



# Congressional Budget Office

November 2, 2017

## **Effects of Climate Change and Coastal Development on U.S. Hurricane Damage: Implications for the Federal Budget**

Interagency Forum on  
Climate Risks, Impacts, and Adaptation

Terry Dinan  
Senior Adviser, Microeconomic Studies Division

This presentation has benefited from collaboration with many CBO employees, including Tristan Hanon, Jon Sperl, David Austin, Jeffrey Kling, Joseph Kile, and Maureen Costantino. It has also benefited from the assistance of others, including Kerry Emanuel of MIT, Thomas Knutson of the National Oceanic and Atmospheric Administration, and Paul Wilson of Risk Management Solutions.

# Presentation Objectives

---

- Present CBO's findings
- Explain methods
- Discuss options for reducing pressure for federal funding

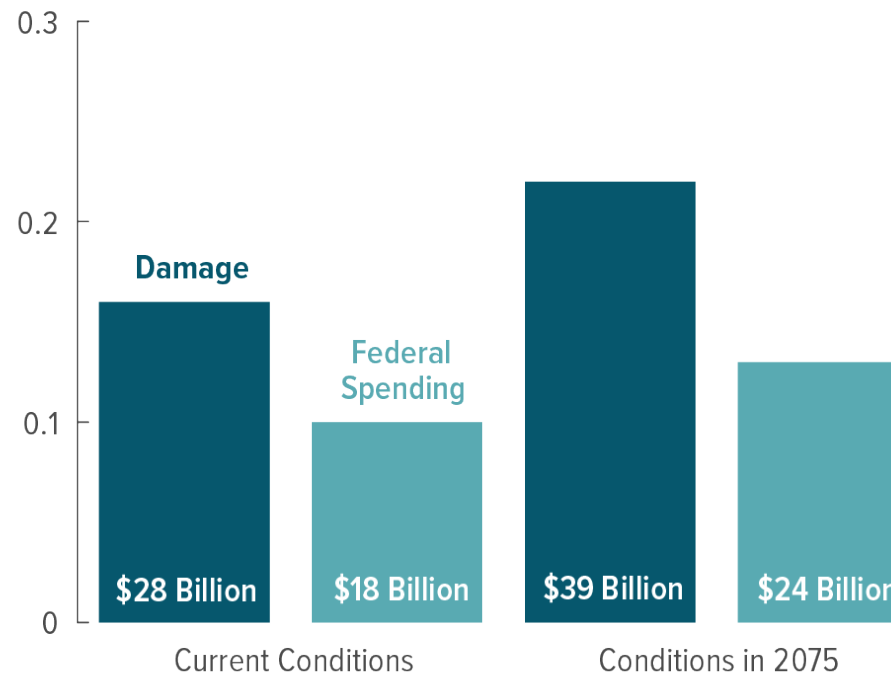
# What Did CBO Estimate?

---

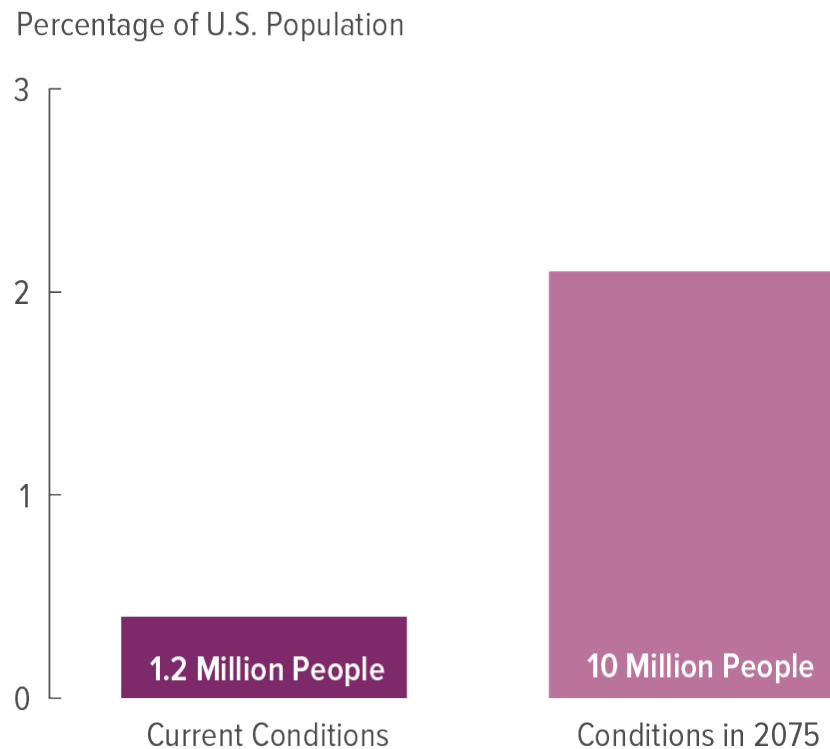
- *Expected* annual hurricane damage
  - Long-run average under a given set of conditions
  - Estimates based on current conditions and conditions in 2075
- *Expected* annual federal spending on hurricanes. Estimates based on:
  - Expected hurricane damage
  - Ratio of federal spending to damage for storms occurring between August 2005 and August 2012

