CLIMATE CHANGE ADAPTATION FOR TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS

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Session: Resiliency in a Changing Climate

October 23, 2013: 3:50 pm – 5:20 pm

U.S. Department of Transportation
Federal Highway Administration

Sustainability

- One of the FHWA's Office of Operations ***Top 11 for 2013***.

Background and Acknowledgments

- Presentation is based on a 2012 exploratory white paper prepared for FHWA Office of Operations
  - ***Planning for Systems Management and Operations as part of Climate Change Adaptation***

  http://ops.fhwa.dot.gov/publications/fhwahop13030/fhwahop13030.pdf

Acknowledgments and Key references

Transportation Research Board (TRB), 2011: Adapting Transportation to the Impacts of Climate Change: State of the Practice 2011. Transportation Research Circular E-C152. Washington, DC, USA.

Transportation Research Board (TRB), 2008: Potential Impacts of Climate Change on U.S. Transportation. Transportation Research Board Special Report 290. National Research Council. Washington, DC, USA.

U.S. Department of Transportation (USDOT), 2011: Policy Statement on Climate Change Adaptation. Washington, DC, USA. Accessed 4 Sept 2012 <http://www.fhwa.dot.gov/environment/climate_change/adaptation/policy_and_guidance/usdotpolicy.pdf>.

Motivation

- An assessment of how TSM&O groups adapt to climate change.
  - Challenges posed to infrastructure design and long-term land-use planning are more easily described
  - Adapting operations strategy given the varied nature of evolving climate and travelers' responses to changing climate

TSM&O needs to consider both effects due to Climate Trends and Events

- Air Temperature
- Precipitation
- Coastal Effects
- Human Health Effects
- Ecological Effects
- Arctic Effects

