Extreme Weather Events: Trends and Implications for Materials

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on behalf of the AASHTO Center for Environmental Excellence

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Center for Environmental Excellence

Goals

Answer the following questions:

- Why is consideration of extreme weather events important?
- Extreme weather trends, past and future: what does the science say?
- How do extreme weather events affect materials?
- How can the materials community prepare for extreme weather trends?

Recent Extreme Weather Events

May 2015 Floods in Houston, TX

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

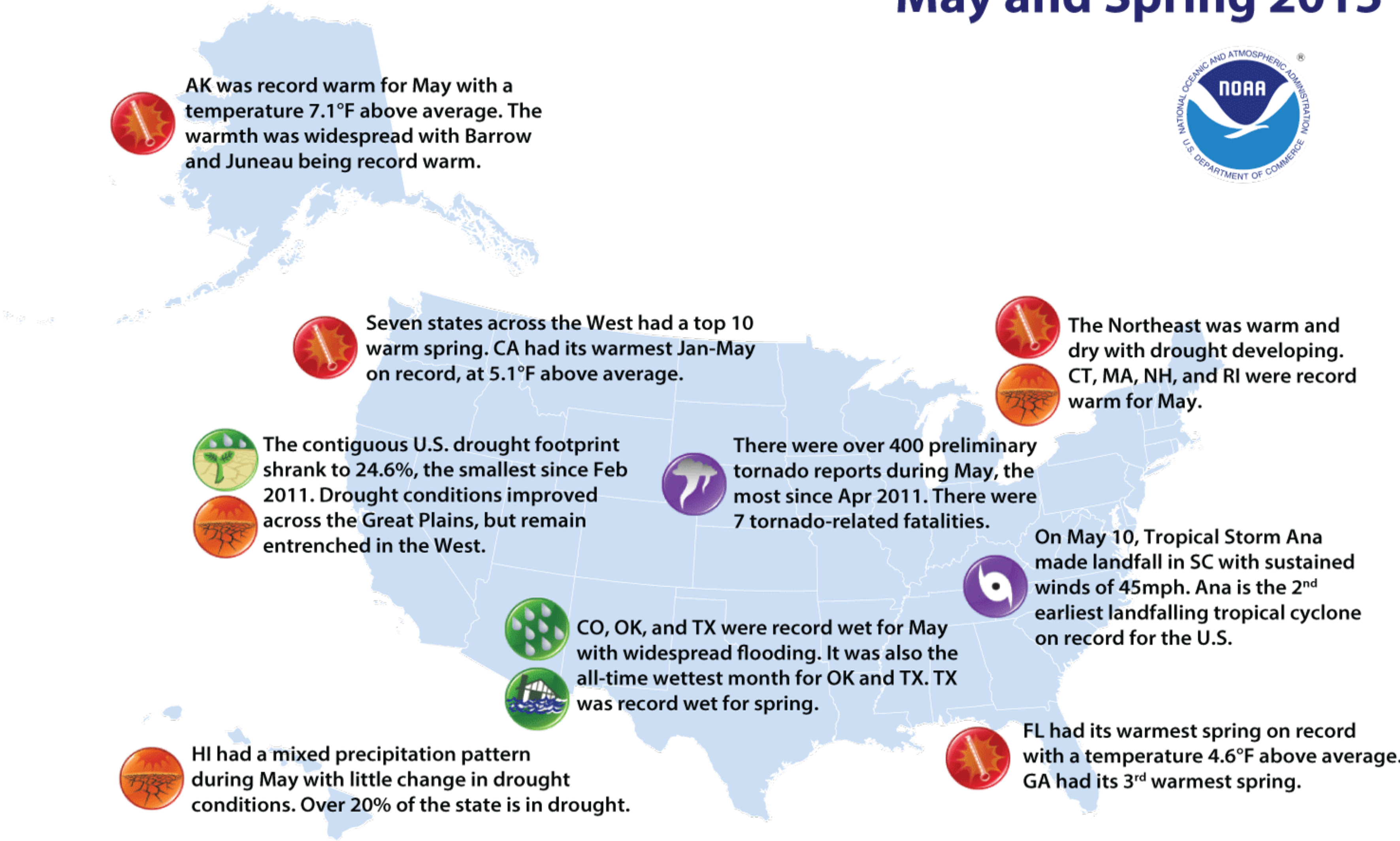
Texas drought, 2011

California wildfires, 2014

Buffalo snow storm, December 2014

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

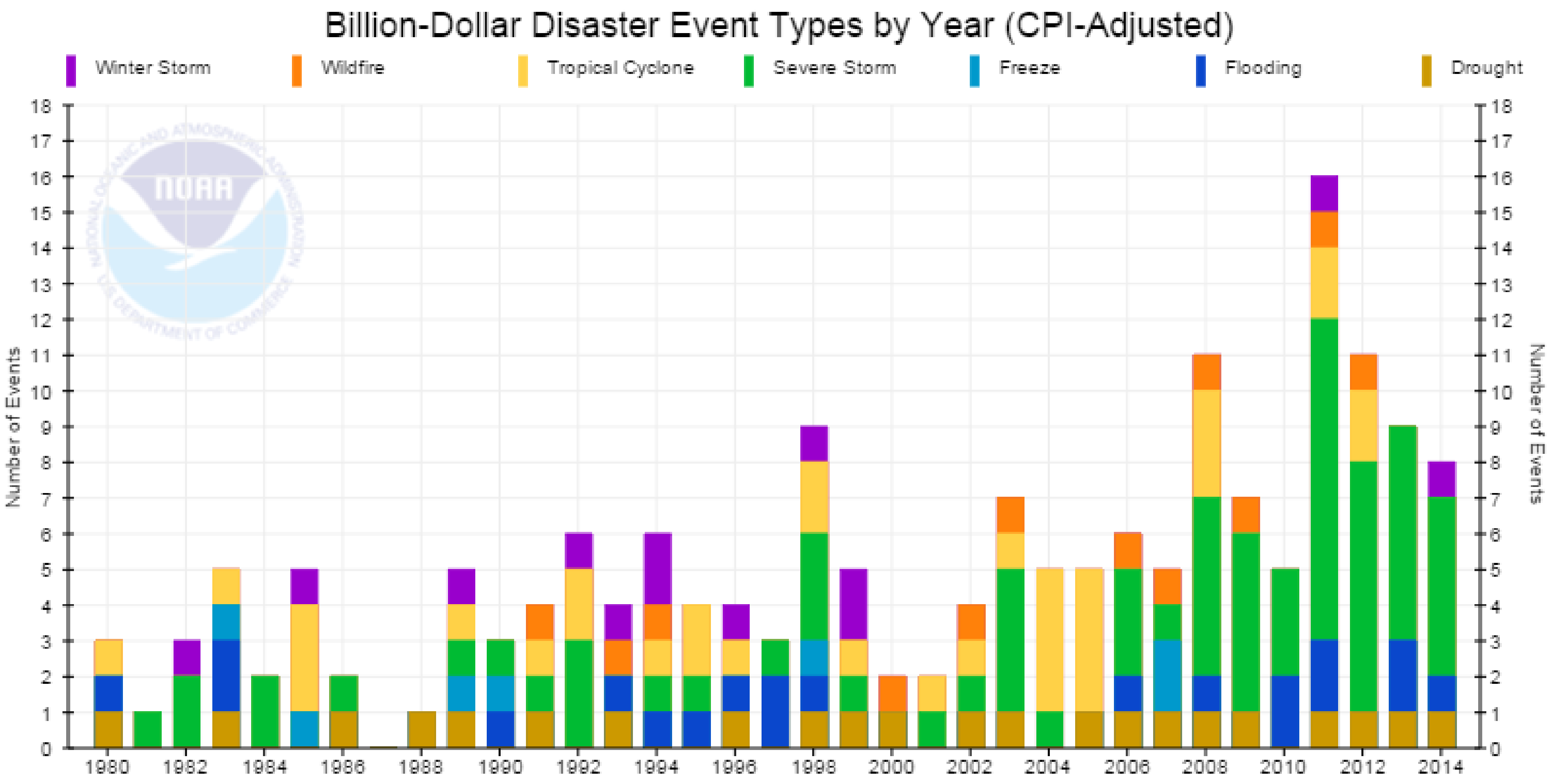
U.S. Selected Significant Climate Anomalies and Events
May and Spring 2015



