

Utah As Art – Basic Map Making Tutorial

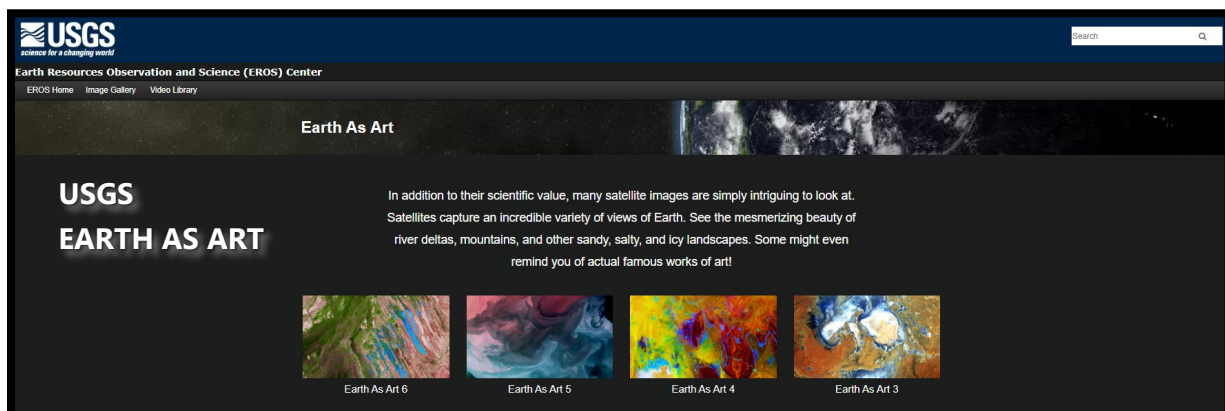
UtahView, Remote Sensing/GIS Laboratory, Utah State University

USGS AmericaView Grant/Cooperative Agreement G18AP00077

by Ellie Leydsman McGinty, UtahView State Coordinator

Overview

The *Utah As Art* map series is a localized version of the USGS *Earth As Art* program (<https://eros.usgs.gov/image-gallery/earth-art>). The goal of this map series is to display the diverse beauty of the state of Utah, to visualize the geography and natural resources in the state, and to demonstrate one of the many values of satellite imagery. While the maps from the *Utah As Art* map series have been developed using advanced cartographic tools and techniques, basic maps and images can be developed and designed by students. This tutorial will describe in detail how to download, process, and display satellite imagery so students may create their own maps and develop a better understanding of Utah's landscape. For this tutorial, students will need access to Esri ArcGIS.

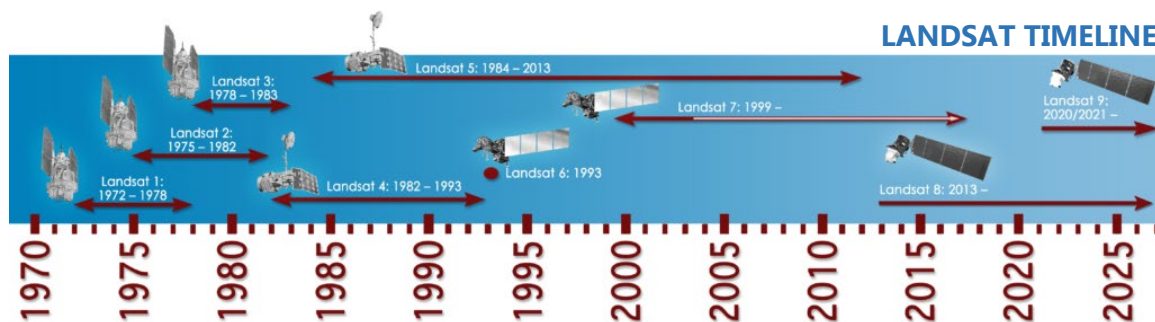


The screenshot shows the USGS Earth As Art website. At the top left is the USGS logo with the tagline "science for a changing world". Below it is the text "Earth Resources Observation and Science (EROS) Center" and navigation links for "EROS Home", "Image Gallery", and "Video Library". A search bar is located at the top right. The main heading is "Earth As Art" with a background image of Earth from space. Below this, the text reads: "USGS EARTH AS ART. In addition to their scientific value, many satellite images are simply intriguing to look at. Satellites capture an incredible variety of views of Earth. See the mesmerizing beauty of river deltas, mountains, and other sandy, salty, and icy landscapes. Some might even remind you of actual famous works of art!". At the bottom, there are four small thumbnail images labeled "Earth As Art 6", "Earth As Art 5", "Earth As Art 4", and "Earth As Art 3".

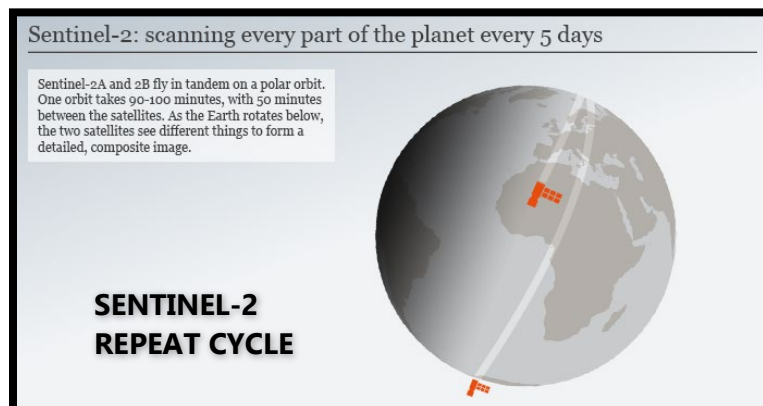


Utah As Art maps are made using Landsat and Sentinel satellite imagery. The Landsat Program is jointly administered by National Aeronautics and Space Administration (NASA) and United States Geological Survey (USGS). The Sentinel program is administered by the European Space Agency (ESA). Both types of satellite imagery are in the public domain and are freely available for download.

The Landsat Program (<https://landsat.gsfc.nasa.gov/>) is a series of Earth-observing satellite missions. The first Landsat mission, Earth Resources Technology Satellite, was launched in 1972. Subsequent satellites were launched in the following decades. Landsat 7, launched in 1999, and Landsat 8, launched in 2013, are currently in orbit and collecting imagery. The Landsat Program provides the longest continuous space-based record (1972-present) of the Earth. Landsat 8 orbits the Earth every 99 minutes at an altitude of 705 kilometers (438 miles). The satellite has a 16-day repeat cycle. The sensor acquires a minimum of 400 new scenes every day. Each Landsat 8 scene or image is roughly 185 kilometers (115 miles) wide by 170 kilometers (106 miles) tall. The ground resolution (i.e. how much distance each pixel represents on Earth) is generally 30 meters.



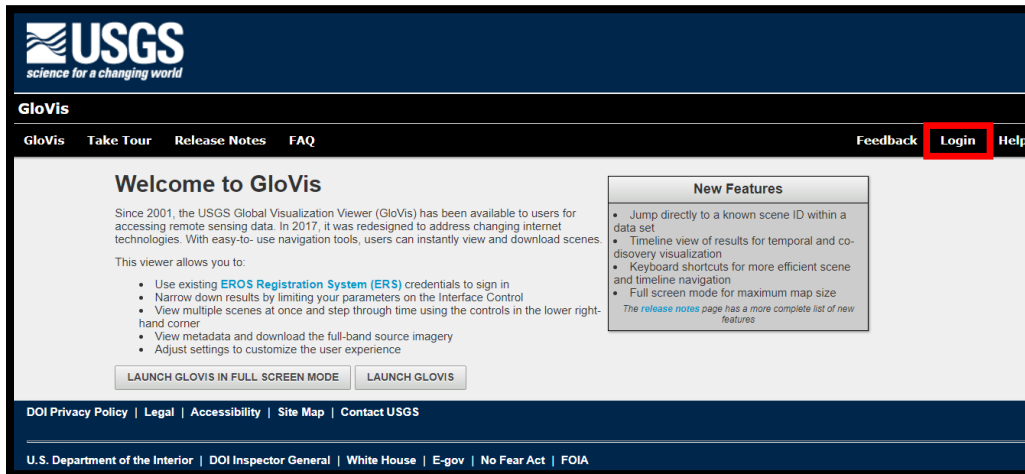
The Sentinel Program (<https://sentinel.esa.int/web/sentinel/missions>) is a series of next-generation Earth observation missions that focus on different aspects of Earth observation, including atmospheric, oceanic, and land monitoring. Sentinel-2, which is used for *Utah As Art* maps, was launched in June 2015 with the goal of monitoring the variability in land surface conditions. Sentinel-2 orbits the Earth every 100 minutes at an altitude of 786 kilometers (488 miles). The repeat cycle is 10 days with one satellite and 5 days with two satellites. The swath width of Sentinel-2 is 290 kilometers (180 miles). The ground resolution, depending on the channel or band, ranges from 10 meters to 60 meters.



