Term Paper: The effect of hurricane patterns on urban development on the Mississippi Gulf Coast
GEOG-5013-997
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Introduction

On August 29, 2005, Hurricane Katrina made landfall 45 miles southeast of New Orleans and crossed the Mississippi Sound to the mouth of the Pearl River in Mississippi.[1] During that 24 hours the category 4 hurricane exhibited 175mph winds, more than 1 inch/hour of rain, and 26-28 ft storm surge that would cause nearly $161 billion in damages and kill 1,833 people[2]. The Insurance Information Institute ranks Hurricane Katrina as the most devastating flood event since 1978 with over $16 billion in national flood insurance program payouts, and more than $41 billion in total claims[3]. Most of the damage was in New Orleans, where levees failed under the strain of overflowing water in Lake Pontchartrain due to heavy rainfall and storm surge, resulting in 70% of residential units being uninhabitable and 50% of the population fleeing as natural disaster refugees.

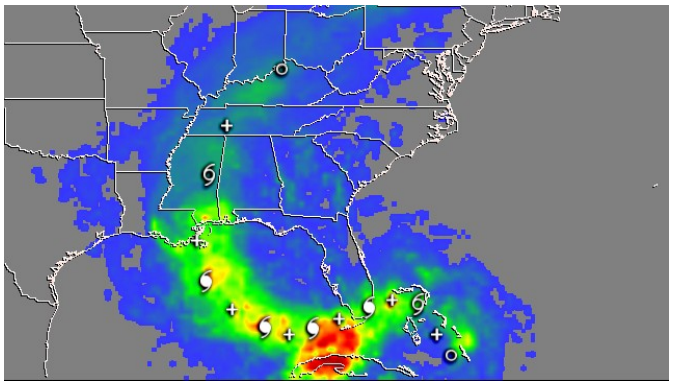


Figure 1: The Path of Hurricane Katrina, August 23-31, 2005

As a result of the enormous insurance claim payout totals, the flood zone designations in many of the coastal areas were changed, and the areas that were hardest hit saw their insurance rates skyrocket. The added cost of home insurance had a detrimental affect on development and redevelopment of the hurricane-affected area. Housing prices fell to the point that developers were reluctant to rebuild in

1 Encyclopedia Online Britannica: Hurricane Katrina, September 2020
2 CNN: Hurriucane Katrina Statistics Fast Facts, August 2020
3 Insurance Information Institute: Facts + Statistics: Flood Insurance, December 2020

newly re-evaluated areas. To this day much of that otherwise desirable beach-front property remains barren.

Data

The data for this project was relatively easy to find, due to the historic nature of Katrina and the necessity to record the event. The US Federal Emergency Management Agency (FEMA) maintains a database of all flood zone data (https://msc.fema.gov/portal/). However, once archived some GIS data can be a challenge to extract. I turned to the data archiving website web.archive.org for FEMA's Katrina data.

For basemap and local feature datasets I turned to the Mississippi Geospatial Data Catalog (opendata.gis.ms.gov). There I found Department of Public Safety infrastructure data and Department of Environmental Quality water resources and elevation data.

FEMA flood data is divided into local political boundary regions, either counties or cities. While it wasn't absolutely necessary to merge the files, for ease of management and display a single flood data layer was generated. Perhaps the most beneficial layer was the Changes Since Last FIRM (CSLF), which outlines what Flood Insurance Rate Map (FIRM) categories have changed, when they changed, and what those changes were. Two distinct layers were generated from this one layer, displaying different attributes concurrently. The first is a hashed layer showing what flood category an area was changed to. The second layer generated is a simple filled polygon to highlight the area that has changed, since at first glance the hashed areas may be difficult to discern.

The last data layer included is the annotation of the extent of storm surge Hurricane Katrina pushed inland. This shows in a dramatic way the extent of the flooding along the Mississippi gulf coast and the necessity to change the way flood maps are evaluated by disaster managers.

Maps

Map 1:

The first map is an overview of the Mississippi gulf coast. Major highways and county boundaries are marked for reference. Unfortunately there is a bug of some kind in the geospatial software that omits some aspects of the map when exporting, such as the county and city annotations, and the road network legend icons. This is a known bug with a patch available, but installation of that patch failed.

