THE GEO PROJECT
GEOSPATIAL EDUCATION & OUTREACH

GEO TUTORIAL

SURFACE WATER MAPPING USING LANDSAT IMAGERY IN ARCGIS PRO

Flavia Xavier
Andrew Nagel
John Cartwright

Geosystems Research Institute
Mississippi State University

AUGUST 2025

The Geospatial Education and Outreach Project (GEO Project) is a collaborative effort among the Geosystems Research Institute (GRI), the Northern Gulf Institute (a NOAA Cooperative Institute), and the Mississippi State University Extension Service. The purpose of the project is to serve as the primary source for geospatial education and technical information for Mississippi.

The GEO Project provides training and technical assistance in the use, application, and implementation of geographic information systems (GIS), remote sensing, and global positioning systems for the geospatial community of Mississippi. The purpose of the GEO Tutorial series is to support educational project activities and enhance geospatial workshops offered by the GEO Project. Each tutorial provides practical solutions and instructions to solve a particular GIS challenge.

SURFACE WATER MAPPING USING LANDSAT IMAGERY IN ARCGIS PRO

Flavia Xavier[1] (flavia.xavier@msstate.edu)
Andrew Nagel[1] (andrewn@gri.msstate.edu)
John Cartwright[1] (johnc@gri.msstate.edu)

[1] Geosystems Research Institute, Mississippi State University

---

REQUIRED RESOURCES
- ArcGIS Pro (v. 3.0 or higher, with Spatial Analyst Extension)
- Internet access to download Landsat image

FEATURED DATA SOURCES
- USGS Earth Explorer: https://earthexplorer.usgs.gov/
 - \> 2025 Landsat Image – New Orleans, LA

OVERVIEW

This tutorial will guide you through the steps of using a Landsat image to calculate the Modified Normalized Difference Water Index (MNDWI) and classify surface water pixels using ArcGIS Pro. The MNDWI highlights water features while suppressing land features such as vegetation, soil, and built-up areas, making it helpful in mapping water. You will learn how to download a Landsat image, process it in ArcGIS Pro, and customize symbology to create a clear visualization of surface water. While the USGS Earth Explorer serves as the data portal for Landsat image acquisition in this tutorial, alternative platforms, such as NASA Earth Data, also offer valuable datasets for similar analyses.

The focus of this tutorial is to help you develop practical skills in identifying and mapping surface water using remote sensing data in ArcGIS Pro. Our case study is located in the New Orleans, LA area. By the end of this tutorial, you will generate a binary water mask from satellite image, which can be used in further spatial analysis and support a wide range of applications, including flood mapping, land cover classification, environmental monitoring, and coastal resilience planning.

STEP 1. DOWNLOAD LANDSAT-9 IMAGE

A. Visit USGS Earth Explorer and log in. If you don't have an account, create one before proceeding. Image downloads are free. If you already have a Landsat image downloaded that you want to work on, you may skip Step 1.

B. In the **Search Criteria** tab, under **Select a Geocoding Method**, click **Feature (GNIS)** to view the options and select **Address/Place.** Ensure you're logged in to enable this option.

C. In the **Address/Place** blank space, type your area of interest. In this tutorial, we will work with the New Orleans area. Type **New Orleans** and click **Show**. Select the location from the suggestions. The map will point to the area.

D. In the **Date Range** tab, set the dates from **1/1/2025** to **1/31/2025**. Next to the Data Range tab, in the **Cloud Cover** tab, set the Cloud Cover Range to **0%-10%** to ensure visibility and improve accuracy, then click **Data Sets**.

E. From the data set options, click **Landsat > Landsat Collection 2 Level 2 > Landsat 8-9 OLI/TIRS CS L2**. Click **Results**.

F. From the options displayed, select the one dated **2025/01/25**. Click the **Download Options** icon 🔽 and choose **Download All Files Now** for **Level-2 Surface Reflectance Bands (13 files)**. We use surface reflectance bands instead of surface temperature bands because they provide atmospherically corrected surface reflectance values that account for atmospheric effects. These bands are ideal for distinguishing between land and water.

G. After the download is complete, move it to your preferred folder and ***unzip*** it. You will work with the *.tif* format files.
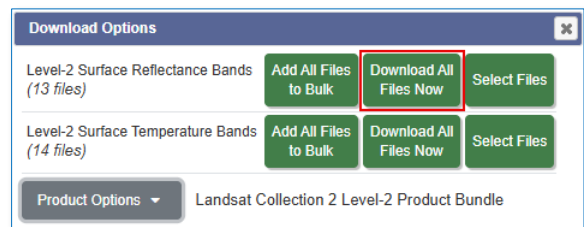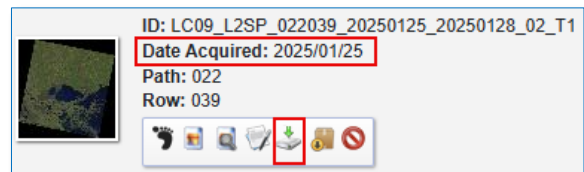
## STEP 2. LOAD THE BANDS INTO ARCGIS PRO AND CREATE A COMPOSITE RASTER

A. Open ArcGIS Pro and either create a new project or open an existing one.

B. Click the **Add Data** button on the ribbon, navigate to the folder where you saved the data, and add both **Band 3** and **Band 6** to your map. These bands typically appear in grayscale. The analysis requires these bands be combined into a single raster.