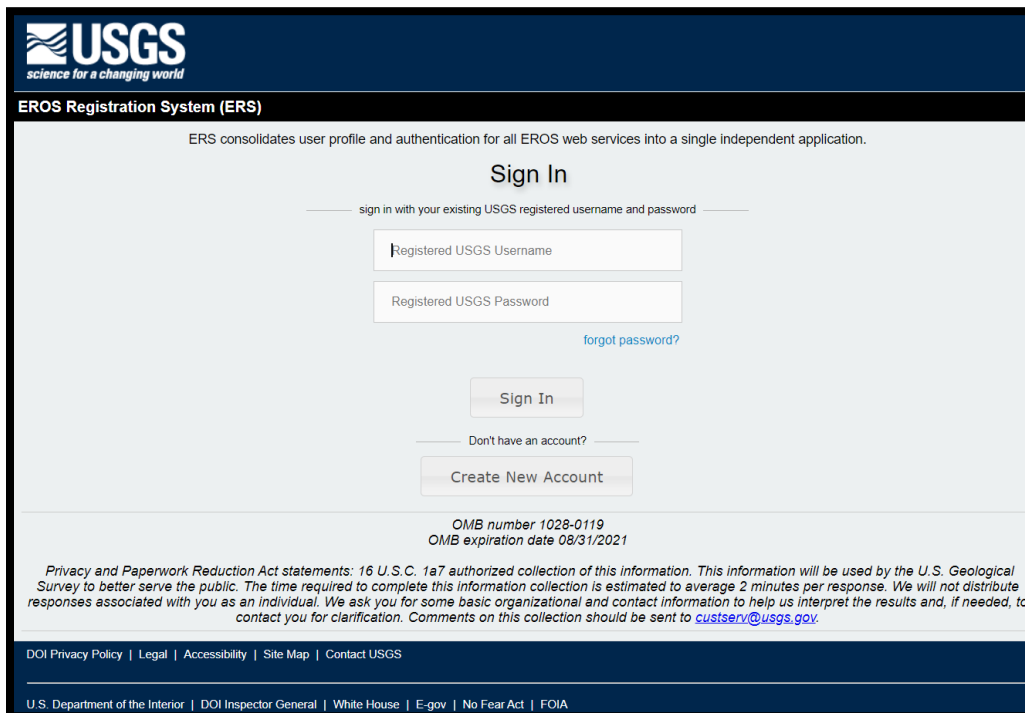
Imagery Download

Landsat and Sentinel-2 imagery are available for download from USGS Earth Explorer (<https://earthexplorer.usgs.gov/>), GloVis (<https://glovis.usgs.gov/>), or LandsatLook Viewer (<https://landsatlook.usgs.gov/>). For this tutorial, you will use GloVis to access and download a Landsat 8 image.

1. Go to **Glovis** (<https://glovis.usgs.gov/>).
2. Click on **Login** to either login to an existing account or to create a new account.

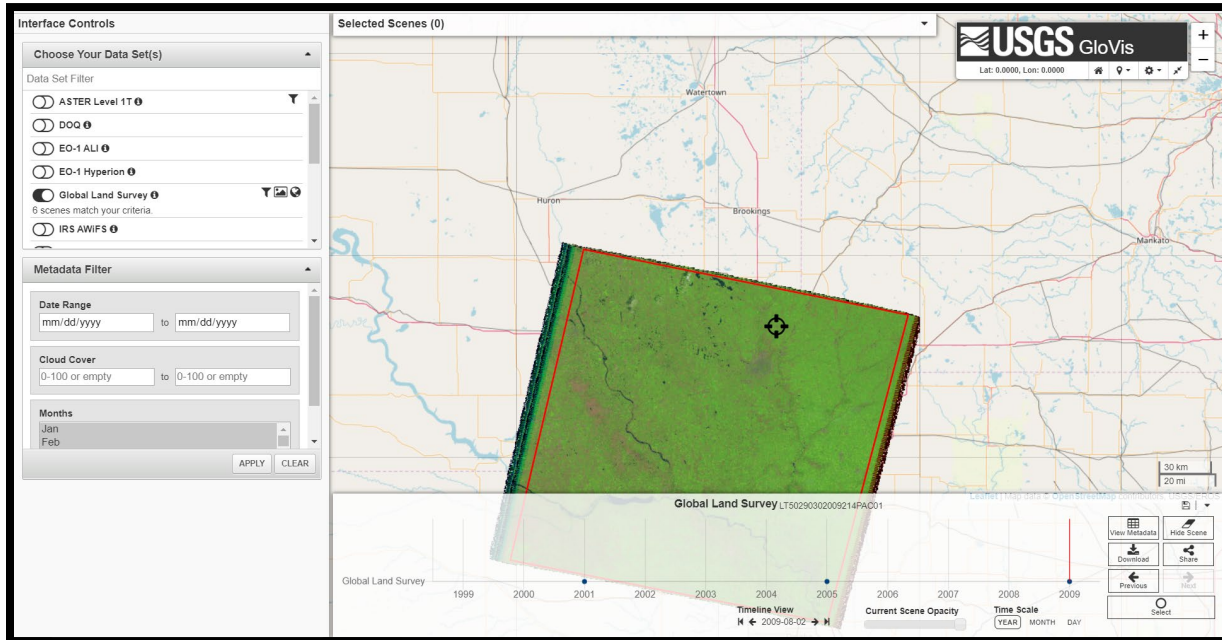


The screenshot shows the USGS GloVis homepage. At the top left is the USGS logo with the tagline "science for a changing world". Below the logo is the "GloVis" header. A navigation bar contains links for "GloVis", "Take Tour", "Release Notes", "FAQ", "Feedback", "Login" (highlighted with a red box), and "Help". The main content area features a "Welcome to GloVis" section with introductory text and a list of capabilities: using EROS Registration System (ERS) credentials, narrowing results, viewing multiple scenes, viewing metadata, and adjusting settings. Below this are two buttons: "LAUNCH GLOVIS IN FULL SCREEN MODE" and "LAUNCH GLOVIS". To the right is a "New Features" box listing updates like direct scene ID access, timeline views, keyboard shortcuts, and full screen mode. The footer includes links for "DOI Privacy Policy", "Legal", "Accessibility", "Site Map", and "Contact USGS", along with "U.S. Department of the Interior | DOI Inspector General | White House | E-gov | No Fear Act | FOIA".



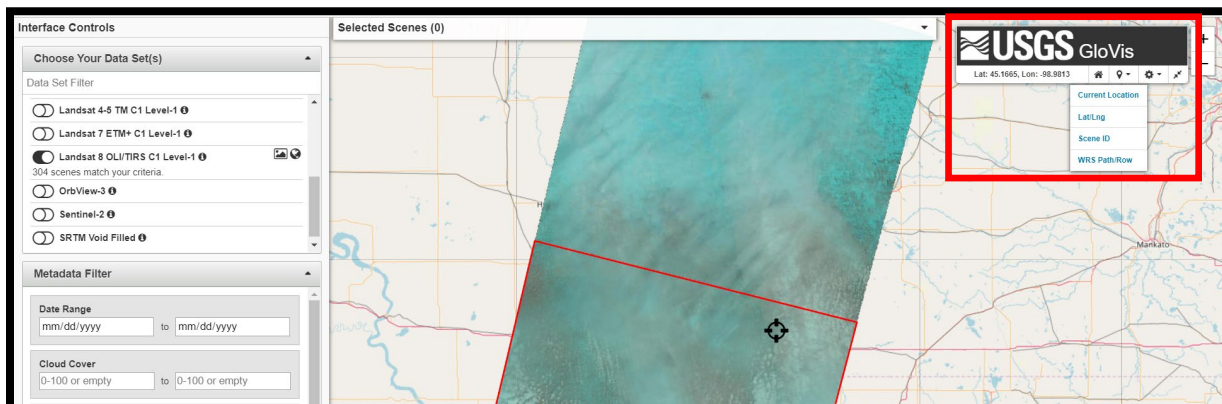
The screenshot shows the "EROS Registration System (ERS)" sign-in page. The USGS logo is at the top left. The page title is "EROS Registration System (ERS)". Below the title, it states: "ERS consolidates user profile and authentication for all EROS web services into a single independent application." The main heading is "Sign In". A sub-heading reads: "sign in with your existing USGS registered username and password". There are two input fields: "Registered USGS Username" and "Registered USGS Password". A "forgot password?" link is located below the password field. A "Sign In" button is centered below the fields. Below the button is a "Don't have an account?" link and a "Create New Account" button. At the bottom, it displays "OMB number 1028-0119" and "OMB expiration date 08/31/2021". A privacy statement follows: "Privacy and Paperwork Reduction Act statements: 16 U.S.C. 1a7 authorized collection of this information. This information will be used by the U.S. Geological Survey to better serve the public. The time required to complete this information collection is estimated to average 2 minutes per response. We will not distribute responses associated with you as an individual. We ask you for some basic organizational and contact information to help us interpret the results and, if needed, to contact you for clarification. Comments on this collection should be sent to custsenr@usgs.gov." The footer includes links for "DOI Privacy Policy", "Legal", "Accessibility", "Site Map", and "Contact USGS", along with "U.S. Department of the Interior | DOI Inspector General | White House | E-gov | No Fear Act | FOIA".

3. After you have created an account and/or logged in to an account, you can now start exploring images that you would like to download for a map. The default image selection is **Global Land Survey** and the default geographic location is **Sioux Falls, South Dakota** (i.e. the location of the USGS Earth Resources Observation and Science Center).

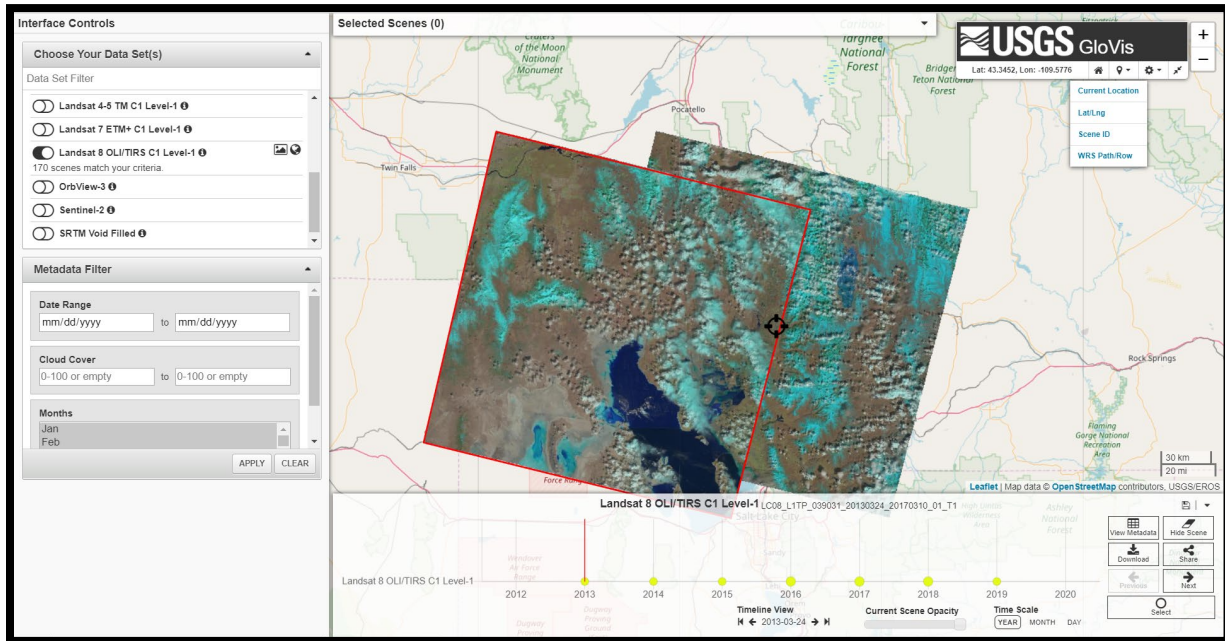


4. Under **Choose Your Data Set(s)**, scroll down to **Landsat 8 OLI/TIRS C1 Level-1** and click on the button to the left. You will now see a Landsat 8 image for the area spanning Sioux Falls, South Dakota.

