FREQUENT QUESTIONS

NOAA Coastal Services Center
LINKING PEOPLE, INFORMATION, AND TECHNOLOGY

Digital Coast Sea Level Rise and Coastal Flooding Impacts Viewer

April 2012

NOAA Coastal Services Center
(843) 740-1200
www.csc.noaa.gov

_____

Contents

Geographic Coverage

Why isn't my state or county included in the viewer?

We are working on it. Gathering the best available lidar-based elevation data and developing hydro-enforced digital elevation models suitable for accurate coastal inundation mapping takes time. Our initial pilot areas (January 2011) were the Houston/Galveston, Texas, and Mississippi areas. We are adding new geography every 2 or 3 months. We plan to be finished in fall 2013.

What are the current status and plans for future updates of the viewer?

A link to a current status map exists on the viewer home page at this address: *www.csc.noaa.gov/digitalcoast/tools/slrviewer/status.jpg*.

This map does not show the Pacific islands that will also be included with the Hawaii update (Guam and CNMI). Currently there are no plans to map Alaska because of a lack of adequate statewide coastal elevation data. The Great Lakes will be mapped (inundation and lake level drop) and included in a separate lake level viewer application in 2013-14.

Data

Where do the data come from?

There are many data layers displayed in the viewer. Each functional tab displays different data.

Sea Level Rise
The maps in this tab show inland extent and relative depth of inundation from 0 to 6 feet above mean higher high water (MHHW). Areas that are hydrologically connected (according to the digital elevation model used) are shown in shades of blue. Low-lying areas, displayed in green, are considered hydrologically "unconnected" areas that may flood. They are determined solely by how well the elevation data capture the area's hydroconnectivity. A more detailed analysis of these areas is required to determine whether they flood given the chosen sea level rise (SLR) value. The inundation maps are created by subtracting the NOAA VDATUM MHHW surface from the digital elevation model.

The data in the maps do not consider natural processes such as erosion, subsidence, or future construction. Inundation is shown as it would appear during MHHW—the average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch {~19 years} (excludes wind driven tides). The data, maps, and information provided should be used only as a screening-level tool.

Visualization Locations
Clickable camera icons display inundation impacts at 0-6 feet above MHHW at various public locations. The water surface was superimposed on existing photographs based on site

elevations taken from digital elevation modes using a free software program called CanVIS, available for free download on Digital Coast: *www.csc.noaa.gov/digitalcoast/tools/canvis*

"Areas not mapped"
These hash-marked areas indicate places where adequate accuracy elevation data (see question on data accuracy) were not available for mapping.

Mapping Confidence
Levels of confidence are depicted on this tab. Blue areas denote a high confidence of inundation, orange areas denote a low confidence of inundation, and unshaded areas denote a high confidence that these areas will be dry given the chosen water level. In this application, 80% is considered a high degree of confidence such that, for example, the blue areas denote locations that may be correctly mapped as "inundated" more than 8 out of 10 times. Areas with a low degree of confidence represent locations that may be mapped correctly (either as inundated or dry) less than 8 out of 10 times.

Confidence mapping is a fairly complicated procedure that is explained in detail in the "Mapping Inundation Uncertainty" document available at *www.csc.noaa.gov/slr/viewer/assets/pdfs/Elevation_Mapping_Confidence_Methods.pdf*. In short, the method includes the uncertainty in the lidar derived elevation data (root mean square error, or RMSE) and the uncertainty in the modeled tidal surface from the NOAA VDATUM model (RMSE). This uncertainty is combined and mapped to show that the inundation depicted in the viewer is not really a hard line, but rather a zone with greater and lesser chances of getting wet.

Data in this tab do not depict uncertainties associated with climate change models and SLR in any way.

"Areas not mapped"
These hash-marked areas indicate places where adequate accuracy elevation data (see question on data accuracy) were not available for mapping.

