LABORATORY ONE

Introduction to ArcGIS Pro and vendor data

University of Mississippi – Department of Geology and Geological Engineering

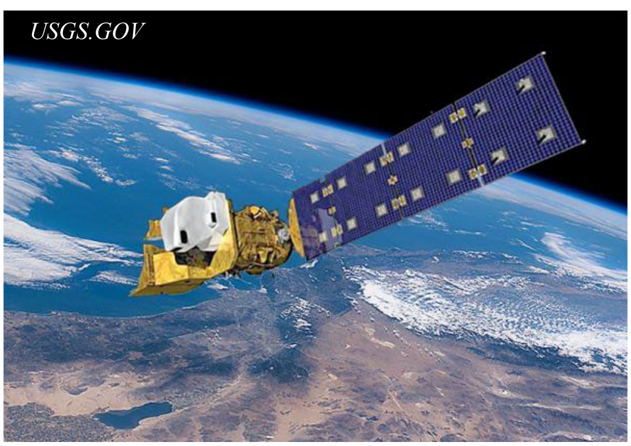
Purpose-

This exercise will attempt to accomplish the following goals:

- Familiarize the student with ArcGIS Pro
- Ordering/downloading imagery from a vendor
- Conduct a tutorial of the ArcGIS Pro application
    - Loading imagery
    - Pixel profiling
    - Color theory

Laboratory introduction-

All laboratories in this class will have the same structure as this laboratory. Each laboratory will include file(s) that each student must complete and submit via BlackBoard except for this laboratory. Most laboratory exercises will use a combination of vector and raster data types. You will be responsible for downloading the appropriate imagery. Exercises will incorporate imagery from satellite-based sensors such as Sentinel and Landsat.



The Landsat satellite program, managed by the United States Geological Survey (USGS) and the National Aeronautics and Space Administration (NASA), has continually collected imagery since 1972. The most recent is Landsat 9, launched on 27 September 2021 (seen left). The entire image repository contains more than four million images and is now all available via public download and cloud access. This was not the case until only a few years ago, when images had to be individually ordered through the mail (1970s-1990s) or as an on-demand database pull and temporary network storage with FTP download. Even with the vastly improved search and delivery system, there is still a challenge for users is finding the most appropriate image. In this lesson, and using the LandsatLook app, you will obtain imagery of the Mississippi Gulf Coast.

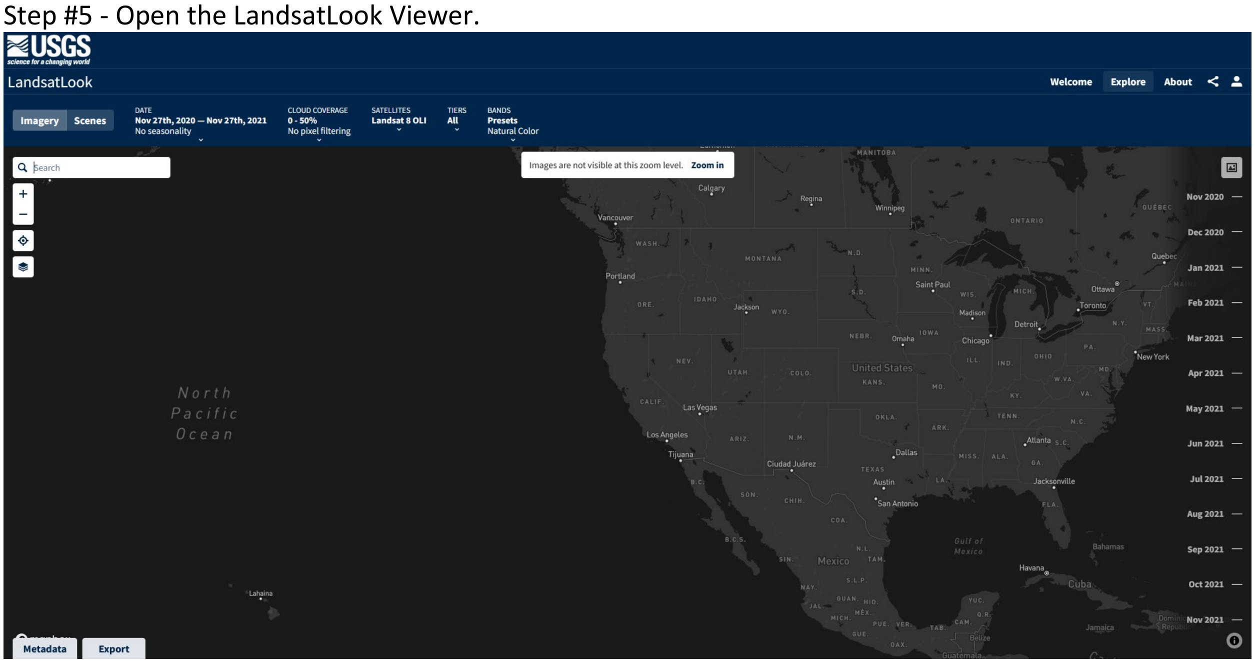
Find and download an image

To find a Landsat image of southern Mississippi, you'll use the LandsatLook app to explore the entire database of free Landsat imagery. You want a relatively recent image with minimal cloud cover. To download the image, you will create a free account for the USGS Earth Resources Observation and Science (EROS) Center, which will allow you to download as much Landsat data as you want.
Landsat imagery can be large. The file you'll download in this lesson has a size of approximately 900 MB. Make sure you have enough disk space on your computer, and enough time to wait for the download, before proceeding. **Also, this app only downloads one band at a time.** This is fine for one or two images, or you wish to keep files in the cloud. To download more data, it is recommended to use EarthExplorer or Glovis.

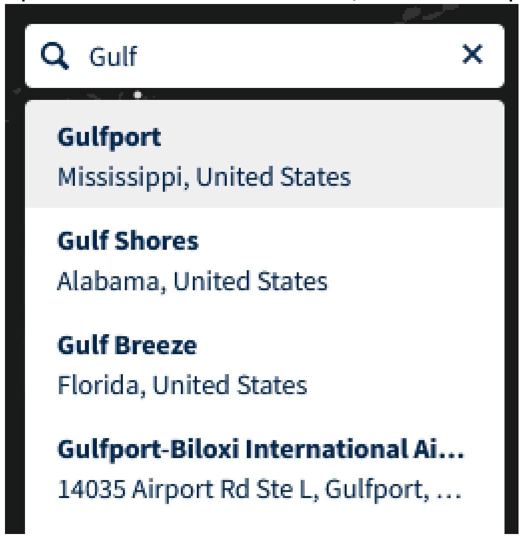
Create an account

To download Landsat data, you need a USGS EROS account. The account is free and does require you to give demographic survey data and contact information. If you already have a USGS EROS account, skip to the next section.
Step #1 - Go to the EROS Registration System.
Step#2 - Follow the onscreen instructions to proceed through the registration process.
Once you complete your registration, a message is sent to your email address to confirm your registration.
Step #3 - Click the link in the email to activate your account.
Locate Mississippi