- Extreme Weather Events
- Wildfires
- Landslides
- Dust Storms

Trends

+

Events

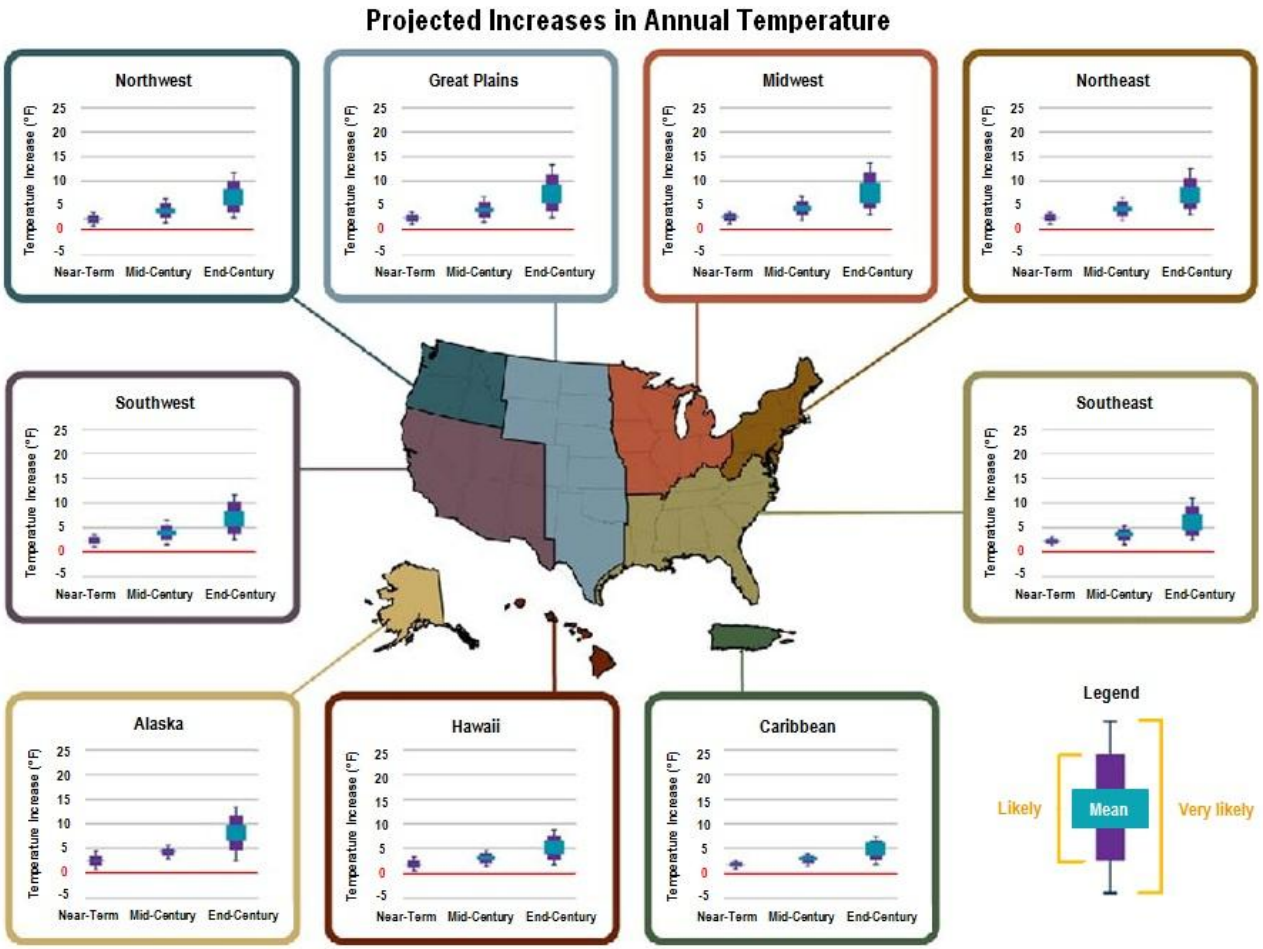
NEW NORMAL

→

Effects on TSM&O

- Increased System Maintenance Needs
- Changes to Practices and Strategies
- Changing Travel Behavior
- Changes to Freight Transportation