Marsh
Maps represent the potential distribution of several marsh and wetland types based on their ecological (tidal) niche and the resulting elevation under several scenarios of sea level rise and sediment accretion. As sea levels increase, each tidal niche raises in relation to this amount, as well as any offsetting accretion values (selected by the user). This can be thought of as a bathtub style model where there is a separate layer or surface for the threshold between each wetland type. As a result, some marshes may migrate into neighboring low-lying areas, while other sections of marsh will be lost to open water. A simple explanation of the mapping assumptions is as follows:

current sea level elevation + amount sea level rise - accretion = net marsh impact

The initial starting condition (0 feet of sea level rise) is derived from NOAA's Coastal Change Analysis Program (C-CAP) (*www.csc.noaa.gov/digitalcoast/data/ccapregional*) land cover data. High and medium intensity development classes are treated as barriers to marsh migration.

A more in-depth method for mapping marsh migration can be found here: *www.csc.noaa.gov/slr/viewer/assets/pdfs/Marsh_Migration_Methods.pdf*

Literature-supported average sediment accretion rates are used.

"Areas not mapped"
These hash-marked areas indicate places where adequate accuracy elevation data (see question on data accuracy) were not available for mapping.

Socioeconomic Vulnerability
By overlaying social and economic data on a map that depicts sea level rise, a community can see the potential impact that sea level rise can have on vulnerable people and businesses.

Social
The Social Vulnerability Index (SOVI), which shows areas of high human vulnerability to hazards, is based on population attributes (e.g., age and poverty) and the built environment. By looking at the intersection of potential sea level rise and vulnerable block groups, one can get an idea of how vulnerable populations might be affected by sea level rise.

Dark red indicates block groups having a high vulnerability, and the lighter reds indicate decreasing vulnerability. The method for creating the SOVI data is available from the University of South Carolina Hazards and Vulnerability Research Institute, the creators of the dataset: *http://webra.cas.sc.edu/hvri/products/sovi.aspx*

Economic
Employment, wages, and the number of establishments (or businesses) exposed to a hazard are strong indicators of a community's overall economic vulnerability. By looking at the intersection of potential sea level rise and the distribution of the economy within a community, one can get an idea of how a local economy might be affected by sea level rise.

Darker colors represent block groups with higher concentrations of employment, wages, and establishments. White represents block groups where data cannot be displayed because of confidentiality issues.

These data represent total business establishments, employment, and quarterly wages aggregated to Census block groups and are from the Bureau of Labor Statistics' (BLS) Quarterly Census of Employment and Wages (QCEW). Methods on how these data are created by BLS are available here: *www.csc.noaa.gov/slr/viewer/assets/pdfs/BLS_Details_Methods.pdf*

Flood Frequency

Shallow Coastal Flooding Areas
Many coastal areas experience periodic minor-to-moderate shallow coastal flooding events—typically as a result of meteorological factors that include high tides, winds, and rain.

This map illustrates the extent of flood-prone coastal areas based on predicted water levels exceeding specific tidal heights as issued by local National Weather Service offices. Each coastal National Weather Service forecast office uses a criterion for coastal flooding based on NOAA tide gage readings. When water levels go above this threshold, impacts to people and property occur. We have used these thresholds to map the inundation extents in order to visualize the flooding that would occur during a forecast flood event. The red areas in the map depict areas that are currently subject to shallow coastal flooding.

"Areas not mapped"
These hash-marked areas indicate places where adequate accuracy elevation data (see question on data accuracy) were not available for mapping.

Tide Gages
NOAA tide stations in the map are "clickable" to see information on the current frequency of coastal flood events and durations compared to hypothetical half-meter and one-meter sea level rise scenarios. The coastal flood event frequencies and durations for tide gauges were calculated using observed tidal data over a three-year period (2007-2009). The future frequency and duration predictions are based on the addition of half-meter and one-meter sea level rise scenarios to the observed water levels over the three-year period. More detail on the methods used to determine the flood frequency can be found here:
www.csc.noaa.gov/slr/viewer/assets/pdfs/CO-OPS_Flood_Frequency_Methods.pdf

What is the accuracy of the mapping used in this tool?