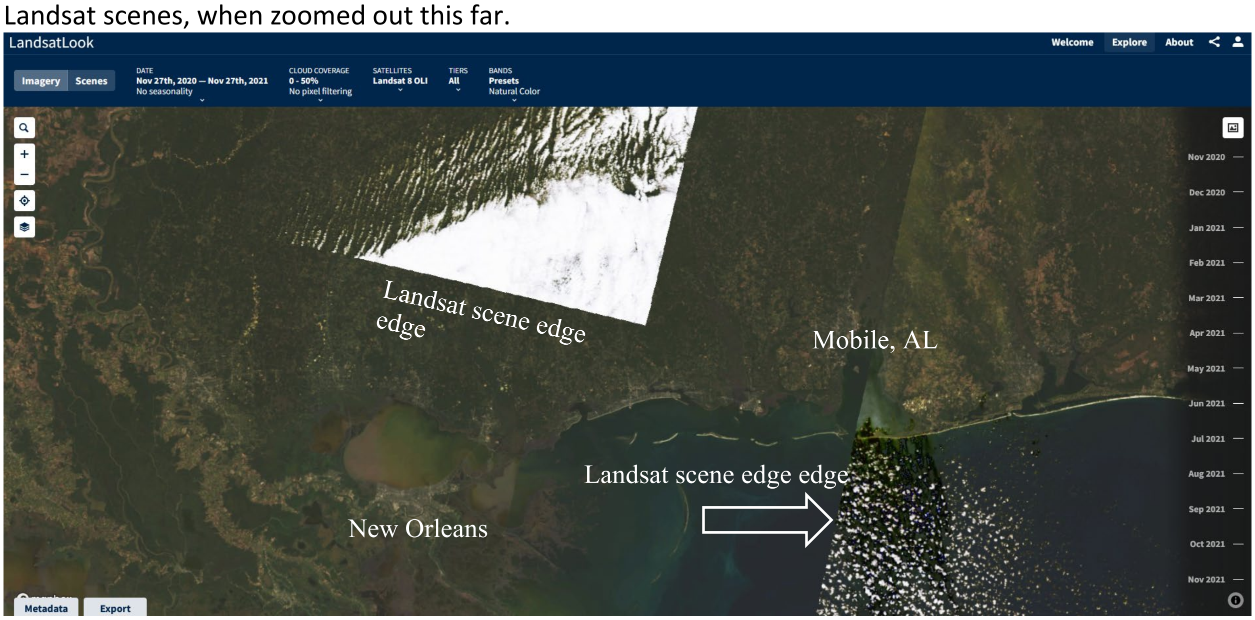
Step #4 - Next, you'll open the LandsatLook Viewer and navigate to Mississippi Gulf Coast.
Note that only USGS Landsat Collection 2 data is available through this app. There are two levels of products available to use. While the introductory remote sensing course uses most Level-1 data, Level-2 has data that is been processed with additional algorithms. This includes the scene-based global Level-2 surface reflectance and surface temperature science products.
Step #5 - Open the LandsatLook Viewer.



The viewer opens to the default extent of the United States. Images will not load until you have zoomed to an appropriate extent. Next, you will change the map extent to the gulf coast of Mississippi.
Step #6 - On the toolbar, click the Search button.
In the Search window, type Gulfport. From the list of results, choose Gulfport, Mississippi.



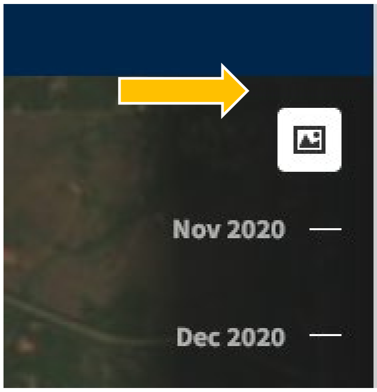
The map extent centers on the city-state of Gulfport. Depending on your browser window size, the windows in the viewer may obscure part of the area.
Pan the map, and zoom if necessary, to see the entire island.
Zoom out five or six times. Compare the waters and urbanization with those around Lake Pantchartrain/New Orleans to the west and Mobile area to the east. You will see the edges of the Landsat scenes, when zoomed out this far.

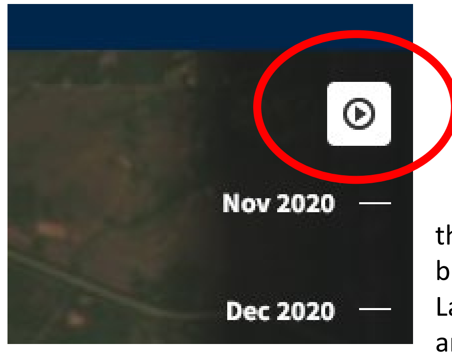


Zoom back to Gulfport.
Find an image

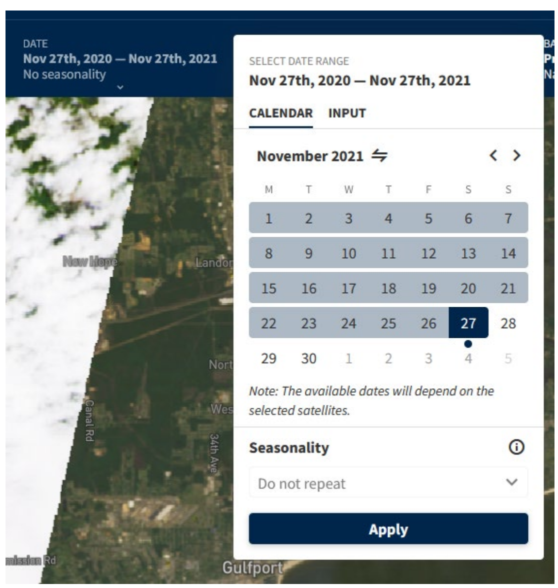
A real urban planning project would use a variety of data types from many sources. The single image you'll download from the Landsat imagery database will instead serve as a starting point, providing a high-quality look at the entire city. Landsat imagery is multispectral, meaning it can be displayed with

different bands of light to emphasize features such as vegetation, coastlines, or man-made structures. The image will be a good reference to which you can add more specialized data.
At the top of the window, you can select the date rage, cloud cover, satellite and sensor, and the tiers of the data. Note that by default the app limits the rage of dates from the last Landsat 8 OLI image of the extend you chose back to one year ago. This setup of the app to provide the users with a time lapse of the data.

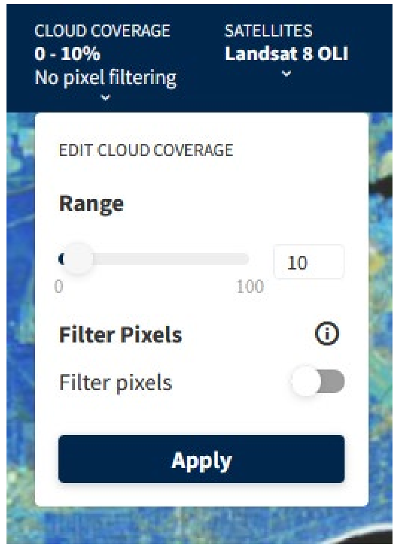




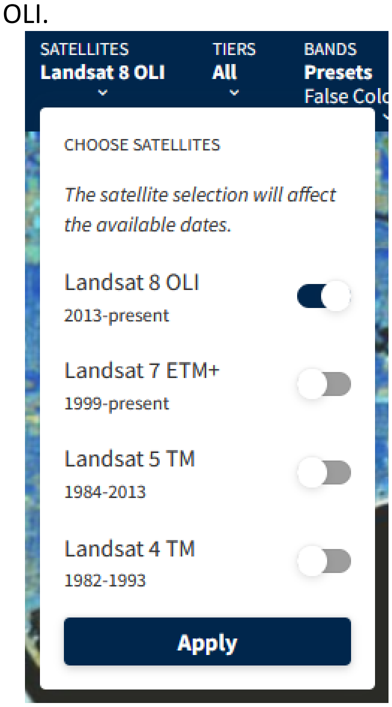
By clicking the time lapse button, you will see all the Landsat 8 OLI data in the archive given by the search criteria at the top of the window. After the app has complied the images, the button will change to a “play” button for you to now click.
This gives you a quick way to see the images and determine the quality of the before you select and download the imagery. You can then click individual dates on the right side of the window to view each Landsat 8 OLI.
For most work the image should be relatively recent. You can also search based on days of the year, which is useful for tracking seasonal trends or specific incidents, such as wildfires. For a general reference image, it should be cloud free and high-quality.



Landsat 8 sun-synchronous orbit allows it to return to a location on Earth approximately every 16 days. At lower latitudes, it is almost inevitable there will be clouds in some or all the scenes. Clouds obscure ground cover and conceal features. Reducing the maximum cloud cover will return results with a clearer view of the area. To help find, cloud-free or limited clouds, select the Cloud Coverage dropdown.