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

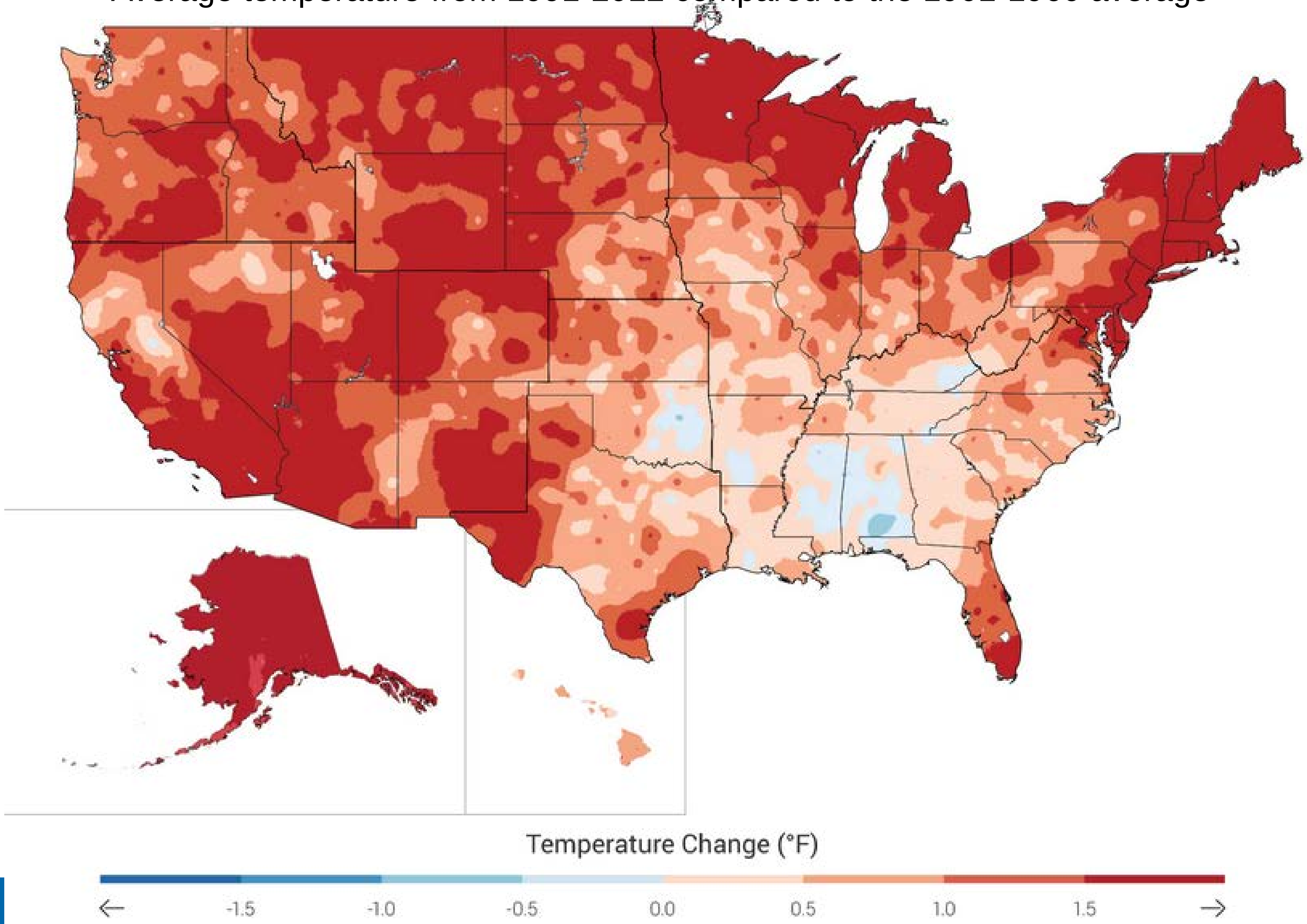
Weather is Getting Costlier



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

