Lab 2: Hurricane Katrina

Understanding physical and social vulnerability

Introduction

Problem

What areas along the Gulf Coast of the United States are particularly vulnerable, physically and socially, to hurricanes?

Hurricane Katrina revealed the extent to which a natural disaster can devastate a community. A variety of geographic variables came into play, such as locales closest to the ocean, of lowest elevation, and where the most rain fell. Social variables, such as where the urban poor lived, also affected the outcome. By charting where the most damage occurred and why, investigators can help plan how to mitigate problems, respond to threats, and protect areas before and during similar events in the future.

Location

Gulf coast of the United States.

Time to complete the lab

Two hours.

Prerequisites

Basic familiarity with GIS.

Data used in this lab

- Census county boundaries (U.S. Census Bureau)
- Digital elevation (USGS)
- Hurricane paths (NOAA)
- Precipitation (weather.gov)
- Geographic coordinate system: GCS_North_American_1983
- Datum: D_North_American_1983
- Projection: Lambert_azimuthal_equal_area

Keywords: risk management; vulnerability; hurricane; precipitation; elevation; poverty; distribution; buffer; clip; join; calculate

Student activity

Strong winds, heavy rain, and storm surges accompany tropical hurricanes, causing extensive damage and casualties and destroying poorly constructed buildings. The intensity of a hurricane is categorized by wind speed**,** starting at 119 kilometers per hour, according to the Saffir-Simpson Hurricane Wind Scale. In addition to the destruction caused by wind, hurricanes generate intense rainfall that can cause flooding. The slower a hurricane moves, the more rain an area will potentially receive. Analysis of these factors, and more, in the aftermath of a hurricane can offer insight into how to better prepare for the next.

Table 1: Hurricane category (cited from www.nhc.noaa.gov/aboutsshs.shtml)

Category	Wind speed (km/h)	Storm surge (m)
H1	119–153	1.2–1.5
H2	154–177	1.8–2.4
H3	178–209	2.7–3.7
H4	210–249	4.0–5.5
H5	>249	>5.5

Table 1. Categories of hurricanes defined by the National Oceanic Atmospheric Administration (NOAA).

As one of the most devastating disasters in United States history, Hurricane Katrina is especially inviting for such analysis. It is ranked the third deadliest hurricane to hit the U.S. mainland. According to the Federal Emergency Management Agency (FEMA), Hurricane Katrina made landfall three times along the Gulf Coast between August 23 and 31, 2005.

In this lab, you will track the path of Hurricane Katrina, considering precipitation and elevation to gauge the *physical* impacts of the hurricane. Also, in assessing whether some people in the region may have been more vulnerable than others, you will consider *social* factors including median household income as well as the percentage of the population with disabilities, those living in poverty, single parents, those under age 5 and those over age 65, and non-English speakers. In the process, you will create maps to indicate the most vulnerable places along the Gulf Coast according to the information you have.

You will

- Map the path of Hurricane Katrina.
- Employ daily precipitation data to map a pattern of rainfall over a nine-day period along the Gulf Coast based on the county level.
- Select the counties with the heaviest rainfall for the period and map the wettest areas along the path of Hurricane Katrina.
- Use a digital elevation model (DEM) to find the areas with the lowest elevation.
- Combine the path of Hurricane Katrina, precipitation, and elevation to see the hurricane's physical impacts along the Gulf Coast.
- Examine socioeconomic data to see spatial distribution.
- Create a social vulnerability index.
- Select and map the most vulnerable areas.

For each step, you will export the maps as image files and deliver them to your instructor.

COLLECT AND PROCESS DATA

Download and extract data from the data.zip file.

1. Download *data.zip*.
2. Extract it to the workspace (i.e., NR422\Lab7\Data).

It is important to view data before moving on to the analysis.

3. Start ArcCatalog.
4. Examine all data in the *Data* folder (you should have *Gulf_Coast1.shp*, *Gulf_Coast_Socioeconomic.shp*, *atl_hurtrack.shp, Rainfall_082305to083105.shp*, and *dem_gulfcoast*).

HURRICANE PATHS

ANALYZE

1. Start ArcMap.
2. Add *Gulf_Coast1.shp* and *atl_hurtrack.shp*.
3. Open the attribute table of *atl_hurtrack.shp*. Notice that there have been almost 40,000 hurricanes in the Atlantic since 1851.
4. Using *Select by Attributes*, select hurricanes since 2000.
5. Export selected data as *Hurricane_Paths_since_2000.shp* and add the exported data. Notice that there are still more than 4,000 hurricanes.
6. Turn off *atl_hurtrack.shp*.
7. Using *Select by Attributes*, select Hurricane Katrina in 2005 from *Hurricane_Paths_since_2000.shp*.
8. Export selected data as *Hurricane_Katrina.shp* and add the exported data.
9. From *Hurricane_Paths_since_2000.shp*, select hurricanes with categories of H1, H2, H3, H4, and H5 according to the Saffir-Simpson Hurricane Wind Scale.
10. Export selected data as *Hurricane_Categories.shp* and add the exported data.
11. Create a map of the path of Hurricane Katrina along the Gulf Coast showing hurricane categories H1 to H5, then save this as Map 1.

