THE GEO PROJECT
GEOSPATIAL EDUCATION & OUTREACH

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GEO TUTORIAL

#QGIS
Dealing with Coastal Flooding series, part 5:
GENERATING FLOODING EXTENT
WITH RASTER CALCULATOR

Krzysztof Raczynski
Andrew Nagel
John Cartwright

Geosystems Research Institute
Mississippi State University

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Geosystems Research Institute, Mississippi State University, Box 9627, Mississippi State, MS 39762-9652

The Geospatial Education and Outreach Project (GEO Project) is a collaborative effort among the Geosystems Research Institute (GRI), the Northern Gulf Institute (a NOAA Cooperative Institute), and the Mississippi State University Extension Service. The purpose of the project is to serve as the primary source for geospatial education and technical information for Mississippi.

The GEO Project provides training and technical assistance in the use, application, and implementation of geographic information systems (GIS), remote sensing, and global positioning systems for the geospatial community of Mississippi. The purpose of the GEO Tutorial series is to support educational project activities and enhance geospatial workshops offered by the GEO Project. Each tutorial provides practical solutions and instructions to solve a particular GIS challenge.

GENERATING FLOODING EXTENT WITH RASTER CALCULATOR

Krzysztof Raczynski [1, 2, 4, 5, 6, 8] chrisr@gri.msstate.edu
Andrew Nagel [3, 7] andrewn@gri.msstate.edu
John Cartwright [7, 9, 10, 11] johnc@gri.msstate.edu

Geosystems Research Institute
Mississippi State University

CRediT: 1: Conceptualization; 2: Methodology; 3: Verification; 4: Resources; 5: Data Curation; 6: Writing - Original Draft; 7: Writing - Review; 8: Visualization; 9: Supervision; 10: Project administration; 11: Funding acquisition

REQUIRED RESOURCES

– QGIS 3+

FEATURED DATA SOURCES

– Click here to access dataset used in this tutorial (24.14 MB).

OVERVIEW

Coastal areas across the United States face increasing challenges from changing water levels, which can lead to more frequent flooding and infrastructure strain. In communities like Bay St. Louis, Mississippi, rising water can make roads impassable, damage property, and disrupt daily life—posing serious concerns for homeowners and local economies.

As part of a planning team, your role is to assess how changing sea levels may impact the safety, infrastructure, and long-term growth of this Gulf Coast community. The focus is on protecting property, ensuring economic stability, and strengthening community resilience. This is the theme of the *Dealing with Coastal Flooding* tutorial series, which includes the following topics:

– Part 1: Creating Raster DEM from LiDAR Data
– Part 2: Spatial Predicates: Preparing Residential Data
– Part 3A: Using Unsupervised Machine Learning for Land Use Land Cover Classification
– Part 3B: Using Supervised Machine Learning for Land Use Land Cover Classification
– Part 4: Hydrologic Raster Preparation: Resampling and Burning Stream Network
– **Part 5: Generating Flooding Extent with Raster Calculator**
– Part 6: Calculating Spatial Statistics of Inundated Areas
– Part 7: Creating 3D Maps of Flooding Projections
– Part 8: 3D Map Animations
– Part 9: Creating and Animating Timeseries

In the previous tutorial we have prepared the DEM by burning the stream network and ensuring channels connectivity. In this part we will perform flood analysis to project water reach for future sea level change projections. Make sure to check the remaining tutorials in the series to learn more about the entire analysis process.

DATA

For this tutorial, we will use the Digital Elevation Model (DEM) with streams burned that was created in the previous part of this series. If you don't have this data, you can use the **Featured Data Sources** link above to download the dataset.

USING SEA LEVEL CALCULATOR

NOAA provides a convenient way to obtain the sea level rise data for different scenarios of the future through their Digital Coast portal. In the search box on the main page, simply search for *Bay St. Louis*, and when the city in Mississippi is suggested, click on it. The page will reload to the map view. Zoom in to our case study area and click somewhere on the coast. A details window will be displayed where you can see different scenarios and time steps associated with the projected increase in sea level. There is an abundance of information in this tool, and we highly recommend you spend some time exploring its capabilities. For this tutorial's purposes, we will only need the table with the projected sea level rise (SLR). You can download it or note the values. For our study area, the projections are presented in Table 1.