The maps in the viewer are derived from source elevation data that meet or exceed the Federal Emergency Management Agency (FEMA) mapping specifications for the National Flood Insurance Program.
- 0.6 feet (18.5 cm) root mean square error (RMSE) for low relief terrain
- 1.2 feet (37.0 cm) RMSE for high relief terrain
Areas that do not have elevation data that meet this criteria are shown as "Areas not mapped" in the viewer.

NOAA's VDatum model adds additional error (RMSE) to the base data that ranges from several centimeters to tens of centimeters depending on location.

What is VDATUM?

The NOAA VDatum model converts elevation data between tidal, orthometric, and ellipsoidal vertical datums, allowing users to establish a common reference system for all elevation

datasets. VDatum is based on a hydrodynamic model to convert between tidal and orthometric datums. For more information: *www.csc.noaa.gov/digitalcoast/tools/vdatum/index.html*

How often is the mapping updated with new elevation data?

Currently sea level rise and coastal flooding mapping data are being added for the first time to the viewer. The main emphasis for 2012-2013 is to populate the viewer with data for all regions (see status question above). New elevation data are being collected all the time by various federal, state, and local entities. It is possible that newer data have been collected since the mapping areas were populated. After the initial regions are mapped, an update strategy will be developed.

How do I access the data layers in the viewer?

There are currently two ways to access the data layers that are shown in the viewer:
1. File Geodatabases – *www.csc.noaa.gov/htdata/Inundation/README.txt*
2. Tiled and Cached REST services – *http://csc.noaa.gov/arcgis/rest/services/dc_slr*

Can I get the digital elevation models (DEMs) that were used to create the layers in the viewer, and how are they different from most other DEMs?

DEMs used to create the layers in the viewer are available upon request. We are not providing them via online download because of data licensing and use restrictions. Metadata explaining use restrictions, appropriate uses, and source data will be included. Building the DEMs for the viewer is by far the most time-consuming process step. DEMs are created by first gathering the best available lidar-based elevation data (see data accuracy question). This includes raw and/or bare earth lidar data, digitized breaklines (where available), National Hydrography Dataset boundaries, National Wetland Inventory boundaries, levee centerlines, and elevations. Not all these sources are used in a single DEM, but rather a combination is used where data gaps exist to adequately condition the DEM for mapping purposes. Conditioning the DEM means including hydro-features and breaklines in the DEM to make sure areas that currently experience flooding are depicted accurately. For example, bridges are removed so breaks in the DEM will not separate water bodies in the final map product. The specifications for hydro-flattening the DEMs for sea level rise (SLR) mapping are more stringent than other national specifications (e.g., USGS) in that smaller hydrologic features are incorporated into the DEM (Any hydro-feature larger than 10 meters or ~30 feet is included). Because these DEMs are created specifically for SLR mapping, they may not be appropriate to use for other applications, such as FEMA floodplain boundary mapping. For example, water feature elevations have been lowered to -1 feet for mapping purposes.

Modeling Approach

How is this tool different from other national sea level rise mapping efforts?

The purpose of this data viewer is to provide a preliminary look at sea level rise and coastal flooding impacts. The viewer is a screening-level tool that uses the highest accuracy elevation datasets available at the time maps were produced.

The criteria used for mapping the various sea levels in the tool were developed to enable consistent mapping on a national scale. They are as follows:

- Use publicly, best available and accessible elevation data that meet FEMA mapping standards
- Map literature-supported levels of sea level rise (SLR)
- Map SLR on top of mean higher high water (MHHW)
- Incorporate local or regional tidal variation of MHHW for each area
- Evaluate inundation for hydrological connectivity
- Preserve hydrologically unconnected areas greater than one acre in size but display separately from hydrologically connected inundation

Why does the tool show inundation starting at mean higher high water (MHHW)?

