ArcGIS Pro – Exercise 2: Rasters

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GIS Data

https://paltiti.info/research-technology/geographic-information-systems/
GIS Data Models: Raster vs. Vector

1) Raster – Images consisting of pixels
   - Shows “real world” surface features
     - reflection & emission (wavelength)
     - brightness, color, contrast

2) Vector – Points, lines, polygons
   - Represents features symbolically
     - outlines, line weight/symbol
     - unique icon
     - colors/patterns
GIS Data Models: Raster vs. Vector

Both data models are:

- **Spatial** – geographic shape and extent
- **Georeferenced** –
  - tied to a particular location in space
  - referenced by a coordinate system
    (location on surface)
The Raster (image) Model

Raster data characteristics:

- Matrix (array) of square cells or ‘pixels’ (picture element)
- Pixels are spatially referenced by coordinates \((x,y)\) – internal/external system
- Spatial dimensions of pixels determine raster resolution
Rasters are more than pretty pictures

- Pixel bit depth
- Bands
- Spatial resolution
- Image format
- Data compression
The Raster (image) Model

Pixels
- Represent (cover) surface area
  - Area can be in meters$^2$, km$^2$, miles$^2$, ...

Q: What about square degrees?
- Have a numeric value called a Digital Number (DN)
- DNs can represent an absolute value (surface elevation)
  or a coded value that requires a look up table (LUT)

**Image data:** A camera CCD collects photons, which are recorded as electron volts. The measurements are then converted to DNs as brightness values, based on a calibrated CCD model. Brightness can be based on an arbitrary or relative scale or modeled to equal surface albedo (0.0 to 1.0).
Furthermore…
### The Raster (image) Model

#### Pixel bit Depth
- Number of possible values (range of DNs) in a pixel
- Based on $2^x$ (bits): $2^8 = 8$ bits

<table>
<thead>
<tr>
<th>Bit Type</th>
<th>No. of values</th>
<th>Range of values</th>
<th>Number type</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 bit (byte)</td>
<td>256</td>
<td>0 to 255</td>
<td>Integer</td>
</tr>
<tr>
<td>16 bit, <strong>unsigned</strong></td>
<td>65,536</td>
<td>0 to 65,535</td>
<td>Integer</td>
</tr>
<tr>
<td>16 bit, <strong>signed</strong></td>
<td>65,536</td>
<td>$-32,768$ to $32,767$</td>
<td>+/- Integer</td>
</tr>
<tr>
<td>32 bit</td>
<td>~ 4B</td>
<td>0 to $4,294,967,295$; $-/+ 2,147,483,648$</td>
<td>Integer (+/–); Real, Floating point</td>
</tr>
</tbody>
</table>
Bands

- Continuous “Layers” within a single image
  - Brightness values: surface reflection or emission
  - Other representation: temperature, elevation, geo unit

- Single band
  - Monochromatic: clear filter, single wavelength
  - Single subject

- Multi-band
  - Red, Green, Blue (RGB): 8-bit x 3 bands = 24 bit (16.78M values)
  - NIR, R, G, B: Satellites 1970s to 1980s
  - UV, VIS, NIR: Several bands across Vis and non-vis

- Hyperspectral
  - Values across the electromagnetic spectrum: 10s to 100s bands
Examples of Raster data:

- 3-band satellite image:
  - 8bit Red, Green, Blue

1-band image,
Unsigned 16 bit values
Single subject:
Topography

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Image formats

- Data compression – data storage & transmission

- **Lossless**, no data lost vs. **Lossy**, data discarded
  - Uncompressed → no data lost: TIFF, GeoTIFF
  - Compressed → no data lost: TIFF (LZW), PNG, JPEG2000
  - Compressed → data lost: JPG, JPEG2000
  - Index (look up table) → data lost: BMP, GIF data lost

- **Spatial Reference**
  - Embedded: GeoTIFF, JPEG2000, JPG, PNG, etc.
  - Detached label: PDS labels: *.lbl, *.xml
The Raster (image) Model

Image resolution
Surface area covered per pixel

- Image width = 13 pixels,
- Surface width = 1 meter (100 cm)
- 100 cm / 13 pixels = 7.7 cm/pix
- Each pixel area ~ 7.7 cm x 7.7 cm
- What is the height of the 20 pixel image?

