# GEO TUTORIAL

#QGIS
*Dealing with Coastal Flooding series, part 7:*
CREATING 3D MAP OF FLOODING PROJECTIONS

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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.*

# CREATING 3D MAP OF FLOODING PROJECTIONS

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## REQUIRED RESOURCES

- QGIS 3+

## FEATURED DATA SOURCES

- Click here to access dataset used in this tutorial (452.4 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 tutorials, we have processed all available data, determined the water reaches for each projection, and categorized buildings as affected and unaffected by water in the Bay St. Louis area. In this tutorial, we will visualize the extents using 3D maps. 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 data prepared in the previous parts: Sea Level Rise (SLR) water reach, Digital Elevation Model (DEM) and Digital Surface Model (DSM), as well as building layers. If you don't have this data, you can use the Featured Data Sources link above to download the tutorial dataset. If necessary, add the data to a QGIS project.

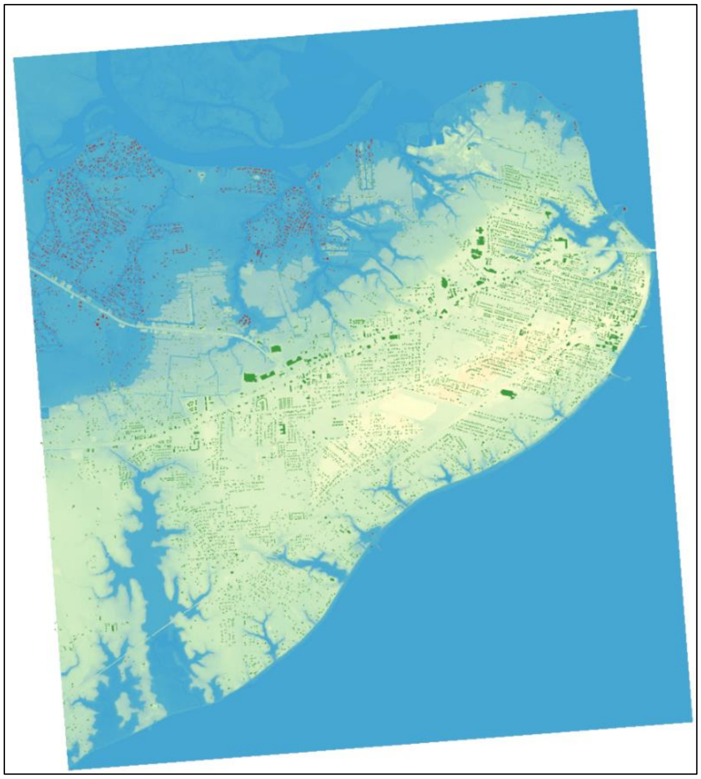

***Fig. 1.*** *Overview of the case study area with 2100 SLR projection, buildings affected (red) and unaffected (green) against DEM background.*

## ASSIGNING HEIGHT DATA

In order to create 3D maps, we need both terrain elevation and building height data. In the first case, our *DEM* contains all the necessary information. The buildings, however, do not contain any attribute that could indicate the height of the structure. In such a case, we can use the constant value for all buildings or use *DSM* information to compute roof elevations. *DSM* contains information on terrain elevation where available, including structures. This means where, e.g., buildings are present, instead of ground elevation, we will have roof elevation. We can use this information to calculate the height of the structures using their spatial extent. To do so, we need to use the *Zonal Statistics* tool available in *Raster Analysis* (*Processing Toolbox*). First, select the ***flooded buildings*** layer as the *input layer* and ***DSM_BayStLouis*** as the *raster layer*. In the *Output column prefix*, put descriptive abbreviations like ***h_*** (height) or ***Z_*** (vertical/z-axis). In the *statistics to calculate*, click the selection button and mark only ***Maximum***, which will provide the maximum pixel value within each building (Fig. 2). Choose the output save location and name (e.g., ***Z_buildings_flooded***) and run the tool. Once finished, go back to the *Parameters* tab, change the input to the ***not-flooded buildings***, choose a new output file (e.g., ***Z_buildings_notflooded***), and rerun the tool. This operation results in the information on maximal measured roof elevation.