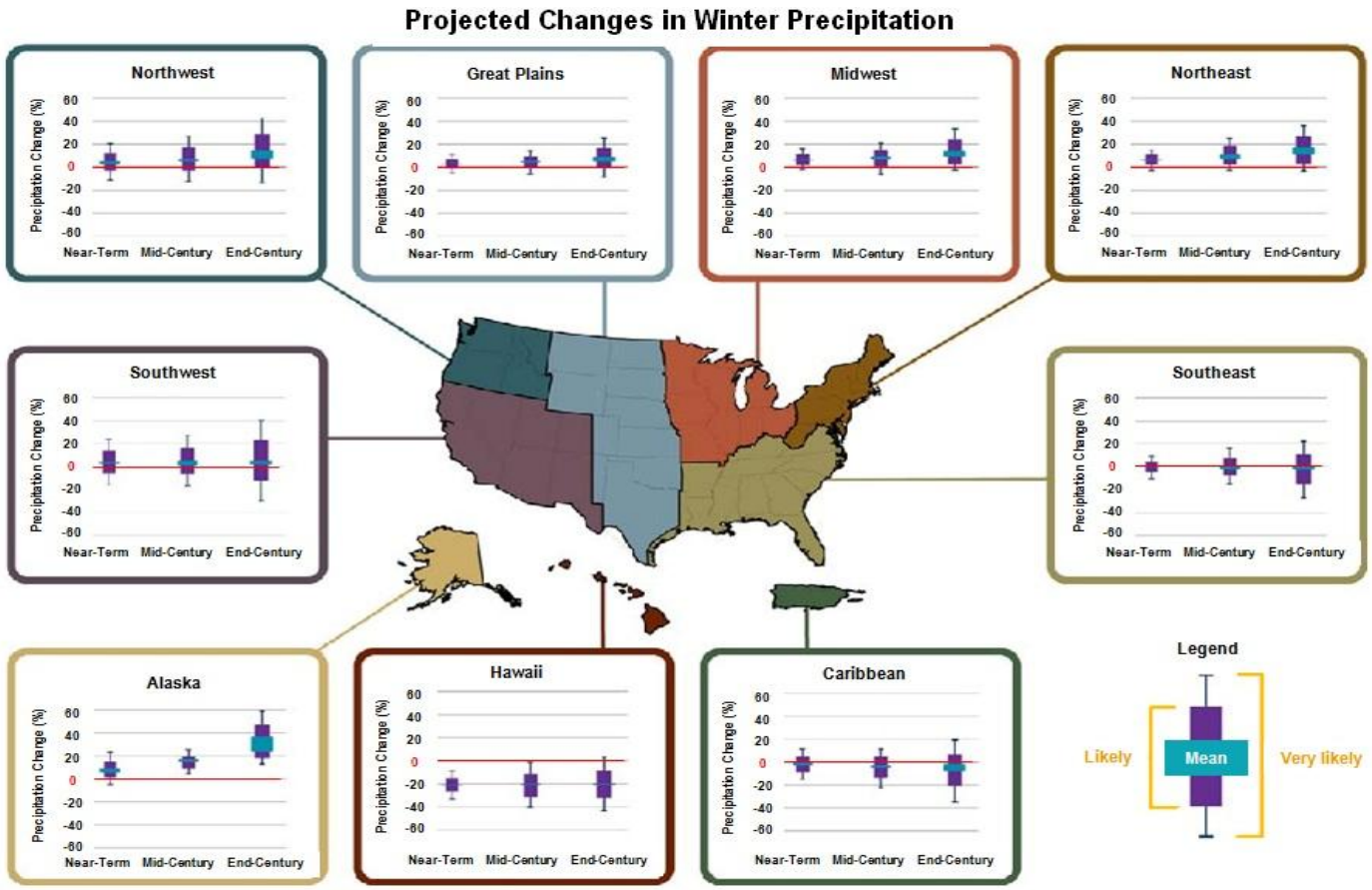
Climate Trends



Source: Projected changes in annual average air temperature for six regions of the U.S., Alaska, Hawaii, and the Caribbean through 2100, relative to 1961-1979 averages, compiled using the A2 (high) and B1 (low) scenarios. [Adapted from ICF International, 2010]

- **Increases will be in the range of 1 to 3°C (1.8 to 5.4°F) by 2039**
- **The magnitude of average temperature increases during the summer is projected to be 3 to 5°C (5.4 to 9°F) across most of North America by the end of the 21st century**