# Expected Hurricane Damage and Related Federal Spending

Percentage of Gross Domestic Product  
(Also shown in dollars based on today's economy)



# Estimates of Substantially Affected Population



# CBO's Approach for Estimating Expected Damage

---

- Step 1: Estimate state-level expected damage under current conditions (the reference case)
- Step 2: Estimate distribution of potential changes in four conditions:
  - State-specific sea levels
  - Frequency of hurricanes of various categories
  - County-specific growth in population
  - County-specific growth in per capita income
- Step 3: Estimate a distribution of state-level expected damage for selected future years on the basis of distributions of projected changes in underlying conditions

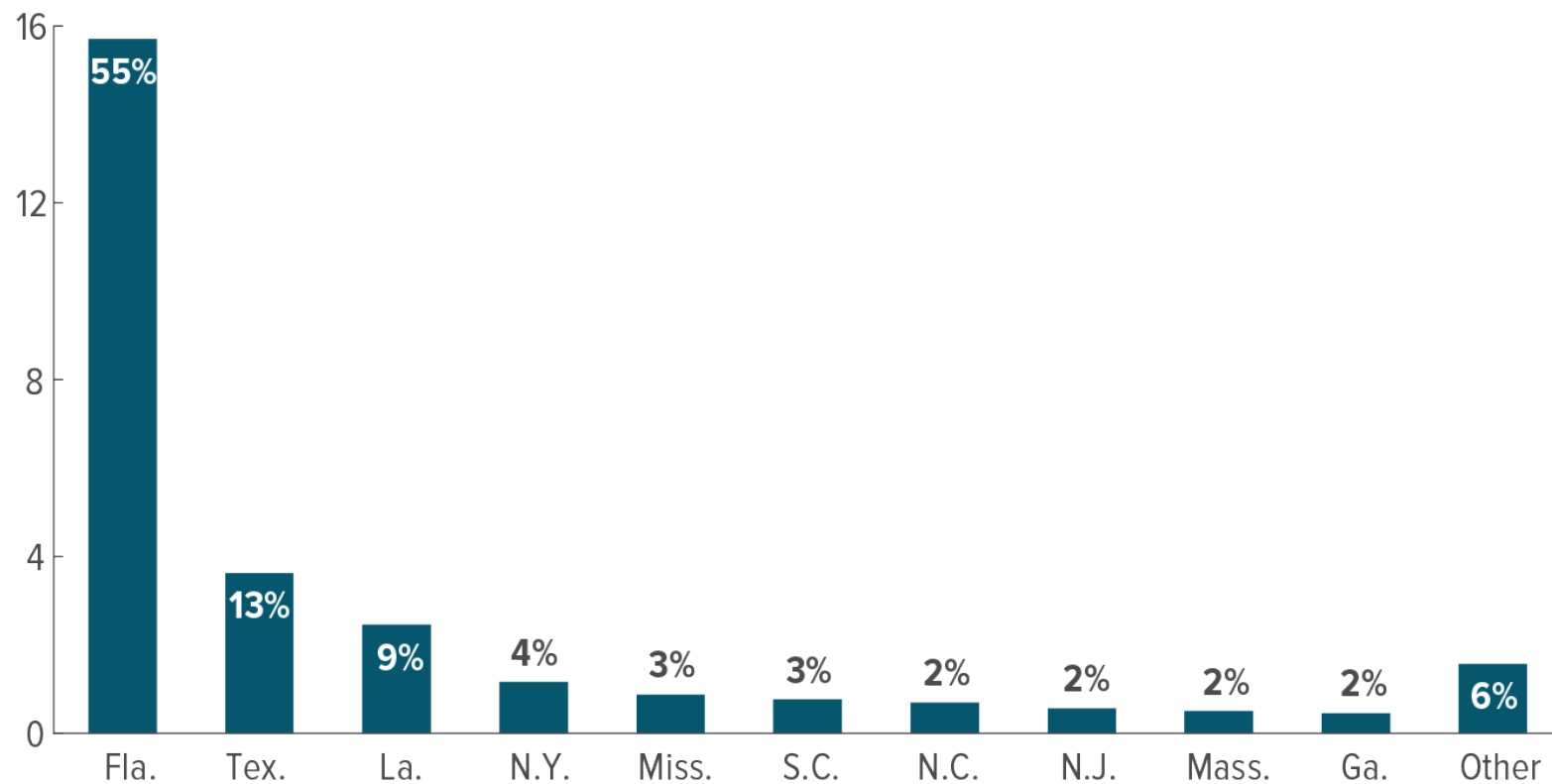
# Step 1: The Reference Case

---

- Indicates expected damage under current conditions:
  - State-specific sea levels
  - Frequency of hurricanes of various categories
  - Value of property exposed to damage
- Relies on Risk Management Solutions' damage functions to translate conditions into expected damage. The expected damage estimate:
  - Reflects the average frequency of each category of hurricane and accounts for *all* of the potential paths that a hurricane might follow
  - Includes a small probability of very costly events