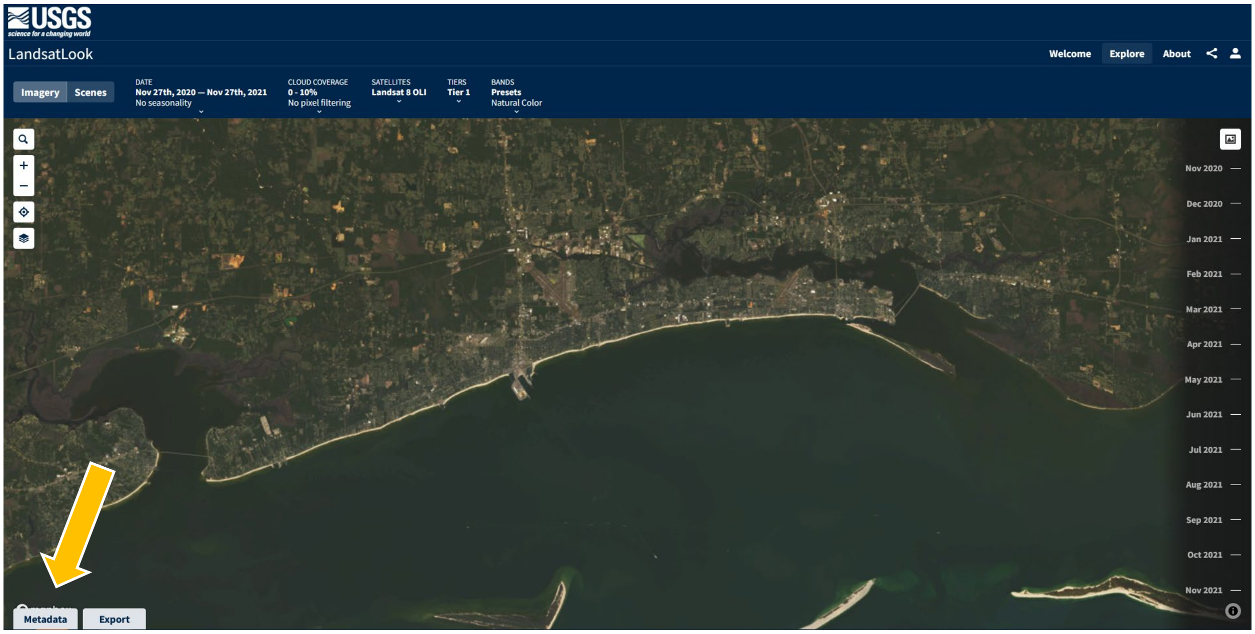


Select the maximum cloud coverage to 10% and select apply.
You can also search for imagery from specific Landsat sensors. All of them capture multispectral imagery, although they use different and have different pixel sizes. They also have different years of operation. The default is Landsat 8 OLI.



NB: Because new Landsat images are added to the database daily, your search may have returned more images. It may also have a more recent image displayed on the map than in the example images.

All images within the map extent that meet your criteria are returned. Additionally, the most recent images are displayed by default. To view the number and type of scenes (e.g. tiers, sensor selected), select the metadata tab in the lower left of the viewer window.



There are approximately 40 scenes contained within the above map extent. Your results maybe different given the location and extent of your zoom as well as the search parameters selected. In the list you will see the product ID, date collected, cloud cover, WES2 path and row, tier level of processing, sensor, and actions you can take with each record. You can click the scene cloud cover attribute header to sort the records based on cloud cover. Do this and find the scenes with the fewest clouds.

Metadata Export

PRODUCT ID	DATE	SCENE CLOUD COVER	PATH	ROW	TIER	SENSOR	ACTIONS
LC08_L2SP_021040_20211115_20211125_02_T1	2021-11-15	0	021	040	T1		Metadata SR Bands ST Bands
LC08_L2SP_021039_20210421_20210430_02_T1	2021-04-21	0	021	039	T1		Metadata SR Bands ST Bands
LC08_L2SP_020038_20210329_20210409_02_T1	2021-03-29	0	020	038	T1		Metadata SR Bands ST Bands
LC08_L2SP_021038_20211115_20211125_02_T1	2021-11-15	0.01	021	038	T1		Metadata SR Bands ST Bands
LC08_L2SP_020038_20211108_20211117_02_T1	2021-11-08	0.01	020	038	T1		Metadata SR Bands ST Bands
LC08_L2SP_020038_20211023_20211103_02_T1	2021-10-23	0.01	020	038	T1		Metadata SR Bands ST Bands
LC08_L2SP_021038_20210507_20210517_02_T1	2021-05-07	0.01	021	038	T1		Metadata SR Bands ST Bands

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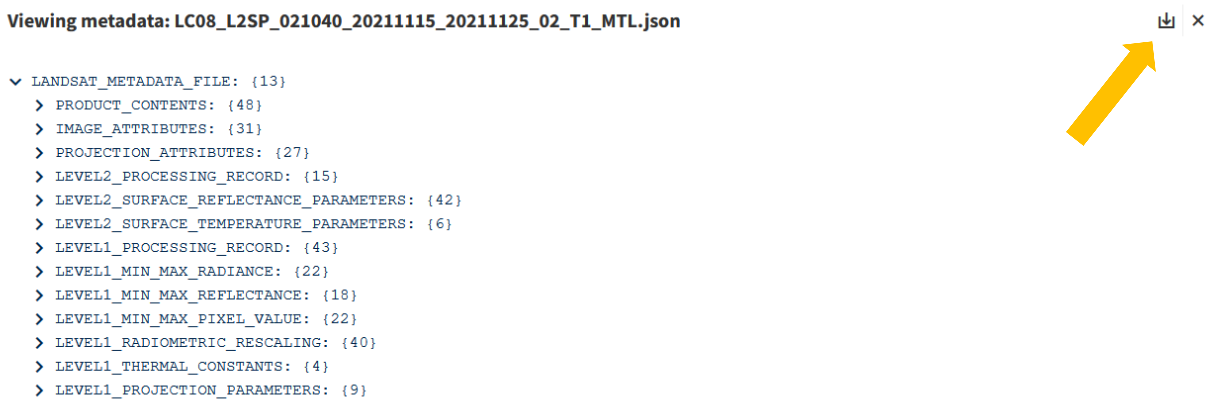
The ID naming scheme is important and worth noting because students will want to create a new name for the data file after downloading. It is HIGHLY advised you do not do this. Keep the naming convention from the USGS. After you have a directory filled with imagery you will appreciate why you kept the original file name. Here is why. Let us examine the first scene listed in the above screenshot: LC08_L2SP_021040_20211115_20211125_02_T1
The LCO8 is Landsat 8 and L2SP is Level 2 processing product. The 021040 is the WRS2 path 21 and row 40 with the collection date listed YYYYMMDD as 20211115 or 15 Nov 2021. The second date of 20211125 is the day on which the imagery was processed. Very important especially for older imagery. USGS will update their algorithms and rerun imagery to create, hopefully, better products.

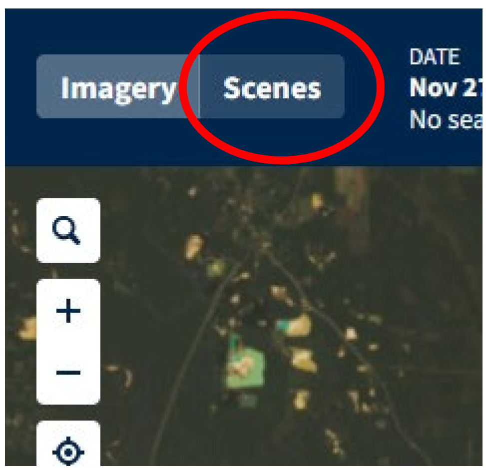
Metadata

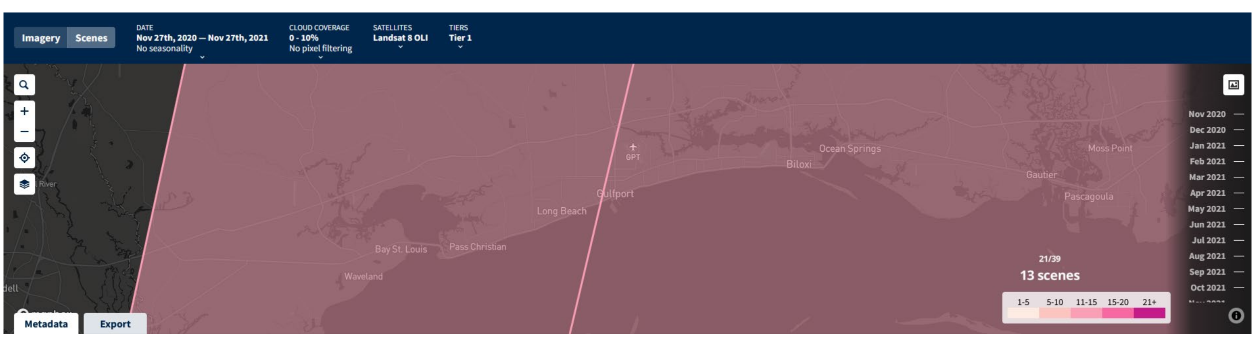
JSON format for later retrieval.