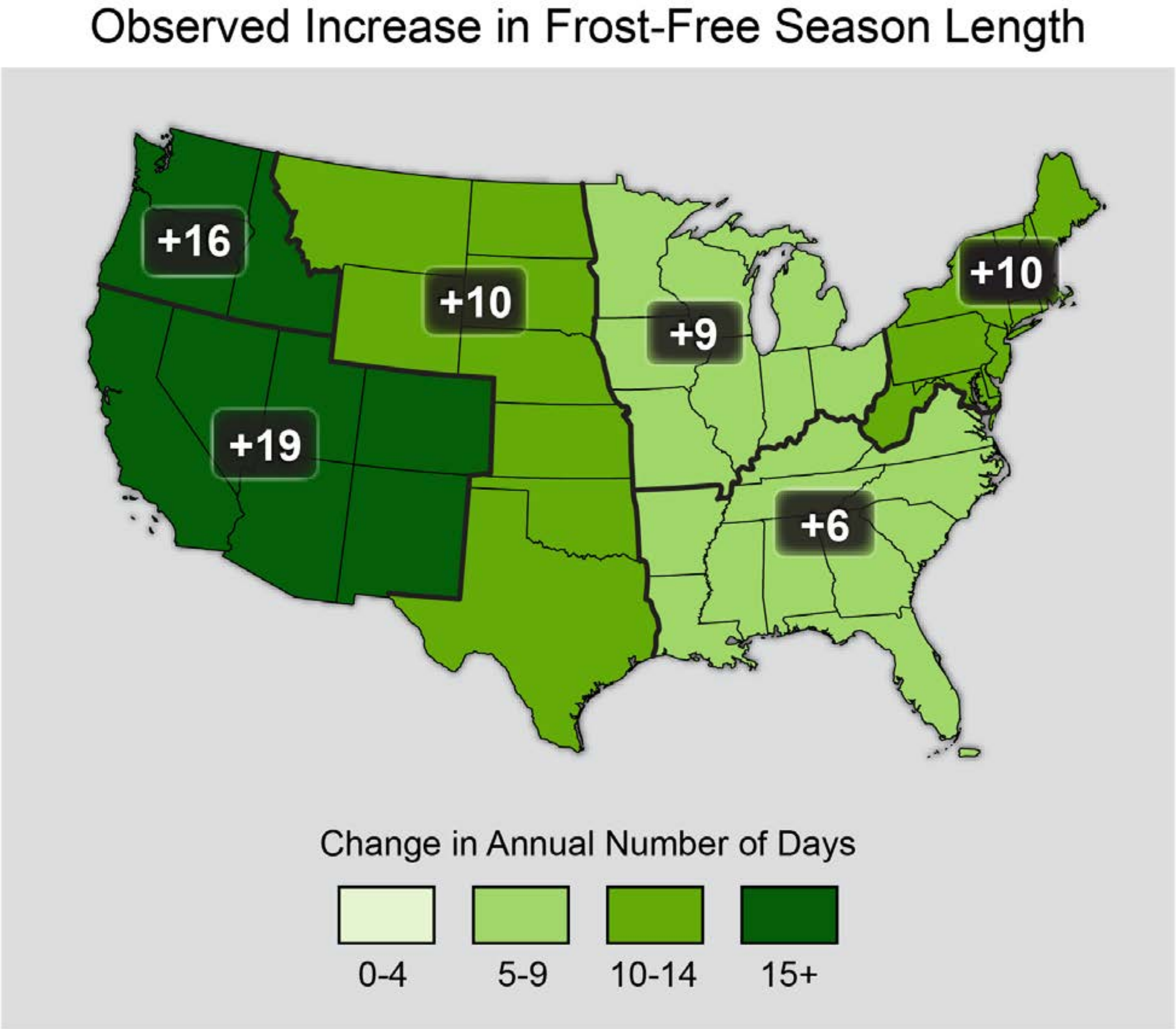
Observed U.S. Temperature Change

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



Source: National Climate Assessment 2014

