North Coast Mapping Descriptions

Geoscience Consultants has developed custom Hindcasted Flooding (Task 1), Risk (Task 2), and Land Cover (Task 3) maps and information for The Nature Conservancy to support an ongoing project in Horry and Georgetown Counties. This document describes the logic employed and some of the specifics of the processing for Tasks 1 and 2. It should be noted that the processing will vary for all areas and is dependent on the information available.

Task 1 – Hindcasted Flooding Depths/Extents

Generation of Hindcasted Flooding Depths/Extents is based on two surfaces – 1) a Digital Elevation Model (DEM) and 2) a Water Elevation Surface (WES). This is a straightforward concept; subtracting water elevations from a DEM. It is, however, the spatial data aspects (e.g., locations, number of data points) and types of information that each historical point represents, which requires a bit more processing.

DEM Generation

Digital Elevation Models (DEM) were constructed from Lidar points in lower elevation areas and filled in with the NOAA SLR DEM in the higher areas (at least 5 meters NAVD88). Both sources are from the 2014 Horry County Lidar data set. The low area DEMs were created using a triangulated integrated network (TIN) algorithm and gridded to a 2 m product. Water – ocean, streams, rivers, and lakes – were taken from the NOAA SLR DEM and expanded on with the use of the Horry County drainage shapefile (supplied by Horry County). The Horry County drainage shapefile was manually edited using DEMs and aerial imagery to reflect the larger features. This data layer was then used to burn in water features (subtraction from DEM).

The resulting DEM was a hybrid 2/5 m product with higher resolution in lower areas and an enhanced water/drainage representation. The DEM was used in all tasks as either a primary data source or to derive additional information.

Building Water Elevation Surfaces

Building a WES for Hurricane Matthew and TS Joaquin was a several step process and included information from several sources. The sources included 1) stream gages, 2) high water marks (HWM), 3) the Myrtle Beach tide station, and 4) deployed sensors. The coverage of information varied between storms for each source except tide stations.

Primary Sources – The primary sources of information were stream gages and tide stations. Stream and tide peaks were chosen for each storm and corrected to NAVD and MHHW (tide station). The tide data was used in conjunction with the VDatum MHHW surface for the area (interpolated using IDW technique). The MHHW surface was offset using the tide station maximum reading for each storm.

The two Primary surfaces were compared and the maximum value used to create a Primary WES.

Secondary Sources – The secondary sources included HWM and deployable sensor information from the USGS. These information sources are very sensitive to local conditions (rain intensity and drainage). Some of the HWM were surveyed (absolute elevations); some were located with heights above ground, but without absolute elevations (relative elevations). The 2 m DEM was used to define the absolute elevation for the relative values; there is additional error in these values. A water elevation surface was then constructed from these secondary point sources using an average gridding algorithm.

The final Water Elevation Surface – The WES was constructed by averaging the secondary and primary surfaces. In some cases there was agreement between the two, in others there was not. In most cases where there was not agreement, the secondary surface was higher than the primary; this is the expected result. As a result the final WES tended to be lower than the secondary surface.

The compound secondary and primary surface was used in conjunction with a drainage model of the area of investigation. A drainage model (vector line features) was constructed from an 18 m DEM of the area with features representing drainage from 1000 cells or more. The stream gage data was interpolated (TIN) and the elevation of the stream gage surface conflated to the drainage model (vector). For each line feature (about 1 mile long) in the model, the average water elevation was used to interpolate a higher resolution Stream Gage Elevation Model.

