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ArcGIS based drone image analyses

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NSF drone eelgrass mapping project along the west coast of North America

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1. Import imagery to ArcGIS and manually digitizer

1.1 Adding Orthomosaics to ArcMap

This section covers adding your processed orthomosaics to ArcMap in order to prepare them for digitization.

1. Open **ArcMap**.
2. Click *File* then *Sign In*.
3. Log in with your ArcGIS Online account that contains your uploaded orthomosaics.
4. Click the *Add Data* icon on the top banner.
   
5. Choose “My Hosted Services” from the dropdown menu.
6. Select your desired orthomosaic to work with and click *Add*.
7. Your orthomosaic will be added to the table of contents on the left.

1.2 Creating a Geodatabase

In this section you will learn how to create a geodatabase and feature layers used by Open Reef for digitizing purposes. This tutorial describes how to create and digitize feature layers for islands, structures, docks, and sea walls. You may create additional feature layers using these instructions as you see fit.

1. Click the Catalog icon in the top banner.
2. The catalog tab will open on the left.
3. Click the Connect To Folder icon at the top of the tab.
4. Locate the folder in which you want to save your digitized files and click OK.
5. Right-click your chosen folder, go to New, and click File Geodatabase.
6. Change the name of the geodatabase (GDB) to something relating to the area to be digitized (ex. Eelgrass_site1).

7. Right-click the new GDB, go to New, and click Feature Class.
8. Create a name and alias for the feature layer to be created.

   Note: Open Reef uses a classifier at the beginning of each feature layer denoting the island that will be digitized followed by the feature to be digitized. For example, when creating a feature layer to digitize structures on Indian River Lagoon we would type “IRL_Structure.”
9. Choose Polygon Features from the “Type” when creating the island, structures, and docks feature layers.
10. When creating the sea walls feature layer, choose Line Features from the “Type” dropdown.
11. Click Next.
12. Choose the coordinate system you wish to work with.

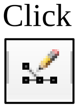
    Note: Open Reef uses WGS 1984 as the preferred coordinate system.
13. Click Next three times then click Finish.
14. Repeat Steps 7-12 until you have all the feature layers you need.
15. The feature layers will now appear under your GDB.

1.3 **Digitizing Orthomosaics**

This section covers Open Reef digitizing practices and helpful tips.

1. Click and drag the feature layers you wish to work with from the catalog tab into the table of contents tab on the left.
2. Once all your feature layers are added, click and drag your orthomosaic so that it is at the bottom of your table of contents.
3. Using the Pan tool, move around the orthomosaic to better understand its layout.
4. Set the Map Scale in the upper banner to 1:250.

   Note: Open Reef digitizes at 1:250 scale for all orthomosaics.
5. Click the Editor Toolbar icon in the top banner.

6. Click the Editor dropdown button and select Start Editing.
7. Click the Create Features icon.
8. The create features tab will open on the right.
9. Select the feature you wish to digitize and select Polygon from “Construction Tools” at the bottom.
10. You can now click around the feature you wish to digitize. Once you are done digitizing the feature you can double-click to finish.
11. Click the Editor dropdown button and select Save Edits.

    Note: You will want to continually save your digitizing this way. If ArcMap were to crash without saving then you would lose everything.
12. Once you are finished digitizing all your features, click the Editor dropdown and select *Stop Editing*.

13. The following are guidelines and helpful tips for digitizing:

    a. **Changing Symbology**: You can change the symbology of your polygon-based feature layers by clicking the Symbol Selector icon (the colored box) under each feature layer in the table of contents. From there, select “Hollow” and set the “Outline Width” to a value of 2. This makes it easier to see what you are digitizing during the process.

    b. **Panning while Digitizing**: You can continue to move around the map by clicking the Pan icon, moving to your new location, and clicking the current feature in the create features tab to continue where you left off. If your mouse has a scroll wheel, you can also click that in the enable panning.

    c. **Minimum Mapping Unit**: Open Reef uses a minimum mapping unit for digitizing islands and structures. For structures, you at least need to digitize the roof. If the structure has a smaller cover on top then you would need to digitize the larger roof underneath it. For islands, if a patch of mangroves are distanced from a larger cluster then you would only need to digitize it if the patch were approximately double the size of your crosshair.

d. **Margin of Error**: Open Reef uses the crosshair while digitizing as a margin of error. As long as the edge of what you are digitizing and your digitized outline are approximately the same distance as the size of your crosshair then you are following best practices. See the examples below for a visual comparison.