Frost-Free Season Length

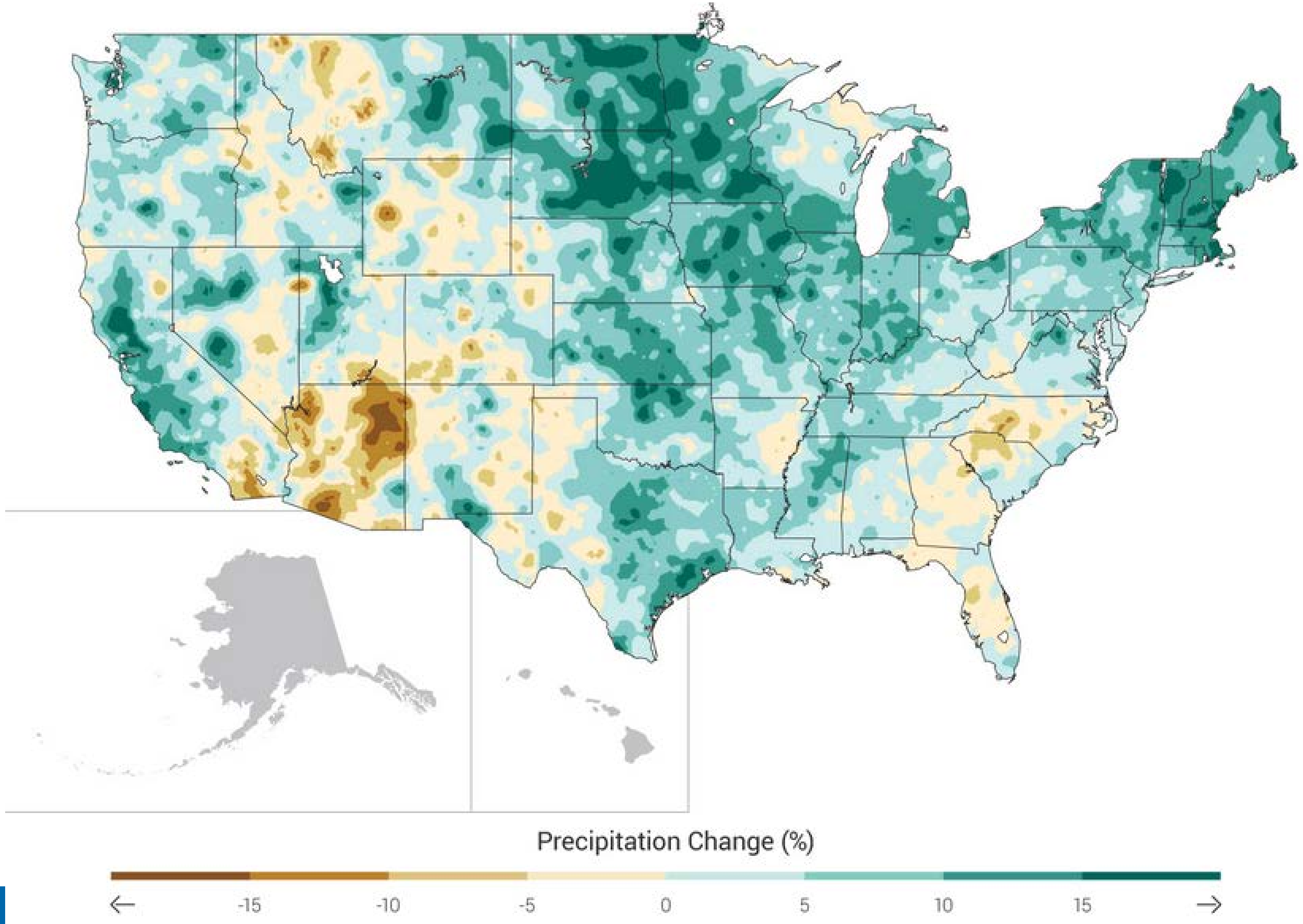


1991-2012 average relative to 1901-1960 average

Source: National Climate Assessment 2014