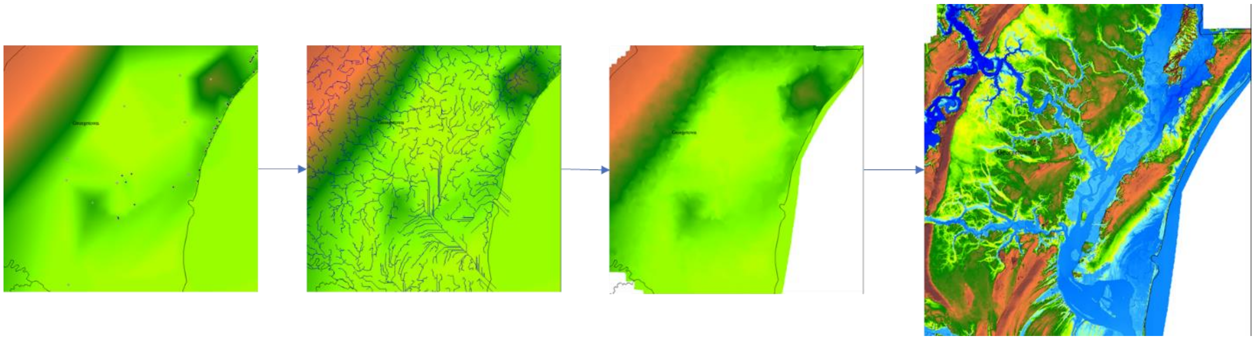

Figure 1. Progression of points to flooding depths

The final Water Elevation Surface model includes not only typical source derived flooding (i.e., Primary Flood Model) but also includes some input from ponding water (puddles) so in some cases it may be higher than a riverine defined hydrodynamic model and represent a worst case scenario for the storms.

Task 2 – Statistical Flooding Risks

Task 2 was carried out using many of the same principles from Task 1. In this case, however, only the primary source information was used (stream gages and tide station). The Task 2 risk surface (Figure 2) is the product of multiple surfaces (DEM, yearly mean, yearly standard deviation, and future offsets to yearly mean and standard deviation; Figure 3) that are used together to define risk values.