# Expected Annual Hurricane Damage in Reference Case, by State

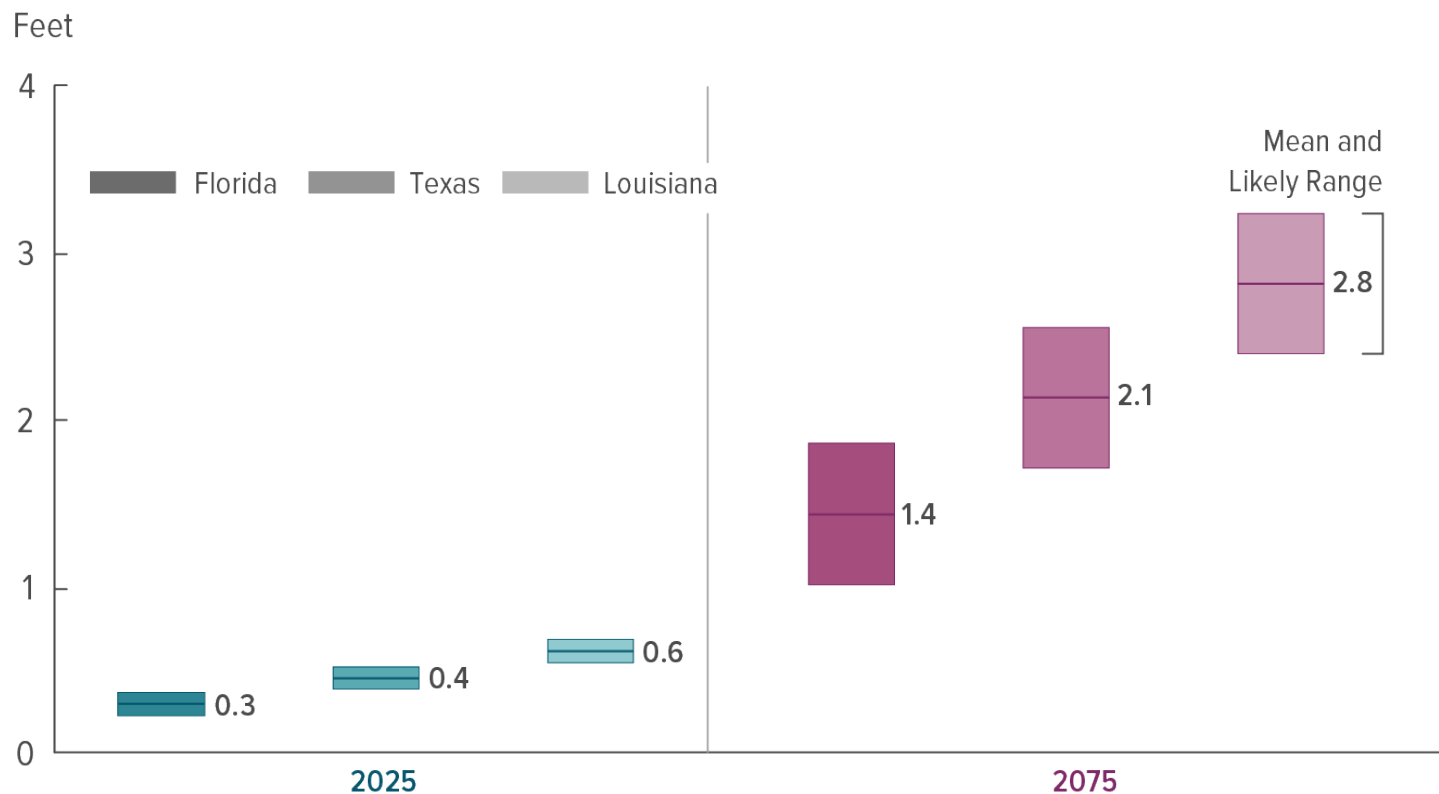
Billions of Dollars





# Step 2. Estimate Changes in Four Conditions Affecting Future Damage: Sea Level Rise

## Sea Level Rise For Selected States



## Step 2. Estimate Changes in Four Conditions Affecting Future Damage: Hurricane Frequencies

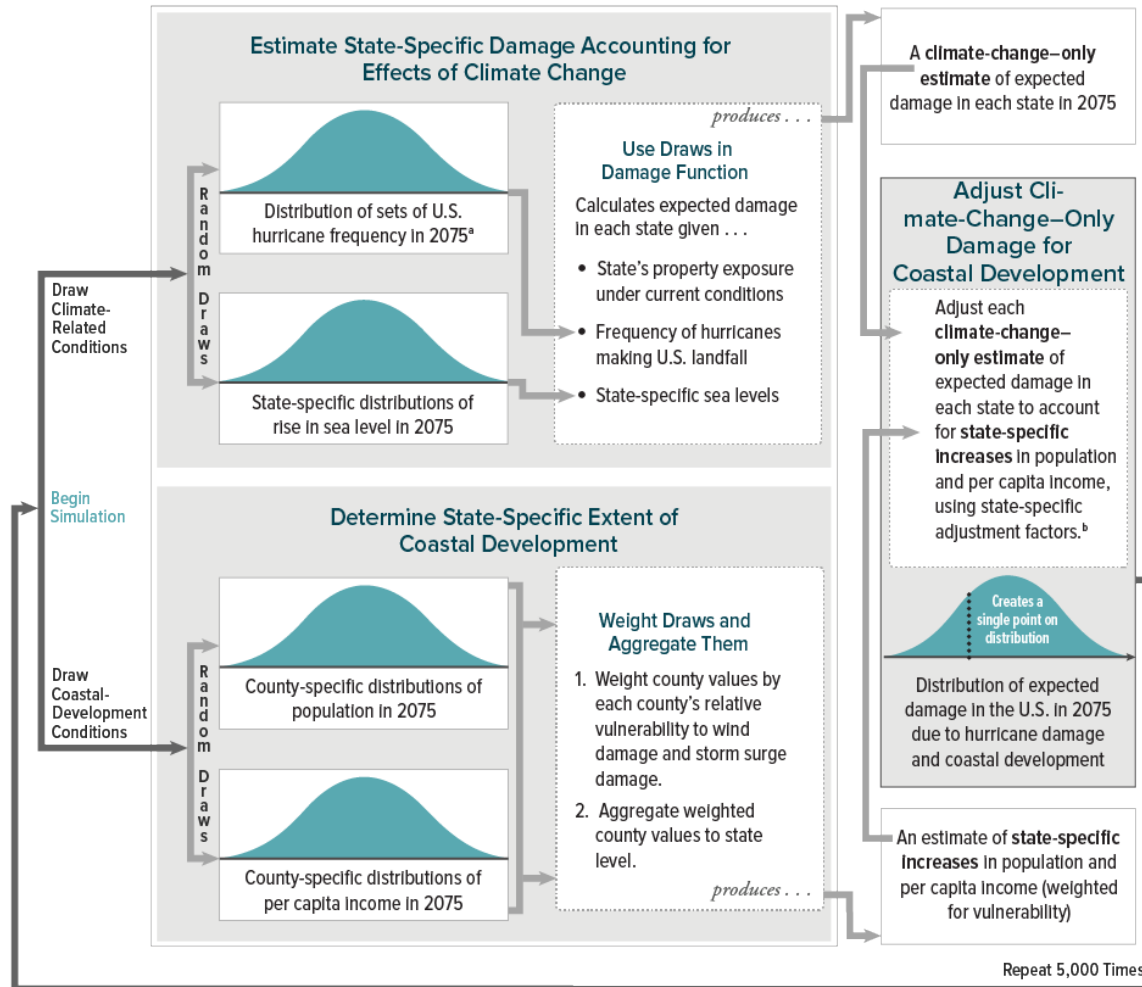
