bms.

The Challenge Of Climate Change And CAT Events For The Insurance Industry

May 8th 2018

Agenda

- Review of extreme weather risk perception
- Objectively review weather/climate data relevant to insurance industry
  - Severe Thunderstorms
  - Wildfires
  - Named Storms
- Key meteorological/Insurance takeaways from 2017 catastrophe events

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Review of extreme weather risk perception

Weather / Climate Scales, Variability and Volatility

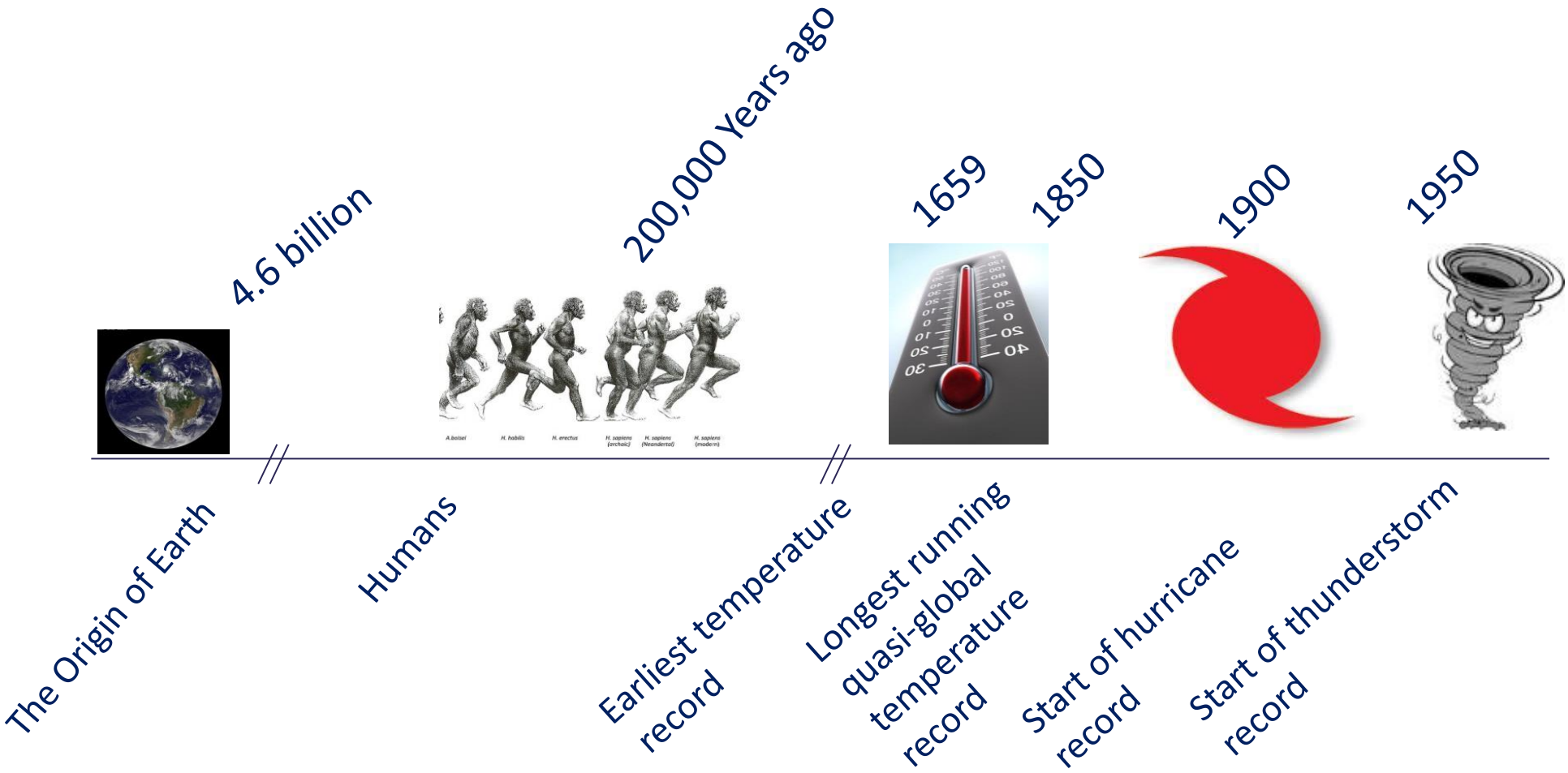
Question:

What is the first extreme weather event that you can remember that was tied to climate change?

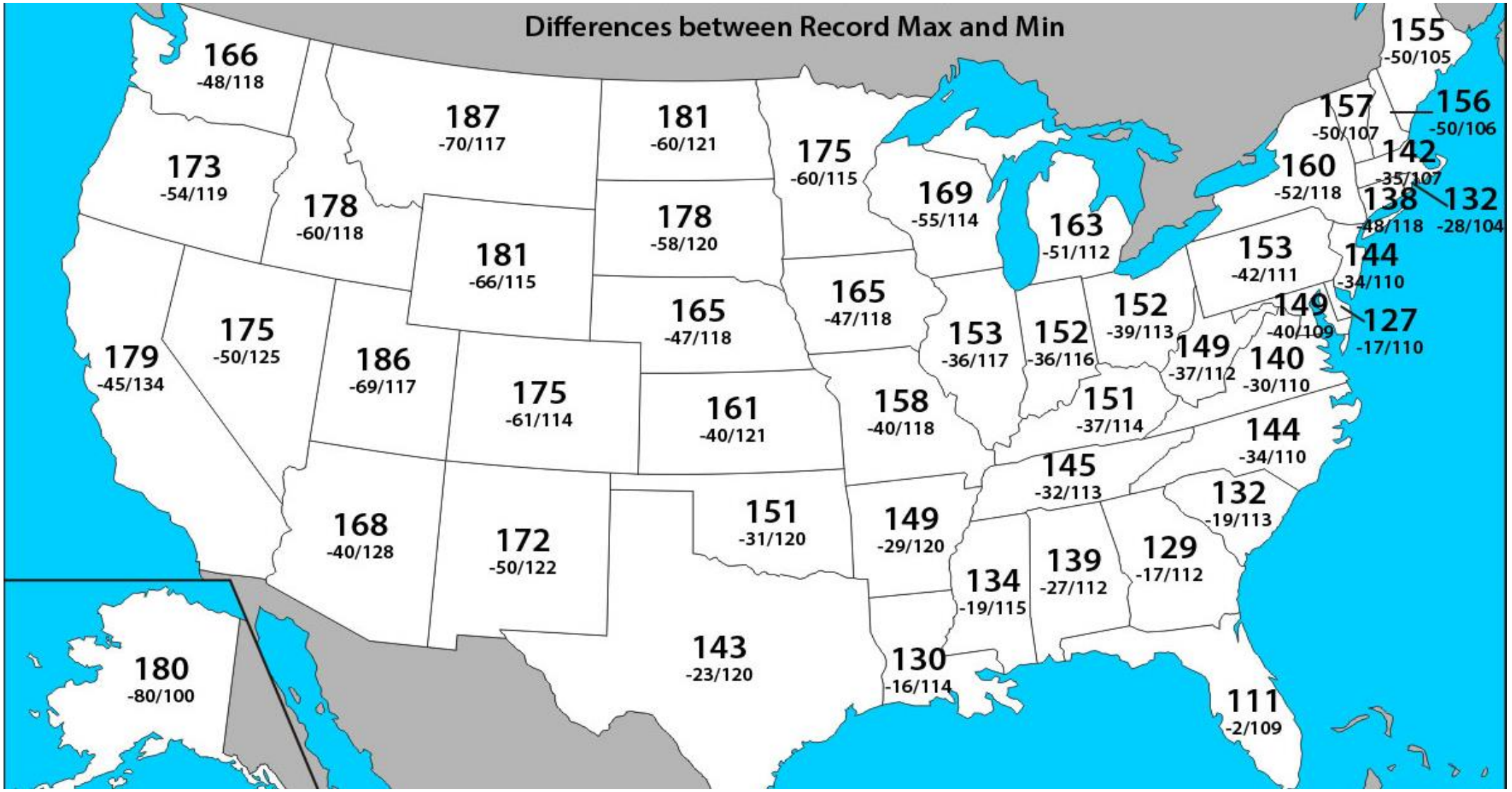
What year was that?

Time Scales of Weather/Climate Records

In the grand picture of time, we have a very short record of weather. Extreme weather requires very long return periods to properly understand the correct severity return period.



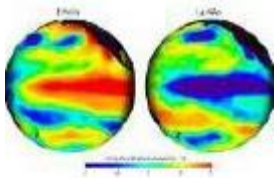
Weather Volatility



Complex Physical Problem

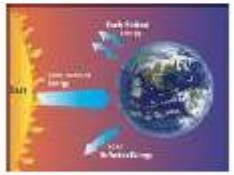
Changes in the atmosphere and/or ocean can trigger changes in the variability and overall state of the weather and climate locally in time and space.

Remote Forcing → **Changing Variability** → **Changing Risk**

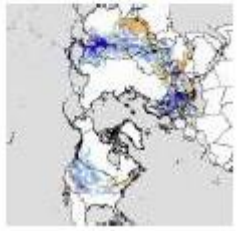


El Nino / La Nina

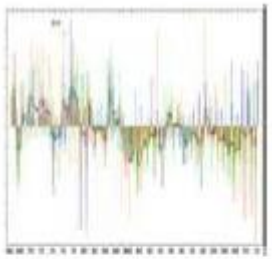
Sea Ice and Glaciers



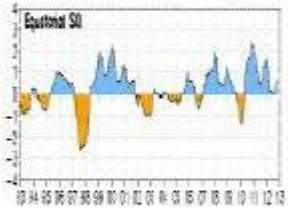
Solar Energy



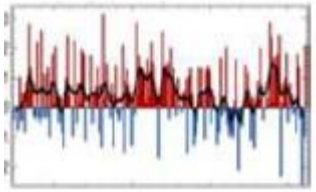
Snow Pack



Upper Air Temperatures



Sea Surface Temperatures



Surface Temperatures

Drought

Tropical Weather

Rainfall / Wind

Severe Storms

Important Timelines in Climate Change

1979: First World Climate Conference adopts climate change as major issue

1985: First major international conference on the greenhouse effect

1988: UN sets up the Intergovernmental Panel on Climate Change (IPCC)

1990: The first report of the IPCC finds that the planet has warmed by 0.5°C in the past century.

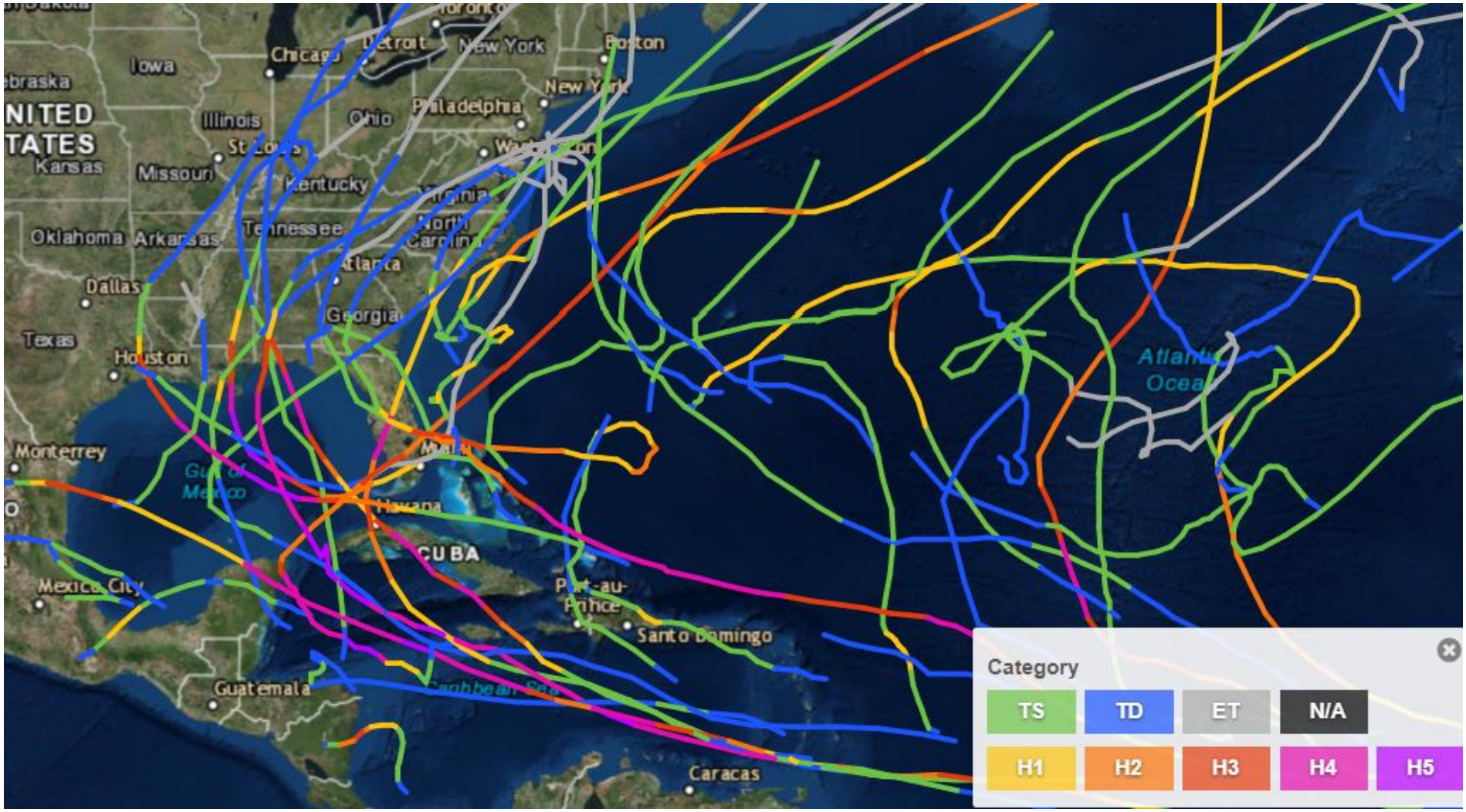
1992: Climate Change Convention, signed by 154 nations in Rio, agrees to prevent “dangerous” warming

1995: First full meeting of the Climate Change Convention

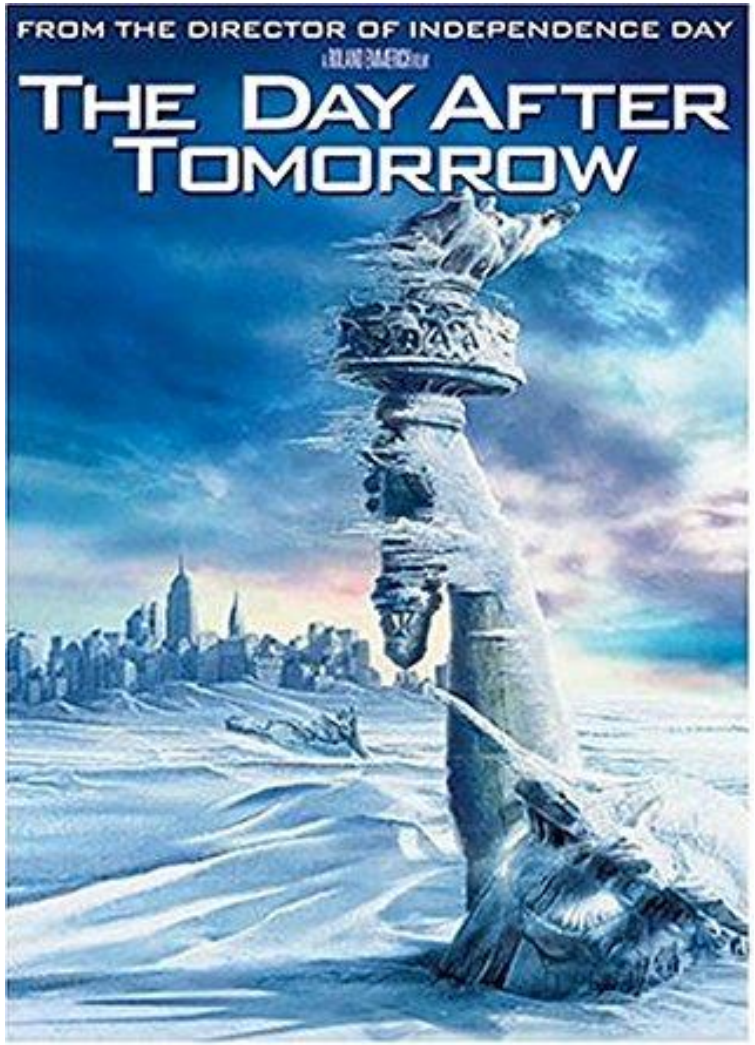
1997: Kyoto Protocol Meeting

2000: IPCC scientists re-assess likely future emissions. A series of major floods around the world raise concerns that global warming is raising the risk of extreme weather events.

Then 2004 and 2005 Hurricane Season



And Like Clock Work – Enter Media



Media Use of Extreme Weather

Weather in the News

Top 5 Network News Topics of 2015

Crime	52 hours / 17% news
Terrorism	39 hours / 13% news
Weather	33 hours / 11% news
Politics	32 hours / 11% news
Accidents/Disasters	32 hours / 10% news

Source: MRC analysis of ABC, CBS and NBC evening newscasts, 1/1 to 12/31, 2015.

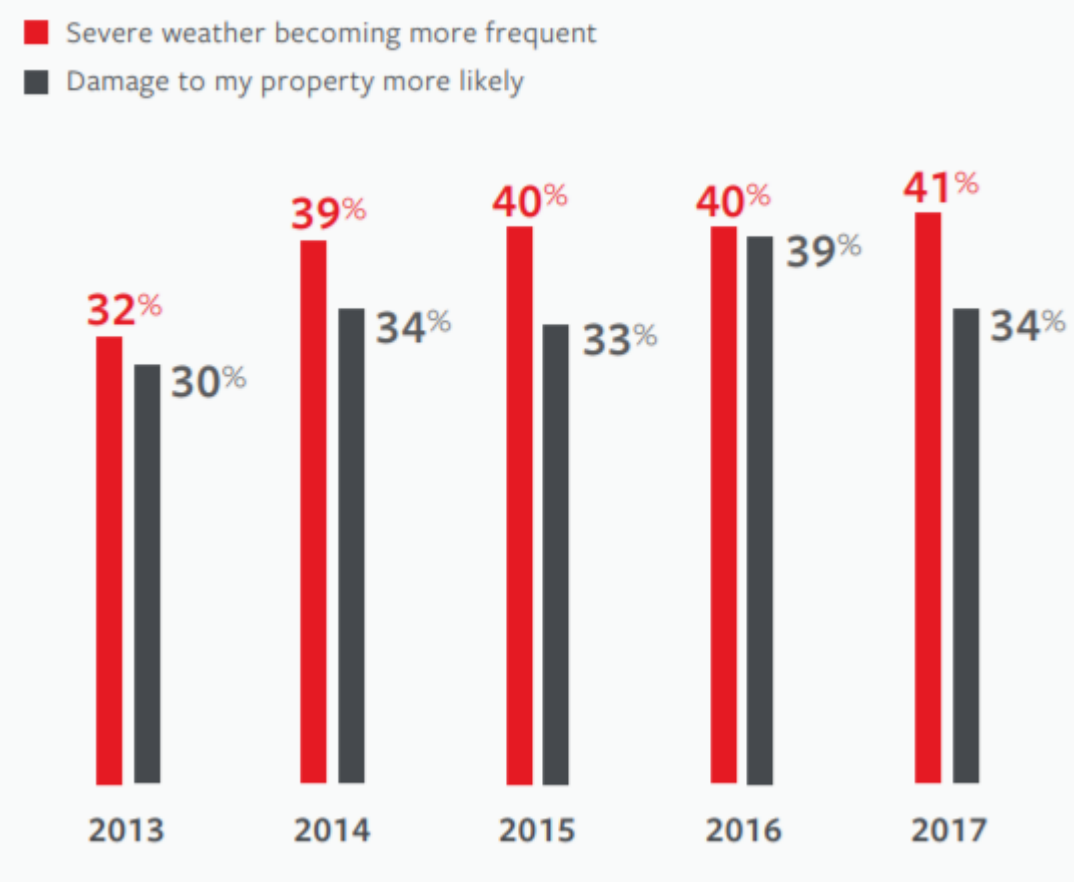
Top Weather Stories of 2015

133 minutes - summer wildfires in several western states
88 minutes - extensive flooding in Texas in May
67 minutes - California drought
60 minutes - Hurricane Joaquin
58 minutes - North and South Carolina Flooding

Overall, the networks spent 97 minutes of airtime in 2015 opining about climate change, including 17 minutes for the climate summit in Paris in December.

