U.S. Billion-dollar Weather and Climate Disasters

Better understanding costs, spatial distribution and estimate uncertainty

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NOAA National Centers for Environmental Information (NCEI)

Center for Weather and Climate

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U.S. Billion-dollar Weather and Climate Disasters

Outline:

- Different Ways to Measure Disaster Impact
- U.S. Data Sources / What we are Measuring
- Disaster Cost Comparison & Mapping
- Monte Carlo Simulation of Cost Uncertainty
- Future Research

Different Ways to Measure Disaster Impact

Disasters


Tornadoes


Wildfires


Floods


Droughts


Heat waves


Snowstorms/ Blizzards


Geophysical


Hurricanes & Tropical Storms

Impacts

Human Health and Wellbeing

Business

Public Infrastructure

Private Property

Environmental Capital (incl. ecosystem services)

What's the right
- Time scale?
- Space scale?
- Size scale?

Measures

Loss of Life

Mental Health

Physical Health

Quality of Life

GDP

Net Economic

Market

Non-market

To capture losses requires a broad array of **public** and **private** data

Disaster Types		Hurricanes/ Tropical Storms	Severe Local Storms	Winter Storms	Crop Freeze	Wildfire	Drought / Heat Wave	Inland / Riverine Flooding
Primary data used in assessments	ISO/Property Claim Service	x	x	x		x		
	FEMA (PDD)	x	x	x	x	x		x
	FEMA (NFIP)	x						x
	USDA/RMA	x	x	x	x	x	x	x
Supplemental data used in assessments	NIFC					x		
	EIA	x	x	x		x	x	
	USACE							x
	State Agencies	x	x	x	x	x	x	x

We seek to account for <u>total, direct losses</u> (i.e., **insured** and **uninsured)** for assets including:

- **physical damage** to **residential, commercial** and **government buildings**,
- **material assets** (content) within a building,
- **time element losses** (i.e., time-cost for businesses; hotel-costs for loss of living quarters)
- **vehicles, boats, offshore energy platforms,**
- **public infrastructure** (i.e., roads, bridges, buildings) and
- **agricultural assets** (i.e., crops, livestock, timber).
- Does not take into account: natural capital losses; healthcare-related costs; value ($) associated with loss of life

What we find: From 1980-2015, the U.S. has experienced **188** distinct billion-dollar weather & climate events - each causing at least $1 billion in direct losses

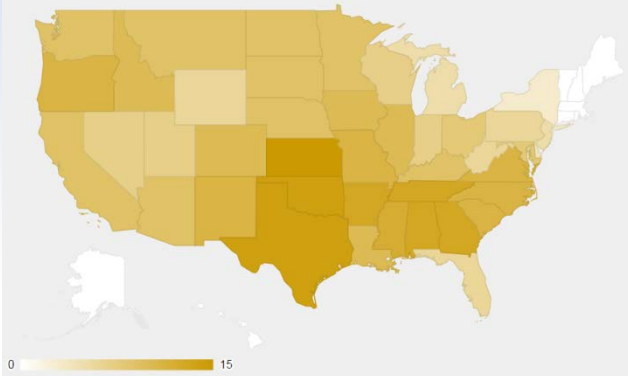
- The total, direct losses from these 188 events **> $1 trillion** (CPI-adjusted to present)

DISASTER TYPE	NUMBER OF EVENTS	PERCENT FREQUENCY	CPI-ADJUSTED LOSSES *(BILLIONS OF DOLLARS)*	PERCENT OF TOTAL LOSSES	AVERAGE EVENT COST *(BILLIONS OF DOLLARS)*
Drought	22	12.4%	$213.2 CI	19.5%	$9.7
Flooding	20	11.2%	$89.2 CI	8.2%	$4.5
Freeze	7	3.9%	$25.1 CI	2.3%	$3.6
Severe Storm	70	39.3%	$156.3 CI	14.3%	$2.2
Tropical Cyclone	34	19.1%	$544.5 CI	49.8%	$16.0
Wildfire	12	6.7%	$27.8 CI	2.5%	$2.3
Winter Storm	13	7.3%	$37.7 CI	3.4%	$2.9

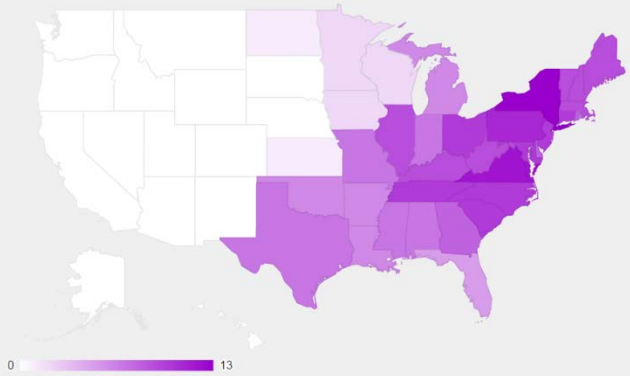
The Nation is weather and climate conscious…for good reason

