



Workshop 105 – Ballroom E

June 2024

Retrieval and Application of On Demand Global Field-scale Actual Evapotranspiration Data Since 1982

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Acquiring ET data from ESPA (EROS Science Processing Architecture) On Demand

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Acquiring Operational Simplified Surface Energy Balance (SSEBop) ET data from the ESPA On Demand Interface

Actual evapotranspiration (ET_a) modeling provides useful information for researchers and resource managers in agriculture and water resources around the world. The SSEBop model is currently used by the US Geological Survey (USGS) to routinely produce ET products using various remote sensing datasets. In part 2 we will look at what Landsat data is, demonstrate how to download ET data from ESPA (EROS Science Processing Architecture) using Landsat data as an input source, and how to create your own actual ET using a reference ET of your choice.

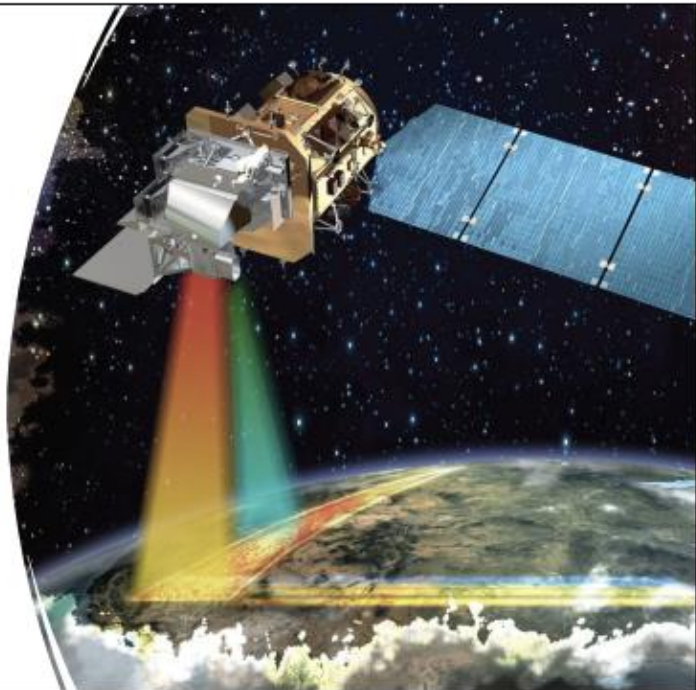
ESPA - EROS Science Processing Architecture On Demand

The screenshot shows the ESPA website interface. At the top left is the USGS logo with the tagline "science for a changing world". Below it is the title "EROS Science Processing Architecture On Demand Interface" and a navigation menu with "Home", "Product Information", and "User Guide". The main content area contains a notice about processing delays, a "USGS System Announcement" section with bullet points, and a "Login Required" button at the bottom.

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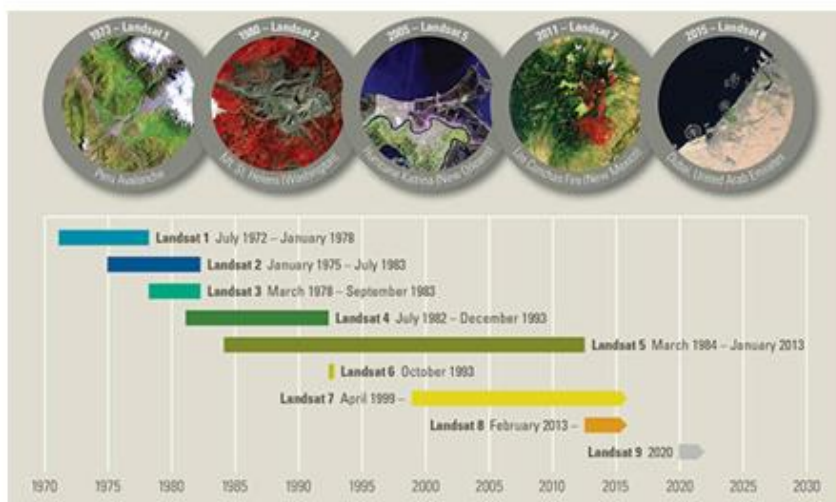
Landsat

Since 1972, Landsat satellites have continuously acquired images of the Earth's land surface, providing uninterrupted data to help land managers and policymakers make informed decisions about natural resources and the environment. Data acquired by Landsat satellites are distributed from the USGS Earth Resources Observation and Science (EROS) Center in Sioux Falls, South Dakota.



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Landsat data history



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Data is organized in collections:

- Collection 1

Original collection of all Landsat data (Landsat 1-7)


- Collection 2

Second major reprocessing effort on the Landsat archive; resulted in several data product improvements that applied advancements in data processing, algorithm development, and data access and distribution capabilities



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- Level-1 → data from Landsat 1-9, radiometrically calibrated and geometrically corrected using ground control points (GCPs) and digital elevation model (DEM) data to correct for relief displacement
 - Real-Time (RT) tier - available for download 4-6 hours after Level-1 product generation
 - Tier 1 (T1) - highest available data quality
 - Tier 2 (T2) - scenes not meeting Tier 1 criteria during processing are assigned to Tier 2 including less accurate orbital information (specific to older Landsat sensors), significant cloud cover, insufficient ground control, etc.
- Level-2 and Level 3 Science Products
- U.S. Analysis Ready Data
 - Level-1 data that are processed into Albers-projected Level-2 Surface Reflectance and Surface Temperature serve as inputs for generating U.S. ARD using an ARD tiling system.




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Level-2 Science Products

Level-2 Science Products are time-series observational data of sufficient length, consistency, and continuity to record effects of climate change, and serve as input into Landsat Level-3 Science Products.

Product	Collection
Landsat Surface Reflectance (Landsat 4-9, worldwide) <i>Measures the fraction of incoming solar radiation that is reflected from Earth's surface to the Landsat sensor</i>	2
Landsat Surface Temperature (Landsat 4-9, worldwide) <i>Represents the temperature of the Earth's surface in Kelvin (K)</i>	2
Landsat Surface Reflectance-Derived Spectral Indices (Landsat 4-9, worldwide) <i>Vegetation, moisture, burn ratio, and snow measurements data</i>	2
Provisional Aquatic Reflectance (Landsat 8-9, worldwide) <i>Measures the spectral distribution of visible solar-reflected radiation upwelling from the upper water column</i>	2



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Level-3 Science Products: Analysis Ready Data (ARD) Inputs

The following Level-3 science products represent biophysical properties of the Earth's surface and are generated from Landsat U.S. Analysis Ready Data (ARD) inputs.

