THE GEO PROJECT
GEOSPATIAL EDUCATION & OUTREACH

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GEO TUTORIAL

#QGIS
Dealing with Coastal Flooding series, part 4:
HYDROLOGIC RASTER PREPARATION:
RESAMPLING AND BURNING
STREAM NETWORK

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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.

HYDROLOGIC RASTER PREPARATION: RESAMPLING AND BURNING STREAM NETWORK

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REQUIRED RESOURCES

– QGIS 3+

FEATURED DATA SOURCES

– Click here to access dataset used in this tutorial (125.3 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 our previous tutorial, we used machine learning to classify land use and land cover based on Landsat imagery. In this section, we will enhance the hydrologic aspect of the terrain by improving the Digital Elevation

Model (DEM). We will use official stream data to improve water routing and *burn* streams into the DEM, allowing for easier water movement during our flooding analysis. The process of *burning rasters* means lowering their value to better resemble river paths, by lowering the elevation of surfaces that cover the channel such as bridges. Make sure to check the remaining tutorials in the series to learn more about the entire analysis process.

DATA

In this tutorial, we will utilize the Digital Elevation Model (DEM) that was created in the exercise at the end of the first tutorial in the series, along with data streams from the official hydrography dataset. You can use the **Featured Data Sources** link above to download the dataset or use the DEM you have created earlier. The streams can be downloaded from the National Map Downloader. If you choose to download the data from there, use the *Hydrography (NHDPlus HR, NHD, WBD)* dataset where you can find ***NHDPlus High Resolution HU-8 extent*** geopackages. The data provided with this tutorial have been limited to the spatial extent of the study area and includes only streams (layer: *NHD_H_03170009_HU8_GPKG—NHDFlowline*). Data was reprojected to ***NAD83 (2011) / Mississippi East*** (EPSG: 6507).

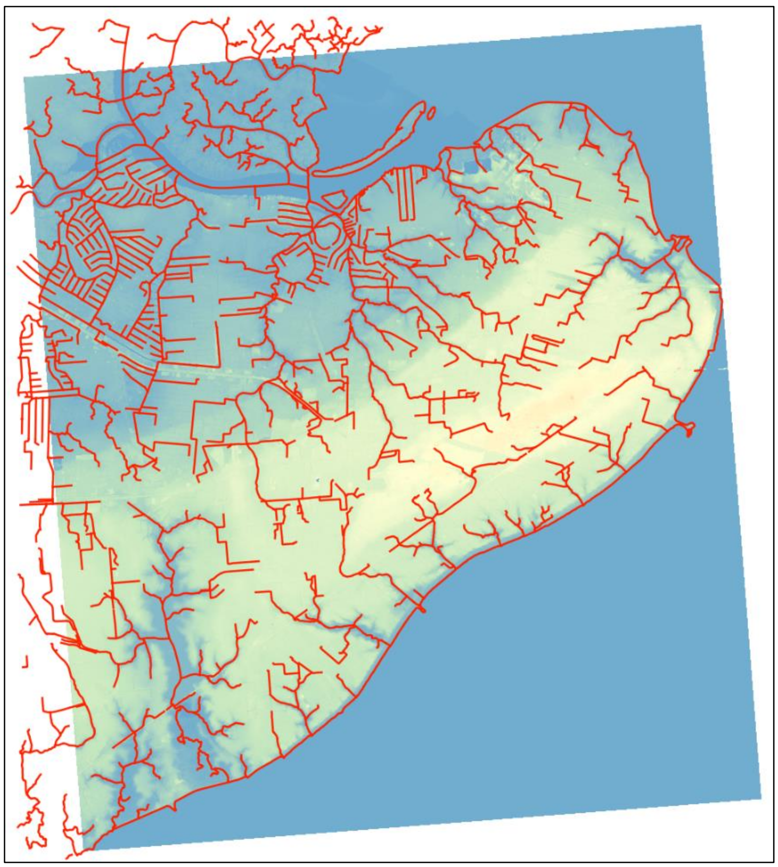

Fig. 1. *Digital elevation model and streams network used in this tutorial.*

CHANGING RASTER RESOLUTION

The input raster has a pixel size of 0.9 meters (90 cm), which is a very fine resolution and can slow the computational processes significantly. For this reason, we will first simplify it by lowering the raster resolution. In the *Layers* panel, right-click on the raster and select *Export*, then *Save As*. Leave the format as ***GeoTIFF*** and provide an output file path. Make sure the ***EPSG 6507*** *CRS* is set and move to the *resolution* settings. In the *Horizontal/Vertical setting*, change the default value to ***10***. This will multiply the initial setting on which the raster was based. Since the original spacing in the point cloud was 30 centimeters, a 10 times higher value will result in a 300-centimeter (3-meter) cell size. It will also lower the size of the input raster 3 times (3 m compared to 90 cm).

