

CREATION OF THE NORTH CAROLINA SEA LEVEL RISE DIGITAL ELEVATION MODEL

The National Ocean Service (NOS) of the National Oceanic and Atmospheric Administration (NOAA) created a digital elevation model (Figure 1) to begin studying the impacts of long-term sea level rise on the coastal ecosystems in the sounds and estuaries of North Carolina. The study led by the Center for Sponsored Coastal Ocean Research/Coastal Ocean Program (CSCOR/COP) of NOS' National Centers for Coastal Ocean Science, and technical support provided by NOS' National Geodetic Survey (NGS), Office of Coast Survey (OCS), and the Center for Operational Oceanographic Products and Services (CO-OPS), cooperated to develop data sets, modeling tools, and maps that will be useful to coastal managers.

The approach was to simulate projected sea level variations for the coastal region using a coastal flooding model that combines a hydrodynamic model of water levels with the high-resolution digital elevation model (DEM). The goal of the project was to predict and assess the impacts of rising sea level on coastal wetland and forest ecosystems in Pamlico, Core, Back, and Bogue Sounds and the adjacent lands in Pamlico, Craven, and Carteret Counties. The DEM integrates the land elevations and the bathymetry at a 6-m horizontal resolution.



Figure 1. The North Carolina Sea Level Rise Digital Elevation Model.

Topographic Data Sources

For developing a combined topographic/bathymetric digital elevation model, various data sources were exploited. Two different data sources of topographic elevation data were utilized. These sources are:

- North Carolina FEMA lidar data, and
- USGS' digital National Elevation Dataset (NED)

The raw FEMA lidar data has a horizontal post spacing of 4 to 6 m and a vertical accuracy of 20 centimeters in coastal counties and 25 cm in inland counties. The bare earth data, the original point data that have been thinned to consist of only the lidar returns that represent the ground surface was utilized. This included removing lidar returns capturing vegetation, buildings, power lines, birds, etc.

General issues apparent in the North Carolina FEMA lidar data was sites of missing data within the study area. For the study area where FEMA lidar was missing, data from the NED was used to fill in gaps. Both of these datasets are vertically referenced to North American Vertical Datum of 1988 (NAVD 88).

2.1. Bathymetric Data

Water depths from historic NOS bathymetric surveys of the North Carolina coast were selected for sounding values from the GEOPHYSICAL DATA SYSTEM (GEODAS) created by NOAA's National Geophysical Data Center (NGDC). About 90% of the study area is covered by NOS sounding data. Bathymetric data sets were processed from nearly 1,659,000 soundings extracted from 148 hydrographic surveys spanning the years 1869 to 2001. Individual surveys were carried out over periods of from several weeks to nine years. Sounding methods reported in GEODAS assume lead line surveys before 1940, and digital echo sounder surveys from 1940 onward.

According to NGDC, the horizontal accuracy of the soundings is generally 30 m, with improved accuracy of recent surveys that employ a differential global position system (DGPS). GEODAS converts original depth units (feet or fathoms) to tenths of meters. For common reference, the original horizontal datum of each survey was transformed to NAD 83(86) using the North American Datum Conversion utility (NADCON). Soundings from the 30 oldest (about 20% of the total) surveys acquired before 1927 were initially converted to NAD 27 and then to NAD 83(86). Historic NOS survey data sets were cleaned of missing depth values (denoted by a depth value of -99999), sorted and merged by year and by original vertical datum. Soundings in each survey were checked against adjacent and overlapping surveys to ensure continuous coverage. Thirty-four spatial-temporal filters were applied to select and compile the best available NOS historical bathymetry for the project area, which resulted in approximately 1,210,910 useful soundings.