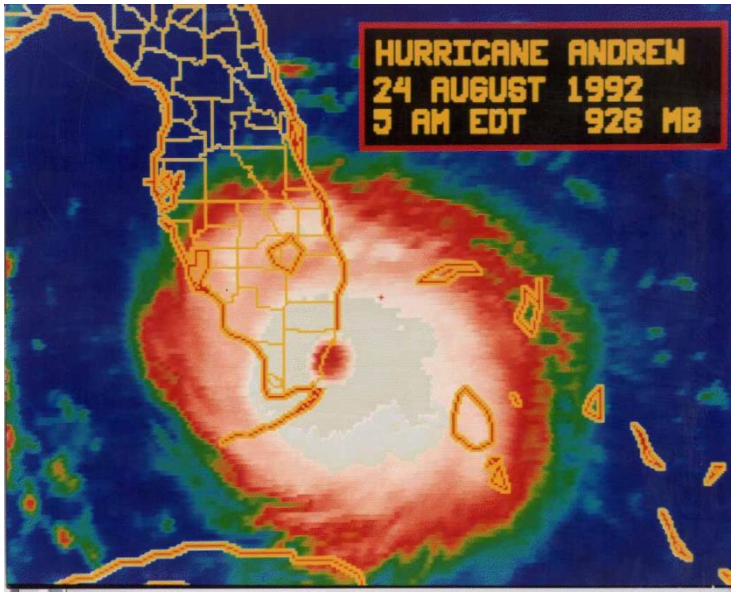
Annual Survey of the Risks – Travelers

Consumers' sense of changing weather patterns has deviated little since 2014, with 41% continuing to say that severe weather has increased in their area over the past few years, and 34% feeling a greater threat to their property.



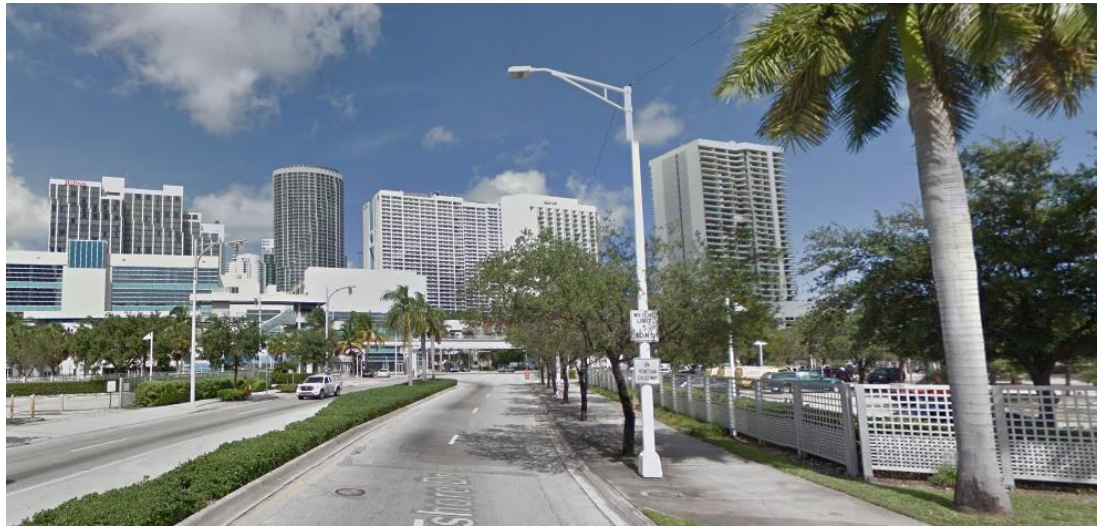
Source: Travelers

Weather Memory Is Generational



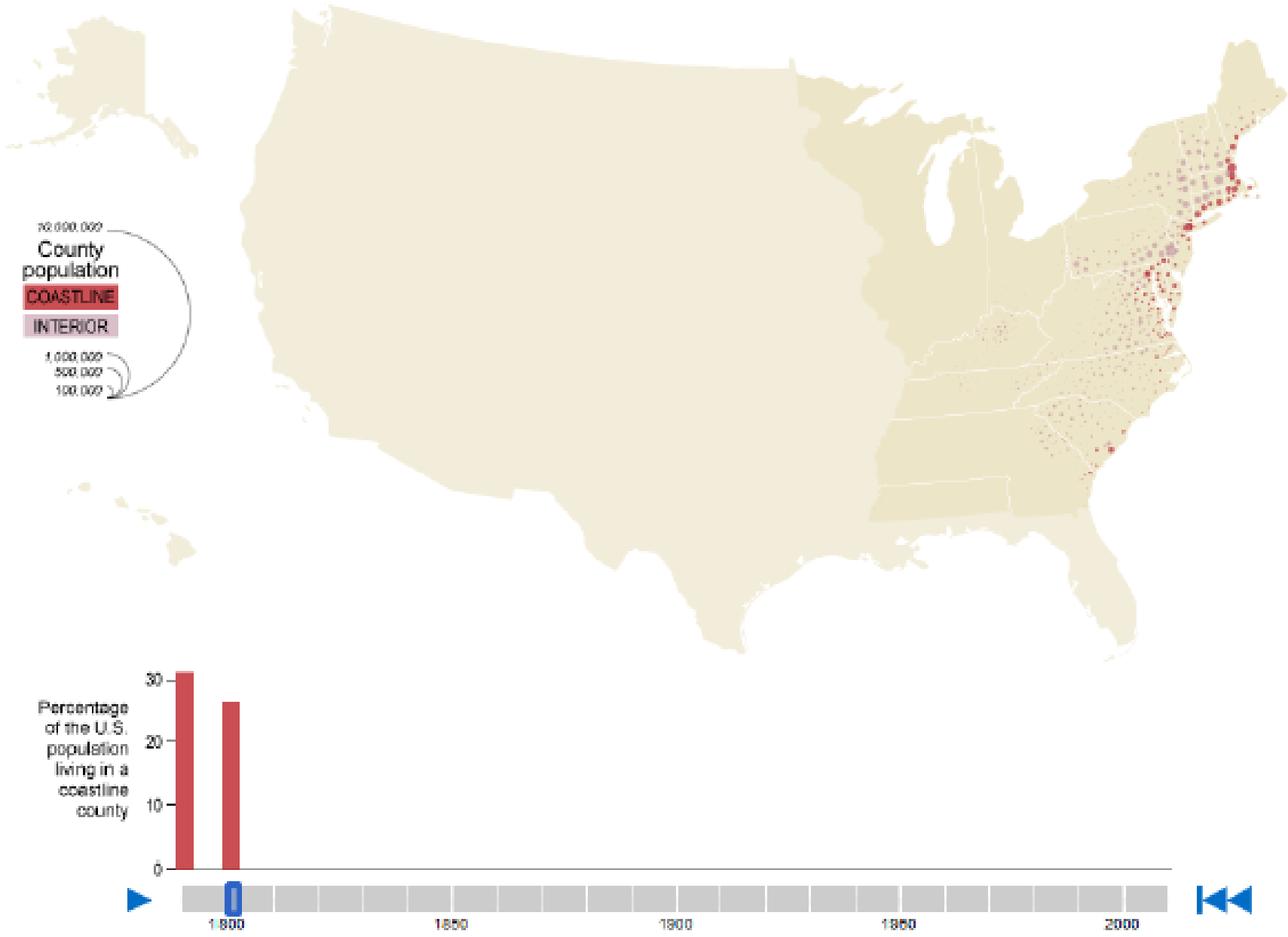
Hurricane Andrew still in memory?

Few people alive even remember the 1926 Miami Hurricane

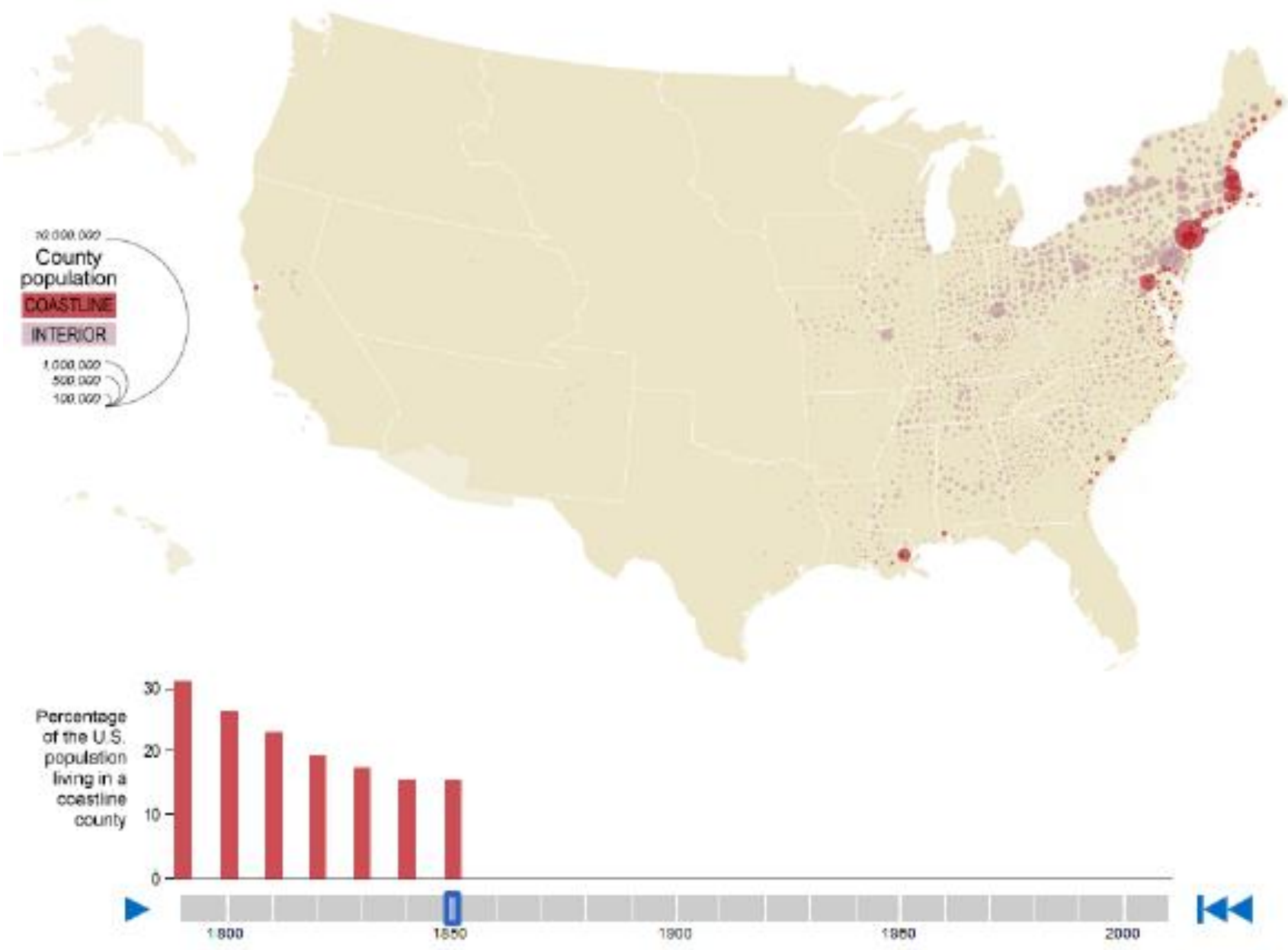


We only really remember the last major weather event.