## ADDING WATER LEVEL ATTRIBUTE

We will also add the water level information as an attribute to each projection. Our vectors presenting water reaches are in the ***Merged SLR layer***. Open its *attribute table*, and click the field calculator button. Create a new field called ***SLRft*** of length ***4*** and ***decimal number (real)*** type. Write the expression below, and click *Ok*:

```
CASE
WHEN "yearFlood"=2030 THEN 0.82
WHEN "yearFlood"=2040 THEN 1.22
WHEN "yearFlood"=2050 THEN 1.69
WHEN "yearFlood"=2060 THEN 2.32
WHEN "yearFlood"=2070 THEN 3.09
WHEN "yearFlood"=2080 THEN 3.95
WHEN "yearFlood"=2090 THEN 4.88
WHEN "yearFlood"=2100 THEN 5.91
END
```

This *case expression* will assign the projected SLR in *ft* to each feature based on the projection year attribute stored in the ***yearFlood*** attribute. The values come from the table we have generated in the [Generating Flooding Extent with Raster Calculator] tutorial. We are now ready to create a new 3D map.

## CREATING 3D MAP

Click the *View* menu, then *3D Map Views*. From the submenu, select *New 3D Map View*. Depending on the QGIS version, the 3D view might open in a very small window. If this is the case for you, you can grab one of the corners and expand it until the map is visible. You can also drag the 3D map window and dock it to any position in the program window (Fig. 3). At first, the navigation on the 3D map may seem counterintuitive:

- hold the *left mouse button* to *pan the view* vertically and horizontally with reference to the screen;
- hold the *right mouse button* and move the mouse forward/backward or use the *scroll wheel* to *zoom in and out* of the map;
- press the *mouse scroll wheel* and move the mouse to *rotate the map*;
- use *compass controls* on the right to map to achieve the same results (Fig. 3).

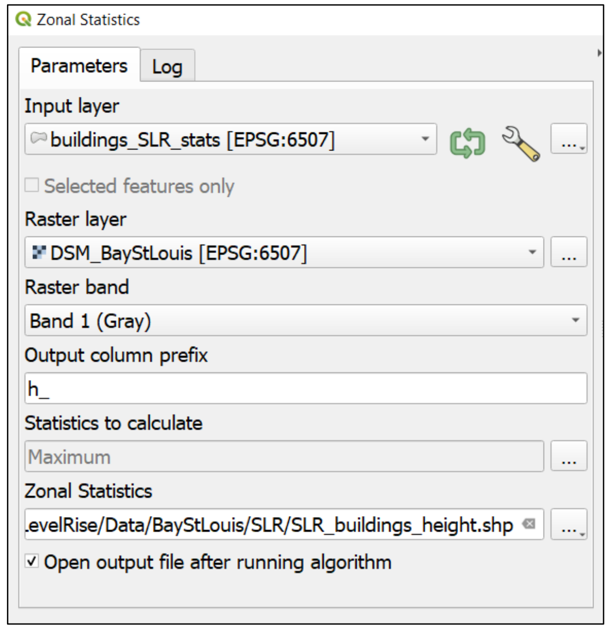


*Fig. 2. Running zonal statistics on DSM allows us to assign roof elevation to building layers.*

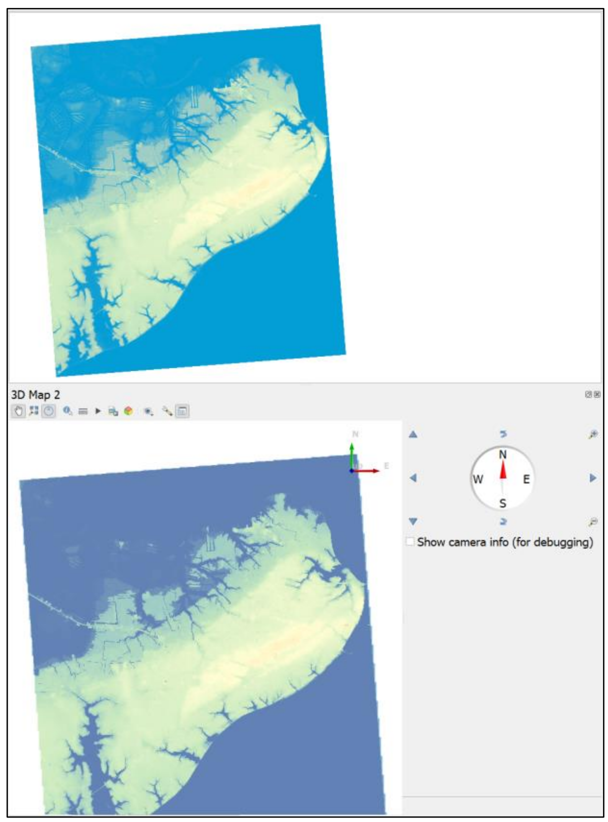


*Fig. 3. 3D map panel docked below map view, with navigation controls on the right. Note that the image has been re-symbolized and may not match what is shown on your screen.*

