New Federal Sea Level Rise Scenarios for the U.S. Coastline

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New Federal Sea Level Rise Scenarios for the U.S. Coastline

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U.S. EPA Office of Research and Development
Disclaimer: This presentation does not necessarily reflect the views or policies of the U.S. EPA
Outline

1. **SLR Task Force**: mandate, purpose, and history
2. **Progress to date**: global and U.S. regional SLR scenarios development, dissemination, and integration with coastal risk management tools
3. **Next steps**: development of new analyses and products
4. **SLR scenarios and risk**: key questions related to scientific assessment, risk management, and use of scenario information in planning
Federal SLR Task Force
Task Force Background

Strong demand for authoritative, consistent, accessible SLR and associated coastal flood hazard scenarios for the entire U.S. coastline, to support coastal preparedness planning and risk management

Much of the foundation already existing in individual agency efforts and capabilities, but with a lack of (1) synthesis and (2) nationwide coverage

In 2015, the WH Resilience Council directed the formation of the **Interagency Sea Level Rise and Coastal Flood Hazard Scenarios and Tools Task Force**
Task Force Background

Co-chairs: John Haines (USGS), William Sweet (NOAA), Chris Weaver (EPA)
Participating agencies: DoD, EPA, FEMA, NASA, NOAA, USACE, USGS

Initial set of key tasks for interagency coordination and development:
- Global SLR scenarios
- Regionalization of the global scenarios
- Integration with coastal risk management tools and processes

Also in direct support of the 4th National Climate Assessment (NCA4)
New Scenarios Development
Before, we only had IPCC ...

Scientific ‘best estimate’ based on numerous studies; represents range of scientifically plausible potential future SLR; meanwhile science evolves and the numbers shift …
Key Deliverable: Jan ‘17

1. **Update Federal estimates** of the range of future global SLR based on existing scientific evidence
   
   (0.3 - 2.5 m by 2100)

2. Develop **scenarios of relative regional SLR** across this range for the U.S. (incl. AK and HI), the Caribbean and the Pacific Island Territories
Summary of Report

Provides, for the first time, a set of regionally appropriate, gridded, relative SLR scenarios for the entire U.S. coastline, synthesizing the most up-to-date science.

Fills a major gap in climate information needed to support a wide range of assessment, planning, and decision-making processes.

Basis for future SLR estimates in the 4th National Climate Assessment (NCA4) cycle, including the Climate Science Special Report (CSSR; expected Nov 2017).
Global SLR Scenarios

- Divided the 0.3-2.5 m range into six discrete scenarios
- Each associated with a given probability of exceedance under different assumptions about GHG emissions
- Also looked out beyond 2100 to 2200

![Graph showing Global Mean Sea Level (GMSL) Scenarios for 2100]

**Table 4.** Probability of exceeding GMSL (median value) scenarios in 2100 based upon Kopp et al. (2014).

<table>
<thead>
<tr>
<th>GMSL Rise Scenario</th>
<th>RCP2.6</th>
<th>RCP4.5</th>
<th>RCP8.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (0.3 m)</td>
<td>94%</td>
<td>98%</td>
<td>100%</td>
</tr>
<tr>
<td>Intermediate-Low (0.5 m)</td>
<td>49%</td>
<td>73%</td>
<td>96%</td>
</tr>
<tr>
<td>Intermediate (1.0 m)</td>
<td>2%</td>
<td>3%</td>
<td>17%</td>
</tr>
<tr>
<td>Intermediate-High (1.5 m)</td>
<td>0.4%</td>
<td>0.5%</td>
<td>1.3%</td>
</tr>
<tr>
<td>High (2.0 m)</td>
<td>0.1%</td>
<td>0.1%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Extreme (2.5 m)</td>
<td>0.05%</td>
<td>0.05%</td>
<td>0.1%</td>
</tr>
</tbody>
</table>
Regionalizing the Global Scenarios

Change in Relative Sea Level (RSL):

\[
\Delta RSL = \Delta SL_G + \Delta SL_{RM} + \Delta SL_{RG} + \Delta SL_{VLM}
\]

Global: \( f(\text{scenario, time epoch}) \)

Regional: \( f(\text{oceanographic factors; dynamic SLR}) \)

Regional: \( f(\text{changes in Earth’s g-field due to ice melt redistribution}) \)

Local: \( f(\text{uplift/subsidence, GIA}) \)

1-degree x 1-degree data product for the U.S. (incl. AK, HI, Caribbean, Islands)
- Along essentially all U.S. coasts outside Alaska, RSL rise projected to be higher than the global average under the higher-end scenarios.