Product	Collection
Dynamic Surface Water Extent (Landsat 4-9, Conterminous U.S., Alaska, Hawaii) <i>Describes the existence and condition of surface water</i>	2
Fractional Snow Covered Area (Landsat 4-9, northern and western Conterminous U.S., Alaska) <i>Indicates the percentage of a pixel covered by snow</i>	2
Burned Area (Landsat 4-8, Conterminous U.S.) <i>Represents per pixel burn classification and burn probability</i>	2

Level-3 Science Products: Scene-based Inputs

The following Level-3 science products are generated from Landsat Level-2 scene-based inputs.

Product	Collection
Provisional Actual Evapotranspiration (Landsat 4-9, Worldwide) <i>The quantity of water that is removed from a surface due to the processes of evaporation and transpiration</i>	2



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Standard Processing Parameters

All Landsat Collection 2 Level-2 products are produced by the Landsat Product Generation System (LPGS) using the following parameters:

- Georeferenced Tagged Image File Format (GeoTIFF)
- Cubic convolution (CC)
- Universal Transverse Mercator (UTM) map projection (Stereographic is used for scenes with a center latitude greater than or equal to -63.0 degrees)
- World Geodetic System (WGS) 84 datum
- MAP (North-up) image orientation



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Landsat Scene Properties

Landsat Product Identifier L2:
LC09_L2SP_168037_20230714_20230716_02_T1
Landsat Product Identifier L1:
LC09_L1TP_168037_20230714_20230714_02_T1
Landsat Scene Identifier: LC91680372023195LGN00
Date Acquired: 2023/07/14
Collection Category: T1
Collection Number: 2
WRS Path: 168
WRS Row: 037
Target WRS Path: 168
Target WRS Row: 037
Nadir/Off Nadir: NADIR
Roll Angle: 0.001

Date Product Generated L2: 2023/07/16
Date Product Generated L1: 2023/07/14
Start Time: 2023-07-14 07:32:57
Stop Time: 2023-07-14 07:33:29
Station Identifier: LGN
Day/Night Indicator: DAY
Land Cloud Cover: 0.00
Scene Cloud Cover L1: 0.00



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Ground Control Points Model: 333
Ground Control Points Version: 5
Geometric RMSE Model: 6.453
Geometric RMSE Model X: 4.728
Geometric RMSE Model Y: 4.391
Processing Software Version: LPGS_16.3.0
Sun Elevation L0RA: 66.57548678
Sun Azimuth L0RA: 113.44698551
TIRS SSM Model: N/A
Data Type L2: OLI_TIRS_L2SP
Sensor Identifier: OLI_TIRS
Satellite: 9
Product Map Projection L1: UTM
UTM Zone: 38
Datum: WGS84
Ellipsoid: WGS84

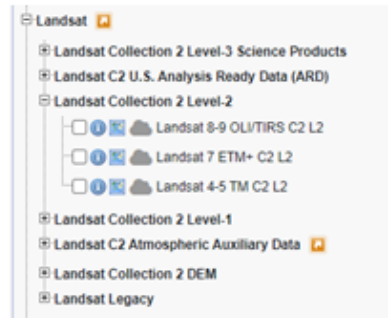
Scene Center Lat DMS: 33°10'37.31"N
Scene Center Long DMS: 45°02'51.97"E
CornerUpperLeftLat DMS: 34°13'21.58"N
CornerUpperLeftLongDMS: 43°47'45.56"E
CornerUpperRight Lat DMS: 34°13'18.16"N
CornerUpperRight Long DMS: 46°17'50.50"E
CornerLowerLeft Lat DMS: 32°06'34.92"N
CornerLowerLeft Long DMS: 43°49'28.31"E
CornerLowerRight Lat DMS: 32°06'31.75"N
CornerLowerRight Long DMS: 46°15'59.76"E
Scene Center Latitude: 33.17703
Scene Center Longitude: 45.04777
CornerUpperLeftLatitude: 34.22266
CornerUpperLeftLongitude: 43.79599
CornerUpperRight Latitude: 34.22171
CornerUpperRight Longitude: 46.29736
CornerLowerLeft Latitude: 32.10970
CornerLowerLeft Longitude: 43.82453
CornerLowerRight Latitude: 32.10882
CornerLowerRight Longitude: 46.26660



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Data Access

- Landsat Collection 2 Level-1 and Level-2 data are available for download from
 - [EarthExplorer](#)
 - [GloVis](#)
 - [LandsatLook Viewer](#)



The data are located under the Landsat category, Landsat Collection 2 Level-1/Level-2 subcategory, and listed as -Landsat 9, Landsat 8, Landsat 7, Landsat 4-5 TM, and Landsat 1-5 MSS datasets.

The EarthExplorer "Additional Criteria" tab for each Collection 2 dataset allows users to select parameters for each Landsat sensor (i.e., Landsat 7 SLC-on/SLC-off, T1/T2/RT, or RMSE range)



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Earth Explorer: EarthExplorer (EE) provides online search, browse display, metadata export, data download and processing support for earth science data from the Earth Resources Observation and Science (EROS) archives of the U.S. Geological Survey (USGS). EE provides an enhanced user interface 24 hours a day, seven days a week.

GloVis: Since 2001, the USGS Global Visualization Viewer (GloVis) has been available to users for accessing remote sensing data. In 2017, it was redesigned to address changing internet technologies. With easy-to-use navigation tools, users can instantly view and download scenes. This viewer allows you to:

- Use existing EROS Registration System (ERS) credentials to sign in
- Narrow down results by limiting your parameters on the Interface Control
- View multiple scenes at once and step through time using the controls in the lower right-hand corner
- View metadata and download the full-band source imagery
- Adjust settings to customize the user experience

LandsatLook: LandsatLook is a tool that allows rapid online viewing and access to the USGS Landsat Collection 2 data. LandsatLook leverages resources available via a commercial cloud environment including Cloud Optimized GeoTIFF (COG) and Spatio Temporal Asset Catalog (STAC) metadata.

Acquiring Landsat ET data from ESPA

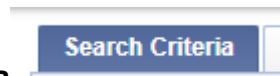
The EROS Science Processing Architecture On Demand Interface provides Landsat data to users at: <https://espa.cr.usgs.gov/index/>.

