**Hurricane Katrina Project**

This GIS project offers you a complete hands-on learning experience. It exposes you to the entire workflow that a seasoned GIS Analyst, a GISCorps volunteer, or a Humanitarian OSM team member will use during the days following a major disaster. The project starts with a question, which is broken down into clear objectives, and it ends with an evidence-supported answer. This particular workflow requires you to obtain data from trusted data providers and to prepare them for spatial analysis. Some data will come as tables, some as rasters, and some as vectors. This GIS project also offers you opportunities to visualize the destructive storm surge and to assess Hurricane Katrina’s destructive power using Esri’s ArcGIS Desktop v.10.4.1.

**A Research Question Directs Our Purpose**

A research question is an interesting question – it identifies what we really want to know and helps us to set the purpose of the entire project (i.e., to answer the question).

*How did Hurricane Katrina affect people and property along Mississippi’s Gulf Coast?*

**Objectives**

Objectives identify the pieces of information we need to collect, build, calculate, etc., in order to answer the question. This project has nine objectives:

1. To describe the resident population before, after, and since the storm.
2. To describe the workforce before, after, and since the storm.
3. To report the size of the study area, in km² (mi²).
4. To describe the site and situation of the study area (see Rodrigue, 2014, or Elrod, 2014, if you need a refresher on these basic geography concepts).
5. To estimate the height of the highest storm surge, in m (ft).
6. To estimate how much land area was flooded by the storm surge, in km² (mi²).
7. To describe in words and to illustrate with maps the geospatial distributions of flooded areas and destroyed areas.
8. To find destroyed roads and estimate the total cost of rebuilding them.

**The Study Area – A Representative Sample**

The region affected by Hurricane Katrina is vast, so we are going to use a representative sample area to represent the whole area.

The sample area will be the populated place known as Long Beach city, which is situated in Mississippi’s Harrison County and at the center of its Gulf Coast.
LAB 06: ISOLATE THE STUDY AREA, TAKE AN INVENTORY OF ROADS

Task 01: To be done in ArcCatalog

We want to extract the street data for Long Beach from the streets data that we have for the entire Mississippi Gulf Coast.

If you had rummaged through all your metadata carefully, then you’d have noticed that the Long Beach city polygon data and the MDEQ streets data were built by two different organizations (US Census Bureau and Mississippi Department of Environmental Quality, respectively), digitized from two different sets of source materials, and intended for use at two different map scales (> 1:500,000 and < 1:10,000, respectively). Consequently the generalized Long Beach polygon boundary does not perfectly trace the road lines that define the Long Beach area.

So, to ensure that you analyze all the streets in Long Beach city, calculate a 20-meter linear buffer around the city polygon and name it studyArea. This polygon is now your official study area polygon.

Next, clip the streets data with your new studyArea polygon; name your output feature class cityStreets.

Next, we want to easily distinguish street segments associated with US Highway 90 from all the other street segments in Long Beach. So, to do that, use the dissolve tool to dissolve all the features by their USHWY attribute values so that all US Highway 90 segments are dissolved into a one record and all the other street segments are dissolved into an ‘other’ record. Name your output feature class cityStreets_dissolve.

**Question 1:** How large is the study area (use your studyArea polygon)? If your data are projected properly, then the [Shape_area] values in your attribute table are reported in m². Report your answer using this format: #.# sq.km (#.# sq.mi).

For example: The study area is 100.0 sq.km (38.6 sq.mi) large.

**Question 2.** If the typical street centerline in your cityStreets_dissolve feature class represents a road with two traffic lanes (Figure 2) and each US-90 centerline represents a road with four traffic lanes (2 lanes going in each direction), then how many total lane-kilometers (and lane-miles) of road are in the study area?

For example: The total length of all road lanes in the study area is 100.0 lane-kilometers (62.1 lane-miles).

*Figure 2.* If a section of road is one mile long and has two lanes, then it covers 2 lane-miles.
GEOREFERENCE AERIAL PHOTOGRAPHS AND CREATE A MOSAIC DATASET

To complete your data collection, you need to prepare a set of aerial photographs that represent on-the-ground conditions immediately after the storm. The NOAA post-hurricane images contain valuable information, but they are not spatially referenced to any location on earth. Each image needs to be **georeferenced**. This lab offers you the opportunity to learn the georeferencing technique and how to create a mosaic dataset.

**Task 02: Georeferencing in ArcMap (Bolstad, Ch. 4, p170-182; 258-271)**

Georeferencing is a technique whereby a raw image is processed so the data stored in its pixels become aligned with the axes of your spatial reference system. Georeferencing involves three steps: a) setting up a **coordinate transformation** (p.153-161) that transforms the raw pixel coordinates to ground coordinates [in this case, metric (NAD83) SPC MS-E coordinates]; b) choosing a **resampling** (p.162-164) method for transferring the pixel values from the raw and unreferenced array to the new and georeferenced array; and c) **rectifying** the image, which is a fancy word for writing the output image.

During **coordinate transformation**, a set of ground control points (GCPs) is created to link raw pixel locations (X source, Y source) to earth-tied locations (X map, Y map). Each GCP must be identifiable in both the unreferenced image and the spatially referenced datasets. You create a link by selecting a pixel location in the unreferenced image (the “from” end is selected first), then selecting the corresponding location in your spatially referenced dataset (the “to” end is selected second). For each raw photo, you are going to create **at least nine** GCPs that are well-distributed across the photo (see Figure 3).