Good Example Bad Example Bad Example

e. **Cleanliness**: Try to avoid jagged edges when digitizing. If part of your feature is the rounded corner of an island, then places several vertices along that line to represent the curvature. See the examples below for a visual comparison.

Cleanliness Examples

Good Example Bad Example

1.4 Uploading Digitized Data to ArcGIS Online

Follow these instructions to upload previously digitized data to ArcGIS Online.

Add the digitized files from one area (island, structures, docks, and sea walls).

1. Click *File* then *Sign In*.
2. Log in using your ArcGIS Online credentials.
3. Click *File*, navigate to “Share As,” and click *Service*.
4. Check the *Publish a service* radio button.
5. Click *Next*.
6. From the “Choose a connection” dropdown, click *My Hosted Services*.
7. Give your file a name relating to the area that was digitized and add “vector” to the end
    a. For example, if we digitized feature layers on Indian River Lagoon we would name the uploaded files as “Indian_River_Lagoon_Vector.”
8. Click *Continue*.
9. The Service Editor window will appear.
10. Leave the default settings under “Parameters.”
11. Click “Capabilities” on the left.
12. Uncheck the *Tiled Mapping* box and check the *Feature Access* box.
13. Click “Feature Access” on the left.
14. The operations allowed will vary depending on what you want to do with the digitized files. For now, only check the *Query* box.
    a. **Note:** Open Reef typically uploads digitized files online with only the capability of querying. This is done so that the files cannot be altered or deleted online.
15. Click “Item Description” on the left.
16. Type a brief summary for the files to be uploaded.
17. Enter several tags identifying the digitized files to be uploaded.
18. Type a broad description that includes the files to be uploaded, how they were

digitized, what the source imagery was, and how those files should be used.

19. Enter access and use constraints as needed.
20. For credits, list your organization and partners.
21. Click “Sharing” on the left.
22. Check the *Everyone (public)* box.
23. Click *Analyze* in the upper-right corner of the window.
24. Resolve any errors rated as “High” severity.
    a. **Note:** Oftentimes the “Medium” and “Low” errors are related to the map and scale ranges. These can be ignored.
25. After resolving the necessary errors, click *Publish* in the upper-right corner of the window.
26. Once the upload is complete your files will be available under your ArcGIS Online account.

2. Band math and vegetation index

2.1 NDVI

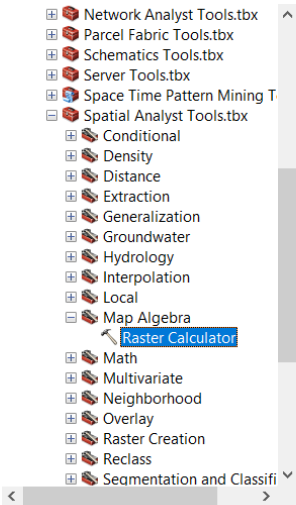
The Normalized Difference Vegetation Index (NDVI) is a standardized index allowing you to generate an image displaying greenness (relative biomass). This index takes advantage of the contrast of the characteristics of two bands from a multispectral raster dataset—the chlorophyll pigment absorptions in the red band and the high reflectivity of plant materials in the near-infrared (NIR) band. NDVI is a well-established indicator for the presence and condition (abundance, vigor and health) of vegetation. It largely compensates for changing illumination conditions, surface slope, and viewing aspects and highlights vegetation condition. Mathematically, NDVI involves the calculation of the red band and near infrared band in multispectral imagery, and has a numerical range of (-1.0, 1.0). The time series NDVI images are able to reflect short-term and long-term vegetation changes and land cover phenology. Other popular indexes such as GEMI (Global Environment Monitoring Index) and the Angular Vegetation Index (AVI) were also developed for examining the condition of vegetations, but NDVI is the most widely used index in the remote sensing field. The NDVI is calculated from band math of multi-spectral data as follows:

$$NDVI = \frac{NIR - RED}{NIR + RED} \quad (1)$$

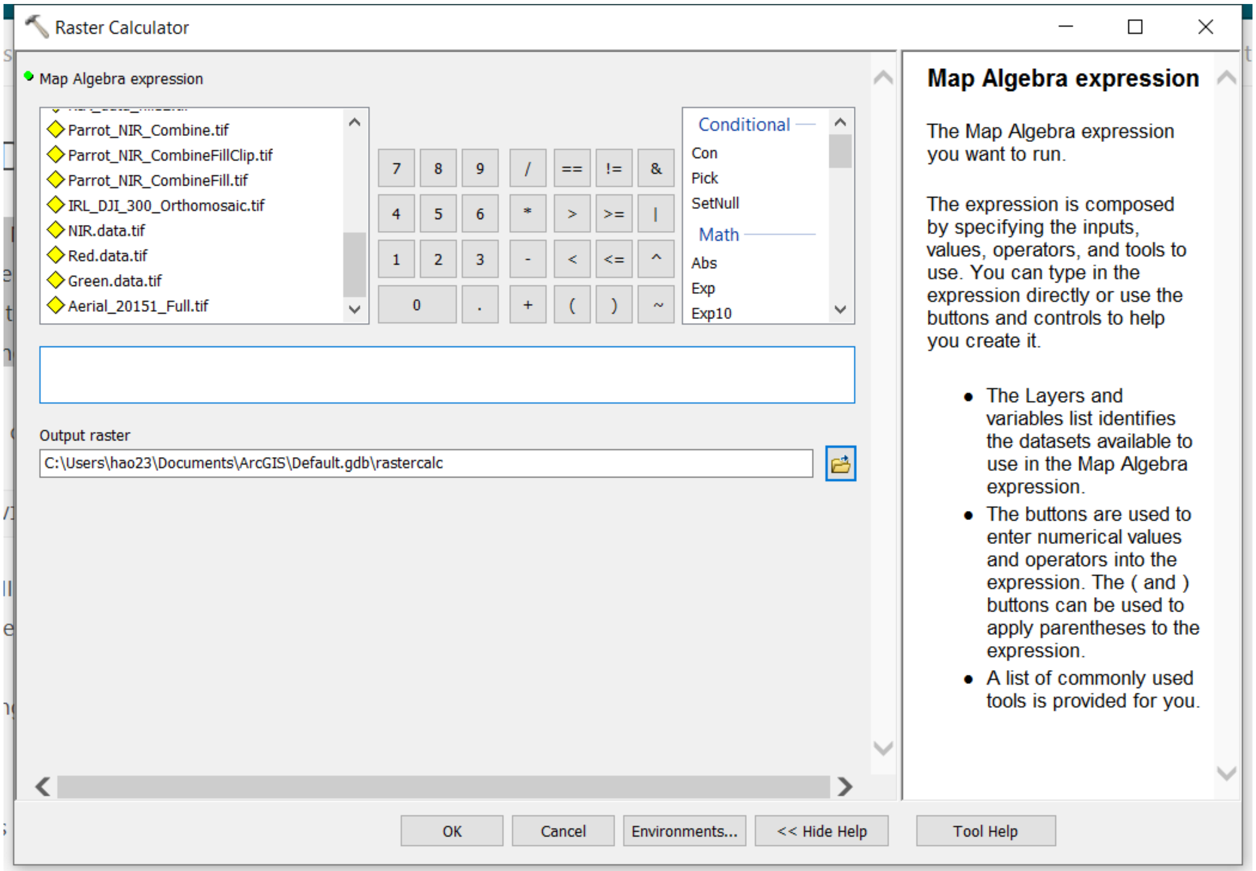
NIR = pixel values from the near infrared band