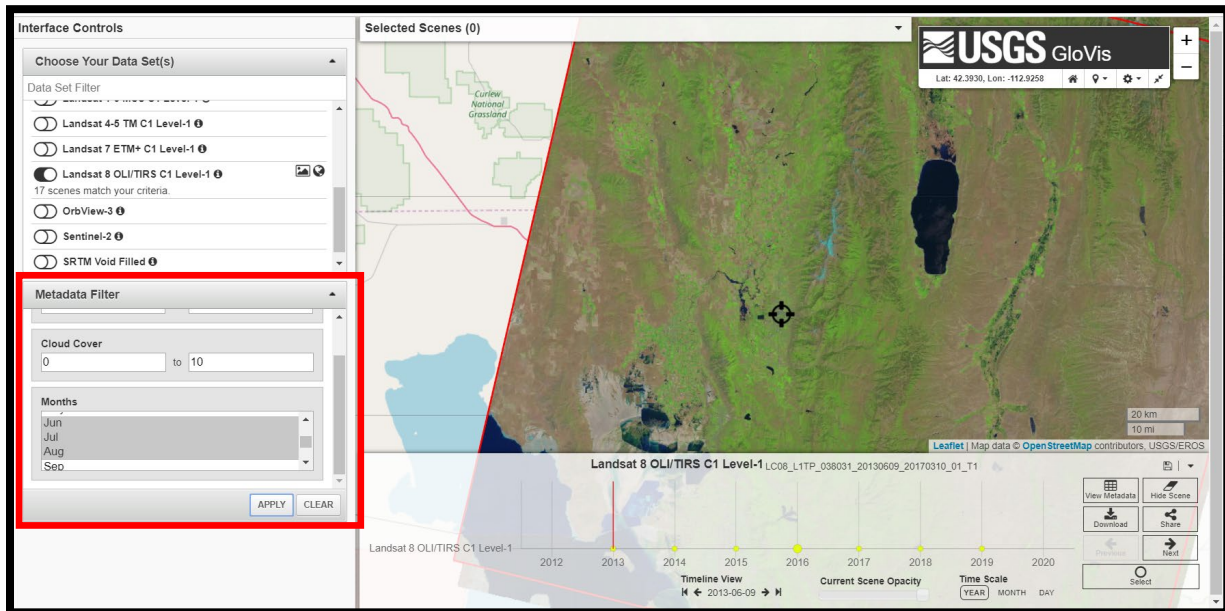
5. You may search for a geographic location of interest. There are a few different ways to do this. You can simply pan across the map to find an interesting geographic area or you can enter a specific geographic location using the tools in the upper right corner. Click on the location pin icon (i.e. the inverted drop shape icon). You can click on **Current Location**, enter a specific **Latitude/Longitude**, **Scene ID**, or **WRS Path/Row**. Click on **Current Location**. Since UtahView is hosted at Utah State University in Logan, Utah, the map will be directed to Logan, Utah.



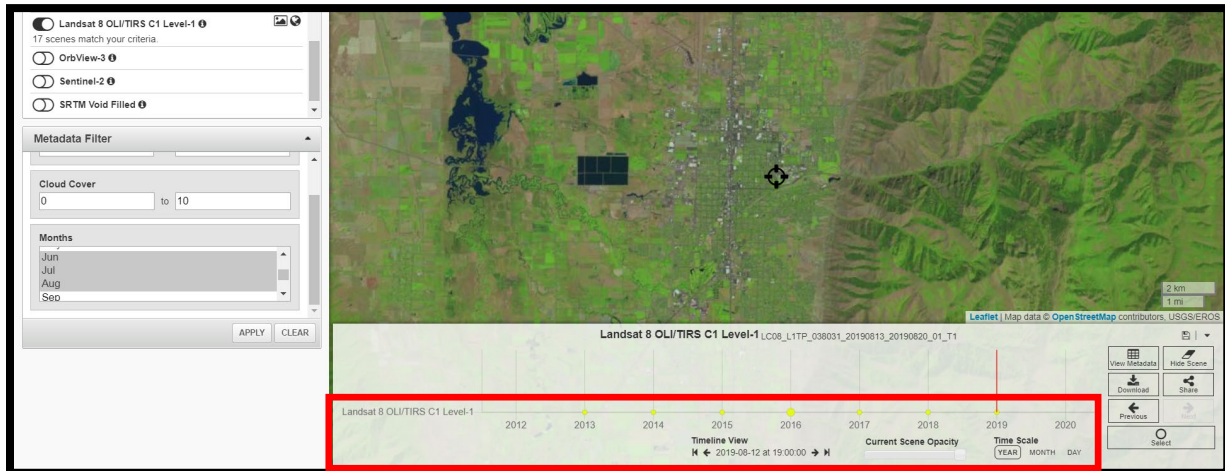
6. Satellite imagery is collected during all seasons and under a variety of weather conditions. Therefore, images will vary dramatically from day to day and season to season and may include cloud cover. Typically, when a cartographer is designing a map, cloud-free images are desired. However, clouds can also make interesting maps. If you are interested in finding images with limited cloud cover, you can specify that under the **Metadata Filter**.



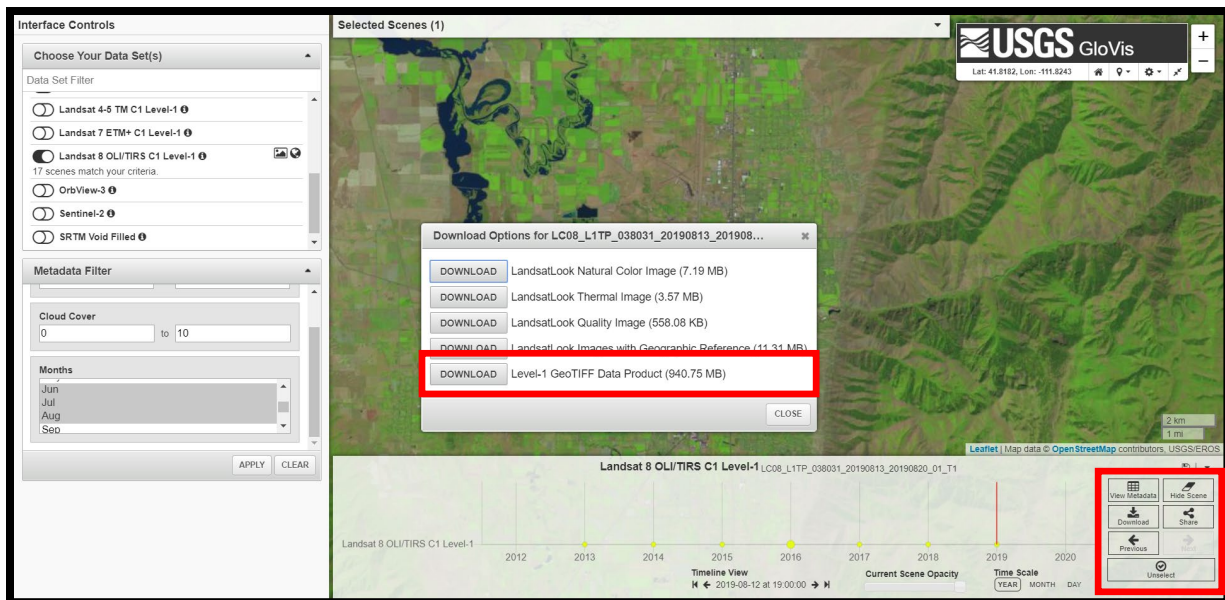
7. Under **Cloud Cover**, specify 0 to 10. Additionally, under **Months**, select the months **June, July, and August**. You can select multiple months by holding down the Ctrl key. You may also specify a **Date Range** if you are interested in a particular date or year. Click **Apply**.



