



Extreme Events 101: Coastal Flooding

Many coastal areas are vulnerable to flooding. Surges from strong storms can damage coastal structures, inundate roadways, and contribute to bridge scour. They can also erode coastlines, increasing the risk of flooding during future storms.¹ Flooding of important evacuation routes can complicate emergency management procedures. When storms arrive at high tide, impacts can be especially severe. Sea level rise will further raise coastal flooding risks in most areas of the United States during storm events.

REGIONAL TRENDS

Global sea level has risen by about 8 inches since 1880. Since 1992, the rate of global sea level rise has been roughly twice the rate observed over the last century. Relative sea level rise varies by region (see Fig. 1) because of various factors, including subsidence (sinking or settling of the land) or uplift (rising of the land), as well as persistent atmospheric or oceanic circulation patterns. For example, subsidence plays an important role in the high rates of relative sea level rise along the Gulf Coast. In contrast, areas in northern California, Oregon, Washington, and Alaska exhibit lower rates of sea level rise where the land surface is slowly rising.²

For the Gulf and Atlantic coasts, tropical storms often cause significant flooding. The intensity, frequency, and duration of North Atlantic hurricanes, as well as the frequency of the strongest hurricanes (Category 4 and 5) have all increased since the early 1980s. Hurricane strikes have been most frequent in Texas, Louisiana, Mississippi, Florida, and North Carolina, but other regions have also experienced significant flooding from coastal hurricanes and storms, including the Northeast during Superstorm Sandy.

REGIONAL PROJECTIONS

Global sea level is projected to rise another 1 to 4 feet by 2100. Relative sea level rise will be greater along some coasts because of subsidence (e.g., in Louisiana, Texas, and parts of the Chesapeake Bay), which will have a significant effect on low-lying transportation infrastructure near the coast.

In the Atlantic, the frequency of the strongest tropical storms (Category 4 and 5 hurricanes) is expected to continue increasing. At the same time, a slight decrease in the total number of tropical storms is projected by climate models; however, these projections are subject to considerable uncertainty. And these projections do not specify if the risk for landfalling storms will change. Regardless, rising sea levels will enhance the potential damage of future storms.



Image: Flooding of Route 528 Mantoloking Bridge and Route 35 in New Jersey after Superstorm Sandy.
Source: [New Jersey DOT](#)

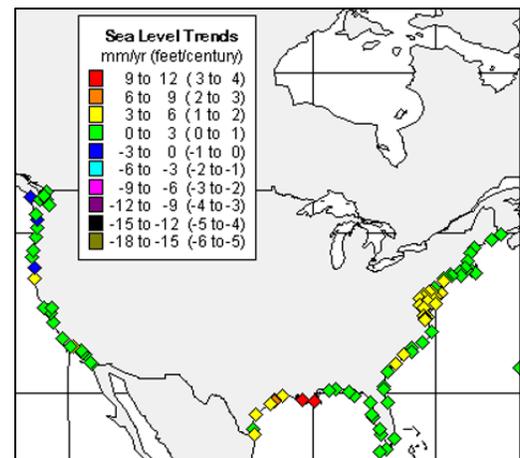


Fig. 1. Sea level trends observed at long-term tide stations.
Source: NOAA

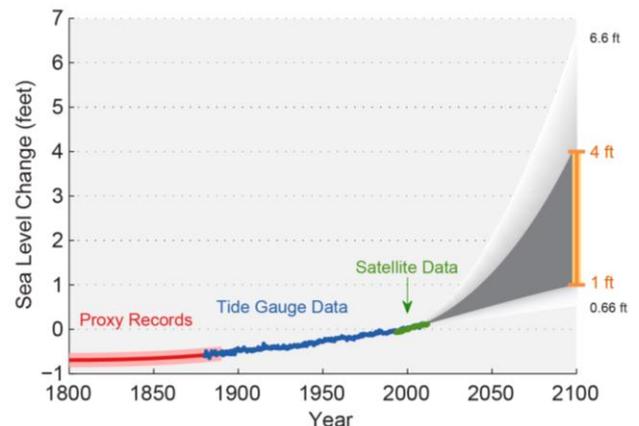


Fig. 2. Observed, and possible future amounts of global sea level rise from 1800 to 2100, relative to the year 2000. Source: 2014 National Climate Assessment

¹ TRB, 2008: <http://onlinepubs.trb.org/onlinepubs/sr/sr290.pdf>

² <http://tidesandcurrents.noaa.gov/sltrends/slmap.html>



RESPONSES

Some state departments of transportation (DOTs) and local governments are addressing the risks of coastal flooding through various activities. Examples include:

- State DOTs and local metropolitan planning organizations (MPOs) in **New York, New Jersey, and Connecticut** are working with the Federal Highway Administration, Federal Transit Administration, and other partners on the *Hurricane Sandy Follow-up and Vulnerability Assessment and Adaptation Analysis*, which is assessing the impacts of the storm on transportation assets within the region, the vulnerability of those assets to the impacts of extreme weather and climate change, and identifying adaptation strategies.³
- **Caltrans** released *Guidance on Incorporating Sea Level Rise* to help assess vulnerability of projects in the planning phase and determine whether to incorporate adaptation measures into the projects.⁴
- **Massachusetts DOT** is conducting a vulnerability assessment of sea level rise and extreme storm events for the Central Artery system – a critical link for regional transportation in the Boston area.⁵ In addition, the **Boston Region MPO** conducted hazard mapping to identify areas where transportation infrastructure and proposed projects may be vulnerable to flooding and storm surge, including consideration of sea level rise. The MPO developed an interactive web tool that maps the transportation network, flood zones, bridge condition, emergency routes, and emergency support facilities.⁶



Image: Flooding during Superstorm Sandy. Source: [FHWA](#)

RESOURCES

- **AASHTO Extreme Weather Events Symposium:** This site provides presentations and a summary white paper from the May 2013 national symposium on the impacts of extreme weather events on transportation. <http://climatechange.transportation.org/symposium/>
- **FHWA Tools for Adaptation:** FHWA has developed various reports and tools that can be used by transportation planners and engineers, including guidance about regional climate impacts, vulnerability assessments, and case studies. http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/summary/index.cfm
- **Transportation Research Board Special Report 90: Potential Impacts of Climate Change on U.S. Transportation:** This report summarizes current and future climate changes on U.S. transportation infrastructure and operations, and identifies potential adaptation options. <http://onlinepubs.trb.org/onlinepubs/sr/sr290.pdf>
- **Third National Climate Assessment, Climate Change Impacts in the United States:** This report assesses the impacts of climate change across the country, including impacts for various sectors (including transportation) and regions, as well as potential responses to these impacts. <http://nca2014.globalchange.gov/>. There is also a report outlining the sea level rise scenarios considered by the Assessment. http://cpo.noaa.gov/sites/cpo/Reports/2012/NOAA_SLR_r3.pdf
- **The U.S. Army Corps of Engineers** provides a calculator that accompanies their sea level rise guidance for civil works projects. <https://corpsclimate.us/ccaceslcurves.cfm>

CONTACTS

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³ http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/

⁴ http://www.dot.ca.gov/hq/tpp/offices/orip/climate_change/documents/Caltrans_ClimateChangeRprt-Final_April_2013.pdf; Guidance: http://www.dot.ca.gov/ser/downloads/sealevel/guide_incorp_slr.pdf

⁵ http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/vulnerability_assessment_pilots/2013-2014_pilots/index.cfm

⁶ Tool: http://www.ctps.org/map/www/apps/eehmApp/pub_eehm_index.html