To get started with ordering data from this website, you need to know the associated Landsat scene ID or filename of the Landsat scene of interest. To obtain this information please visit the USGS EarthExplorer website at: <https://earthexplorer.usgs.gov/>

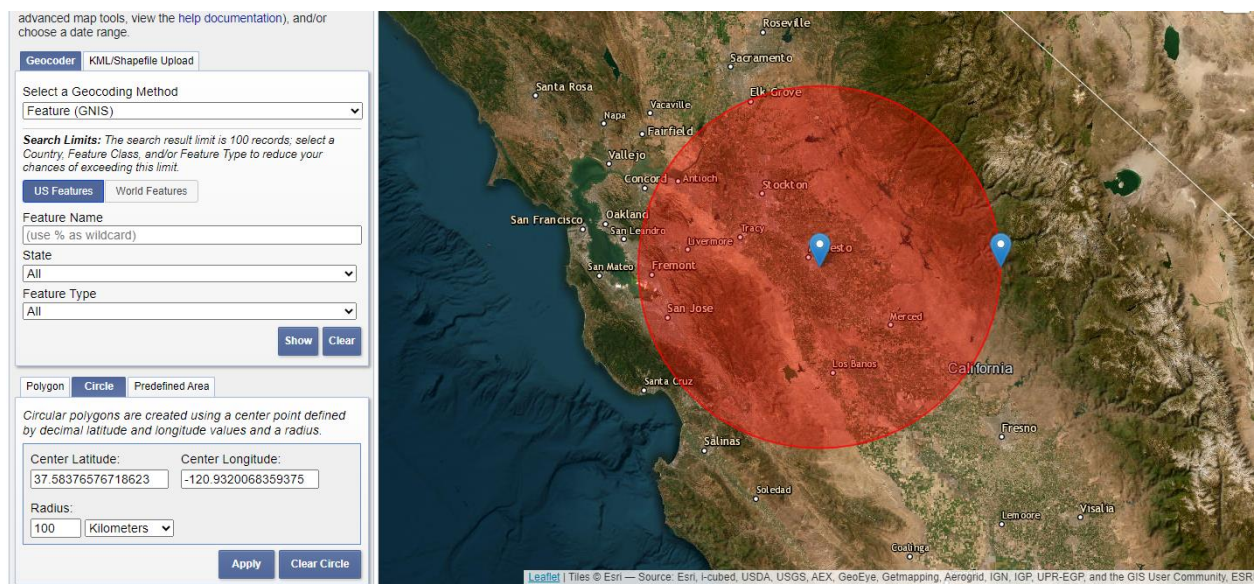
EarthExplorer is a web tool that allows you to search, query, and order earth science data from the USGS archives. A log-in with the EROS Registration System is required. Please log-in or create a new user account. You can register on the EarthExplorer Homepage by clicking 'Login' in the top right corner. Once logged in you will see your name in the top right corner:



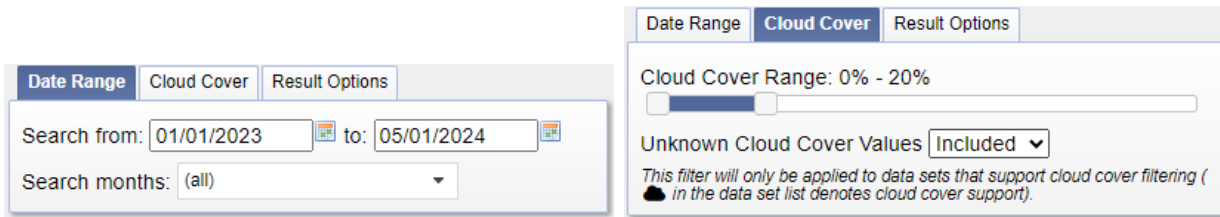
Now, let's search for some Landsat scenes. In this workshop we are working with 2 Landsat scenes around the Sacramento, CA area.



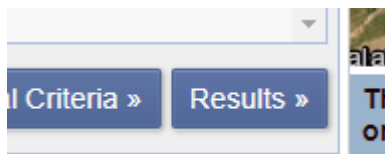
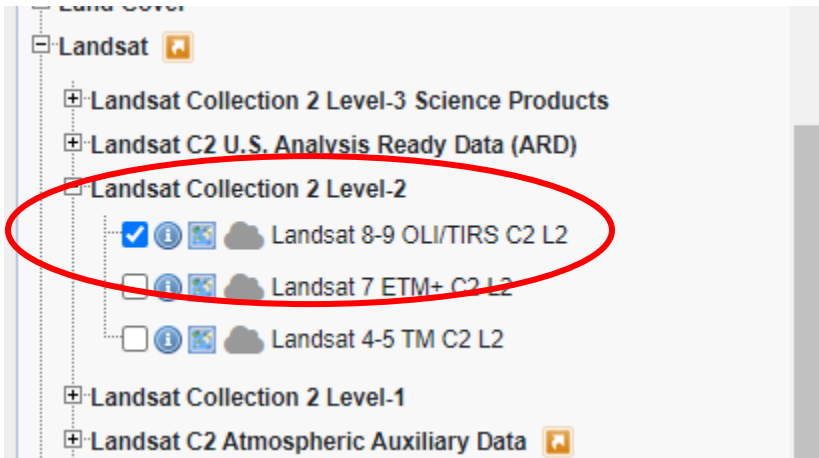
Under the **Search Criteria** tab, define your area of interest. Here we decided to use the Circle option to drop a pin in a location of interest and create a 100 km radius in which to search for data.



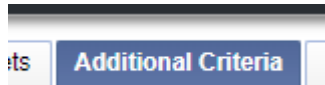
After that, define the **Date Range** and the **Cloud Cover** that you like to use in the Landsat scenes. These values change depending on the intended use of the data. In general, the Cloud Cover range can be set to 0%-20%.



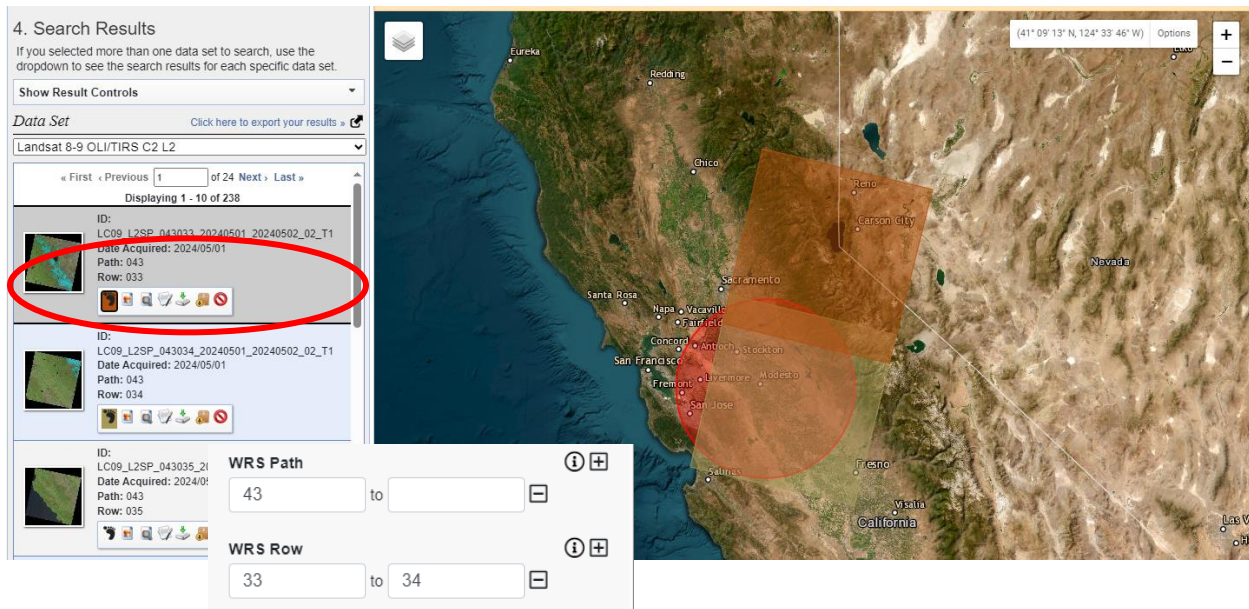
Next, we need to select what data we want to use with the **Data Sets** tab. Here we select Landsat Collection 2 Level-2.