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Summary of Raster model

- Contain pixel values & spatial information (x,y)
- Do not have associated attribute table (maybe LUT?)
- Potentially very large file sizes (Kilobytes to Terabytes)
- Can be enhanced (color, brightness, sharpness, etc.)
  to reveal greater surface detail for mapping
- In GIS: Can be reprojected (georectification, image warp)
- Recommended: edit (change pixel values) in other software
Exercise 2: Working With Rasters

1. Create new ArcGIS Project
2. Add image data
3. View properties and metadata
4. Enhance the image
5. Pan & Zoom
6. Mosaic 4 images together for unified enhancement
7. Add DEM/DTM and give symbology
2. Working With Rasters

Begin a new session
- If ArcGIS Pro is still open, go ahead and close it
- Not necessary to save any changes to the first project

1) Launch ArcGIS Pro
2) On the New Project window, click: Start without a template

3) In the new Untitled project, make sure the Contents Pane is open on the left and the Catalog pane is open on the right
2. Working With Rasters

4) **Catalog pane**: right-click on Folders to Add Folder Connection

5) Navigate to & select **ArcGIS_Pro_Session2** folder on the left, click on **Exercise_2_Working_With_Rasters** in main window
6) From the top menu, select **Insert** and click on **New Map**
   - Don’t need to open drop-down menu

7) In **Catalog**, open:
   - **Exercise_2_Working_With_Rasters** folder and **Ex2_rasters** folder
   - Right-click on **Jezro_Orthomosaic.tif**
   - Select **Add to Current Map**

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**Map Frame** acts as a dataset manager for the files within **Contents**. Controls Map Projection of the work environment.
2. Working With Rasters

- The file is now in the **Contents Pane**, and in the new **Map**

What do these values represent?

- Move the hand cursor across the screen.
- Q: How do the numbers change at the bottom?
- Click a pixel.
- Q: What values are given?

What units are these?
Before anything else, **save the Project!**

- Click Save Project icon above tabs
- Navigate to project directory
  - First: Highlight project directory to the left
- Then name your project:
  Exercise_2_Jezero  (no spaces or extensions)
2. Working With Rasters

Create a Group Layer – acts as a subdirectory in Contents

- When working in ArcGIS projects, files clutter quickly!
- Organize as you go

- R-click on Map, select New Group Layer
- Name Group Layer: Rasters
- Drag image into Group Layer

What happens when you click on the check box?
2. Working With Rasters

Metadata and Properties: Right-click image for drop-down menu

- Metadata: example of “data about data”

Every data set and layer has properties!
Layer Properties provides detailed information about images

- Data Source: file location
- Raster Info: Data specs

Spatial Reference
- Projection
- Datum
2. Working With Rasters

Reminder: Spatial Reference
- Datum: 3D approximation of a planetary globe
- Projection: 2D mathematical representation of a planetary surface
2. Working With Rasters

The **Map Frame** [project data manager] also has **Properties**:

- Select Map (top of Contents file list): R-click > properties
- Map frame has no projection until first dataset added

[Diagram of Map Properties window with callouts to:
- Search for new projection
- Import projection from another dataset: Dropdown arrow
- Click on “+” to add projection to favorites for quick access
- Source of Map Frame projection]
2. Working With Rasters

General Properties: Display Units, Reference Scale, Rotate map

- Current name (renamable)
- Actual units of dataset
- Change units to...

Group Layer Properties:
- Rename
- Visibility based on zoom
- Metadata?
2. Working With Rasters

Image Enhancement
- Not editing data, only how displayed
  Q: What changes data? Resampling!
- In Contents: select Jezero_Orthomosaic.tif
- Ribbon adds: Raster Layer, Data

Enhance the appearance of the image:
- Symbology
- Stretch Type
- Transparency
- Brightness & Contrast

How do the different stretches make the image appear?