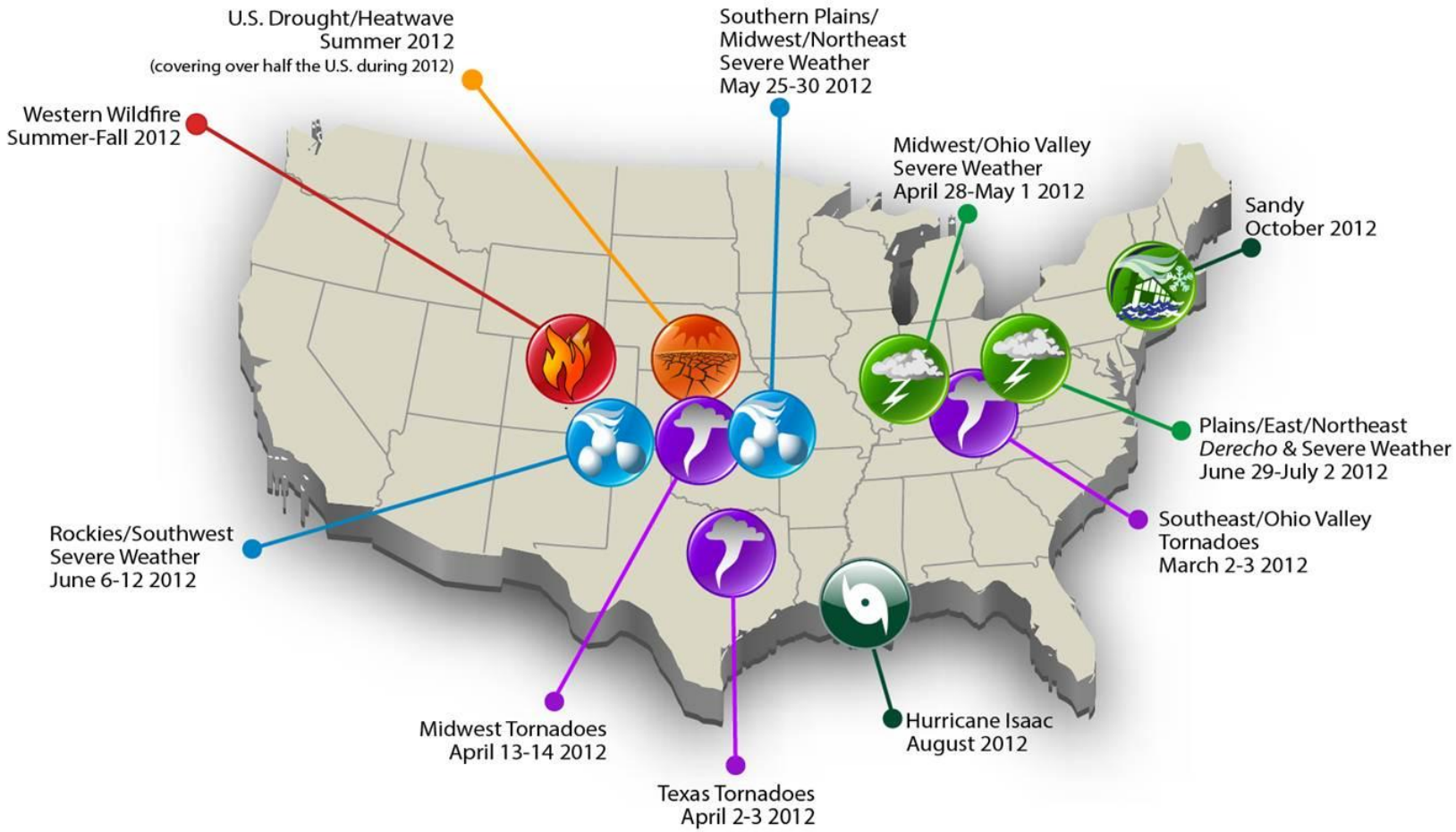
Climate Trends



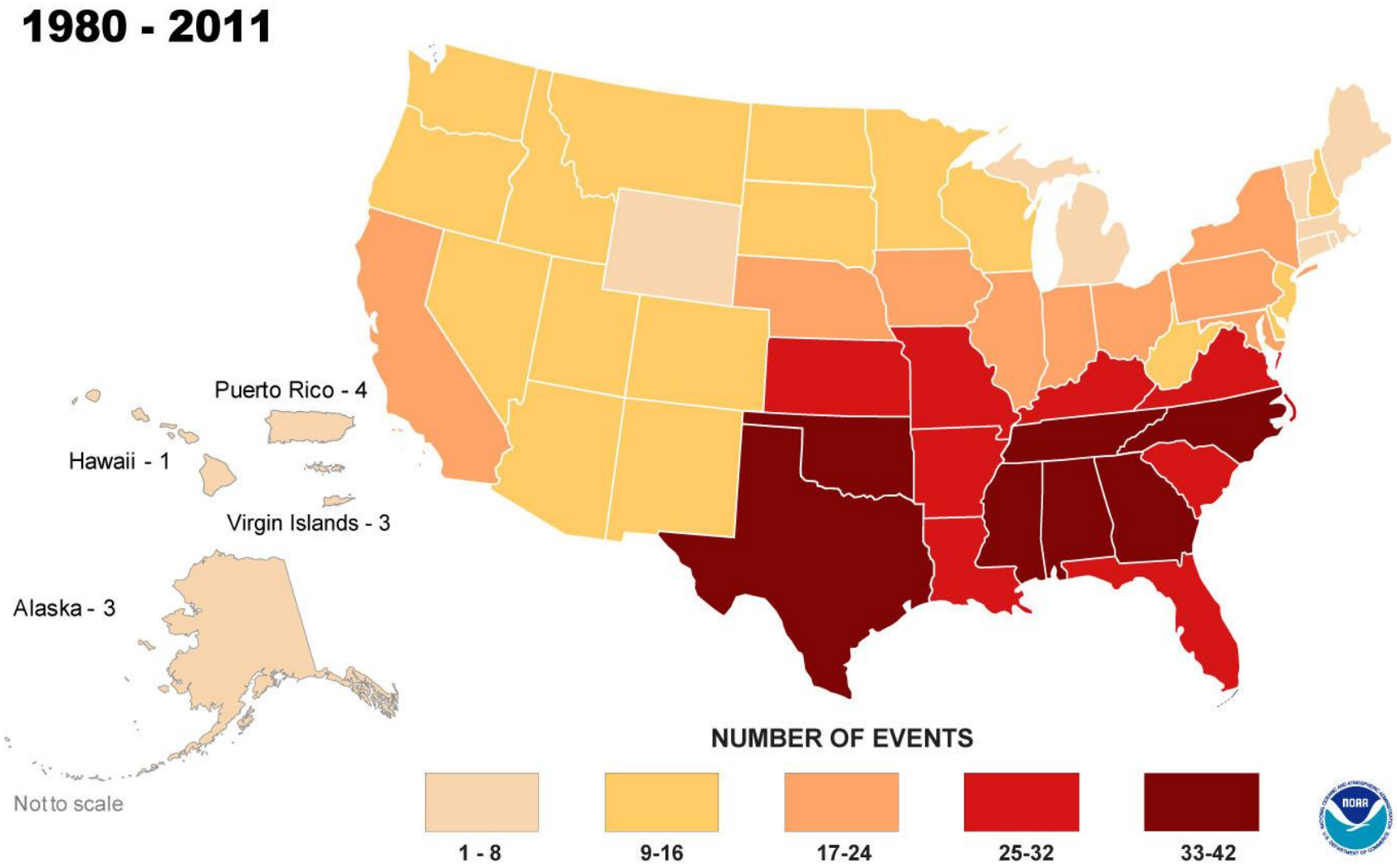
Source: Projected changes in winter average precipitation for six regions of the U.S., Alaska, Hawaii, and the Caribbean through 2100, relative to 1961-1979 averages, compiled using the A2 (high) and B1 (low) scenarios. [Adapted from ICF International, 2010]

- Precipitation projections can vary widely across models
- Snow season length and snow depth are projected to decrease across most of North America
- Rain/snow line is expected to shift northward and to higher elevations, causing more winter precipitation to fall as rain and less as snow