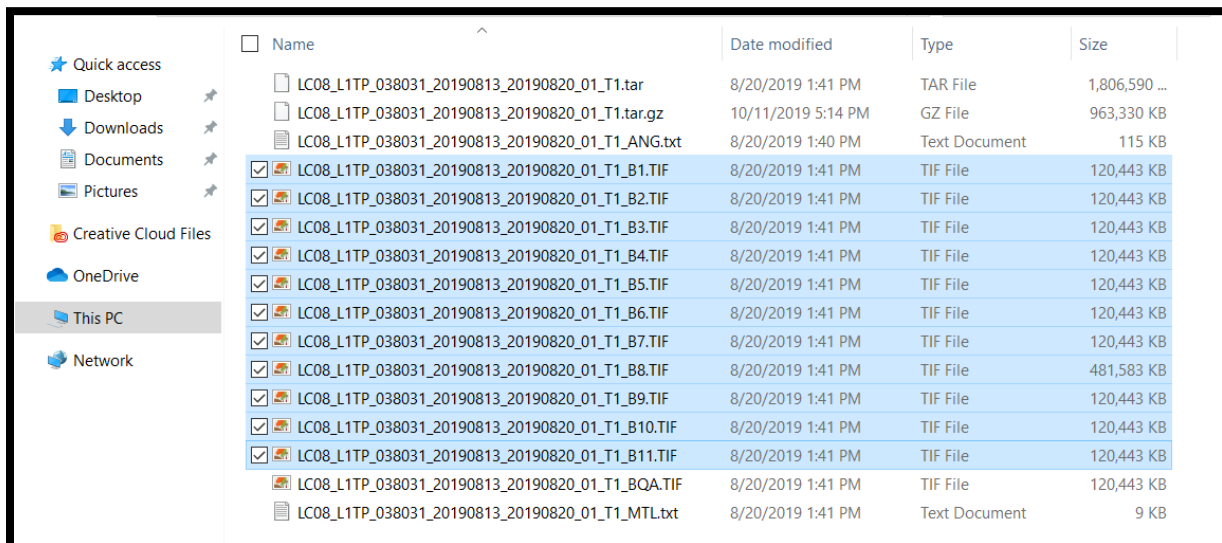
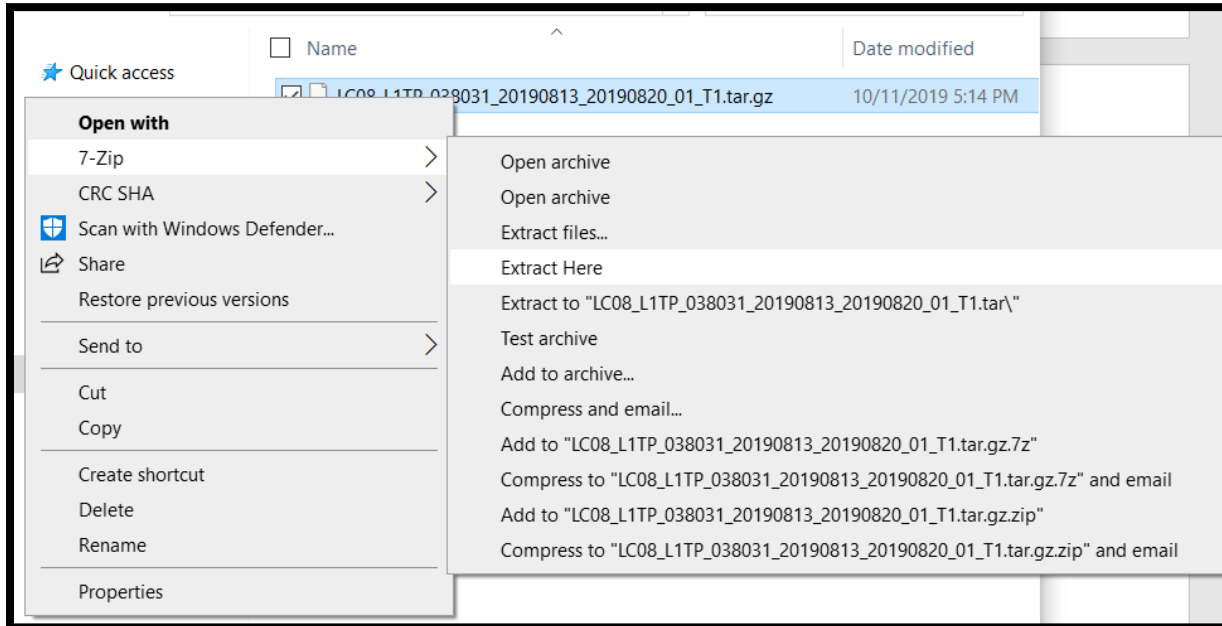
8. You may now begin exploring different images for the geographic location of interest by using the **Timeline View**. Use the arrow icons to look through the images until you find one that you are interested in. In this instance, the images that will be shown are Landsat 8 images that were collected during the months of June, July, and August and have 0 to 10 percent cloud cover. You can always expand your search to include images with greater cloud cover and images that were collect during other months.



9. Once you have found an image that you are interested in downloading, click the **Select** button in the lower right and then click **Download**. In this example, a Landsat 8 image from 2019-08-13 will be downloaded. A window will pop up with a few different download options. Click the **DOWNLOAD** button next to **Level-1 GeoTIFF Data Product**. This option will include all of the data that you will need to make a map.



10. Depending on your internet connection, the download may take several minutes. The file name for this particular image is **LC08_L1TP_038031_20190813_20190820_01_T1.tar.gz**. You will need a file unzipping software, such as **7-Zip** (<https://www.7-zip.org/>) to extract the files. You will need to extract the files by **right clicking** on the file and selecting **Extract Here**. You will need to repeat this step with the extracted file. **Right click** on the .tar file and select **Extract Here**. You will see several files. There are 11 image files (e.g. B1.TIF), a quality assurance file (i.e. BQA.TIF), and two metadata files (i.e. MTL.txt and ANG.txt). For the 11 image files, each file represents a band or channel. The last part of the file name identifies the band (e.g. B1.TIF represents Band 1).



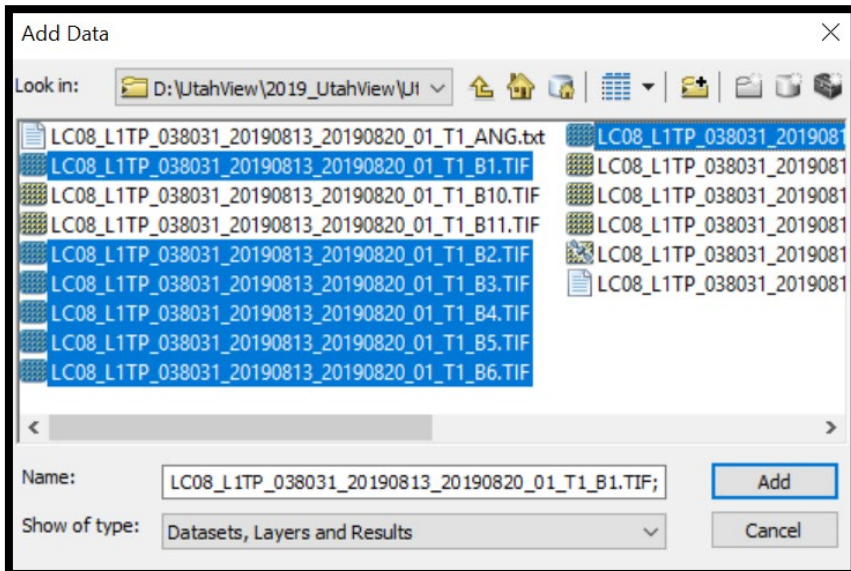
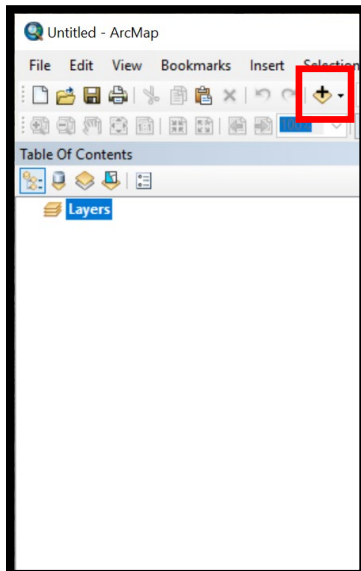
Landsat sensors measure different ranges of frequencies along the electromagnetic spectrum. Each range is called a band or channel. Landsat 8 has 11 bands. You will combine these bands to create your maps. For instance, a natural or true color image is composed of red, green, and blue bands.

LANDSAT 8 BANDS

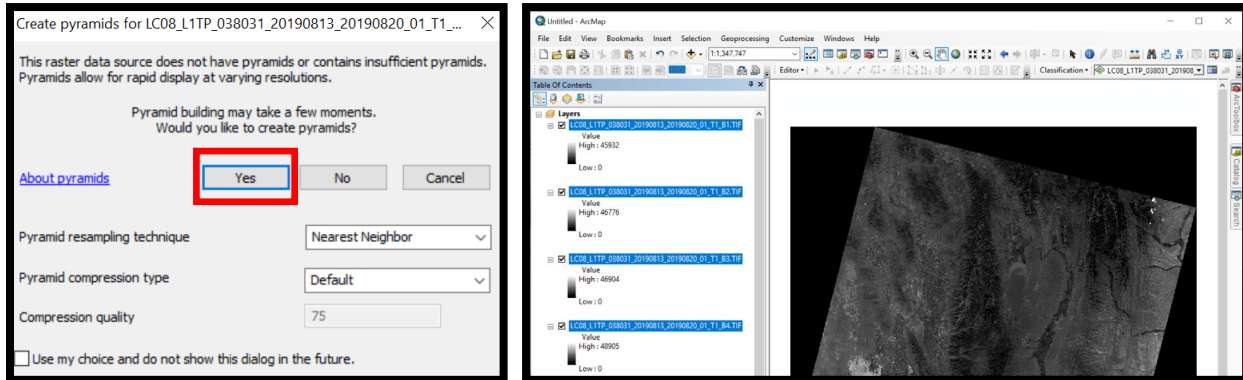
	Bands	Wavelength (micrometers)	Resolution (meters)
Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) Launched February 11, 2013	Band 1 - Coastal aerosol	0.43 - 0.45	30
	Band 2 - Blue	0.45 - 0.51	30
	Band 3 - Green	0.53 - 0.59	30
	Band 4 - Red	0.64 - 0.67	30
	Band 5 - Near Infrared (NIR)	0.85 - 0.88	30
	Band 6 - SWIR 1	1.57 - 1.65	30
	Band 7 - SWIR 2	2.11 - 2.29	30
	Band 8 - Panchromatic	0.50 - 0.68	15
	Band 9 - Cirrus	1.36 - 1.38	30
	Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100
	Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100

Imagery Processing

1. Open **Esri ArcMap**. Click on the **Add Data** button in ArcMap and navigate to the directory that contains the Landsat 8 files that you just downloaded. Select Band 1 through Band 7. Click **Add**.