For inundation studies for which increased water level scenarios are required to determine the amount of land affected by sea level inundation, the elevation of a tidal datum (such as mean high water, or MHHW, in areas with diurnal tides) is often used as the base elevation. This is because the high water datum represents the elevation of the normal daily excursion of the tide where the land area is normally inundated. Taking this normal extent of inundation into account is important when trying to delineate land areas inundated by abnormal events such as storm surge, tsunami run-up, or sea level change. For more detail, see this NOAA technical report at *www.csc.noaa.gov/digitalcoast/_/pdf/SLC_Technical_Considerations_Document.pdf*.

Is this viewer based on a "bathtub" modeling approach?

Generally, the process used to map sea level inundation in this viewer can be described as a modified bathtub approach or linear superposition method. The maps in this tool take into account local tidal variability using the NOAA VDATUM model. Tide ranges vary greatly along the U.S. coastline; therefore the highest of the high tides are at different distances relative to the elevation of the land. Taking this into account shows immediate impacts in the viewer, because most developable land is above MHHW.

In addition, the maps take into account the hydroconnectivity of inundated areas, which distinguishes it from a simple bathtub approach. However, the maps also show low-lying areas, which are considered hydrologically "unconnected" areas that may flood. Both hydrologically connected and unconnected areas are determined solely by how well the elevation data capture the area's hydraulics.

Does this viewer show timing of inundation levels (e.g., 3 feet by 2100)?

This viewer does not show specific timing of inundation depths. This is by design. One-foot depth increments are mapped above MHHW up to 6 feet. This range covers most of the sea level rise projections found in recent scientific literature, which range from extrapolation of the existing sea level trends to >2 meters by 2100. We leave it up to the use to select which inundation level to use at a particular planning horizon. This way the tool serves many projection scenarios and time horizons, similar to the many state and local sea level rise and adaptation strategies. The only component of the tool that uses any timing is the "advanced options" in the Marsh tab. This feature enables the user to select both a high, medium, or low sediment accretion rate, and time horizon in intervals of 25 years. For this section the tool uses an algorithm based on the acceleration of sea level rise from the Intergovernmental Panel on Climate Change (IPCC) 2007 A1B climate scenario, now considered a conservative estimate.

Do the maps shown in this viewer take into account levees and/or hydraulic features (culverts, pipes, levees, bridges)?

The digital elevation models used to map sea level rise in this tool do not incorporate a detailed pipe network analysis or engineering-grade hydrologic analysis (for example, culverts and ditches may not be incorporated, resulting in incorrectly mapped areas).

Levee information from the U.S. Army Corps of Engineers National Levee Database will be displayed in the viewer to show federal and some state levee locations. Levee information has not been explicitly incorporated into the mapping but is used for validation of inundation areas.

Do the maps take into account future changes in geomorphology, shoreline change, etc.?

The mapped sea level rise levels (SLR) in this tool do not incorporate future changes in coastal geomorphology and assume present conditions will persist. Geomorphologic changes associated with natural processes and human actions will, of course, be vital in controlling future SLR inundation extents. Failing to consider these processes is a significant limitation of the mapping process. As the scientific community continues to increase its understanding of and skill in predicting these critical processes, the functionality of the tool can be updated. Until then, the above-mentioned effects are still sufficiently unknown that they may compound or offset each other in unpredictable ways, such that including only some processes may cause greater error than ignoring them.

How is the marsh migration mapping different from maps generated from the Sea Level Affecting Marshes Model?

The wetland transition modeling within this tool is based on a rule set similar to that used within the Sea Level Affecting Marshes Model (SLAMM) tool, in that certain categories of wetlands are assumed to occupy designated ecological niches, based on their elevation in relation to existing and future tidal regimes. NOAA's marsh migration modeling is based on NOAA's Coastal Change Analysis Program (C-CAP) land cover data, and does not map the same

categories that are typically modeled within SLAMM, which is typically based on National Wetland Inventory (NWI) data.