Observed U.S. Precipitation Change

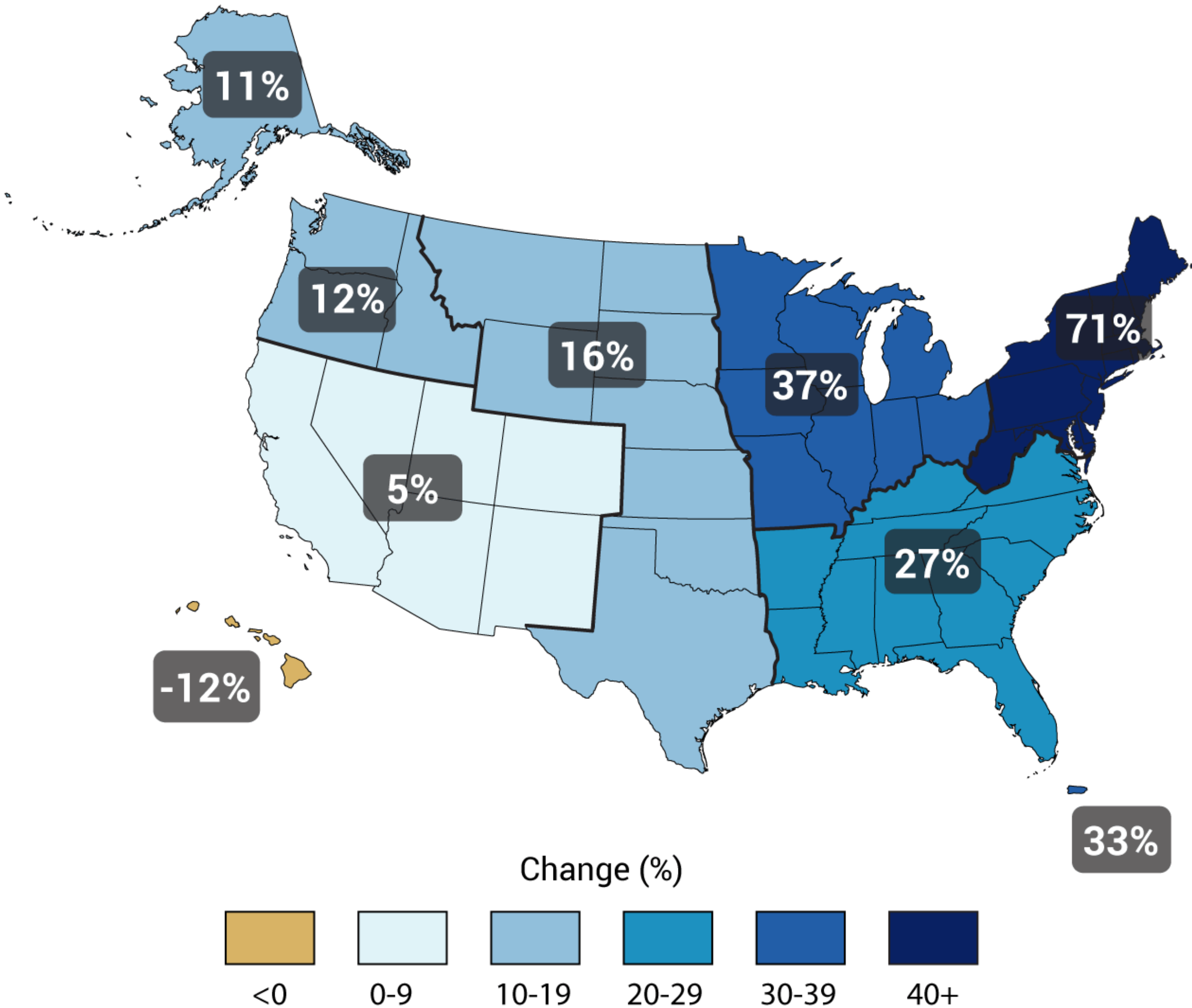
Average annual precipitation from 1991-2012 compared to the 1901-1960 average