**Figure 3.** A GCP/link table. X and Y Source values indicate the “from” pixel column and row positions. X and Y Map values indicate, in this case, the “to” coordinates on the SPC MS-E grid. Total RMS Error (a.k.a. RMSE) indicates coordinate transformation model performance.
In ArcMap, the **georeferencing toolbar** will let you set and use your nine GCP/links to build a *polynomial coordinate transformation model* (e.g., a 1st, 2nd or 3rd -order polynomial) to transform raw pixel coordinates (X source, Y source) into metric coordinates (X map, Y map) AND mitigate some warping errors ([p.258-262](#)). For each model, a **Total RMS Error** value is calculated to indicate model fitness ([p.176-178](#)). High RMSE values can suggest one or more GCP/links were not placed well OR the polynomial model you picked cannot bend the image, so warping artifacts might appear in your output image. Low RMSE values can suggest GCPs are placed well AND your polynomial model does a good job of mitigating the distortions. For this lab, an acceptable total RMSE is 1.5 meters or shorter.

Once the new array of empty grid cells is created, image **resampling** will move pixel values from the input array to the output array. Three raster resampling methods ([p.180-181](#)) are available: nearest neighbor; bilinear interpolation; and cubic convolution. The nearest neighbor method is useful only when you’re moving nominal pixel data (e.g., land cover classes or codes), so won’t use it in this case. The bilinear interpolation and cubic convolution methods are useful when you need to move values taken from a continuous field (e.g., an aerial photograph with three bands of brightness values; a DEM with elevation values; etc). Between the two, the bilinear interpolation method works fastest, but the cubic convolution method can produce smoother-looking results.

**Rectifying** is simply the process of outputting your work to a new raster (Figure 3).

![Image of Save As dialog box](#)

**Figure 3.** The **Rectify**... option. The Name sets the output image name. The Output location points to your default geodatabase. Chose a Resampling method that’s appropriate for continuous data. Set your output NoData pixel value as 0 and your output cell size as 1 (meter).
Task 03: Creating a mosaic dataset via ArcCatalog 🌞

A mosaic dataset is a data model that allows you to store, manage, and query a collection of rasters, but view the collection “as if it were a single mosaicked image.” A mosaic dataset works by creating a geodatabase object that points to one or more rasters (e.g., just like a layer in ArcMap points to data in a geodatabase). Mosaic datasets can be added as layers to map documents, queried like tables, edited, and updated. Mosaic datasets improve machine performance because your machine doesn’t need to pan or zoom one massive image; rather, just the tiles that overlap your view window.

To create a mosaic dataset, right-click your database and use New > Mosaic Dataset. Give your mosaic dataset a useful name and specify the metric (NAD83) SP MS-E spatial reference system. In this case, you don’t need to specify many special properties because all your new georeferenced rasters are already in the same format, share the same spatial reference system, and have the same pixel size. Sweet!

To populate your mosaic dataset, right-click your mosaic dataset and Add Rasters....

You’ll notice that the ‘adding’ process happens really fast. It happens fast because you’re not copying ~50 MB worth of data; rather, you’re just making a list of pointers between your rasters and the mosaic dataset.

SOFTWARE BUG ALERT: If your output mosaic dataset appears all black, then you’ll need to Calculate Statistics again. This can be accomplished by right-clicking the mosaic dataset and, you guessed it, choosing Calculate Statistics.

Question 3: Create a table that presents each raw photo by: a) filename (with extension); b) the number of GCPs used to georeference it; c) the order of the polynomial model (i.e., 1st, 2nd, or 3rd order polynomial) used to transform its coordinates; d) the RMSE value associated with model fitness; and e) the resampling method you used to transfer pixel values from the raw photo to the new image.

Question 4: Read and compare your 2005-vintage mosaic dataset (post-hurricane) with the 2004-vintage NAIP image (pre-hurricane). Which spots in your mosaic dataset were georeferenced well and which spots seem to have problems? Describe good/bad spots in such a way that a member of the public can know where and what you’re talking about.

Question 5: The terms ‘image cell size’ and ‘image resolution’ are often, and erroneously, used synonymously. Take close looks at your 2004 and 2005 image properties and displays, and explain the meaningful difference between these two terms.

Read everything before doing anything!
Task 04: Adding and symbolizing geospatial data in ArcMap

Add your studyArea polygon as a new layer and change its symbol properties so that you can see an outline, but no fill.

Next, add one of Esri’s basemaps as a new reference layer.

Next, add your new post-hurricane mosaic dataset as a new layer and check to see if you have complete coverage of the shoreline. If so, then you can remove the layer or just turn it off. If not, then go back to Task 2 and fix what needs fixing.

Question 6: Describe the site and situation of your study area.

Deliverables

Build a well-written report for Lab 06. Include your name, date, lab title, and page numbers. Your report should be printed on 8.5” by 11” stock. Set all page margins to be 0.7”, except for the left margin, which should be set to 1.2”. Use 1.5 line spacing, set the normal font face to be Bookman Antiqua, Bookman Old Style, or Georgia, and set the normal font size to be 11 points. All section headings should be in bold face and not orphaned.

Your report should include five sections with headings: Purpose, Objectives, Methods and Data, Answers, and a Summary. Your Purpose and Objectives sections should be written in your own words and must address the specific purpose and specific objectives of Lab 06 (and not the general purpose or general objectives of the entire project). The Answers section should include answers to any questions posed during the lab as well as any supporting tables or figures. In the Summary section, discuss what you learned, identify anything that you found interesting or difficult, and identify any connection you made between the work you did for this lab and the work you could do for another course or project. If you can, describe a moment when your mental “light bulb” burned brighter (or flickered).

Note:

All tables and figures must be numbered, have useful captions, and be referenced by their numbers in your text. Captions should not be orphaned and should, when appropriate, indicate units of measure. All tables and figures must be inserted inline with your text (add an extra line space before and after to separate them from the adjacent paragraphs) and they must conform to the margin and font requirements specified above. You want your report to look professional; applying a consistent design styles throughout your report helps you do that.

References