- 188 distinct U.S. Billion-dollar weather and climate disasters: 1980-2015*

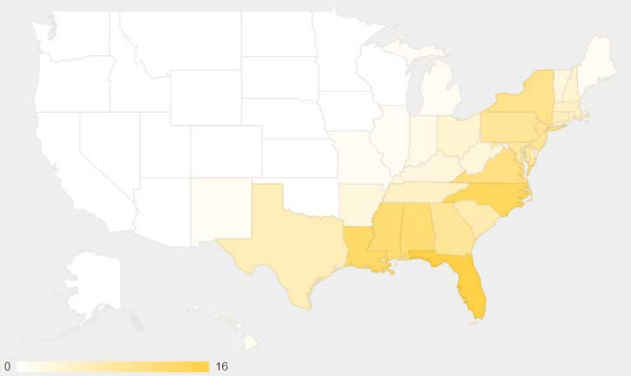
Droughts and Heat Waves



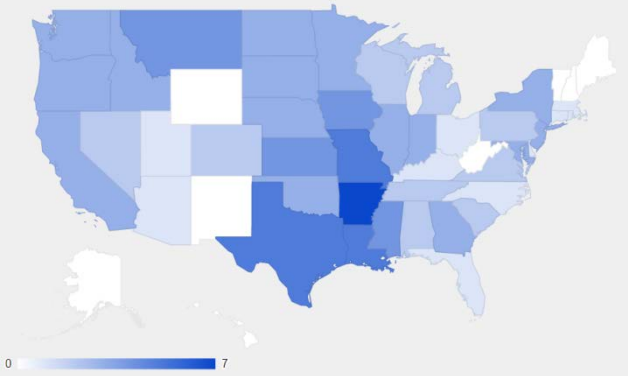
Winter Storms



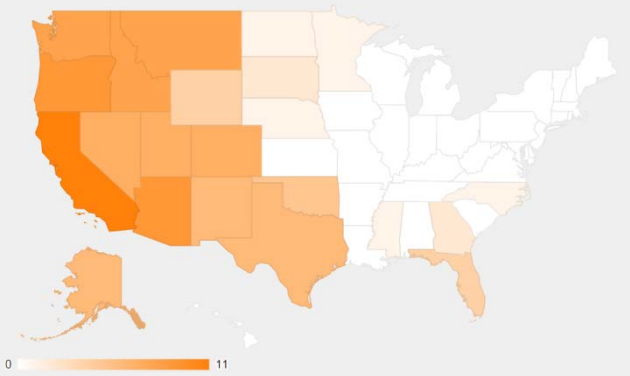
Tropical Cyclones



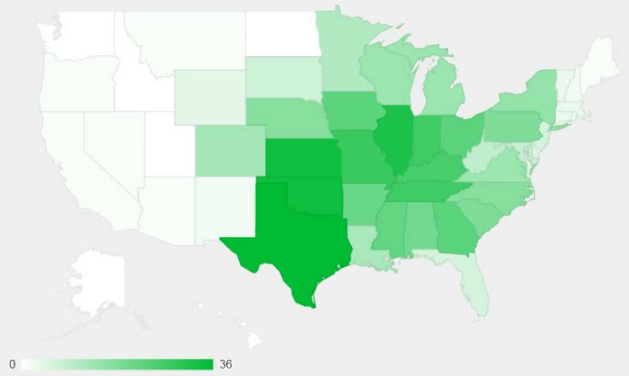
Flooding



Wildfires



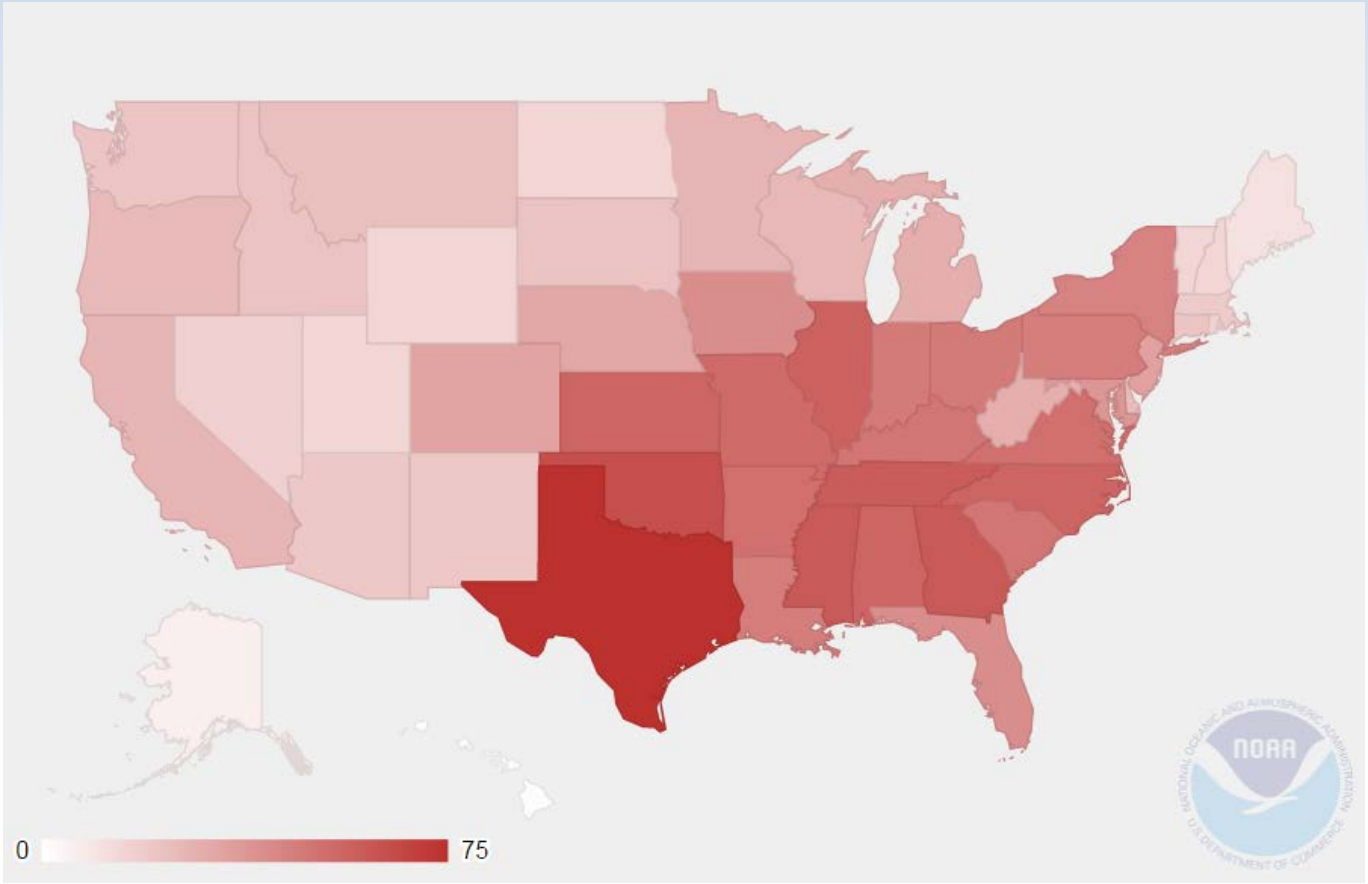
Severe Local Storms



*188 weather and climate disasters reached or exceeded $1 billion during this period (CPI-adjusted)

Please note that the map reflects a summation of billion-dollar events for each state affected (i.e., it does not mean that each state shown suffered at least $1 billion in losses for each event).

