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EROS Science Processing Architecture (ESPA) On-Demand Interface User Guide

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Executive Summary

This document presents a high-level description of the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center Science Processing Architecture (ESPA), which provides on-demand processing and customization services for the remotely sensed science products.

This document is under Land Satellites Data System (LSDS) Configuration Control Board (CCB) control. Please submit changes to this document, as well as supportive material justifying the proposed changes, via Change Request (CR) to the Configuration Management Tool.

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Section 1 Introduction

1.1 Background

Landsat data have been produced, archived, and distributed by the U.S. Geological Survey (USGS) since 1972. Scientists and users rely on Landsat data as well as data obtained by other Earth Observation (EO) missions for historical study of the Earth's surface change but have shouldered the burden of postproduction processing to create application-ready datasets. In compliance with guidelines established through the Global Climate Observing System (GCOS), USGS produces Landsat science products to support land surface change studies.

The USGS Earth Resources Observation and Science (EROS) Center Science Processing Architecture (ESPA) is an incubation environment that provides users with an on-demand interface (<https://espa.cr.usgs.gov/>) to process and customize Landsat science products. These products are provided to build a framework for maturing long-term remote sensing datasets suited for monitoring, characterizing, and understanding the Earth's surface change over time. The framework's implementation includes basic customization services and Level 2 and Level 3 Landsat products processing to provide application-ready datasets for user community evaluation.

The customization services that ESPA offers include:

- Reprojection
- Spatial subsetting
- Pixel resizing
- Multiple output formats

ESPA is composed of the following two key elements:

- Bulk Ordering
- Bulk Ordering Application Programming Interface (API)*

*The API feature is available for all registered users. The API enables users to write clients to interact with all Bulk Ordering capabilities. More information about the API can be found in Section 4.

1.2 Purpose and Scope

This user guide focuses on the Bulk Ordering component available from <https://espa.cr.usgs.gov/>, which is the primary mechanism for accessing ESPA science products.

1.3 Document Organization

This document contains the following sections:

- Section 1 provides an introduction

- Section 2 describes the available products
- Section 3 provides an explanation of the user interface
- Section 4 provides an explanation of application programming interface
- Section 5 provides information about user services
- Appendix A represents Landsat Cloud Optimized GeoTIFF (COG) file characteristics
- Appendix B represents Landsat Georeferenced Tagged Image File Format (GeoTIFF) file characteristics
- Appendix C represents Landsat Hierarchical Data Format (HDF) file characteristics
- Appendix D represents Landsat binary file characteristics
- Appendix E provides a list of acronyms
- Appendix F provides the document change history
- The References section contains a list of reference materials

Section 2 Available Products

This section provides detailed information about the available Landsat products on ESPA. Available products and processing options are also summarized in Table 3-1. A summary of product availability by input data is also available from <https://espa.cr.usgs.gov/static/docs/available-products.html>.

Note: Due to processing system limitations ESPA does not allow ordering Landsat Collection 2 Level 1 or Level 2 data without any customization or without any higher level processing option. In order to retrieve Landsat data in their native format, users are advised to use USGS EarthExplorer (EE) or the USGS EROS Machine-to-Machine (M2M) Application Programming Interface (API).

Note: ESPA processing and customization services for Landsat Collection 1 data were discontinued in December 2022.

2.1 Landsat Collection 2 Products

ESPA offers on-demand science products processing and customization services for Landsat Collection 2 data. The Collection 2 Landsat 4 and 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Landsat 8-9 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) Level 1 and Level 2 scenes can be submitted for customization. On-demand processing of Collection 2 Provisional Aquatic Reflectance science product is available using Collection 2 Level 1 product identifiers (IDs). The Collection 2 Level 2 product IDs can be submitted for generation of Landsat Surface Reflectance-derived spectral indices generation and Collection 2 Provisional Actual Evapotranspiration. Available Collection 2 products are described in Sections 2.1.1 through 2.1.3.

The Landsat Level 1 metadata (MTL.txt and MTL.xml) and angle band coefficients file (ANG.txt) are distributed with all Landsat Collection 2 orders. Similarly, the Collection 2 Pixel Quality Assessment (QA_PIXEL) and Radiometric Saturation Quality Assessment (QA_RADSAT) files are distributed with Landsat Collection 2 orders. The Pixel Quality Assessment (QA) contains information about cloud, cloud confidence, cloud shadow, snow/ice, and water. The Radiometric Saturation QA is a bit-packed representation of which spectral bands were saturated during data capture, yielding unusable data. Additional information about the Collection 2 Pixel QA and Radiometric Saturation QA bands are provided in the [Landsat 4-7 Collection 2 Level 2 Science Product Guide](#) and [Landsat 8-9 Collection 2 Level 2 Science Product Guide](#).

2.1.1 Input Products

Selecting this option delivers the Landsat Collection 2 Level 1 or Level 2 scenes. This option is available only if a customization option is requested for the input Level 1 or Level 2 data, or if the Level 2 data is ordered with spectral indices. Additional information about Landsat Level 1 products are available from [Landsat 4-5 TM Collection 2 Level 1 Data Format Control Book](#), [Landsat 7 ETM+ Collection 2 Level 1 Data Format Control Book](#), and [Landsat 8-9 OLI/TIRS Collection 2 Level 1 Data Format](#)

[Control Book](#). The Landsat Level 2 Surface Reflectance and Surface Temperature products are described in [Landsat 4-7 Collection 2 Level 2 Science Product Guide](#) and [Landsat 8-9 Collection 2 Level 2 Science Product Guide](#).

Note: On-demand generation of Collection 2 Level 2 Surface Reflectance or Surface Temperature products is NOT available from ESPA. These products are retrieved from operational Landsat Product Generation System (LPGS) processing stream for customization and/or spectral indices calculation in ESPA.

Landsat 8-9 OLI/TIRS Collection 2 Level 1 Input Products output contains:

- Level 1 data files (Bands 1, 2, 3, 4, 5, 6, 7, 9, 10, and 11)
- Level 1 Pixel QA file (QA_PIXEL).
- Level 1 Radiometric Saturation QA (QA_RADSAT)
- Extensible Markup Language (XML) metadata (productID.xml)
- Level 1 metadata files (MTL.txt and MTL.xml)
- Angle band coefficients file (ANG.txt)

Landsat 8-9 OLI/TIRS Collection 2 Level 2 Input Products output contains:

- Level 2 Surface Reflectance (SR) data files (SR Bands 1, 2, 3, 4, 5, 6, and 7; SR Aerosol QA, Radiometric Saturation QA)
- Level 2 Surface Temperature (ST) data files (ST Band 10, Surface Temperature Uncertainty, Thermal Radiance, Upwelled Radiance, Downwelled Radiance, Atmospheric Transmittance, Emissivity estimated from ASTER GED, Emissivity standard deviation, Pixel distance to cloud)
- Level 2 Pixel QA file (QA_PIXEL)
- Level 1 Radiometric Saturation QA (QA_RADSAT)
- XML metadata (productID.xml)
- Level 1 metadata files (MTL.txt and MTL.xml)
- Angle band coefficients file (ANG.txt)

Landsat 7 ETM+ Collection 2 Level 1 Input Products output contains:

- Level 1 data files (Band 1, 2, 3, 4, 5, 6 low gain, 6 high gain, and 7)
- Level 1 Pixel QA band (QA_PIXEL)
- Level 1 Radiometric Saturation QA (QA_RADSAT)
- XML metadata (productID.xml)
- Level 1 metadata files (MTL.txt and MTL.xml)
- Angle band coefficients file (ANG.txt)

Landsat 7 ETM+ Collection 2 Level 2 Input Products output contains:

- Level 2 SR data files (SR Bands 1, 2, 3, 4, 5, and 7; Atmospheric Opacity, Radiometric Saturation QA, Surface Reflectance Cloud QA)