Table 1. Sea level rise projections for area of Bay St. Louis, Mississippi (in feet).

Scenario	2030	2040	2050	2060	2070	2080	2090	2100
High	0.85	1.29	1.92	2.72	3.74	4.97	6.26	7.55
Intermediate High	**0.82**	**1.22**	**1.69**	**2.32**	**3.09**	**3.95**	**4.88**	**5.91**
Intermediate	0.79	1.12	1.49	1.90	2.37	2.93	3.60	4.36
Int. Low	0.75	1.09	1.36	1.67	1.97	2.28	2.58	2.89
Low	0.72	0.96	1.23	1.47	1.68	1.88	2.06	2.26

Looking at the main graph where regional observations are available, if the current rate remains unchanged, Bay St. Louis will struggle with SLR between the *intermediate* and *intermediate high* future scenarios. For our tutorial, we will look at the ***Intermediate High*** scenario.

CLASSIFYING AREAS UNDER WATER

To determine which pixels will be underwater in the future, we will use *Raster Calculator*, which is located in the *Raster* menu. After opening the tool, in the *raster bands* box, double-click on ***DEMwithStreams*** to apply its name in the *raster calculator expression*. Now, we need to build an expression that will inform the tool what we want to do with our raster. In the predictions table (Table 1) we can see that the first estimate, for the year 2030, is that the sea level will increase by ***0.82 ft***. To identify which raster cells are below that threshold, we need to write:

```
"DEMwithStreams@1" <= 0.82
```

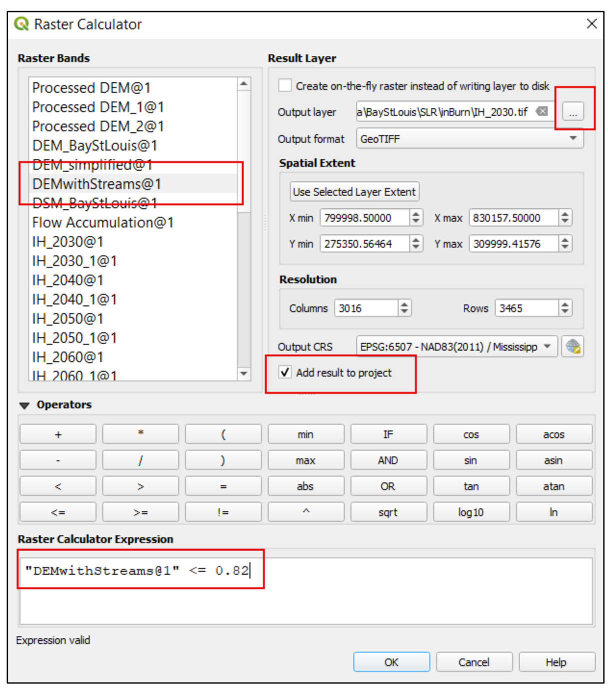

Fig. 1. Raster calculator setting for the 2030 SLR projection.

In the above expression, ***DEMwithStreams@1*** is the name of the DEM layer, which we double-clicked from *raster bands*. This name may be different for you (the *@1* part indicates *band 1*). On the right side of the window, set the *Output layer* save location. Leave remaining settings unchanged (Fig. 1), then click *OK*. The provided expression will produce a True-False raster, where each pixel value is compared to the value of 0.82. If the raster value meets the condition (is lower or equal to), then it will be marked as *1* (*true*), while if the condition is not met (value is higher), then it will be marked as *0* (*false*).

A new raster will be added to the map once the calculation is finished. You can adjust the *style* to display *Paletted/Unique* values and classify them to represent values of *0* in ***green*** (cells not flooded) and *1* in ***red*** (cells flooded) (Fig. 2).