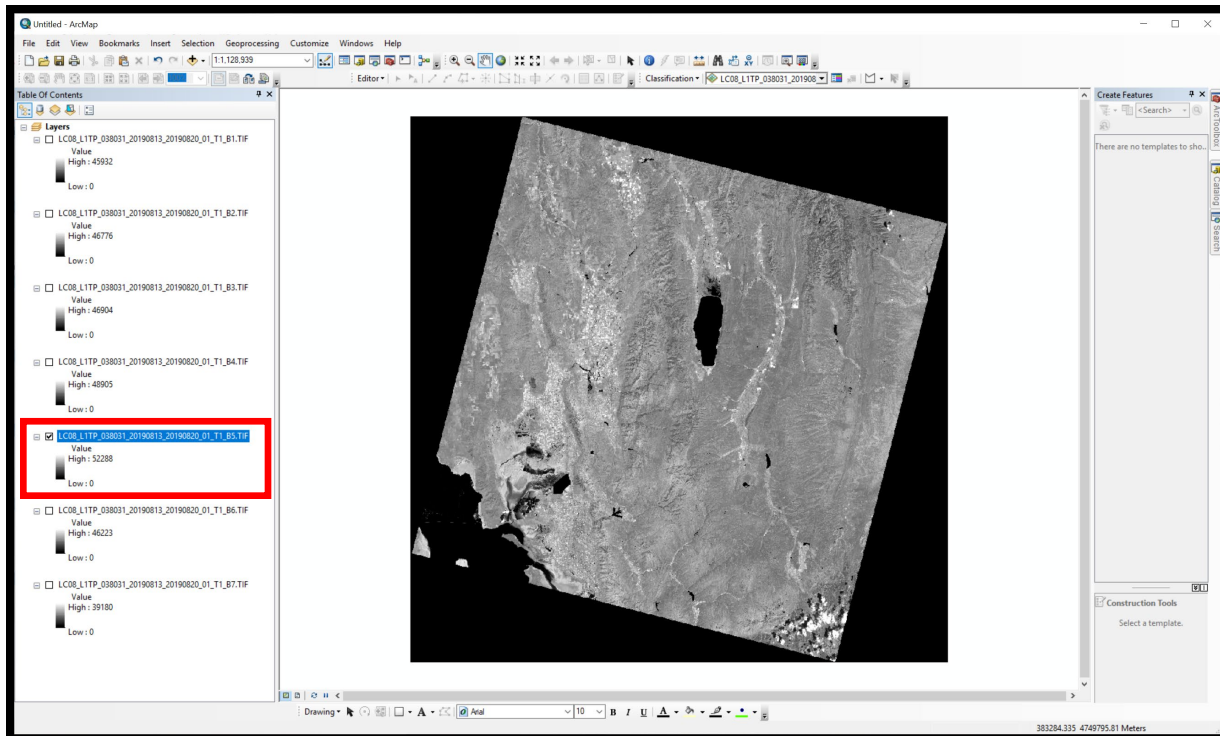
2. When you add the seven bands, a window in ArcMap will appear that asks if you want to build pyramids. Select **Yes**. Once the pyramid files are built, you will see the seven bands in ArcMap. Each of the seven bands are grayscale images.



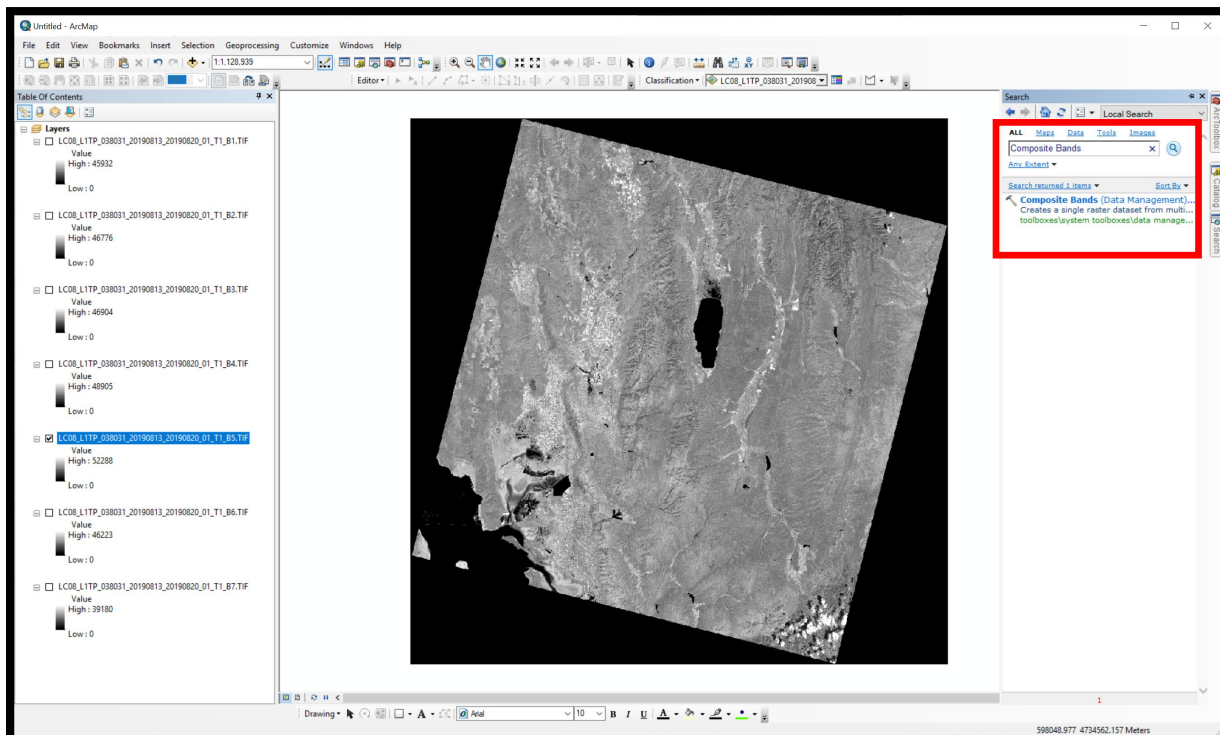
3. Inspect the various bands by turning on and off the layers in the **Table of Contents**. You will notice that different features are more pronounced with different bands. For example, turn on Band 5 (i.e. B5.TIF). Band 5 is the near infrared band and it represents data collected along the electromagnetic spectrum from 0.85 to 0.88 micrometers. In this image, you will notice that water features are very pronounced.

LANDSAT 8 BAND USES

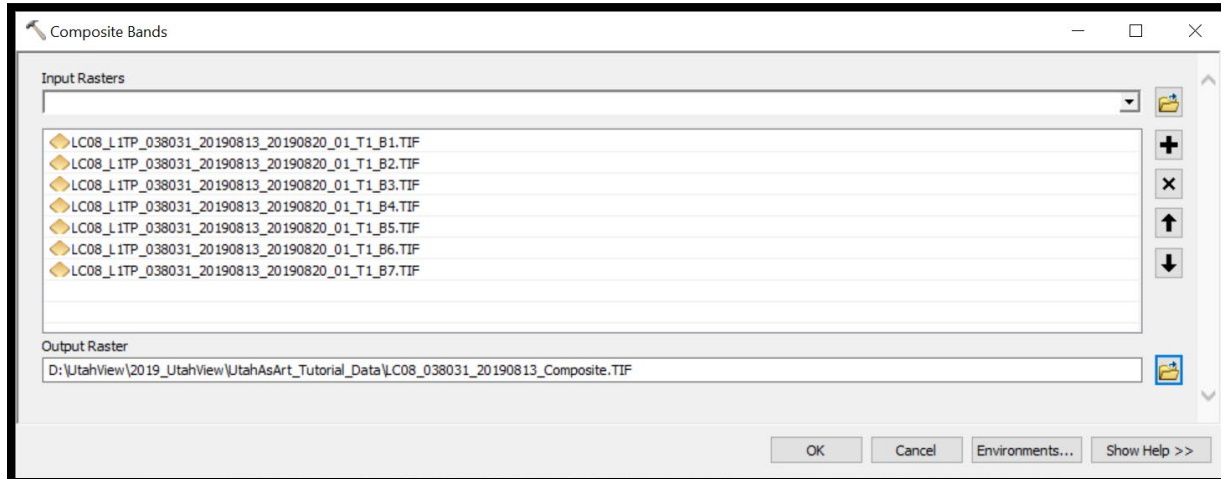
Band	Wavelength	Useful for mapping
Band 1 – coastal aerosol	0.43-0.45	coastal and aerosol studies
Band 2 – blue	0.45-0.51	Bathymetric mapping, distinguishing soil from vegetation and deciduous from coniferous vegetation
Band 3 - green	0.53-0.59	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 4 - red	0.64-0.67	Discriminates vegetation slopes
Band 5 - Near Infrared (NIR)	085.-0.88	Emphasizes biomass content and shorelines
Band 6 - Short-wave Infrared (SWIR) 1	1.57-1.65	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 7 - Short-wave Infrared (SWIR) 2	2.11-2.29	Improved moisture content of soil and vegetation and thin cloud penetration
Band 8 - Panchromatic	.50-.68	15 meter resolution, sharper image definition
Band 9 – Cirrus	1.36 -1.38	Improved detection of cirrus cloud contamination
Band 10 – TIRS 1	10.60 – 11.19	100 meter resolution, thermal mapping and estimated soil moisture
Band 11 – TIRS 2	11.5-12.51	100 meter resolution, Improved thermal mapping and estimated soil moisture