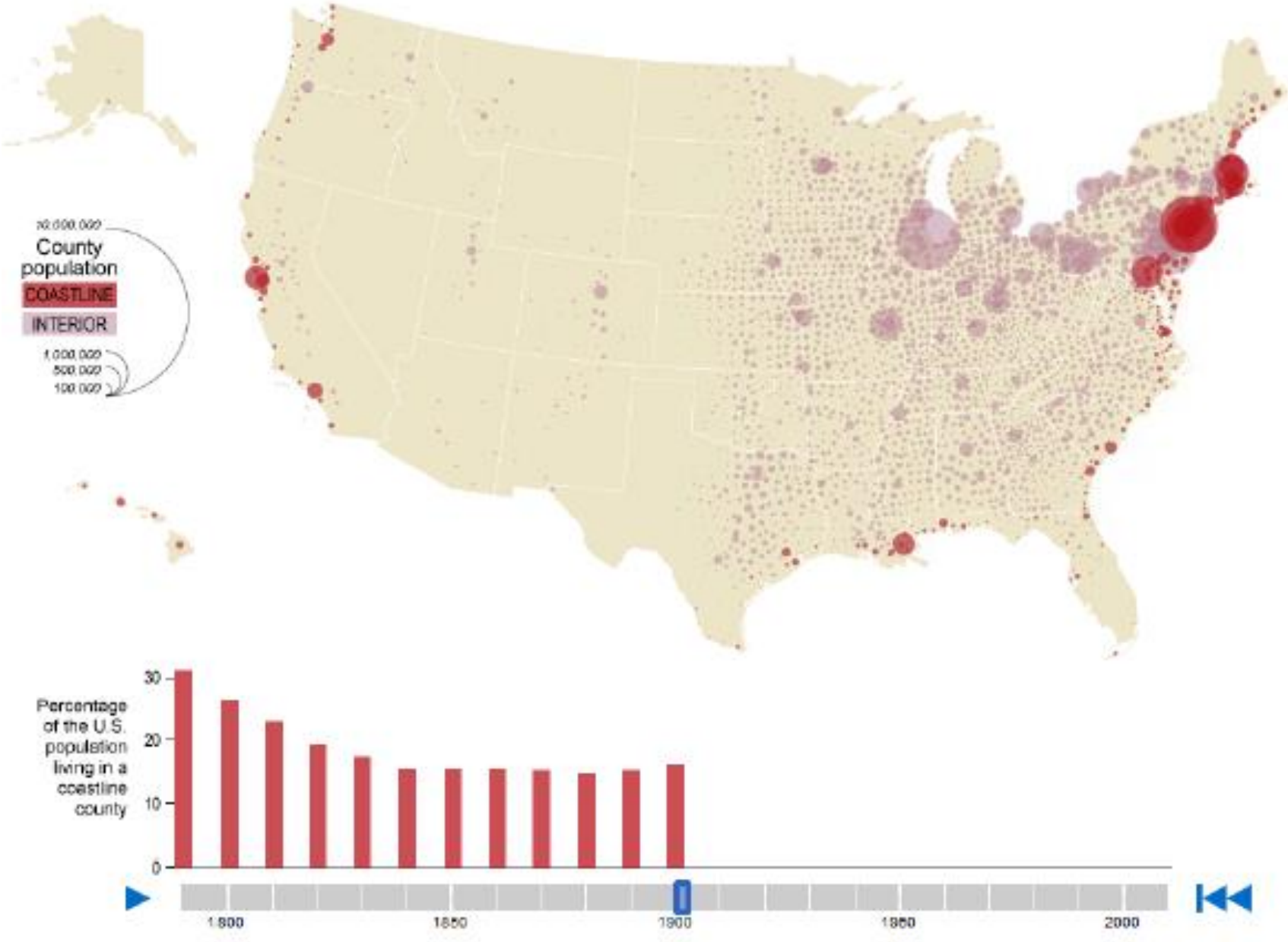
U.S. Population 1800



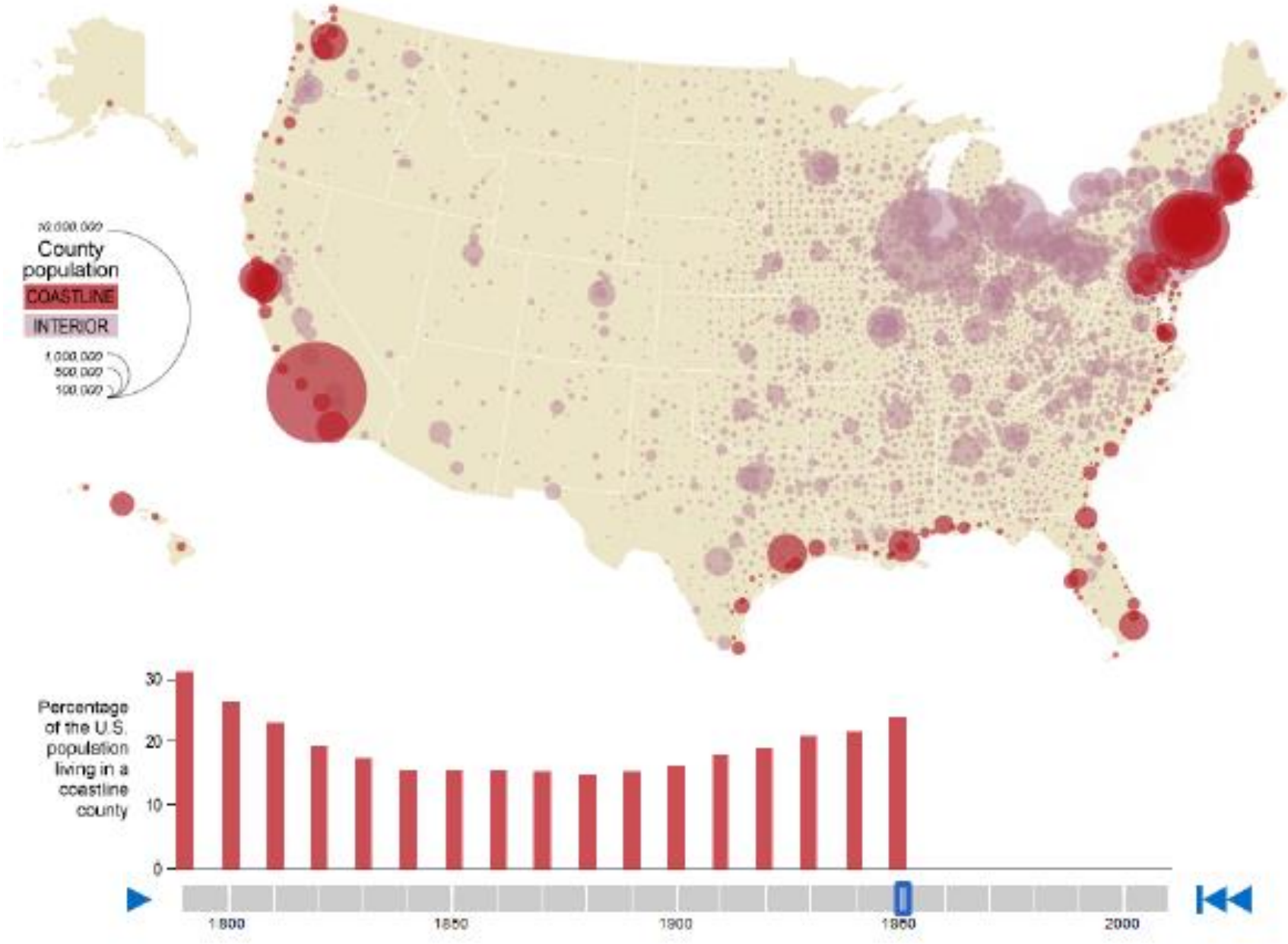
U.S. Population 1850



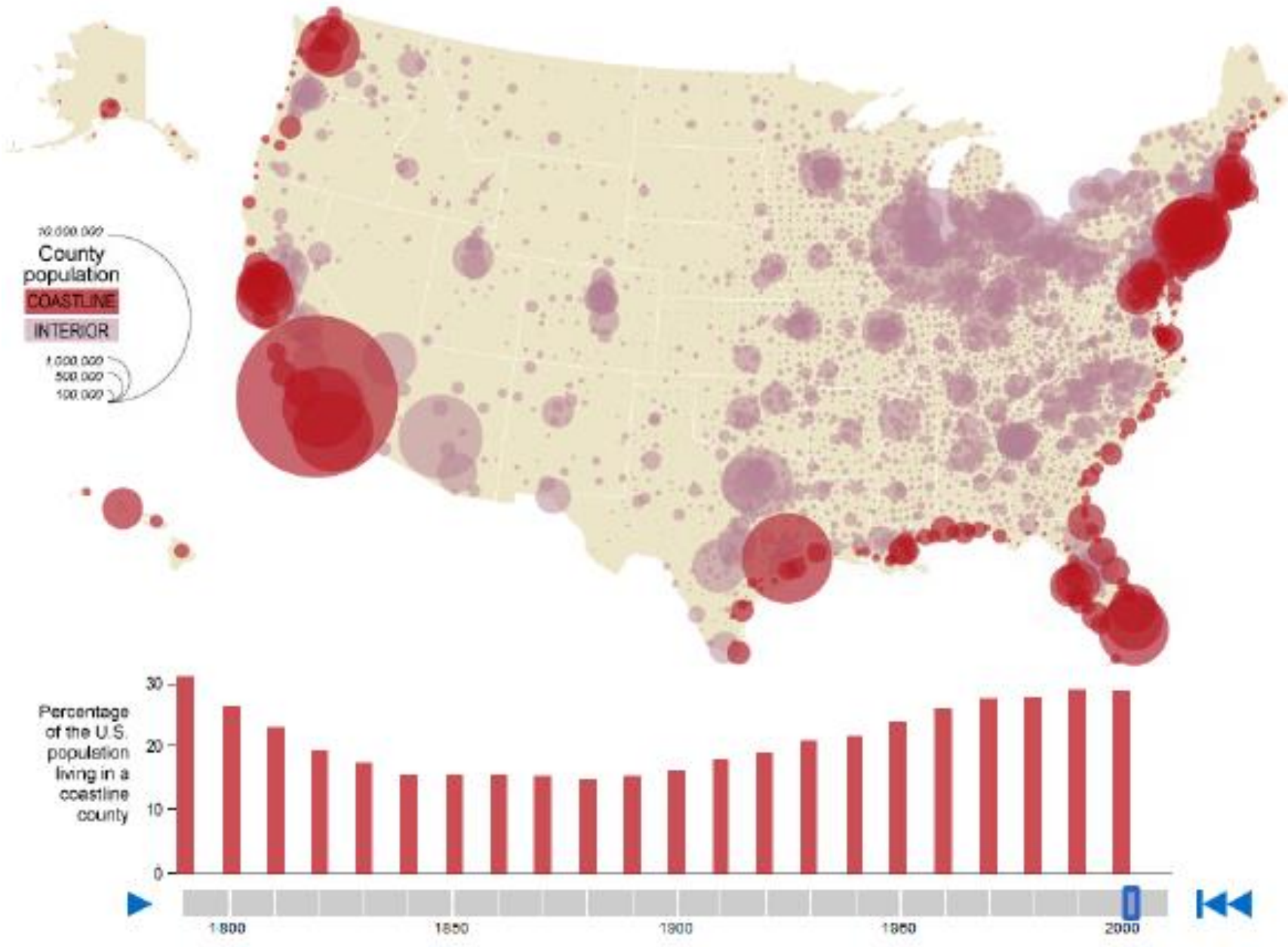
U.S. Population 1900



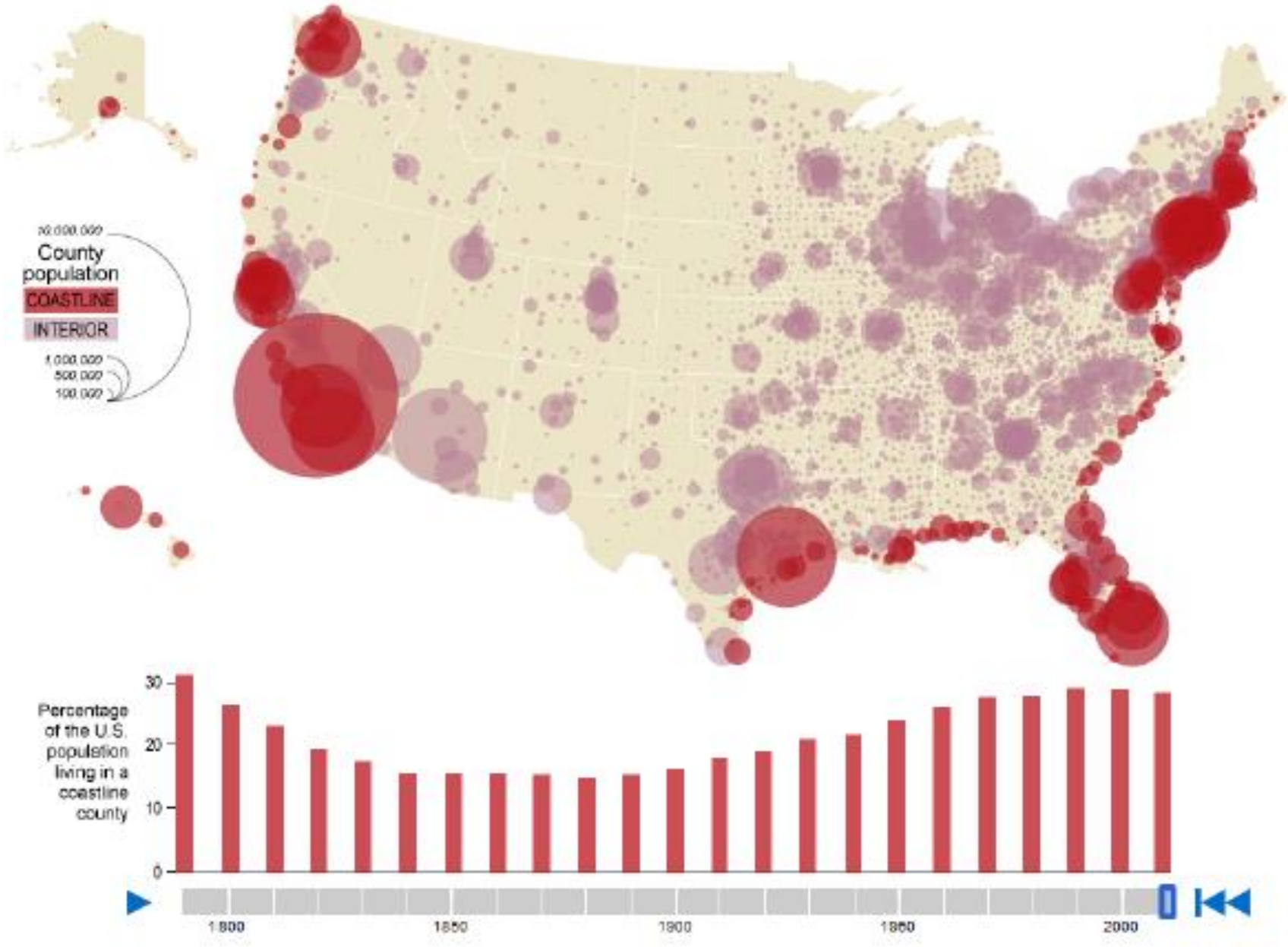
U.S. Population 1950



U.S. Population 2000



U.S. Population 2010



Disaster By Design

Tiki Island, TX - 1.39 sq miles (3.6 km²) with a population of 968

Natural Catastrophes Increasing?

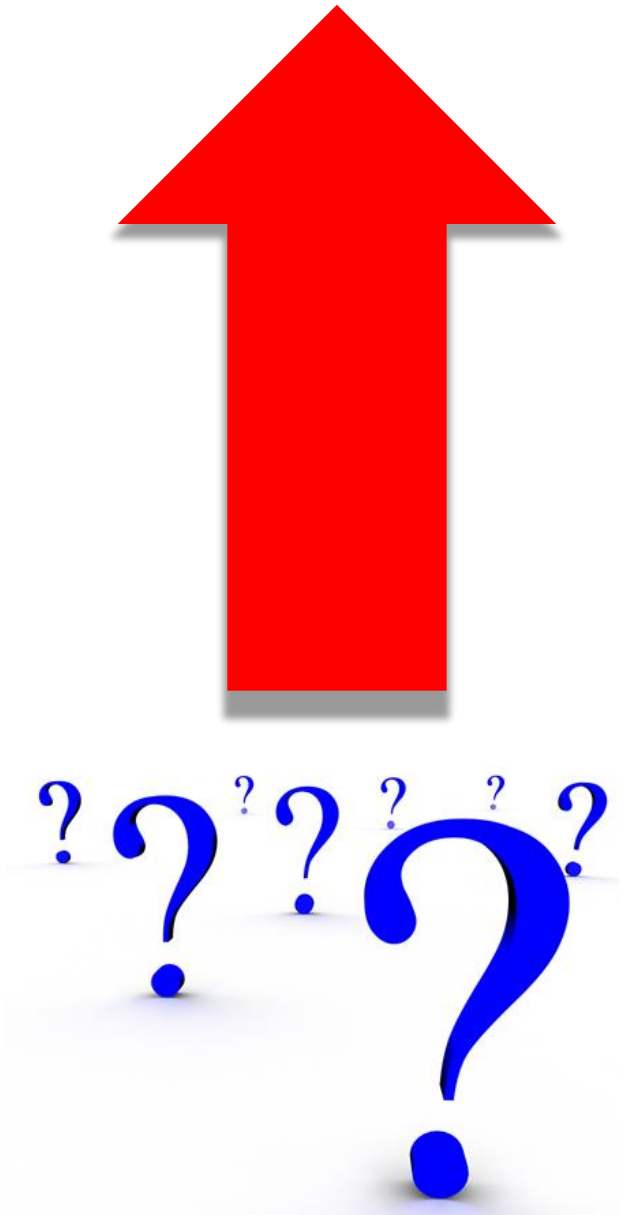
Increasing Population

Increasing Values

Concentration in Exposed Areas

Insurance Penetration

Changing Hazards



Poll – Are they getting worse over the last 5-10 yrs?

- Severe Storms
- Wildfires
- Heavy Rain/Flood Events
- Named Storms

Official Reports on the Weather Trends:

Evidence, and how it stacks up:

Severe Weather – The quality of data makes any conclusion about long-term trends problematic and, therefore, there is low confidence in observed trends in small spatial-scale phenomena, such as tornadoes and hail.

Rainfall – It is likely that since 1951 there have been statistically significant increases in the number of heavy precipitation events in more regions than there have been statistically significant decreases, but there are strong regional and sub-regional variations in the trends.

Flooding – Even though there has been an increase in what scientists call “extreme precipitation” events, there is very little evidence to suggest that this increase has been accompanied by an increase in floods.

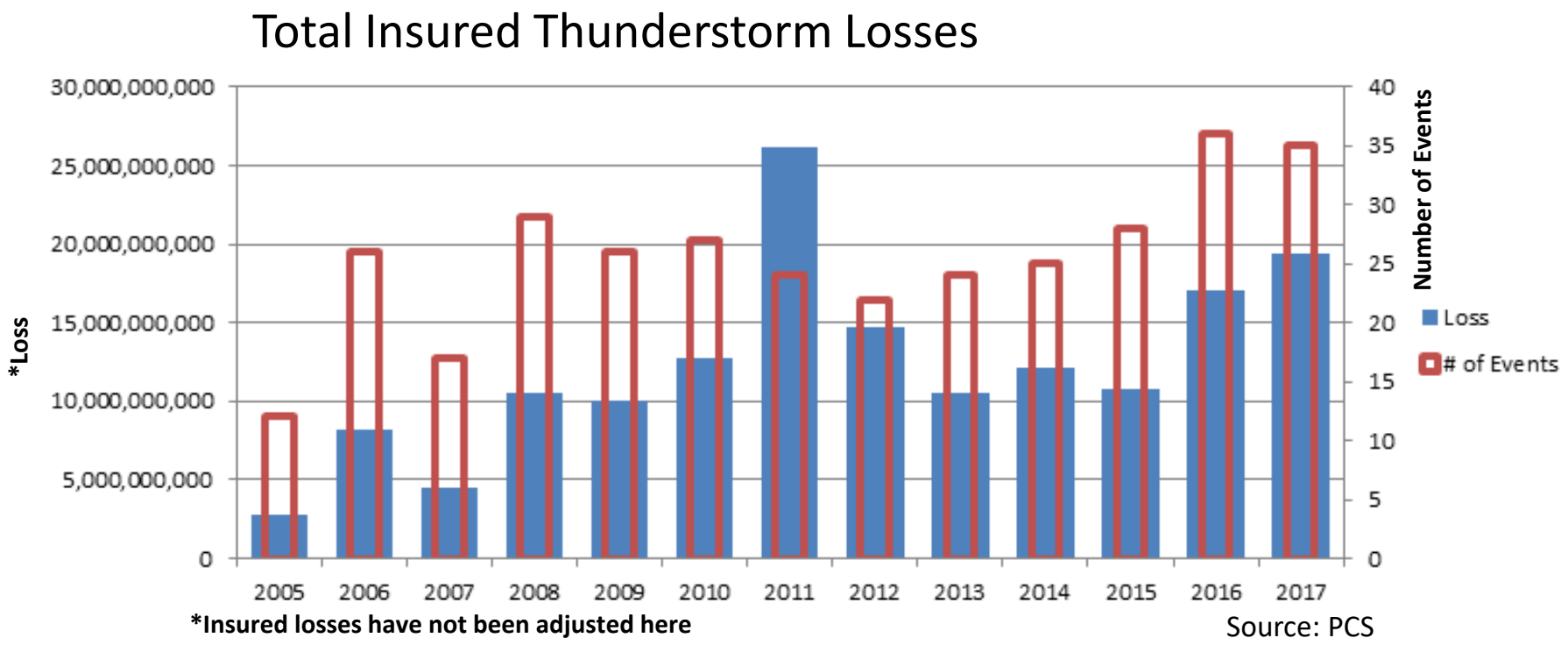
Tropical Cyclone – After accounting for past changes in observational capabilities, the current data indicates no significant observed trends in tropical cyclones.

Source: IPCC SREX and AR5 Reports

Weather / Climate Data

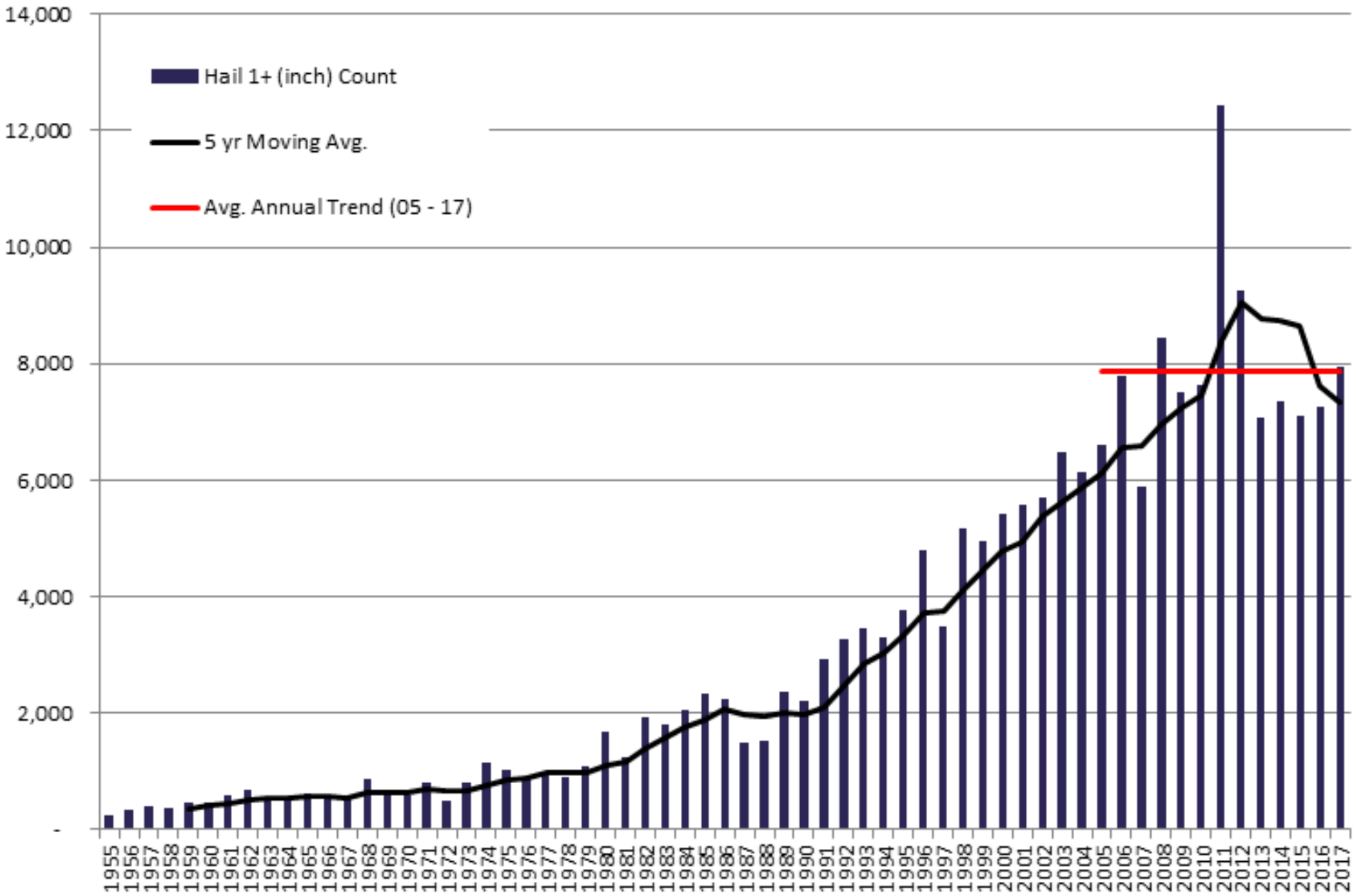
Severe Weather

Severe Storm Events

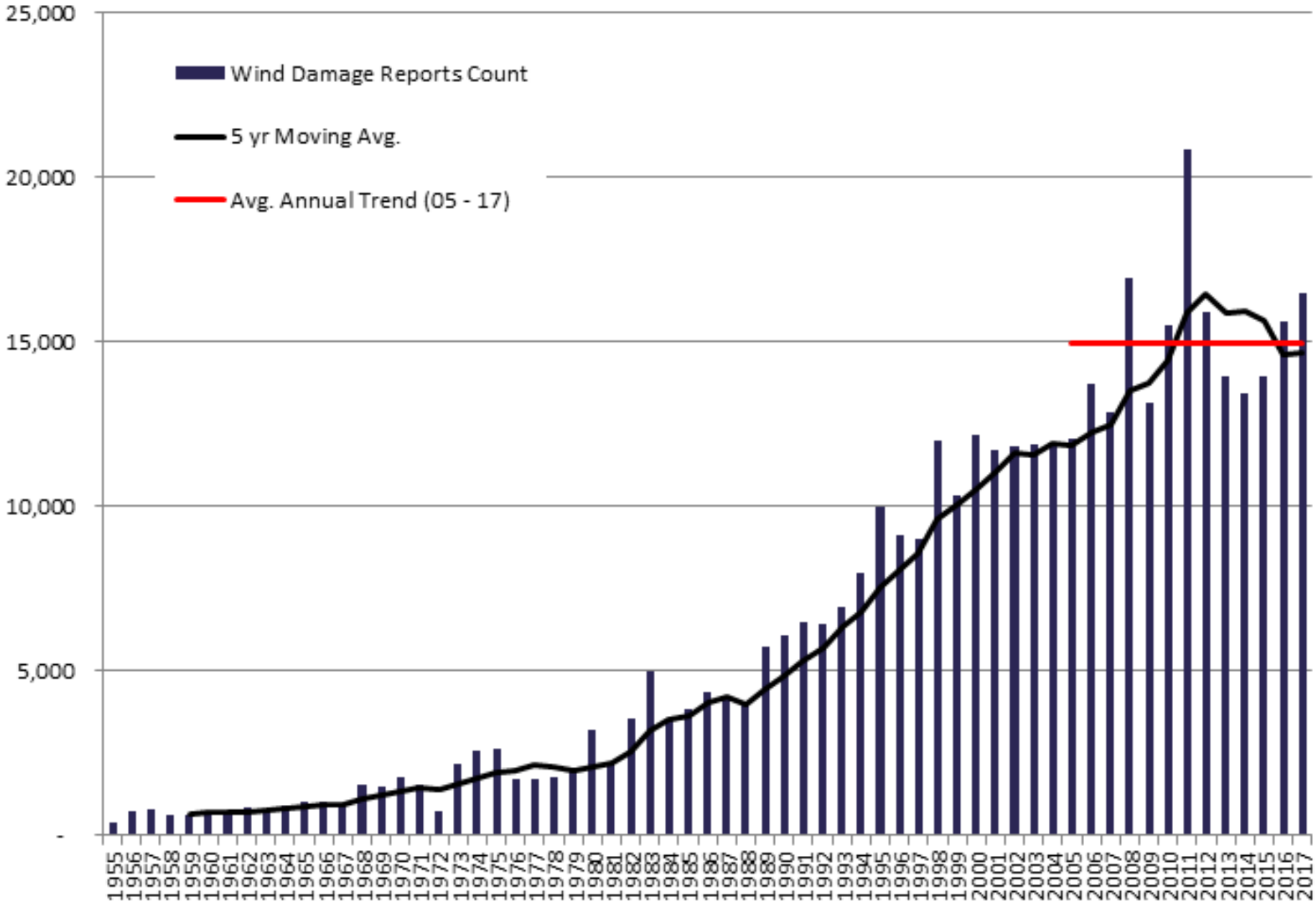


- Insured losses from thunderstorms are, as is typical, being driven by large hail events impacting urban areas.
- The only two major tornados of EF-3 or greater hit urban areas in 2017:
  - East New Orleans event on Feb 7, less than $85M in loss.
  - Hattiesburg, MS event on Jan 21, less than $127M in loss.