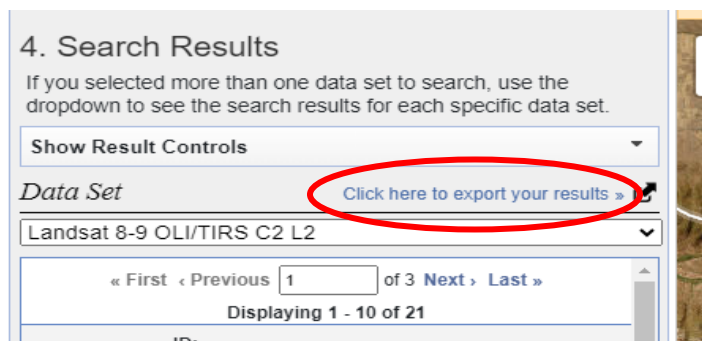
and hit **Results** and get 242 scenes that met the search criteria entered. To further limit the numbers of scenes we go back to the Additional



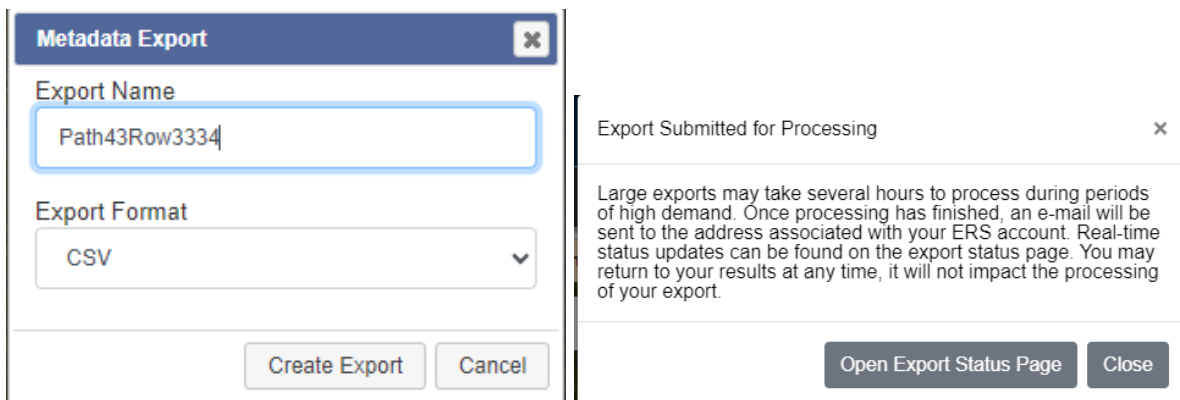
Criteria tab and select 2 Landsat scenes (locations) only: WRS path and row 43, 33 and 43, 34 in our example (see WRS Path and WRS Row screenshot below). The new selection has 63 Landsat scenes. The scene ID is provided as the first property of each scene in the result window.



To obtain all 63 scene IDs at once, we will use the **export your results** functionality. This allows us to export all the metadata for the scenes into a text file.



Click on the black arrow symbol. Enter a name and choose .csv for the Export Format. Click **Create Export**.



The metadata .csv file will be available on the **Export Status Page** and emailed to you which takes usually 10-15 minutes to show up in your inbox.

Your metadata export file is now available to download from <https://m2m.cr.usgs.gov/export/663a5c83e5c149ae/>.

This link will expire after 72 hours. If the file cannot be downloaded within this time frame, you will need to submit another export request. Please note: large exports can take several minutes to load in some software packages.


Export ID: 663a5c83e5c149ae


Export Type: CSV

Export Name: Path2627Row29

Status: Available

Click on the link to download the file to a location on your computer and unzip the folder

 [landsat_ot_c2_l2_667490a0fbd92aa.csv](#)

containing the csv file.  [landsat_ot_c2_l2_667490a0fbd92aa.zip](#)

In case the website is not available, the .csv file for this search is available at https://edcftp.cr.usgs.gov/project/SSEBop/WaterSciCon2024/Landsat_IDS/ for download.

Open the .csv file and copy the first column (excluding the text in the column header) named **Landsat Product Identifier L2** into a new text file. Here we named ours **landsat_product_ids.txt**. This new text file will be used by the ESPA website to download the ET data for the scenes selected in the next steps.

The screenshot shows an Excel spreadsheet with a table of Landsat product identifiers. The table has columns A through G. Column A is highlighted with a red box and contains the following product IDs (rows 2-28):

- LC09_L2SP_043033_20230123_20230313_02_T1
- LC09_L2SP_043034_20230123_20230313_02_T1
- LC08_L2SP_043033_20230131_20230208_02_T1
- LC08_L2SP_043034_20230131_20230208_02_T1
- LC09_L2SP_043033_20230208_20230311_02_T1
- LC09_L2SP_043034_20230208_20230311_02_T1
- LC08_L2SP_043033_20230405_20230412_02_T1
- LC08_L2SP_043034_20230405_20230412_02_T1
- LC09_L2SP_043033_20230413_20230415_02_T1
- LC09_L2SP_043034_20230413_20230415_02_T1
- LC09_L2SP_043033_20230429_20230501_02_T1
- LC09_L2SP_043034_20230429_20230501_02_T1
- LC09_L2SP_043033_20230515_20230517_02_T1
- LC09_L2SP_043034_20230515_20230517_02_T1
- LC09_L2SP_043033_20230531_20230602_02_T1
- LC09_L2SP_043034_20230531_20230602_02_T1
- LC09_L2SP_043033_20230616_20230618_02_T1
- LC09_L2SP_043034_20230616_20230618_02_T1
- LC09_L2SP_043033_20230702_20230704_02_T1
- LC09_L2SP_043034_20230702_20230704_02_T1
- LC08_L2SP_043033_20230710_20230718_02_T1
- LC08_L2SP_043034_20230710_20230718_02_T1
- LC09_L2SP_043033_20230718_20230720_02_T1
- LC09_L2SP_043034_20230718_20230720_02_T1
- LC08_L2SP_043033_20230726_20230805_02_T1
- LC08_L2SP_043034_20230726_20230805_02_T1
- LC09_L2SP_043033_20230803_20230805_02_T1