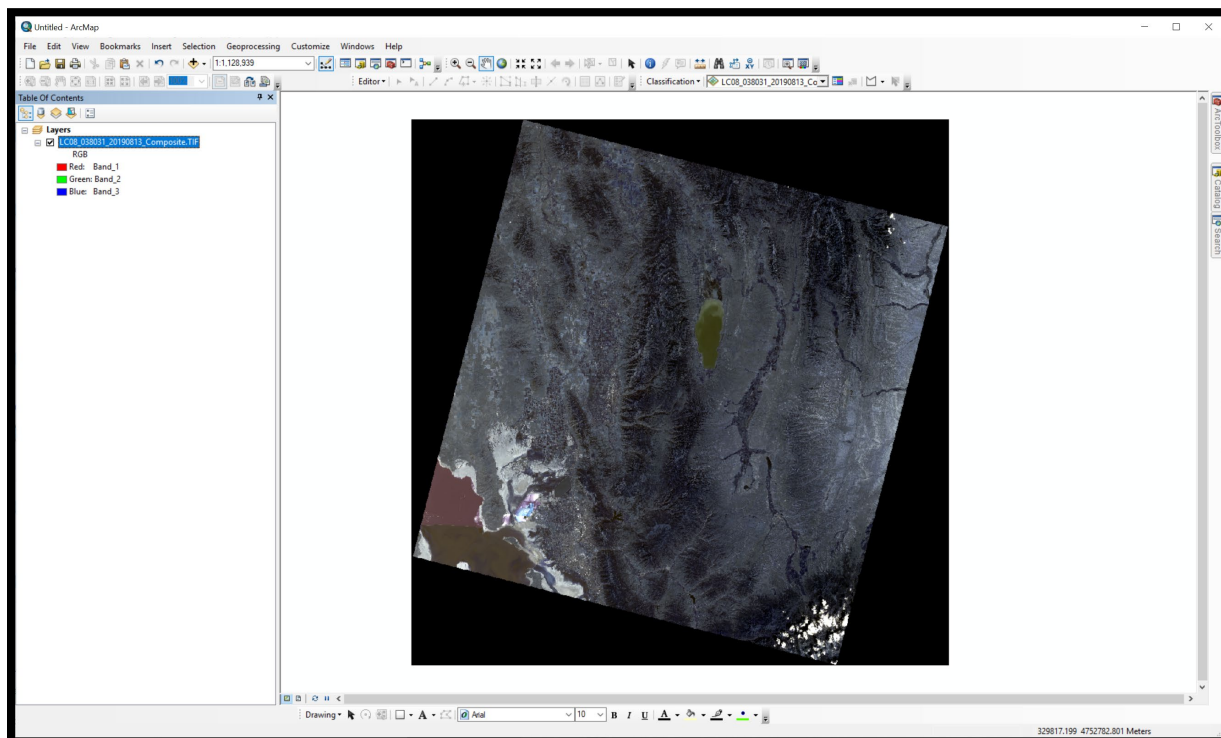
4. In order to create a natural color image, you will need to combine the bands in ArcMap using the **Composite Bands** tool. In the Search tab, type Composite Bands. Open the tool.



5. Under **Input Rasters**, enter in Bands 1 through 7. You can use the dropdown menu to enter in the bands from the **Table of Contents** or you can navigate to the directory that contains the Landsat 8 files. Under **Output Raster**, navigate to the correct directory and name the output file. In this example, the output file will be named **LC08_038031_20190813_Composite.TIF**. Click **OK**.

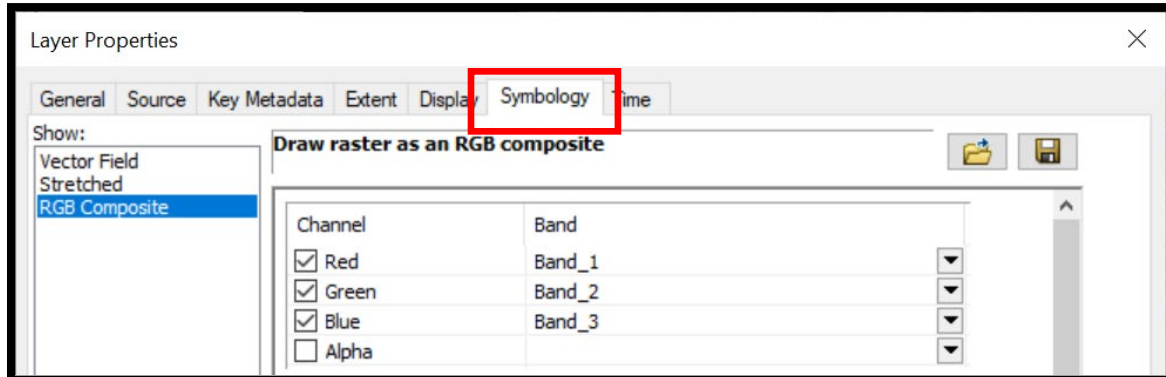


6. The output (**LC08_038031_20190813_Composite.TIF**) will be a dark image with some blue undertones, but the output may vary depending on the scene and geographic location of interest.