The hydrology and terrain are implied in this map. Inclusion of elevation data and hydrography clutters the map, making it difficult to read. However, the flood zone polygons clearly show where low

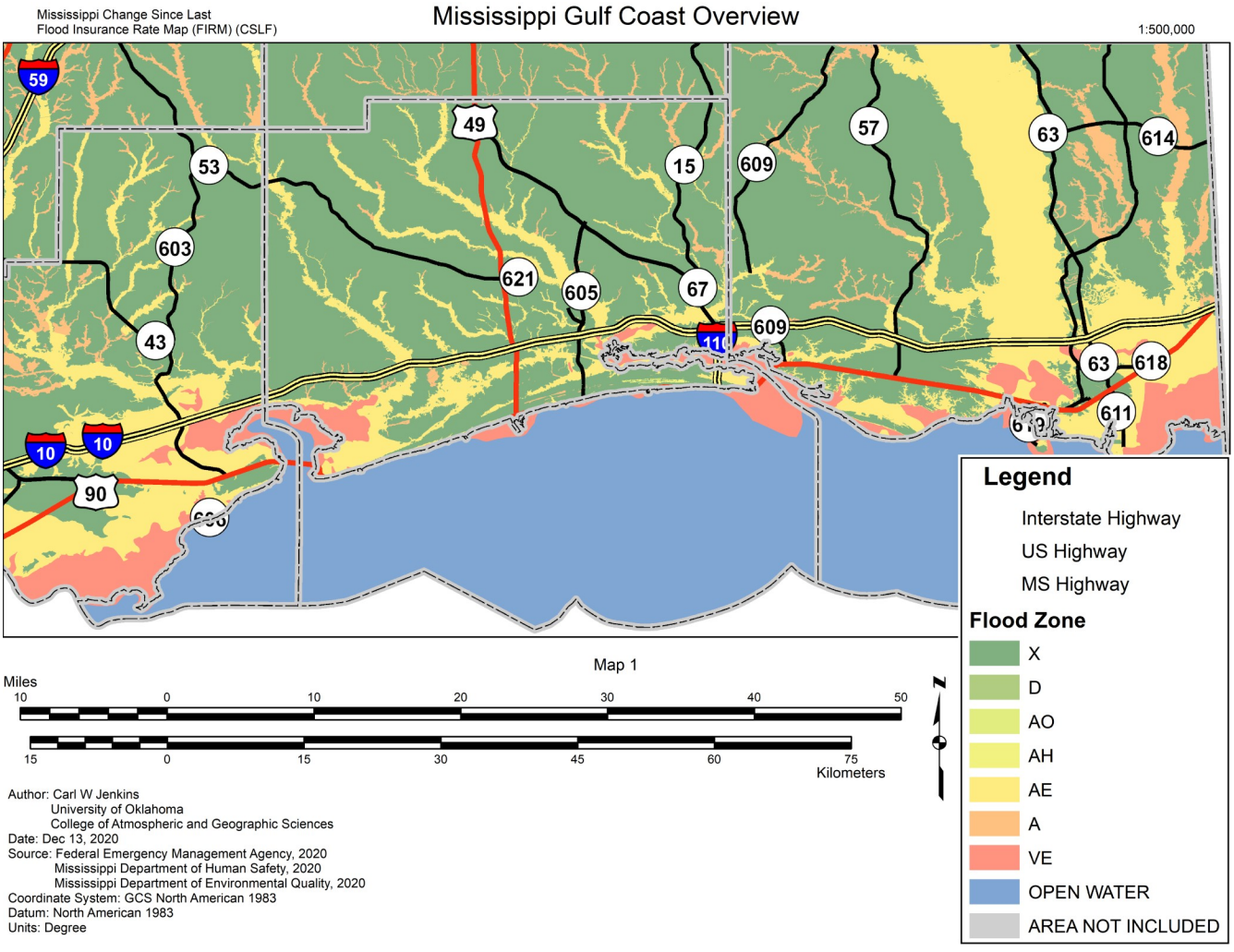


Figure 2: Flood Zone Overview

riverbed areas are versus higher terrain. As the elevation of the map changes, the flood zones change, but don't necessarily go down. This is because runoff from heavy rains further upstream pose an equal risk for flooding as storm surge near the coast.