Question 1: ***How many hurricanes in categories H1 to H5 have hit the Gulf Coast since 2000?***

VISUALIZE

Map 1 shows the path of Hurricane Katrina along the Gulf Coast.

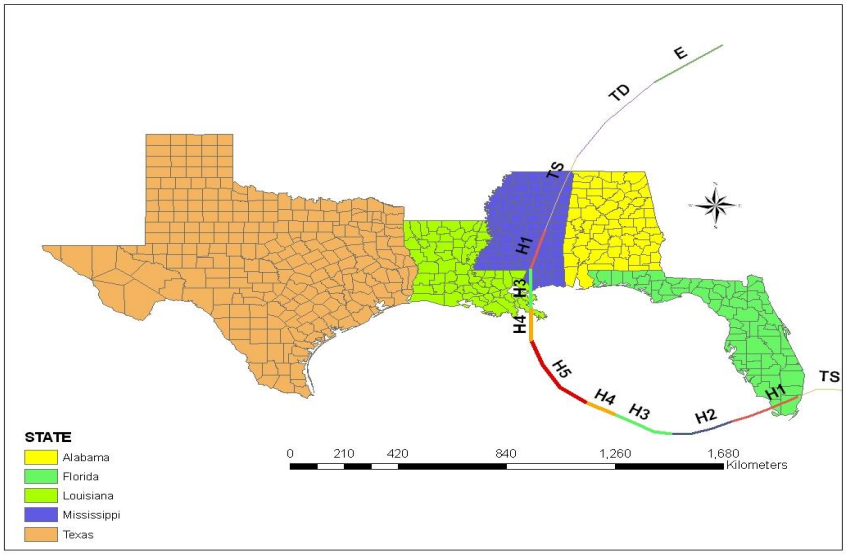

Figure 1. Map 1 charts the path of Hurricane Katrina.

PRECIPITATION

ANALYZE

1. To Map 1, add *Rainfall_082305to083105.shp*.
2. Open the attribute table.
3. Using the *Add Field* tool, create a new field called Rain_Total.
4. Using the *Field Calculator*, sum up all rainfall for August 23–31, 2005.
5. On the *Symbology* tab, using *Quantities*, draw a graduated color map of total rainfall along the path of Hurricane Katrina.
6. Create a map of the average rainfall along the Gulf Coast for August 23–31, 2005, then save this as Map 2.

Question 2: ***When did Hurricane Katrina become a category H5 hurricane?***

Question 3: ***Which county had the heaviest rainfall when Katrina passed the Gulf Coast?***

Question 4: ***Indicate the counties that had an average of more than 10 inches of rainfall over a nine-day period.***

VISUALIZE

Map 2 shows the average rainfall along the Gulf Coast for August 23–31, 2005.

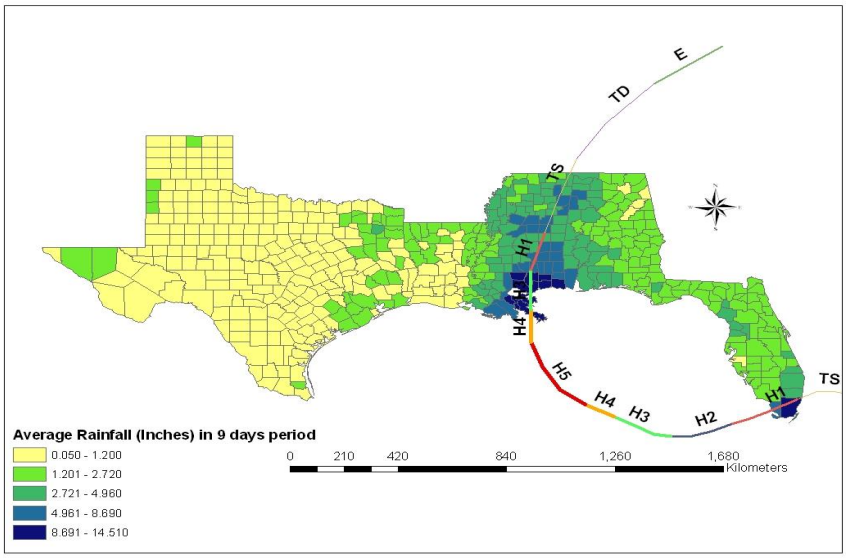

Figure 2. Map 2 charts the average rainfall along the Gulf Coast for August 23–31, 2005.