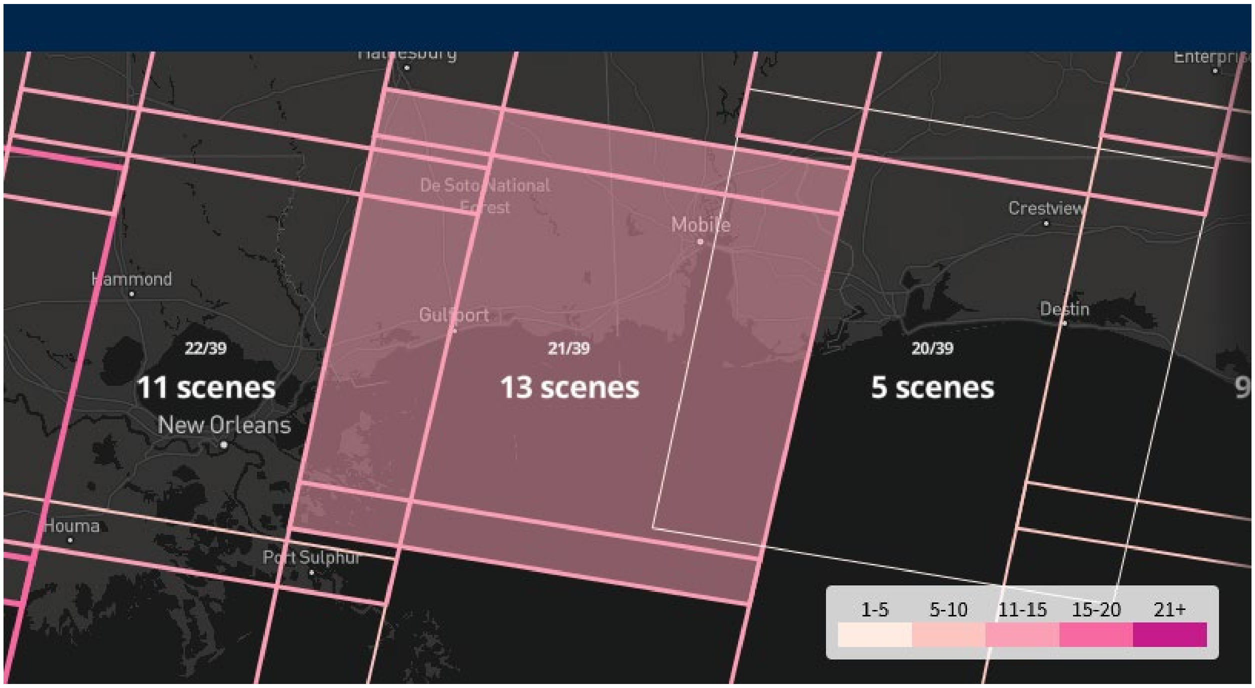
While you are on the list of the scenes in the metadata tab, sort the records on “path”. You will see there are path 021 and 022 depending on your extent and zoom level. You will also see there are scenes from row 038, 039, and 040. These are all using the [WRS2 world reference system](#).

Go to the upper left of the view screen and click the “scenes” button. This will display the footprints of the actual images and you can begin to see the WRS2 with Landsat 8 scenes having some overlap to each path.





You can see there is a row transition in the vicinity of Gulfport. This is why there are 40 scenes in the search results, even though Landsat 8 has a 16-day revisit time which should have yield only 12-13 scene during the year.



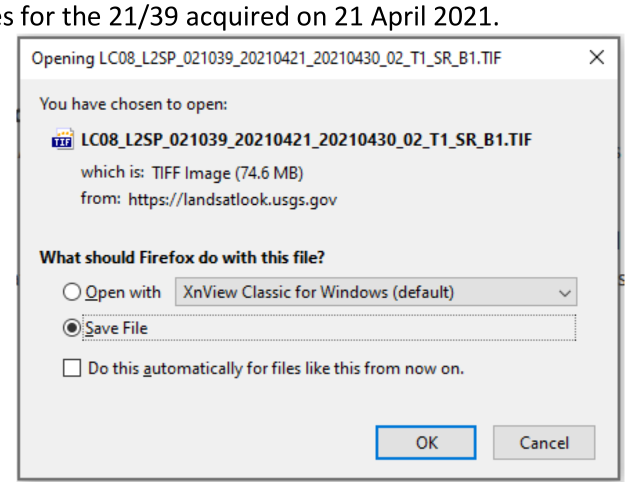
You can zoom out a little further to see the path/row (21/39) and there are 13 scenes given the search criteria.
Going back to the metadata tab, zoom in to Gulfport and resort the scenes for the fewest clouds. You are now ready to download data.

Download data

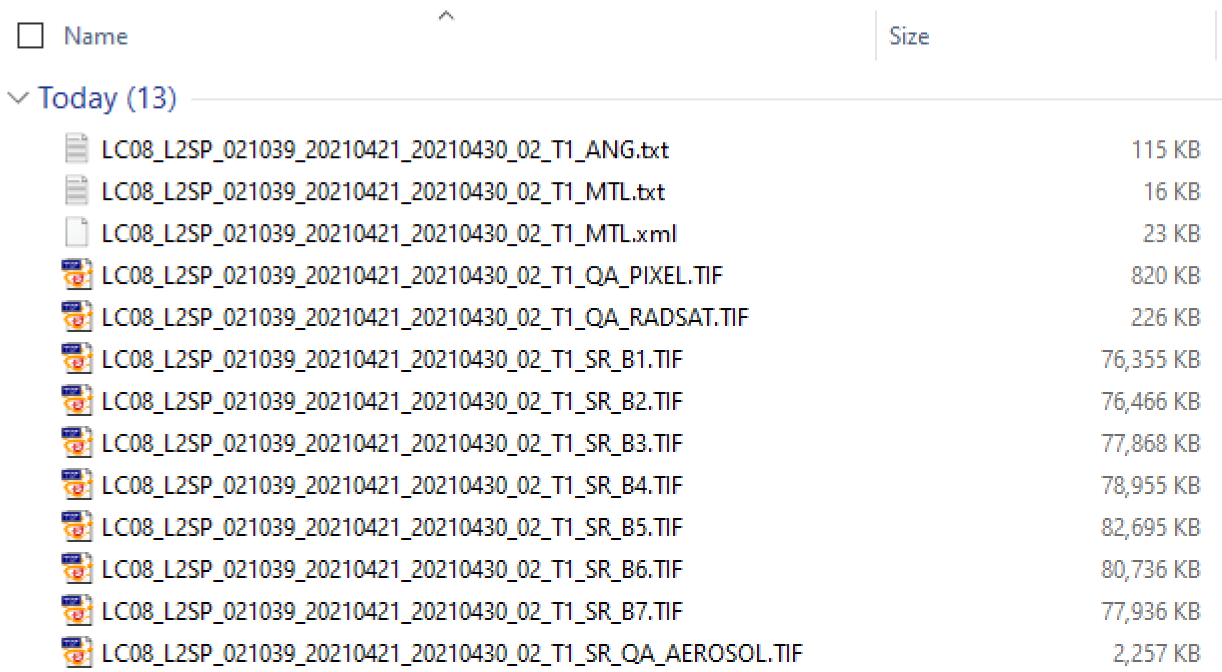
Now that you have identified a scene with the fewest clouds, it is time to download. You can learn to use the data in the cloud or copy the image ID to use in [EarthExplorer] to download an entire scene. For this example, we will download one band at a time.

