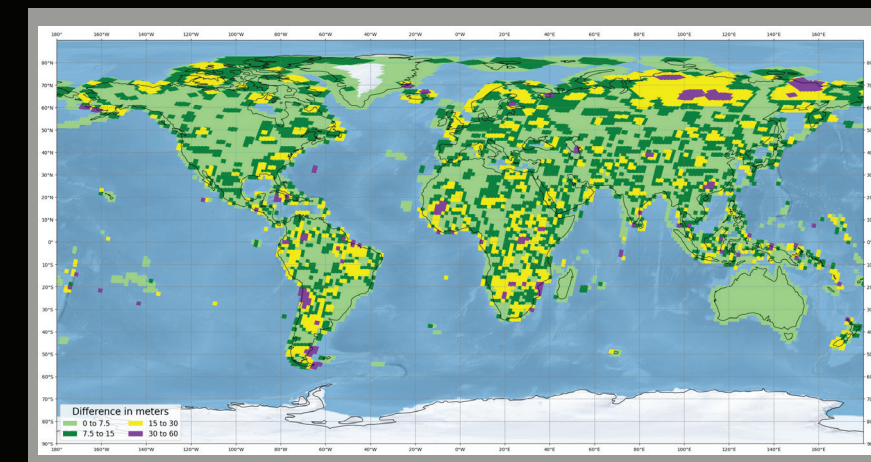


Figure 4. Improved geometric accuracy. Map shows the estimated net offsets (in meters) between Landsat Collection 1 and Collection 2 Ground Control Points for each Landsat WRS-2 Path/Row. The Landsat 8 OLI Ground Control Points were re-baselined to the European Space Agency Copernicus Sentinel-2 Global Reference Image to improve per pixel geodetic accuracy and interoperability of the global Landsat archive. Image credit: USGS.

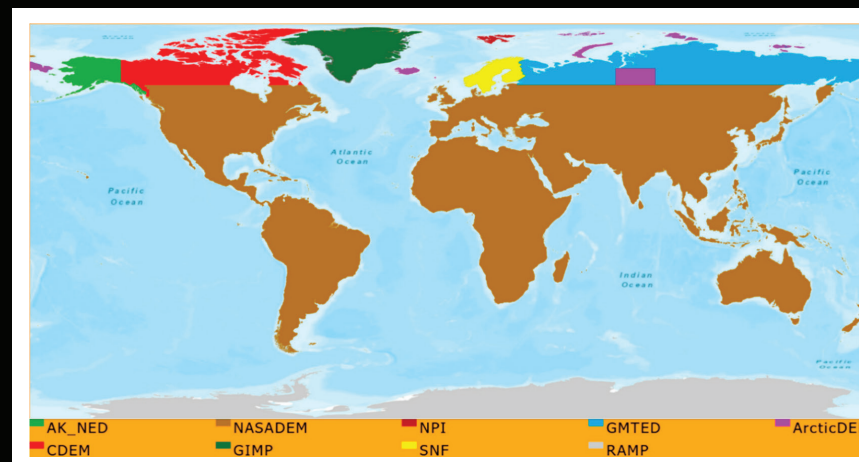


Figure 5. Updated digital elevation modeling (DEM) sources: AK_NED (Alaska National Elevation Dataset), ArcticDEM (WorldView-derived Arctic DEM), CDEM (Canadian DEM), GIMP (Greenland Ice Mapping Project DEM), GMTED (Global Multi-resolution Terrain Elevation Data), NASADEM (NASA Shuttle Radar Topography Mission), NPI (Norwegian Polar Institute Elevation Data), RAMP (Radarsat Antarctic Mapping Project), and SNF (Sweden, Norway, and Finland National Elevation Data). Image credit: USGS.

Landsat Collection Tiers

Landsat Collections are organized by a tiered inventory structure to indicate the quality of data and the level of processing. The three tiers are Real-Time, Tier 1, and Tier 2.