Source: National Climate Assessment 2014

Observed Change in Heavy Precipitation

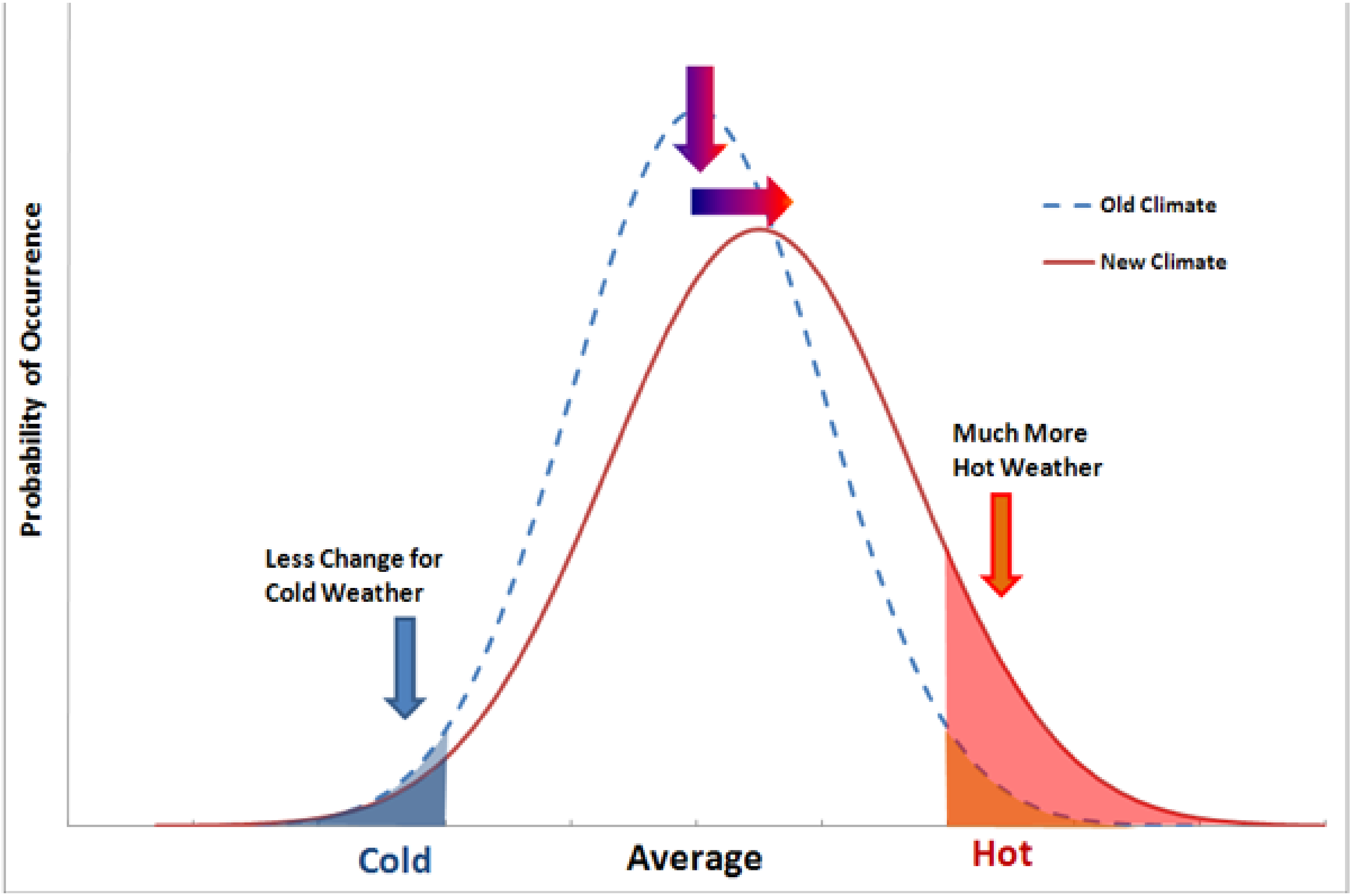
Change in amount of precipitation falling in heaviest 1% of all daily events, 1901-2012



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

What Does It All Mean?