---

- CBO used 18 different sets of projections of hurricane frequencies for each future year. Each set contained a single projection for each category of hurricane.
- The 18 sets are based on different estimates of:
  - The effect of climate change on hurricane-causing conditions, such as sea surface temperatures and wind shear
  - The effect of changes in hurricane-causing conditions on hurricane landfalls in the United States
- The projections generally showed increases in the most intense hurricanes.

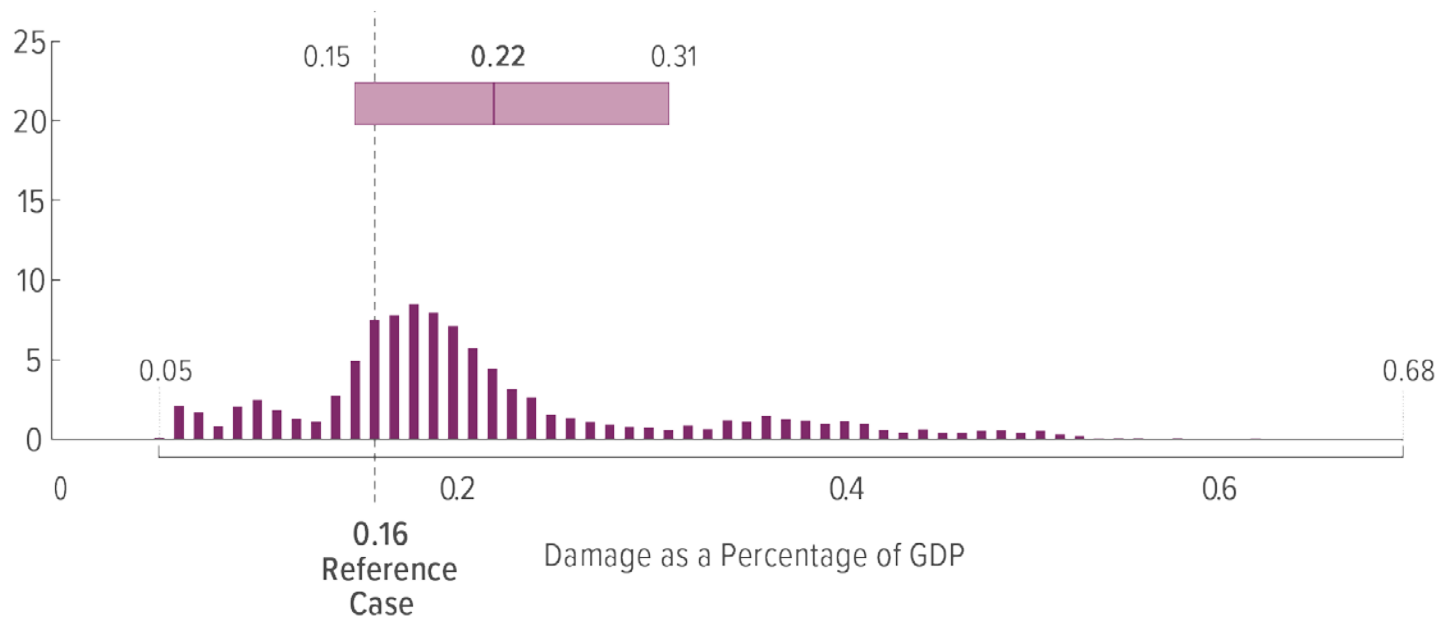
## Step 2. Estimate Changes in Four Conditions Affecting Future Damage: County-Level Population and Per Capita Income