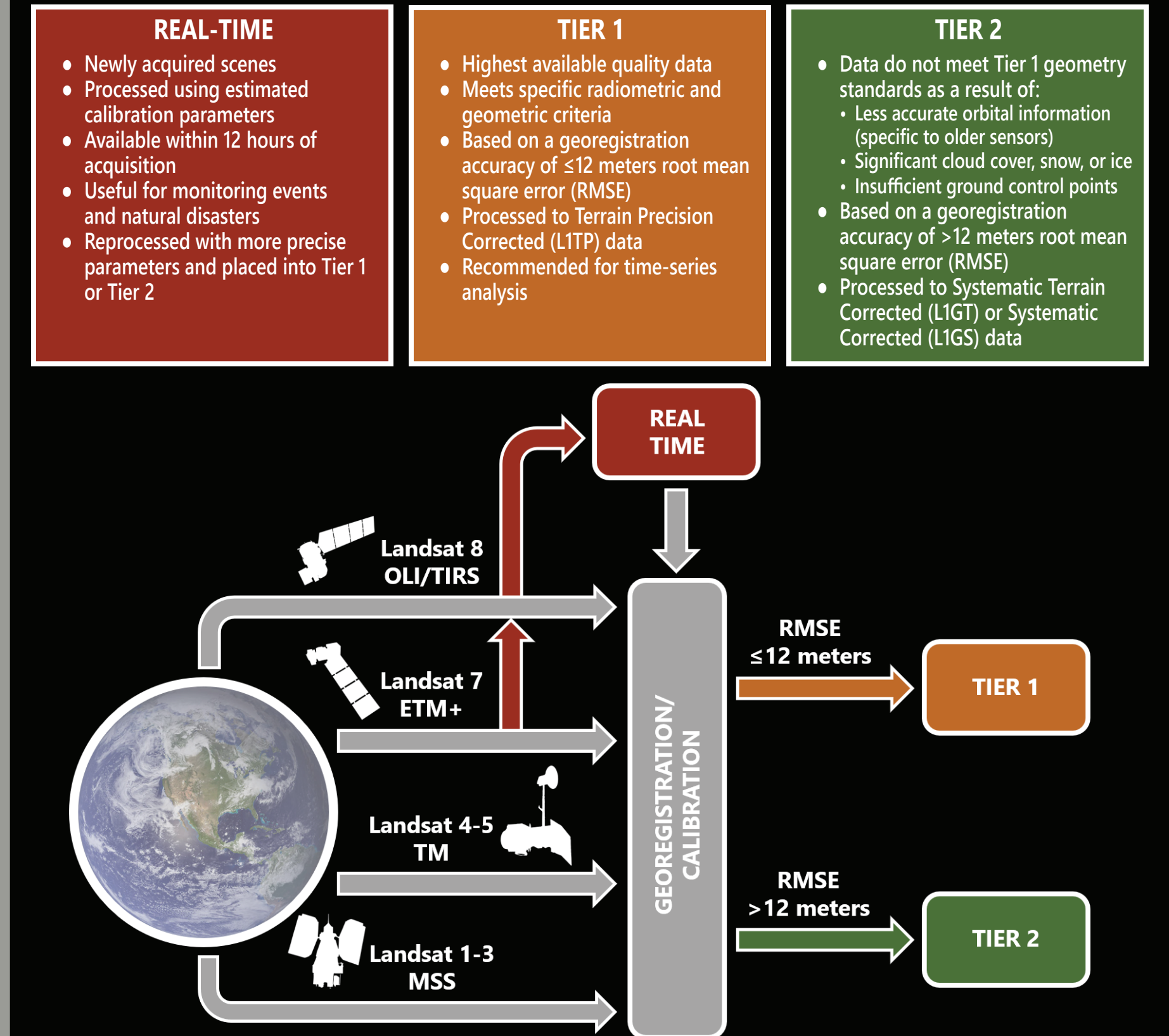


Figure 6. Landsat Collection processing for newly acquired Landsat data and the Landsat data archive, showing tiered inventory structure.

For more information on Collection Tiers:

For more information on Levels of Processing:

Landsat Levels of Processing

Landsat data are processed using the Landsat Product Generation System (LPGS), an extensive software system that performs geometric and radiometric corrections using standard processing parameters. Each Landsat scene is processed to one of three processing levels. Terrain Precision Corrected (L1TP) data provide the highest quality data for time-series analyses.

Table 2. Landsat Collections processing levels.

| LANDSAT LEVELS OF PROCESSING | |
|--------------------------------------|---|
| Terrain Precision Correction (L1TP) | Radiometrically calibrated and orthorectified using ground control points and digital elevation model (DEM) data to correct for relief displacement. Note: L1TP processing provides the highest quality data. The success rate for creating L1TP products varies by sensor, but also by cloud cover. In cases where scene and/or sensor issues or insufficient reference data cause L1TP processing to fail, L1GT or L1GS products are created. |
| Systematic Terrain Correction (L1GT) | Radiometrically calibrated with systematic geometric corrections applied using spacecraft ephemeris data and DEM data to correct for relief displacement. Note: L1GT processing is the highest level of radiometric and systematic correction possible for Landsat 7 and Landsat 8 scenes collected over Antarctica. |
| Systematic Correction (L1GS) | Radiometrically calibrated with systematic geometric corrections applied using spacecraft ephemeris data. Note: L1GS products are created when the locational accuracy is not sufficient to apply terrain corrections, such as with insufficient ground control points, opaque clouds that obscure the ground, or locational errors greater than the search distance for ground control. |