The Notepad window, titled 'landsat_product_ids.txt', contains the following text:

```

LC09_L2SP_043033_20230123_20230313_02_T1
LC09_L2SP_043034_20230123_20230313_02_T1
LC08_L2SP_043033_20230131_20230208_02_T1
LC08_L2SP_043034_20230131_20230208_02_T1
LC09_L2SP_043033_20230208_20230311_02_T1
LC09_L2SP_043034_20230208_20230311_02_T1
LC08_L2SP_043033_20230405_20230412_02_T1
LC08_L2SP_043034_20230405_20230412_02_T1
LC09_L2SP_043033_20230413_20230415_02_T1
LC09_L2SP_043034_20230413_20230415_02_T1
LC09_L2SP_043033_20230429_20230501_02_T1
LC09_L2SP_043034_20230429_20230501_02_T1
LC09_L2SP_043033_20230515_20230517_02_T1
LC09_L2SP_043034_20230515_20230517_02_T1
LC09_L2SP_043033_20230531_20230602_02_T1
LC09_L2SP_043034_20230531_20230602_02_T1
LC09_L2SP_043033_20230616_20230618_02_T1
LC09_L2SP_043034_20230616_20230618_02_T1
LC09_L2SP_043033_20230702_20230704_02_T1
LC09_L2SP_043034_20230702_20230704_02_T1
LC08_L2SP_043033_20230710_20230718_02_T1
LC08_L2SP_043034_20230710_20230718_02_T1
LC09_L2SP_043033_20230718_20230720_02_T1
LC09_L2SP_043034_20230718_20230720_02_T1
LC08_L2SP_043033_20230726_20230805_02_T1
LC08_L2SP_043034_20230726_20230805_02_T1
LC09_L2SP_043033_20230803_20230805_02_T1
LC09_L2SP_043034_20230803_20230805_02_T1
LC09_L2SP_043033_20230811_20230818_02_T1
LC09_L2SP_043034_20230811_20230818_02_T1
LC09_L2SP_043033_20230819_20230821_02_T1
LC09_L2SP_043034_20230819_20230821_02_T1
LC08_L2SP_043033_20230827_20230905_02_T1
LC08_L2SP_043034_20230827_20230905_02_T1
LC09_L2SP_043033_20230904_20230906_02_T1
LC09_L2SP_043034_20230904_20230906_02_T1
LC08_L2SP_043033_20230912_20230918_02_T1
LC08_L2SP_043034_20230912_20230918_02_T1

```

Alternative option: If you just need a few scenes or prefer to hand select scenes, you can copy the ID from the EarthExplorer search results directly into a text file.

Once you have the landsat_product_ids.txt file you can visit the ESPA website at <https://espa.cr.usgs.gov/index/> to download the ET data.

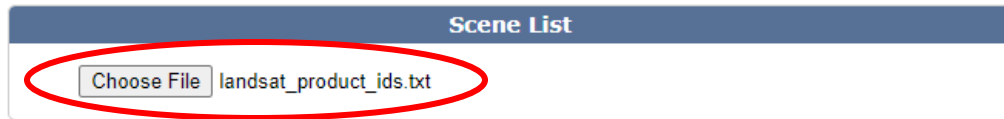
At the bottom of the ESPA Homepage there are 2 options:

Current Offerings

Bulk Ordering	Bulk Ordering API
<p>Bulk ordering allows a list of Landsat scenes to be submitted for additional processing beyond what is available through the standard Landsat Level-1 processing.</p> <p>This is the primary mechanism to gain access to LSRD's provisional and prototype data products.</p>	<p>The API enables end-users to write their own clients to interact with all Bulk Ordering capabilities.</p> <p>The Bulk Ordering API is implemented as a REST service using HTTP and JSON and is accessible from most programming languages.</p>
Order Data	Access API Information

We will use the left one called **Bulk Ordering**. Click on **Order Data** to start the ordering process. Here we'll enter all the information needed to download ET data. Under "Add Input Products", select the txt file we just created.

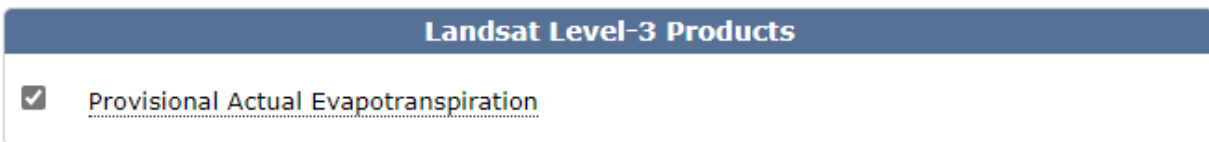
Add Input Products ([Show Available Products](#))



Scene List

landsat_product_ids.txt

Next, select the **Provisional Actual Evapotranspiration** product.

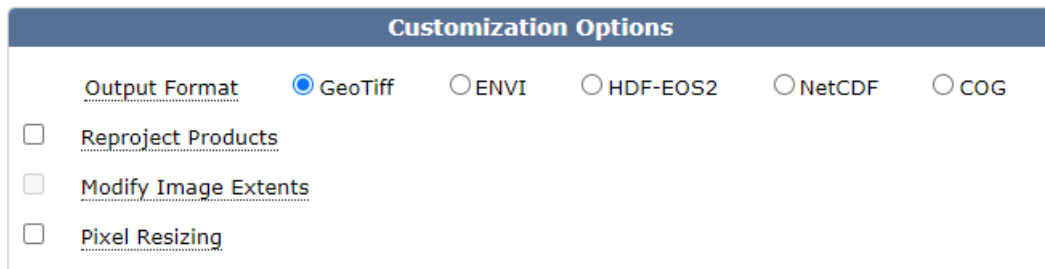


Landsat Level-3 Products

Provisional Actual Evapotranspiration

Lastly, pick an output format. For this training we selected **GeoTiff**.

Customize Outputs



Customization Options

Output Format GeoTiff ENVI HDF-EOS2 NetCDF COG

Reproject Products

Modify Image Extents

Pixel Resizing

Leave all other default settings and hit the **Submit** button at the bottom of the page.

Order submitted successfully! Your OrderId is espa-skagone@contractor.usgs.gov-05172024-095136-799

Requested: 63	Completed: 0	Open: 63	Waiting on data: 0
Order: espa-skagone@contractor.usgs.gov-05172024-095136-799		Date Ordered: 2024-05-17 09:51:36.799289	
Status: ordered		Date Completed: None	
Requested Processing: Output Format is geotiff			
Products by sensor: olitirs8_collection_2_I2: evapotranspiration , olitirs9_collection_2_I2: evapotranspiration ,			
The ESPA Bulk Downloader is available HERE		<input type="button" value="Show JSON"/>	<input type="button" value="CANCEL"/>

Product	Status	Product URL	Chksum URL	Note
LC08_L2SP_043034_20240407_20240418_02_T1	oncache			None
LC08_L2SP_043034_20240322_20240403_02_T1	oncache			None
LC08_L2SP_043033_20240322_20240403_02_T1	oncache			None

The following window will appear. It has information such as your order number, how many scenes were ordered, etc.