- CBO approximated changes in exposed property in each coastal state by changes in population and per capita income in its counties.
- County-level projections were based on individual counties' historical growth rates and the projected growth rate for the United States as a whole.
- CBO built a distribution around each county's projected point estimate, accounting for:
  - Individual county shocks
  - Regional shocks
- County growth rates were weighted by the county's vulnerability to wind and storm surge damage and aggregated to the state level.

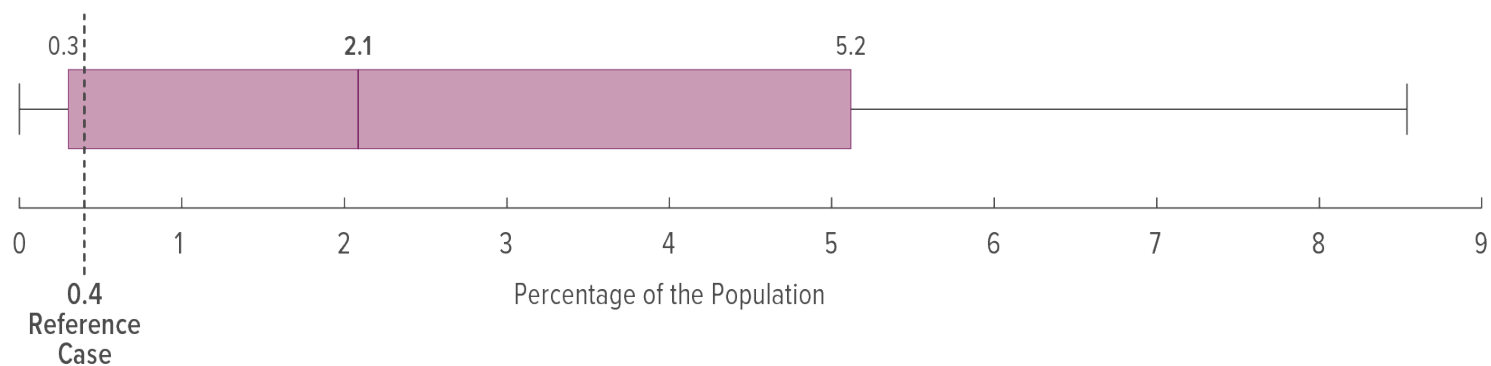
# Step 3. Estimate Future Expected Damage for Each State on the Basis of Distributions of the Four Underlying Factors