Practice these operations for a minute until you are comfortable navigating the map.
Now that our map is set, let's prepare the appropriate data for the *2100 SLR projection*. If your ***merged SLR layer*** is in edit mode[1], save changes and turn the editing mode off. Open the *merged SLR layer Properties*, and under the *Source* tab, use *Query Builder* to limit the displayed features:

```
"yearFlood" = 2100
```

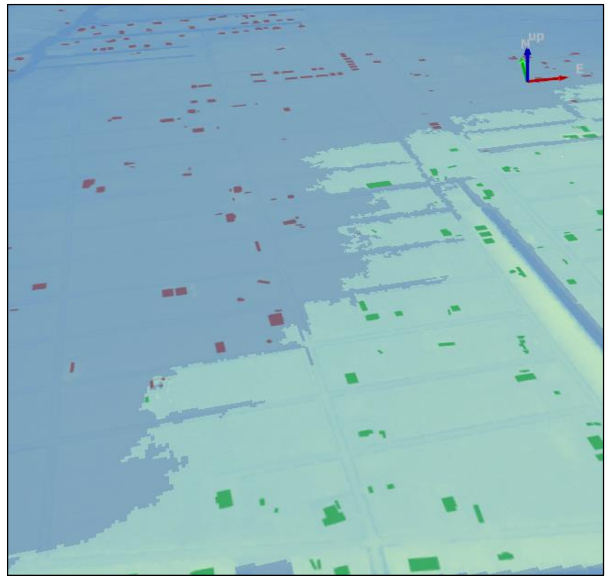

*Fig. 4. 3D map view automatically updates to reflect any changes made in the main project.*

Repeat the process for buildings that are not affected by SLR (***buildings_notflooded*** layer):

```
"projYear" = 2100
```

The ***flooded buildings*** for the 2100 projection do not require the use of *Query Builder*, as all of them are included in the 2100 projection; however, if you wish to work with a different time projection, such as 2050, the view needs to be limited accordingly. In such a case, the following *expression* should be used:

```
"earlyFlood" <= 2050
```

Let's also set colors in layer styling:

– green for ***buildings_notflooded*** layer;
– red for ***buildings_flooded***;
– blue, opacity 40% for ***merged SLR layer***.

When we adjust the changes on the map, our 3D map is updating the view; however, besides the ability to move and rotate the map in 3 dimensions, there is not much 3D to it yet (Fig. 4).

## APPLYING VERTICAL EXTRUSION

For the buildings to be displayed as 3D objects with vertical dimension, we need to apply the 3D styling settings. In the *Properties* for both the ***building layers with heights added*** (both layers produced in Assigning Height Data section), switch the tab to *3D view*, then change ***No symbols*** to ***Single Symbol*** (Fig. 5). Since we have height information stored in the attribute, click the button on the right to *Extrusion* (Fig. 5), then hover the mouse over the *Field type* setting and choose our ***h_max*** attribute (prefix may vary according to what you used in the first section). Apply the 3D View updates.

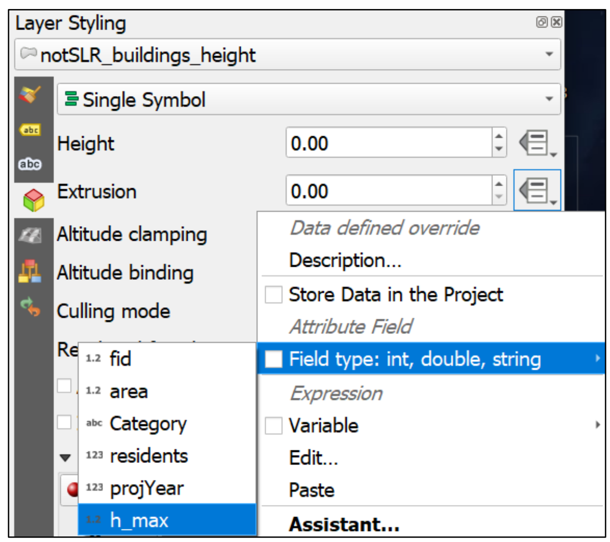


*Fig. 5. 3D extrusion setting allows the vertical shift of the features in the 3D map view.*

You will momentarily see the 3D map update with the buildings now being extruded vertically by the value

[1] You can verify this by checking the icon on the left of the layer name in the Layers panel. If there is pencil icon, the layer is in edit mode. Yellow pencil means all changes are saved but edit mode is on, while red pencil means the changes in the layer were not saved yet.

provided in the attribute. Repeat the process for the *second building* layer as well as the *merged SLR projection* layer (use ***SLRft*** attribute created in Adding Water Level Attribute section).