- Level 2 ST data files (ST Band 6 (merged), Surface Temperature Uncertainty, Thermal Radiance, Upwelled Radiance, Downwelled Radiance, Atmospheric Transmittance, Emissivity estimated from ASTER GED, Emissivity standard deviation, Pixel distance to cloud)
- Level 2 Pixel QA band (QA_PIXEL)
- Level 1 Radiometric Saturation QA (QA_RADSAT)
- XML metadata (productID.xml)
- Level 1 metadata files (MTL.txt and MTL.xml)
- Angle band coefficients file (ANG.txt)

Landsat 4 and 5 TM Collection 2 Level 1 Input Products output contains:

- Level 1 data files (Band 1, 2, 3, 4, 5, 6, and 7)
- Level 1 Pixel QA band (QA_PIXEL)
- Level 1 Radiometric Saturation QA (QA_RADSAT)
- XML metadata (productID.xml)
- Level 1 metadata files (MTL.txt and MTL.xml)
- Angle band coefficients file (ANG.txt)

Landsat 4 and 5 TM Collection 2 Level 2 Input Products output contains:

- Level 2 SR data files (SR Bands 1, 2, 3, 4, 5, and 7; Atmospheric Opacity, Radiometric Saturation QA, Surface Reflectance Cloud QA)
- Level 2 ST data files (ST Band 6, Surface Temperature Uncertainty, Thermal Radiance, Upwelled Radiance, Downwelled Radiance, Atmospheric Transmittance, Emissivity estimated from ASTER GED, Emissivity standard deviation, Pixel distance to cloud)
- Level 2 Pixel QA band (QA_PIXEL)
- Level 1 Radiometric Saturation QA (QA_RADSAT)
- XML metadata (productID.xml)
- Level 1 metadata files (MTL.txt and MTL.xml)
- Angle band coefficients file (ANG.txt)

Filenames utilize the Landsat product identifier (product ID), for example
 “LC09_L1TP_198024_20220424_20220424_02_T1” for Landsat 9 Level 1,
 “LC09_L2SP_198024_20220424_20220426_02_T1” for Landsat 9 Level 2,
 “LC08_L1TP_220071_20170207_20200905_02_T1” for Landsat 8 Level 1,
 “LC08_L2SP_220071_20170207_20200905_02_T1” for Landsat 8 Level 2,
 “LE07_L1TP_039037_20080728_20200912_02_T1” for Landsat 7 Level 1,
 “LE07_L2SP_039037_20080728_20200912_02_T1” for Landsat 7 Level 2,
 “LT05_L1TP_029030_20100805_20200824_02_T1” for Landsat 5 Level 1, and
 “LT05_L2SP_029030_20100805_20200824_02_T1” for Landsat 5 Level 2.

2.1.2 Provisional Aquatic Reflectance

Collection 2 Level 2 Provisional Aquatic Reflectance (AR) is available for Landsat 8 and Landsat 9. To process a Collection 2 AR, a Landsat 8 or Landsat 9 Level 1 Combined (LC08/LC09) or OLI-Only (LO08/LO09) product ID must be submitted. Additional information about the C2 AR science product is available in the [Landsat 8-9 Collection 2 Level 2 Provisional Aquatic Reflectance Product Guide](#).

The Collection 2 Aquatic Reflectance product package for L8-9 contains:

- Aquatic Reflectance for visible bands (AR Bands 1, 2, 3, 4, 5)
- Rayleigh-corrected Reflectance (RHORC Bands 1, 2, 3, 4, 5, 6, 7)
- Processing flags (L2_FLAGS)
- Water mask (WATER_MASK)
- Atmospheric auxiliary bands (Water Vapor, Surface Pressure, Wind Speed, Tropospheric Nitrogen Dioxide, Ozone)
- Digital elevation model (HEIGHT)
- Solar and sensor angles (Solar Zenith Angle, Solar Azimuth Angle, Viewing Zenith Angle, Viewing Azimuth Angle) and scattering angle (SCATTANG)
- Level 1 Pixel QA file (QA_PIXEL). More information about Landsat 8-9 QA_PIXEL band can be found in [Landsat 8-9 Collection 2 Level 2 Science Product Guide](#).
- Level 1 Radiometric Saturation QA (QA_RADSAT). More information about Landsat 8-9 Level 1 QA_RADSAT can be found in [Landsat 8-9 Collection 2 Level 2 Science Product Guide](#).
- Level 2 Aquatic Reflectance metadata file (productID.xml)
- Level 1 metadata files (MTL.txt and MTL.xml)
- Angle band coefficients file (ANG.txt)

AR filenames utilize the product ID followed by “_AR_”, as exemplified by “LC08_L1TP_161042_20171008_20210225_02_T1_AR_BAND*”.

Rayleigh-corrected filenames utilize the Level 1 product ID followed by “_RHORC_”, as exemplified by “LC08_L1TP_161042_20171008_20210225_02_T1_RHORC_BAND*”.

2.1.3 Provisional Actual Evapotranspiration

Collection 2 Level 3 Provisional Actual Evapotranspiration (ETa) is available for Landsat 4-9. Using an improved parameterization of the surface energy balance model, the Collection 2 Level 3 ETa provides a revised estimate of daily water transfer from the Earth's surface to the atmosphere in units of water depth (mm). To process Collection 2 ETa, a Level 2 Science Product (L2SP) product ID must be provided. The required Surface Temperature is read from the Collection 2 L2SP. Additional information about the ETa science product is available in the [Landsat 4-9 Collection 2 Level 3 Provisional Actual Evapotranspiration Product Guide](#).

The C2 ETa product package contains:

- Actual Evapotranspiration (ETA)
- Evapotranspiration fraction (ETF)
- Evapotranspiration Uncertainty (ETUN)
- Level 3 Actual Evapotranspiration metadata file (productID.xml)
- Level 2 Pixel QA file (QA_PIXEL). More information about C2 Pixel QA is provided in the [Landsat 4-7 Collection 2 Level 2 Science Product Guide](#) and [Landsat 8-9 Collection 2 Level 2 Science Product Guide](#).
- Level 1 Radiometric Saturation QA (QA_RADSAT). More information about Level 1 QA_RADSAT can be found in [Landsat 4-7 Collection 2 Level 2 Science Product Guide](#) and [Landsat 8-9 Collection 2 Level 2 Science Product Guide](#).
- Level 3 Evapotranspiration metadata file (productID.xml)
- Level 1 metadata files (MTL.txt and MTL.xml)
- Angle band coefficients file (ANG.txt)

Filenames utilize the L2SP product ID followed by product filename, as exemplified by "LC08_L2SP_029029_20130712_20200912_02_T1_ETA.*"

Note: Due to lack of Surface Temperature information, the Collection 2 Level 2 Surface Reflectance (L2SR) products cannot be processed to Actual Evapotranspiration.

2.1.4 Spectral Indices

Landsat Collection 2 Level 2 Surface Reflectance is used to derive several spectral indices products, as listed below. To process a Collection 2 spectral indices a Level 2 product ID must be provided. The Level 2 Surface Reflectance is retrieved from Landsat Collection 2 archive for spectral indices processing. The characteristics of spectral indices are described on <https://www.usgs.gov/landsat-missions/landsat-surface-reflectance-derived-spectral-indices>.

- Normalized Difference Vegetation Index (NDVI)
- Enhanced Vegetation Index (EVI)
- Soil Adjusted Vegetation Index (SAVI)
- Modified Soil Adjusted Vegetation Index (MSAVI)
- Normalized Difference Moisture Index (NDMI)
- Normalized Burn Ratio (NBR)
- Normalized Burn Ratio 2 (NBR2)
- Normalized Difference Snow Index (NDSI)

The Landsat Collection 2 spectral indices do not include a saturation flag. Surface Reflectance of saturated pixels is unreliable and users are advised to use the accompanied Level 1 QA_RADSAT band to mask saturated pixels from their analysis.