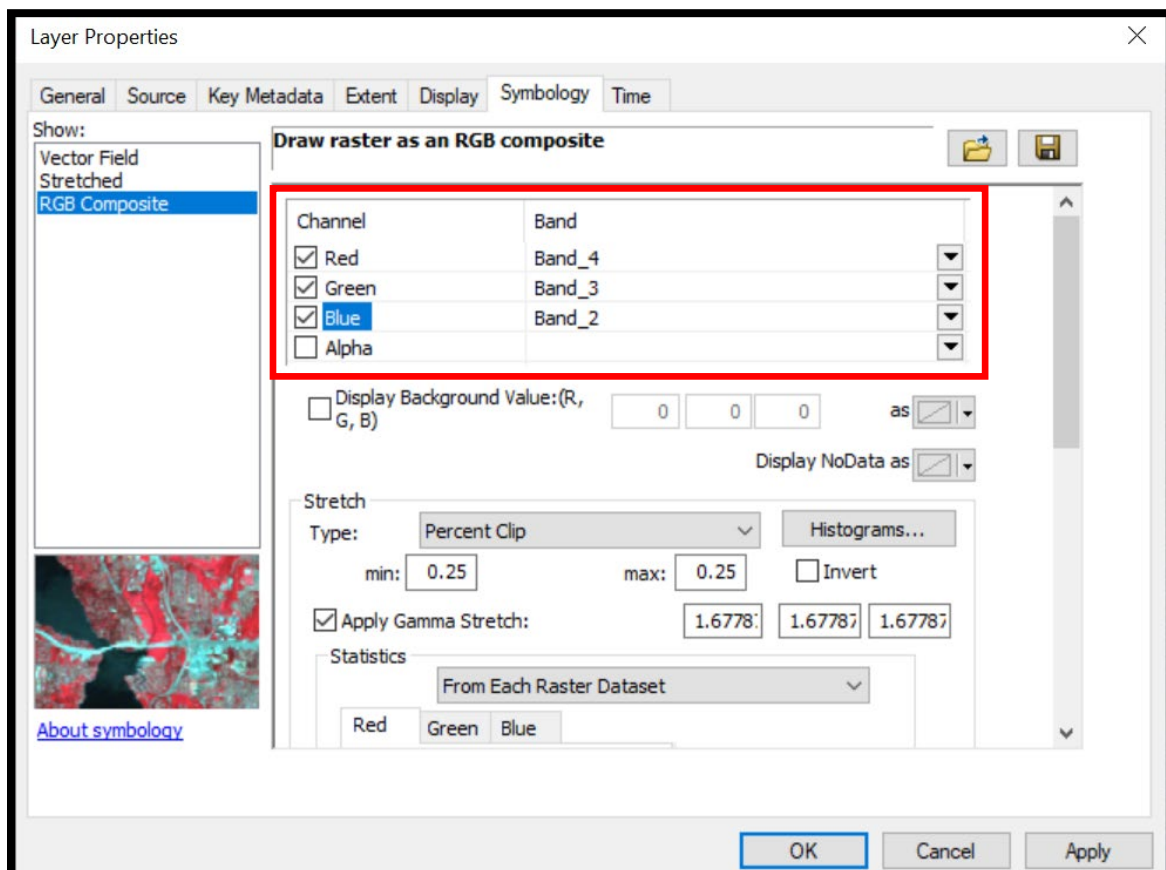


Imagery Display

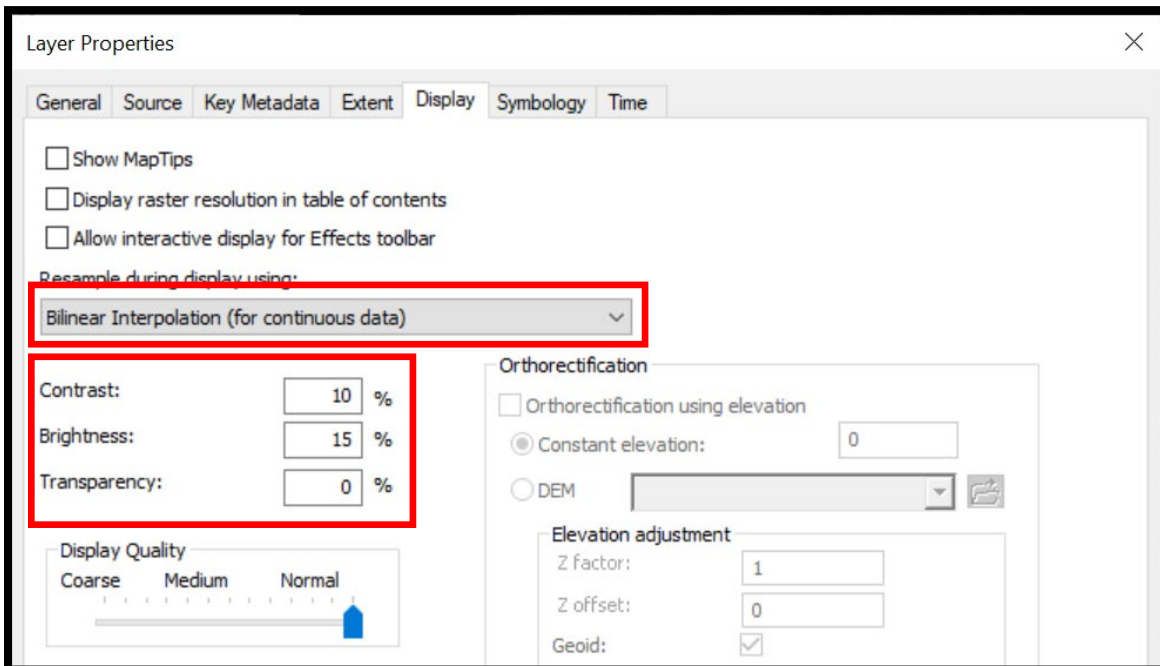
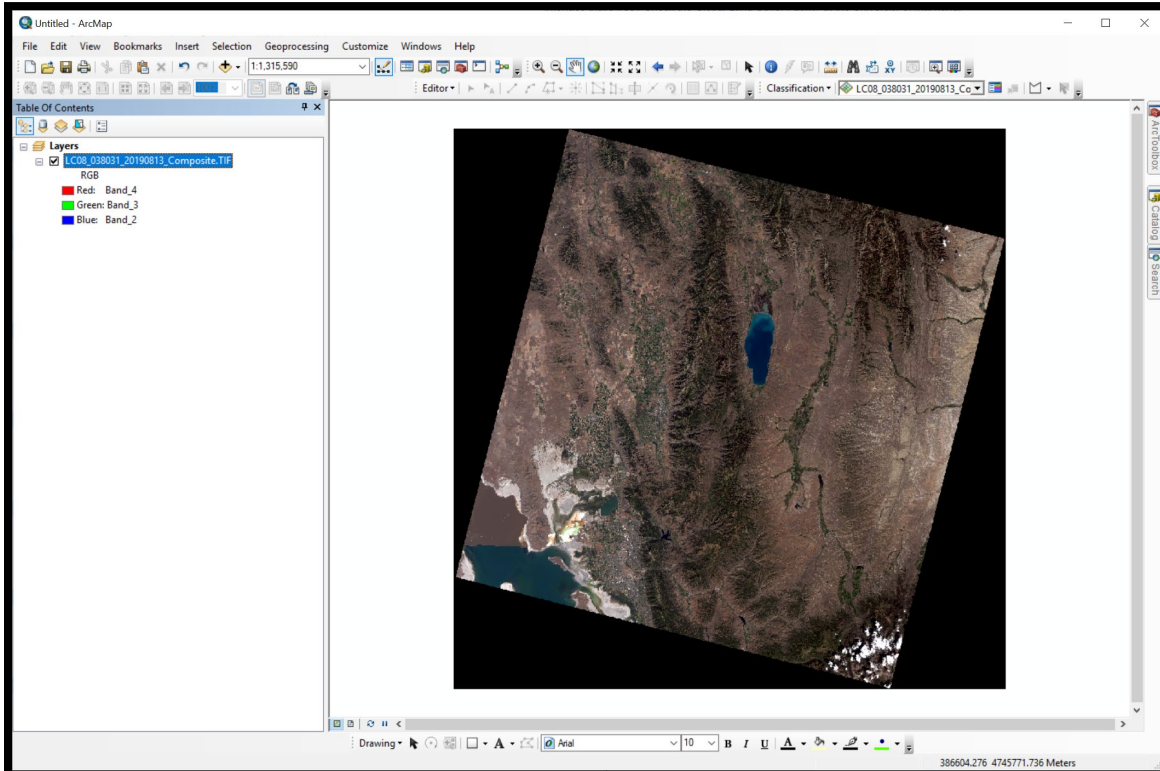
1. To change the display of the image, you will need to change the image properties. **Right click** on the new composite image and select **Properties**. Click on the **Symbology** tab.

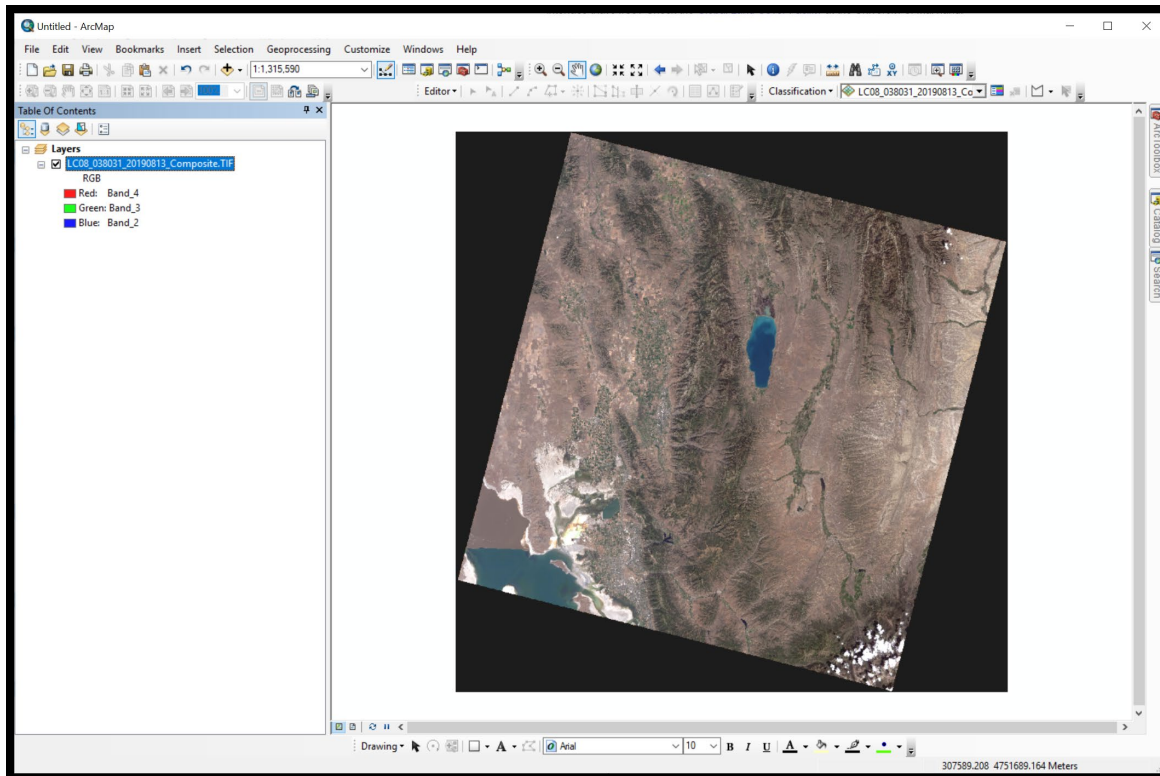


2. To create a natural color image, you will need to change the band designations. Currently, Band 1 is assigned to the Red Channel, Band 2 is assigned to the Green Channel, and Band 3 is assigned to the Blue Channel. Under the **Red Channel**, use the dropdown menu to select **Band_4**. Under the **Green Channel**, use the dropdown menu to select **Band_3**. Under the **Blue Channel**, use the dropdown menu to select **Band_2**. Click **OK**.

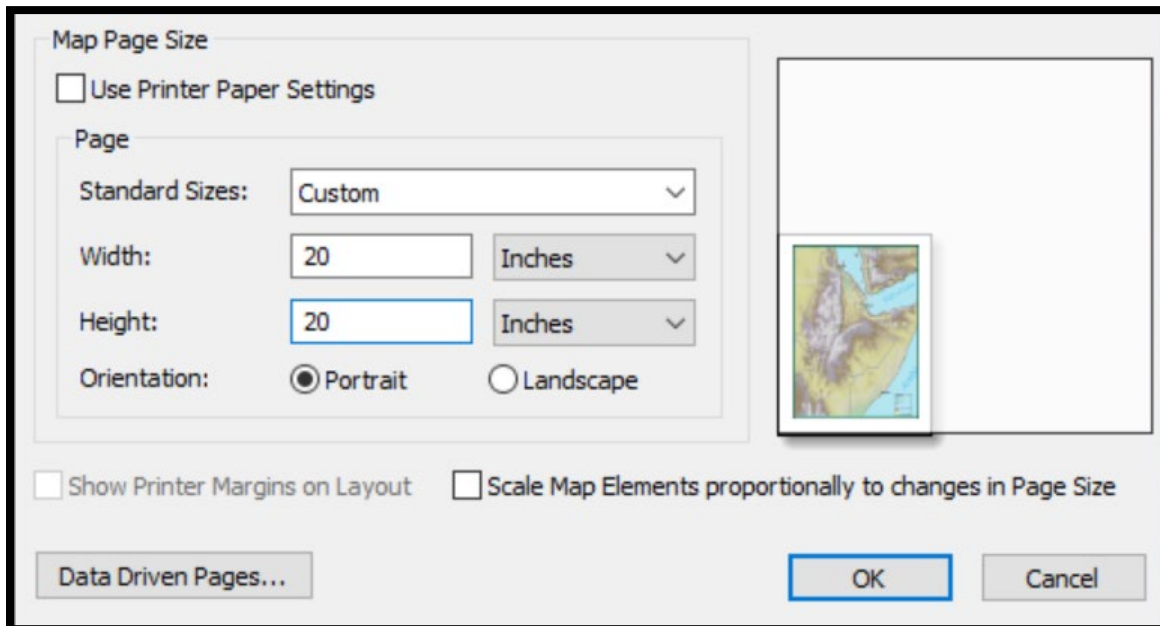


3. The image is now natural color, but it still appears to be dark. Depending on the scene you selected, you may or may not need to go into the properties to change some of the display settings. For this image, go back into the **Properties**, click on **Display**, and increase the **Brightness** to **15%**. Also, while you are in the Display settings, use the dropdown menu below **Resample during display using:** to select **Bilinear Interpolation (for continuous data)**.