The most dangerous and costly areas to develop are VE, defined as coastal areas that have a 1% or greater chance to flood each year, and greater than 26% over a 30-year term, such as during a mortgage. A similar insurance rate is paid by the A-series of flood zones, A being a general flood condition with the same 1%/26% risks as VE. AO differentiates river or stream flood areas, while AE and AH are floodplain and inland water body zones respectively. X zones are not expected to flood and are at elevations above the 500-year flood marks. D zones are undetermined because they have not been evaluated, and can generally be considered safe.

Map 2:

The second map shows the effect of storm surge from Hurricane Katrina. Not unexpectedly the surge flowed upstream several miles where the banks are wider. Somewhat surprising, however, is the amount of terrain the surge climbed over terrain not part of the natural drainage system. Storm surge is not a gentle flooding over time, but is more akin to a giant swell or wave of water, not too dissimilar to a tsunami, although not usually to that extent. It was this storm surge flooding that caused the most damage and loss of life in Mississippi, and the primary reason the flood zones were re-evaluated afterward.

In some areas the storm surge pushed 20 miles inland. There it mixed with excessive runoff from the torrential rainfall to back up into smaller rivers and streams, flooding many areas that had not been flooded in a century or longer. As that abidance of water eventually flowed toward the ocean it extended the period of time that coastal communities were flooded. Areas already with too much water found themselves is even more rushing in to replace that which naturally flowed back into the sea.