- None: Display values between the potential minimum and maximum.
- Minimum Maximum: Display values between the actual minimum and maximum.
- Percent Clip: Cut off percentages of highest and lowest values.
- Standard Deviation: Display values between a specified number of standard deviations.
- Histogram Equalize: Display values with histogram equalize.
- Custom: Display values with custom histogram.
- Histogram Specification: Display values with histogram specification.
- Esri: Highlight the contrast of moderate values while minimizing the impact of extreme high and low values.
2. Working With Rasters

Dynamic Range Adjustment (DRA):
- Stretch pixel values as you go...

On the Map ribbon:
- Highlight Explore to pan & zoom

- With the image selected, activate DRA under Raster Layer
- Click Stretch Type for enhancement style
- Zoom in to a particular region (it doesn't work when the entire image is visible)

Q: What happens when you zoom vs pan around?
2. Working With Rasters

A bit more about **Explore**
- Activates PAN Tool
- **Hover** over for Mouse config

Zoom to full extent
- Fixed Zoom in
- Fixed Zoom out
- Go to exact coordinates
- Step back/forward in zoom history
2. Working With Rasters

Image Mosaic
ArcGIS Pro can mosaic 2 or more images into a group and treat them as a single entity

Follow these steps:
1) Create a geodatabase
2) Create a raster mosaic
3) Add images to the mosaic.
   - Files SHOULD BE in the same projection (not necessarily the same resolution)

Remember to save your project...
2. Working With Rasters

Image Mosaic: Why do this?
- Seams, different pixel ranges, separate stretch

Images might have different DN range, projection, extent, etc.
2. Working With Rasters

Image Mosaic (continued)

1) Create a geodatabase:
   - In Catalog, right-click on Exercises_2_Working… directory, select: New > File Geodatabase
   - Name it Ex2_raster_mosaic.gdb
2. Working With Rasters

Image Mosaic (continued)

2) Create a mosaic data set

- In Catalog, right-click on the new geodatabase, select: New > Mosaic Dataset
- This will bring up a Geoprocessing window over Catalog in the right pane.
Image Mosaic (continued)

2) Create a mosaic data set (continued)

In Geoprocessing window:

- Output Location is already filled
- **Mosaic Dataset Name**, enter: CTX_mosaic
- **Coordinate System**: click on globe to right and find in Layers: Equirectangular_Mars_2000_Sphere_IAU
- Toggle **Pixel properties** and enter:
  - 1 for number of bands, 8-bit unsigned for Pixel Type (pixel type is found in image properties)
2. Working With Rasters

Image Mosaic (continued)

2) Create a mosaic data set (continued)

- When the form is complete, click **Run** at the bottom right of the window
- A green box with Create Mosaic Dataset Completed will appear
- Close the window by clicking on the X to the top right
2. Working With Rasters

Image Mosaic (continued)

3) Add images to mosaic

- From Catalog, drag the **CTX_mosaic** to the **Contents** and put into the **Rasters** group layer
- Turn off **Jezero_Orthomosaic.tif**
- No images are visible, because we have to add them!

- In **Catalog**, right-click on **CTX_mosaic** > Add Rasters...
- This will bring up a new Geoprocessing pane
2. Working With Rasters

Image Mosaic (continued)

3) Add images to mosaic (continued)

- In the geoprocessing window, click on the +folder to input the images
- Navigate to the Ex2_rasters directory. Make sure the text window to the lower right lists: All Types
2. Working With Rasters

Image Mosaic (continued)

3) Add images to mosaic (continued)

- Select all four Murray-Lab_CTX images and click OK
- Finally, toggle Raster Processing in the geoprocessing window and check both boxes for Calculate Statistics and Build Raster Pyramids (not required)
- When the form is completed, click Run to the bottom right

- A green box with Create Mosaic Dataset completed will appear
- Close window by clicking on the X to the top right
Image Mosaic (continued)

- In Contents, r-click: CTX_mosaic > Zoom to Layer to see mosaic
- In Contents, turn off Boundary and Footprint

What is the DN range of the mosaic?

Remember to save your project...
2. Working With Rasters

Image Mosaic (continued)

4) Some additional steps...