Product	Status	Product URL	Chksum URL	Note
48801682 - LC08_L2SP_150031_20220923_20220929_02_T1	oncache			None

We are interested in the **Status** of the order. At the beginning it's listed as **oncache** and will change to **Download** once the order is processed at the EROS Center. Therefore, please refresh the page for the status to update. This will take different amounts of time for each order, depending on the number of scenes ordered, etc. This order took about 15 minutes to complete. The next step is to download the desired scene(s).

1) Manual Download option:

We selected 1 scene for demonstration in this document.

LC09_L2SP_043034_20230208_20230311_02_T1 (file name:
LC090270292023053102T1-SC20240507180704.tar.gz)

Product	Status	Product URL	Chksum URL	Note
LC09_L2SP_043034_20230208_20230311_02_T1	complete	Download	Checksum	None

Click on the **Download** link in the Status field and save the files to your folder. Unzip the files. The following files are included in the zip folder:

-  LC090430342023020802T1-SC20240517145728.tar.gz
-  LC090430342023020802T1-SC20240517145728.tar
-  LC09_L2SP_043034_20230208_20230311_02_T1_QA_RADSAT.tif
-  LC09_L2SP_043034_20230208_20230311_02_T1_QA_PIXEL.tif
-  LC09_L2SP_043034_20230208_20230311_02_T1_MTL.xml
-  LC09_L2SP_043034_20230208_20230311_02_T1_MTL.txt
-  LC09_L2SP_043034_20230208_20230311_02_T1_ETUN.tif
-  LC09_L2SP_043034_20230208_20230311_02_T1 ETF.tif
-  LC09_L2SP_043034_20230208_20230311_02_T1 ETA.tif
-  LC09_L2SP_043034_20230208_20230311_02_T1_ANG.txt
-  LC09_L2SP_043034_20230208_20230311_02_T1.xml

A product description for each file can be found at <https://www.usgs.gov/landsat-missions/landsat-collection-2-provisional-actual-evapotranspiration-science-product> and includes the following information:

Package Contents

C2 Provisional ETa products are generated at the 30-meter spatial resolution. C2 Provisional ETa packages contain the following files:

Actual Evapotranspiration (ETA): Provides a per-pixel estimate of daily water transfer from the Earth's surface to the atmosphere in units of water depth in millimeters (mm).

ET fraction (ETF): Represents unitless fraction of ETr, nominally varying between 0 and 1 (in SSEBop model the maximum ET fraction is 1.0). This can be used in combination with user provided reference ET (ETr) to create a more accurate ETa which considers local weather conditions.

ET Uncertainty (ETUN): Provides ET product uncertainty in units of water depth (mm) using the ETr auxiliary data.

Level 2 Pixel Quality Assessment (QA_PIXEL): The bit combinations that define certain quality conditions. More information about Pixel Quality Assessment can be found in the [Landsat 4-7 Collection 2 Level 2 Science Product Guide](#) and [Landsat 8-9 Collection 2 Level 2 Science Product Guide](#).

Metadata: Includes Actual Evapotranspiration Landsat scene information in XML format (Product_ID.xml) and Level-1 metadata in.txt and XML format.

2) Bulk Download option:

The ESPA website also offers a bulk download option where data can be downloaded by order number. To navigate to the bulk downloader click on the [**HERE**](#) link located above the list of scenes.

The ESPA Bulk Downloader is available [HERE](#)

This will redirect you to a code repository named “bulk-downloader”. Now there are different options on how to install and use the tool:

- Install with pip automatically:

```
pip install git+https://code.usgs.gov/espa/bulk-downloader.git
download_espa_order.py -h
```

- Clone this repository:

```
git clone https://code.usgs.gov/espa/bulk-downloader.git bulk-downloader
cd bulk-downloader
python ./download_espa_order.py -h
```

- [download the stand alone zip](#) file which only requires python (and request library) to run. The link will initiate the download of zip file. Save the file to your system when prompted. Don't forget to unzip the folder.

Once you've used any of the above methods to download the tool, the next step is to make a python environment to execute the tool. Use Anaconda, miniforge, or another application of your choice to create an environment including Python and the request library.

```
(base) C:\>conda create --name bulk_dl_espa
Channels:
- conda-forge
Platform: win-64
Collecting package metadata (repodata.json): done
Solving environment: done

## Package Plan ##

environment location: C:\Users\... \AppData\Local\miniforge3\envs\bulk_dl_espa
```

```
(base) C:\>conda activate bulk_dl_espa
```

```
(bulk_dl_espa) C:\Users>cd ... \scenes\bulk-downloader-master
(bulk_dl_espa) C:\Users\... \scenes\bulk-downloader-master>
```

python download_espa_order.py -d C:\Users\...\scenes -u *username*

```
(bulk_dl_espa) C:\Users\... \scenes\bulk-downloader-master>python download_espa_order.py -d C:\Users\... \scenes -u
C:\Users\... \scenes\bulk-downloader-master\download_espa_order.py:237: SyntaxWarning: invalid escape sequence '\p'
'Windows: C:\python36\python download_espa_order.py -e your_email@server.com -o ALL -d C:\some\directory\with\free\
space'
Password:
2024-05-17 10:32:48,884| File 1 of 63 for order: espa-skagone@contractor.usgs.gov-05172024-095136-799
2024-05-17 10:32:56,864| File 2 of 63 for order: espa-skagone@contractor.usgs.gov-05172024-095136-799
2024-05-17 10:33:04,745| File 3 of 63 for order: espa-skagone@contractor.usgs.gov-05172024-095136-799
2024-05-17 10:43:26,529| File 60 of 63 for order: espa-skagone@contractor.usgs.gov-05172024-095136-799
2024-05-17 10:43:34,859| File 61 of 63 for order: espa-skagone@contractor.usgs.gov-05172024-095136-799
2024-05-17 10:43:49,520| File 62 of 63 for order: espa-skagone@contractor.usgs.gov-05172024-095136-799
2024-05-17 10:43:57,136| File 63 of 63 for order: espa-skagone@contractor.usgs.gov-05172024-095136-799
```