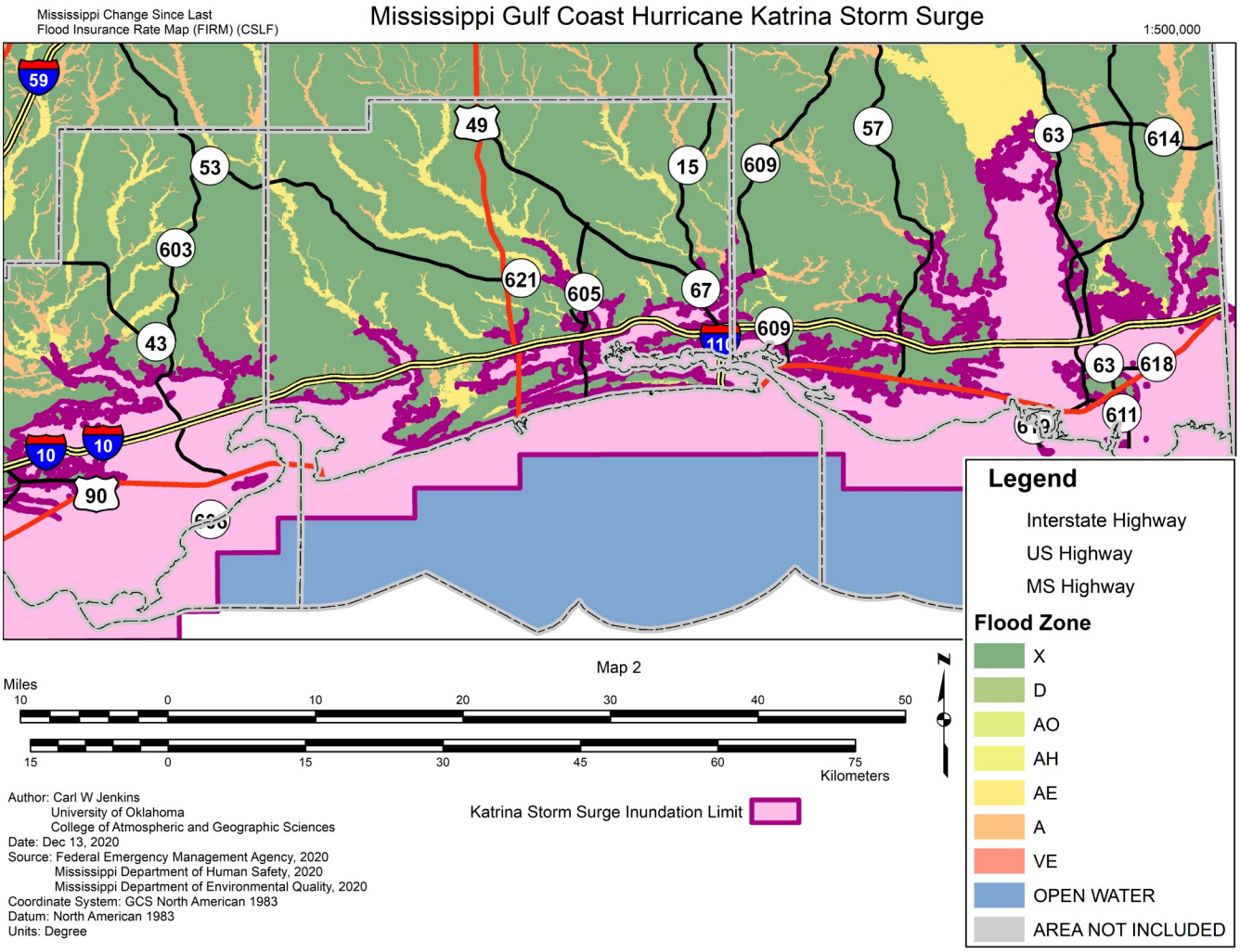


Figure 3: Katrina Storm Surge Inundation Limits

Map 3:

The third maps is the busiest and most cluttered of the series, showing all of the available data on a single frame in order to relate the storm surge area with the flood zones that were re-evaluated. The current flood zones are used as the base layer, covered then by the Hurricane Katrina Storm Surge Inundation Limit layer. The CSLF hashed and highlight layers next show the relationship between where Hurricane Katrina had some of the greatest, least expected effects, and the zones that were consequently re-evaluated. Lastly for reference the infrastructure and county boundaries layer it's on top.

