Extreme Weather Events: Trends and Implications for Transportation Emergency Management

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on behalf of the AASHTO Center for Environmental Excellence

Prepared for:

AASHTO Special Committee on Transportation Security and Emergency Management Annual Meeting

August 13, 2015

Goals

Answer the following questions:

- What does the science say about extreme weather trends, past and future?
- What do these trends mean for transportation security and emergency management?
- What are the research priorities in this area?

May 2015 Floods in Houston, TX

Recent Extreme Weather Events

Maybe You've Noticed…

- Flooding in Houston, TX, May 2015
- Flooding in Michigan, August 2014
- Flooding in Colorado, September 2013
- Superstorm Sandy, October 2012
- Tropical Storm Lee, September 2011
- Hurricane Irene, August 2011
- Heat Wave in Midwest, summer 2011

Maybe you've noticed…

Texas and Oklahoma, May 2015

Michigan, August 2014

Colorado, September 2013

Vermont, August 2011

Photo sources (clockwise): AP Photo/Brandon Wade, AP Photo/Carlos Osorio, Colorado DOT, VTrans

Not to mention…

Washington landslide, March 2014

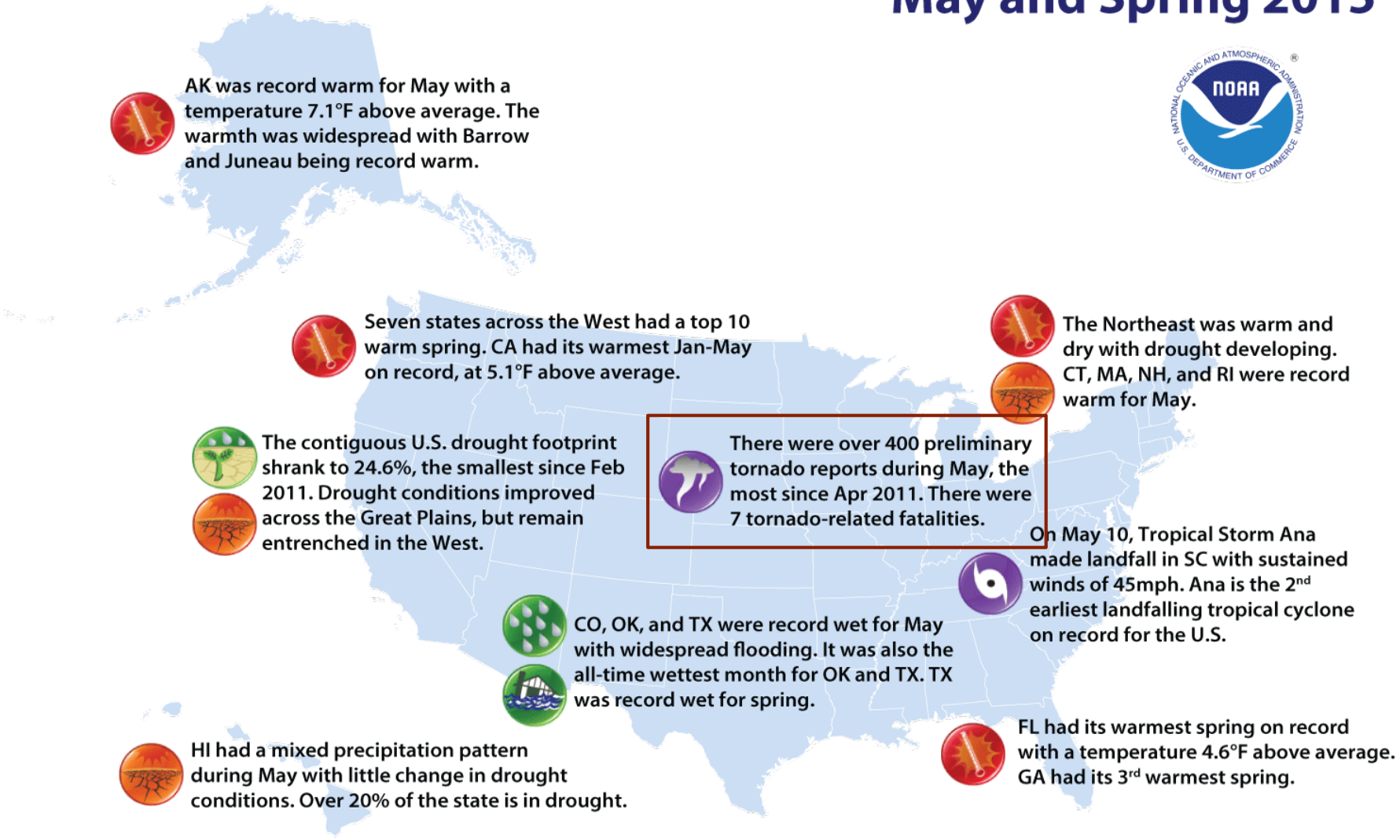
Texas drought, 2011

California wildfires, 2014

Buffalo snow storm, December 2014

Photo sources (clockwise): USGS, City of Austin, Fox News, necn

U.S. Selected Significant Climate Anomalies and Events
May and Spring 2015



AK was record warm for May with a temperature 7.1°F above average. The warmth was widespread with Barrow and Juneau being record warm.

Seven states across the West had a top 10 warm spring. CA had its warmest Jan-May on record, at 5.1°F above average.

The Northeast was warm and dry with drought developing. CT, MA, NH, and RI were record warm for May.

The contiguous U.S. drought footprint shrank to 24.6%, the smallest since Feb 2011. Drought conditions improved across the Great Plains, but remain entrenched in the West.

There were over 400 preliminary tornado reports during May, the most since Apr 2011. There were 7 tornado-related fatalities.

On May 10, Tropical Storm Ana made landfall in SC with sustained winds of 45mph. Ana is the 2nd earliest landfalling tropical cyclone on record for the U.S.

CO, OK, and TX were record wet for May with widespread flooding. It was also the all-time wettest month for OK and TX. TX was record wet for spring.

HI had a mixed precipitation pattern during May with little change in drought conditions. Over 20% of the state is in drought.

FL had its warmest spring on record with a temperature 4.6°F above average. GA had its 3rd warmest spring.

The average U.S. temperature during May was 60.8°F, 0.6°F above average. The spring U.S. temperature was 53.2°F, 2.2°F above average. May U.S. precipitation was 4.36 inches, 1.45 inches above average and the wettest month of any month on record. The spring precipitation total was 9.33 inches, 1.39 inches above average.

Please Note: Material provided in this map was compiled from NOAA's State of the Climate Reports. For more information please visit: http://www.ncdc.noaa.gov/sotc