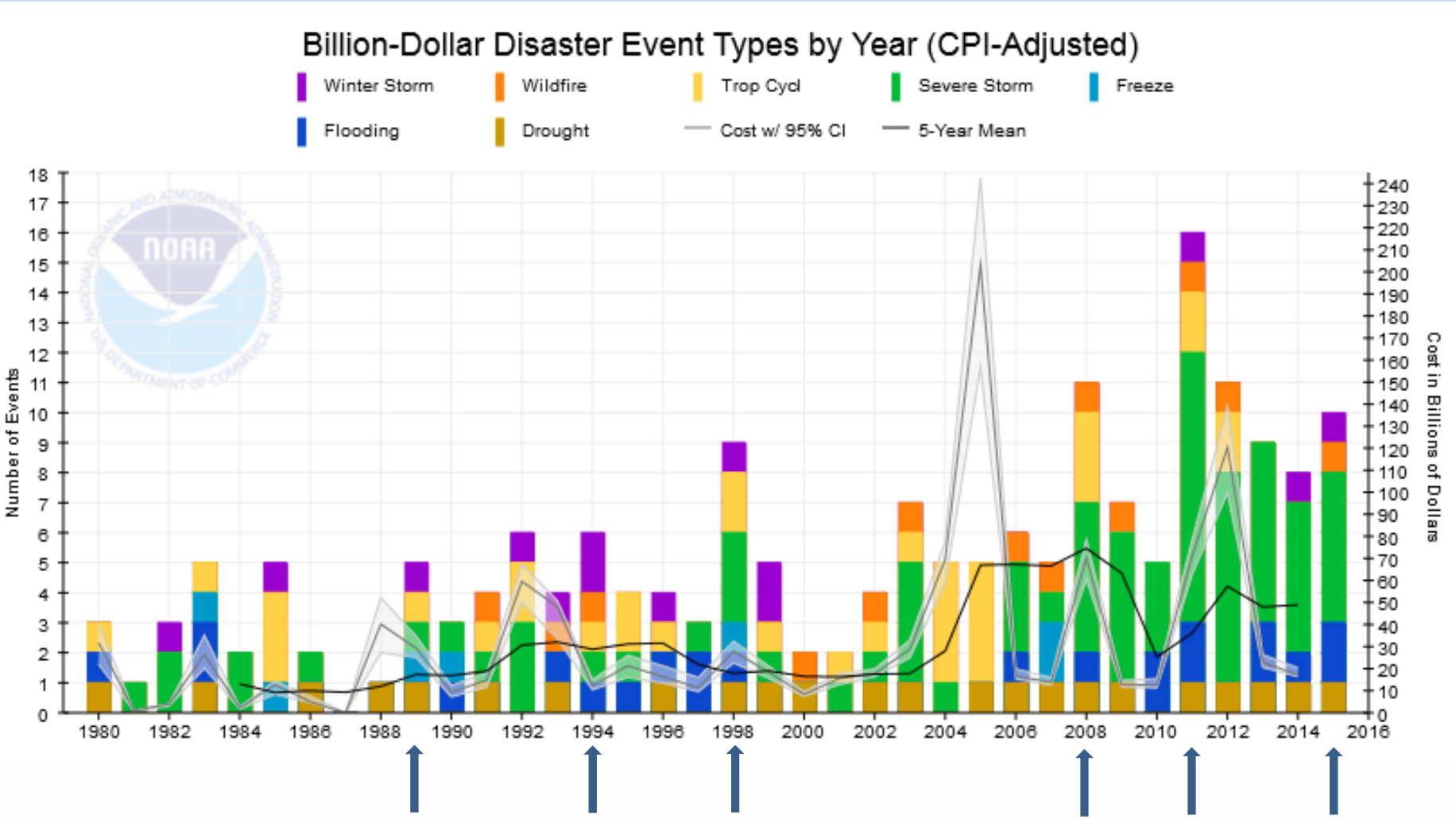
From 1980–2015, the U.S. **South/Central** and **Southeast** regions experienced a higher frequency of billion-dollar disaster events than any other region



- 188 weather and climate disasters reached or exceeded $1 billion during this period (CPI-adjusted)

Please note that the map reflects a summation of billion-dollar events for each state affected (i.e., it does not mean that each state shown suffered at least $1 billion in losses for each event).

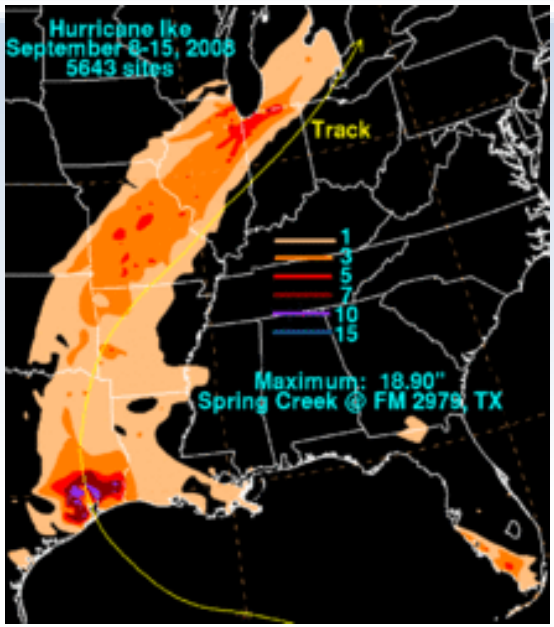
U.S. Billion-dollar event frequency, annual cost and 5-year cost average (1980–2015)