Both tools also allow users to account for some amount of accretion, but SLAMM has the ability to do so in a more spatially/temporally variable way. It also has the ability to model several additional processes (erosion, etc.), if users have such detailed information to supply. Finally, SLAMM must be run by the user, whereas NOAA's files have all been preprocessed, allowing the user to select the appropriate outputs based upon the scenario of choice.

How is accretion handled in the marsh impact modeling tab of this tool?
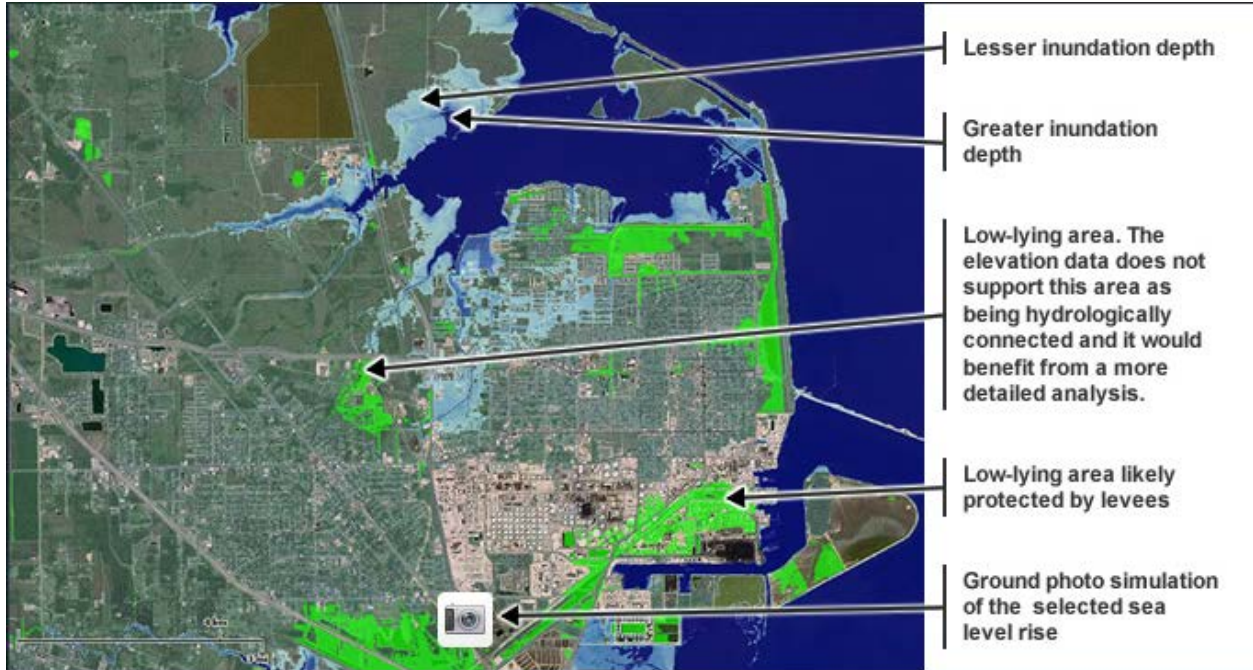
While accretion can be highly variable, depending on the geography of an area, proximity to sources of sediment, and specific types of wetland species present, this information is often lacking in the detail needed to drive the detailed wetland impacts models that users desire. Because there are few national sources of these data, NOAA has chosen several average values. These values include no accretion, low level (2 millimeters (mm)/year), moderate level (4 mm/year), and high level (6 mm/year) accretion.