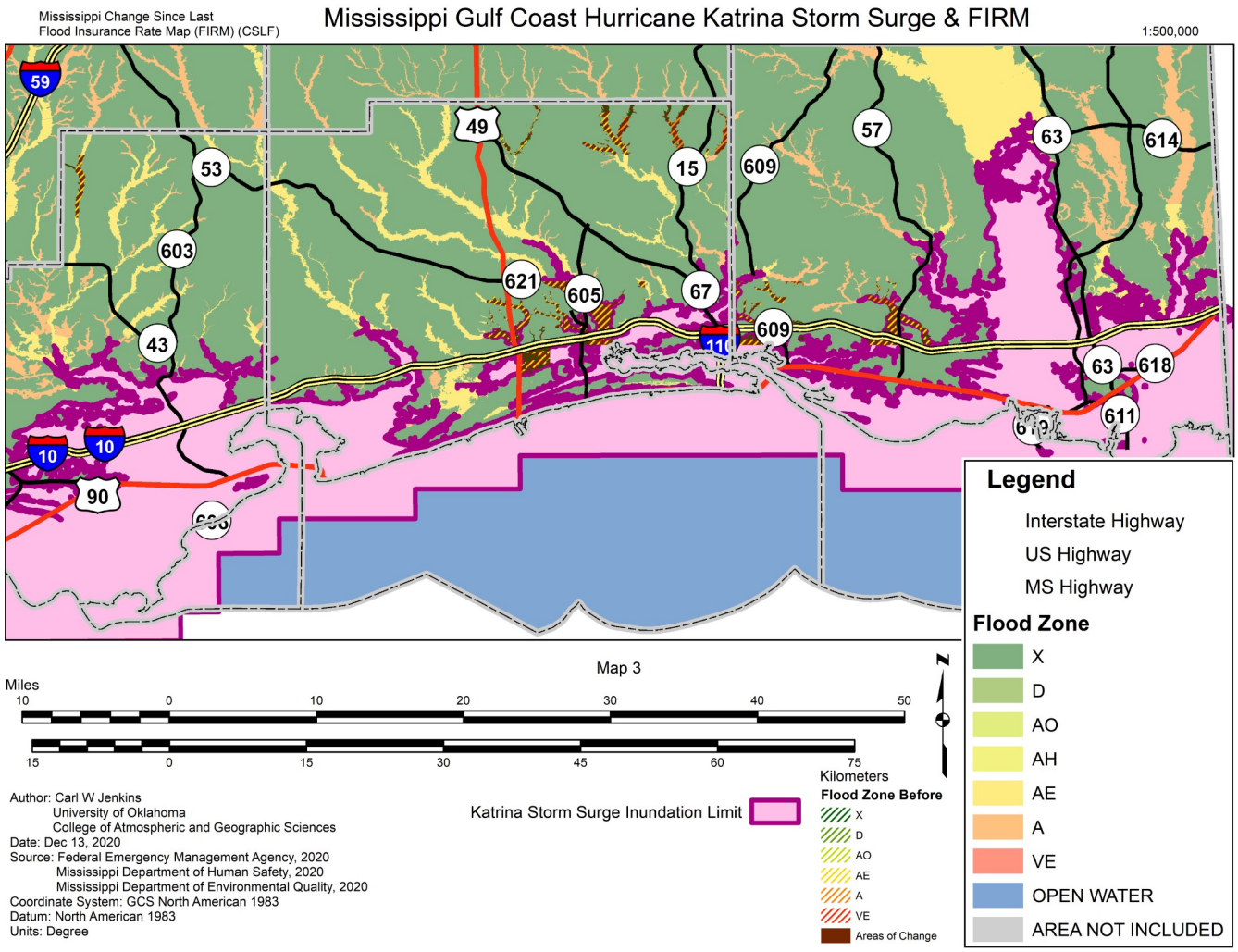


Figure 4: Hurricane Katrina Storm Surge Overlaid with Flood Insurance Rate Map Changes

You'll notice that many times the flood zone category changes along the county borders. There are a variety of factors that contribute to this, including individual differences of opinion by each county's evaluators, and differing criteria for a given county building and insurance code. This means that it's possible to save considerable money on flood insurance by choosing a property that lies a few yards over the county line if it provides a more favorable flood zone category rating.

Map 4:

The final map strips away the clutter of the storm surge layer to show the current flood zone map with the CSLF layer overlaid on it. It's important to note that virtually all areas categorized VE remain undeveloped due to the extremely high cost of redevelopment, and areas within the A-series are elevated, either on stilts, on piles, or sometimes on graded land reinforced with retaining walls. The cost