As reflected in the metadata file (productID.xml), the NoData value of the Landsat Collection 2 Spectral Indices is -19999 (instead of more common -9999 value) to ensure valid data are not marked as NoData.

Note: Both Level 2 Science Products (L2SP) and Level 2 Surface Reflectance (L2SR) products can be processed to Spectral Indices.

Section 3 User Interface

The ESPA interface is the primary mechanism used to request on-demand processing and services for the available products.

3.1 Submitting Order

To submit an order for science data production, users interact with the “New Order” page on the bulk ordering interface: <https://espa.cr.usgs.gov/>. The page consists of three sections: Notices (when applicable), scene list upload, and product options, as shown in Figure 3-1.

3.1.1 Login Credentials

A USGS Registered Username and password are required to access the bulk ordering interface. This is the same credential used to access EarthExplorer (<https://earthexplorer.usgs.gov/>). To register, visit <https://ers.cr.usgs.gov/register>.

3.1.2 Scene List

The first step in submitting an order for science data production is to create a scene list. The scene list is a text file (*.txt), listing one Landsat scene identifier on each line. Scenes and granules from different sensors can be ordered separately or concurrently. The list can be easily generated by performing a spatial and temporal inventory search through EarthExplorer and exporting search results to a spreadsheet from which filenames can be extracted.

Due to processing system limitations, a user cannot have more than 10,000 open units. There is also a limit of 5,000 units per individual order (i.e., scene and/or granule IDs). Generally, smaller orders can be delivered faster. An example of a scene list is below:

```
espa_request.txt
LC09_L1TP_039037_20220430_20220430_02_T1
LC09_L2SP_038037_20211216_20220121_02_T1
LT05_L1TP_038037_20120505_20200820_02_T1
LC08_L1TP_095066_20210412_20210416_02_T1
LE07_L2SP_005052_20201206_20210103_02_T1
LT04_L2SP_027027_19821208_20200925_02_T2
```

Add Input Products ([Show Available Products](#))

Scene List

No file chosen

Select Product Contents

Source Products

Input Products

Additional Processing

Landsat Level-2 Products

Provisional Aquatic Reflectance - Only Available for Landsat 8 & 9

Spectral Indices

Landsat Level-3 Products

Provisional Actual Evapotranspiration

Customize Outputs

Customization Options

Output Format COG GeoTiff ENVI HDF-EOS2 NetCDF

Reproject Products

Modify Image Extents

Pixel Resizing

Add Order Description

Order Description (optional)

Figure 3-1. ESPA On-Demand Order Page

3.1.3 Supported Processing Options by Product

Table 3-1 displays the available products and options in ESPA.

Product	Landsat 4-5 TM, Landsat 7 ETM+, Landsat 8-9 OLI/TIRS Collection 2 Level-1	Landsat 4-5 TM, Landsat 7 ETM+, Landsat 8-9 OLI/TIRS Collection 2 Level-2
Input Product	X ⁽¹⁾	X ⁽¹⁾
Level 2 Products	X	
Level 3 Products		X ⁽³⁾
Spectral Indices		X ⁽³⁾
Customize Outputs	X ⁽²⁾	X

Table Key: TM Thematic Mapper, ETM+ Enhanced Thematic Mapper Plus, OLI Operational Land Imager, TIRS Thermal Infrared Sensor,

(1) Landsat Collection 2 Input Product can be Level 1 or Level 2.

(2) Reprojection and pixel resizing options do not apply to the Panchromatic Band (Band 8 Landsat 7 ETM+ & Band 8 Landsat 8-9 OLI).

(3) Landsat Collection 2 spectral indices and Collection 2 Level 3 Actual Evapotranspiration are only available with Level 2 Input Products IDs.

Table 3-1. Available ESPA On-Demand Processing Options

3.1.3.1 Real Time Landsat Data Products

Before newly acquired Landsat 8 Level 1 scenes are assigned a tier designation, they are placed into the Real Time (RT) tier until finalized TIRS line-of-sight model parameters (7 to 10 days) have been applied to the data.

Users can order Landsat RT scenes; however, if an RT scene is replaced by final Tier 1 (T1) or Tier 2 (T2) data before ESPA begins processing the order containing the RT scene, processing will fail, and the user will need to reorder the T1/T2 scene.

3.1.4 Source Products

In the “Source Products” section:

- The Input Products are the Landsat Collection 2 Level 1, or Collection 2 Level 2 scenes accompanied by metadata obtained from the USGS archive. Characteristics of the input source products can be found using the links provided in Table 3-2.

Input Product	Characteristics
Landsat Collection 2 Level 1	https://www.usgs.gov/landsat-missions/landsat-collection-2-level-1-data
Landsat Collection 2 Level 2	https://www.usgs.gov/landsat-missions/landsat-collection-2-level-2-science-products

Table 3-2. Characteristics of Input Products

3.1.5 Landsat Level 2 Products

Currently, Landsat 8-9 Collection 2 Level 2 Provisional Aquatic Reflectance and Landsat 4-9 Collection 2 spectral indices and associated metadata are available from ESPA.

3.1.6 Landsat Level 3 Products

Landsat 4-9 Collection 2 Provisional Actual Evapotranspiration science products are available under this section (see Section 2.1.3).

3.1.7 Customization Options

Customized Products uses original Input Products and applies any selections from the “Customization Options” section. Clicking any of the boxes along the left side of the “Customization Options” section will expand the options for output format, reprojection, spatial subsetting, and resampling (Figure 3-2). Customized products must be checked for output format, projection, resizing and extent.

Including data from multiple sensors in an order will result in equivalent customization options. For example, if Exelis Visual Information Solutions (ENVI) is selected as an output format, both products will be produced as ENVI binaries. Likewise, if the pixel resizing is set to 100 meters, both datasets will be sampled to 100 meters.

Note: Selection of the customization options may result in out-of-range values depending on the resampling method provided. Additionally, the Panchromatic Band (Band 8 Landsat 7 ETM+ & Band 8 Landsat 8-9 OLI) is not carried through to the customized output product.

Customization Options

Output Format COG GeoTiff ENVI HDF-EOS2 NetCDF

Reproject Products

Projection: ▾

Latitude of Origin

Central Meridian

1st Standard Parallel

2nd Standard Parallel

False Easting

False Northing

▾ Datum

Modify Image Extents

Decimal Degrees Meters

Upper left X coordinate

Upper left Y coordinate

Lower right X coordinate

Lower right Y coordinate

Pixel Resizing

Meters

Resample Method: ▾

Figure 3-2. ESPA On-Demand Customization Services

3.1.7.1 Output Format

Customized Input Products, Level 2 and 3 science products, and/or Spectral Indices can be output in the following formats: Cloud Optimized GeoTIFF (COG; “.TIF”), Georeferenced Tagged Image File Format (GeoTIFF; .tif), Exelis Visual Information Solutions (ENVI) binary (“.img”), Network Common Data Form (NetCDF; “.nc”) or Hierarchical Data Format – Earth Observing System version 2 (HDF-EOS2; “.hdf”). The ESPA default file format is COG. The COG file format is an extension of the GeoTIFF file format that enables more flexible access to geospatial data. Specifications of COG file format offered through ESPA are described in [Landsat Cloud Optimized GeoTIFF Data Format Control Book](#). The HDF-EOS2 is based on HDF-4 file format. The HDF-

EOS2 files distributed by ESPA store the actual data as external bands (*_hdf.img) to adhere to the file size limitations for the HDF-4 files.

3.1.7.2 Reproject Products

Available products can be reprojected from the native Universal Transverse Mercator (UTM) or Polar Stereographic (Landsat Level 1 defaults) to a different UTM zone, Geographic, Albers Equal Area (AEA), or Polar Stereographic projection. The underlying software performing the reprojections is the Geospatial Data Abstraction Library (GDAL; <http://www.gdal.org/>.)