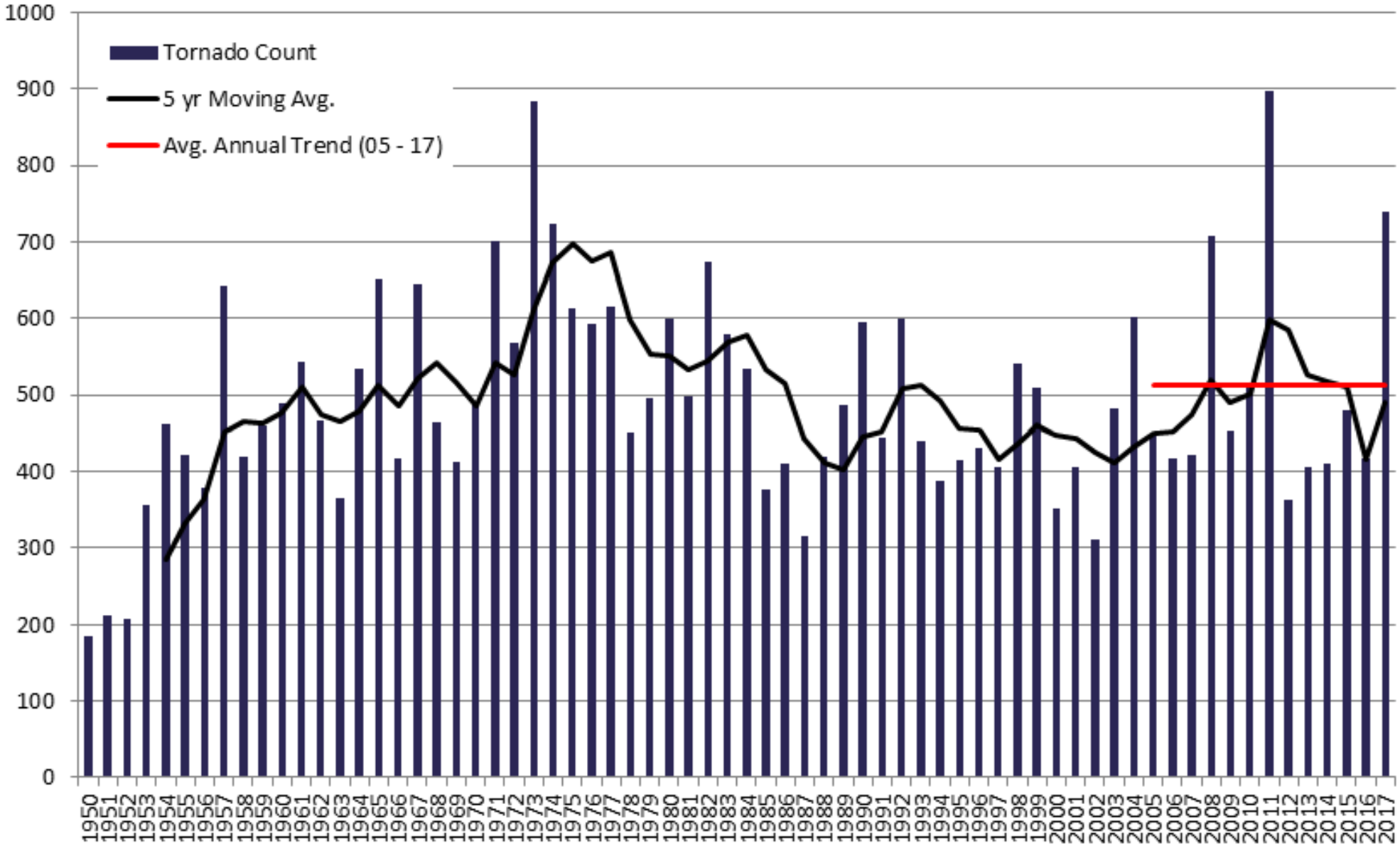
U.S. Annual Counts of Hail Reports of 1 inch+



U.S. Annual Counts of Wind Damage Reports



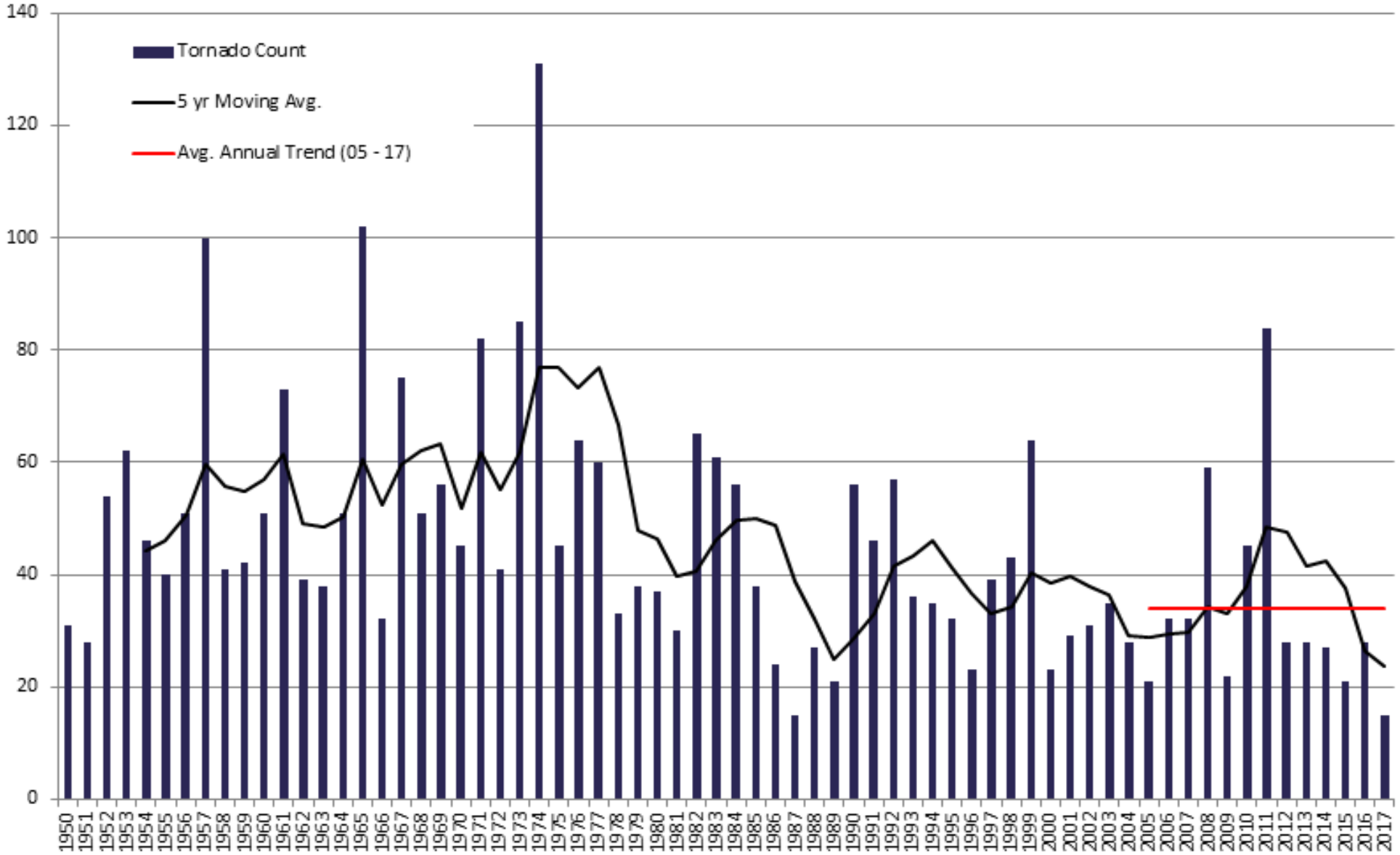
U.S. Annual Count of EF-1+ Tornadoes



Little to no trend in tornado counts of EF-1 and greater

Source: NOAA Storm Prediction Center

U.S. Annual Count of EF-3+ Violent Tornadoes



Downward trend in major tornado counts.

Source: NOAA Storm Prediction Center

Major Tornado Drought?

Although last year's tornado count was above normal, there has been a clear lack of major tornadoes. Thankfully, none have recently hit a major city.

- Tornado storm reports are running 57% of normal.
- Hail storm reports are running 49% of normal.
- Wind storm reports are running 74% of normal.

	Days Between EF4			Days Between EF5		
	Start Date	End Date	Number of Days	Start Date	End Date	Number of Days
1	7/18/2004	11/15/2005	484	5/3/1999	5/4/2007	2,922
2	6/6/1999	7/25/2000	414	4/4/1977	4/2/1982	1,823
3	4/10/2009	4/24/2010	378	**5/20/2013**	**?**	**1,813**
4	**4/29/2017**	**?**	**373**	5/31/1985	3/13/1990	1,746
5	5/19/1960	4/25/1961	340	6/16/1992	7/18/1996	1,492
6	6/71984	5/10/1985	336	5/5/1960	4/3/1964	1,428
7	6/24/2003	5/12/2014	322	5/25/2008	4/27/2011	1,066

NOAA SPC - Data starts 1950. Data as of 5/17/2018

Matter of Luck

Source: Twin tornadoes are seen near Dodge City, Kansas, with Dodge City Raceway Park in the foreground on Tuesday, May 24, 2016. (Instagram/bradguay)

Severe weather losses are often a matter of luck. There were many close calls in 2016, such as this major tornado that occurred just three miles south of Dodge City, Kansas. Hail storms in Texas made direct hits on major urban areas leading to high insured losses.

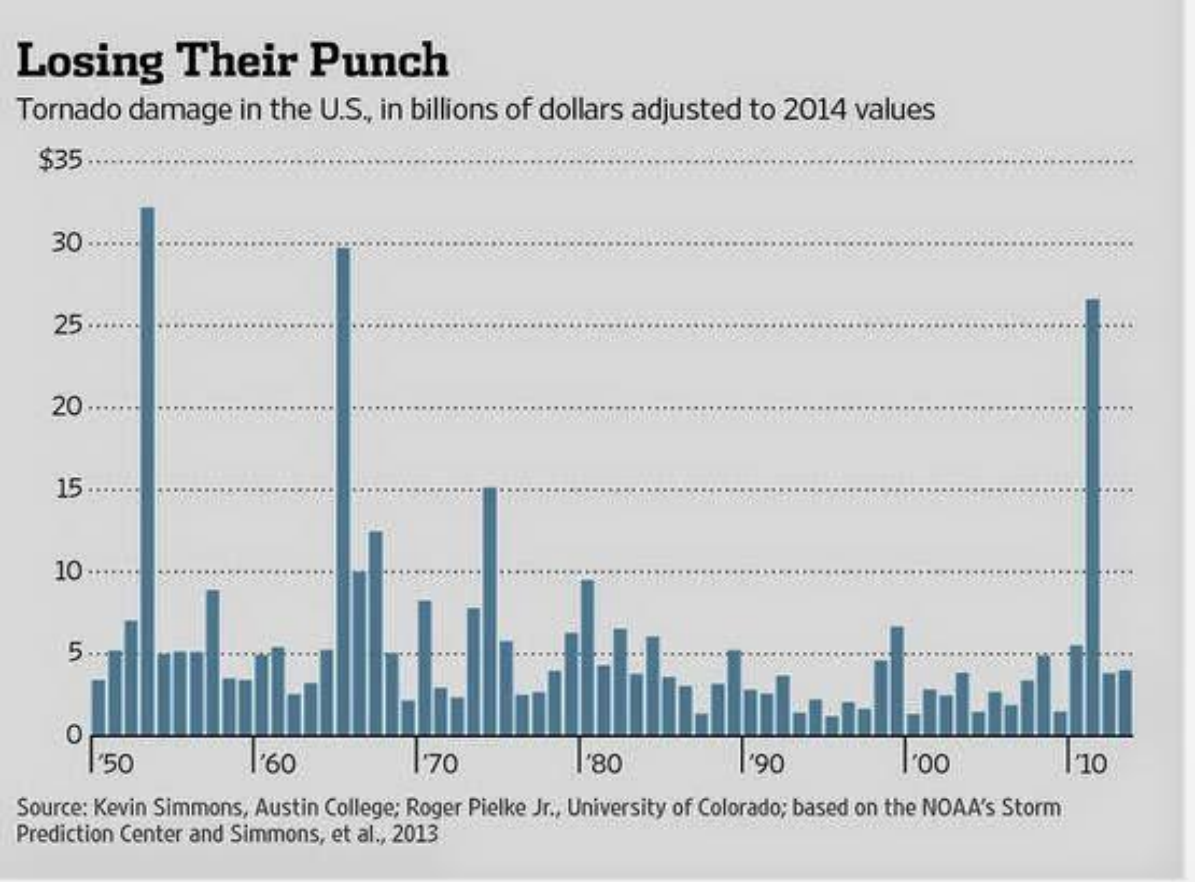
Tornado Damage Normalized

The graph represents an estimation of how much tornado damage would occur in the U.S. if each year's tornadoes occurred with the levels of population and development of today.

Average annual losses from the entire 63-year period across the U.S. are $5.9B.

The average annual loss of the first 32 years is $7.6B.

Since 1982, a period of 31 years shows an average annual loss of $4.1B.



Source: WSJ

Weather / Climate Data

Wildfire

Wildfire Events

Top 20 Most Destructive California Wildfires

	FIRE NAME *(CAUSE)*	DATE	COUNTY	ACRES	*STRUCTURES*	DEATHS
1	**TUBBS** *(Under Investigation)*	October 2017	Sonoma	36,807	**5,643**	22
2	**TUNNEL - Oakland Hills** *(Rekindle)*	October 1991	Alameda	1,600	**2,900**	25
3	**CEDAR** *(Human Related)*	October 2003	San Diego	273,246	**2,820**	15
4	**VALLEY** *(Electrical)*	September 2015	Lake, Napa & Sonoma	76,067	**1,955**	4
5	**WITCH** *(Powerlines)*	October 2007	San Diego	197,990	**1,650**	2
6	**NUNS** *(Under Investigation)*	October 2017	Sonoma	54,382	**1,355**	2
7	**THOMAS** *(Under Investigation)*	December 2017	Ventura & Santa Barbara	281,893	**1,063**	1
8	**OLD** *(Human Related)*	October 2003	San Bernardino	91,281	**1,003**	6
9	**JONES** *(Undetermined)*	October 1999	Shasta	26,200	**954**	1
10	**BUTTE** *(Powerlines)*	September 2015	Amador & Calaveras	70,868	**921**	2
11	**ATLAS** *(Under Investigation)*	October 2017	Napa & Solano	51,624	**781**	6
12	**PAINT** *(Arson)*	June 1990	Santa Barbara	4,900	**641**	1
13	**FOUNTAIN** *(Arson)*	August 1992	Shasta	63,960	**636**	0
14	**SAYRE** *(Misc.)*	November 2008	Los Angeles	11,262	**604**	0
15	**CITY OF BERKELEY** *(Powerlines)*	September 1923	Alameda	130	**584**	0
16	**HARRIS** *(Under Investigation)*	October 2007	San Diego	90,440	**548**	8
17	**REDWOOD VALLEY** *(Under Investigation)*	October 2017	Mendocino	36,523	**544**	9
18	**BEL AIR** *(Undetermined)*	November 1961	Los Angeles	6,090	**484**	0
19	**LAGUNA** *(Arson)*	October 1993	Orange	14,437	**441**	0
20	**ERSKINE** *(Under Investigation)*	June 2016	Kern	46,684	**386**	2

**"Structures" include homes, outbuildings (barns, garages, sheds, etc) and commercial properties destroyed.
***This list does not include fire jurisdiction. These are the Top 20 regardless of whether they were state, federal, or local responsibility.

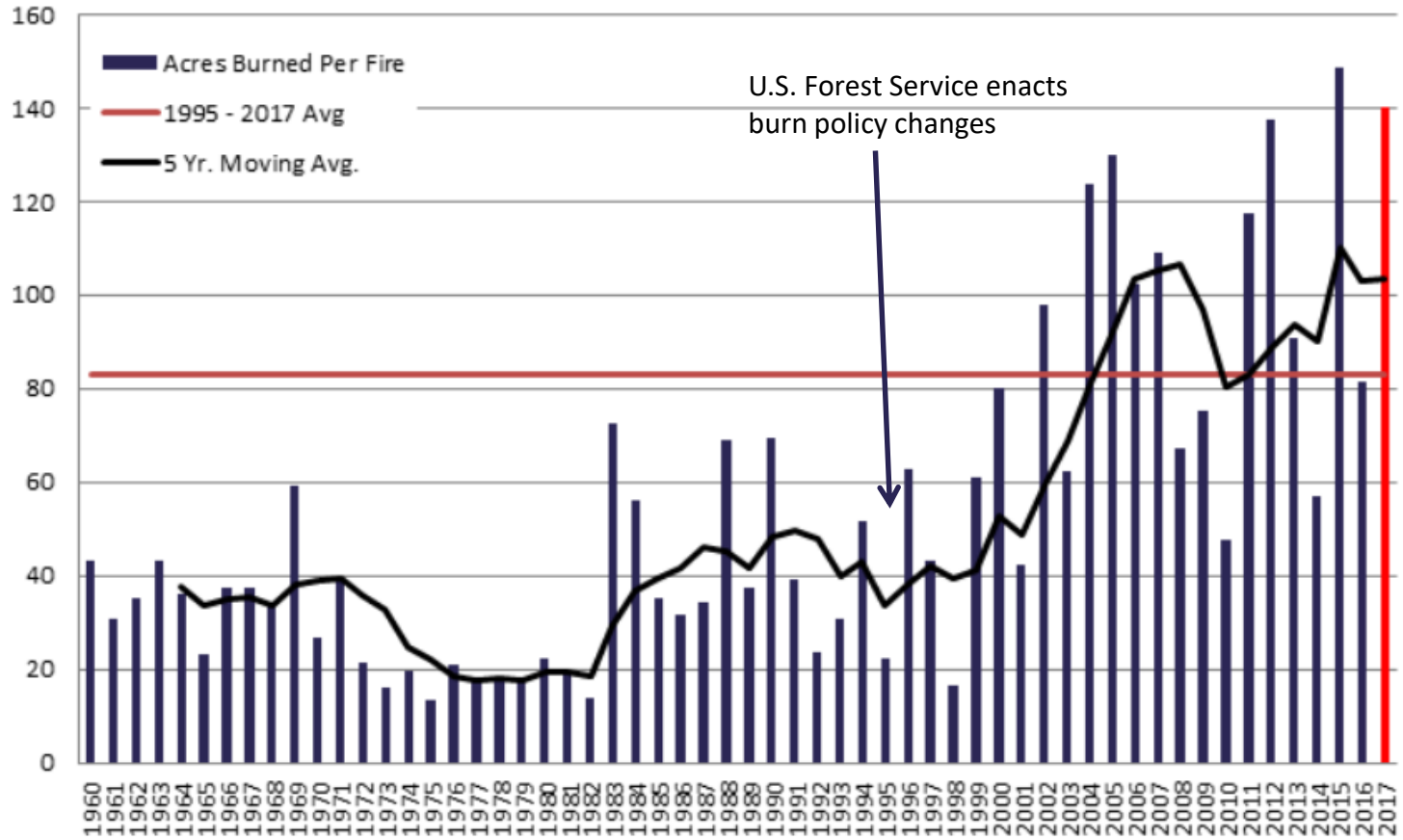
CAL FIRE

1/12/2018

2017 will be the largest wildfire loss year ever recorded, with well over $13B in insured losses occurring in the U.S. alone. It crushes the previous largest loss year of 1991, which, in today's dollars, would be an insured loss of $3.4B.

U.S. Wildfire Burn Frequency

The National Interagency Fire Center (NIFC) and National Interagency Coordination Center maintained wildfire records from 1960 to 1982 before the NIFC began its current method of data compilation from states and other agencies in 1983.