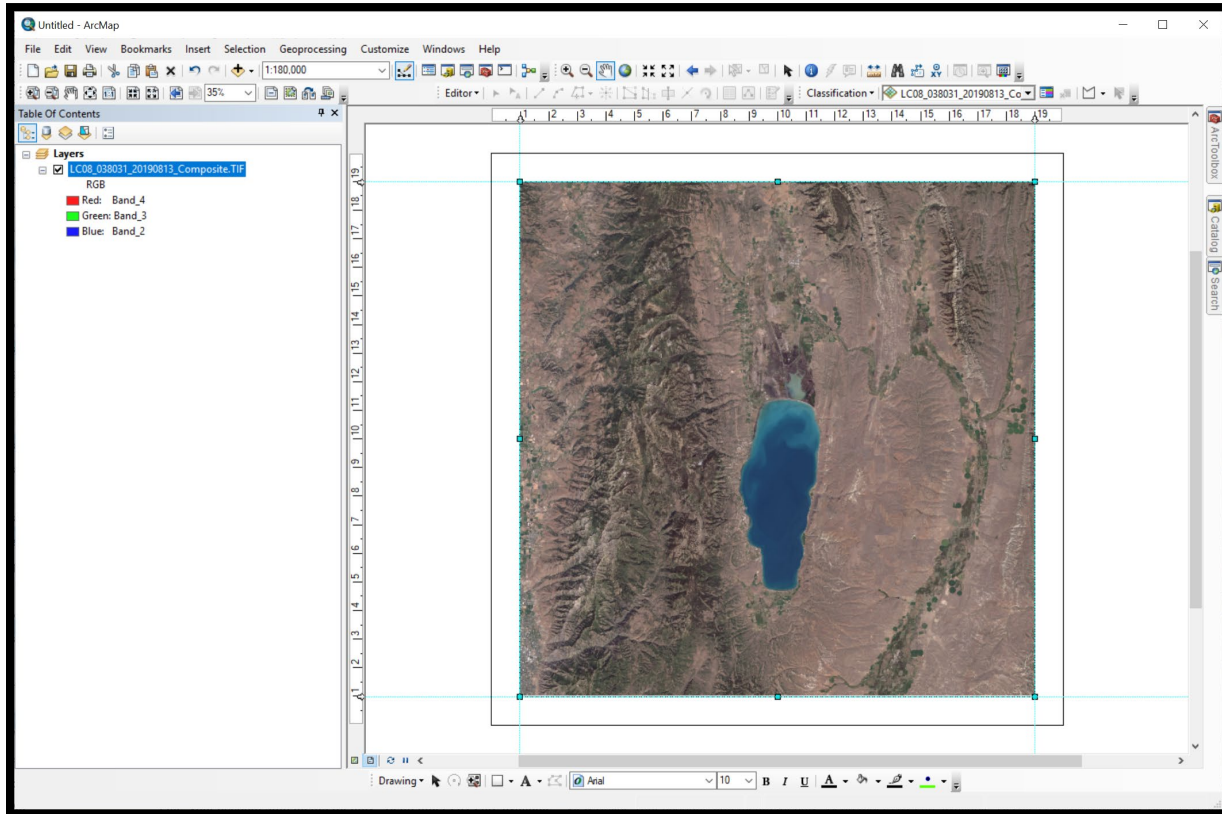




4. At this point, you can decide what your map extent will be. In this example, Bear Lake will become the focus of the map. Begin designing your map by going to the Layout View in ArcMap. Click on **View** and then **Layout View**. Then, go to **File** and then **Page and Print Setup**. Under **Map Page Size**, unclick the box next to **Use Printer Paper Settings**. Specify your map dimensions as **20" x 20"**. Click **OK**.

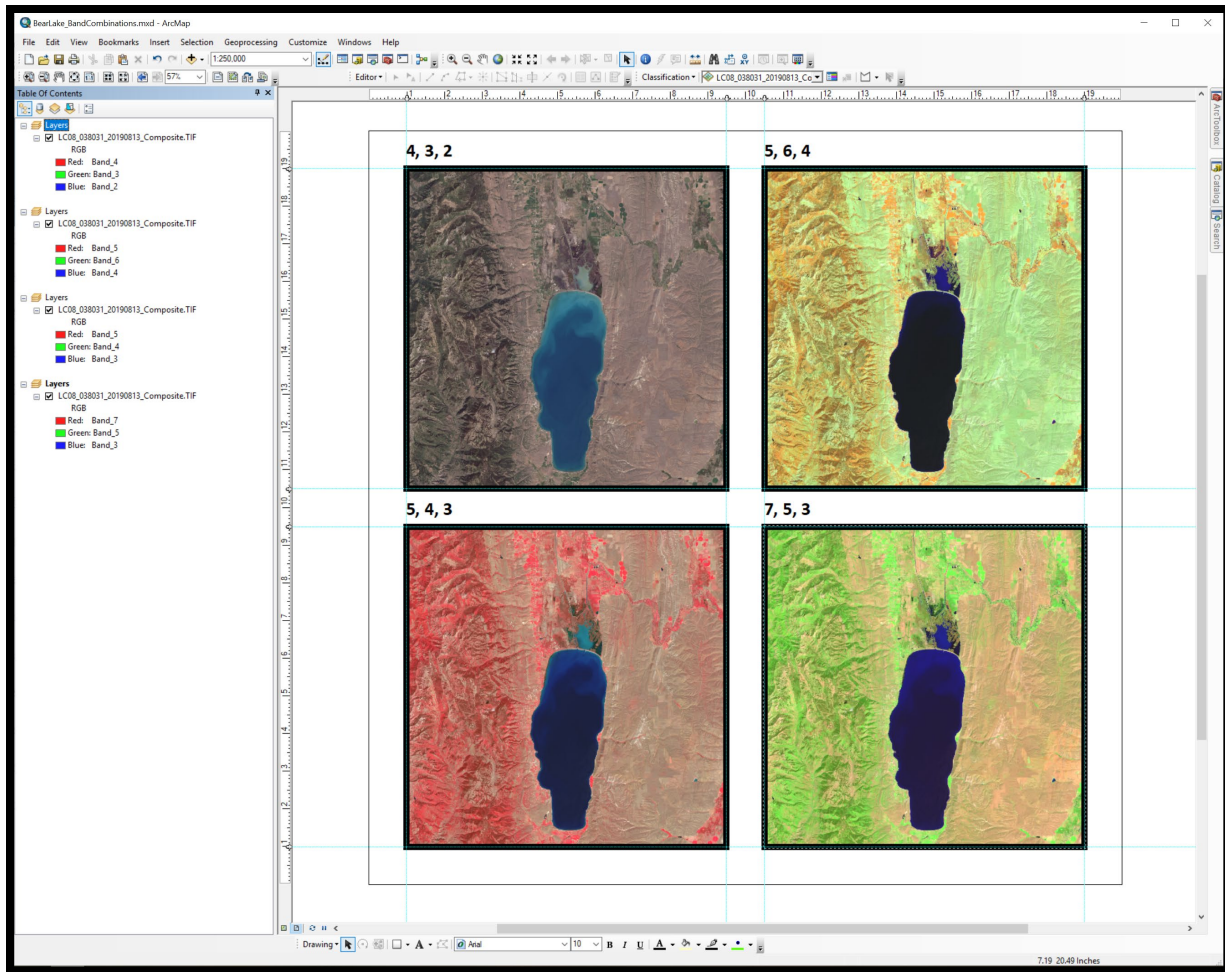


5. Use the map/document guides to place a one-inch margin around your map. You can do this by clicking on the 1" and 19" markers on both the horizontal and vertical rulers. Expand the layout to fit within the new dimensions. The actual map should measure 18" x 18".

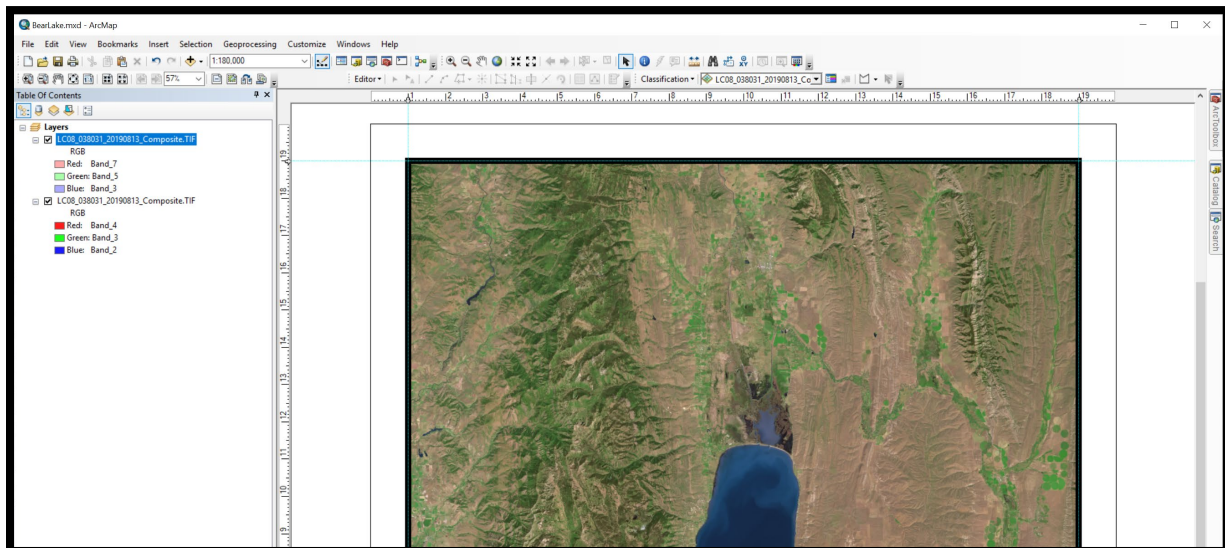


6. At this point, you can start making adjustments to your map by changing band combinations, adding in other band combinations, and/or by changing some of the other properties. Use the table below to visualize different band combinations.

Landsat 8 Band Combinations	
Natural Color	4, 3, 2
False Color (Urban)	7, 6, 4
Color Infrared (Vegetation)	5, 4, 3
Agriculture	6, 5, 2
Atmospheric Penetration	7, 6, 5
Healthy Vegetation	5, 6, 2
Land/Water	5, 6, 4
Natural with Atmospheric Removal	7, 5, 3
Shortwave Infrared	7, 5, 4
Vegetation Analysis	6, 5, 4



7. For this map, two different band combinations will be used. A band combination of 7, 5, 3 will be overlain on top of the 4, 3, 2 (natural color) image with a transparency of 65%. Experiment with different band combinations, transparency levels, brightness levels, and contrast levels.



8. Once you have defined your layout and designed your map, you can now add important map elements, such as a title, north arrow, and scale bar. To add a title, go to **Insert**, and then select **Title** or **Text**. Either one will allow you to give your map or image a title. To add a north arrow or scale bar, go to **Insert**, and then select **North Arrow** and/or **Scale Bar**. After you have finished your map, you can export it out as an image (.jpeg/.tif) or .pdf. Go to **File** and then **Export Map**. You now have a beautiful map that you can share with your friends and family. Have it printed out or use it a desktop background for your computer.