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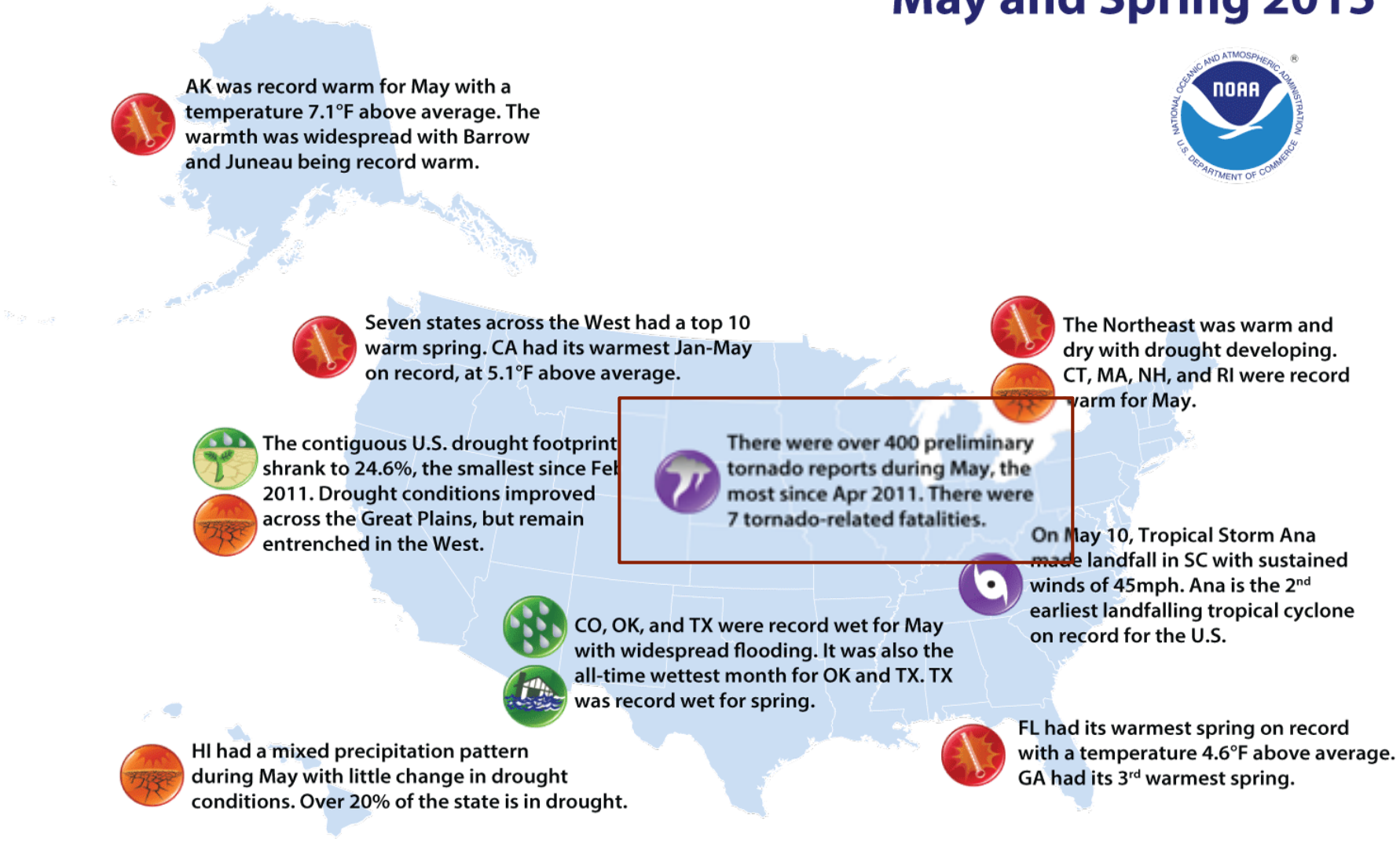

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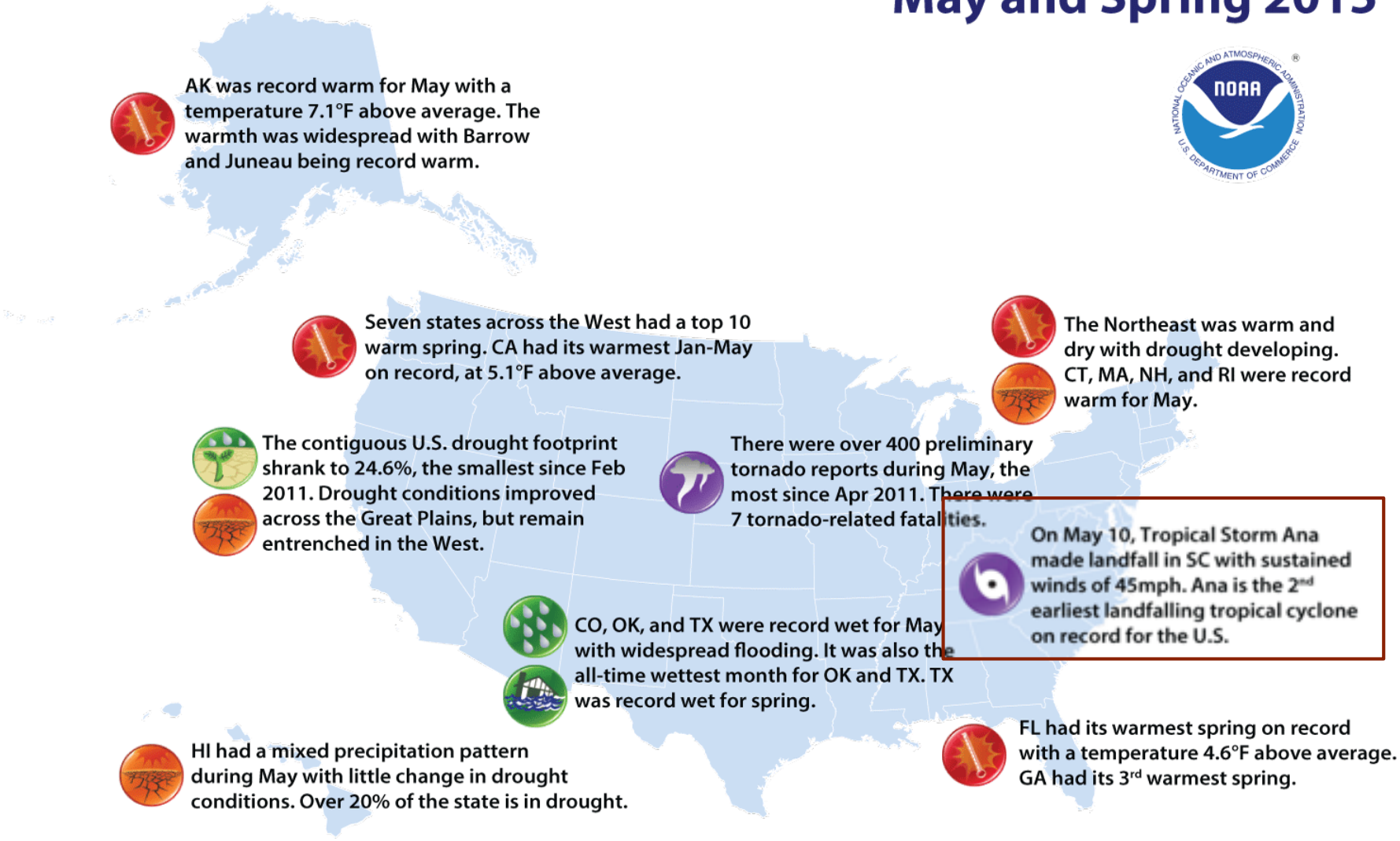