Source: NIFC

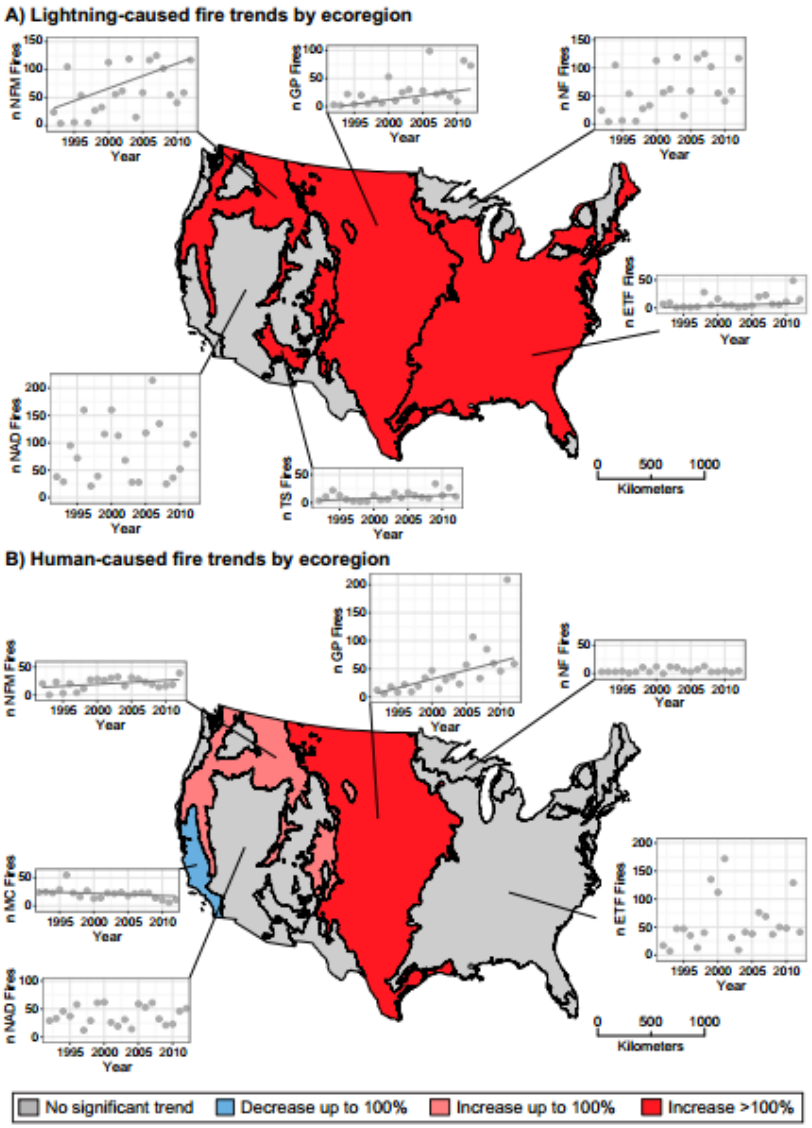
Reasons?

Larger Fires - Changing firefighting tactics and land use.

Extended fire season - more heat and fuel, and shifts between wet and dry periods.

Human-caused Fires

- 2017 and 2016 were large loss years for wildfires.
- Both the Fort McMurray and Gatlinburg fires were caused by human action and totaled $3.6B in insured losses.
- Humans cause 84% of wildfires in forests.
- Lightning accounts for the rest, occurring mainly in mountainous, sparsely populated areas.
- Observations show climate change has extended fire season across the U.S. by zero to two weeks, while human-started fires increased the length by three months!
- Humans extend fire season into colder parts of the season. Lightning fire season has changed very little and is still common in the warm season, as expected.



Source: Human-started wildfires expand the fire niche across the United States.
http://www.pnas.org/content/early/2017/02/21/1617394114

Wildland-Urban Interface (WUI) is Growing

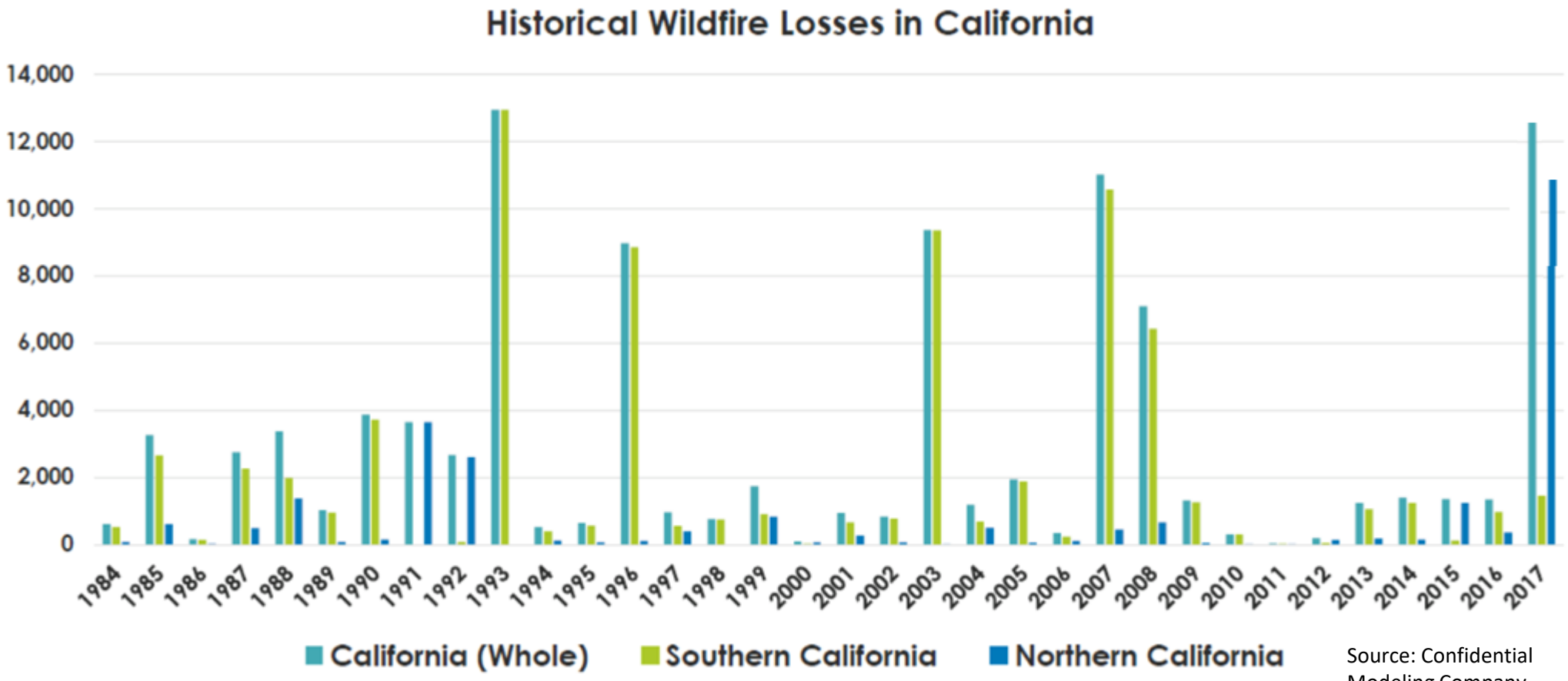
1993

2016

Source: Monitoring Trends in Burn Severity (MTBS Unnamed California Wildfire San Diego Area

This unnamed wildfire that occurred in San Diego in 1993 burned very few structures. Today it would be a major wildfire loss for the insurance industry. The WUI is growing more populous, the likely result being greater wildfire losses in the future.

Model Adjusted Wildfire Loss



Source: Confidential Modeling Company

Based on historical analysis of wildfire perimeters and adjusted for new exposure that has moved into the WUI, 2017 wildfire losses don't appear to be that large.

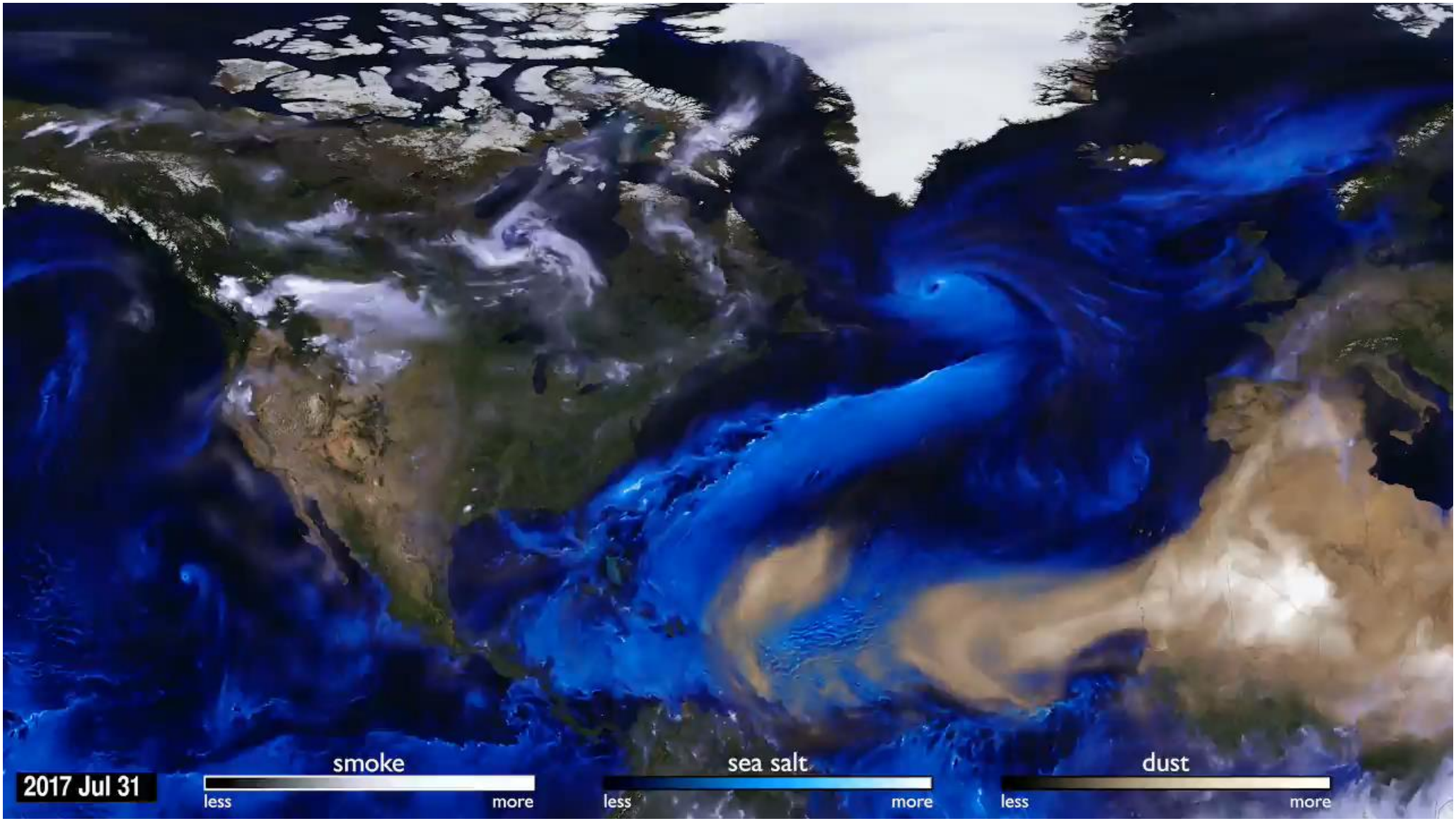
Unlike this year, historically Southern California has had several large fires.

(Note that the modeling company here can't be named)

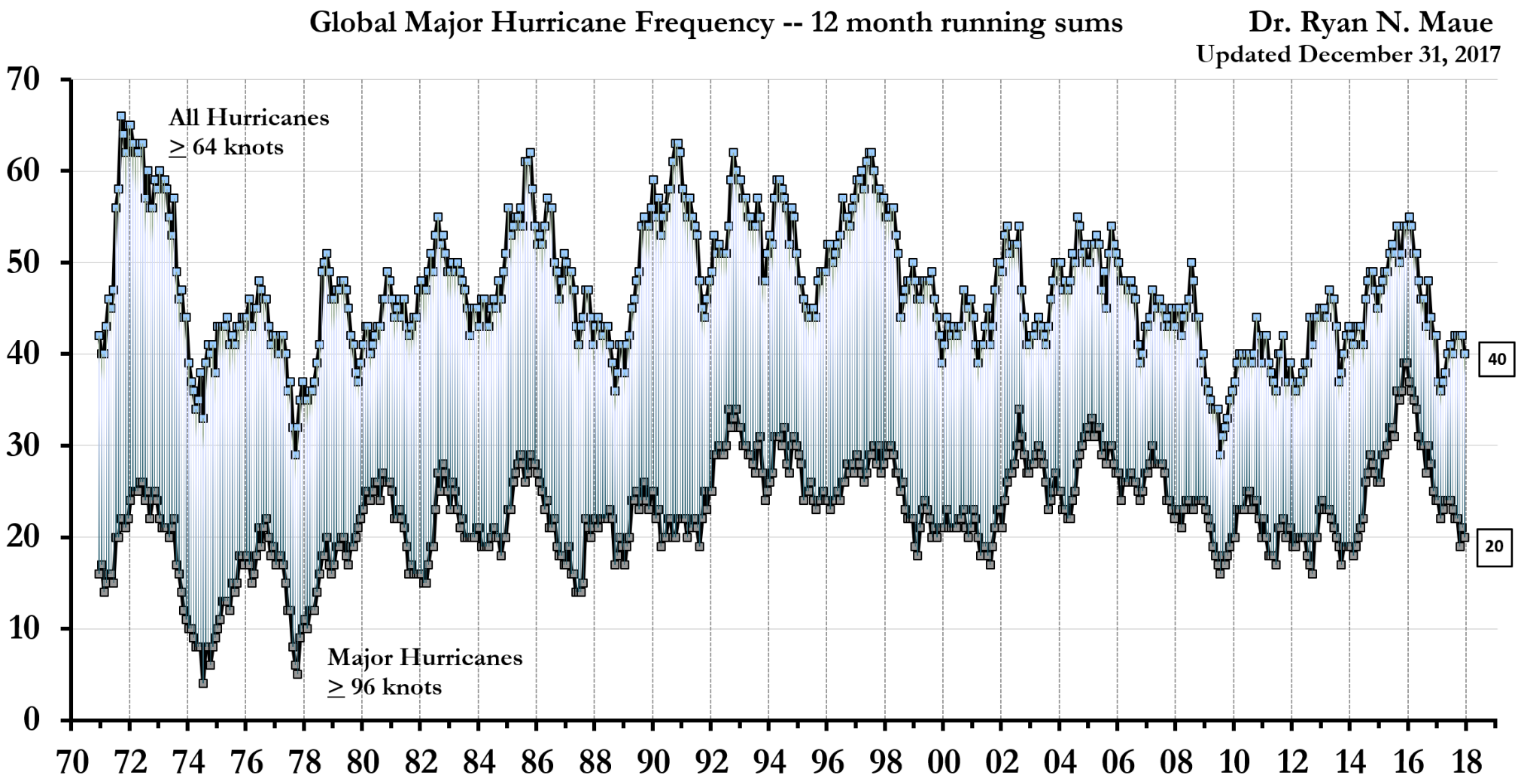
Weather / Climate Data

Named Storm / Hurricane

2017 Hurricane Season In Review



Global Hurricane Frequency



Is there a trend? The top time series is the number of global tropical cyclones that reached at least hurricane-strength force. The bottom time series is the number of global tropical cyclones that reached major hurricane strength.

Global Tropical Cyclone Landfalls

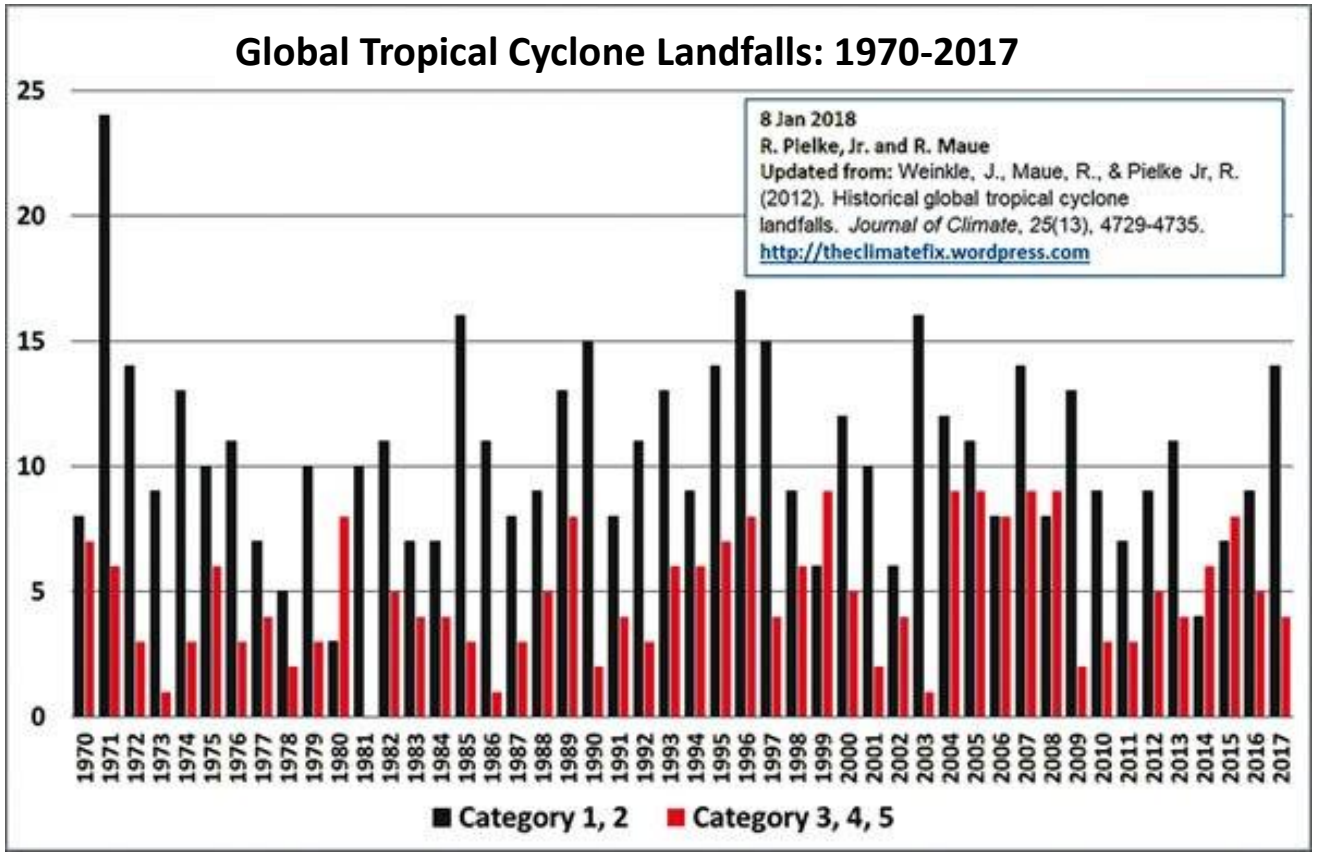
- How many tropical cyclones (of hurricane+ strength) have made landfall globally, and how has that varied/changed?

- No simple trend, no evidence of increasing landfalls.