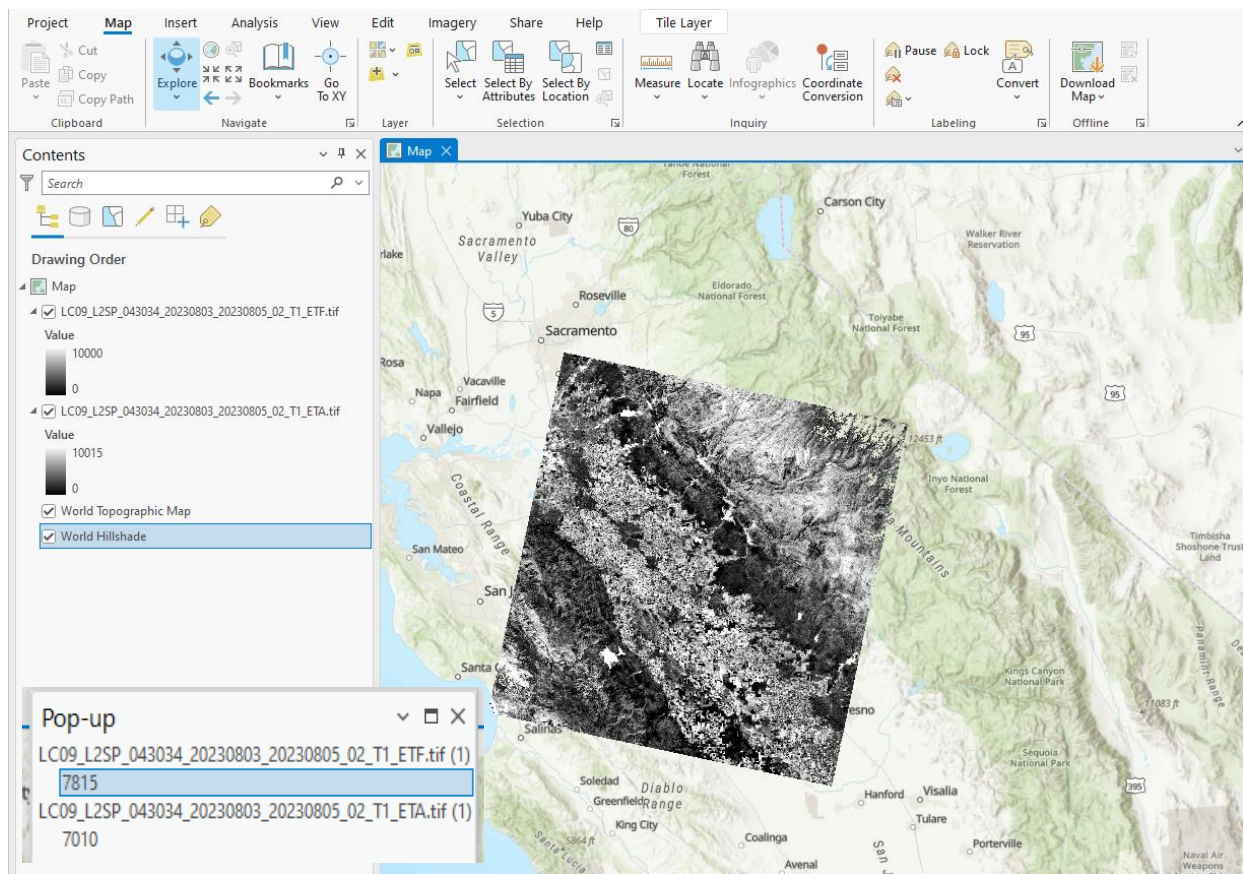
The username is the same as created at the beginning for the Earth Explorer application.

Landsat ET data

The ETa data is provided as a raster in GeoTiff format. Let's take a look at the one Landsat scene for Central Valley, California.

To examine the ET files further let's open them using an GIS software. For this document we chose ArcPro to visualize the ET raster files.

Open the ArcPro application and **Add** the files for August 03 2023 **LC09_L2SP_043034_20230803_20230805_02_T1_ETF.tif** and **LC09_L2SP_043034_20230803_20230805_02_T1_ETA.tif**.



The files are displayed with a black-white color ramp (low to high values respectively). In this example (random pixel), the ETf = 7815 and ETa = 7010. Those values are representing a scaled value. For the ETf raster as a fraction and for the ETa in millimeter (mm). To get the actual fraction for ETf, multiply the value * 0.0001 = ETf fraction, and the ETa as value * 0.001 = value in mm. This information can also be found at the end of the **metadata file LC09_L2SP_043034_20230803_20230805_02_T1.xml**.

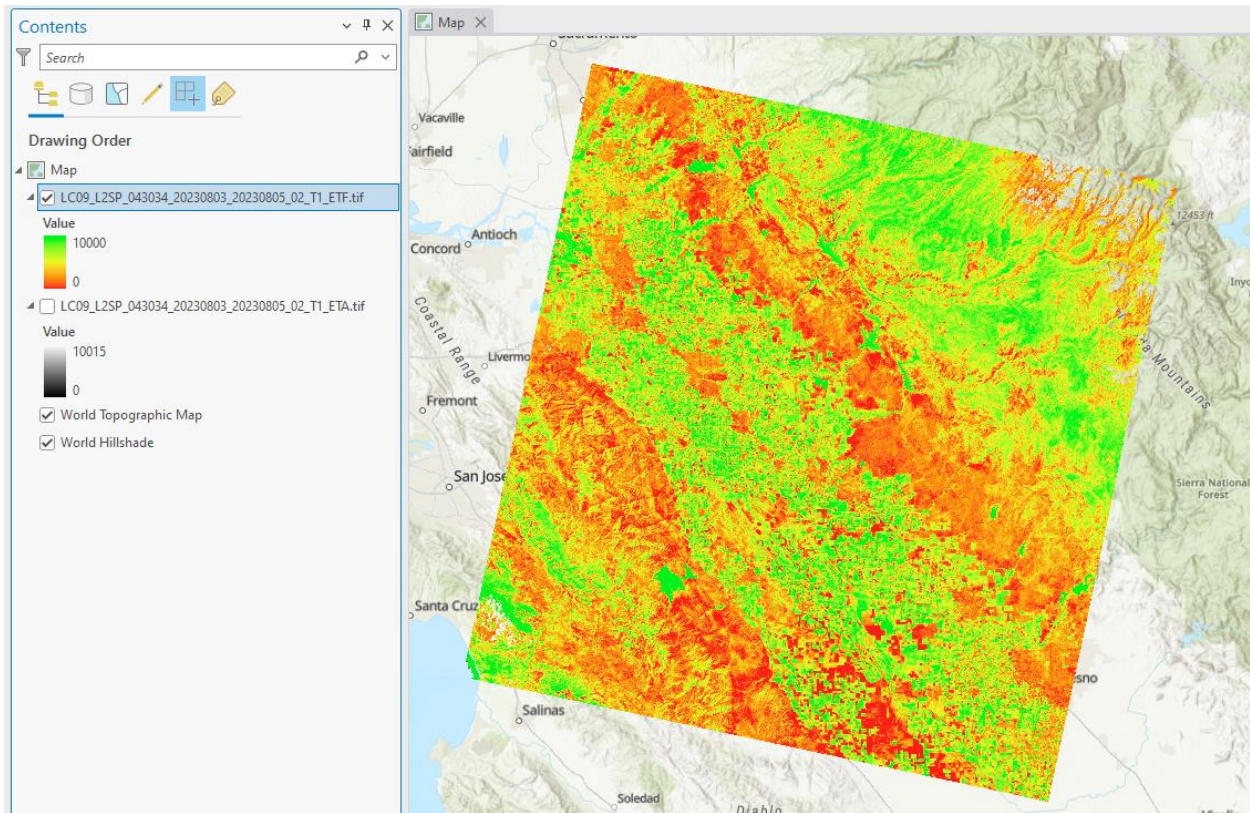
```

<band product="evapotranspiration" source="sr_refl" name="ETF" category="image"
data_type="INT16" nlines="7721" nsamps="7591" fill_value="-9999"
scale_factor="0.00010000">
  <short_name>LC09ETF</short_name>
  <long_name>Evapotranspiration fraction</long_name>
  <file_name> LC09_L2SP_043034_20230803_20230805_02_T1_ETF.tif </file_name>
  <pixel_size x="30" y="30" units="meters"/>
  <resample_method>none</resample_method>
  <data_units>unitless</data_units>
  <valid_range min="0.000000" max="10000.000000"/>
  <app_version>et_3.1.0 (Collection 2)</app_version>
  <production_date>2024-05-17T15:03:30Z</production_date>
</band>
<band product="evapotranspiration" source="sr_refl" name="ETA" category="image"
data_type="INT16" nlines="7721" nsamps="7591" fill_value="-9999"
scale_factor="0.00100000">
  <short_name>LC09ETA</short_name>
  <long_name>Evapotranspiration actual</long_name>
  <file_name> LC09_L2SP_043034_20230803_20230805_02_T1_ETA.tif </file_name>
  <pixel_size x="30" y="30" units="meters"/>
  <resample_method>none</resample_method>
  <data_units>mm</data_units>
  <valid_range min="0.000000" max="20000.000000"/>
  <app_version>et_3.1.0 (Collection 2)</app_version>
  <production_date>2024-05-17T15:03:30Z</production_date>
</band>