In the metadata tab, under the actions column there are SR (surface reflectance) bands and ST (surface temperature) bands. For this example, we will download the surface reflectance bands. You can download only the bands you need such as red and near-infrared (nir) to calculate NDVI algorithm. ArcGIS Pro understands the Landsat metadata file (MTL) be sure to download all the bands.

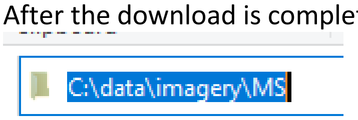
Download each of the files for the 21/39 acquired on 21 April 2021.



These are geoTIFFs with the same file name as the ID with the addition of *SR* for surface reflectance and the OLI band name. In the file above is band 1, *B1*. These files can take a long time to download. Note in the following image that the surface reflectance bands are nearly 60MB each.



After the download is complete, move the files to your project data directory. An example is:



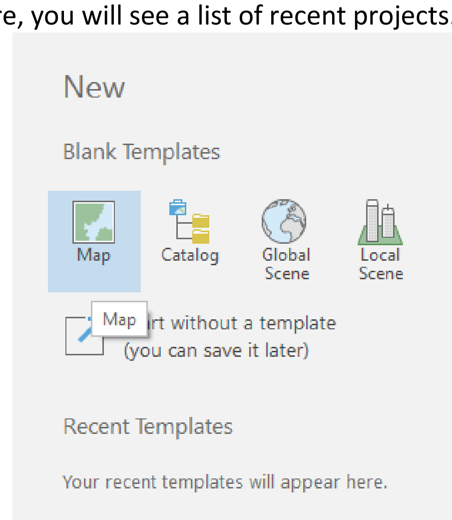
This makes it easier to prepare and use the data in projects.

Open the image in ArcGIS Pro

Depending on your internet connection, this step will need to wait until all the files are complete. This is another reason to investigate using the cloud services to storage and process data instead of moving it to your computer.

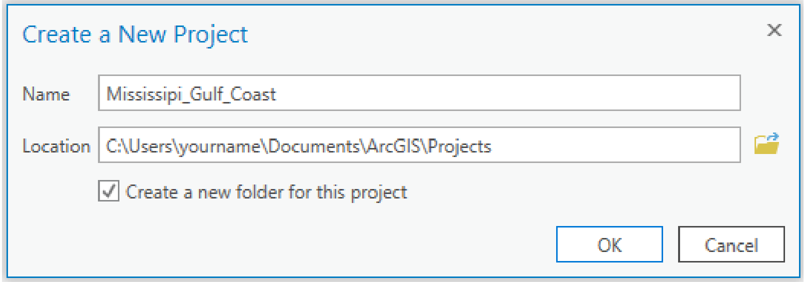
NB: Be sure you have created an ArcGIS Pro or an ArcGIS account. Use your go.olemiss.edu account for this purpose so IT can associate the university site license to your account.

When you open ArcGIS Pro, you are given the option to create a new project or open an existing one. If you have created a project before, you will see a list of recent projects.



The **Map** template creates a project with a default basemap.

In the **Create** a New Project window, change the project name to **Mississippi_Gulf_Coast**.



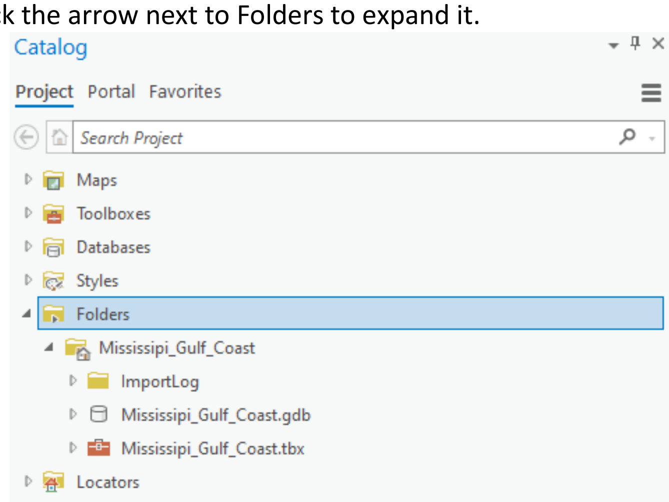
TIP: By default, the project is saved to the ArcGIS folder, located in your **Documents** folder. If you want to save the project elsewhere, browse to a different location.

Click OK.

The project opens and displays a map view. In default ArcGIS Pro configuration, the **Catalog** pane is to the right of the map. The **Catalog** pane contains all the folders, files, and data associated with this project. You will use this pane to establish a folder connection to the Mississippi_Gulf_Coast folder you created earlier.

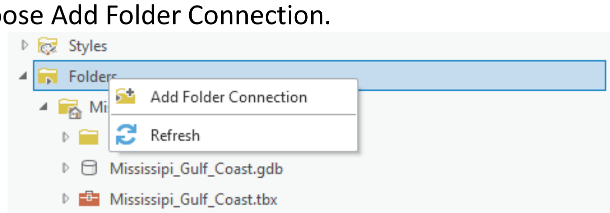
TIP: If you have used ArcGIS Pro before, your **Catalog** pane may be in a different place or not visible at all. To show the **Catalog** pane, click the View tab on the ribbon at the top of the window. In the **Windows** group, click **Catalog**.

In the **Catalog** pane, click the arrow next to Folders to expand it.



The default folder associated with the project is Mississippi_Gulf_Coast a folder that was made when you created the project, and which shares the project's name. The folder contains some empty geodatabases and toolboxes but no actual data.

Right-click Folders and choose Add Folder Connection.

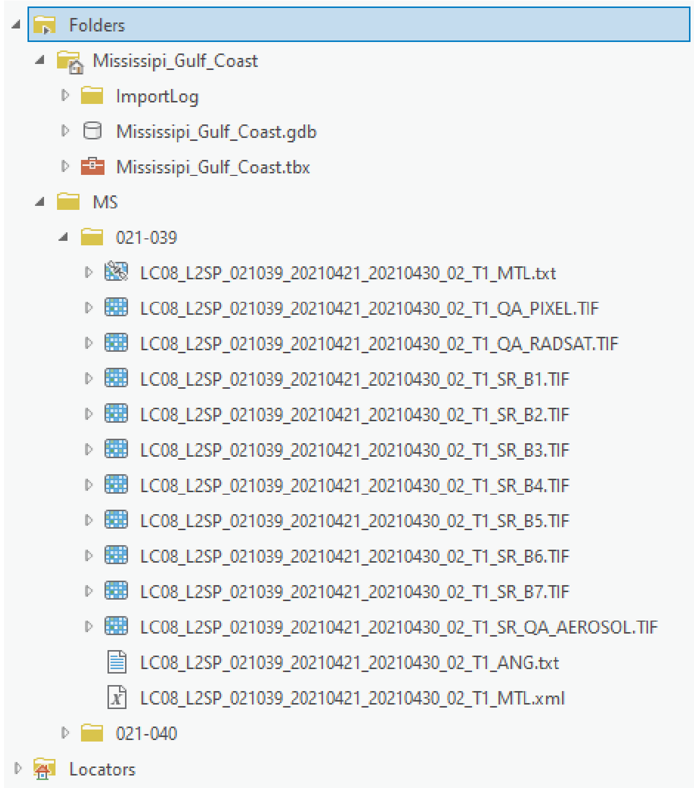


The **Add Folder Connection** window appears, showing a directory of your computer's files.

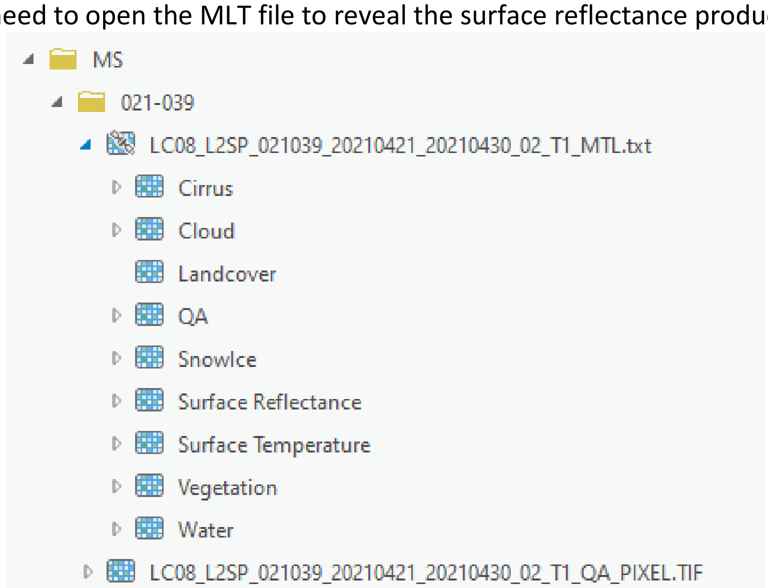
Browse to and select the **MS** folder where you extracted your Landsat image.