- 2017 had 18 total landfalls:
  - 14 Category 1 or 2
  - Four Category 3, 4 or 5

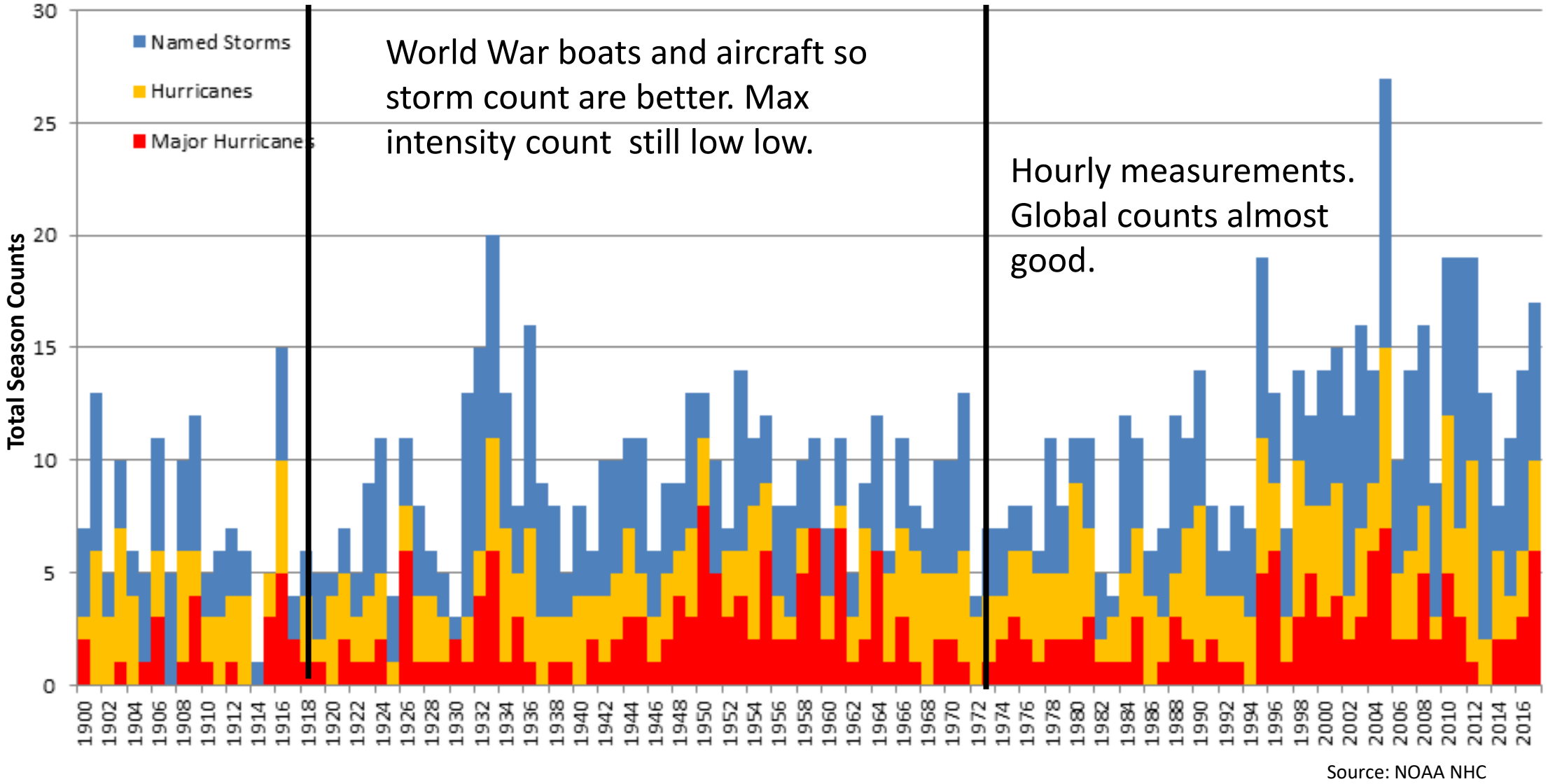
The annual averages between 1970-2017 are:

- 15.3 total
- 10.5 Category 1 and 2
- 4.7 Category 3+



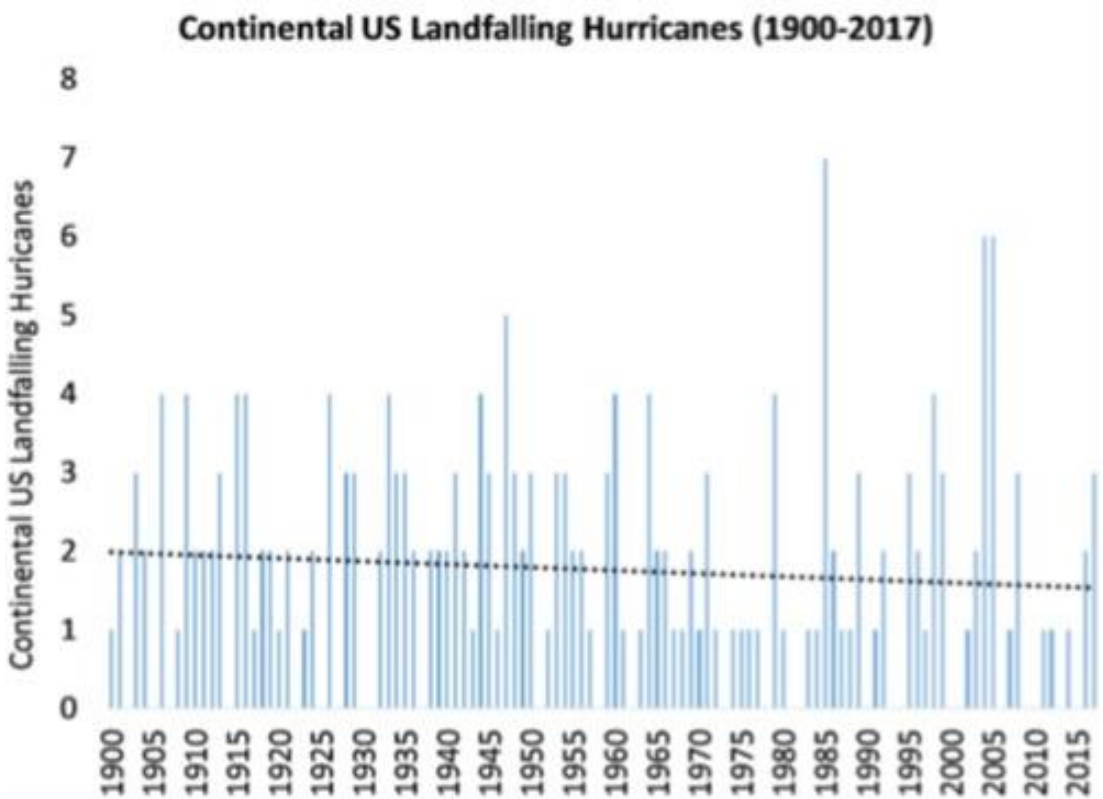
Atlantic Named Storm Activity

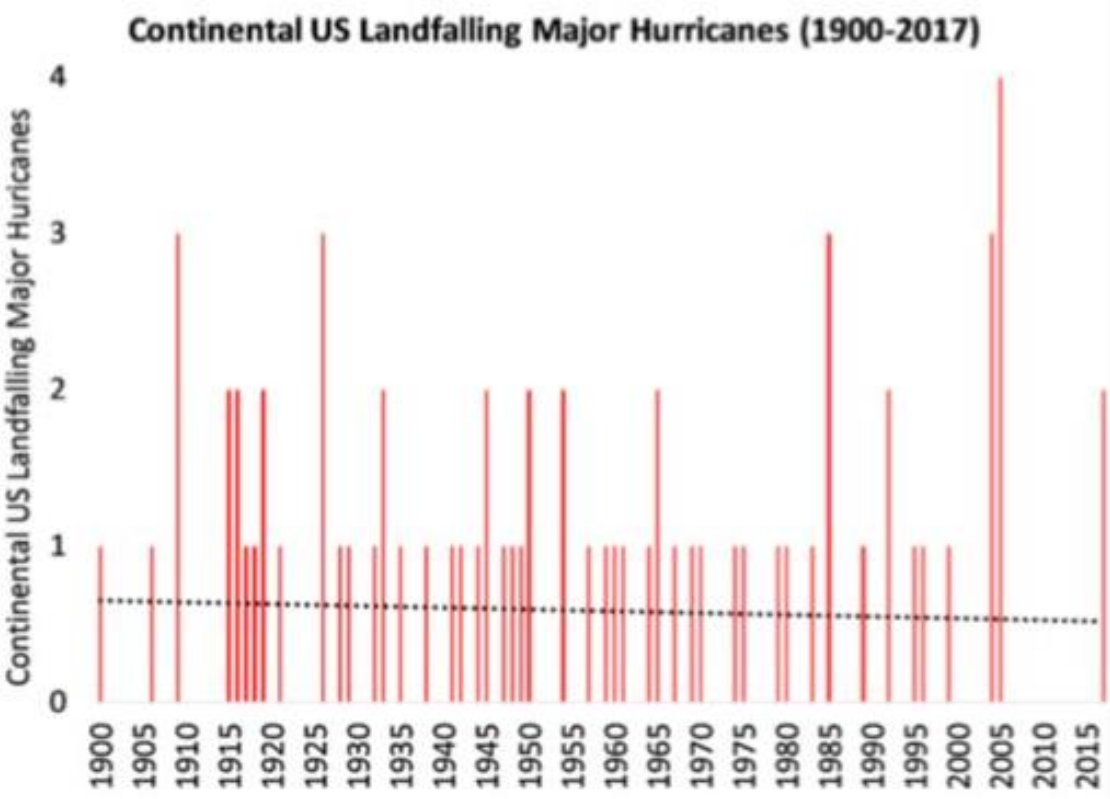
Occasional measurements. Maximum intensity rarely measured. Storm count may be low.



Source: NOAA NHC

U.S. Landfalls

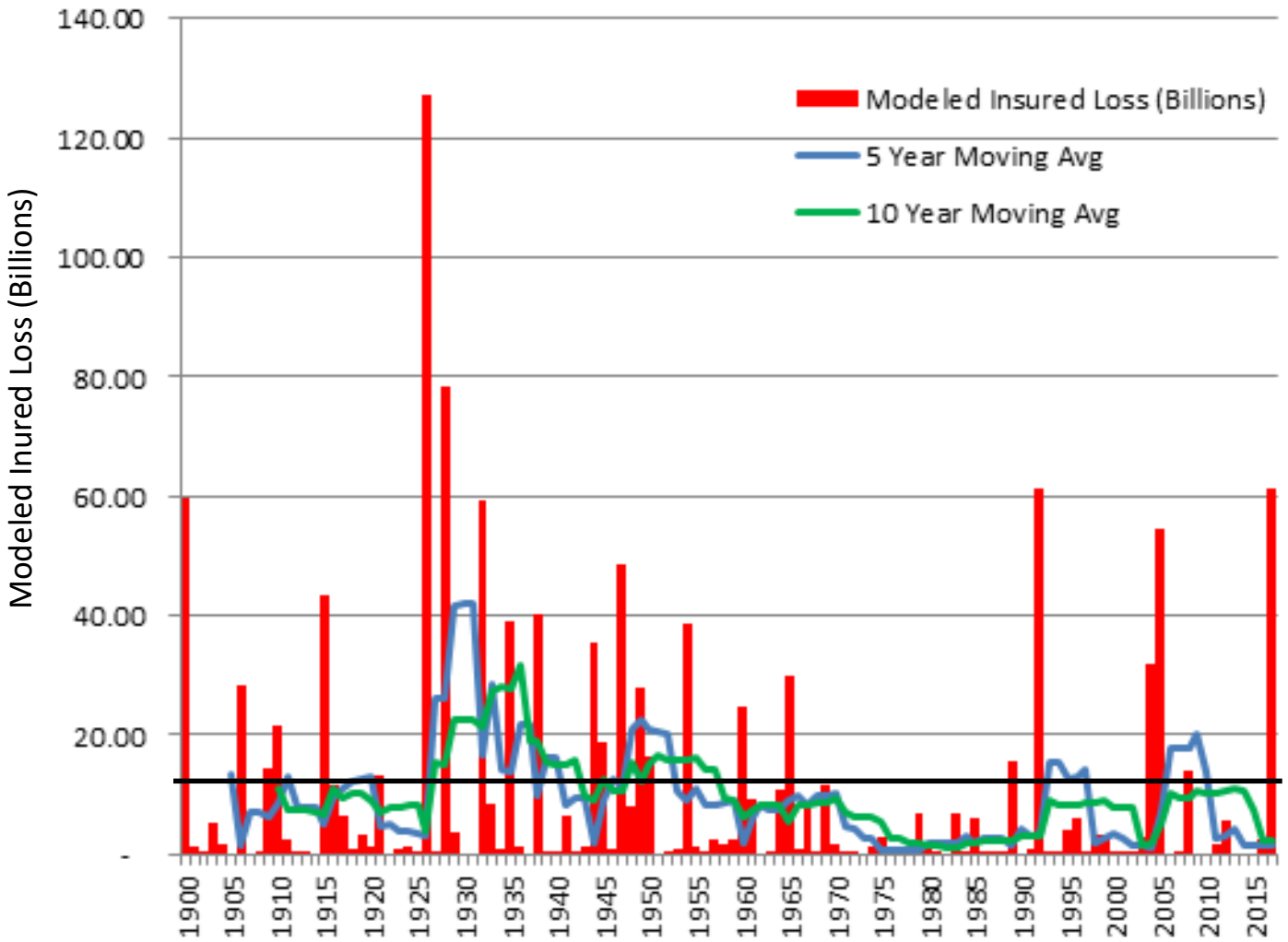




The U.S. coast is in an unprecedented hurricane drought! This is terrifying!
Population and wealth along parts of the U.S. coast have exploded since the last stormy period.

Source: NOAA NHC and Roger Pielke Jr.

Named Storm Insured Loss Trend



Long Term Average
Insured loss 10 Billions

Source: Confidential
Modeling Company

- Using modeled losses removes the uncertainty of adjusting historical losses to account for socioeconomic factors.
- Insured losses are at multi-decadal lows with much higher insured loss occurring between 1930 - 1960.

Insurance Industry Capital and Profitability

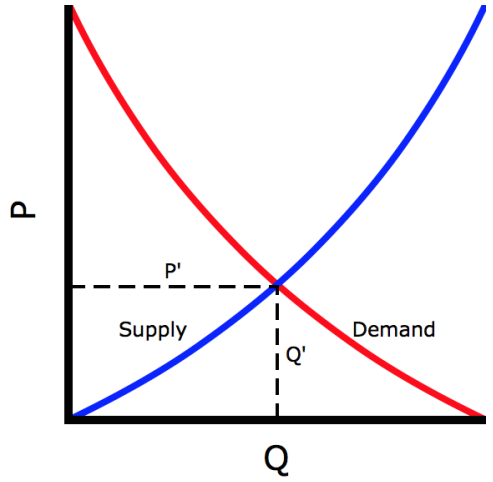
Catastrophe Reinsurance Pricing

Analytics

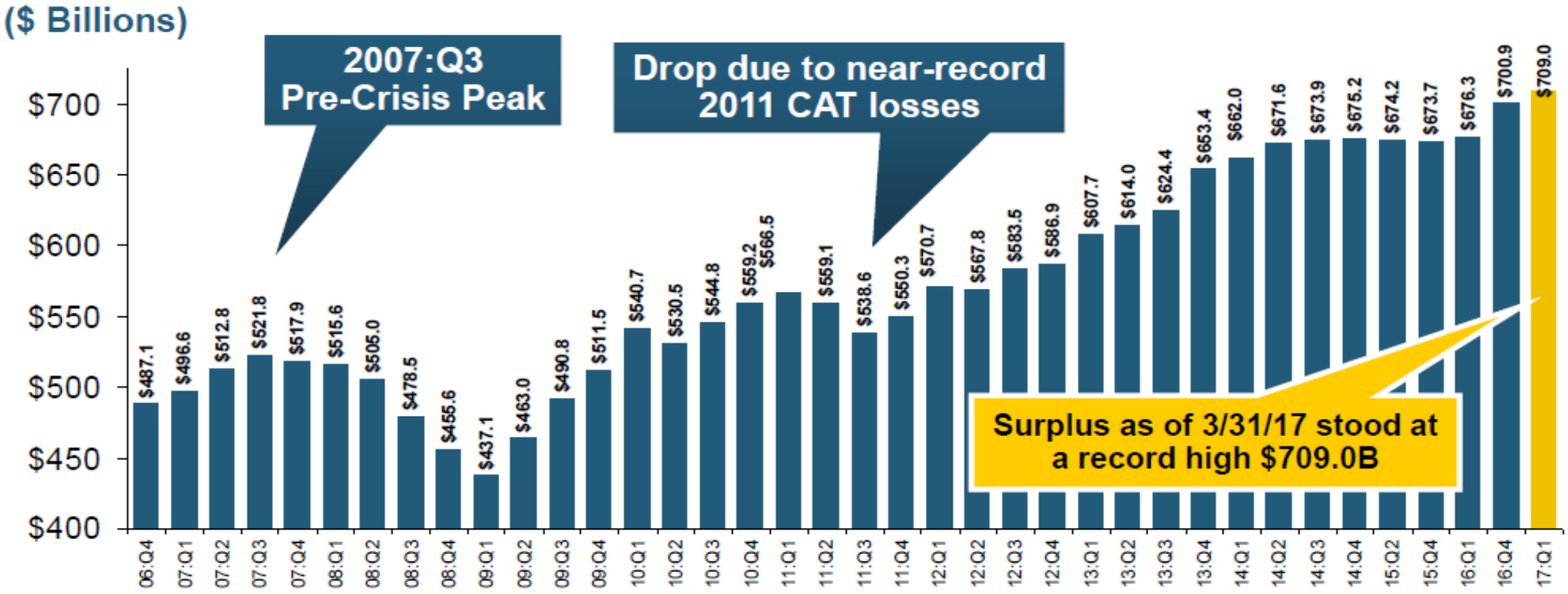
- Multiple Models
- AAL/EL
- Standard Deviation
- TIV Change
- Demand Surge
- Storm Surge
- Reinsurers' Expense Load

OR

Supply and Demand



Policyholder Surplus, Quarterly, 2006:Q4–2016:Q4



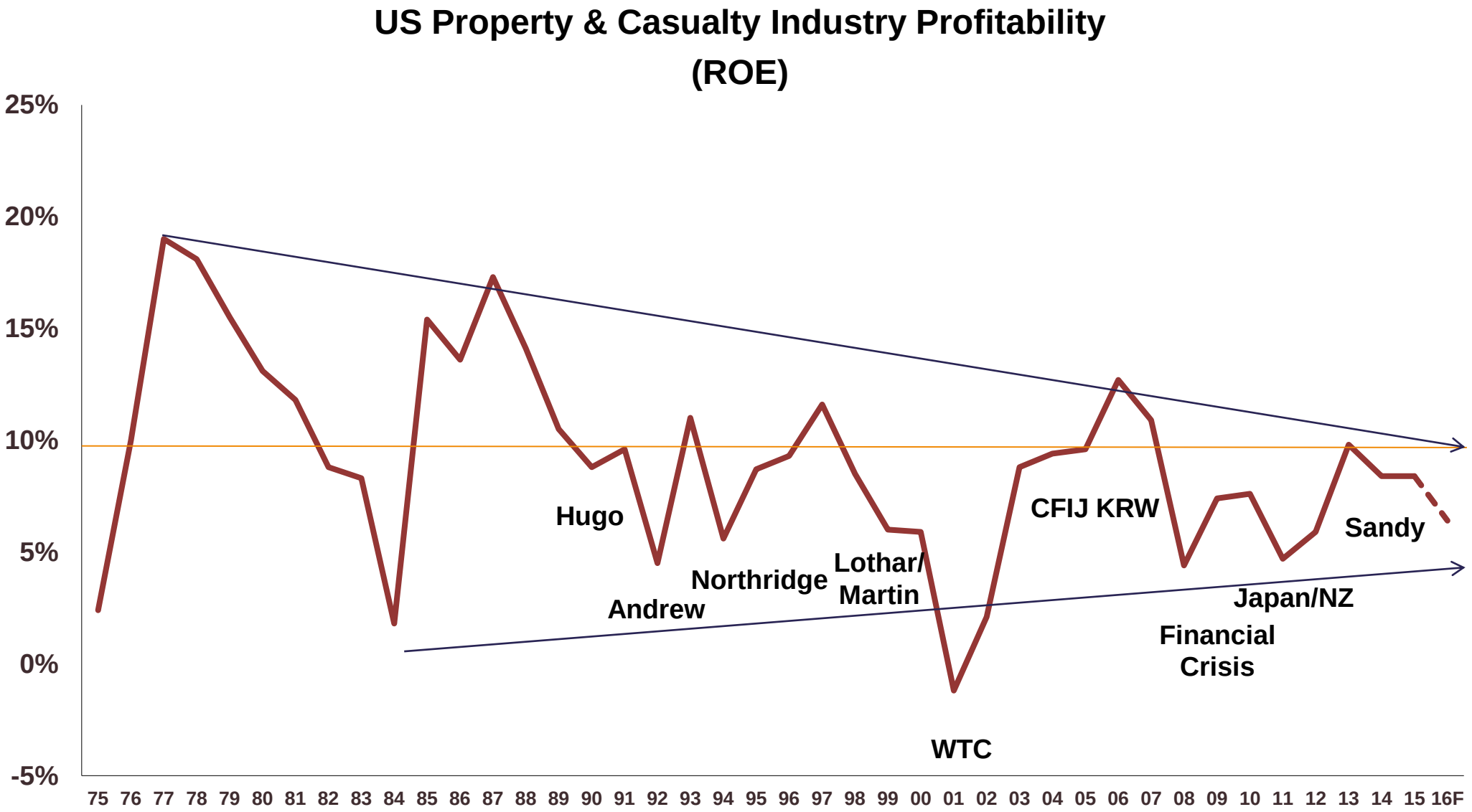
The industry now has $1 of surplus for every $0.76 of NPW, the strongest claims-paying status in its history.