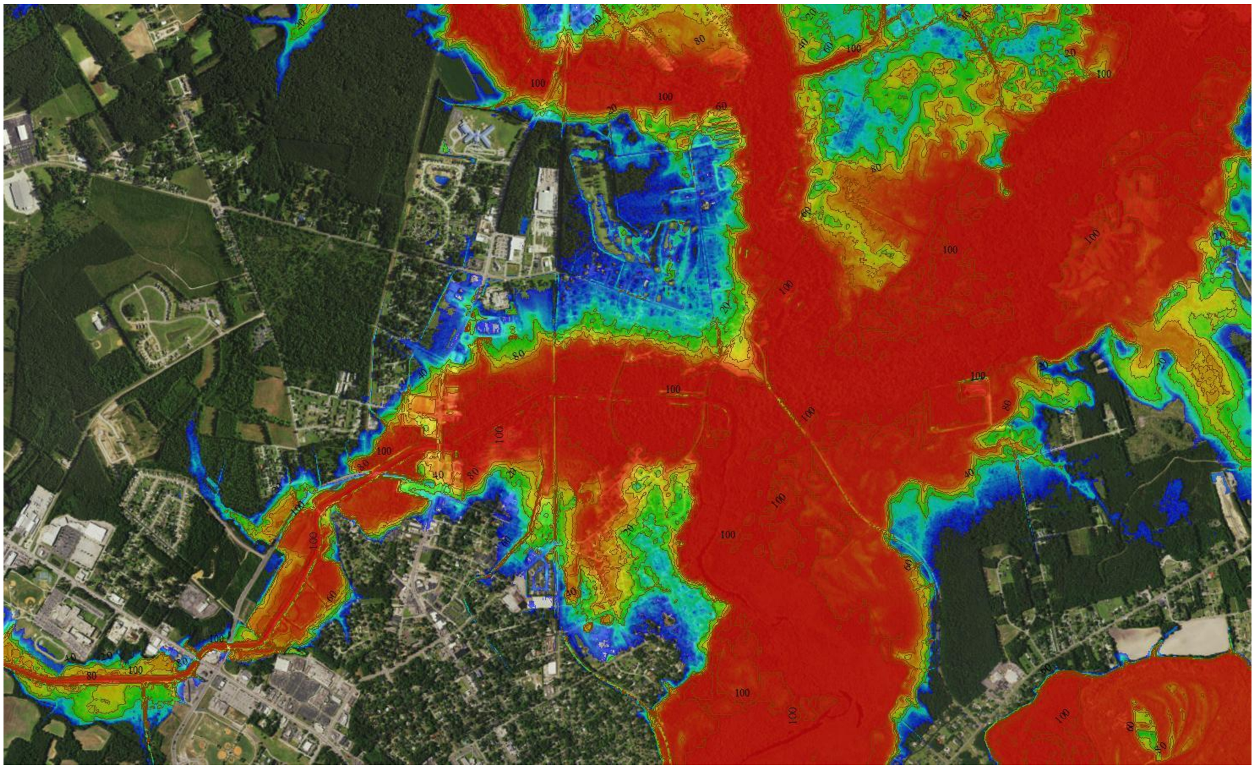

Figure 2. Risk Surface - percent risk of yearly inundation

Yearly Mean – The primary sources (see Task 1) are used to generate this surface. Yearly high gage water elevations (more than 3 years) are calculated from online data sources (primarily USGS). The process of interpolating the values across the entire study area also used the DEM derived stream network (Task 1) to generate the surfaces – both mean and standard deviation (see below). To define the initial surface (which was then used to set elevations in the drainage network) a combination of krigging and triangulated irregular network (TIN) techniques were used, but in other areas use of a specific interpolation routine will depend on how the data is distributed. Like Task 1, the mean yearly mean high water ocean levels (still water surge) were used in tandem with the stream gage data. The still water surge does not include wave affects (run-up) so it is a conservative estimate. The FEMA flood zone along the coast is significantly larger as a result of modeling waves and the potential for storms beyond the historic data. Where the two sources of values differed, the gage information (typically higher) was used.

Yearly Standard Deviation – The same data sources used to generate the mean surface were analyzed to provide a standard deviation for each gage. Likewise, the ocean water level info was also used to calculate a standard deviation. The same interpolation routines and logic in prioritizing values used in computing the yearly mean were also employed in the standard deviation surface generation.

Future Offsets – Future yearly surfaces (2035, 2060) were created using the present Yearly Mean and and an offset (increase) based on the EPA's "Stormy" future scenario for the area (CREAT. Climate Scenarios Projection Map[1]) which indicates a 14 and 27% increase in the rain intensity of the 100 yr storm for 2035 and 2060 respectively. The increases at the 99% level (e.g., 0.14 * 100 yr event) were calculated for each river gage station and a 2035 and 2060 offset surface calculated based on each

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[1] https://epa.maps.arcgis.com/apps/MapSeries/index.html?appid=3805293158d54846a29f750d63c6890e)

stations increase in gage elevations. No changes were made to the standard deviations for the stream gages.

In coastal areas (within about 10 mi of the coastline) the surface also included SLR considerations. SLR values were taken from the USACE Climate Change Adaption site[2] using the values from Springmaid Pier. The values from 5 curves were used (NOAA and USACE) and the average SLR for each time (2035 and 2060) computed along with the standard deviation of the predictions.

These offsets were then applied to the existing surfaces to arrive at Yearly Mean and Yearly Standard Deviation surfaces for 2035 and 2060.