This value is handled as a constant through time, and applied as constant through space. This means that while it is consistently applied (providing a simple apples-to-apples style comparison nationally), it does not account for any spatial (or temporal) variations that exist. If users are aware of such variations for the geographies in which they are interested, they should look at each of these locations with the different levels of accretion selected within the tool.
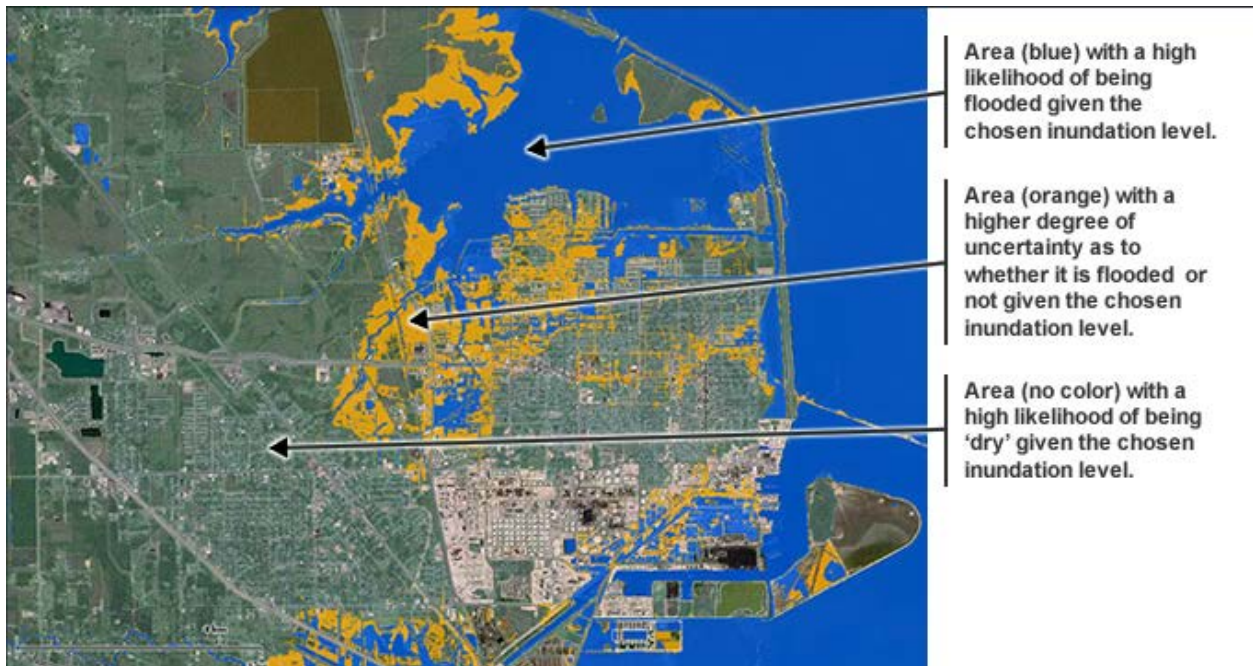
Using the Tool

What am I looking at in each tab or section of the tool?

Sea Level

Lesser inundation depth

Greater inundation depth

Low-lying area. The elevation data does not support this area as being hydrologically connected and it would benefit from a more detailed analysis.

Low-lying area likely protected by levees

Ground photo simulation of the selected sea level rise

Confidence

Area (blue) with a high likelihood of being flooded given the chosen inundation level.

Area (orange) with a higher degree of uncertainty as to whether it is flooded or not given the chosen inundation level.