The Albers Equal Area selection requires user definition of projection parameters and offers choices for datum while the Polar Stereographic reprojection allows entry of parameters. UTM accepts only a zone parameter and North/South hemisphere specification. Geographic system projects the coordinates into decimal degrees. A full list of parameters is provided in Table 3-3. A graphical example of reprojection is shown in Figure 3-3.

Input Parameters	AEA Projection	UTM Projection	Geographic Projection	Polar Stereographic Projection
Units	Meters	Meters	Decimal Degrees	Meters
Latitude of Origin	-90.0 to 90.0			
Latitude True Scale				-180.0 to 180.0
Longitudinal Pole				-90.0 to -60.0 (South), 60.0 to 90.0 (North)
Central Meridian	-180.0 to 180.0			
1 st Standard Parallel	-90.0 to 90.0			
2 nd Standard Parallel	-90.0 to 90.0			
False Easting	Any float			Any float
False Northing	Any float			Any float
Datum	WGS84, NAD27, NAD83			
Zone		1-60 North, 1-60 South		

Table key: UTM Universal Transverse Mercator, WGS84 World Geodetic System 1984, NAD27 North American Datum 1927, NAD83 North American Datum 1983

Table 3-3. Possible Input Parameters for Product Reprojection in ESPA

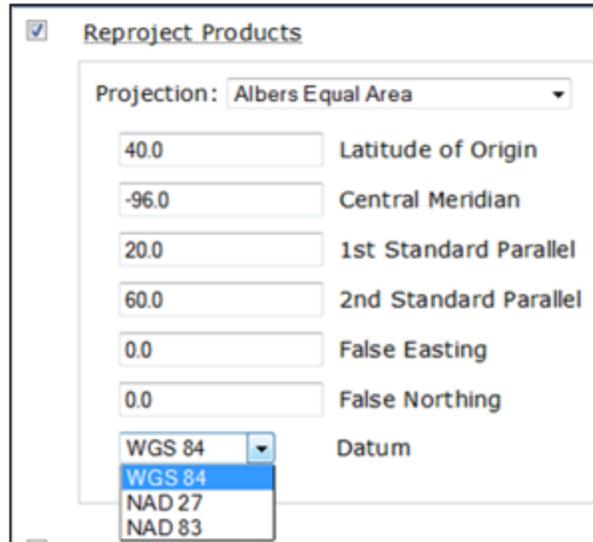


Figure 3-3. Examples of ESPA On-Demand Projection Parameter Entry

3.1.7.3 Modify Image Extents

If the user requires modification of image extents, the output projection must be specified, and entries for the corner points must be in the proper units (decimal degrees for Geographic; meters for Albers Equal Area, Polar Stereographic, and UTM).

3.1.7.4 Pixel Resizing and Resampling

The last two customization options are for pixel resizing and resampling. Users can up- or down-sample the available products between 30 and 5,000-meters (m). Pixel size must be in decimal degrees if a Geographic projection is used.

Resampling methods include nearest neighbor, bilinear interpolation, and cubic convolution. As QA bands use discrete, integer-level data, these bands are always resampled with nearest neighbor.

3.1.7.5 Customized Image Limitations

Due to processing system limitations, there are some restrictions for customized outputs.

- a) Maximum number of pixels: This customization limit is applied to all products and sets a maximum of 200 million pixels per image. The total number of pixels is calculated based on Equation 3-1 where the image width and height are derived from maximum and minimum X and Y values in the target projection system.

$$total\ pixels = \frac{Source\ Image\ Width \times Source\ Image\ Height}{Target\ Resolution^2}$$

Equation 3-1. Total Number of Pixels in Customized Image

- b) Pixel resizing: This customization limit is also applied to all products. For customized products, the minimum and maximum pixel size ranges are enforced as listed in Table 3-4.

Pixel resizing unit	Minimum	Maximum
Decimal Degrees (d)	0.0002695	0.0449155
Meters (m)	30	5000

Table 3-4. Pixel Resizing Limits

- c) Panchromatic Band removal: The Panchromatic Band (Band 8 Landsat 7 ETM+ & Band 8 Landsat 8-9 OLI) included in the input Landsat 7, 8, and 9 Level 1 products are not carried through to the final output product.

3.1.8 Order Description

Users may enter an order description if they wish to help identify the contents of the order for themselves. The “Submit” button at the bottom of the page will send the request to production.

As soon as the order is received, an email acknowledgment is delivered to the user. The email contains a link to tracking information for the order.

3.2 Order Tracking

Product requests are delivered to a hypertext transfer protocol over transport layer security (HTTPS) site. Email notification of location is sent to the user when all files in the order have completed processing. Users can also use the “Show Orders” feature in the ESPA On-Demand Interface (ODI) to monitor the status of production and go directly to the download site as files complete.

Clicking on “Show Orders” presents an entry field requesting the email address associated with the order. The email address will be the same as what is on file in the user’s EarthExplorer account. After entering the address and clicking “Submit,” a listing is shown of all orders for that address (Figure 3-4).

The orders are assigned names that include email address, date of submission, and a unique identifier can be used to differentiate requests. For example: “scientist@usgs.gov-12172014-155922” is an order placed by scientist@usgs.gov on December 17, 2014.

The general status of each order is noted next to the order name, and any comments the user entered regarding the order are also displayed. Statistics are provided for each order, indicating the total number of products ordered, and the number of orders currently available for download.



Showing all orders for

Order ID	Products Ordered	Products Complete	Status	Note
04042017-115131-888	19	19	complete	XXXXXXXXXXXXXXXXXXXXXXXXX Compositing tile r04c01 for L7. Order parameters: mask product cloud processing level toa ulx -2362425 uly 2277435 lrx -2062425 lry 1977435. See the order template file for standard tile compositing parameter values.
04042017-115128-244	8	8	complete	XXXXXXXXXXXXXXXXXXXXXXXXX Compositing tile r04c01 for L8. Order parameters: mask product cloud processing level toa ulx -2362425 uly 2277435 lrx -2062425 lry 1977435. See the order template file for standard tile compositing parameter values.
04042017-114717-057	20	20	complete	XXXXXXXXXXXXXXXXXXXXXXXXX Compositing tile r09c07 for L7. Order parameters: mask product cloud processing level toa ulx -562425 uly 777435 lrx -262425 lry 477435. See the order template file for standard tile compositing parameter values.
04042017-114713-226	23	23	complete	XXXXXXXXXXXXXXXXXXXXXXXXX Compositing tile r09c07 for L8. Order parameters: mask product cloud processing level toa ulx -562425 uly 777435 lrx -262425 lry 477435. See the order template file for standard tile compositing parameter values.

Figure 3-4. ESPA On-Demand 'Show Orders' Page

The order names listed are linked to the distribution site. File-based details can be found there, and users can download any of the files in the order that have completed (Figure 3-5). An email notice is sent to the user only when all files are complete.

Requested: 1	Completed: 1	Open: 0	Waiting on data: 0
Order: 012	-05032022-083859-	Date Ordered: 2022-05-03 08:38:59.012310	
Status: complete		Date Completed: 2022-05-03 08:49:30.620399	
Requested Processing: Reproject to geographic, resize pixels to 0.0025 dd, image extents set to ulx:120.0366 uly:38.249 lrx:121.8906 lry:37.3614, Output Format is geotiff			
Products by sensor: tm5_collection_2_l2: l1, sr_ndvi, sr_evi, sr_savi, sr_msavi, sr_ndmi, sr_nbr, sr_nbr2, stats ,			
The ESPA Bulk Downloader is available HERE		<input type="button" value="Show JSON"/>	

Product	Status	Product URL	Checksum URL	Note
45823964 - LT05_L2SP_120034_19860206_20200918_02 _T1	complete	Download	Checksum	

Figure 3-5. ESPA On-Demand Distribution Page

3.2.1 Cancel Order

Orders submitted for processing can be canceled by the user. Figure 3-6 shows the cancellation option, which is located on the individual orders' status page. Once confirmed, all scenes that have not completed processing will be cancelled and any previously processed scenes from that order will be deleted from disk. Order cancellation is not available for orders that have completed processing.