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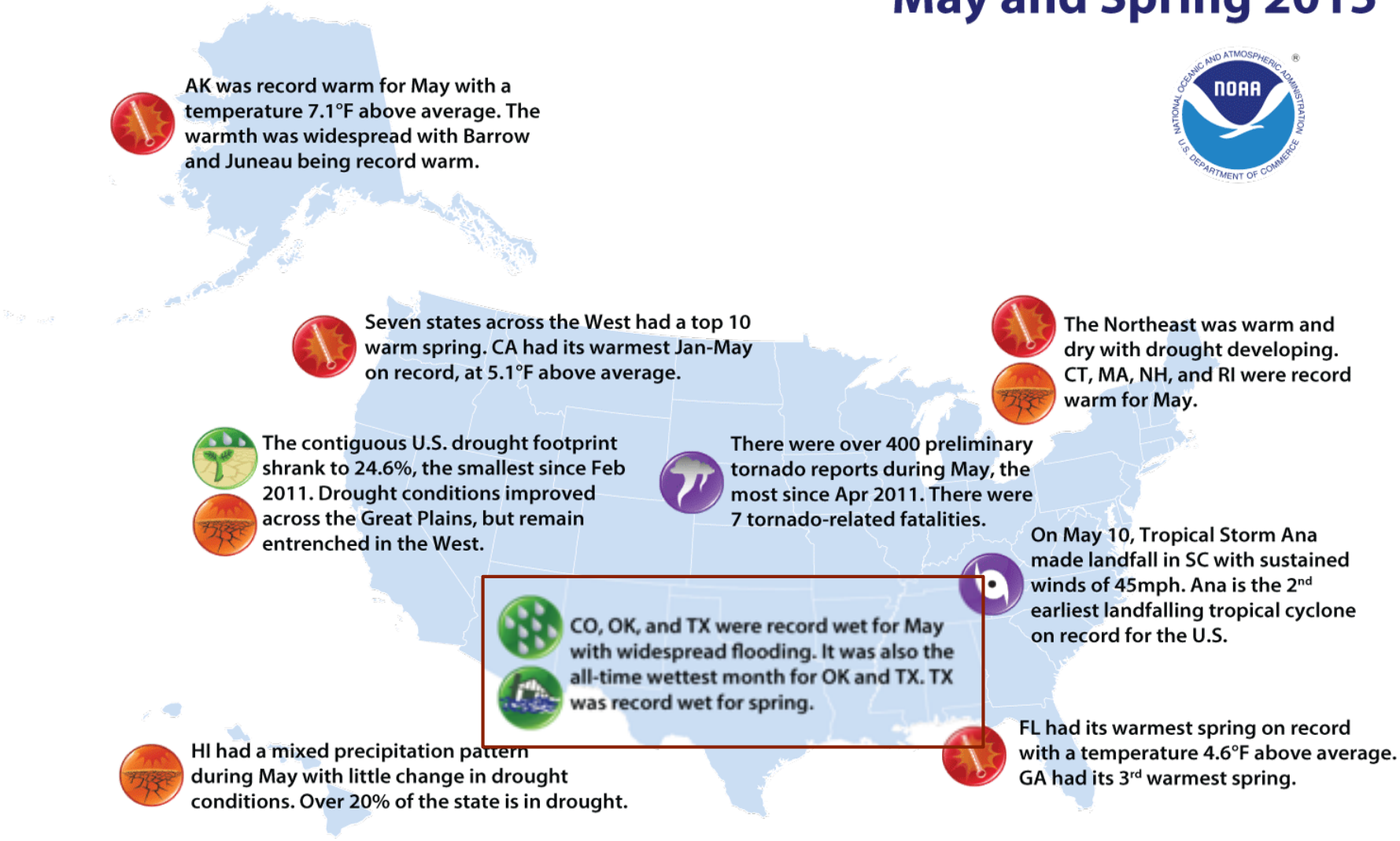

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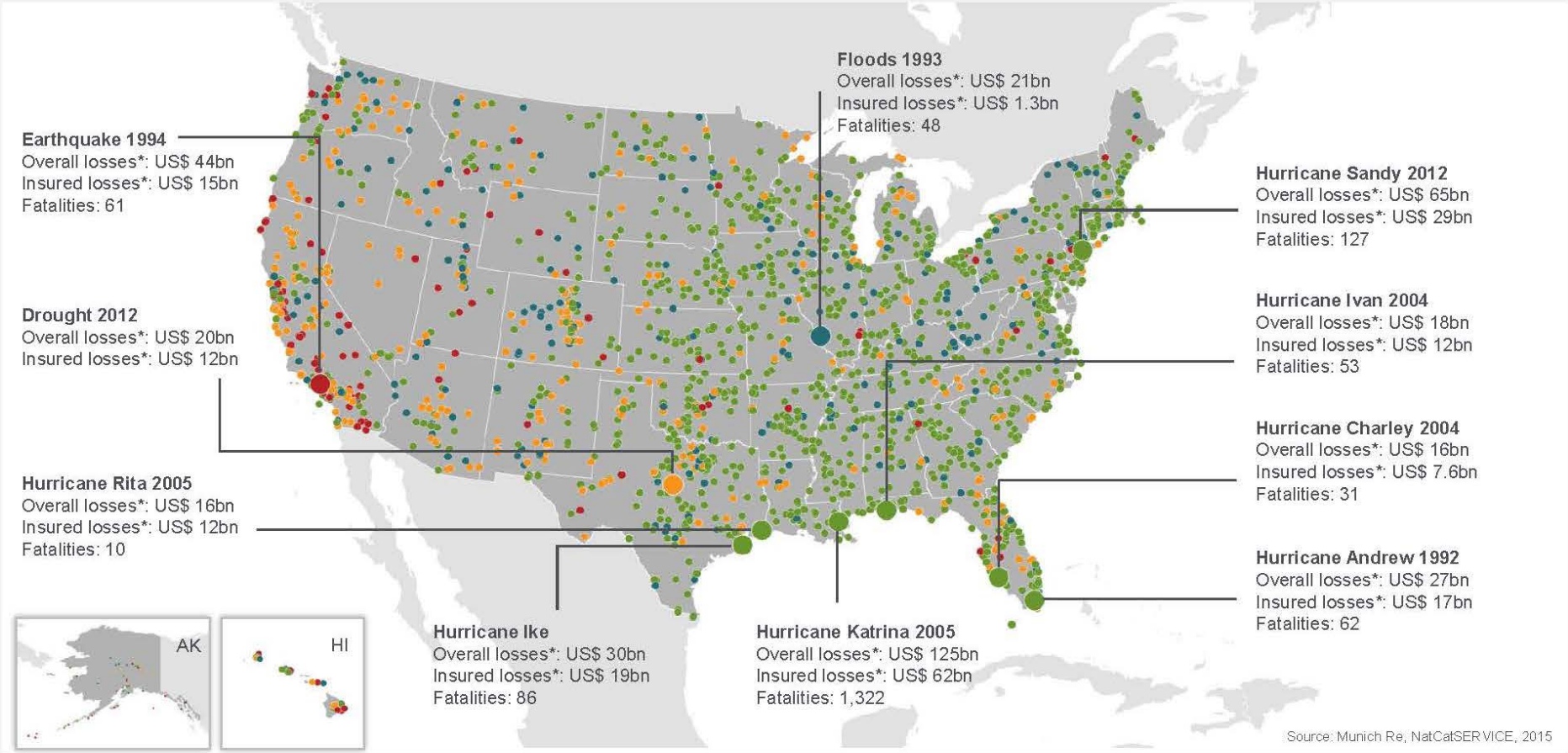
NatCatSERVICE

Loss events in the U.S. 1980 – 2014

Geographical overview

Munich RE



○ **Loss events**

◯ **Selection of catastrophes**

*Losses in original values

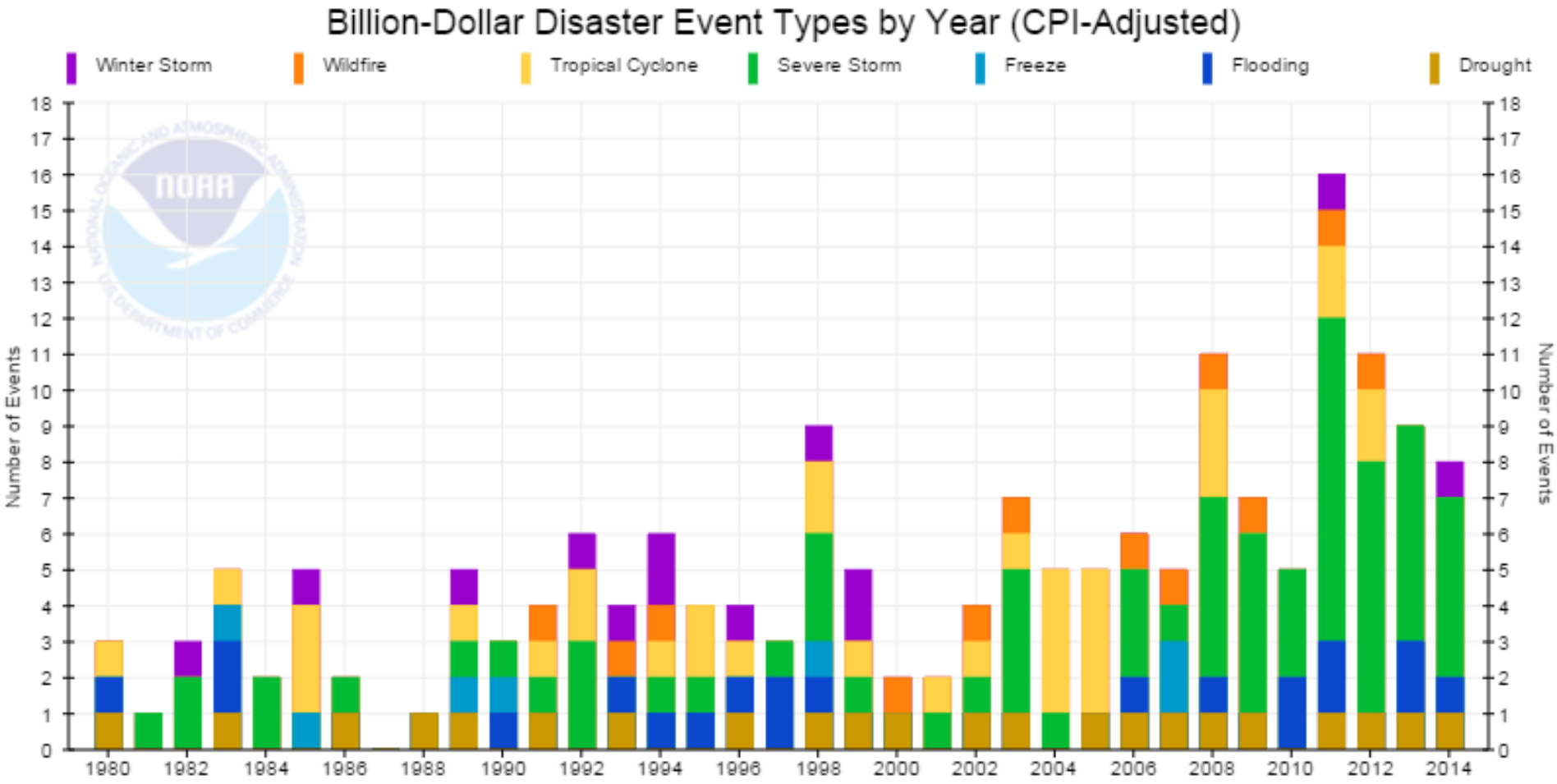
● **Geophysical events**
(Earthquake, tsunami, volcanic activity)