RASTERIZATION

To work with the raster DEM and stream network, we need to change the stream layer from vector to raster. To do so, select the streams layer in the *Layers* panel and select the *Raster* menu, then under *Conversion*, click on the *Rasterize* tool. Streams should be set by default as the *Input layer* since we marked them as active in the *Layers* panel. Now, set *A fixed value to burn* as ***1***, since we are not using an existing field. This results with a value of *1* in every pixel where the stream is present and *NoData* (click at the *Assign a specified NoData value to output bands* to set *NoData*) value where there are no streams. In the *output raster size units*, set to **georeferenced units** and change both *resolutions* to ***10***. Save the *rasterized* output (Fig. 2) and click *Run*.

Once the streams are rasterized, they will be added to the *Layers* panel; however, they might not appear correctly on the map. This happens if CRS is not correctly detected. In such a case, open the newly created layer *Properties*, and in the *Source* tab, set CRS to ***EPSG: 6507***. You might need to zoom in on the map to see the newly created raster with streams in black (default).

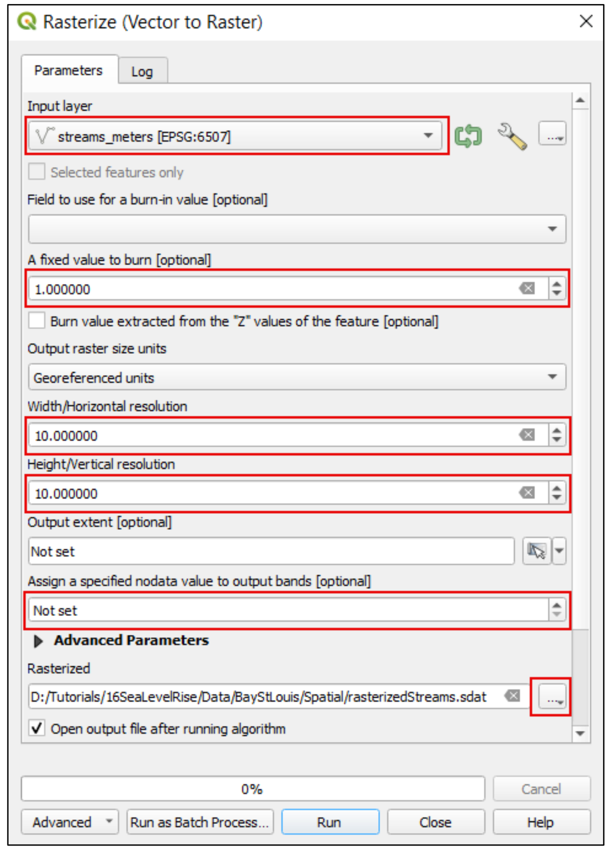

Fig. 2. Rasterize tool allows to change vector data to raster.

RASTER ALIGNMENT

If you zoom in on your map, you will notice that the two rasters are not aligned correctly, and the pixels from streams are not corresponding to the spatial extent of pixels in the DEM layer (Fig. 3). If we want to perform joint operations between the rasters they must be aligned. To do so, in the *Processing Toolbox*, search for *resample*, or open the *GRASS* tab, then *Raster*. Run the *r.resample* algorithm. In the *Input raster layer*, set ***rasterized streams***, then expand advanced parameters. Under *GRASS GIS 7 region extent*, click on the arrow down on the right of the extent button, and select ***Calculate from layer***. In the displayed list, look for ***simplifiedDEM***. Save the output, then *Run* the tool (Fig. 4). This operation adjusted the spatial extent to match the *simplifiedDEM*, and pixels from streams are now properly aligned.

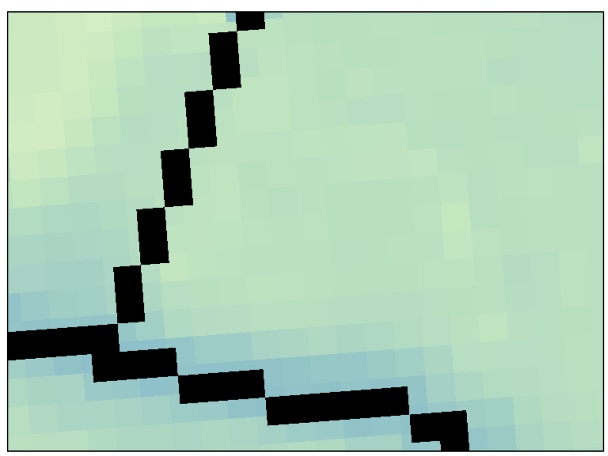

Fig. 3. To perform operations between two rasters, they must be correctly aligned.