Extreme Weather Affects Transportation and Materials

Extreme Weather	Impacts
Extreme Heat	• Asphalt softening and rutting, cracking, pavement blow-ups
Increased Freeze Thaw Conditions	• Frost heaves, potholes
Permafrost Thaw	• Foundation settlement, increased slope instability, landslides, shoreline erosion
Heavy or Extended-duration Precipitation Events	• Increased risk of landslides, slope failures, floods, and road washouts • Higher soil moisture levels, affecting structural integrity of infrastructure • Degradation of road base, pavement strength loss from standing water • Increase in bridge scour from increased streamflow

Extreme Weather Affects Transportation and Materials (continued)

Extreme Weather	Impacts
Drought	• Subsurface soil contraction, pavement damage, longitudinal cracking (in areas with expansive soils)
Storm Surge/Sea Level Rise	• Saltwater encroachment, materials degradation • Subsidence/heave of road embankments

Source: City of Austin

Extreme Weather and Materials

- Lots of materials assumptions rest on climate/weather
  - Asphalt grading
  - Soil saturation, fluid and mechanical stability
  - Soil stability
  - Time-dependent properties (e.g., thermal expansion and contraction)
- Do those assumptions still hold?

Case Study: Pavement Mix Design in Mobile, AL

Extreme Minimum Pavement Temperature (°C)	Seven-Day Maximum Pavement Temperature (°C)					
	46 (114.8°F)	52 (125.6°F)	58 (136.4°F)	64 (147.2°F)	70 (158°F)	76 (168.8°F)
-40 (-40°F)	PG 46-40	PG 52-40	PG 58-40	PG 64-40	PG 70-40	PG 76-40
-34 (-29.2°F)	PG 46-34	PG 52-34	PG 58-34	PG 64-34	PG 70-34	PG 76-34
-28 (-18.4°F)	PG 46-28	PG 52-28	PG 58-28	PG 60-28	PG 70-28	PG 76-28
-22 (-7.6°F)	PG 46-22	PG 52-22	PG 58-22	PG 64-22	PG 70-22	PG 76-22
-16 (3.2°F)	PG 46-16	PG 52-16	PG 58-16	PG 64-16	PG 70-16	PG 76-16
-10 (14°F)	PG 46-10	PG 52-10	PG 58-10	PG 64-10	PG 70-10	PG 76-10

historical

future

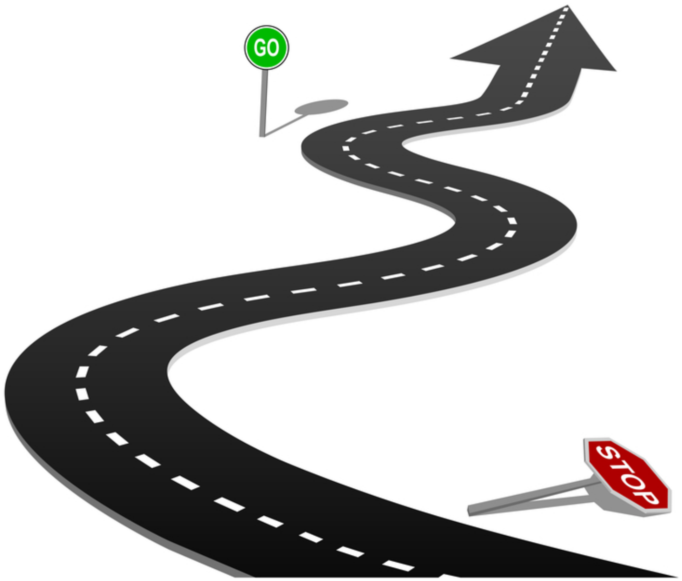
Source: U.S. DOT, 2014, Engineering Analysis and Assessment Case Studies (Gulf Coast Study, Phase 2, Task 3.2)

How Can the Materials Community Prepare for Extreme Weather Trends?

- Materials are a key component of the solution
- The right materials and/or installation techniques can help prevent weather impacts
  - Erosion-resistant aggregate blends
  - Erodible fills near high value structures
  - Novel anti-icing strategies
  - “Smart” pavements
  - Sustainable materials and technologies

Where Do We Go from Here?

- **Continue to understand the problem**
  - Improve monitoring and tracking of weather variables and their effects on materials
  - Identify and review climate and weather-related assumptions
  - Increase coordination between maintenance crews and engineers
- **Learn from each other**
  - Peer learning from states whose “normal” climate is your “new normal”?
  - Change materials where appropriate
- **Identify areas for further research**



Q&A

Thank you!

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