● **Meteorological events**
(Tropical storm, extratropical storm, convective storm, local storm)

● **Hydrological events**
(Flood, mass movement)

● **Climatological events**
(Extreme temperature, drought, wildfire)

Weather is Getting Costlier

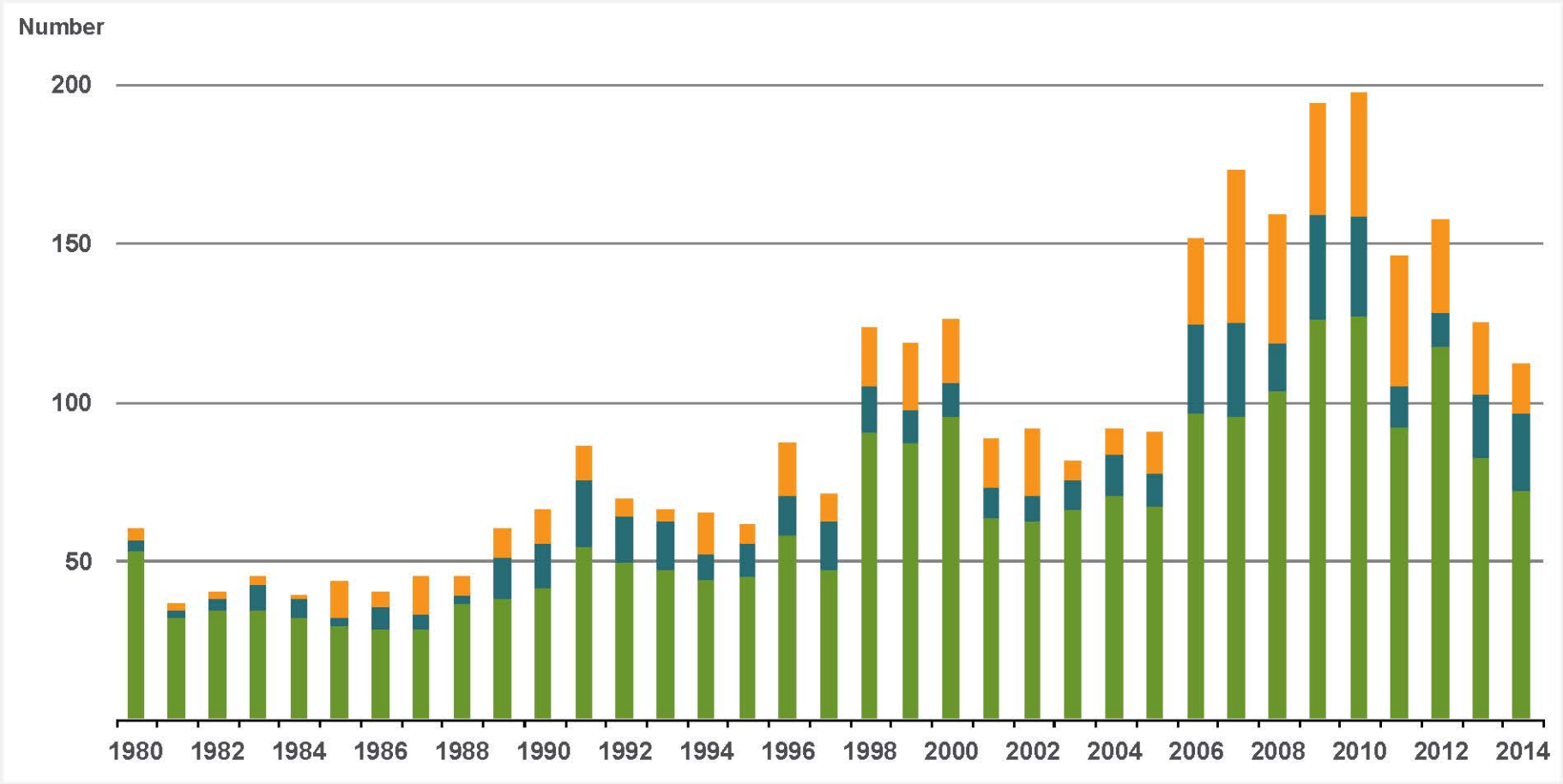


Source: NOAA - https://www.ncdc.noaa.gov/billions/time-series

NatCatSERVICE

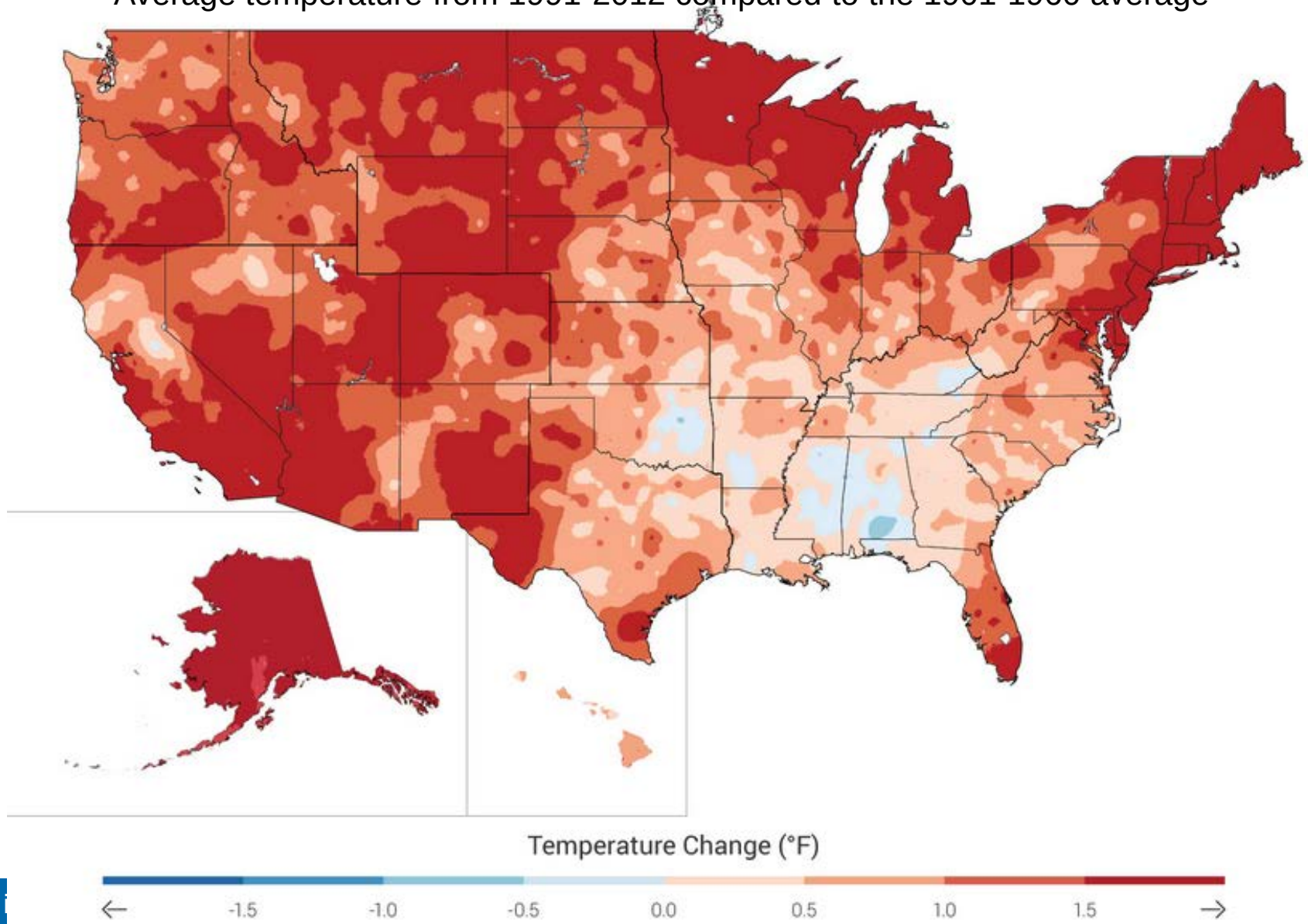