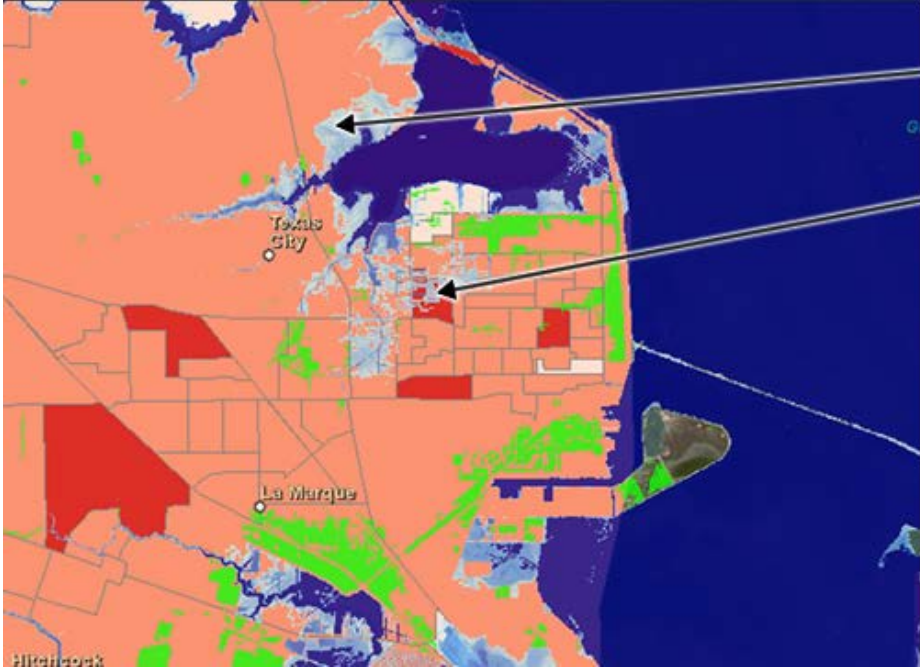Area (no color) with a high likelihood of being 'dry' given the chosen inundation level.

Marsh

Zone of transition between salt and freshwater wetlands (transitional / brackish marsh)

Unaffected upland cover type

Developed areas are always protected from SLR

Social Vulnerability

Medium risk blockgroup vulnerable to sea level rise

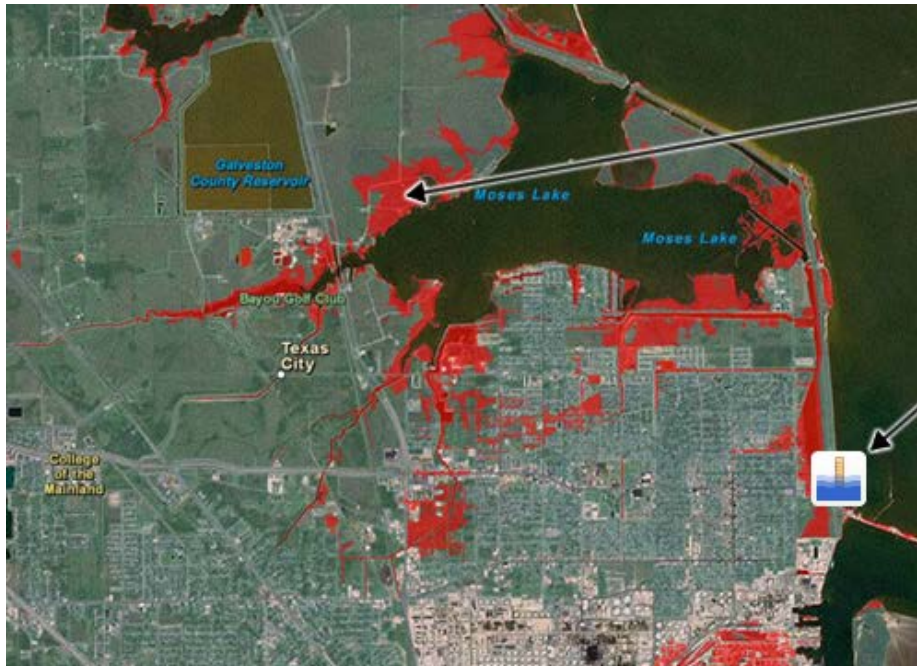High risk blockgroup vulnerable to sea level rise