You've probably noticed that once we set the 3D styling options, the objects on the map lost their colors and are now displayed in white and gray. This occurs because once *3D styling* is applied, the standard map styling no longer has any effect on the 3D view. We can control the colors on the map, by adjusting the *diffuse*, *ambient*, and *specular* colors in the *shading* 3D settings for each layer. Adjust these colors for all three layers until you are satisfied with the look of your map. Additionally, in the *Rendered facade* of the SLR layer representing water reach, change the parameter to ***Roofs*** *only* and *Altitude clamping* to ***Absolute***, as well as *Opacity* to ***40-50%***. Save the project, as QGIS can sometimes crash the first time you apply the next step.

Now that our vectors have vertical extrusion, let's apply the elevation model. Go back to the 3D Map window and click options, then *Configure*.. In the *Terrain* tab, change *Type* from *Flat Terrain* to ***DEM*** and set elevation to ***DEM_BayStLouis*** (do not use DSM, as it contains building heights, and we are using separate 3D objects for this). If you want to improve your map style, you can replace the DEM background image with some satellite imagery, like the *Landsat* image we have downloaded previously, or use a plugin like *QuickMapServices* to add *Google* or *Bing* Satellite (Fig. 6).

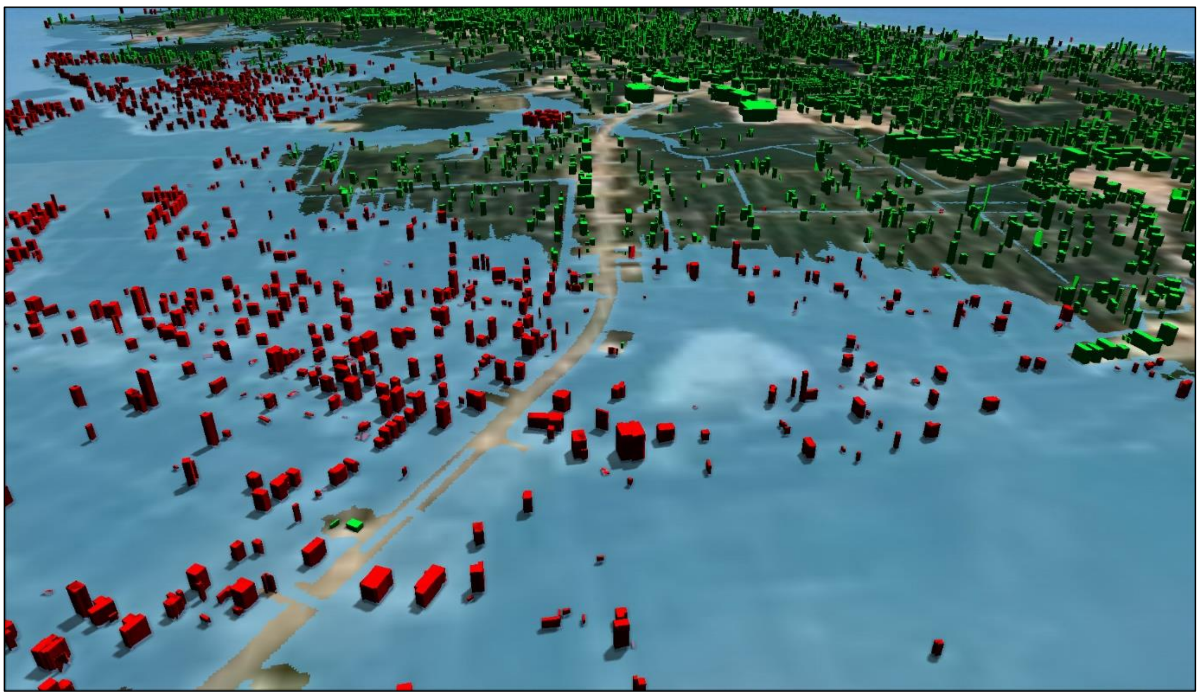

***Fig. 6.*** *The resulting 3D map of 2100 SLR projection with affected buildings in red and unaffected buildings in green. A Google satellite background is incorporated using the QuickMapServices plugin.*

## CONCLUSION

This GEO Tutorial guided you through creating a 3D map visualization of projected SLR impacts in Bay St. Louis, Mississippi. By integrating both DEM and DSM data, we assigned height attributes to buildings and applied vertical extrusion to differentiate between affected and unaffected structures. The application of 3D styling and water level attributes allowed for a clear representation of the 2100 SLR projection. These visualizations offer valuable insights for coastal resilience planning, making complex spatial data more accessible. Ultimately, this visualization approach supports informed decision-making for mitigating flood risk in vulnerable communities.