Weather-related loss events in the U.S. 1980 – 2014

Number of events



Observed U.S. Temperature Change

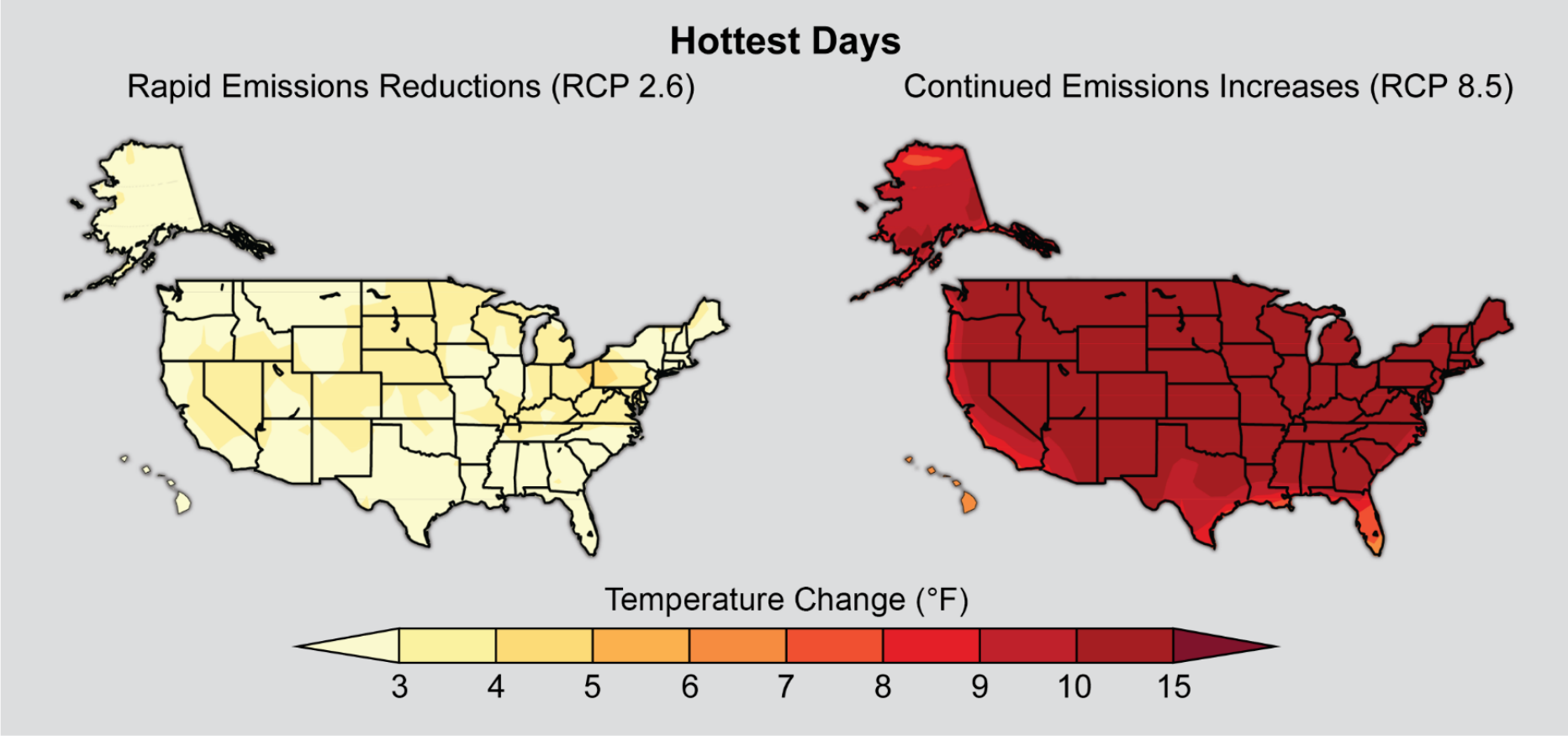
Average temperature from 1991-2012 compared to the 1901-1960 average



Source: National Climate Assessment 2014

Projected Change in Extreme Heat

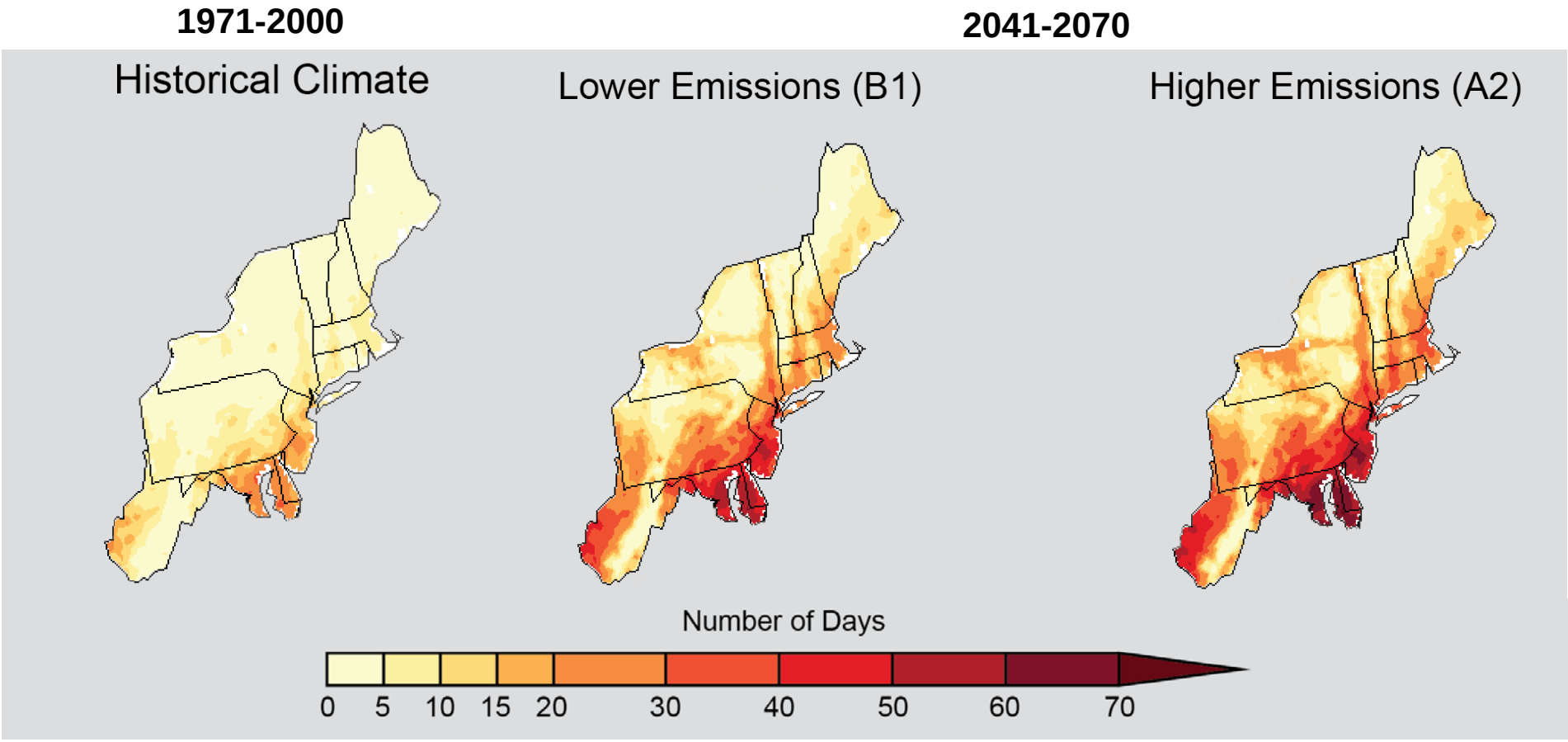
Projected temperature change of hottest temperature (2081-2100 average compared to 1986-2005)