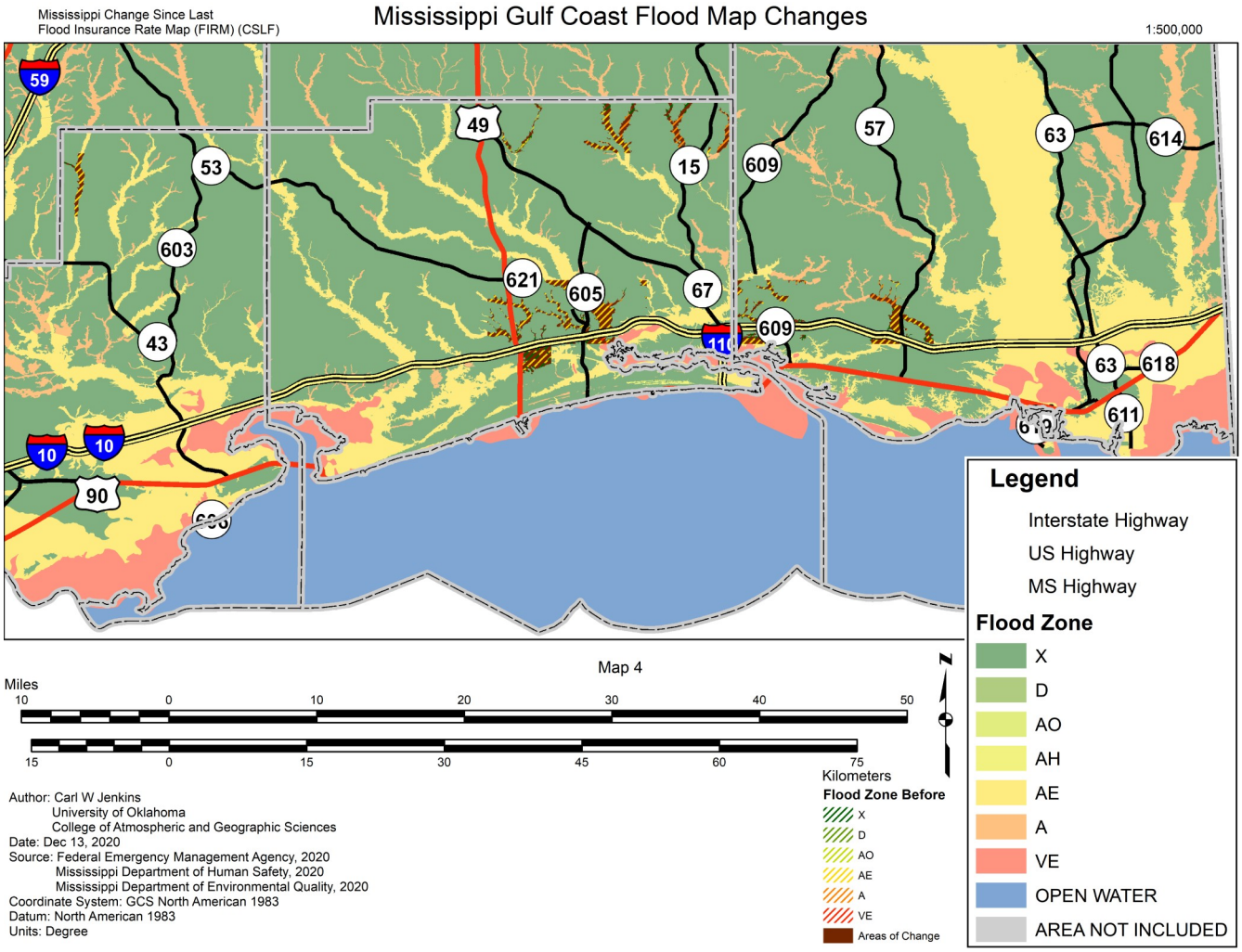


Figure 5: Change Since Last FIRM

of elevation is offset by a reduction in flood-insurance cost, so long as the elevation raises the foundation of the structure above the 500-year flood line.

Conclusion

A study of the Mississippi Change Since Last Flood Insurance Rate Map (FIRM) (CSLF) series shows how severe weather such as hurricanes can change human behavior, such as urban development. The idea that human development is changing the climate and local weather pattern is presented ubiquitously in science and media, but little consideration is given to the idea that humans remain at the mercy of Mother Nature.

It may be interesting to note, however, that the effect of Hurricane Katrina did not directly influence urban development patterns along the Mississippi gulf coast, but rather the insurance industry's reaction to the costs incurred insuring policy-holders who's personal property was devastated by it. The reason for a lack of development is less likely to avoid the dangers of the next hurricane, but rather economic. Higher property insurance rates result in paying more for a property than the property is otherwise worth.

Bibliography

1 Encyclopedia Online Britannica: Hurricane Katrina, September 2020

https://www.britannica.com/event/Hurricane-Katrina

2 CNN: Hurriucane Katrina Statistics Fast Facts, August 2020

https://www.cnn.com/2013/08/23/us/hurricane-katrina-statistics-fast-facts/index.html

3 Insurance Information Institute: Facts + Statistics: Flood Insurance, December 2020

https://www.iii.org/fact-statistic/facts-statistics-flood-insurance

Figure 1: NASA Earth Observatory: Hurricane Katrina

https://earthobservatory.nasa.gov/images/15407/hurricane-katrina

Image produced by Hal Pierce (SSAI/NASA GSFC) and caption by Steve Lang (SSAI/NASA GSFC).