2010:Q1 data includes $22.5B of paid-in capital from a holding company parent for one insurer's investment in a non-insurance business.

Sources: ISO, A.M .Best.

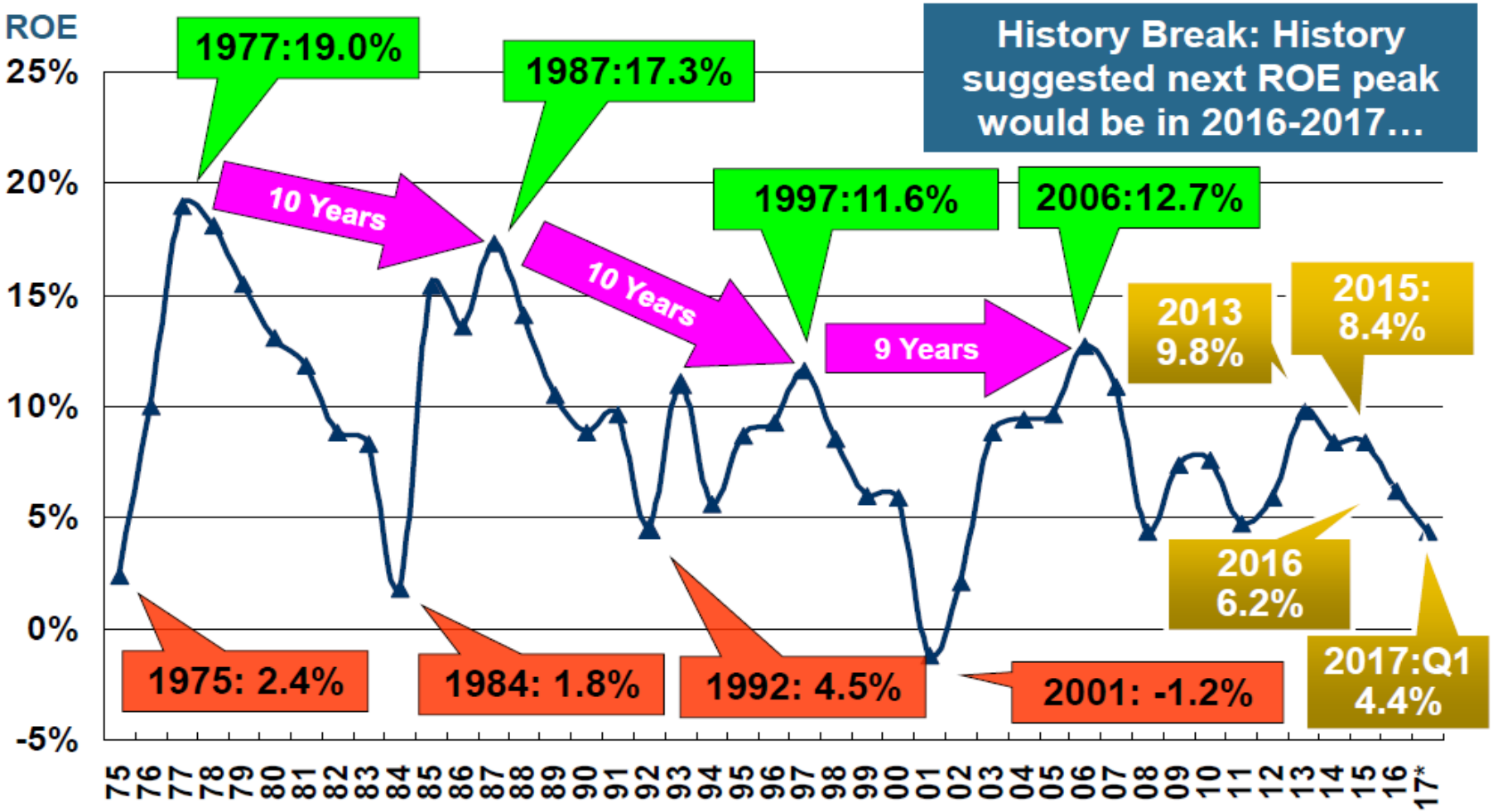
The P/C insurance industry entered 2017 in very strong financial condition.

Industry's Overall Profitability



Sources: III, NAIC, ISO, A M Best, Conning

Profitability Peaks & Troughs in the P/C Insurance Industry, 1975 – 2017:Q1



*As of Q1:2017; Profitability = P/C insurer ROEs. 2011-16 figures are estimates based on ROAS data. Note: Data for 2008-2014 exclude mortgage and financial guaranty insurers.

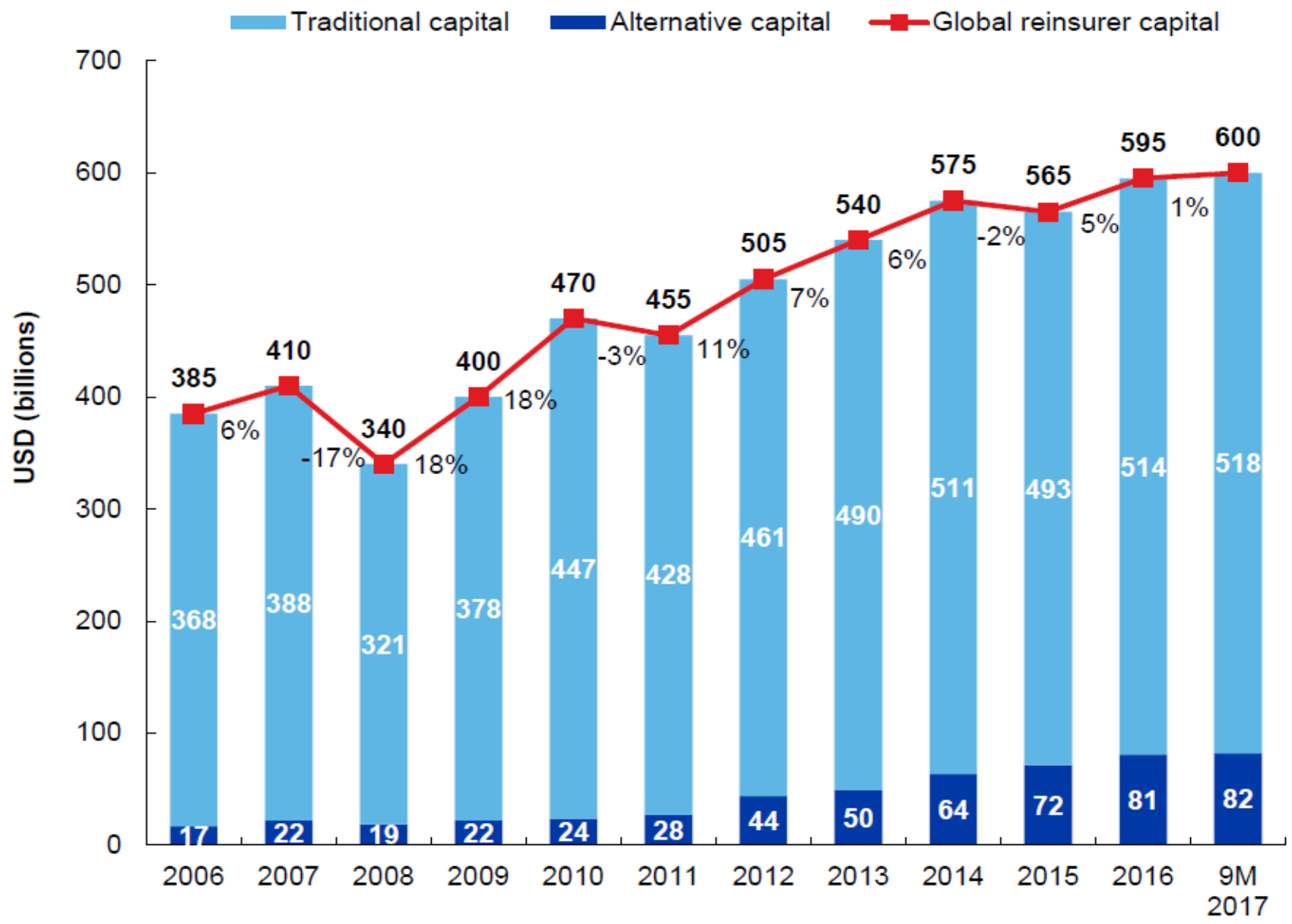
Source: Insurance Information Institute; NAIC, ISO, A.M. Best, Conning

Historical Results

Reinsurer vs. P/C Industry

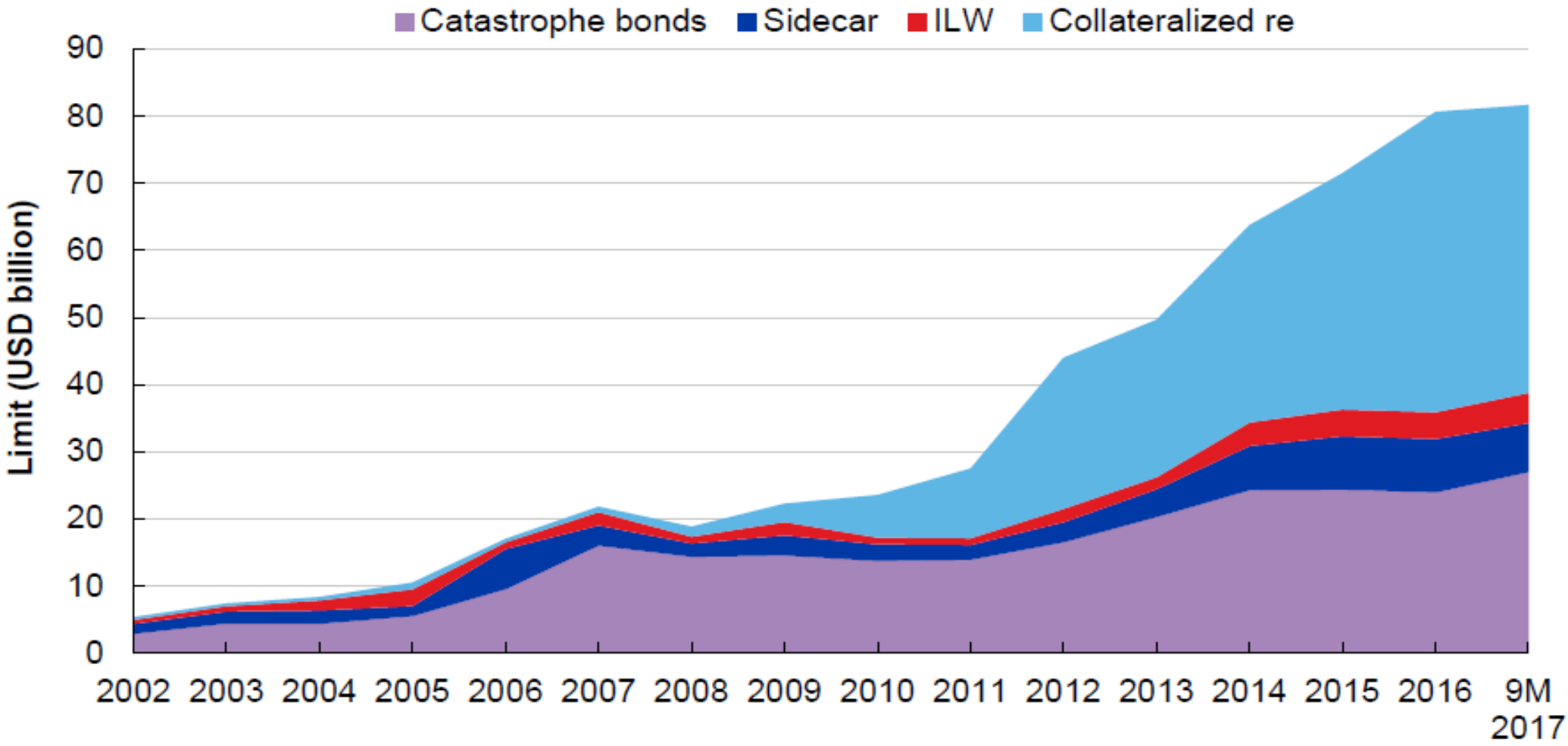
Year	Reinsurer Combined Ratio	P/C Industry Combined Ratio
1996	102.90%	106.02%
1997	101.50%	101.63%
1998	105.90%	105.74%
1999	114.00%	107.86%
2000	112.80%	110.27%
2001	139.30%	116.00%
2002	117.40%	107.31%
2003	101.10%	100.19%
2004	105.50%	98.49%
2005	126.00%	100.91%
2006	94.20%	92.44%
2007	93.50%	95.61%
2008	100.40%	105.12%
2009	92.30%	100.41%
2010	94.50%	102.49%
2011	107.10%	108.34%
2012	96.20%	103.15%
2013	86.80%	96.35%
2014	91.00%	97.21%
2015	92.30%	97.95%
2016	95.10%	100.76%

Change in Global Reinsurer Capital



Sources: Company financial statements and Aon Benfield Analytics / Aon Securities Inc.

Alternative Capital Deployment



Source: Aon Securities Inc.

How Does This Impact Program Managers

- The insurance industry had a record high surplus of $710B entering the 2017 hurricane season, compared with less than $600B when Sandy hit in 2012, and slightly more than $400B when Katrina hit in 2005.
- What if Irma was a $200 billion event? How would Carriers/Reinsurers respond?

Lessons Learned from 2017

PCS Estimate of Insured Property Damage – By Line of Business

PCS ID	Event Name	Total Loss	Personal	Commercial	Auto
1743	Hurricane Harvey	$ 15,703,600,000	$ 2,948,500,000	$ 8,179,600,000	$ 4,575,500,000
1744	Hurricane Irma	$ 17,212,765,000	$ 9,937,600,000	$ 6,676,425,000	$ 598,740,000
1745	Hurricane Maria	$ 23,974,550,000	$ 2,623,000,000	$ 20,970,000,000	$ 381,550,000
1747	Atlas Fire	$ 2,438,000,000	$ 1,732,000,000	$ 674,000,000	$ 32,000,000
1748	Tubbs Fire	$ 7,329,100,000	$ 5,300,000,000	$ 1,960,000,000	$ 69,100,000
1749	Mendocino Lake Complex Fire	$ 624,100,000	$ 488,000,000	$ 129,500,000	$ 6,600,000
1754	Thomas Fire	$ 1,735,300,000	$ 850,000,000	$ 872,500,000	$ 12,800,000
1755	Creek Fire	$ 266,550,000	$ 161,000,000	$ 102,000,000	$ 3,550,000
1756	Lilac Fire	$ 99,390,000	$ 73,000,000	$ 24,700,000	$ 1,690,000
TOTAL		$ 69,383,355,000	$ 24,113,100,000	$ 39,588,725,000	$ 5,681,530,000

PCS ID	Event Name	Total Loss	Personal	Commercial	Auto
1743	Hurricane Harvey	100%	19%	52%	29%
	RMS		*32%*	*61%*	*7%*
1744	Hurricane Irma	100%	58%	39%	3%
	RMS		*67%*	*32%*	*4%*
1745	Hurricane Maria	100%	11%	87%	2%
	RMS		*56%*	*44%*	--
	AIR		*19%*	*79%*	*2%*

*Please note that BMS is contractually prohibited from sharing individual PCS event loss estimates publically.

Demand Surge

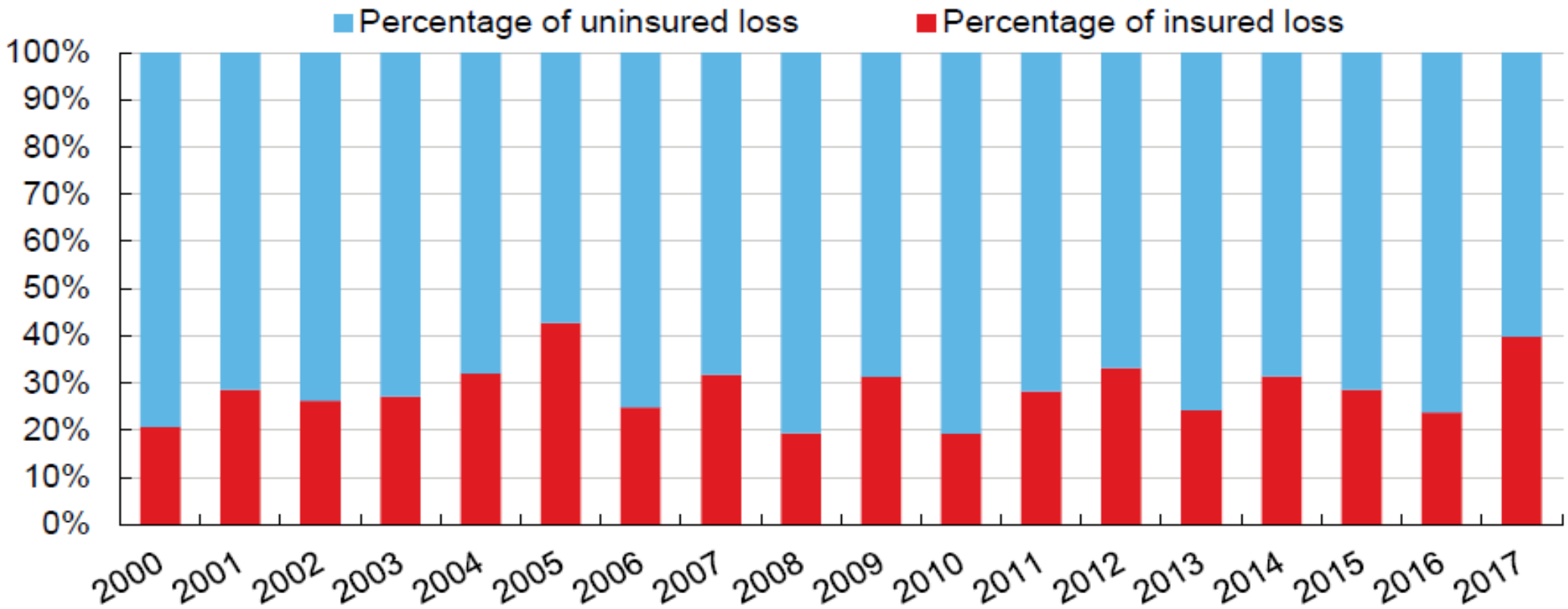
- At the start of 2017, there were 57,000 independent claims adjusters.
- Large insurers also contract with independent adjusters.
- This created a bottleneck for loss adjustors and caused the prices on loss adjustment expense to increase up to 25 percent, triggering possible loss beyond the normal standards.
- Technology is also helping.