The NOS sounding data are referenced to one of several vertical datums; each sounding has associated metadata that lists whether the depth value is referenced to Mean Low Water (MLW), Mean Lower Low Water (MLLW), or the low water datum (LWD), which is defined for North Carolina as 0.5 feet (0.15 meters) below the local Mean Water Level (MWL). MWL is the average water level over the available record. Analysis of tidal data included in NOAA hydrographic reports reveals that LWD is usually used for surveys within Pamlico Sound at locations far from inlets. Vertical accuracy of the NOS soundings conforms to the international hydrographic standard: 0.3 m in 0 - 20 m of water, 1.0 m in 20 - 100 m of water, and 1% of the water depth in waters of 100 m depth or deeper. Figure 2 below shows the age of the NOS historical data as well as the sounding density.

Recent bathymetry data from the U.S. Army Corps of Engineers (USACE) originate from 54 small surveys processed to 61,573 soundings for some of the inlets. Where applicable, these channel soundings blend with or supersede the NOS bathymetry.

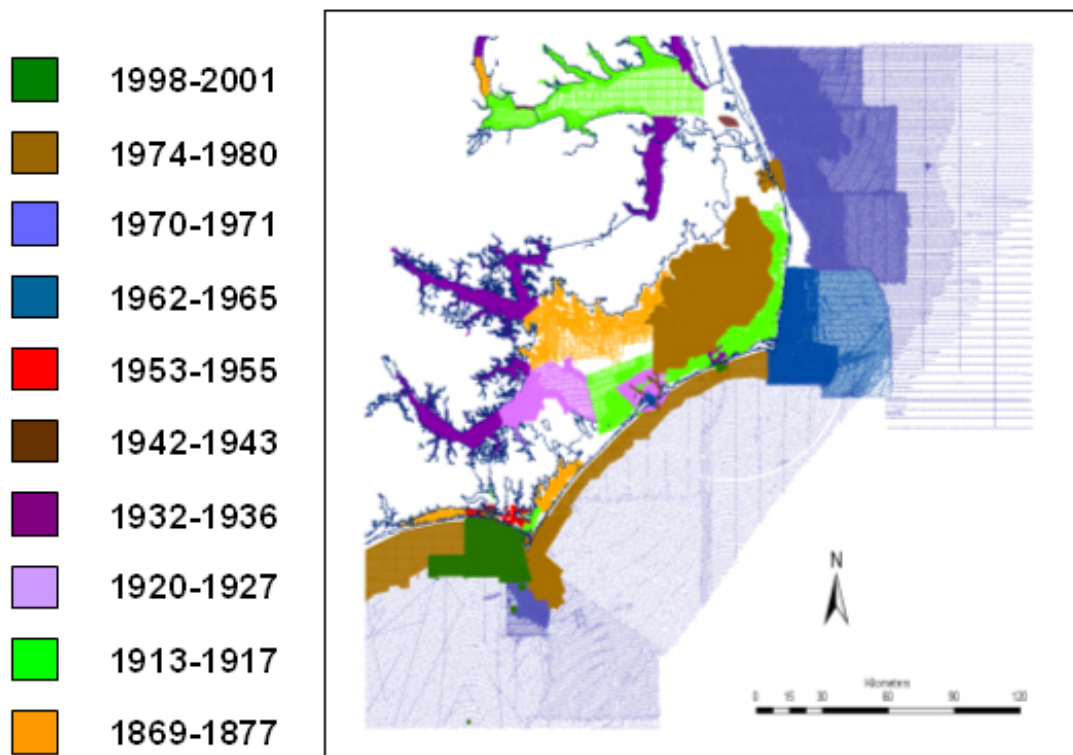


Figure 1. Dates and Location of soundings from NOS surveys in North Carolina.

Re-referencing the Bathymetric Data

Each bathymetric data point was adjusted to local MSL based on the tidal datums produced from the tidal model of the region. These tidal models were created for incorporation into the Vertical Datum Transformation (VDatum) utility. The model produced these tidal datums at all nodes in a finite element mesh. The datums for an

element were determined by taking the average of the datums at the three nodes that compose an element. To adjust a bathymetric data point to MSL, first the data point was located within one of the grid elements. Next, the difference between MLW and MSL or MLLW and MSL for that element was applied to the bathymetric sounding point depending on the original sounding reference. For points where the metadata indicated that the data came from a LWD area, the bathymetry was adjusted 0.15 meters to MSL.