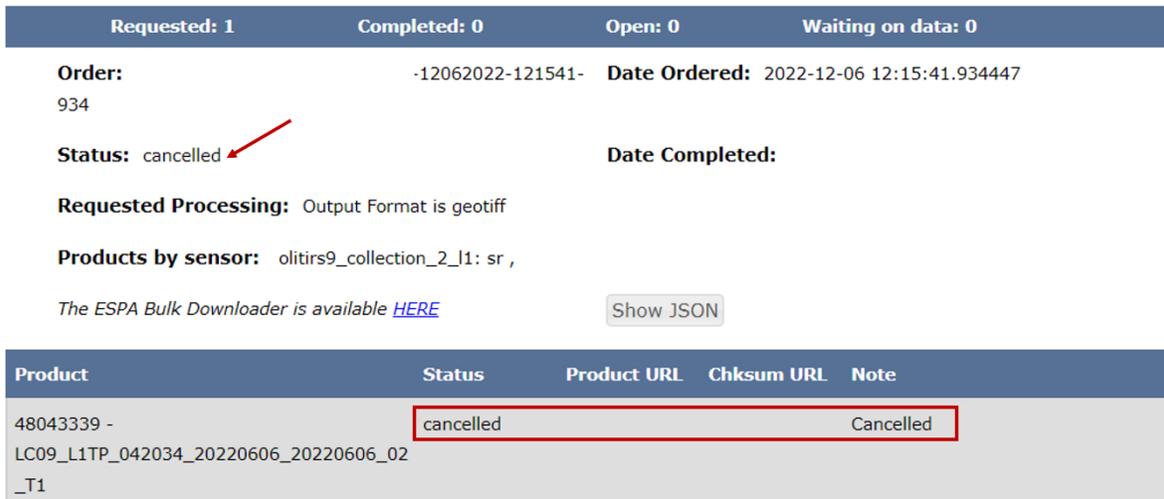
Note: Once order cancellation is confirmed, the action cannot be undone and the order must be resubmitted if desired.



The screenshot shows an order status page with a dark blue header bar containing the following statistics: Requested: 71, Completed: 0, Open: 71, and Waiting on data: 0. Below the header, the order details are displayed: Order ID is -12062022-121541-934, Date Ordered is 2017-06-26 11:48:30.090016, Status is 'ordered', and Date Completed is empty. The Requested Processing is 'resize pixels to 35 meters, Output Format is geotiff'. The Products by sensor are 'olitirs8_collection: surface reflectance, l2 pixel qa'. A note at the bottom left states 'The ESPA Bulk Downloader is available on [GitHub](#)'. A 'Show JSON' button is located at the bottom center, and a 'CANCEL' button is at the bottom right, with a red arrow pointing to it.

Figure 3-6. Cancel Order

To confirm that an order has been successfully cancelled, check that the status of the order displays “cancelled” (Figure 3-7). Verification that the individual scenes within a cancelled order are cancelled can also be done by checking the scene status and notes.



The screenshot shows an order status page with a dark blue header bar containing the following statistics: Requested: 1, Completed: 0, Open: 0, and Waiting on data: 0. Below the header, the order details are displayed: Order ID is -12062022-121541-934, Date Ordered is 2022-12-06 12:15:41.934447, Status is 'cancelled', and Date Completed is empty. The Requested Processing is 'Output Format is geotiff'. The Products by sensor are 'olitirs9_collection_2_l1: sr'. A note at the bottom left states 'The ESPA Bulk Downloader is available [HERE](#)'. A 'Show JSON' button is located at the bottom center. Below the order details is a table with the following columns: Product, Status, Product URL, Chksum URL, and Note. The table contains one row with the following data: Product ID is 48043339 - LC09_L1TP_042034_20220606_20220606_02_T1, Status is 'cancelled', Product URL is empty, Chksum URL is empty, and Note is 'Cancelled'. A red box highlights the 'cancelled' status and the 'Cancelled' note.

Figure 3-7. Order Cancellation Verification

3.2.2 Status Message

Each product within an order contains a status, indicating its activity within ESPA. Table 3-5 describes each status message and its meaning.

Status	Interpretation
Submitted	ESPA has received the order request but has not yet determined source product availability.
On Cache	ESPA has found the source product(s) are available for processing.
On Order	The source product(s) are not immediately available, so ESPA has placed an order to the source and is awaiting the source product(s).
Queued	ESPA will attempt to process your orders once they reach the front of the queue.
Processing	ESPA is now processing your order.
Error	ESPA has received an order that could not be processed as requested. Errors will always be described in detail in the "Note" column of the order status. Some possible errors: <ul style="list-style-type: none"> • Solar zenith angle is too high (>76 degrees) to accurately retrieve surface reflectance • Auxiliary data are not yet available for the date requested
Retry	An order that could not previously be completed is set to be run again. For products missing auxiliary data for SR retrieval, ESPA retries every 24 hours.
Complete	The order has completed successfully and is ready for download.
Unavailable	ESPA determined the order could not be completed successfully, so it will not be retried.
Cancelled	Processing for this scene/order has been cancelled.

Table 3-5. ESPA Order Status Messages / Meanings

3.3 Download

As files complete processing, they can be downloaded along with their checksums any time directly from the site linked to the user's email address. Notification of delivery is not emailed to the user until all the files in the order are complete.

3.3.1 File Archive Format

The download site contains compressed file archives (.tar.gz), inside of which will be the requested files.

For Landsat Collection 2 data, the archives are formatted as follows:

LXSSPPRRRRYYYYMMDDCCTX-SCyyyymmddhhmmss.tar.gz

where:

L	Landsat
X	Sensor (“T” = TM; “E” = ETM+; “O” = OLI; “T” = TIRS; “C” = OLI/TIRS)
SS	Satellite (“04” = Landsat 4; “05” = Landsat 5; “07” = Landsat 7; “08” = Landsat 8; “09” = Landsat 9)
PPP	Path
RRR	Row
YYYY	Year of acquisition
MM	Acquisition month
DD	Acquisition day
CC	Landsat Collection number (“02” for Collection 2)
TX	Tier (“01” for Tier 1; “02” for Tier 2; “RT” for Real Time)
SC	Science dataset
yyyy	Year of ESPA processing
mm	Month of ESPA processing
dd	Day of ESPA processing
hh	Hour of ESPA processing
ss	Seconds of ESPA processing.

Additional information, such as the date ordered, date completed, and requested processing options are listed within the order download page (Figure 3-5).

3.3.2 Distribution Methods

Distribution is currently via direct download from an HTTPS site, which generally requires each file be downloaded individually. Bulk downloads are possible, as noted below.

3.3.3 ESPA Bulk Download Client

A Python-based Bulk Download client is available for downloading either a single ESPA order, or the entire order queue. Python 2.7 or greater is required to run the client.

The tool is available from <https://code.usgs.gov/espa/bulk-downloader/>.

Section 4 Application Programming Interface

4.1 Overview

The ESPA Application Programming Interface (API) is the underlying architecture on which the On-Demand Interface operates. The API's basic functionality allows end users to use a machine-to-machine interface to query order options, place orders, check order status and acquire download URLs. The API is implemented as a Representational State Transfer (REST) service using Hypertext Transfer Protocol (HTTPS) and JavaScript Object Notation (JSON) and therefore is compatible with most programming languages. An overview of the ESPA JSON REST API, object definitions, and operations is at <https://espa.cr.usgs.gov/static/docs/api-readme.html>.

4.2 Documentation

The official ESPA API documentation is at <https://espa.cr.usgs.gov/static/docs/api-readme.html>.

An example Python script for placing and downloading orders through ESPA API is available on <https://espa.cr.usgs.gov/static/docs/api-readme.html>. The example code includes sample JSON data that can be submitted to the ESPA API. The JSON files are constructed using the sensor/dataset objects, input scene/granules, output products, and optional order description, projection information, image extents, pixel resizing, and resampling method of the output products. Table 4-1 lists the sensors/dataset that ESPA supports with the corresponding JSON object names.