Economic Vulnerability

Blockgroup vulnerable to sea level rise with a medium level of employees

Blockgroup with data unable to be displayed due to confidentiality issues.
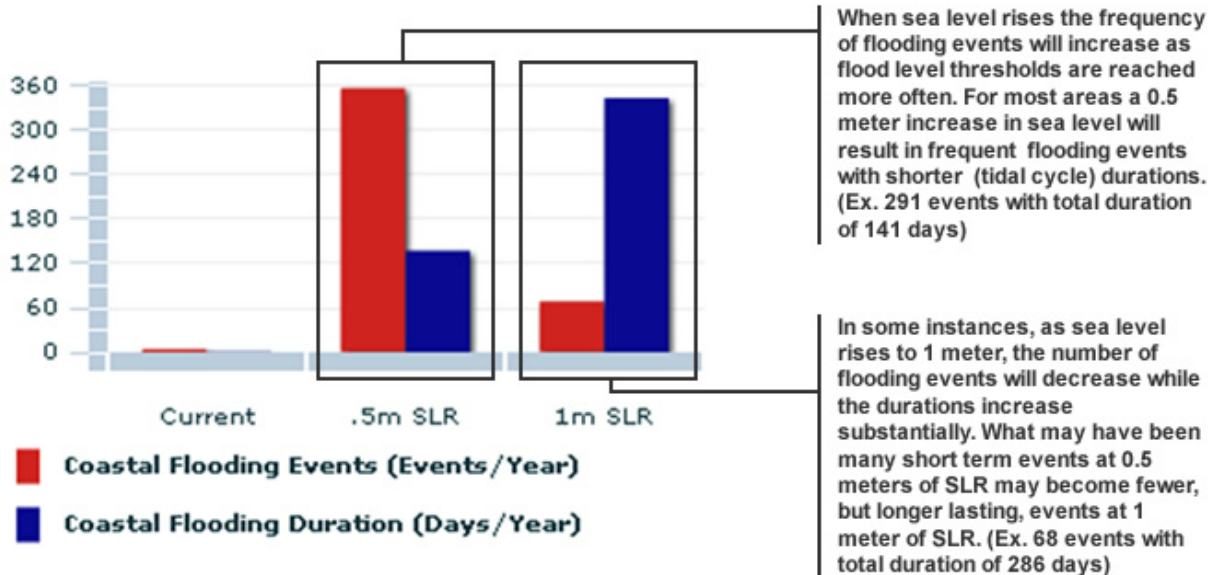
Flood Frequency

Areas susceptible to impacts from shallow coastal flooding based on local tidal heights thresholds.

NOAA Tide Station location. When selected, you will see values for the frequency of current flooding events and durations based on a 3-year average from 2007-2009, as compared with hypothetical values for half-meter and one-meter sea level rise scenarios.

Tide Gages

When sea level rises the frequency of flooding events will increase as flood level thresholds are reached more often. For most areas a 0.5 meter increase in sea level will result in frequent flooding events with shorter (tidal cycle) durations. (Ex. 291 events with total duration of 141 days)

In some instances, as sea level rises to 1 meter, the number of flooding events will decrease while the durations increase substantially. What may have been many short term events at 0.5 meters of SLR may become fewer, but longer lasting, events at 1 meter of SLR. (Ex. 68 events with total duration of 286 days)

How do I get my regional or local GIS data to overlay with the layers in this viewer?

Because the main focus of this tool is to provide a national preliminary look at sea level rise and coastal flooding impacts, ingesting regional or local GIS data into the viewer is impractical. Because of scale, data quality, and consistency issues, we currently do not incorporate these data. The model we are using for regional and local implementation, which will take the national level analysis to the next level, is for regional and local users to either obtain our data layers, or ingest them as Web map services. See the above question on data access. This strategy enables regional and local users to visualize the data layers on their own desktop or Web mapping GIS applications for visualization and analysis.

Can I get the viewer source code?

The viewer was built using the ESRI ArcGIS API for Flex (see *http://help.arcgis.com/en/webapi/flex/index.html*) and is available upon request.

User Feedback

How do I provide feedback on this tool?

If you have questions or comments about the Sea Level Rise and Coastal Flooding Impacts Viewer or want to request data or information, you can submit them via the Digital Coast's Feedback page: *www.csc.noaa.gov/digitalcoast/feedback.html*