The final output files contain all saved points (i.e., those that were not eliminated in the process described above) adjusted to MSL. Negative bathymetry values indicate a depth below local MSL and positive bathymetry values indicate a height above local MSL.

Merged Topographic/Bathymetric Dataset

A preliminary merge on a small portion of the topographic and bathymetric datasets was performed to work out the processing procedures (Figure 2) that would be utilized when constructing the final combined topographic and bathymetric digital elevation model. For the final DEM, the bathymetry data was transformed from MSL to NAVD 88 with the VDatum utility. Then the North Carolina FEMA lidar bare-earth point data and the USGS NED data were merged with the bathymetric point data. The data was gridded in Applied Imagery's Quick Terrain Modeler utilizing a triangulation with linear interpolation algorithm. The final DEM has a horizontal spacing of 6.0 m and a vertical datum of NAVD 88.

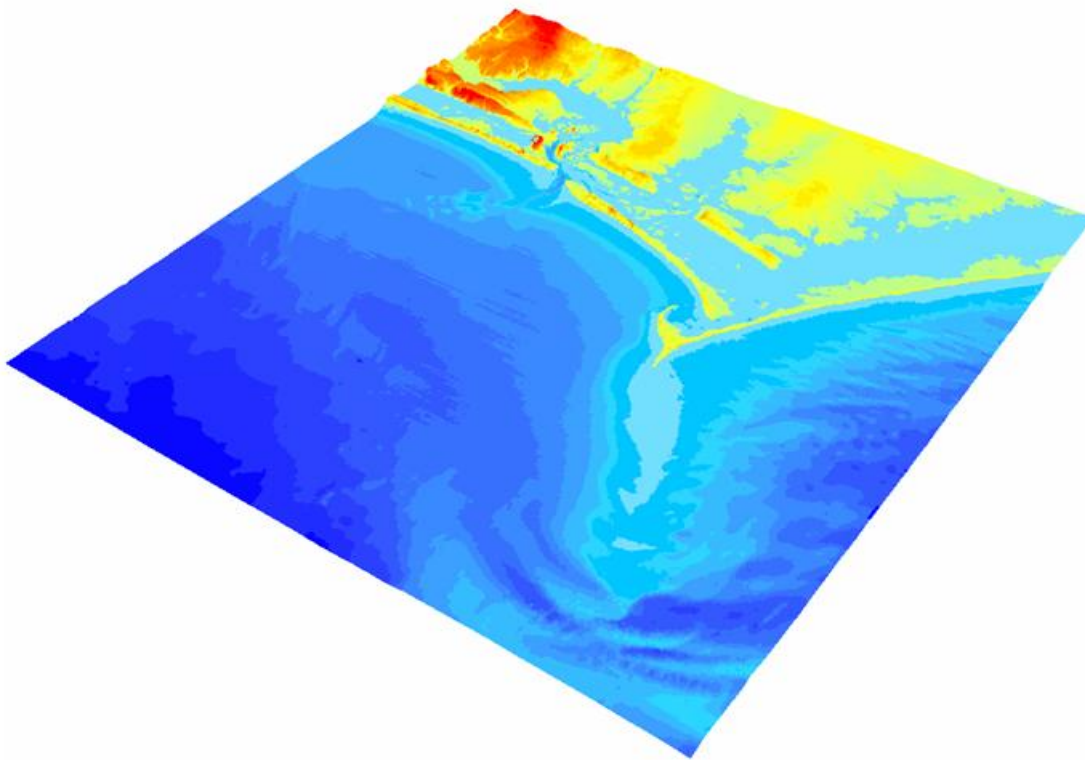


Figure 2. Isometric view of the preliminary topographic/bathymetric DEM created for designing the proper procedures for the merging of North Carolina elevation datasets.