Sensor/Dataset	JSON Object
Landsat 4 TM Collection 2 Level 1	"tm4_collection_2_l1"
Landsat 4 TM Collection 2 Level 2	"tm4_collection_2_l2"
Landsat 5 TM Collection 2 Level 1	"tm5_collection_2_l1"
Landsat 5 TM Collection 2 Level 2	"tm5_collection_2_l2"
Landsat 7 ETM+ Collection 2 Level 1	"etm7_collection_2_l1"
Landsat 7 ETM+ Collection 2 Level 2	"etm7_collection_2_l2"
Landsat 8 OLI-TIRS Collection 2 Level 1	"olitirs8_collection_2_l1"
Landsat 8 OLI-TIRS Collection 2 Level 2	"olitirs8_collection_2_l2"
Landsat 8 OLI-only Collection 2 Level 1	"oli8_collection_2_l1"
Landsat 9 OLI-TIRS Collection 2 Level 1	"olitirs9_collection_2_l1"
Landsat 9 OLI-TIRS Collection 2 Level 2	"olitirs9_collection_2_l2"
Landsat 9 OLI-only Collection 2 Level 1	"oli9_collection_2_l1"

Table 4-1. Available sensors/products

List of the input scenes/granules ("inputs") and product options ("products") are specified within the body of JSON object. Available product options for Landsat are provided in Table 4-2.

Product	JSON Keyword
Level 1 and Level 2 Input Product	"l1"
Spectral indices	"sr_ndvi", "sr_evi", "sr_savi", "sr_msavi", "sr_ndmi", "sr_nbr", "sr_nbr2", and "sr_ndsi"
Provisional Aquatic Reflectance*	"aq_refl"
Provisional Actual Evapotranspiration**	"et"

Table key: * Provisional Aquatic Reflectance is available for Landsat 8-9 OLI and Landsat 8-9 OLI-TIRS data. ** Provisional Actual Evapotranspiration is NOT available for Landsat 8-9 SR-only (L2SR) scenes.

Table 4-2. Available Product Options for Landsat Collection 2

Table 4-3 lists the “projection” options that are supported for ESPA outputs.

Projection	JSON Keyword
Universal Transverse Mercator (UTM)	"utm"
Polar Stereographic	"ps"
Albers Equal Area	"aea"
Geographic	"lonlat"

Table 4-3. Projection Options

Available file “format” options for ESPA outputs are listed in Table 4-4.

File Format	JSON Keyword
Cloud Optimized GeoTIFF (COG; .TIF)	"cog"
Georeferenced Tagged Image File Format (GeoTIFF; .tif)	"gtiff"
Exelis Visual Information Solutions (ENVI) binary (.img)	"envi"
Hierarchical Data Format – Earth Observing System – 2 (HDF-EOS2; .hdf)	"hdf-eos2"
Network Common Data Form (NetCDF; .nc)	"netcdf"

Table 4-4. File Format Options

Section 5 User Services

Landsat science products and associated interfaces are supported by User Services staff at USGS EROS. Feedback on the usability of the data products distributed from the ESPA is encouraged and welcome. Any scientific feedback, questions, comments, or interface problems can be directed to USGS EROS Customer Services:

Email: custserv@usgs.gov

Phone: 1-605-594-6151

Phone (toll-free): 1-800-252-4547

User support is available Monday through Friday from 8:00 a.m. to 4:00 p.m. Central Time. Inquiries received outside of these hours will be addressed during the next business day.

Appendix A Landsat Cloud Optimized GeoTIFF File Characteristics

NOTE: A Landsat 8 Collection 2 Level 1 product ID is used only as an example. Landsat 4-5 TM, Landsat 7 ETM+, and Landsat 9 OLI/TIRS files have similar characteristics (with the exception of Aquatic Reflectance product availability).

Description	Example File Size (Kbytes)	Example File Name
Source Level 1 data file (10) (Bands 1-7 and 9-11)	69,319	LC08_L1TP_023030_20191007_20200825_02_T1_B*.TIF
Source Level 1 data file (Panchromatic Band 8)	285,413	LC08_L1TP_023030_20191007_20200825_02_T1_B8.TIF
Source Product Metadata file (1)	8	LC08_L1TP_023030_20191007_20200825_02_T1_MTL.txt
Source Product Metadata file (1)	12	LC08_L1TP_023030_20191007_20200825_02_T1_MTL.xml
Angle Band Coefficients file (1)	114	LC08_L1TP_023030_20191007_20200825_02_T1_ANG.txt
Radiometric Saturation QA file (1)	231	LC08_L1TP_023030_20191007_20200825_02_T1_QA_RAD SAT.tif
Per-pixel Band 4 Angle Band Files (4)	3,821	LC08_L1TP_023030_20191007_20200825_02_T1_*.TIF
Level 1 Pixel QA file (1)	829	LC08_L1TP_023030_20191007_20200825_02_T1_QA_PIXE L.TIF
Metadata	18	LC08_L1TP_023030_20191007_20200825_02_T1.xml

Table key: TM Thematic Mapper, ETM+ Enhanced Thematic Mapper Plus, OLI Operational Land Imager, TIRS Thermal Infrared Sensor, HDF Hierarchical Data Format, SDS Science Data Set, IMG ENVI Binary Image Format, NA Not Applicable, TOA Top of Atmosphere, SR Surface Reflectance, QA Quality Assessment, XML Extensible Markup Language, HDR Header file format, BT Top of Atmosphere Brightness Temperature, CFMask C version Function of Mask, AR Aquatic Reflectance, ET Evapotranspiration

Table A-1. Landsat Cloud Optimized GeoTIFF File Characteristics for Collection 2

Appendix B Landsat GeoTIFF File Characteristics

NOTE: A Landsat 8 Collection 2 Level 1 product ID is used only as an example. Landsat 4-5 TM, Landsat 7 ETM+, and Landsat 9 OLI/TIRS files have similar characteristics (with the exception of Aquatic Reflectance product availability).

Description	Example File Size (Kbytes)	Example File Name
Source Level 1 data file (10) (Bands 1-7 and 9-11)	121,520	LC08_L1TP_023030_20191007_20200825_02_T1_B*.tif
Source Level 1 data file (Panchromatic Band 8)	485,891	LC08_L1TP_023030_20191007_20200825_02_T1_B8.tif
Source Product Metadata file (1)	8	LC08_L1TP_023030_20191007_20200825_02_T1_MTL.txt
Source Product Metadata file (1)	12	LC08_L1TP_023030_20191007_20200825_02_T1_MTL.xml
Angle Band Coefficients file (1)	115	LC08_L1TP_023030_20191007_20200825_02_T1_ANG.txt
Radiometric Saturation QA file (1)	121,520	LC08_L1TP_023030_20191007_20200825_02_T1_QA_RAD SAT.tif
Per-pixel Band 4 Angle Band Files (4)	121,520	LC08_L1TP_023030_20191007_20200825_02_T1_*.tif
Level 1 Pixel QA file (1)	121,520	LC08_L1TP_023030_20191007_20200825_02_T1_QA_PIXE L.tif
Metadata	38	LC08_L1TP_023030_20191007_20200825_02_T1.xml

Table key: TM Thematic Mapper, ETM+ Enhanced Thematic Mapper Plus, OLI Operational Land Imager, TIRS Thermal Infrared Sensor, HDF Hierarchical Data Format, SDS Science Data Set, IMG ENVI Binary Image Format, NA Not Applicable, TOA Top of Atmosphere, SR Surface Reflectance, QA Quality Assessment, XML Extensible Markup Language, HDR Header file format, BT Top of Atmosphere Brightness Temperature, CFMask C version Function of Mask, AR Aquatic Reflectance, ET Evapotranspiration

Table B-1. Landsat GeoTIFF File Characteristics for Collection 2

Appendix C Landsat HDF File Characteristics

NOTE: A Landsat 5 Collection 2 Level 1 TM product ID is used only as an example. Landsat 4 TM, Landsat 7 ETM+, and Landsat 8-9 OLI/TIRS files have similar characteristics.