```

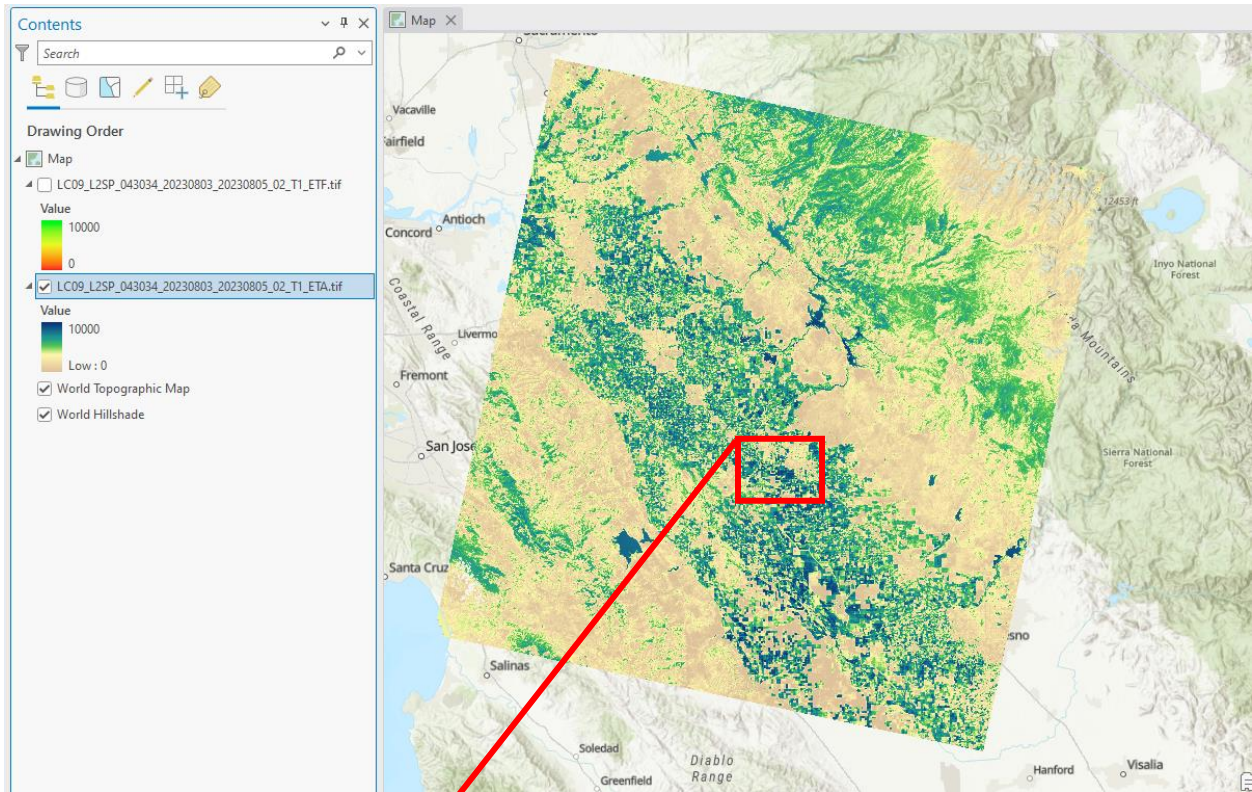
Next, **change the color ramp** to red-to-green for ETf and brown-to-green for ETa.

Let's take a look at the ET fraction (ETf):



The red colored pixels represent a low ETf value while green areas are high ETf value pixels.

On the other hand, ETa looks like this with darker (blue) pixels representing high ET values and lighter (brown) areas indicating lower ETa values:



And a zoomed in view:



The ET_a that is available for download is created by multiplying the ET_f as following:



The reference ET data used can be obtained from the [USGS ScienceBase website](https://www.usgs.gov/sciencebase). The citation is as follows:

Schauer, M.P., Senay, G.B., and Kagone, S., 2022, High Resolution Daily Global Alfalfa-Reference Potential Evapotranspiration Climatology: U.S. Geological Survey data release, <https://doi.org/10.5066/P9R877Q8>.

We also provided the reference ET data set in the workshop materials (https://edcftp.cr.usgs.gov/project/SSEBop/WaterSciCon2024/Reference_ET/) for your convenience.

Following, we are going to explore the Python code on how to create different aggregations of the ET data for water resource monitoring. The document is named *3_Creating suitable data for water resources applications.pdf*.