ELEVATION

ANALYZE

1. To Map 2, add *dem_gulfcoast*, which is a DEM with 1 kilometer spatial resolution along the Gulf Coast.
2. Using the *Reclassify* tool, create a reclassified DEM (*ArcToolbox* » *Spatial Analyst Tools* » *Reclass* » *Reclassify*).
3. Using *Select by Attributes*, select elevation values ≤ 0 (meters) below mean sea level. For more information, in ArcGIS Help, search for "reclassify."
4. Draw and save two maps: elevation and reclassified elevation (maps 3 and 4).

Question 5: ***Which three counties have low elevation and high precipitation?***

Question 6: ***Do maps 1, 2, 3, and 4 indicate physical vulnerability? If so, explain why.***

VISUALIZE

Map 3 shows elevation along the Gulf Coast.

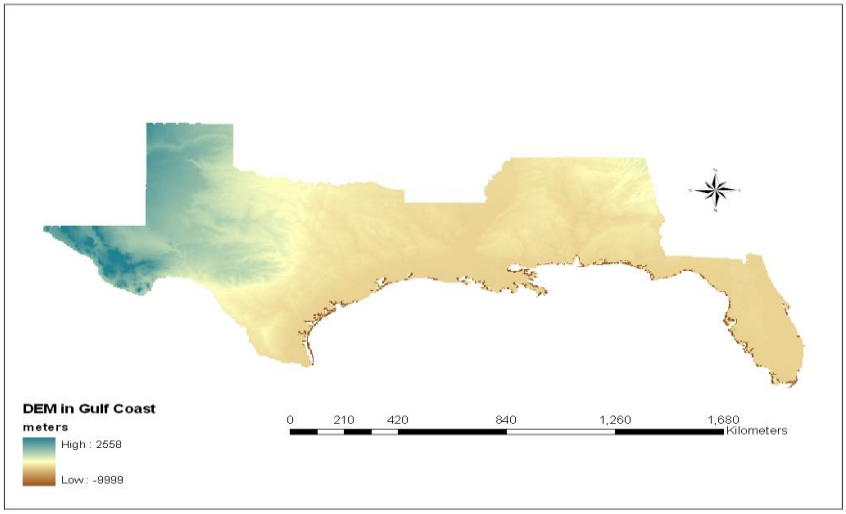

Figure 3. Map 3 shows the digital elevation model of the Gulf Coast.

Map 4 shows reclassified elevation along the Gulf Coast.

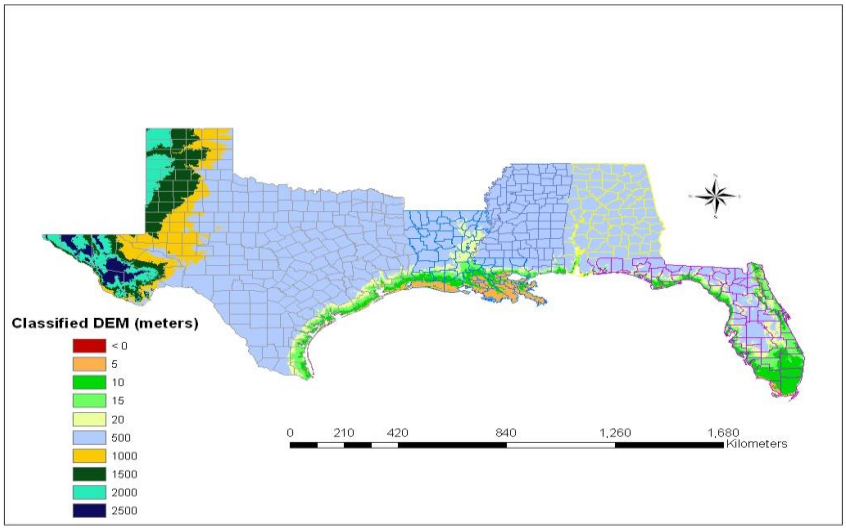

Figure 4. Map 4 shows a Reclassified DEM of the Gulf Coast.

SOCIOECONOMICS

ANALYZE

1 Add *Gulf_Coast_Socioeconomic.shp*. It contains the following social vulnerability indicators: median household income (Med_Income), percentage of population with disabilities (Disability), percentage of population living in poverty (Poverty), percentage of single parents (Single_Par), percentage of population under age 5 and over age 65 (Down5_Up65), and percentage of non-English speakers (Can_t_ENG).

2 Open the attribute table.

3 To analyze social impact using socioeconomic characteristics, data must be normalized. Divide each social vulnerability indicator by the maximum value of each indicator (e.g., 3,360,536 in poverty) and store the result in the appropriate IDX field. For instance, IDX_POVERTY (normalized poverty) is calculated by dividing the property field by the maximum of poverty (3,360,536). Repeat this step for all social vulnerability indicators, **except for median household income** because the median household income influences social vulnerability differently than other indicators.