FLOW DIRECTION

We will also need the raster representing *flow direction* to properly burn the streams. There are a couple of tools that can produce this; however, the fastest will be the *Fill Sinks* tool. This tool, as the name suggests, allows you to fill in sinks that might be present in the DEM. It is generally recommended to run this tool when doing hydrological analysis on any not filled DEM. You should be very careful when using it on the DEM where streams are not burned, as you might lose significant parts of the stream network due to bridges or other structures. We won't fill sinks at this moment, but we can use the tool to obtain the flow direction raster. In the *Processing Toolbox*, open *SAGA NextGen* (or *SAGA* for older versions). Under *Terrain Analysis – Hydrology* (*Terrain Analysis – Preprocessing* in old SAGA) run the *Fill sinks (wang & liu)* algorithm. Use ***simplifiedDEM*** as input and lower the *minimum slope* to ***0.001***. Save the *flow direction output* to a file.

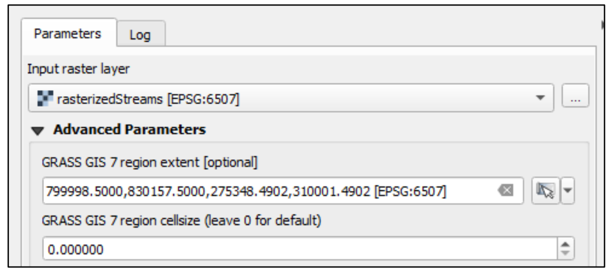

Fig. 4. *Rasters might be aligned using r.resample tool from GRASS package or Align Rasters tool in the Raster menu.*

BURNING STREAMS

Now that we have all the data we need, we can burn streams into our DEM. To do so, under the same *SAGA* tab, find the tool called *Burn streams network into DEM* and run it. In the inputs, set DEM to ***simplifiedDEM***, *streams* to ***alignedStreams***, and *flow direction raster* to previously computed layer. There are three main methods to burn the streams:

- ***Decreasing the cell's value by epsilon***, which lowers the value of the raster where the streams are present by a defined constant called epsilon (set in field below);
- ***Lower the cell's value to the neighbor's minimum value minus epsilon***, similar to the first method with the additional step of replacing the cell value with the lowest value that its neighboring cells have and then subtracting the constant;
- ***Trace the stream network downstream***, which uses flow direction to determine where the water came from and retrace its reach.

In general, the third method provides the most accurate estimation; however, it is sensitive to input quality. For our use any of these approaches will work, but the ***lower the cell's value to the neighbor's minimum value minus epsilon,*** with epsilon set to relatively high value, could provide the best results. You can experiment with different approaches to see the difference or use this setting with epsilon set to ***3***. Save the output and *run* the algorithm.

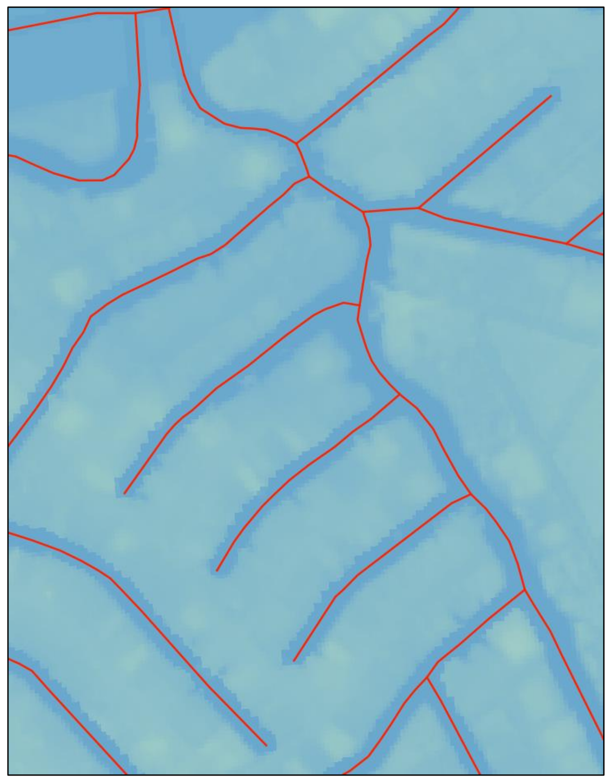

Fig. 5. *Vector streams (in red) and the stream network burned in DEM.*

Now that we have the DEM with forced stream connectivity (Fig. 5), we can move to calculating water reach in different SLR scenarios featured in the following tutorial.

CONCLUSION

This concludes our GEO Tutorial, where you learned how to prepare hydrologic raster to ensure connectivity. You have also learned how to align rasters, to ensure the computations are performed correctly. If you are interested in expanding your knowledge and working on similar topics, please check out the remaining tutorials in this series.