The **MS** folder is added under **Folders** in the **Catalog** pane.

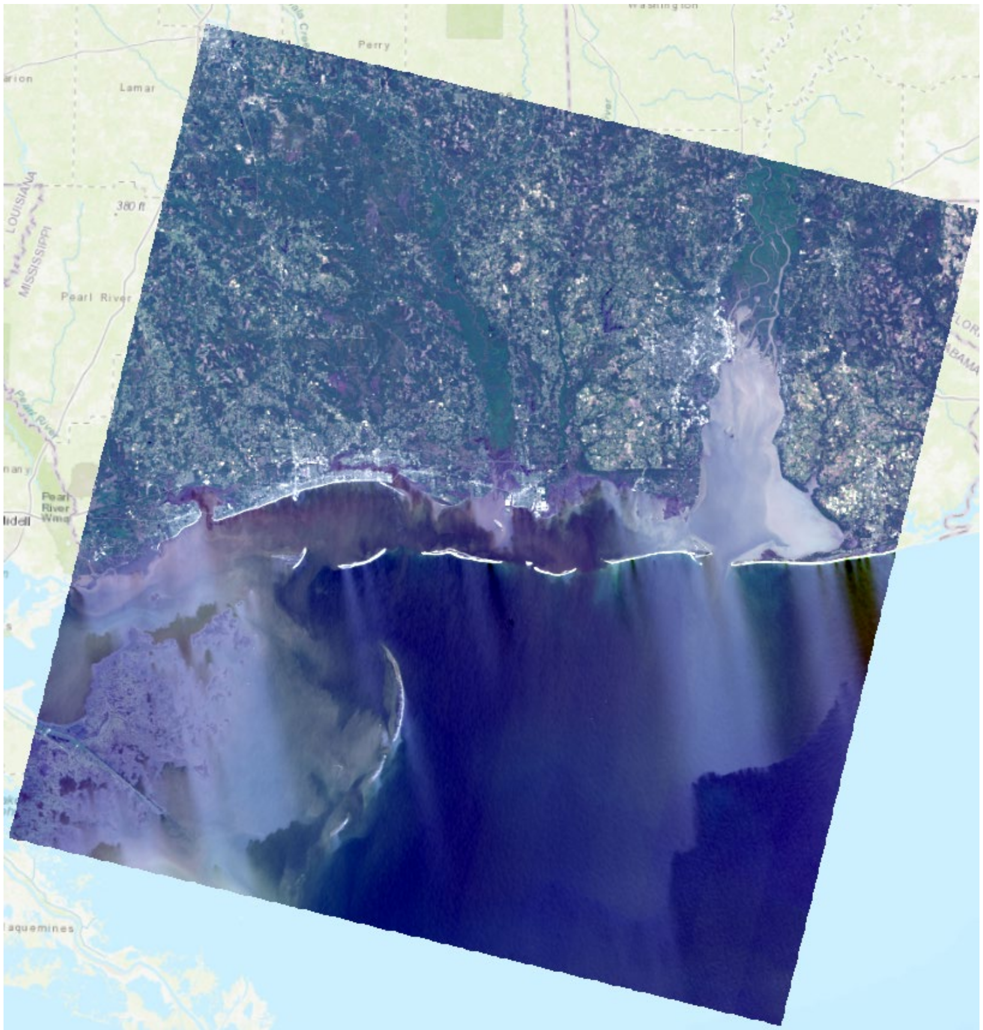
Expand the **MS** folder.



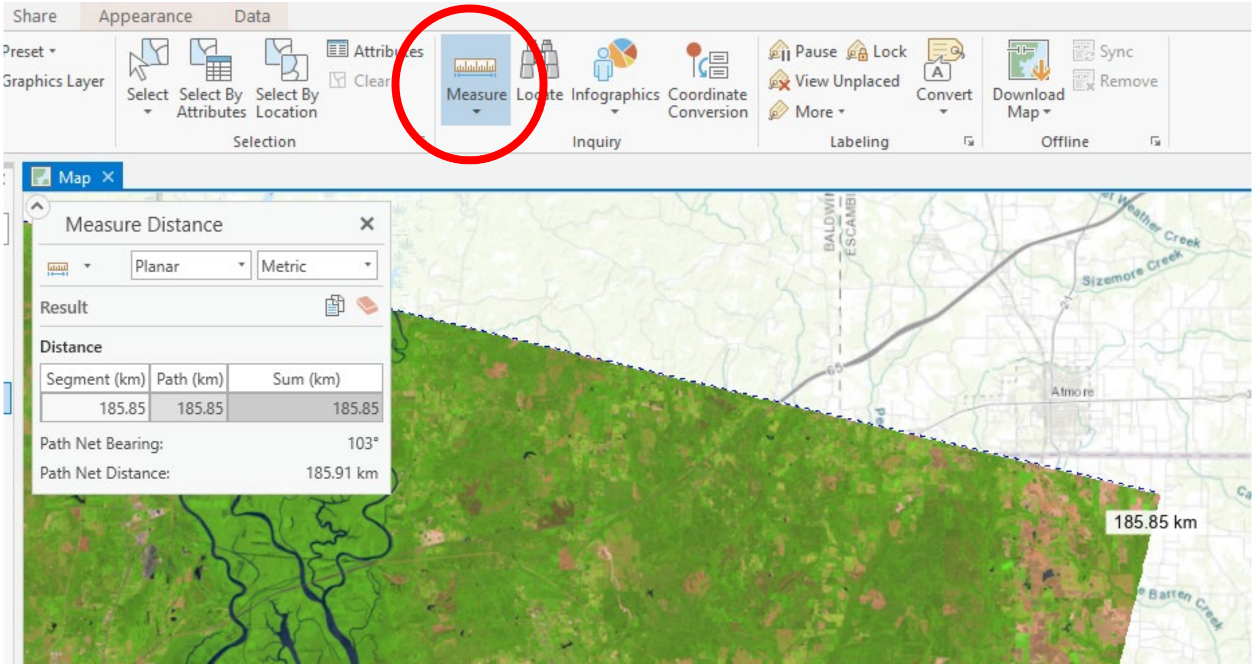
In the directory structure above, imagery is divided into path/row. For Gulfport, the imagery is in path 21, row 39. The folder contains the 12 individual spectral bands. To display a single multispectral image that contains all the bands, you'll add the first file on the list, which ends with MTL.txt. MTL.txt indicates a metadata text file, but it is a raster product that has been generated with the information in the metadata file. You need to open the MLT file to reveal the surface reflectance products.



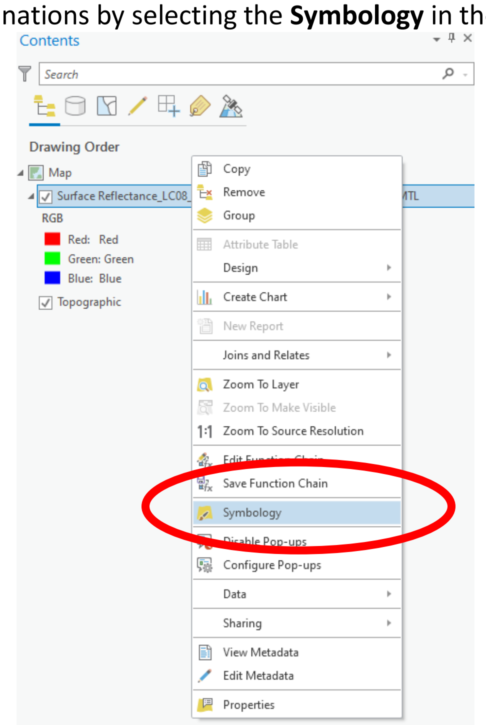
Select the **Surface Reflectance** product and drag the raster icon onto the map.
NB: If a window appears, asking to build pyramids for the image, click Yes.