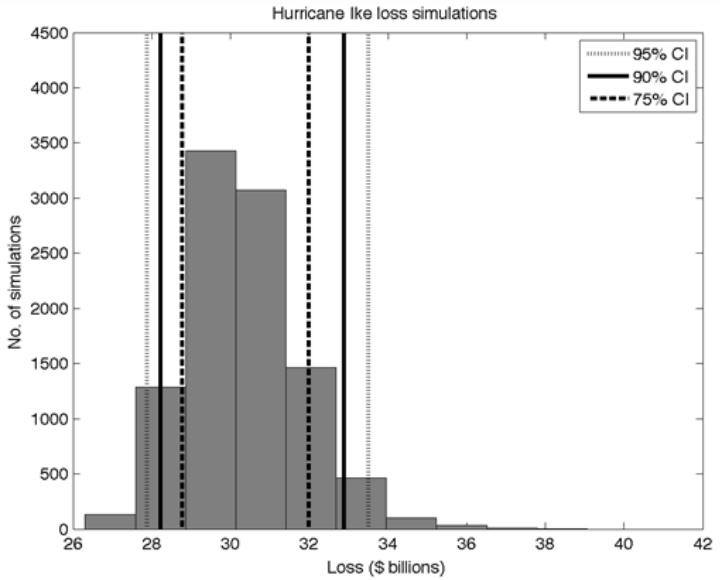
- In 2015, the U.S. experienced five distinct B$D disaster event types; ≥ 5 event types occurs infrequently

Latest research: Monte Carlo simulations to assess event cost uncertainty / confidence intervals

	PCS Comm. ($ million)	PCS Residential ($ million)	PCS Auto. ($ million)	FEMA PDD ($ million)	FEMA NFIP ($ million)
Alabama	-	-	-	13.1	1.7
Arkansas	12.5	35.0	8.5	2.5	-
Illinois	50.0	150.0	40.0	108.0	54.3
Indiana	80.0	230.0	20.0	93.0	32.3
Kentucky	110.0	405.0	18.0	18.9	-
Louisiana	50.0	50.0	35.0	263.0	321.0
Missouri	16.0	50.0	10.0	-	42.5
Ohio	255.0	960.0	40.0	39.6	-
Penn.	8.0	63.0	4.0	-	-
Texas	4000.0	5500.0	300.0	2464.0	2185.9
Other losses:					
Offshore rigs, platforms	3000.0				
Agriculture & Forestry	825.0				



	3% Normal	3% Uniform	5% Normal	5% Uniform
Minimum	26,539	26,669	26,308	26,518
Maximum	40,922	35,468	39,065	35,571
Mean	30,356	30,451	30,334	30,445
Median	30,233	30,382	30,191	30,355
75% CI	28,808 31,974	28,592 32,368	28,772 31,995	28,518 32,435
90% CI	28,311 32,903	28,003 33,205	28,232 32,883	27,963 33,327
95% CI	27,998 33,661	27,720 33,668	27,886 33,508	27,634 33,802



Source: Smith and Matthews, 2015: Quantifying Uncertainty and Variable Sensitivity within the U.S. Billion-dollar Weather and Climate Disaster Cost Estimates

Case 3 results: 5% perturbation on values, parameters normally distributed

For more detail on data, methodology and uncertainty, see:

- Smith and Matthews, 2015: Quantifying Uncertainty and Variable Sensitivity within the U.S. Billion-dollar Weather and Climate Disaster Cost Estimates. *Natural Hazards*, 77, 1829-1851 (https://www.ncdc.noaa.gov/billions/docs/smith-and-matthews-2015.pdf)

- Smith, A.B. and R. Katz, 2013: U.S. Billion-dollar weather and climate disasters: Data sources, trends, accuracy and biases. *Natural Hazards*, 67, 387–410 (https://www.ncdc.noaa.gov/billions/docs/smith-and-katz-2013.pdf)

Future research & analysis efforts:

Allocation of disaster event final cost share by category…

- households, businesses, insurers, state and Federal government, non-profit disaster relief, etc.
- compare disaster categories, geographic regions, etc.

For More Information

NOAA's National Centers for Environmental Information:

www.ncei.noaa.gov

- U.S. Billion Dollar Disasters: www.ncdc.noaa.gov/billions/

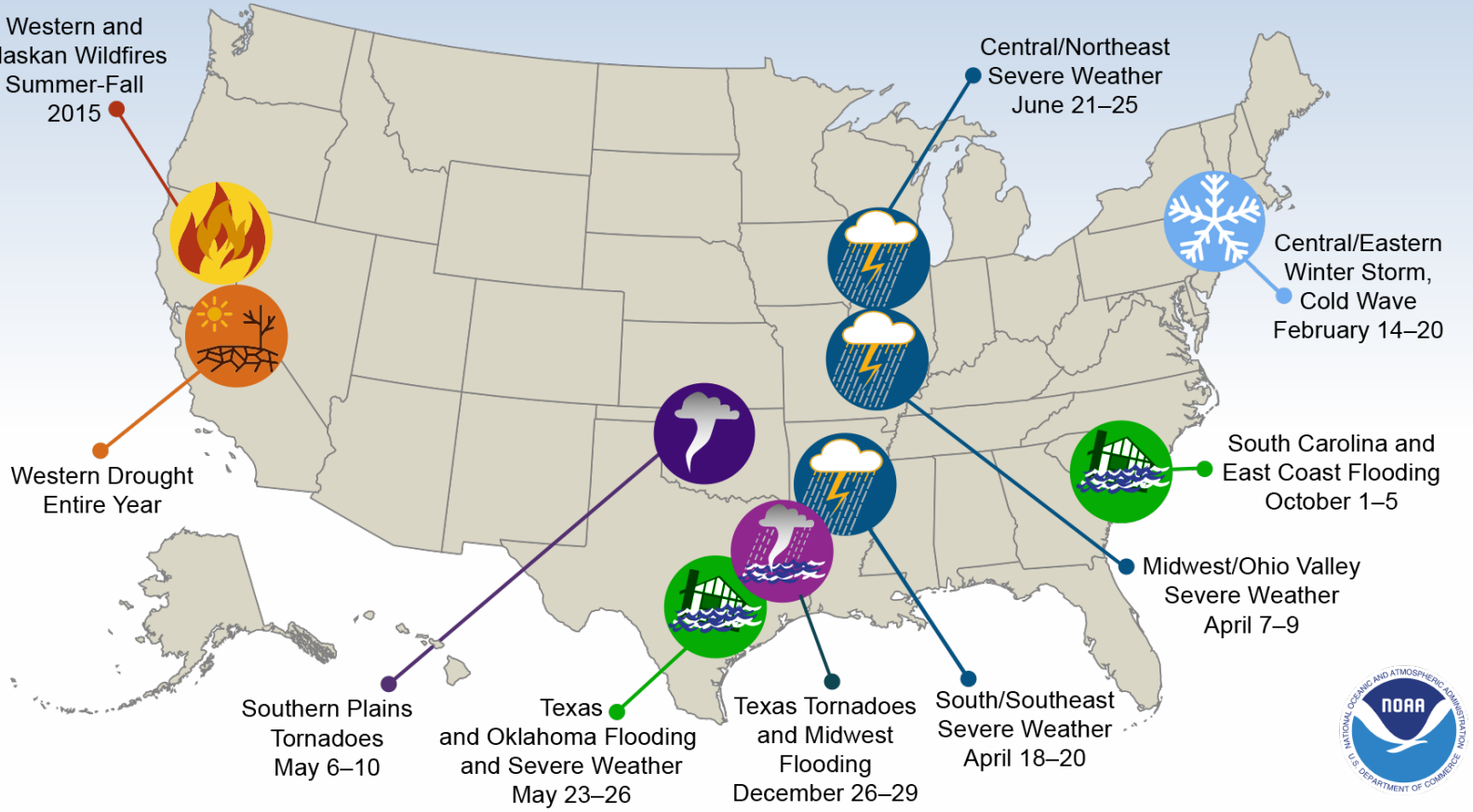
NOAA Contact:

Adam.Smith@noaa.gov, **828-271-4183**

(National Centers for Environmental Information - Center for Weather and Climate)

Backup slides (more detail)

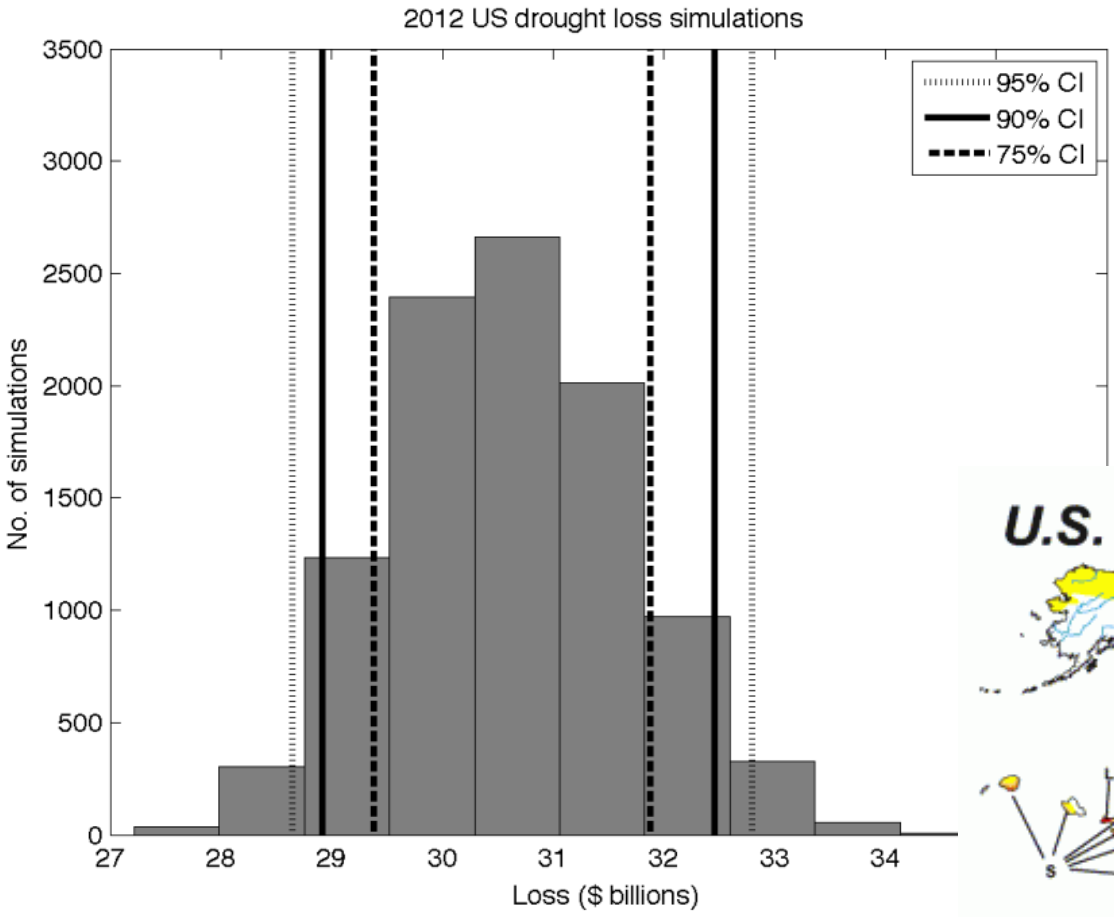
2015: U.S. Billion-Dollar Weather and Climate Disasters

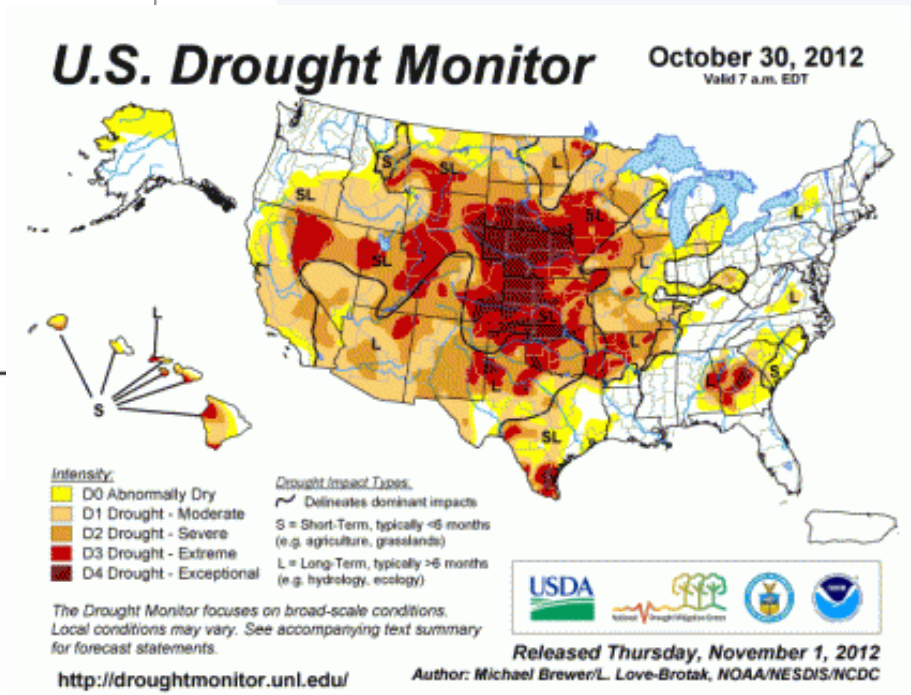


This map denotes the approximate location for each of the 10 billion-dollar weather and climate disasters that impacted the United States during 2015.