C. To combine the bands into a single multi-band raster, go to **Analysis** tab and click **Tools**. In the **Geoprocessing** pane, search for **Composite Bands**. Open the tool and under **Input Rasters**, click the drop-down arrow to select **Band 3** first (Green, band 1), then **Band 6** (SWIR1, band 2) in that order. This will assure that the resulting raster aligns with the expected band positions for the MNDWI calculation (*MNDWI = (Green − SWIR1) / (Green + SWIR1)*). Name your **Output**
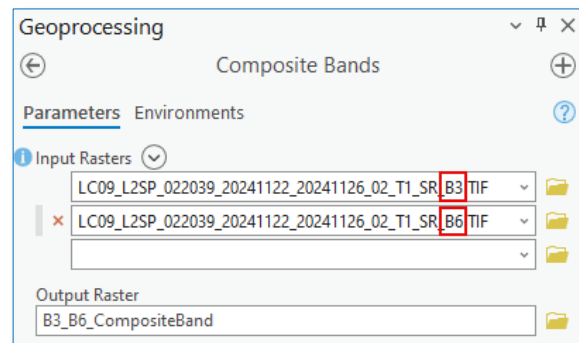
Raster as desired and click run. The output will be a two-band raster with the necessary inputs for the MNDWI calculation (see image 2 in the figure on the last page for reference).

STEP 3. CALCULATE THE MNDWI FOR SURFACE WATER ANALYSIS

A. To compute the MNDWI index, click on your newly created **composite band layer** on the Contents pane to activate it. Go to the **Imagery** tab, **Tools** group, click **Indices**, then select **MNDWI** 💧. In the MNDWI window, set your composite raster as the input. Assign the first band to **Band 1** (which corresponds to your Band 3 – or Green band), and the second band to **Band 2** (which is your Band 6 – or the SWIR1 band). Again, band order matters! Click **OK**. After the tool runs, you will see a new raster with MNDWI values, where water typically appears brighter, with values > 0.
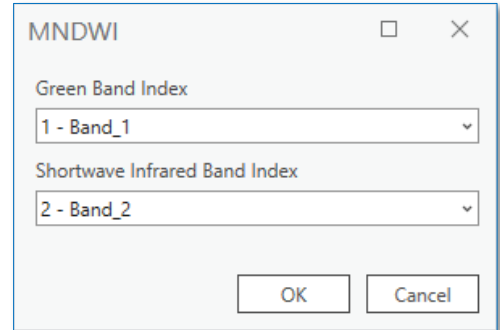
## STEP 4. RECLASSIFY THE MNDWI TO CREATE A WATER MASK

Now, you will convert the continuous MNDWI values into a binary raster to classify pixels as either *water* or *non-water*, isolating the water features in the image.

A. Go to the **Analysis** tab and click **Tools**. Search for **Reclassify (Spatial Analyst Tools)**. In the Reclassify window, select your MNDWI composite band raster as input and click **Classify**.

B. In the Classify window set Classes to **2** and change the method to **Manual Interval**, this will allow you to specify the upper values for each class. For this tutorial, you will type **0** then **1** as entries for the **upper values.** Values < 0 will now be 0 (non-water), and values > 0 will be classified as 1 (water). Keep in mind that MNDWI thresholds can vary by region and season, so feel free to test different cutoffs based on your image. Click **OK**.

C. The table in the Geoprocessing pane will populate with the *Start*, *End,* and *New* values. Update the **New** values with the threshold upper values, choose an output name, and click **Run**. This creates a binary raster where 1 = water and 0 = non-water.
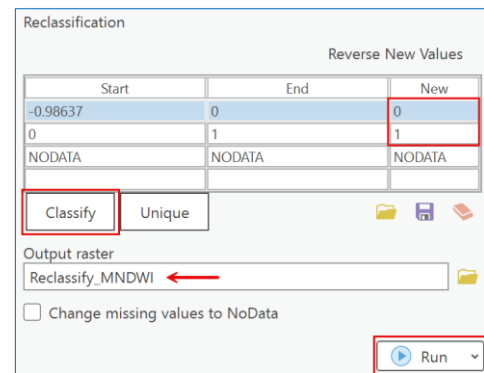
STEP 5. SYMBOLIZE TO VISUALIZE THE WATER MASK, SAVE AND SHARE YOUR MAP