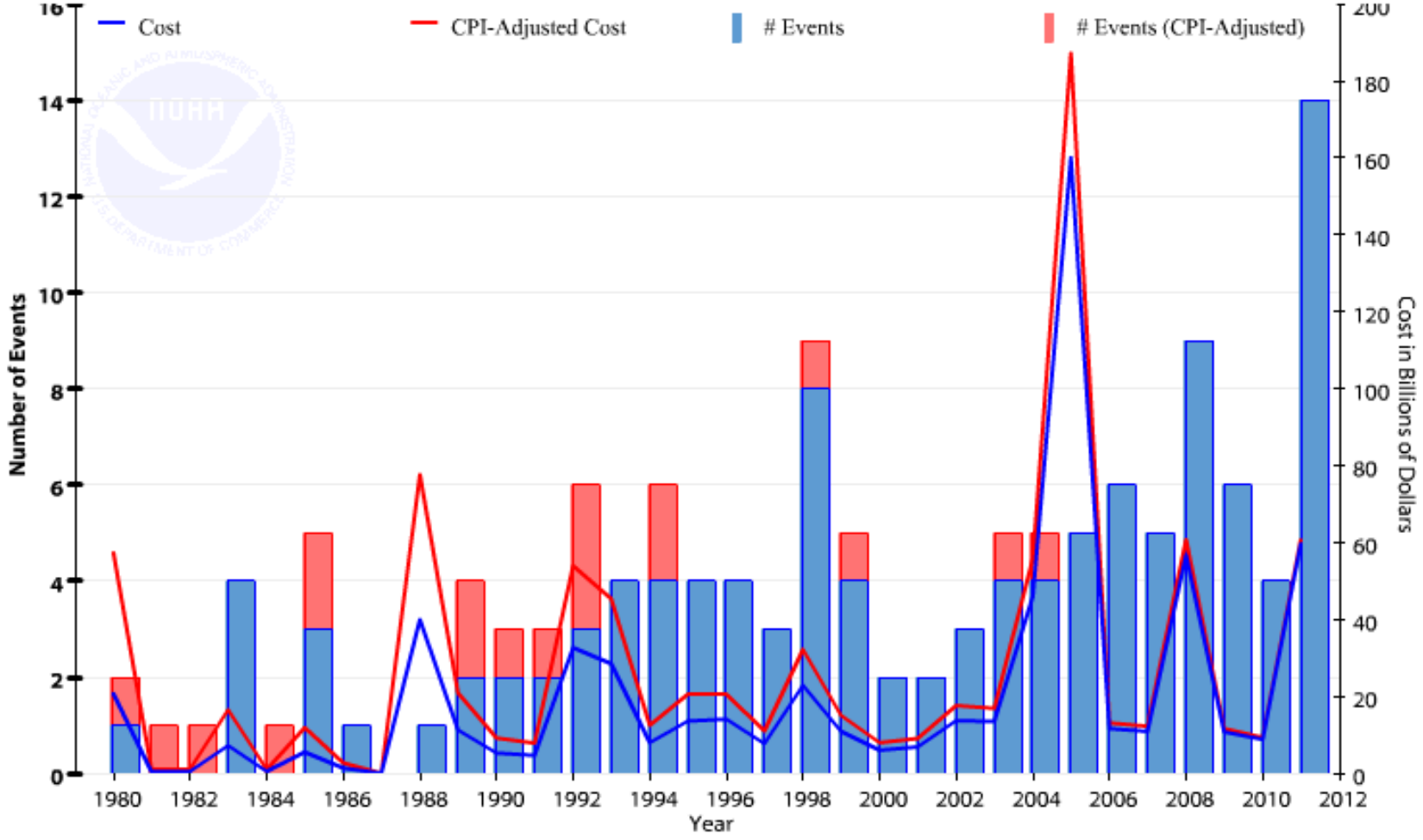
U.S. 2012 Billion-dollar Weather and Climate Disasters



Billion Dollar Weather Disasters



Billion Dollar Weather Disasters



Weather-related Costs

- **Direct costs to State DOTs are:**
  - **$2 billion/year on snow and ice control**
  - **$5 billion/year on snow & ice infrastructure repairs**
- **Indirect costs in terms of travel time delay for…**
  - **all travelers is $11.6 billion/year from snow/ice/fog**
  - **the freight community is $8.7 billion/year nationwide; $3.1 billion/year in the 50 largest cities**
- **Considering lost wages, taxes and retail sales of a <u>one-day shutdown</u>, the costs are estimated to be $3.8 billion across 15 northern states**

System Impacts: Scale Versus Frequency

Impact

10 9 8 7		**Complete** Failure
6 5 4		**Temporary** Operational **Failure**
3 2 1		**Reduced** Capacity

TSM&O in an Uncertain Future

- Increased uncertainty for predicting annual TSM&O needs
- Shifts in TSM&O resources will likely be necessary as climate change causes changes in transportation needs
- The degree to which long-term planning considers climate change impacts could impact TSM&O needs