Red = pixel values from the red band

1. Find raster calculator in ArcGIS toolbox: toolboxes\system toolboxes\spatial analyst.



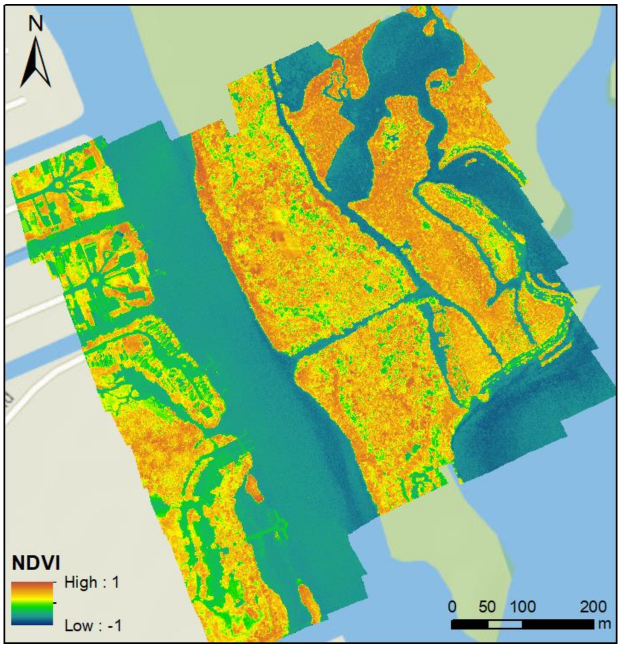
2. Run the Raster Calculator as shown below:



3. Input the Map Algebra, the basic equation is (NIR-Red)/(NIR+Red). Some times the pixel value is int, we need to *1.0 to convert it to float for the NDVI value. The map Algebra is:

```
(("NIR.data.tif" - "Red.data.tif")  * 1.0) / ("NIR.data.tif" + "Red.data.tif")
```

4. Assign an output raster location, if out put to a folder, it is better to use the file extension name of *.tif. See the below image for a sample output NDVI map.



2.2 Band math

The input bands for NDVI is NIR and Red band from the drone. Using the same band math method, more land feature index can be calculated from five bands of the drone mapping. Namely, NIR, Red edge, Red, Green, and Blue.

2.2.1 GEMI method

The Global Environmental Monitoring Index (GEMI) is a nonlinear vegetation index for global environmental monitoring from satellite imagery. It's similar to NDVI, but it's less sensitive to atmospheric affects. It is affected by bare soil; therefore, it's not recommended for use in areas of sparse or moderately dense vegetation.

```
GEMI=eta*(1-0.25*eta)-((Red-0.125)/(1-Red))
```

where,

```
eta=(2*(NIR^2-Red^2)+1.5*NIR+0.5*Red)/(NIR+Red+0.5)
```

NIR = pixel values from the near infrared band

Red = pixel values from the red band

2.2.2 PVI method

The Perpendicular Vegetation Index (PVI) is similar to a difference vegetation index; however, it is sensitive to atmospheric variations. When using this method to compare different images, it should only be used on images that have been atmospherically corrected.

```
PVI=(NIR-a*Red-b)/(sqrt(1+a²))
```

NIR = pixel values from the near infrared band

Red = pixel values from the red band

a = slope of the soil line

b = gradient of the soil line

2.2.3 GEMI method

The Global Environmental Monitoring Index (GEMI) is a nonlinear vegetation index for global environmental monitoring from satellite imagery. It's similar to NDVI, but it's less sensitive to atmospheric affects. It is affected by bare soil; therefore, it's not recommended for use in areas of sparse or moderately dense vegetation.

```
GEMI=eta*(1-0.25*eta)-((Red-0.125)/(1-Red))
```