- In 2015, there were 10 weather and climate disaster events with losses exceeding $1 billion each across the United States
- These events include a drought event, 2 flooding events, 5 severe storm events, a wildfire event, and a winter storm event

	ISO/PCS	FEMA (state/local disaster assistance)	FEMA (NFIP)	USDA	Army Corps	NIFC	State Agencies
Data	Provided: Residential, - Commercial property - Business interruption, - Vehicles (insured w/ comprehensive cover) -Boats, Inland marine -Demand surge Not provided: Agriculture, Flooding, Aviation, Ocean Marine, Loss above limits	Provided: Government disaster assistance, debris removal, financial aid Public Assistance, Housing Assistance, Individual Assistance, Small Business loan Assistance	Provided: Insured flood loss for residential and commercial properties	Provided: Insured multi-peril crop/livestock insurance payouts, crop progress and quality reports market value of crop production	Provided: Annual flood event summaries and major flood event reports that detail levee damage, other damages	Provided: Wildfire losses to structures; commercial timber; wildfire suppression costs, deaths; acreage burned	Provided: Total estimated crop losses Surveyed % of properties with multi-peril and flood insurance
Temporal Period	1949- present	1964-present (state) 1989-present (county)	1968-present	1948-present (state) 1989-present (county)	1983-present	1960-present	By specific disaster
Spatial Resolution	State-level	State-level County-level	State-level	State-level County-level	River-basin, State-level	Region, State, county	State-level
Update Lag Time	Weeks to months	Weeks to months	Several months	Weekly, monthly, Annual (depending on data product)	Annual report	Days to weeks	Several months
Data Sources	Surveys of insurers, market share analysis, air/ground damage surveys, interviews, etc.	State and local disaster needs / grants	Flood insurance payouts	Farmer and field surveys; data from partner insurance companies	Floodplain, household and business surveys	Fields reporting, state and local fire authorities	Local and State farm reporting to USDA; city / state damage assessment
Changes in Recording Threshold	$1 M (1949-1981) $5 M (Jan. 1982-1997) $20 M (Jan. 1997-present)	County/per capita indicators adjusted each fiscal year to reflect changes in CPI. Assists in FEMA's evaluation of disaster impact at county-scale (e.g., $2.83,	Single-family dwelling limits: 1977-1994 Structure$150k Content:$50k 1994-2009 Structure$250k Content:$100k	Many programs (e.g., SURE, NAP,LIP) offer assistance from 50% -85% Major crop insurance policy revision in 1994		Stats after 1983 were compiled by states and agencies. Stats before 1983 undergoing reanalysis	


2012 US drought loss simulations
95% CI
90% CI
75% CI
No. of simulations
Loss ($ billions)
0
500
1000
1500
2000
2500
3000
3500
27
28
29
30
31
32
33
34


U.S. Drought Monitor
October 30, 2012
Valid 7 a.m. EDT
Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional
Drought Impact Types:
Delineates dominant impacts
S = Short-Term, typically <6 months (e.g. agriculture, grasslands)
L = Long-Term, typically >6 months (e.g. hydrology, ecology)
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.
http://droughtmonitor.unl.edu/
USDA
Released Thursday, November 1, 2012
Author: Michael Brewer/L. Love-Brotak, NOAA/NESDIS/NCDC

2015: U.S. Billion-Dollar Weather and Climate Disasters summaries:

Western Drought - *2015*: Drought conditions were present across numerous western states (CA, NV, OR, WA, ID, MT, UT, AZ) with the most severe conditions continuing to plague California for all of 2015. The agriculture sector was again impacted by a lack of rainfall resulting in hundreds of thousands of acres of farmland remaining fallow and requiring excess groundwater pumping to irrigate existing agriculture interests. Wildfire conditions were further enhanced by the ongoing drought. California experienced extensive damage from both drought and wildfire impacts. Drought conditions did improve dramatically across Texas and Oklahoma, in the form of several major flood events. *Total Estimated Costs:* ≥$1[1]; 0 Deaths

Texas Tornadoes and Midwest Flooding - *December 2015*: A powerful storm system packing unseasonably strong tornadoes caused widespread destruction in the Dallas metropolitan region, damaging well over 1,000 homes and businesses. This same potent system also produced intense rainfall over several Midwestern states triggering historic flooding that has approached or broken records at river gauges in several states (MO, IL, AR, TN, MS, LA). The flooding has overtopped levees and caused damage in numerous areas. This historic storm also produced high wind, snow and ice impacts from New Mexico through the Midwest and into New England. Overall, the storm caused at least 50 deaths from the combined impact of tornadoes, flooding and winter weather. *Total Estimated Costs:* ≥$1[1]; 50 Deaths

Western and Alaskan Wildfires - *Summer-Fall 2015*: Wildfires burned over 9.9 million acres across the U.S. in 2015, surpassing 2006 for the highest annual total of U.S. acreage burned since record-keeping began in 1960. The most costly wildfires occurred in California where over 2,500 structures were destroyed due to the Valley and Butte wildfires with the insured losses alone exceeding $1.0 billion. The most extensive wildfires occurred in Alaska where over 5 million acres burned within the state. There was extensive burnt acreage across other western states, most notably (OR, WA, ID, MT, ND, CO, WY, TX). *Total Estimated Costs:* ≥$1[1]; 12 Deaths