# Results: Distribution of Expected Damage in 2075



# Results: Percentage of Population Living in Counties With Substantial Expected Hurricane Damage in 2075

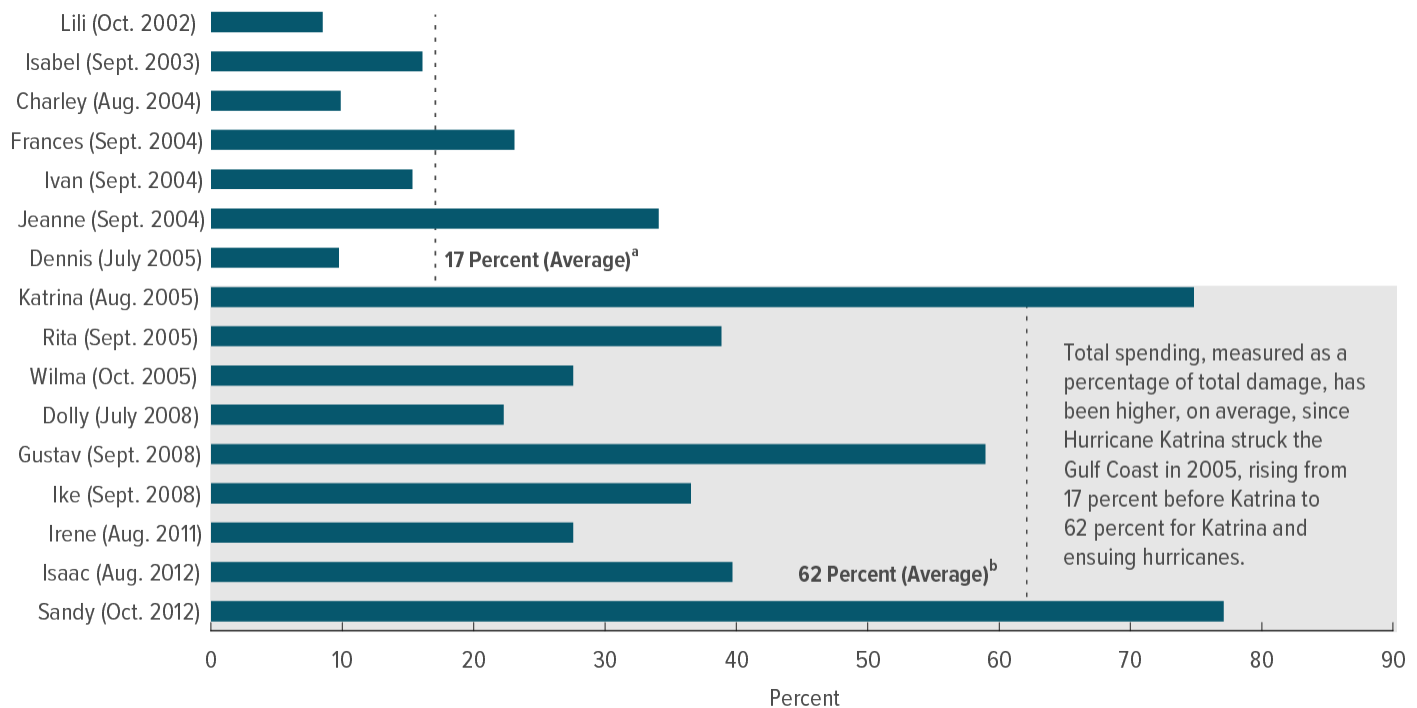


# Results: Attribution of Increased Damage to Climate Change and Coastal Development

- The increase in mean expected damage consists of two components:
  - The sum of the increases in mean damage caused by each effect in isolation
    - \$35 billion due to climate change
    - \$40 billion due to coastal development
  - The increase caused by the interaction of the two effects: \$45 billion
- CBO attributed the interaction effect to climate change and coastal development on the basis of their shares of the first component.
- According to that method:
  - 45 percent of the total increase stems from climate change.
  - 55 percent of the total increase stems from coastal development.