Figures 2-5:

Federal Emergency Management Agency, 2020

Mississippi Department of Human Safety, 2020

Mississippi Department of Environmental Quality, 2020

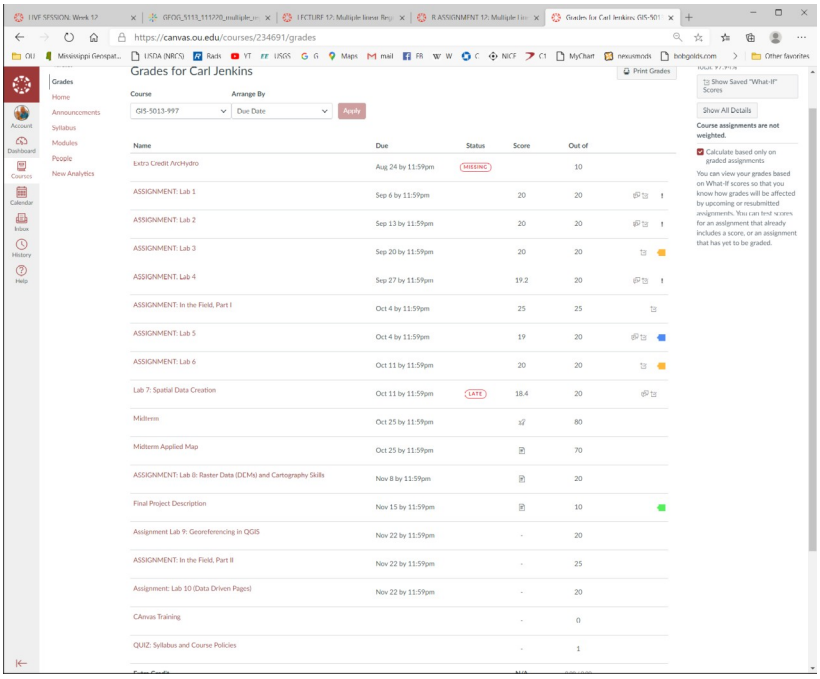
Evaluation

I enjoyed the class despite the comments I will make here. As a geospatial professional I have the pleasure of doing work I enjoy and find incredibly interesting. I am constantly learning new things through the course of my regular work, and seeking out professional development via a graduate level education is logical as I advance to the senior levels of my career. However I have some fairly strong opinions about this course in particular, especially in light of its place in this curriculum.

1. GIS5013, Introduction to GIS is a 1000-level course with a 5000-level credit. As a graduate program for Geospatial Technology and introductory course is out of place and inappropriate. Despite the graduate-level course number this course should not be included in this graduate-level curriculum, rather it should be one of several geospatial-focused prerequisites to enter the program. Two other prerequisites would be undergraduate statistics and physical geography.

2. GIS5013, Introduction to GIS is a 1000-level course with a 5000-level tuition attached. This course is overpriced for the level on content it provides.

3. The grading of assignments lagged behind the pace of the course. Grades often lagged more than a month behind. When coursework is built upon the previous week, but no timely evaluation of student work is provided any systemic errors are repeated, compounding the negative effect of imperfect learning.



4. Incomplete or unclear lab directions. Seeding the potential for bullet 3 is the recurrence of unclear lab requirements and instructions. The lab instructions fell somewhere in the middle between an introductory class and an experience used class. My experience with requirements, templates, and standards is that they are always spelled out in detail, even repeatedly so. That was not the case in most of our labs. For example, Lab 5 described adding maps elements such as “title, source, north arrow, etc.,” and does not go on to specify other, required-for-grade aspects of map marginalia. Grading is done via a checklist/rubric to ensure all aspects of the assignment are completed correctly, but all aspects are not provided students when the lab uses descriptors such as “etc.”

5. The coursework was not necessarily in the order as described in the syllabus, or on the Canvas dashboard, and in some cases was incomplete, or wrong, or “broken.” It may be true that flexi-

bility is required in these uncertain and unusual times. But equally true is that poor planning promotes poor performance. Datasets that have been removed from links, or changed, should be discovered prior to assigning the work to students to enhance confident learning and reduce confusion when something doesn't work as expected. Did the student do something wrong, or is it the software, the system, the network, the source, or the instruction? Software tools and processes should be well established and documented before lecture and instructions are provided to prevent learning on-the-fly by instructors who are unable to demonstrate a tool or function that is a performance requirement in the lesson.

6. There is a vast resource of training through ESRI online learning, and some universities leverage this in their favor. This also benefits the students who can potentially study to gain professional certification. The lessons are largely automated, curated by ESRI, and kept up to date. It probably isn't a complete solution, however including several of the 3, 5, and 7-day courses during the semester holds promise and value for both students and instructors.