- Minimize re-drawing time by creating **Overviews**
  - In Catalog, right-click: CTX_mosaic
    and select: Optimize > Build Views
  - Accept defaults and click **Run**
    → Notice the seams go away

- With CTX_mosaic selected, click Mosaic Layer
- Experiment with Stretch Type, DRA, Enhancement
2. Working With Rasters

DEM or DTM data
Digital Elevation/Terrain Models represent surface elevation in pixel values. This can be represented with a color ramp or 3D rendering.

- Follow these steps:
  1) Add dataset to Map Frame
  2) Set transparency to 30%
  3) Use Symbology to color ramp
  4) Use Mosaic footprint to Clip Raster
2. Working With Rasters

DEM data

1) Add dataset to Map

- In Catalog, navigate to the Ex2_rasters folder
- Right-click on syrtis_dtm > Add To Current Map
  - If the program asks to calculate statistics or build pyramids, click Yes
- In Contents, r-click on syrtis_dtm > Zoom To Layer
2. Working With Rasters

DEM data (continued)

2) Make transparent 30%

- Click Raster Layer at the top of the ribbon and set the Transparency (above Effects) to 30%. The image is very large compared to the mosaic.

- Use cursor to click on light and dark pixels in the DEM. The number represents meters above or below the Reference Elevation.

What is the Reference Elevation for Mars? There is no Sea Level...
2. Working With Rasters

DEM data (continued)

3) Use Symbology to color ramp

- From Raster Layer ribbon, click Symbology icon (not drop-down list)
- From Symbology pane on the right, try various color ramps
- From the Symbology drop-down list, select Shaded Relief

Note data values:

- Range is 8-bit, though image is 32-bit
- Based on number of classifications
2. Working With Rasters

DEM data (continued)
3) Symbology (continued)

- In the Symbology pane, set Z Scale Factor to 3. Click Return
- Experiment with Azimuth (0-360° direction of the Sun) and Altitude (angle of Sun above horizon) values
2. Working With Rasters

DEM data (continued)
3) Symbology (continued)
- In the Symbology pane, set Scaling > Adjusted
  - Experiment with the **Pixel size power** and **Pixel size factor**
- Set Z Scale Factor to 3. Try 10. Try 100.
- Adjust Azimuth and Altitude
2. Working With Rasters

Raster clipping
4) Use Mosaic footprint to Clip Raster
- It is possible to clip out part of an image to a specified area. Here, we are going to clip the DEM using the Boundary of CTX_mosaic.

- Close the Symbology pane
- From the menu, select **Analysis** and click the **Tools** icon. This will bring up another **Geoprocessing** pane.
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Geoprocessing Tool Box
The ArcGIS Pro version of ArcToolbox, a huge library of applications for specific tasks

Favorites and recent

ALL the tools

Specialty tools

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Raster clipping (continued)

4) Use Mosaic footprint to Clip Raster (continued)

- Search for the tool if you don’t know where to find it
  - In the Geoprocessing text window, type Clip
  - Select Clip Raster
2. Working With Rasters

Raster clipping (continued)
4) Use Mosaic footprint to Clip Raster (continued)
   - In the Geoprocessing - Clip Raster pane, drag `syrnis_dtm` from Contents into the Input Raster window
   - For Output Extent, click drop-down arrow, select Rasters\CTX_mosaic\Boundary
   - Enter a name for Output Raster Dataset or leave as default
   - Click on folder to select GDB
   - Clear NoData Value to leave it blank. Best practice: set within bit-depth range.
   - Run process
2. Working With Rasters

Raster clipping (continued)

4) Use Mosaic footprint to Clip Raster (continued)

- A new image file named syrtis_dtm_clip is created
- Turn off or remove the original syrtis_dtm
- Zoom in to new image, make 60% transparent, and give it a Shaded Relief color ramp
Exercise 2 Summary:

1. Created new ArcGIS Project with New Map
2. Added image & DTM data
3. Viewed properties and metadata
4. Enhanced the image data
5. Pan & Zoom
6. Created a Geodatabase
7. Create an image mosaic
8. Clipped a DTM with a polygon