South Carolina and East Coast Flooding - *October 2015*: Historic levels of flooding impacted South Carolina causing widespread damage to many homes, businesses, public buildings and infrastructure. This interrupted commerce and closed major transportation corridors (such as I-95) for weeks as rivers slowly receded. Locally extreme rainfall totals exceeding 20-inches were common resulting from the convergence of a powerful low pressure system / frontal boundary and copious moisture from Hurricane Joaquin in the Atlantic. *Total Estimated Costs:* ≥$1[1]; 25 Deaths

Central and Northeast Severe Weather - *June 2015*: Severe storms across numerous Central and Northeast states (CO, CT, IA, IL, MD, MI, NJ, NY, PA, SD, VA, WI) with widespread hail and high wind damage. *Total Estimated Costs:* ≥$1[1]; 1 Death

Texas and Oklahoma Flooding and Severe Weather - *May 2015*: A slow-moving system caused tremendous rainfall and subsequent flooding to occur in Texas and Oklahoma. The Blanco river in Texas swelled from 5 feet to a crest of more than 40 feet over several hours causing considerable property damage and loss of life. The city of Houston also experienced flooding which resulted in hundreds of high-water rescues. The damage in Texas alone exceeded $1.0 billion. There was also damage in other states (KS, CO, AR, OH, LA, GA, SC) from associated severe storms. *Total Estimated Costs:* ≥$1[1]; 31 Deaths

Southern Plains Tornadoes - *May 2015*: Tornado outbreak across the Southern Plain states (IA, KS, NE, OK, CO, SD, TX) with 122 tornadoes. The most costly damage occurred across Texas and Oklahoma. *Total Estimated Costs:* ≥$1[1]; 4 Deaths

South/Southeast Severe Weather - *April 2015*: Severe storms across the South and Southeastern states (AL, AR, FL, GA, KS, LA, MS, NC, OK, SC, TN, TX). High winds and severe hail created the most significant damage in Texas. *Total Estimated Costs:* ≥$1[1]; 0 Deaths

Midwest/Ohio Valley Severe Weather - *April 2015*: Severe storms across the Midwest and Ohio Valley including the states (AR, IA, IL, IN, KS, KY, MI, MO, NC, OH, OK, PA, TN, TX, WI, WV). Large hail and high winds created the most damage across Missouri and Illinois. *Total Estimated Costs:* ≥$1[1]; 2 Deaths

Central and Eastern Winter storm, Cold Wave - *February 2015*: A large winter storm and associated cold wave impacted many central, eastern and northeastern states (CT, DE, GA, IL, KY, MA, MD, ME, MI, NC, NH, NJ, NY, OH, PA, RI, SC, TN, VA). The city of Boston was particularly impacted as feet of snow continued to accumulate causing load-stress on buildings and clogging transportation corridors. Total, direct losses in Massachusetts alone exceed $1.0 billion for this event, with considerable damage in many other states. *Total Estimated Costs:* ≥$1[1]; 30 Deaths

[1] Further cost figures on individual events in 2015 will be updated when data are finalized.

Methodological equations (by event type):

Severe/winter storm

$$TOTAL\ LOSS = \sum_{i=\ all\ states} \left[m_{i,PCS_{comm}} v_{i,PCS_{comm}} + m_{i,PCS_{res}} v_{i,PCS_{res}} + m_{i,PCS_{auto}} v_{i,PCS_{auto}} + m_{i,FEMA_{NFIP}} v_{i,FEMA_{NFIP}} + v_{i,FEMA_{PDD}} * \left(v_{i,FEMA_{PDD}} > m_{i,PCS_{total}} v_{i,PCS_{total}} \right) + v_{i,state} + v_{i,USDA} + v_{i,other} \right]$$

where

$m_{i,PCS_{comm}}$ is the multiplier for commercial PCS

$m_{i,PCS_{res}}$ is the multiplier for residential PCS

$m_{i,PCS_{auto}}$ is the multiplier for automotive PCS

$m_{i,FEMA_{NFIP}}$ is the multiplier for FEMA NFIP

and these multipliers are defined as:

$$\text{Multiplier} = \frac{100}{insurance\ participation\ rate}.$$

Tropical cyclone

$$TOTAL\ LOSS = \sum_{i=\ all\ states} \left[m_{i,PCS_{comm}} v_{i,PCS_{comm}} + m_{i,PCS_{res}} v_{i,PCS_{res}} + m_{i,PCS_{auto}} v_{i,PCS_{auto}} + m_{i,FEMA_{NFIP}} v_{i,FEMA_{NFIP}} + v_{i,FEMA_{PDD}} * \left(v_{i,FEMA_{PDD}} > v_{i,PCS_{total}} \right) + v_{i,state} + v_{i,USDA} + v_{i,other} \right]$$

where

$v_{i,PCS\_total} = v_{i,PCS\_comm} + v_{i,PCS\_res} + v_{i,PCS\_auto}$ (NOTE: no multipliers involved)

$m_{i,PCS_{comm}}$ is the multiplier for commercial PCS

$m_{i,PCS_{res}}$ is the multiplier for residential PCS

$m_{i,PCS_{auto}}$ is the multiplier for automotive PCS

$m_{i,FEMA_{NFIP}}$ is the multiplier for FEMA NFIP

and

$$\text{Multiplier} = \frac{100}{insurance\ participation\ rate}$$

Non-tropical flooding

$$TOTAL\ LOSS = \sum_{i=\ all\ states} \left[m_{i,FEMA_{NFIP}} v_{i,FEMA_{NFIP}} + v_{i,FEMA_{PDD}} + v_{i,state} + v_{i,USDA} + v_{i,other} \right]$$

where

$m_{i,FEMA_{NFIP}}$ is the multiplier for FEMA NFIP

and

$$\text{Multiplier} = \frac{100}{insurance\ participation\ rate}$$

Drought/heatwaves

$$TOTAL = \sum_{i=\ all\ states} \left[m_i v_{i,cropInsPayout} + v_{i,incFeedCost} + v_{i,FEMA_{PDD}} + v_{i,state} + v_{i,USDA} + v_{i,other} \right]$$

where

$m_i = \frac{100}{p_{acres\_insured} * p_{crop_{yield_{cov}}}}$ and $p_{acres\_insured}$ is a perturbed value

