Development of a GIS Tool for the Preliminary Assessment of the Effects of Predicted Sea Level and Tidal Change on Transportation Infrastructure

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Background

The purpose of this research project is to develop an interactive Geographic Information System (GIS) based planning tool which will provide capabilities for the identification of transportation infrastructure potentially at risk from projected sea level changes. The emphasis is on those facilities (roads, rail, transit, air, seaports) that are managed or maintained by the Florida Department of Transportation (FDOT) and their local partners (counties and MPOs), identified as critical infrastructure. The identification of affected facilities will assist and inform transportation planning processes by highlighting potential avoidance, minimization, or mitigation concerns and provide decision support for adaptive management and mitigation strategy development.

As the first phase of a multiphase effort, challenging aspects of the process have included: 1) identifying and constructing suitable digital elevation data; 2) developing a process for creation of statewide sea level rise inundation surfaces considering the variability of the topography and hydroscape in Florida (i.e. hydroconnectivity). This poster illustrates the processes for compiling a statewide digital elevation dataset and creating inundation surfaces, as well as developing a planning tool interface and functions used to identify, select and summarize infrastructure potentially at risk from sea level changes.

The GIS tool, component data layers and resulting inventory of transportation facilities will be incorporated into Florida's Efficient Transportation Decision Making process (ETDM) Internet application to assist and facilitate in the long range transportation planning process of FDOT and its partners.

Future research will refine the regional scale approach and develop sea level, tide and topographic data sources that meet the requirements of a local scale/site level approach. Increasing the resolution, or granularity of the sea level change projections and resultant inundation surfaces are the objectives of the next two phases of this research. Initial efforts to develop a methodology for creation of inundation layers derived from regional scale sea level change projections are presented.

Inputs

NOAA Tide Gauge Station Locations

![NOAA Tide Gauge Station Locations](image1)

NOAA Tide Gauge Data

This graphic illustrates the typical data collected by each tide station. These records can be accessed at: [http://tidesandcurrents.noaa.gov/](http://tidesandcurrents.noaa.gov/)

NOAA Sea Level Trends

In addition to tide and sea level data, NOAA also calculates sea level trends. This is a graphic of the trend for the Key West tide station. This value, adjusted for local vertical land motion, is used in calculating sea level change Projections and inundation Surfaces.

Sea Level Change Projections

8724580 - Key West, FL: 2.2 (mm/yr)

- USACE High Rate
- USACE Intermediate Rate
- USACE Low Rate (Current Rate)

This graph shows the results of calculating sea level change projections using the USACE methodology, which was adapted from the original 1987 National Research Council methodology. It combines the NOAA trend data with the equivalent global value of 3.7mm and the time frame for the projection. A coefficient the represents rate of rise generates the low, intermediate or high curves. Additional information on this methodology can be found here: [http://www.corpclimate.us/ocaseslcurves.cfm](http://www.corpclimate.us/ocaseslcurves.cfm)

Digital Elevation Model

A major challenge was creation of a statewide digital elevation model (DEM). Existing topographic data (National Elevation Dataset) proved problematic from a vertical accuracy perspective. Therefore, a combination of 2008 Lidar data, collected for the coastal areas and sources from the Florida Division of Emergency management and the NOAA Coastal Services Center, was mosaicked with an inland composite of topographic data sources developed by the Florida Fish and Wildlife Research Institute. This mosaic resulted in a 5-meter resolution, statewide DEM with a vertical accuracy of approximately 10-inches in the coastal area.
Sea Level Change Surface Model

This is the GeoPlan workflow for creating statewide inundation and depth layers resulting from projection of sea level change for a given time period. Critical steps in the process are: 1) conversion of the projected values referenced to the mean sea level datum (MSL) to the NAVD88 terrestrial datum; and 2) determining the hydrologic connectivity of the inundated areas. Step 2 is a major enhancement to the simple bathtub inundation method, by eliminating isolated inundation areas with elevations lower than the projected sea level surface.

Sea Level Change Surface Calculator

This surface model illustrated above forms the foundation for the sea level change surface calculator. This is an ArcMap tool that automates the processing and creation of inundation and depth surfaces and layers. In addition, it provides for increased functionality and flexibility when working with different datasets, whether statewide, regional or local.

The primary inputs to the tool are the tide station feature layer and the desired DEM. Once the tide station attribute table is chosen, the tool returns either station or region names to be processed. The user then selects the Stations/Regions, and the Time period/Projection to process. The user can then choose which surfaces to create: projected sea level change inundation layer, projected sea level change depth layer, or both. The file output location path is then specified.

Within the calculator many processes are in play. For example, there are automated routines for handling the naming structure of each surface. Also included are routines that allow for user-selected surfaces to be handled and processed dynamically independent of table order.

Regional Sea Level Change Projections

A major research component of this project is evaluating methods to determine the “area of influence” of a given tidal station. That is, what is the geographic region around a station where the data collected by that station reasonably applies. These regions could be determined by characteristics of the natural environment or by administrative boundaries. Relevant to the FDOT’s requirements, it was determined that their District boundaries would provide a logical basis for summarizing potentially vulnerable infrastructure.

As illustrated in this graphic, one method that is being tested involves weighting tide station sea level change projections by their area weighted mean. Other methods for calculating regional weighted means are being currently being investigated.

As with the statewide surfaces, critical steps in the process are: 1) conversion of the projected values referenced to the mean sea level datum (MSL) to the NAVD88 terrestrial datum; and 2) determining the hydrologic connectivity of the inundated areas. Step 2 is a major enhancement to the simple bathtub inundation method, by eliminating isolated inundation areas with elevations lower than the projected sea level surface.
**Sketch Planning Tool**

Inundation layers created using the calculator are visualized within the Sketch Planning Tool. The application is built on the license-less ESRI ArcReader platform using ArcObjects. This allows for easy and free distribution while still taking advantage of mapping functions pioneered by the ESRI suite of products.

The visualization process starts with a statewide view of inundation. From there the user can select filters that narrow down the results to view an area of interest. The user can measure distances, open feature tables and query the data to return features that will be inundated during a given projection period. Also included is a report generation function which summarizes the infrastructure potentially at risk, as well as key attributes about that infrastructure.

Any number of data layers can be included in the Tool. A listing of the layers available in the prototype are displayed in the Table of Contents on the left side of the user interface. Critical layers needed for the vulnerability analysis include FDOT-derived data from RCI, SIS and the Unified Basemap Repository (UBR), as well as the sea level change inundation layers for the time periods of interest (2040 and 2060). Additional inundation layers spanning the time period 2010 – 2100 at decadal intervals will be included to enable visualization of alternative and “what-if” scenarios.

**Bathtub Method Results:**

**No Hydrologic Connectivity Filter**

**With Hydrologic Connectivity Filter**

**Example Inundation Results:**

Southwest Florida

The results shown here are one example of the various inundation surfaces created. The graphic on the left shows potentially inundated areas (in blue) using the bathtub method. The graphic on the right shows potentially inundation areas (in blue) using the bathtub method enhanced with the connectivity filter, which eliminates isolated inundation areas with elevations lower than the projected sea level surface.