where,

```
eta=(2*(NIR²-Red²)+1.5*NIR+0.5*Red)/(NIR+Red+0.5)
```

NIR = pixel values from the near infrared band

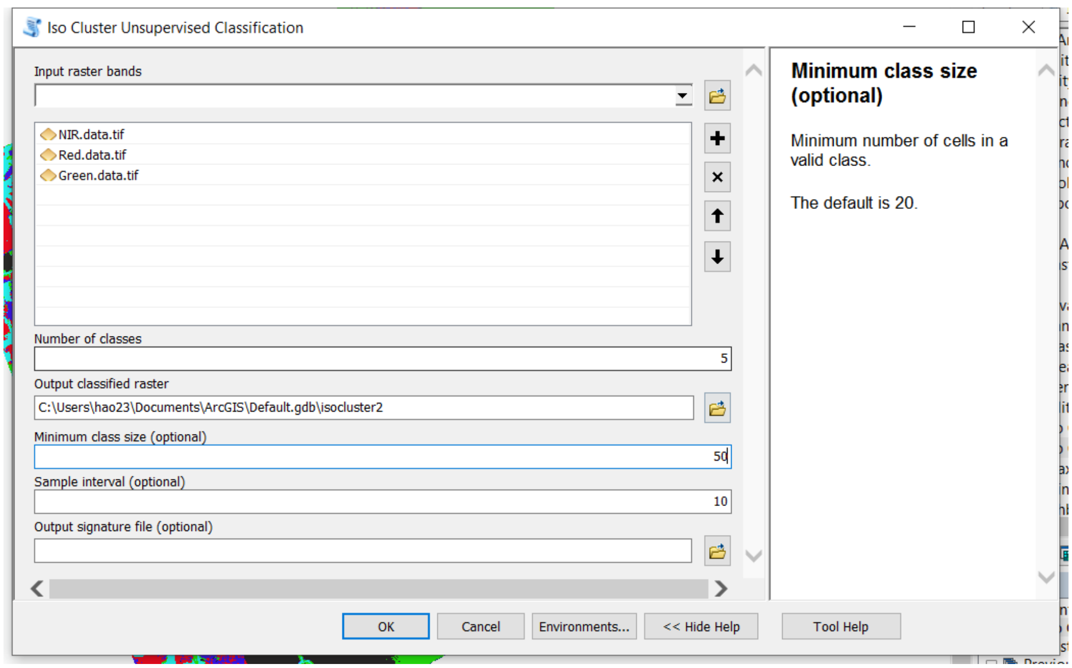
Red = pixel values from the red band

3. Classification

In ArcGIS, the Image Classification toolbar provides a user-friendly environment for creating training samples and signature files used in supervised classification. The Maximum Likelihood Classification tool is the main classification method. A signature file, which identifies the classes and their statistics, is a required input to this tool. For supervised classification, the signature file is created using training samples through the Image Classification toolbar. For unsupervised classification, the signature file is created by running a clustering tool. Spatial Analyst also provides tools for post-classification processing, such as filtering and boundary cleaning.

In this training manual, we will use a simple unsupervised classification (Iso Cluster Unsupervised Classification) as an example. This tool combines the functionalities of the Iso Cluster and Maximum Likelihood Classification tools. It outputs a classified raster. It optionally outputs a signature file. The resulting signature file from this tool can be used as the input for another classification tool, such as Maximum Likelihood Classification, for greater control over the classification parameters.

1. Open the ArcGIS toolbox, in Spatial Analyst Tools → Multivariate → Iso Cluster Unsupervised Classification.



2. We use NIR, Red, and Green bands for the classification in this example. More bands could be included depending on the classification purpose.
3. Assign number of class that expected to be classified. To provide the sufficient statistics necessary to generate a signature file for a future classification, each cluster should contain enough cells to accurately represent the cluster. The value entered for the minimum class size should be approximately 10 times larger than the number of layers in the input raster bands.
4. Assign the output location and click OK to run. Wait a moment, then it can generate the unsupervised classification results.

5. A post-classification process is needed, combining with ground truth observation. Each cluster need to be assigned to a class manually. Below is an example result.