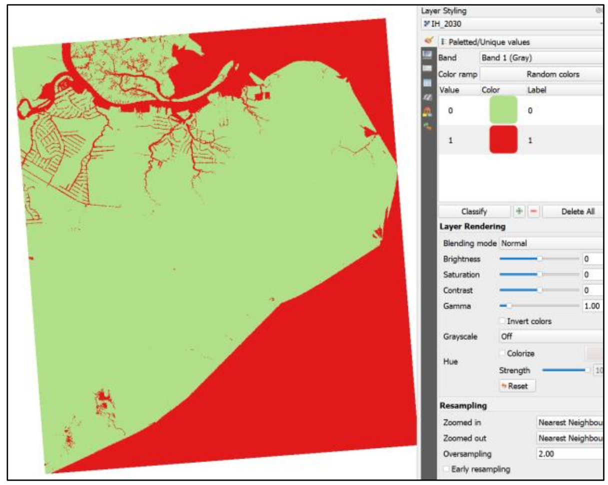

Fig. 2. *The output raster is true-false classified, where flooded cells are marked with the value of 1.*

VECTORIZING

Let's transfer the obtained raster to vector data. Select the *Raster* menu again and choose *Conversion*, then from the submenu select *Polygonize (Raster to Vector)*. As the *input layer*, set the newly computed ***2030 projection***. There is only one band in the raster; therefore, you don't need to set any other parameters. Choose the save file under *vectorized* and run the tool. A new vector layer will be added to the view. Select it in the *Layers* panel, then click on the *Select Features by Expression* tool on the *Selection Toolbar* or push the [CTRL] + [F3] key combination. We will use the

```
"DN" = 0
```

expression to select all polygons that are not within the projected SLR range:

The DN field was created during *vectorizing* and contains the output value from the *Raster Calculator* (raster cell value). Click *Select Features* and close the window. Turn on the *editing mode* for the layer and *remove selected features*.

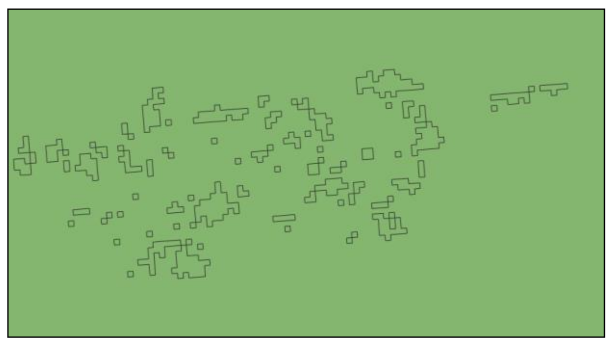

Fig. 3. *Example of pixels not aggregated during rasterization.*

CLEANING OUTPUTS

Output layer will represent water reach for the chosen time horizon; however, the data still needs to be cleaned as there are multiple issues like ***many single-pixel disjoined cases***, ***geometry holes***, and ***classification internal borders***.

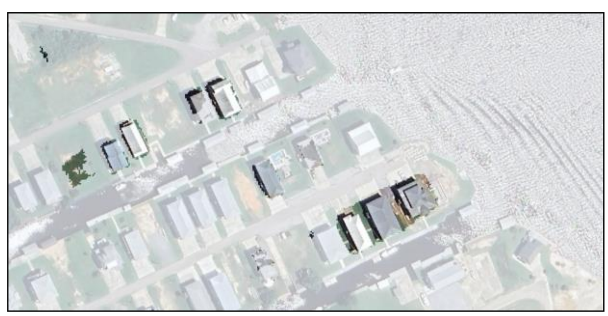

Fig. 4. *Geometry holes due to small elevation differences.*

To deal with the issue of small disjointed features, we can create a tiny buffer around each feature and disjoint the ones that have overlapping areas, then remove any that are not intersecting with stream data. To do this, open the *Vector Geometry* tab in the *Processing Toolbox* and run the *Buffer* tool. Create a tiny buffer (e.g., ***0.3 meter***, which was our original LiDAR accuracy) around each projection scenario. The remaining parameters can be set as default. Once the buffer is created, run the *Dissolve* tool (*Vector* menu, *Geoprocessing Tools*). Select ***keep disjoint features separate***. This will also eliminate the single pixels classified inside the polygons that artificially increase the number of features (Fig. 3).

Next, open the *Extract by Location* tool available under *Vector Selection* in the *Geoprocessing Toolbox* and *extract features from* the ***dissolved layer*** that *intersect* with the ***streams*** vector layer. Save the output.