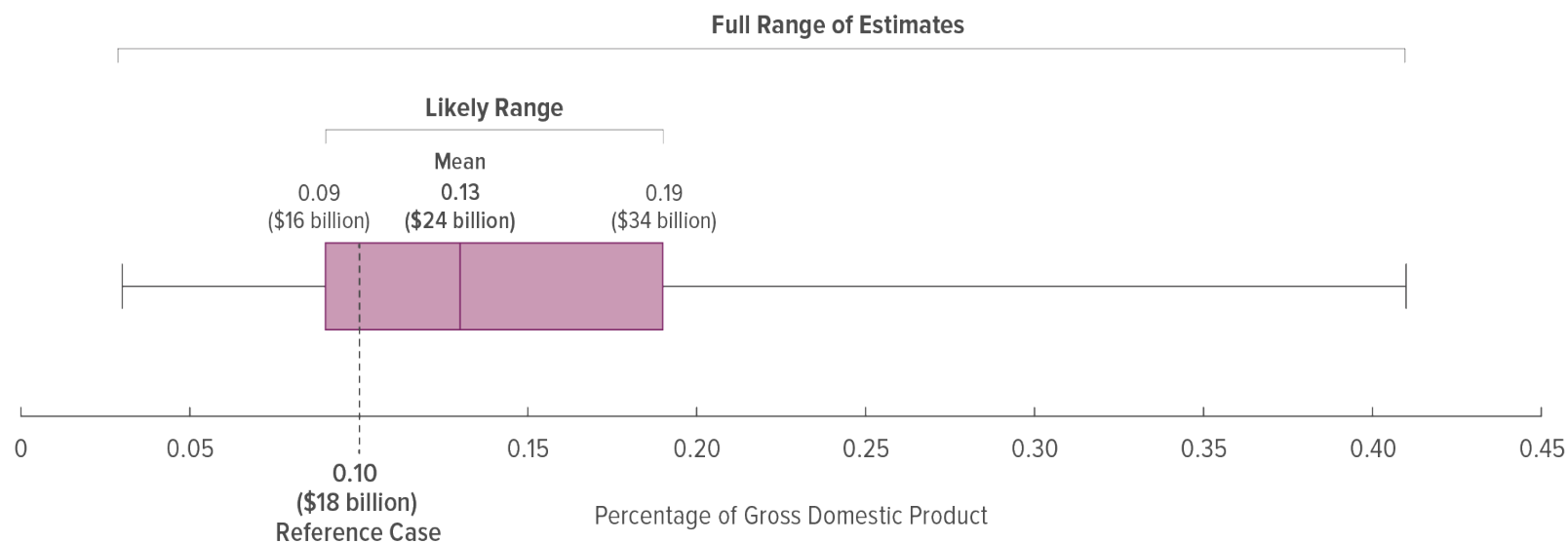
# How Much Federal Spending Results From Hurricane Damage?

## Federal Spending as a Percentage of Total Economic Damage for Selected Hurricanes, 2000–2015





# Results: Estimates of Federal Spending on Hurricane Damage in 2075, Based on Historical Cost Scenario



# Approaches for Reducing Pressure for Federal Assistance: Limit Greenhouse Gas Emissions

---

- A coordinated global effort could lessen hurricane damage between now and 2075, but the result would be uncertain.
- Effects would most likely be realized in the second half of the century.
- Sea level rise is relatively insensitive to changes in emissions in the next few decades.

# Approaches (continued): Shift More Costs to State and Local Governments and to Private Entities

---

- To the extent that households, businesses, and state and local governments in coastal areas do not bear the full cost of hurricane damage, such growth is subsidized by U.S. taxpayers.
- Shifting costs would increase incentives for private and public entities to take measures to limit expected damage.
- Such a shift could be achieved by:
  - Expanding flood insurance and raising premiums
  - Increasing the minimum amount of statewide per capita damage used to determine when to provide federal assistance
  - Increasing state and local cost share of assistance for projects receiving money from FEMA's Disaster Relief Fund

# Approaches (continued): Invest in Structural Changes to Reduce Vulnerability to Damage

---

- Measures are beneficial if up-front costs are more than offset by decreases in expected costs from hurricane damage.
- A CBO study in 2007 found that projects undertaken by FEMA's Pre-Disaster Mitigation Program reduced expected future costs by \$3 for every \$1 spent.
  - The estimate was uncertain.
  - Past projects may not reliably indicate the effectiveness of future projects.
  - A complete analysis would need to take into account the possibility that hazard mitigation measures would encourage development in vulnerable areas.

# Concluding Thoughts

---

- CBO estimates that:
  - Expected damage from hurricanes will grow more quickly than GDP.
  - The share of the population facing substantial damage will grow fivefold by 2075.
  - On the basis of past patterns, federal spending on hurricanes will also grow more quickly than GDP.
- Limiting greenhouse gas emissions may have little effect on damage in the next few decades.
- Pressure for federal spending might be reduced by:
  - Shifting costs to states, localities, and private entities
  - Investing in infrastructure to reduce vulnerability

# Where Can You Find the Work Underlying This Presentation?

---

*Potential Increases in Hurricane Damage in the United States:  
Implications for the Federal Budget*

[www.cbo.gov/publication/51518](http://www.cbo.gov/publication/51518)

*CBO's Approach to Estimating Expected Hurricane Damage:  
Working Paper 2016-02*

[www.cbo.gov/publication/51610](http://www.cbo.gov/publication/51610)

Contact: [terry.dinan@cbo.gov](mailto:terry.dinan@cbo.gov)