- Along much of the Pacific Northwest and Alaska coasts, RSL rise projected to be less than the global average.

- RSL rise increases NOAA coastal flood ‘advisory’ and ‘warning’ conditions in coming decades within most U.S. coastal cities.

Figure 13. Total RSL change at 1-degree resolution for 2100 (in meters) relative to the corresponding (median-value) GMSL rise amount for that scenario. To determine the total RSL change, add the GMSL scenario amount to the value shown.
With SLR, your freeboard disappears.
NOAA ‘Nuisance’ High Tide Monitoring and Future Scenarios

Due to SLR, flood risk is increasing; the annual frequency of minor flooding is accelerating in many U.S. cities (left).

Flood frequency monitoring relative to scenarios may assist in planning (right).
NOAA Tide Gauge Norfolk (Sewells Point), VA

Number of days per year that water levels exceeding 0.53 m (about 1.75 ft) above highest average tide.
Current Status: Dissemination of Scenarios

- Report and raw data available now:
  - [https://tidesandcurrents.noaa.gov/publications/techrpt083.csv](https://tidesandcurrents.noaa.gov/publications/techrpt083.csv)
  - USGS ‘story map’ and geospatial viewer/access tool in development; coming soon

- In the process of integrating these updated scenarios into existing Federal tools and capabilities for coastal planning and decision support:
  - NOAA SLR Viewer
  - USACE Sea Level Calculator
  - USGS Coastal Change Hazards Portal

- In 4th NCA, CSSR (see also [https://scenarios.globalchange.gov/sea-level-rise](https://scenarios.globalchange.gov/sea-level-rise))
Next Steps: New Products
Next Steps: New Analyses and Products

(In process) Expanded spatial analysis of coastal flood frequency changes for most NOAA tide gauge locations implied by these new SLR numbers (e.g., subset shown right)

(Planned) Regional frequency analysis to produce a gridded set of extreme water level probabilities for U.S. coastline to assess future changes (away from tide gauges) using the SLR scenarios
(Planned) Develop gridded set of extreme wave probabilities for U.S. to estimate scenarios of total water level (sea level, surge, waves) for U.S.

Next Steps: New Analyses and Products

Figure 2.7 Components of Extreme Total Water and Extreme Still Water Level Measurements
This study focuses on Extreme Still Water Levels. (adapted from Moritz et al. 2015)
Next Steps: New Analyses and Products

Integrate SLR and derivative scenarios into existing USGS landform change and coastal vulnerability tools.
SLR Scenarios and Risk
Current Status: Translation & User Support

Task Force engaged in ongoing, but ad hoc, efforts to translate the technical information and provide guidelines on its use for a range of users.

- Plan is to expand and systematize this part of the enterprise going forward.

Task Force standing ready to provide support for resilient rebuilding in the Harvey-, Irma-, & Maria-affected areas, in collaboration with FEMA and others.

- For example, see previous, USGCRP-coordinated post-Sandy efforts (http://www.globalchange.gov/browse/sea-level-rise-tool-sandy-recovery).
Risk Management in Coastal Environment

SLR presents major challenge for coastal communities:

- Direction is clear
- Impacts are manifesting now
- The pace of rise is likely to accelerate
- "When", not "if"

Meanwhile, we have SLR science ...
Key Qs About Practical Applications

How to deal with multiple SLR assessments, scenarios, projections (& over such a wide range)?

What about the “worst case” scenarios (that keep getting worse)?

How about the new probabilistic projections?

*What kinds of strategies are helpful for selecting relevant and useful scenarios for your needs?*
There’s so much SLR science! And it’s changing so fast! What does it all mean for me??

Scientists nearly double sea level rise projections for 2100, because of Antarctica

Energy and Environment

Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites

Robert E. Kopp, Bradley M. Horton, Christopher M. Little, Jerry A. Mitrovica, Michael Oppenheimer, J. H. Boxma, Benjamin H. Strauss, and Claude Tebaldi

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Abstract

Sea-level rise due to both climate change and non-climate factors threatens coastal settlements, infrastructure, and ecosystems. Projections of mean global sea-level (MSL) rise are used to generate information and advice to decision-makers to understand current and future flood risk. These projections are critical for long-term planning, and are subject to considerable uncertainty. How much sea-level rise will occur between now and the end of the century? This is a question that has not yet been answered with any level of certainty. In this paper, we present probabilistic projections of global mean sea level for the 21st and 22nd centuries.