Source: National Climate Assessment 2014

Projected Change in Extreme Heat

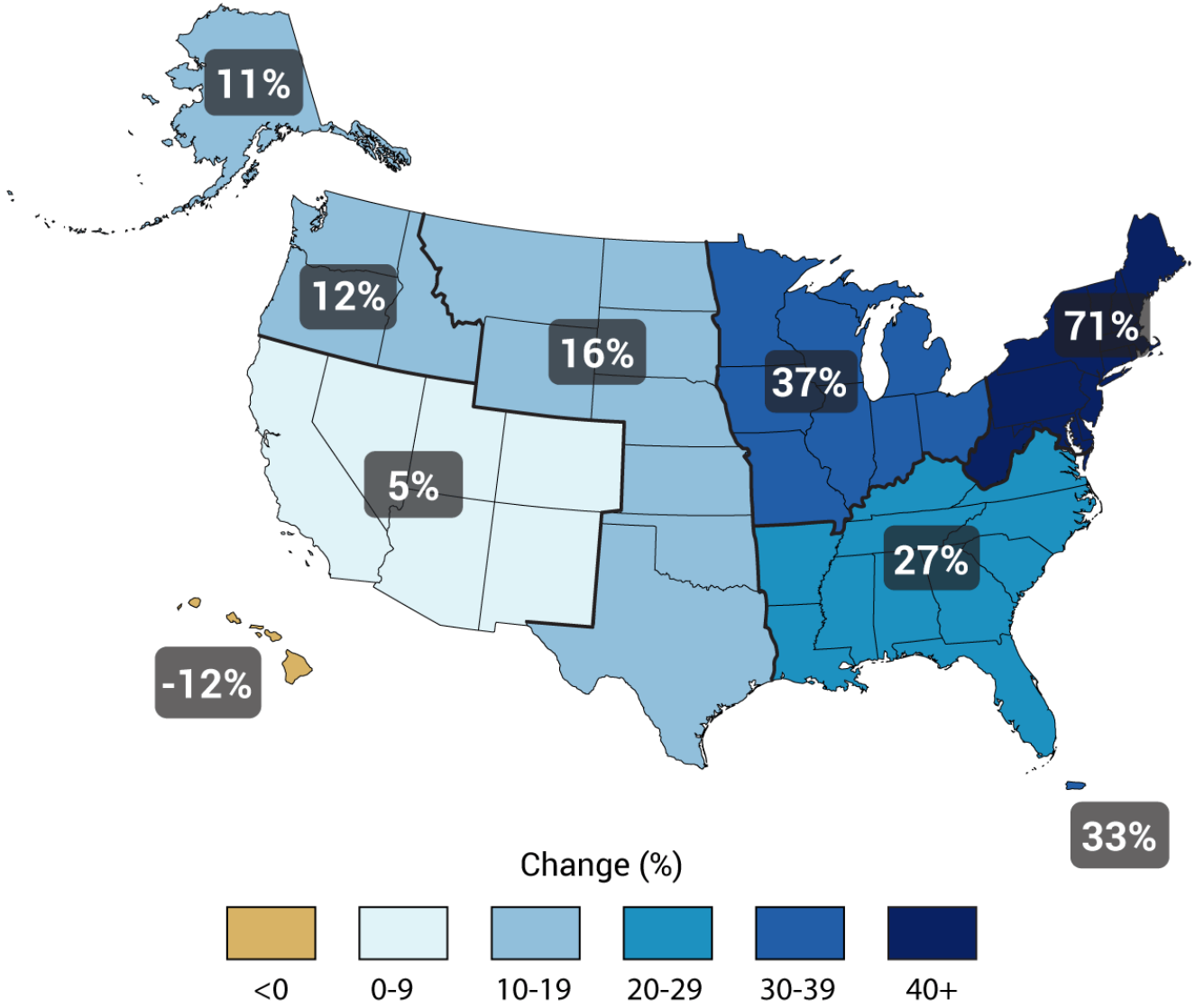
Projected number of days per year above 90°F (2041-2070 average compared to 1971-2000)



Source: National Climate Assessment 2014

Observed Change in Heavy Precipitation

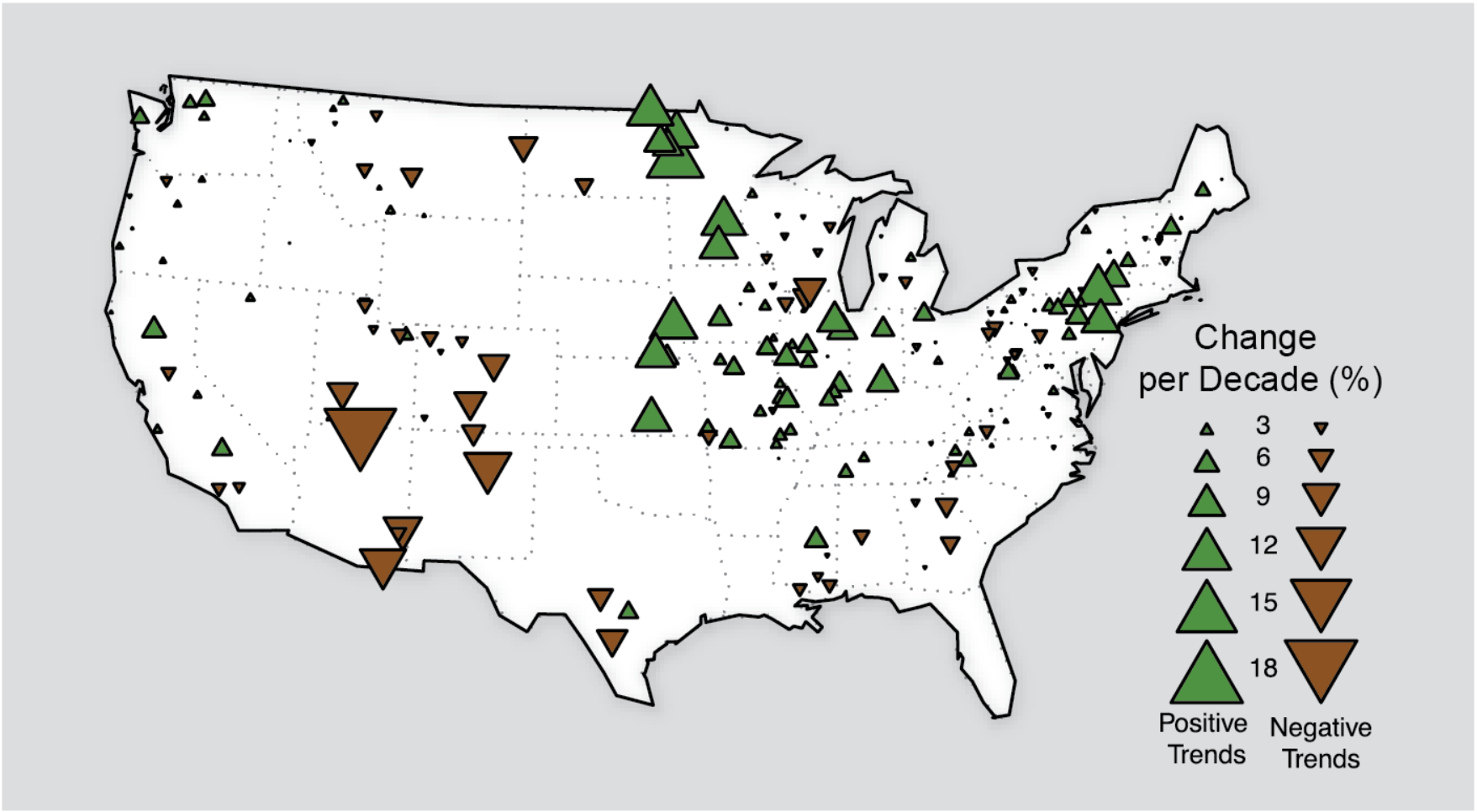
Change in amount off precipitation falling in heaviest 1% of all daily events, 1901-2012