Climate Change Effects and Potential Responses: System Maintenance

- **Shifting rain/snow/ice line**
  - Changes in resource needs (e.g., less snow fighting, more ice fighting, more flooding)
  - Altered construction and maintenance schedules
- **Increased frequency, duration and intensity of droughts**
  - Changes in vegetation management
- **Increased coastal and inland flooding**
  - Increased and more frequent use of resources (e.g., staff, evacuation materials)
- **Increase in magnitude and duration of severe heat waves**
  - Altered construction and maintenance schedules
  - Deploy "quick maintenance" patrols to address potholes and buckling issues

The Iowa DOT reports that in a typical year an average of $400,000 is spent to make temporary and permanent repairs related to pavement buckling due to thermal expansion forces; costs may be $2000 for a single repair (IDOT, 2012).

Climate Change Effects and Potential Responses: System Operations

- **Increased coastal and inland flooding**
  - Increased and more frequent use of resources (e.g., staff, evacuation materials)
- **Increase in intensity of tropical cyclones, rising sea levels, increased occurrence of wildfires**
  - Broader preparedness for potential evacuation
  - Increase TMC staff and ITS resources to provide traveler information during evacuations
  - More frequent disaster preparation, operations and recovery
- **Increase in energy demand**
  - Need for more resilient TMC communications and ITS hardware

Thirty-one hurricane events have caused $417 billion (adjusted for inflation) in damage in the United States since 1980 (NOAA, 2012).

Climate Change Effects and Potential Responses: Travelers and Traveler Behavior

- **Increased exposure to hazardous driving conditions (e.g., flooding, road conditions, smoke from wildfires) and human health impacts**
  - Increased need for timely, accurate and relevant traveler information from TMC's and private sector information service providers to support route and mode choice, departure times
  - Less consistent mode split impacting day-to-day congestion and safety issues
  - Potential mode shift to/from alternate modes, e.g., using transit, biking, or walking
  - Increased emphasis on carpooling and teleworking to reduce impacts to highways

A data-driven study on Chicago transit ridership showed that CTA bus ridership and weekend ridership are more sensitive to extreme weather than rail ridership and weekday, respectively, and that some weather conditions like fog or blizzards can increase transit ridership. The study found that weekend ridership changed more than weekday ridership (Guo, et al., 2007).

Climate Change Effects and Potential Responses: Freight Transportation

- **Increased frequency, duration and intensity of droughts; increased coastal and inland flooding**
  - Restricted access to ports and shipping channels for inland waterways
  - Mode shift – e.g., from inland waterways to highways due to changes in reliability

About 423 million tons of goods (3% of all tonnage) and about 176 billion ton-miles (5% of all ton-miles) were carried by water, with the Mississippi River system being the most active freight waterway (RITA, 2007).

- **Increase in magnitude & duration of severe heat waves**
  - Mandatory freight diversion to more robust alternate routes
  - Dynamic or seasonal restrictions for trucks or rail during times of high heat, reducing either acceptable speed or weight
  - Policy and regulation changes to restrict truck size and weights

Framing the Questions: Agency Considerations

- **What is needed?**
  - **Increasing capability to manage more frequent and more severe climate events**
  - **Introducing risk assessment in transportation operations planning**
  - **Integration with other adaptation efforts**
  - **Integration across system elements, jurisdictions, and modes**
  - **An organization and workforce capable of managing all of the above**

Framing the Questions: Agency Considerations

- **What can we do to improve our abilities to manage the system?**
  - Build more robust, resilient and flexible Intelligent Transportation Systems
  - Integrate sophisticated weather and road condition information into transportation operations centers
  - Establish greater inter- and intra-agency cooperation, especially for resource/asset management and resource allocation
  - Examine Standard Operating Procedures for rapid mobilization and deployment
  - Cross-train staff, especially for unusual events

Thank you

- **Questions?**
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