Introduction

Sea-level rise is one of the most prominent consequences of climate change. It impacts settlements and ecosystems both through permanent inundation of the low-lying areas and by increasing the frequency and severity of storm surges. This is particularly true for low-lying islands and coastal communities as well as large regions along the coasts of many countries. The impacts of sea-level rise are felt both through changes in the frequency and intensity of extreme weather events and through changes in the local mean sea-level conditions. These changes can have significant economic and social impacts on coastal communities.

Sea-level rise is caused by changes in the volume of water in the ocean, changes in the earth’s gravitational field, and changes in the shape of the earth. The most significant cause of sea-level rise is the melting of glaciers and ice sheets, which is caused by the warming of the atmosphere and oceans.

Sea-level rise is a complex problem with many different drivers and feedbacks. The rate of sea-level rise is not constant, and it is projected to change over time.

This paper presents a new probabilistic projection of global mean sea level for the 21st and 22nd centuries. The projections are based on a comprehensive analysis of the current understanding of the drivers of sea-level rise, and they are designed to provide decision-makers with information to help them understand the potential impacts of climate change.

Conclusion

Sea-level rise is a complex problem with many different drivers and feedbacks. The rate of sea-level rise is not constant, and it is projected to change over time.

This paper presents a new probabilistic projection of global mean sea level for the 21st and 22nd centuries. The projections are based on a comprehensive analysis of the current understanding of the drivers of sea-level rise, and they are designed to provide decision-makers with information to help them understand the potential impacts of climate change.

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Scientific Synthesis and Integration

The new scenario products attempt to integrate scientific state-of-the-art:

- Increased upper bound to 2.5 m (by 2100) to acknowledge substantial new science since 2012
- Leveraged improved transparency and ‘scientific bookkeeping’ of Kopp et al. probabilistic approach to integrate multiple lines of scientific evidence and map discrete scenarios back to IPCC emissions pathways (RCPs)
- Comprehensively regionalized the global SLR scenarios for whole U.S. coastline

But … providing transparent guidance to make these science products more usable in practice remains an urgent work in progress
Key Qs About Practical Applications

How to deal with multiple SLR assessments, scenarios, projections (& over such a wide range)?

What about the “worst case” scenarios (that keep getting worse)?

How about the new probabilistic projections?

What kinds of strategies are helpful for selecting relevant and useful scenarios for your needs?
Many decisions are being made now
Not just short-term, but long-term too
For major infrastructure, 100 years from now is actually TODAY
Need to manage risk
Risk Framing: Core Principles

Define what we value (what is at risk); make this transparent, and put these things front and center in the assessment.

Define what we wish to avoid (consequences) for these valued things.

Carry out analyses to identify what risky outcomes can't be ruled out (prioritize according to which risks are greatest).

Don't just ask: “What’s most likely to happen?” Also: “How bad could things get?”
What aspects of future change are most closely linked to climate-related risk and thus need to be assessed?

- Often extremes and threshold-crossing rather than simply the mean state
- Future changes that may be low-probability but have very large consequences
- Trends in other global change drivers that can increase exposure to climate-related risk (e.g., population growth), or interact with climate change to exacerbate risk

Scenarios play a key role in appropriately considering these in planning
Risk Framing: Notes on Use of Scenarios

Thinking and framing - cognitive benefits of scenarios:

- Can use multiple scenarios to bound risk and support near- and long-term planning
- Systematize consideration of key factors in climate hazard, vulnerability
- Force reorganization of mental models by challenging assumptions
- Help avoid ‘failures of imagination’
Risk Framing: Notes on Use of Scenarios

Disproportionate fraction of total risk may be associated with low-probability outcomes - plausible worst-case scenarios - we need to pay close attention to these when risk tolerance and flexibility are low

- High-value assets at risk (low tolerance for failure); long time horizons; limited ability to adapt, change, revisit the decision
- Need a plausible upper bound – used for guiding you as to your overall system risk, plus informing you what options need to remain open over the long term
- Can use scientific ‘best guess’ future as a lower bound in risk assessment, to be used as a benchmark for near-term planning; use monitoring to determine path
Questions & Discussion

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