NOTE: An “.img” file is included for each Science Data Set (SDS) within an HDF file because each band is stored as an external SDS.

Description	Example File Size (Kbytes)	Example File Name	Science Data Sets
Source data file	32	LT05_L1TP_018034_19850904_20200918_02_T1.hdf	Grid <ul style="list-style-type: none"> • SDS1 band1 • SDS2 band2 • SDS3 band3 • SDS4 band4 • SDS5 band5 • SDS6 band6 • SDS7 band7 • SDS8 radsat_qa • SDS9 pixel QA • SDS10 solar zenith angle • SDS11 solar azimuth angle • SDS12 viewing zenith angle • SDS13 viewing azimuth angle
Source Binary file (9)	55,099	LT05_L1TP_018034_19850904_20200918_02_T1_B* hdf.img	NA
Source Metadata	8	LT05_L1TP_018034_19850904_20200918_02_T1_MTL.txt	NA
Angle Coefficients File	34	LT05_L1TP_018034_19850904_20200918_02_T1_ANG.txt	NA
Radiometric Saturation QA file	55,099	LT05_L1TP_018034_19850904_20200918_02_T1_QA_RADSAT_hdf.img	NA
Level 1 Pixel QA file	110,198	LT05_L1TP_018034_19850904_20200918_02_T1_QA_PIXEL.hdf.img	NA
Metadata	26	LT05_L1TP_018034_19850904_20200918_02_T1.xml	NA
Level 1 Product Metadata file	8	LT05_L1TP_018034_19850904_20200918_02_T1_MTL.txt	NA
Level 1 Product Metadata file	12	LT05_L1TP_018034_19850904_20200918_02_T1_MTL.xml	NA

Description	Example File Size (Kbytes)	Example File Name	Science Data Sets
Angle Band Coefficients file	115	LT05_L1TP_018034_19850904_20200918_02_T1_ANG.txt	NA

Table key: TM Thematic Mapper, ETM+ Enhanced Thematic Mapper Plus, OLI Operational Land Imager, TIRS Thermal Infrared Sensor, HDF Hierarchical Data Format, SDS Science Data Set, IMG ENVI Binary Image Format, NA Not Applicable, TOA Top of Atmosphere, SR Surface Reflectance, QA Quality Assessment, XML Extensible Markup Language, HDR Header file format, CFMask C version Function of Mask

Table C-1. Landsat HDF File Characteristics for Collection 2

Appendix D Landsat Binary File Characteristics

NOTE: A Landsat 4 Collection 2 Level 2 TM product ID is used only as an example. Landsat 5 TM, Landsat 7 ETM+, and Landsat 8-9 OLI/TIRS files have similar characteristics.

Description	Example File Size (Kbytes)	Example File Name
Surface Reflectance data file (6)	119,277	LT04_L2SP_023028_19821212_20200918_02_T1_SR_B*.img
Surface Reflectance header file (6)	1	LT04_L2SP_023028_19821212_20200918_02_T1_SR_B*.hdr
Surface Reflectance Quality file	59,638	LT04_L2SP_023028_19821212_20200918_02_T1_SR_CLOUD_QA.img
Surface Reflectance Quality header file (7)	1	LT04_L2SP_023028_19821212_20200918_02_T1_SR_CLOUD_QA.hdr
Surface Reflectance Atmospheric Opacity file (1)	119,277	LT04_L2SP_023028_19821212_20200918_02_T1_SR_ATMOS_OPACITY.img
Surface Reflectance Atmospheric Opacity header file (1)	1	LT04_L2SP_023028_19821212_20200918_02_T1_SR_ATMOS_OPACITY.hdr
Radiometric Saturation QA file (1)	59,638	LT04_L2SP_023028_19821212_20200918_02_T1_QA_RADSAT.img
Radiometric Saturation QA header file (1)	1	LT04_L2SP_023028_19821212_20200918_02_T1_QA_RADSAT.hdr
Surface Temperature QA file (1)	118,699	LT04_L2SP_023028_19821212_20200918_02_T1_ST_QA.img
Surface Temperature QA header file (1)	1	LT04_L2SP_023028_19821212_20200918_02_T1_ST_QA.hdr
Surface Temperature Intermediate Bands file (7)	118,745	LT04_L2SP_023028_19821212_20200918_02_T1_ST_*.img

Description	Example File Size (Kbytes)	Example File Name
Surface Temperature Intermediate Bands header (7)	1	LT04_L2SP_023028_19821212_20200918_02_T1_ST_*.hdr
Pixel QA file (1)	59,638	LT04_L2SP_023028_19821212_20200918_02_T1_QA_PIXEL  .img
Pixel QA header file (1)	1	LT04_L2SP_023028_19821212_20200918_02_T1_QA_PIXEL.hdr
Metadata	24	LT04_L2SP_023028_19821212_20200918_02_T1.xml
Source Product MTL Metadata file (1)	8	LT04_L2SP_023028_19821212_20200918_02_T1_MTL.txt
Source Product XML Metadata file (1)	22	LT04_L2SP_023028_19821212_20200918_02_T1_MTL.xml
Angle Band Coefficients file (1)	115	LT04_L2SP_023028_19821212_20200918_02_T1_ANG.txt

Table key: TM Thematic Mapper, ETM+ Enhanced Thematic Mapper Plus, OLI Operational Land Imager, TIRS Thermal Infrared Sensor, HDF Hierarchical Data Format, SDS Science Data Set, IMG ENVI Binary Image Format, NA Not Applicable, TOA Top of Atmosphere, SR Surface Reflectance, QA Quality Assessment, XML Extensible Markup Language, HDR Header file format, BT Top of Atmosphere Brightness Temperature, CFMask C version Function of Mask

Table D-1. Landsat Binary File Characteristics for Collection 2

Appendix E Acronyms

AEA	Albers Equal Area
API	Application Programming Interface
AR	Aquatic Reflectance
ASTER GED	Advanced Spaceborne Thermal Emission and Reflection Radiometer Global Emissivity Dataset
BT	Brightness Temperature
C2	Collection 2
CCB	Configuration Control Board
CFMask	C version of Fmask
COG	Cloud Optimized GeoTIFF
CONUS	Conterminous United States
CR	Change Request
CSV	Comma Separated Values
EE	EarthExplorer
ENVI	Exelis Visual Information Solutions
EO	Earth Observation
EROS	Earth Resources Observation and Science
ESPA	EROS Science Processing Architecture
ET	Evapotranspiration
ETa	Actual Evapotranspiration
ETf	Evapotranspiration fraction
ETM+	Enhanced Thematic Mapper Plus
ETUN	Evapotranspiration Uncertainty
EVI	Enhanced Vegetation Index
Fmask	Function of Mask
GCOS	Global Climate Observing System
GDAL	Geospatial Data Abstraction Library
GeoTIFF	Georeferenced Tagged Image File Format
HDF	Hierarchical Data Format
HDF-EOS2	Hierarchical Data Format for Earth Observation Systems (version 2)
HDR	Header File
HTTPS	Hypertext Transfer Protocol Secure
JSON	JavaScript Object Notation
km	Kilometer
L1	Level 1
L2	Level 2
L2SP	Level 2 Science Product
L2SR	Level 2 Surface Reflectance
LaSRC	Land Surface Reflectance Code
LEDAPS	Landsat Ecosystem Disturbance Adaptive Processing System
LSDS	Land Satellites Data System
LST/E	Land Surface Temperature and Emissivity
m	Meter