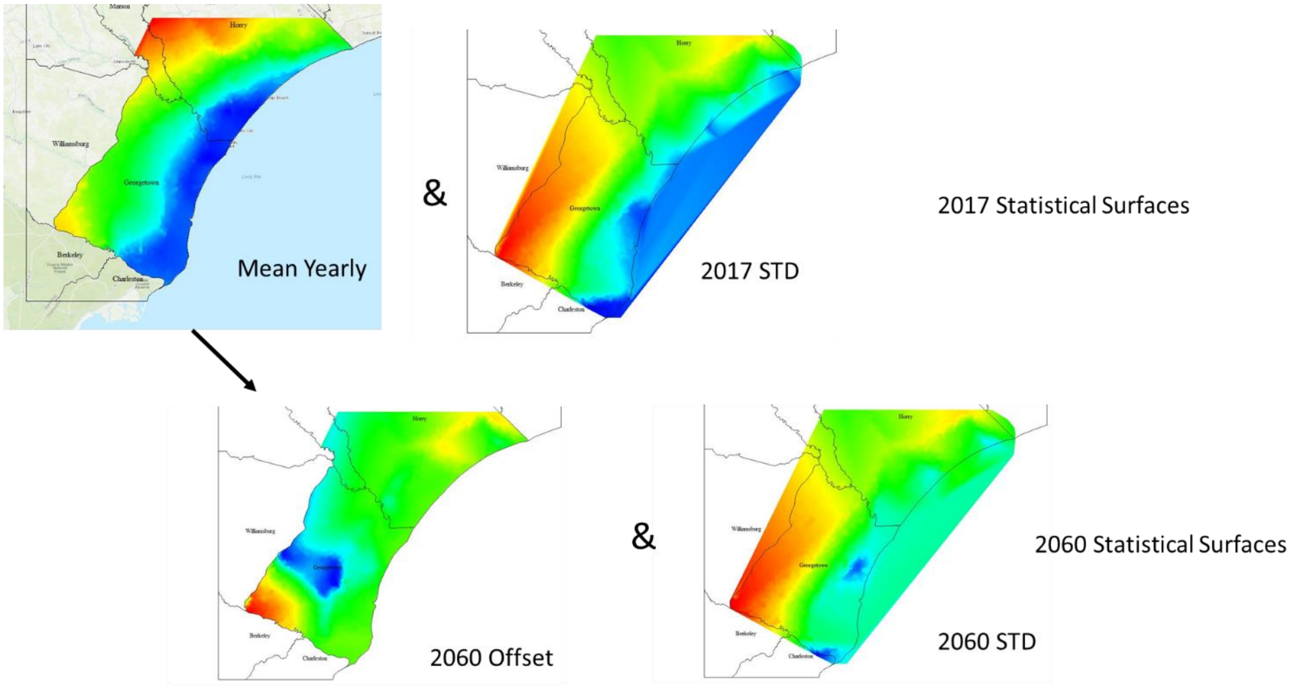

Figure 3. Task 2 surfaces

Risk Values – The surfaces for present and future years were compared with the DEM generated in Task 1 to define Z scores for each pixel. The basic process is outlined in Figure 4; the Inundation level is defined by the Yearly Mean surface, the shape of the normal curve at each point (pixel) is defined by the Yearly Standard Deviation surface and the Elevation Profile is defined by the DEM (see Figure 4 below).

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[2] http://www.corpsclimate.us/ccaceslcurves.cfm#

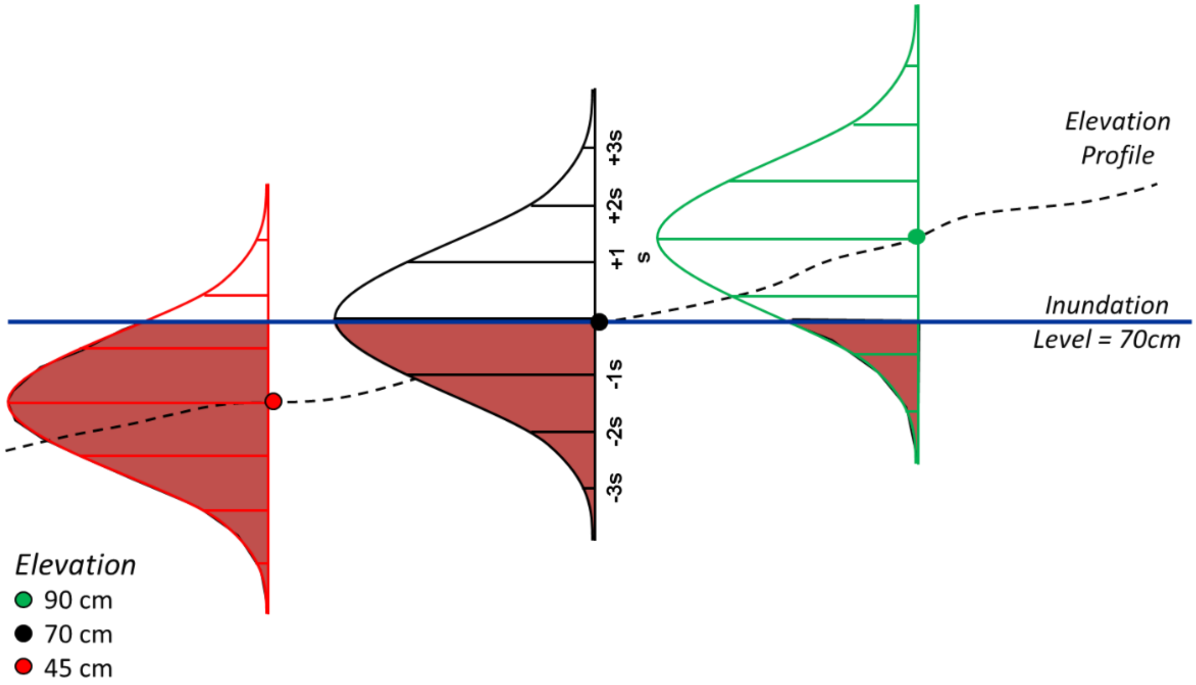

Figure 4. Basic calculation schematic

The first part of the calculation is to generate a Z-Score, which is analogous to the amount of 'red color' in each normal population in Figure 4. The Z-score was generated using the equation:

(DEM – yearly mean)/yearly standard deviation

The z-score values are then converted to risk percentages, a more user-friendly format, using a normal probability equation and the results mapped. In essence, every pixel in the entire study area has a risk value, however, the mapping stops at about the 99% risk level.