A. The reclassified raster will be automatically added to your map. In the Contents pane, right-click on it and select **Symbology**. Set value 1 to **blue** to represent water, and value 0 to **no color** or a color of your choice. Click **Save Project** 🖫.
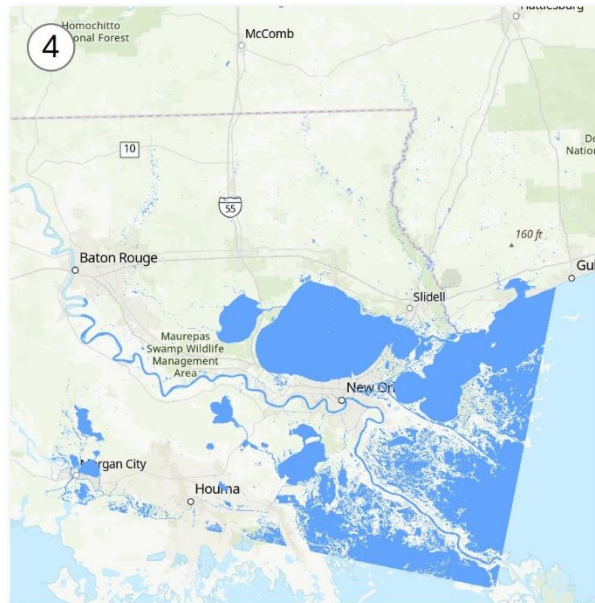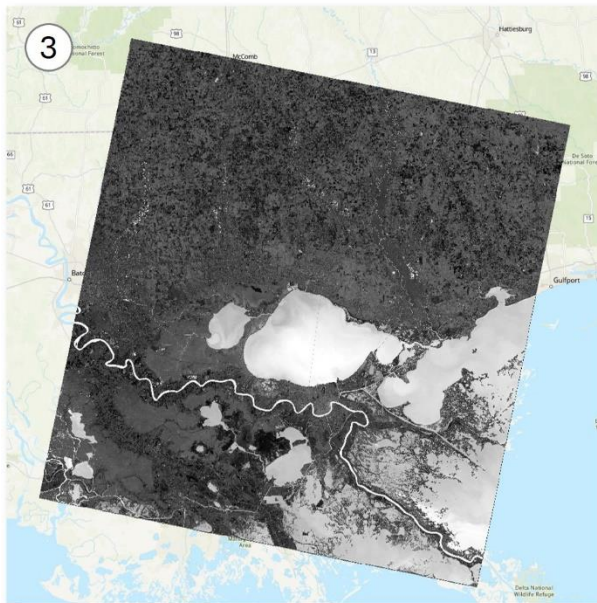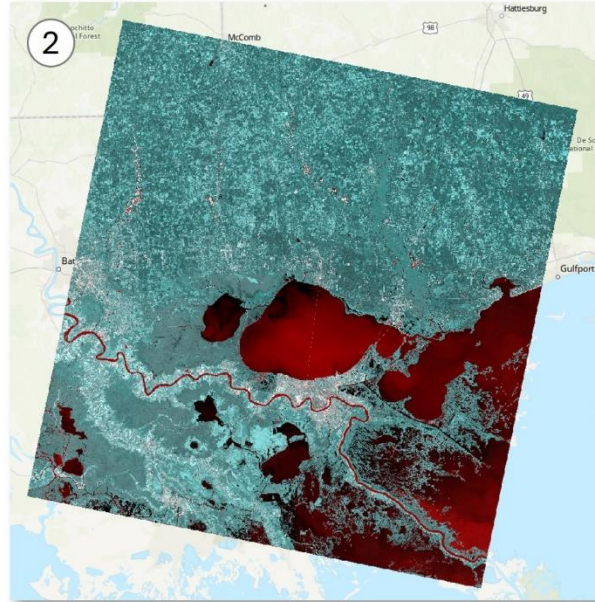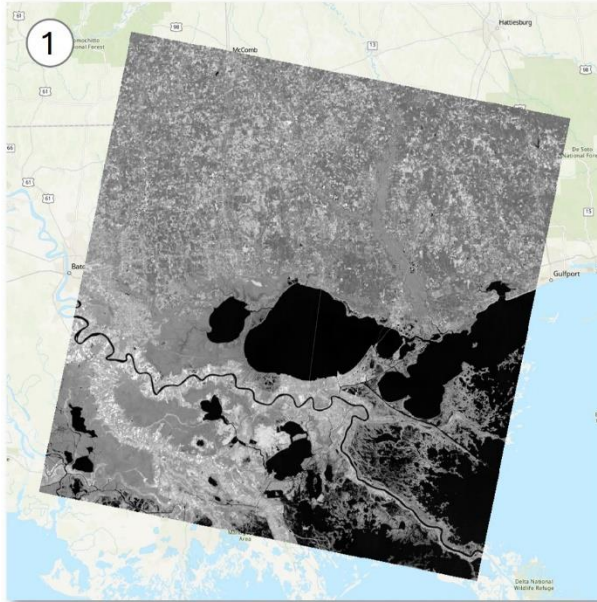
At this point, you've created your water mask and are now ready to design a layout and share your results! The mapping process you followed is illustrated above: 1) the original Landsat image downloaded in Step 1, 2) the composite raster created with bands 3 and 6 as seen in Step 2, 3) the raster with the MNDWI calculated in Step 3, and 4) the reclassified output with the water mask extracted in Steps 4 and 5. The resulting map highlights the water bodies and supports critical applications. Continue exploring other areas and applying these techniques to your own projects to uncover new insights and broaden your geospatial expertise!