MSAVI	Modified Soil Adjusted Vegetation Index
MSI	Multispectral Instrument
MTL	Metadata Text File Extension
NA	Not Applicable
NAD27	North American Datum 1927
NAD83	North American Datum 1983
NBR	Normalized Burn Ratio
NBR2	Normalized Burn Ratio 2
NC	NetCDF File Format
NDMI	Normalized Difference Moisture Index
NDSI	Normalized Difference Snow Index
NDVI	Normalized Difference Vegetation Index
NetCDF	Network Common Data Form
NIR	Near Infrared
ODI	On-Demand Interface
OLI	Operational Land Imager
PS	Polar Stereographic
QA	Quality Assessment
QC	Quality Control
RADSAT	Radiometric Saturation
REST	Representational State Transfer
RHORC	Rayleigh-corrected Reflectance
RT	Real Time
SAVI	Soil Adjusted Vegetation Index
SDS	Science Data Set
SR	Surface Reflectance
ST	Surface Temperature
SWIR	Shortwave Infrared
T1	Tier 1
T2	Tier 2
TIRS	Thermal Infrared Sensor
TM	Thematic Mapper
TOA	Top of Atmosphere
URL	Uniform Resource Locator
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
VI	Vegetation Index
WGS84	World Geodetic System 1984
XML	Extensible Markup Language

Appendix F Document Change History

Document Version	Publication Date	Change Description
1.0	11/11/2013	Initial Draft
1.1	12/01/2013	Revised after Peer Review
1.2	01/06/2013	Updated with DownThemAll network preference instruction
1.3	06/04/2014	Corrected link to SI Product Guide
1.4	06/26/2014	Modified system login details
2.0	07/29/2014	Added new output format and projection option descriptions
2.1	08/04/2014	Added file format characteristics and appendices.
2.2	08/27/2014	Added MODIS MOD/MYD09 & MOD/MYD13 input options, output files; GeoTIFF output files added; 'fmask' changed to 'cfmask' in file output.
2.3	10/10/2014	Split processing options into more subsections, Land Product Characterization System (LPCS) integration, statistics generation, ability to download only metadata, users must "Define Projection" before modifying image extent.
2.4	10/22/2014	Expanded descriptions of reprojection parameters, updated on-demand order page figure to include statistics generation.
2.5	12/23/2014	Updated "Customization Options" section to show that QA bands are always resampled with Nearest Neighbor. Addition of Landsat 8 products. Updated figures and text to reflect ESPA website updates. Added LPCS processing addition to ESPA.
2.6	03/25/2015	Added ESPA Bulk Download client information to "Download" section.
2.7	9/22/2015	Corrected URLs in document
2.8	10/19/2015	Changed number of days in Section 2.3; adjusted server limits in download plugin documentation and graphic
2.9	12/01/2015	Minor formatting and typo corrections.
3.0	12/16/2015	Added caveat for maximum pixel count per grid. Updated tables to indicate cloud mask (CFmask) ordering option for Landsat products.
3.1	03/01/2016	Added caveat for Intercomparison & Statistics generation – currently not supported for Landsat Level 1 products.
3.2	05/10/2016	Updated link for ESPA bulk download client.
3.3	07/01/2016	Added description of order status messages. Updated links to Land Surface Reflectance Code (LaSRC) Product Guide.
3.4	10/07/2016	Added API information, NetCDF output & corresponding graphics.
3.5	12/07/2016	Updated links to Landsat Missions Website

Document Version	Publication Date	Change Description
3.6	01/13/2017	Added TM/ETM+ Collection 1 information and examples. Updated incorrect graphic of ordering interface. Added note about per-order maximum pixel limit (200 million). Added Table caption to ESPA order status table. Noted that only C5 MODIS products are currently available.
3.7	01/18/2017	Addition of MODIS C6 products.
3.8	03/15/2017	Added OLI/TIRS Collection 1 information and examples. Added caveat stating that TIRS-only (LT8 or LT08) data cannot be run to Brightness Temperature.
3.9	03/31/2017	Addition of MODIS LST/E (MO/YD11A1) to description, appendix, etc. Addition of .tar.gz archive name examples for pre-collection Landsat, Collection 1 Landsat, and MODIS (Section 2.3.) Removed "Provisional" stats from all instances of LaSRC (C1 only.)
4.0	04/06/2017	Removal of Landsat pre-collection data. Added explanation of Real Time (RT) data, and how it may not be available if it is removed from L1 archive and processed to Tier 1 or 2. Moved TOA, BT and CFMask to separate section (they are not CDRs.) Added link to ECV webpage. Updated figures with most recent ESPA interface.
4.1	06/26/2017	Removed CFMask product option information and replaced with pixel_qa product option information. Added order cancellation information.
4.2	10/05/2017	Replaced the terms high-level and higher-level with science data products. Corrected various typos.
4.3	12/04/2017	Added "top of atmosphere" before "brightness temperature" to clarify that BT products are not atmospherically corrected.
4.4	03/13/2018	Removed reference to CDR/ ECV, update graphics. Removed DownThemAll references (Section 2.32, Figure 2.8)
4.5	07/25/2019	Added of MODIS /VIIRS NDVI processing capability.
Version 1.0 LSDS-1417	08/01/2019	Added Water-Leaving Reflectance information
Version 2.0 LSDS-1417	January 2020	Changed Water-Leaving Reflectance to Provisional Aquatic Reflectance.
Version 3.0 LSDS-1417	April 2020	Corrected Spectral Indices information link
Version 4.0 LSDS-1417	June 2020	Added the Provisional Actual Evapotranspiration science product
Version 5.0 LSDS-1417	March 2021	Removed outdated GitHub links, added relevant GOES-R ABI information
Version 6.0 LSDS-1417	May 2021	Added Landsat Collection 2 information
Version 7.0 LSDS-1417	October 2021	Added relevant Collection 2 NDSI information
Version 8.0 LSDS-1417	May 2022	Added relevant Landsat 9 Collection 2 information
Version 9.0 LSDS-1417	June 2022	Added relevant Collection 2 Aquatic Reflectance information
Version 10.0 LSDS-1417	August 2022	Added relevant information about Collection 2 Provisional Actual Evapotranspiration
Version 11.0 LSDS-1417	September 2022	Added MODIS Collection 6.1 information

Document Version	Publication Date	Change Description
Version 12.0 LSDS-1417	October 2022	Removed GOES-R ABI information (LPCS support discontinued)
Version 13.0 LSDS-1417	December 2022	Removed Landsat Collection 1 information
Version 14.0 LSDS-1417	May 2023	Added COG file format availability
Version 15.0 LSDS-1417	January 2024	Removed Intercomparison and Statistics information. Added QA RADSAT information
Version 16.0 LSDS-1417	September 2024	Removed MODIS and VIIRS information
Version 17.0 LSDS-1417	April 2025	Change default file format from GeoTIFF to COG
Version 18.0 LSDS-1417	January 2026	Remove Panchromatic Band from customized products output

References

Please see <https://www.usgs.gov/landsat-missions/landsat-acronyms> for a list of acronyms.

USGS/EROS. LSDS-1618. Landsat 4-7 Collection 2 Level 2 Science Product Guide <https://www.usgs.gov/media/files/landsat-4-7-collection-2-level-2-science-product-guide>

USGS/EROS. LSDS-1619. Landsat 8-9 Collection 2 Level 2 Science Product Guide <https://www.usgs.gov/media/files/landsat-8-9-collection-2-level-2-science-product-guide>

USGS/EROS. LSDS-2340. Landsat 8-9 Collection 2 Level 2 Provisional Aquatic Reflectance Product Guide <https://www.usgs.gov/media/files/landsat-8-9-collection-2-level-2-provisional-aquatic-reflectance-product-guide>

USGS/EROS. LSDS-2349 Landsat 4-9 Collection 2 Level 3 Provisional Actual Evapotranspiration Product Guide <https://www.usgs.gov/media/files/landsat-4-9-collection-2-level-3-provisional-actual-evapotranspiration-product-guide>