   To normalize median household income, first subtract the maximum median household income from each value in the Med_Income field (i.e., [Med_Income] - 70,835). Then divide each difference by the maximum median household income minus the minimum median household income (i.e., ([Med_Income] - 70,835) / (70,835 - 16,504)). A value of 1 in the IDX field indicates highest vulnerability.

4 Calculate the total impact of socioeconomic characteristics by using the *Field Calculator* to sum the normalized fields into the field IDX_VUL_CT.

5 Create a map of the distribution of social vulnerability along the Gulf Coast (Map 5).

6 Select the top 10 socially vulnerable counties and create a map indicating these counties (Map 6).

Question 7: ***Where are the 10 most socially vulnerable areas? Use the attribute table prepared from the census variables to answer this question.***

Question 8: ***You have seen and created various maps. Considering all you have learned in this lab, which parts of the Gulf Coast are most at risk? Explain why.***

VISUALIZE

Map 5 shows distribution of social vulnerability along the Gulf Coast.

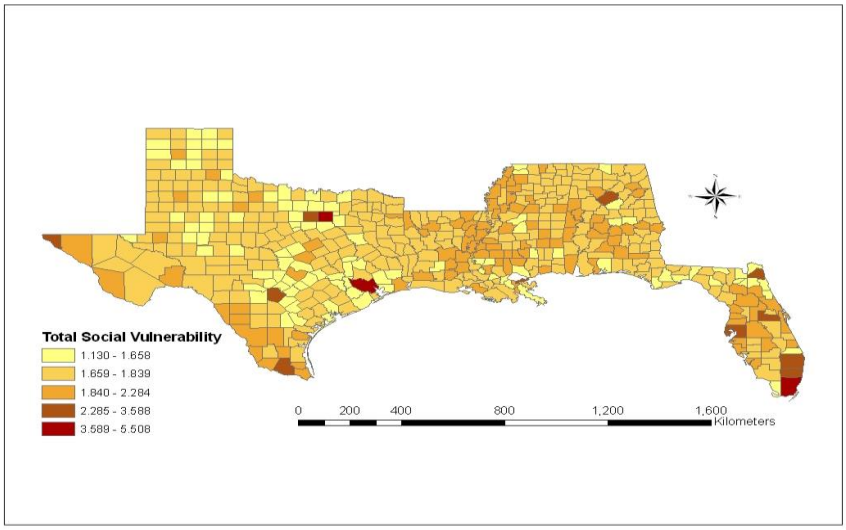

Figure 5. Map 5 shows social vulnerability along the Gulf Coast.

Map 6 shows the top 10 socially vulnerable counties along the Gulf Coast.

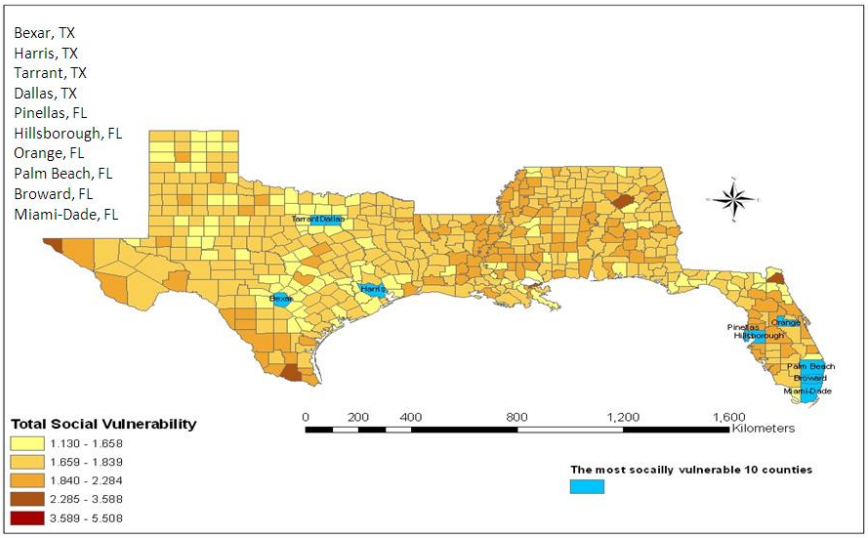

Figure 6. Map 6 shows the top 10 socially vulnerable counties along the Gulf Coast.

Submit your work

Submit the following:

- Maps 1 and 2, indicating the path of Hurricane Katrina along the Gulf Coast and the average rainfall by county for August 23–31, 2005. Show the location of the highest rainfall as a result of Hurricane Katrina.
- Maps 3 and 4, showing elevation. Indicate which county is located below sea level.
- Maps 5 and 6, illustrating the most socially vulnerable areas of the region.
- Answers to questions 1–8.