In the **Map** pane, at full extent, you can clearly see the size of a Landsat image with the footprint of approximately 190km. ArcGIS Pro recognizes the correct band names from the MTL file and the symbology is correctly assigned to the image. Even the NOData pixels have been automatically symbolized with transparency.



You can change the band combinations by selecting the **Symbology** in the **Contents** pane.

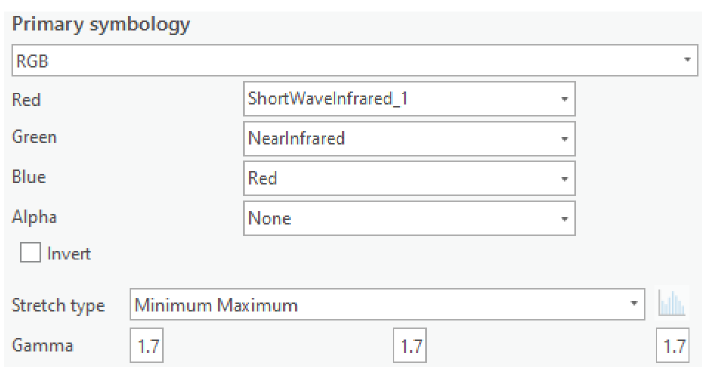


TIP: If you have used ArcGIS Pro before, your Contents pane may be in a different place or not visible at all. To show the Contents pane, click the View tab on the ribbon. In the Windows group, click Contents. The **Symbology** pane appears. The **Primary Symbology** section lists the bands used to display the image (they are also shown in the **Contents** pane). By default, the Red, Green, and Blue bands are used. These bands cover parts of the EM spectrum visible to the human eye and together approximate a natural view of the landscape. For urban development, a view that emphasizes features relevant to the city may be more appropriate. The following table lists each band and what it shows best:

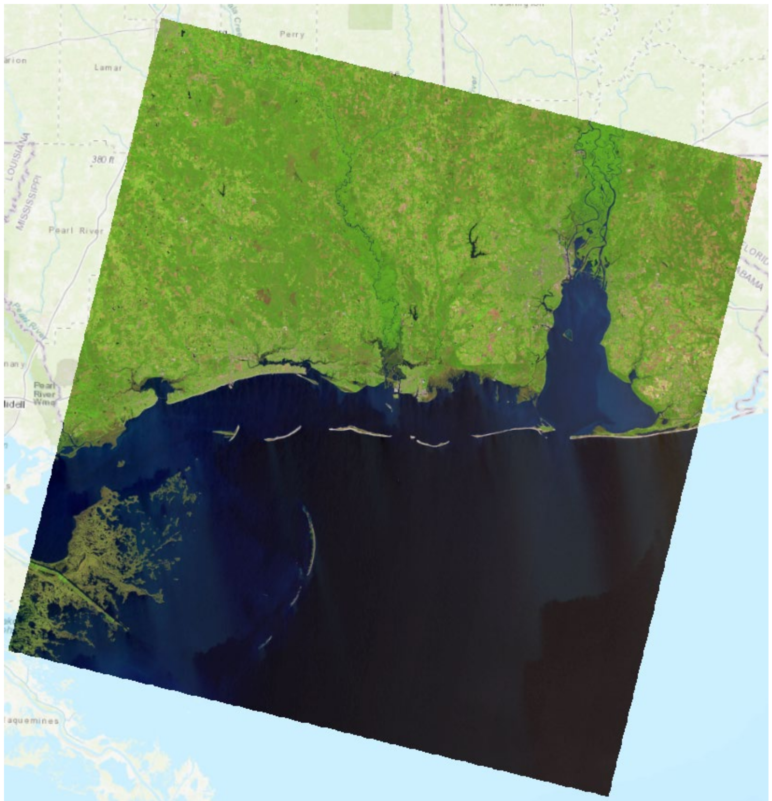
Band Number	Name	What this band shows best
1	Coastal Aerosol	Shallow water, fine dust particles
2	Blue	Deep water, atmosphere
3	Green	Vegetation
4	Red	Man-made objects, soil, vegetation
5	Near Infrared	Shorelines, vegetation
6	Shortwave Infrared 1	Cloud penetration, soil and vegetation moisture
7	Shortwave Infrared 2	Improved cloud penetration, soil and vegetation moisture
8	Panchromatic	Black and white imagery, crisper detail
9	Cirrus	Cirrus clouds
10	Thermal Infrared 1	Thermal mapping, estimated soil moisture
11	Thermal Infrared 2	Improved thermal mapping, estimated soil moisture

The **Red** band would emphasize the man-made objects of Gulfport's urban environment, while the **Near Infrared** band would emphasize its coastlines and tight boundaries. The **Shortwave Infrared 1** band would also be useful to mitigate the appearance of the clouds in the image and highlight water sediment.

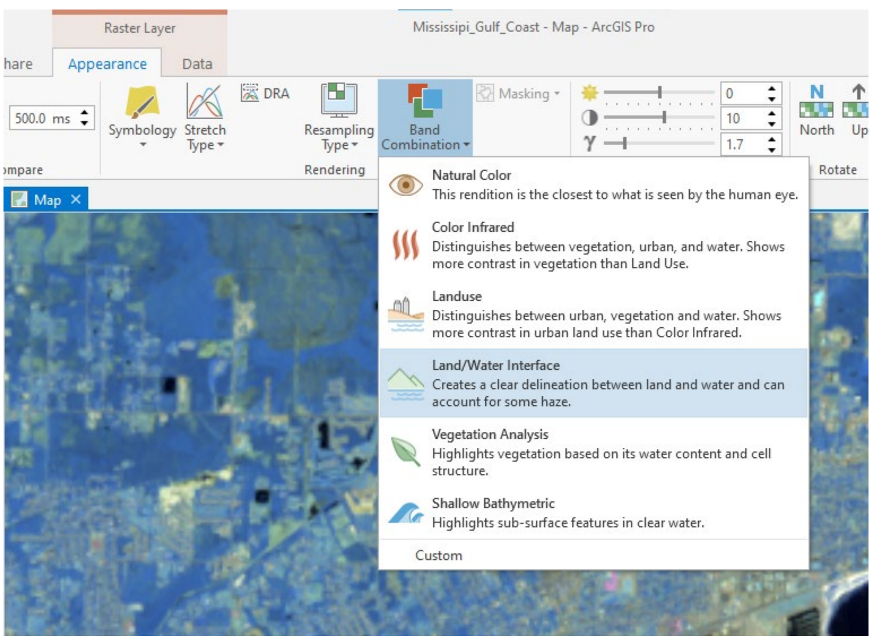
In the **Symbology** pane, change the first band to **ShortWaveInfrared_1**, the second band to **NearInfrared**, and the third band to **Red**. Additionally, change the histogram stretch type to **Minimum Maximum**.