Source: National Climate Assessment 2014

Flooding Trends

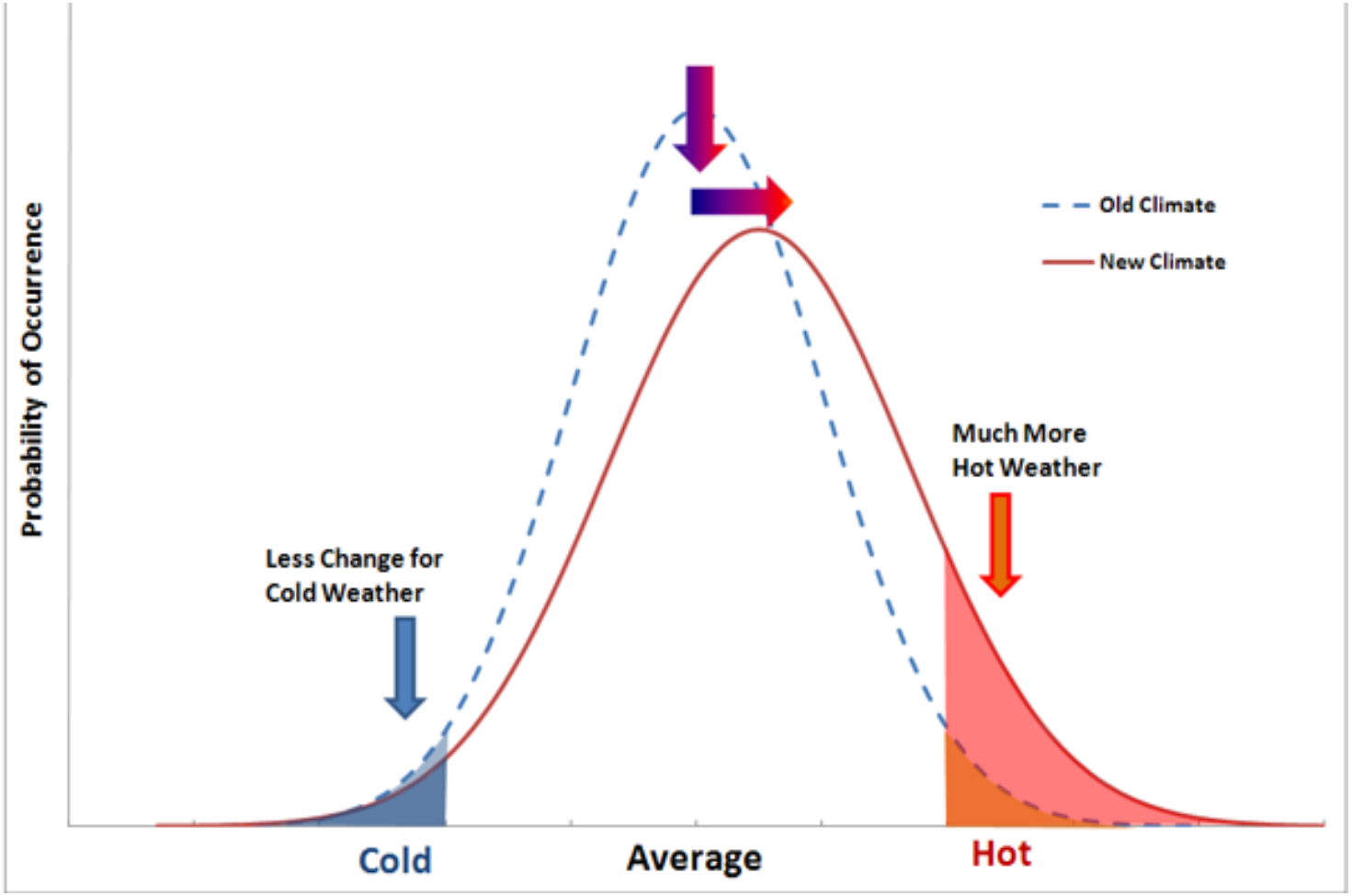
Change in annual flood magnitude, 1920-2008



Source: National Climate Assessment 2014

A New Normal?

- Climate change is widening and shifting weather probability distributions



Source: Huber, Daniel G. and Gulledge, Jay. 2011. "Extreme Weather and Climate Change: Understanding the Link and Managing the Risk" Science and Impacts Program. Center for Climate and Energy Solutions: Arlington, VA. Available at: http://www.c2es.org/publications/extreme-weather-and-climate-change

Trends Projected to Continue, Accelerate

- Increase in average and extreme temperatures, heat wave intensity
- Increasing number of frost-free days
- Increased precipitation variability
- Increased drought intensity in the Southwest
- Increased hurricane intensity and rainfall

Ongoing Research

- NOAA
  - Weather-Ready Nation Program
    - *http://www.nws.noaa.gov/com/weatherreadynation*
  - National Centers for Environmental Information
    - *Climate/Extreme Weather Monitoring, State of the Climate, Climate Extremes Index*
- National Academies of Science
- Universities

What Does It All Mean?