Wildfire

$$TOTAL\ LOSS = \sum_{i=\ all\ states} \left[m_{i,PCS_{comm}} v_{i,PCS_{comm}} + m_{i,PCS_{res}} v_{i,PCS_{res}} + m_{i,PCS_{auto}} v_{i,PCS_{auto}} + v_{i,FEMA_{PDD}} * \left(v_{i,FEMA_{PDD}} > v_{i,PCS_{total}} \right) + v_{i,state} + v_{i,USDA} + v_{i,NFIC} + v_{i,other} \right]$$

where

$v_{i,PCS\_total} = v_{i,PCS\_comm} + v_{i,PCS\_res} + v_{i,PCS\_auto}$ (NOTE: no multipliers involved)

$m_{i,PCS_{comm}}$ is the multiplier for commercial PCS

$m_{i,PCS_{res}}$ is the multiplier for residential PCS

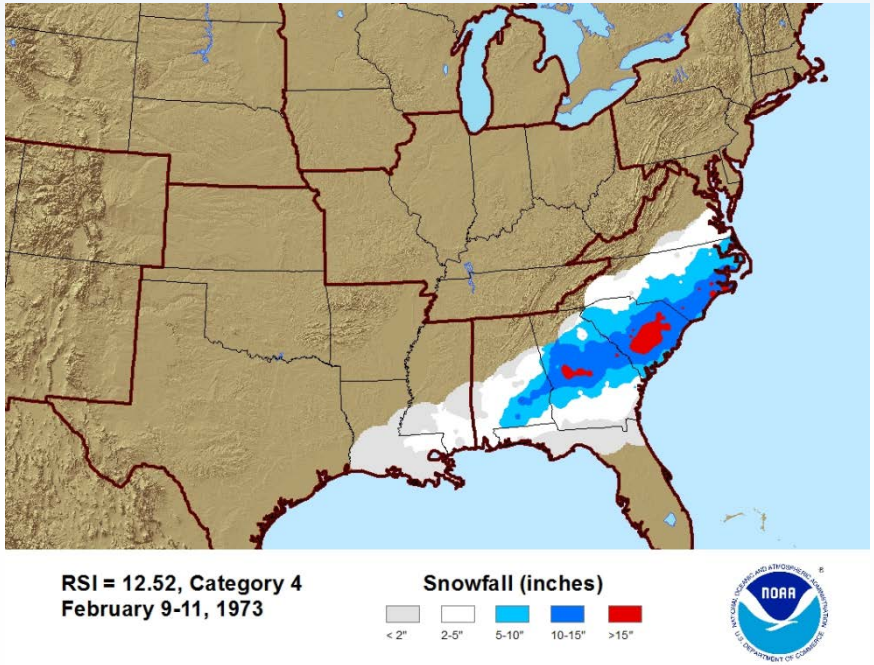
$m_{i,PCS_{auto}}$ is the multiplier for automotive PCS

and

$$\text{Multiplier} = \frac{100}{insurance\ participation\ rate}$$

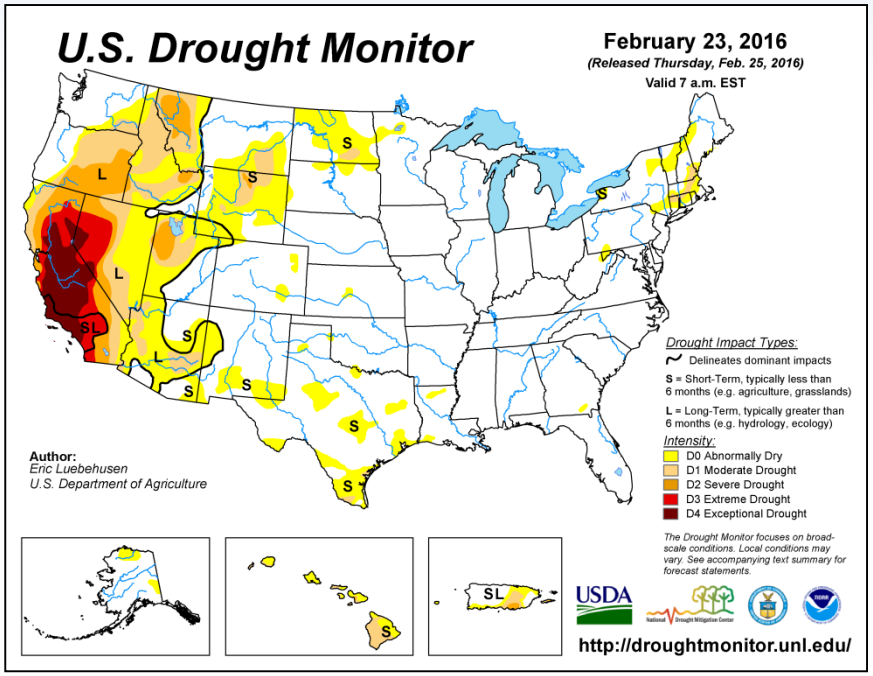
Snow Disaster Support (FEMA)

- FEMA uses NCEI historical snow information to adjudicate requests for snowfall disaster relief
- FEMA is actively supporting NCEI's effort to overhaul the historical snowfall database to:
  - Incorporate more historical National Weather Service data previously digitized from paper
  - Improve quality control of the underlying data
  - Utilize a larger and broader and cleaner set historical snowfall information
  - Provide a more effective snowfall data coordination point for Federal and State partners



US Drought Monitor & Drought.gov

- NCEI hosts www.drought.gov, the primary public face of the interagency National Integrated Drought Information System
  - NIDIS supports preparedness, mitigation, planning and response to drought across multiple jurisdictional scales
- Additionally, NCEI provides support for the weekly US Drought Monitor Assessment, upon which USDA bases billions of dollars drought relief decisions annually



NOAA Extreme Weather Information Sheets

- NOAA Extreme Weather Information Sheets provide residents with a "one-stop" ready reference containing phone numbers and Web site information residents can use during potentially life-threatening weather emergencies.
- Published each year for the Atlantic hurricane season, the NOAA Extreme Weather Information Sheets provide critical information for contacting government officials and monitoring information resources.

See: http://www.ncddc.noaa.gov/activities/weather-ready-nation/newis/