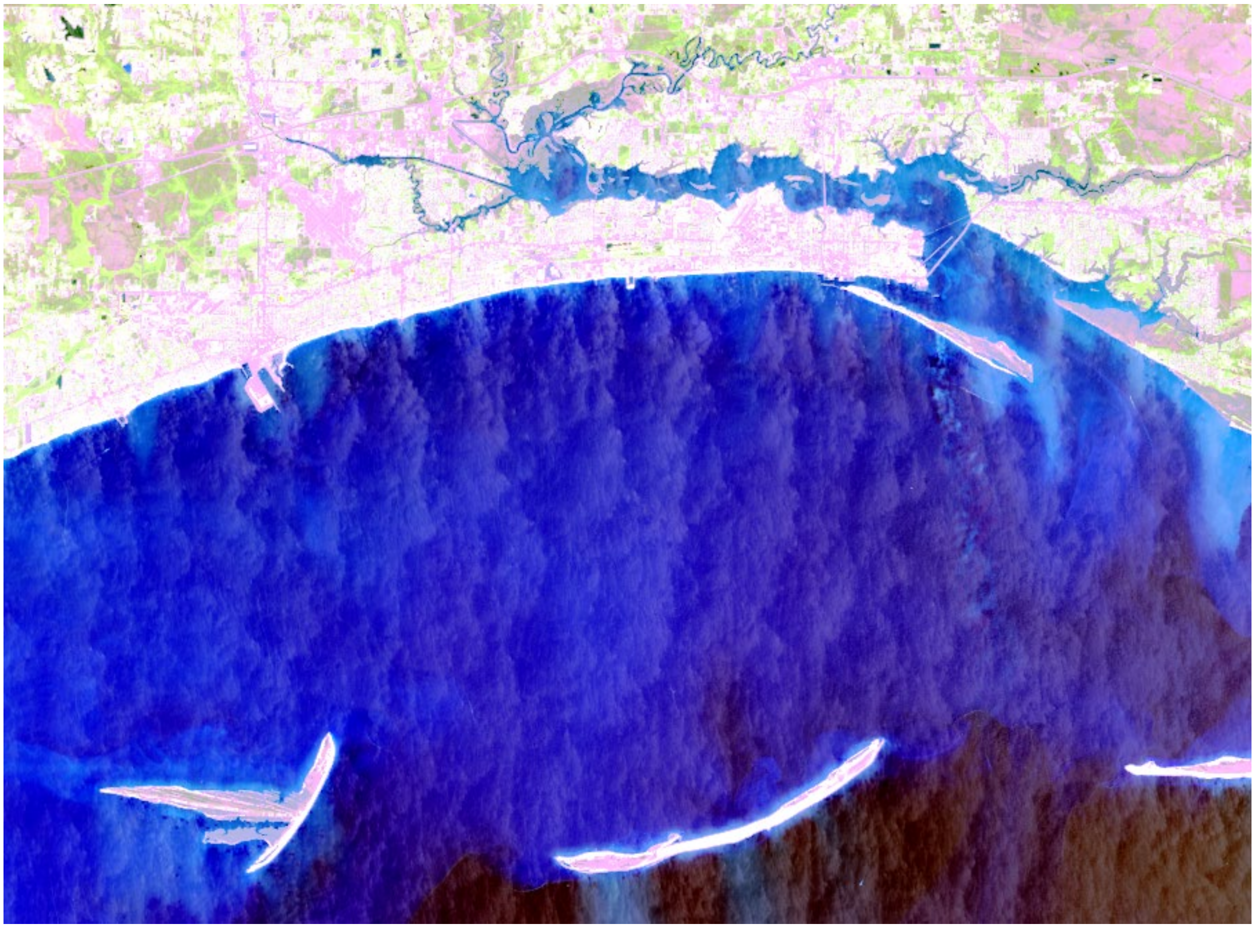
The image on the map changes automatically.



The coastlines are much more defined, and urban areas appear as distinct.
Other popular band combinations can be found under the **Raster Layer** tool ribbon and **Band Combinations.**



Feel free to try different band combinations and histogram stretch types. The following is a histogram equalization. You can observe the shallow marine turbidity plumes moving off shore.



On the **Quick Access Toolbar** to the upper left of the application window, click the **Save** button to save the project.

In this lesson, you searched the massive, nearly 50-year database of imagery captured by Landsat satellites to find one showing the Mississippi Gulf Coast. After locating the image, you downloaded it, opened it in ArcGIS Pro, and changed its band combination to better show the region.

Exercise 1

Familiarize yourself with the ArcGIS Pro application and the many menu options and buttons. For help, pass the mouse over the button in question and a description of the button will display in the lower left corner of the Viewer. Use HELP or press F1 for additional assistance.

CHANGING BAND COMBINATIONS

You will be able to change the band combinations and associate the RED-GREEN-BLUE of your computer screen to specific spectral responses for each band. The image you are viewing is a subset of a Sentinel-2 image acquired on 18 September 2017. ONLY the 10-m bands are stored in the geoTIFF. A single sensor, multi-spectral instrument (MSI) collects the 13 spectral bands onboard the Sentinel-2 spacecraft. **<u>Complete the TABLE at the end of the laboratory for Sentiel-2 MSI bands.</u>**

By selecting the band combination 3-2-1 the R-G-B of the computer screen will display nearly the same visible light signature that your own eyes would have seen when the image was captured.

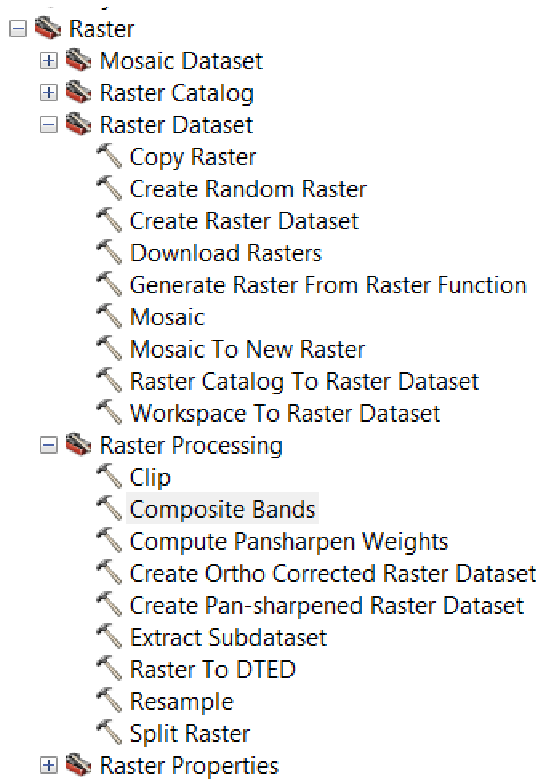
Try assigning layer 4 (MSI Band 8) to all three display colors (RGB). The pixels with the highest reflectance in the spectrum detected in band 8 will display whiter. Area with little reflectance will appear more black. Note that band 4 infrared have a wavelength of 0.784-9.00 μm, in the infrared portion of the spectrum. Therefore, features that absorb in this spectrum will appear black. Confirm this with Sardis Reservoir. The water of Sardis will absorb energy in the infrared spectrum.

Try the spectra order of bands 1,2,3 assigned to display colors Red, Green, Blue. This band combination will display the color blue reflectance as red, green as green and red as blue.

NOTE FOR <u>FUTURE</u> WORK:

To create this spectral and spatial subset, ArcGIS was used. When downloading imagery, the data is typically delievered in separate bands. Sentinel-2 data has 13 individual files. To create a SINGLE image you must "COMPOSITE" the images into the correct order. Other software use the term "STACK". In ArcGIS, you could search the term composite or it is found in the following location:

System Toolboxes/Data Management Tools/Raster/Raster Processing/Composite Bands



Exercise 2

With the Sentinel-2 data in the Viewer, load in additional vector data from the laboratory data package.

Practice MERGING the vector data into a single feature class.

Change the symbology of the vector data.

Metadata:

The transportation data came from the USGS National Transportation Dataset (NTD) for Mississippi found at the National Map. *Why do you suppose there are three (3) different files? Is there a difference in the three vector files?* Here is the link to the Metadata:

https://www.sciencebase.gov/catalog/item/4f70b1f4e4b058caae3f8e16

Exercise 3

With the Sentinel-2 and vector data in the Viewer (dataspace), load in an imagery Basemap from ArcGIS. Compare the pixel sizes and use the Image Analysis tools to add transparency to the Sentinel-2 data so you can view the imagery Basemap below your data in the viewer. Arrange the data layers in the Table of Contents (ToC). The data is rendered in the bottom-up direction so the data listed on top of ToC is seen on top of the viewer.

Explore the imagery and comment in class about the pixel size and how will you can interpret the Sentinel-2 imagery.

Deliverables-

For this laboratory you must complete the following table and participate in the discussions. Throughout the semester you will be required to fill out reports, save files, and/or print exercises to be used as the laboratory grade.

SENTINEL-2 Bands **Name:**___________________________________

Band #	Used in laboratory	Resolution (meter/pixel) (m/px)	Spectral window (nm) and general name (*also known as bandwidth*) (example response: ***420-430nm Blue***)
B01			
B02	X – Layer 1		
B03	X – Layer 2		
B04	X – Layer 3		
B05			
B06			
B07			
B08	X – Layer 4		
B08A			
B09			
B10			
B11			
B12			