Implications for Transportation Systems

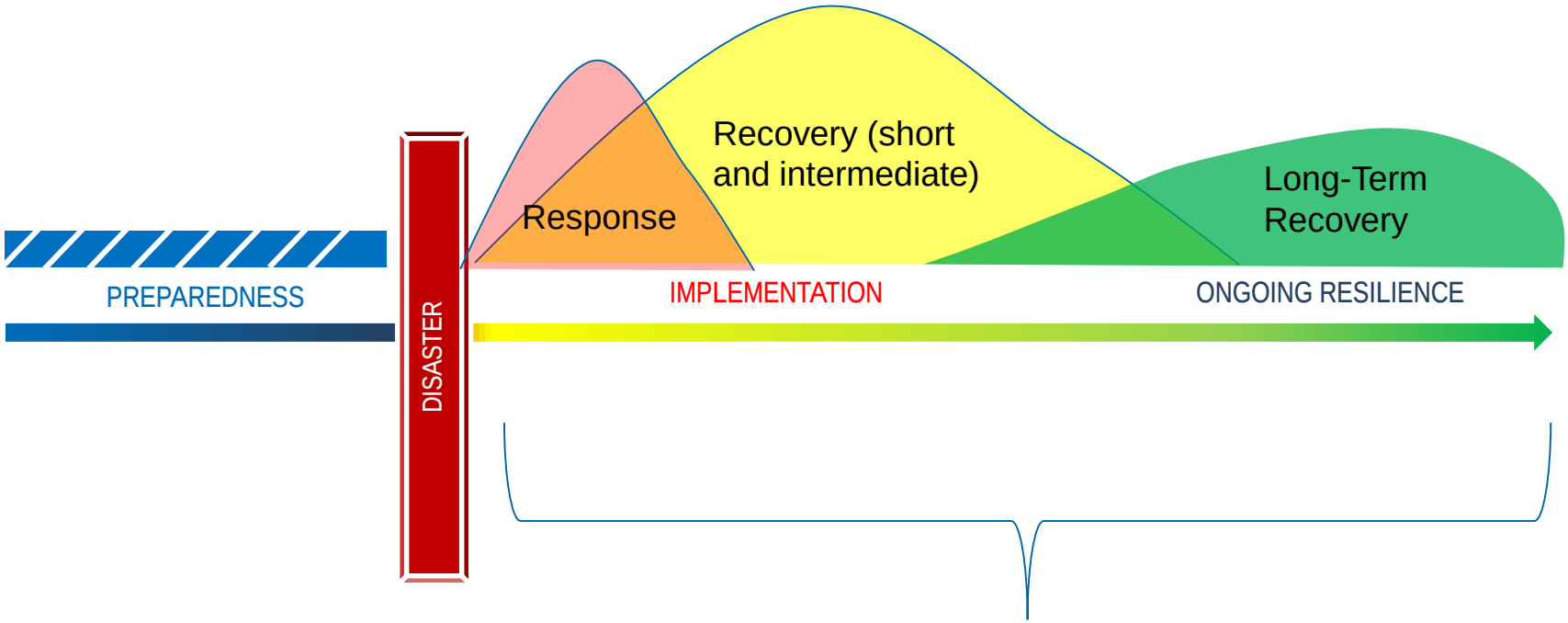
Extreme Weather	Impacts
Flooding / Heavy Downpours	• Road/bridge washouts • Cut off access to communities or resources • Risk of hazardous cargo accidents
Tropical Cyclones	• Need for evacuation • Hazardous driving conditions • Flooding and roadway washouts (especially from storm surge)
Wildfires	• Need for evacuation
Winter Storms	• Hazardous driving conditions • Cut off access to communities or resources
Extreme Heat	• Pavement deterioration, increased maintenance needs

Whose Job is Resilience?

What Does This Mean for Emergency Management?

- More events (natural hazards), increasing unpredictability
  - How can budget/emergency operations planning be done effectively?
- Added incentive to continue to improve, implement best practices
  - E.g., work with other parts of the organization to reduce impacts, reduce the need for emergency management
  - Can we get ahead of disasters with selective improvements?
- Reviewing and adjusting worst case scenarios, as necessary
- Increased need to coordinate with other departments and agencies (e.g., state agencies, NWS)
- Importance of Road Weather Information System (RWIS) effectiveness

Timelines for Resilience



- Much of the traction in terms of investment has been *post-disaster* (FEMA reimbursements, rebuilding); this is where $$ is
- Emergency Management plays a role in all phases

Example Best Practices

- Vulnerability assessments of critical infrastructure
- Evacuation planning
- Improved internal and external coordination
- Communications interoperability
- Public communication about real-time weather risks, road conditions

Example Best Practices

- Investment/operations trade-off analysis
- Opportunistic infrastructure hardening
- Post-event debriefs and analysis
- Staff training (and cross-training)
- Drills and tabletop exercises

Example Strategies

- Arizona DOT

  Preliminary Study of Climate Adaptation for the Statewide Transportation System in Arizona (2013)

  - Conduct emergency contingency planning
  - Integrate emergency evacuation procedures into operations
  - Separate budgets for maintenance versus emergency response

- Caltrans

  2009 California Climate Adaptation Strategy (2009)

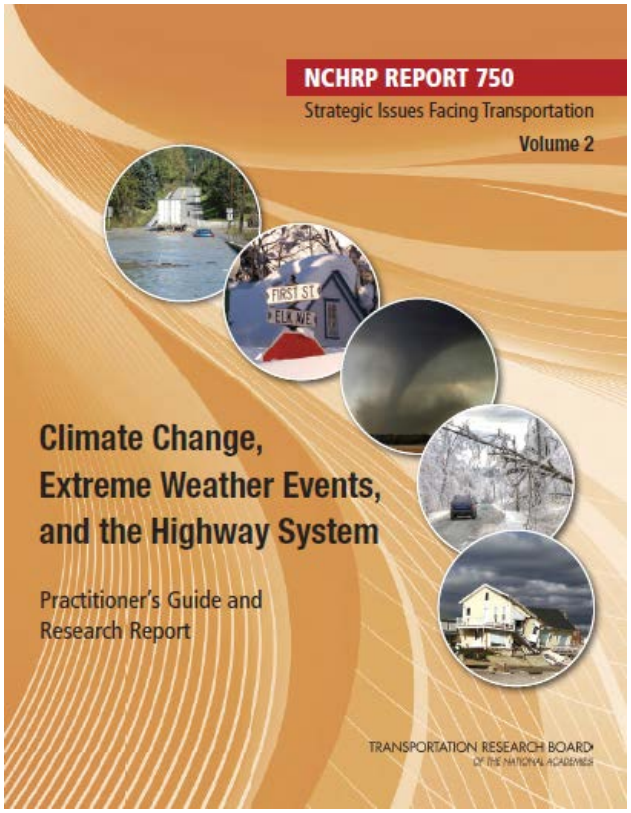
  - Assess type of extreme weather-related information necessary to respond to district emergencies and incorporate into existing operations management plans
  - Identify how climate impact information can be integrated into existing ITS and Transportation Management Center Operations

Example Strategies

- Maryland SHA

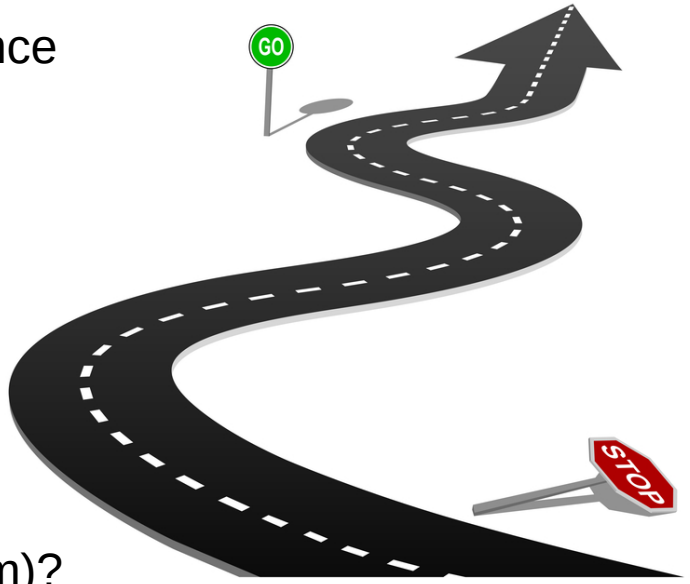
  Climate Change Adaptation Policy (2012)

  - Review equipment needs related to extreme weather response
  - Coordinate plowing and road closure decisions with neighboring states
  - Update contra-flow plans
  - Create checklist for on-scene incident response managers
  - Enhance cross-training in emergency management tasks
  - Install systems to automatically adjust signal timing to traffic conditions, especially on key detour routes
  - Implement an automated system for detecting stoplights affected by power outages
  - Develop integrated tracking of major incidents between Statewide Operations Centers and Traffic Operation Centers



Where Do We Go from Here?

- **Continue to understand the problem**
  - Improve monitoring and tracking of weather trends, vulnerabilities, and response options
- **Continue to integrate toward All-Hazards emergency preparedness**
- **Engage other transportation disciplines to create multi-dimensional approaches**
  - E.g., National Operations Center of Excellence
- **Learn from each other**
  - Peer learning from states whose "normal" climate is your "new normal"?
- **Identify information needs and new approaches**
  - What information do emergency managers need to make decisions (near- and long-term)?



Q&A

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