Finally, let's deal with the issue when some of the houses are located in the inundated areas but were not indicated as flooded houses (Fig. 4). This is usually due to the way our DEM was generated. The shifts of terrain were interpolated from elevations around the houses that were classified as ground, very close to the elevation in our raster calculation. This forms a slight upward shift in the elevation model that might result in an *island* formation. We can safely assume that houses located in such a way (Fig. 4) will be flooded or at least completely cut off from dry land and so affected by SLR. We need to fix our projections to account for these issues. We can automatically detect *holes* in the feature and remove them using the *Delete Holes* tool (*Vector Geometry*, *Processing Toolbox*). When you open the tool, all you need to do is to indicate the *Input layer*. Providing *maximal area* will limit the tool interactions to only the holes that are smaller than the given value. Since the tool only eliminates holes in the feature that have the full ring around, we can assume the threshold of between 250 m² (2690 ft²; average area of a house in the US) and 5000 m² (53,819 ft²; a couple of housing units). You can also run the tool as a batch process to automatically handle all projections during the exercise.

EXERCISE

Repeat the process of generating SLR for the Intermediate High scenario for the remaining time horizons. Use batch processing (check our tutorial [Batching GIS Tasks: a Way To Speed Up Repetitive Procedures] if you are not familiar with this topic) to speed up the computations (to execute the *Raster Calculator* in batch, you need to run it from the *Processing Toolbox*, under *Raster analysis*, instead of from the menu). You can also batch process the *Polygonize* tool. Once completed, prepare a map presenting the reach of water depending on the targeted year (Fig. 5). If you wish to be precise, once all the issues are removed from the output projection, you can run a negative buffer to remove the added earlier tiny extent (e.g., -0.3 if you followed the values in this tutorial).

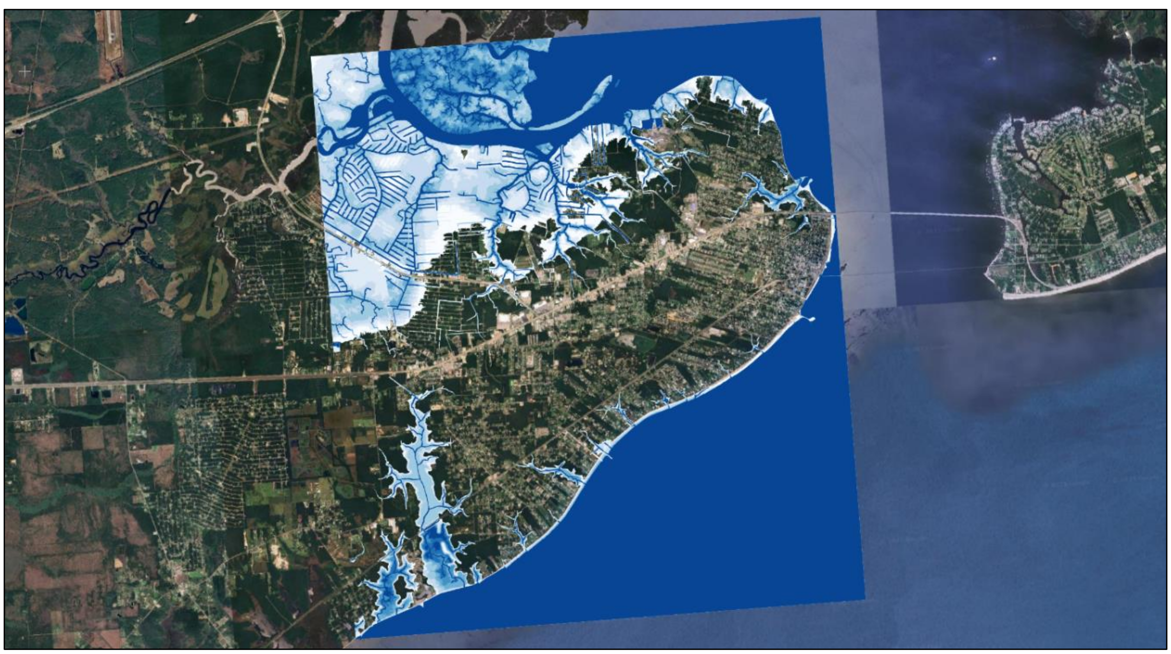

Fig. 5. *The projections of sea level rise in Bay St. Louis area under Intermediate High scenario.*

CONCLUSION

This concludes our GEO Tutorial, where you learned how to use raster calculator to generate flooding extent according to future projections of sea level rise. If you are interested in expanding your knowledge and working on similar topics, please check out the remaining tutorials in this series.