Source: WSJ

California Wildfires

- Catastrophe risk modeler RMS calculates the region sustained $3 billion to $6 billion of insured and economic losses as of Oct. 12. The figures do not include automobile or crop losses, and RMS wrote in a blog post that long-term business interruption to the wine industry “could result in a higher total loss.” (Insurance Journal)
- The vast majority of the wine country claims originated in Sonoma County, where the bulk of the deaths occurred and losses now total $6.9 billion. A total of 14,686 claims have been filed by residents and businesses in Sonoma County. Another 2,470 claims have been filed in Napa County. (Sacramento Bee)

The Protection Gap

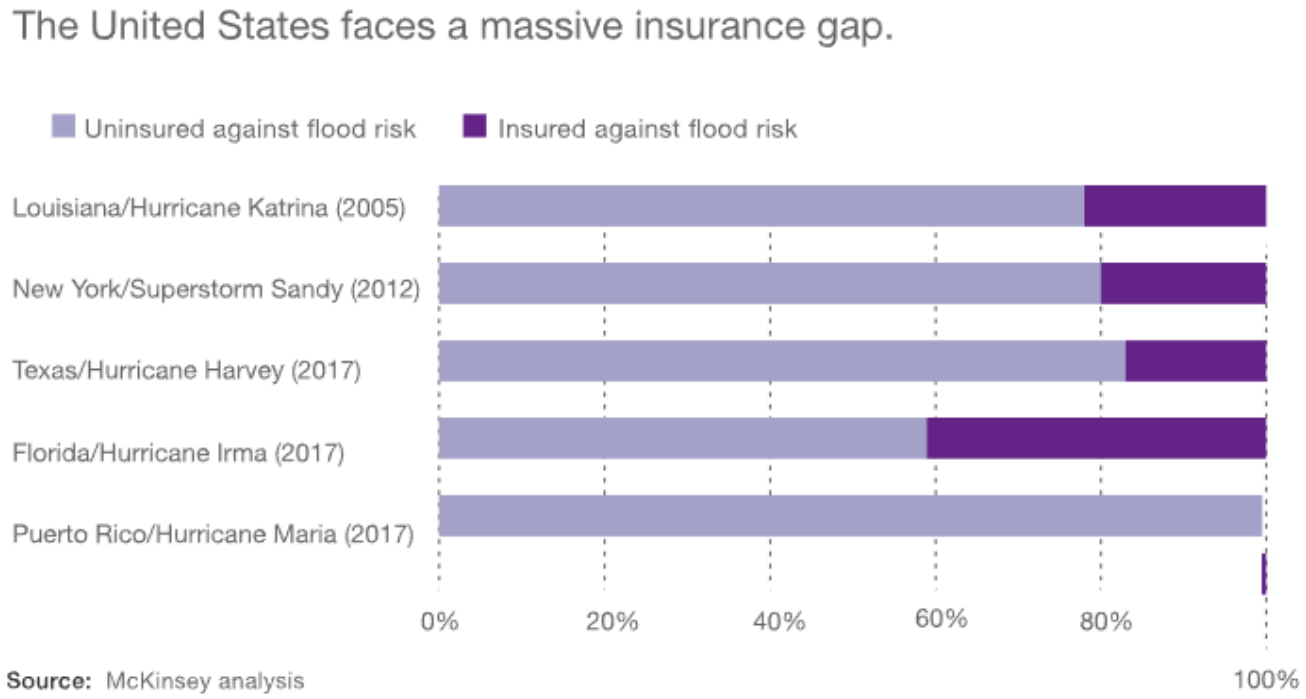


Source: Aon Benfield Analytics

Opportunities for Program Managers

Flood is a Growth Area

Flood insurance penetration in counties most affected by Harvey, Irma, and Maria reveals that as many as 80% of Texas homeowners, 60% of Florida homeowners, and 99% of Puerto Rican homeowners did not have flood insurance. Across the country, the low flood insurance take-up rate has been worrisome for some time.



Business Interruption Insurance

Source: AP

- According to the Federal Emergency Management Agency (FEMA), almost 40% of small businesses never reopen their doors after a disaster.
- Recent data from the CNBC Small Business Survey also shows that most small business owners don't spend much time thinking about the environment as a critical factor to their business.
- Survival of the fittest — or those with the best insurance.

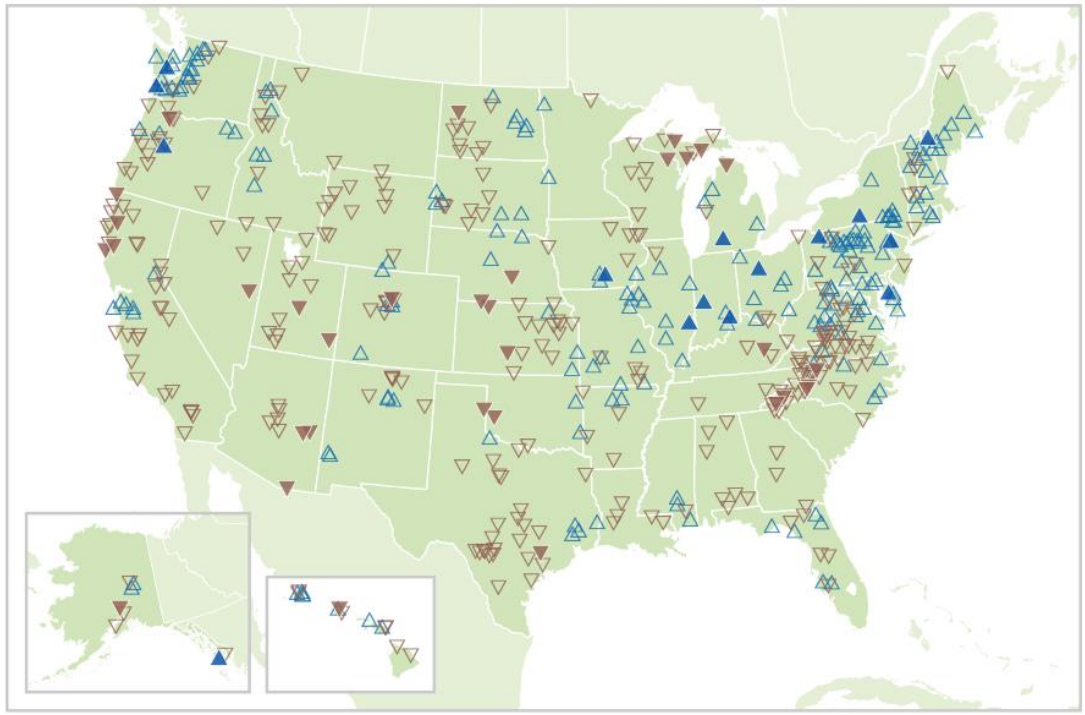
Thank You –
Question and Answers

Weather / Climate Data

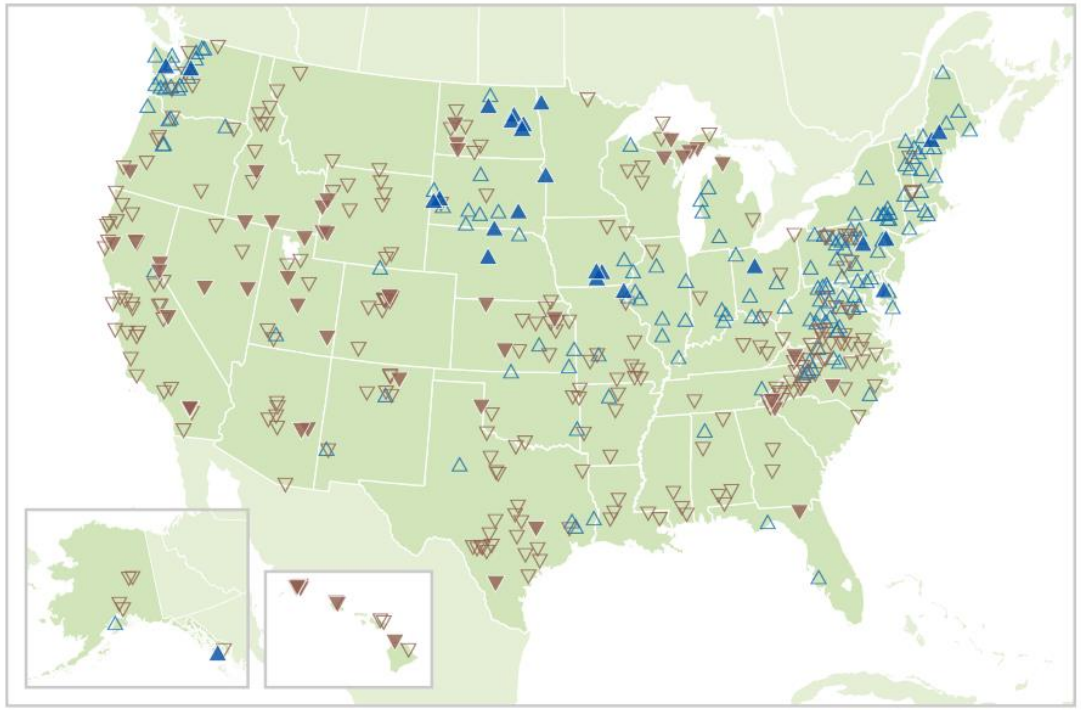
Rainfall / Flood

River Flood Frequency and Magnitude

Change in the Magnitude of River Flooding in the United States, 1965–2015



Change in the Frequency of River Flooding in the United States, 1965–2015



▼ **Significant decrease**

▽ **Insignificant decrease**

△ **Insignificant increase**

▲ **Significant increase**

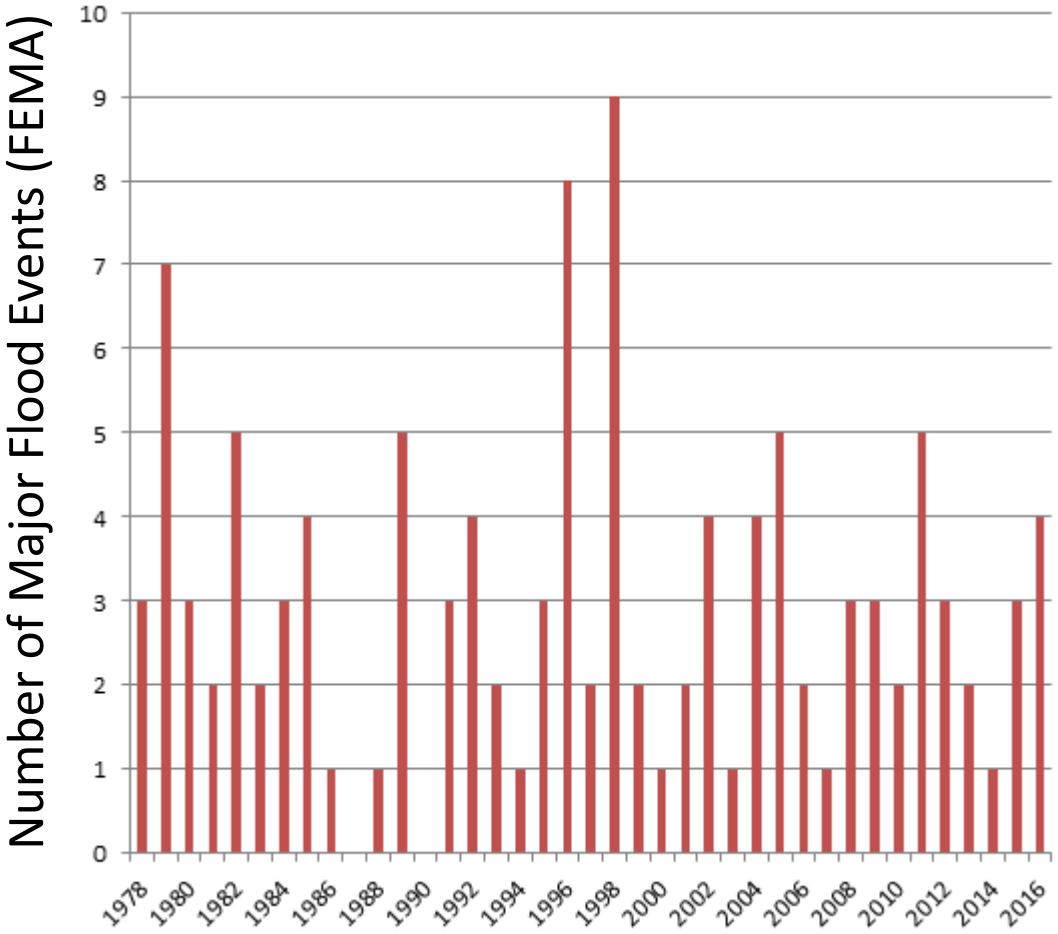
Data source: Slater, L., and G. Villarini. 2016 update and expansion to data originally published in: Mallakpour, I., G. Villarini. 2015. The changing nature of flooding across the central United States. Nature Climate Change 5:250–254.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climate-indicators.

Flood Losses Continue

- Major U.S. flood events continue to be a major loss focus.
- 2016 had three major flooding events:
  - Late winter severe storms – March
  - Texas torrential rains – April
  - Louisiana flooding – August
- 2017 had two major flooding events:
  - Hurricane Harvey
  - Hurricane Irma
- However, no real trend in flood event since 1978

Major Flood Event of at least 1,500 FEMA claims.



Source: FEMA

The 1-in-1000-year rainfall/flood event

12 The number of these rainfall events that have occurred across the U.S. since 2010.

2016 April – Houston, TX

June – Greenbrier, Kanawha and Nicholas Counties, WV

July – Ellicott City, MD

August – Louisiana Floods

2017 Late April/early May – southern MO

August – Hurricane Harvey – Houston, TX

A 1-in-1,000-year rain event is a statistical way of expressing the probability of such a massive rainfall occurring in any given year in a given location. There is less than a 0.1 percent chance of it happening in any given year.

No New U.S. Extreme Rainfall Records

U.S. Record Point Rainfalls

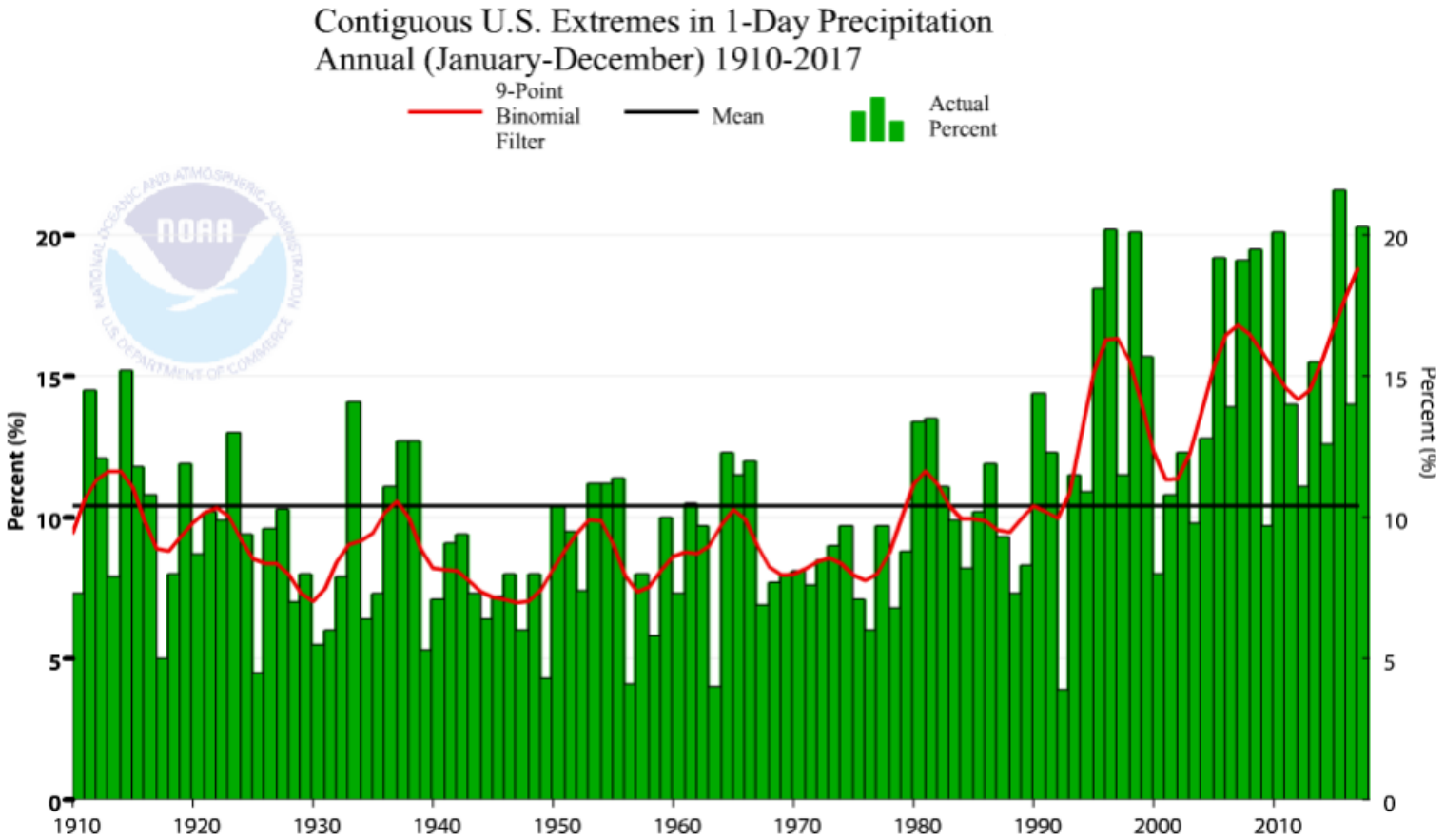
Time	Rainfall	Location	Date
1 minute	1.23″	Unionville, MD	7/4/1956
5 minutes	2.03″	Alamogordo Creek, NM	6/5/1960
12 minutes	2.30″	Embarrass, WI	5/28/1881
15 minutes	3.95″	Galveston, TX	6/4/1871
30 minutes	7.00″	Cambridge, OH	7/16/1914
40 minutes	9.25″	Guinea, VA	8/24/1906
42 minutes	12.00″	Holt, MO	6/22/1947*
1 hour	13.80″	Central WV	5/4-5/1943
1 hour 30 minutes	14.60″	Central WV	5/4-5/1943
2 hours	15.00″	Woodward Ranch, (D'Hanis) TX	5/31/1935
2 hours 30 minutes	19.00″	Rockport, WV	7/18/1889
2 hours 45 minutes	22.00″	Woodward Ranch, (D'Hanis) TX	5/31/1935*
3 hours	28.50″est.	Smethport, PA	7/18/42*
4 hours 30 minutes	30.70″	Smethport, PA	7/18/42*
12 hours	34.30″	Smethport, PA	7/17-18/1942
18 hours	36.40″	Thrall, TX	9/9/1921
24 hours	43.00″	Alvin, TX	7/25-26/1979
4 days	62.00″	Kukaiau, Hamakua, HI	2/27-3/2/1902
8 days	82.00″	Kukaiau, Hamakua, HI	2/27-3/6/1902
1 month	148.83″	Mt. Waialeale, Kauai, HI	3/1982
1 month (mainland)	71.54″	Helen Mine, CA	1/1909
1 year	704.83″	Kukui, Kauai, HI	1982
1 year	332.29″	MacLeeod Harbor, AK	1976
1 year (mainland)	204.12″	Laurel Mountain, OR	1996

*constitutes a world record

No U.S. location has experienced a record rainfall in terms of the amount of rain in a given amount of time. This suggests the rain rate has not increased.

Source: Wunderground.com Chris Burt

Extreme Precipitation

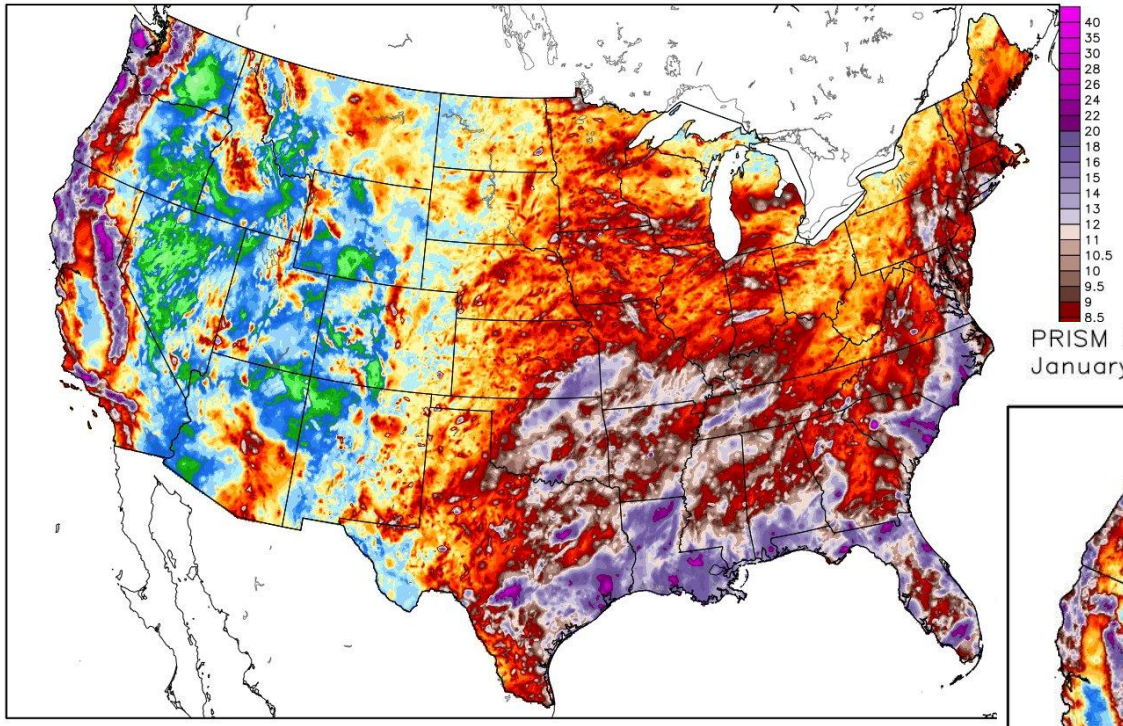


The U.S. Climate Extreme Index quantifies the observed changes in one-day precipitation extremes across the U.S.

Since 1990, there has been an increase in the area of the U.S. that has experienced a one-day extreme rainfall.

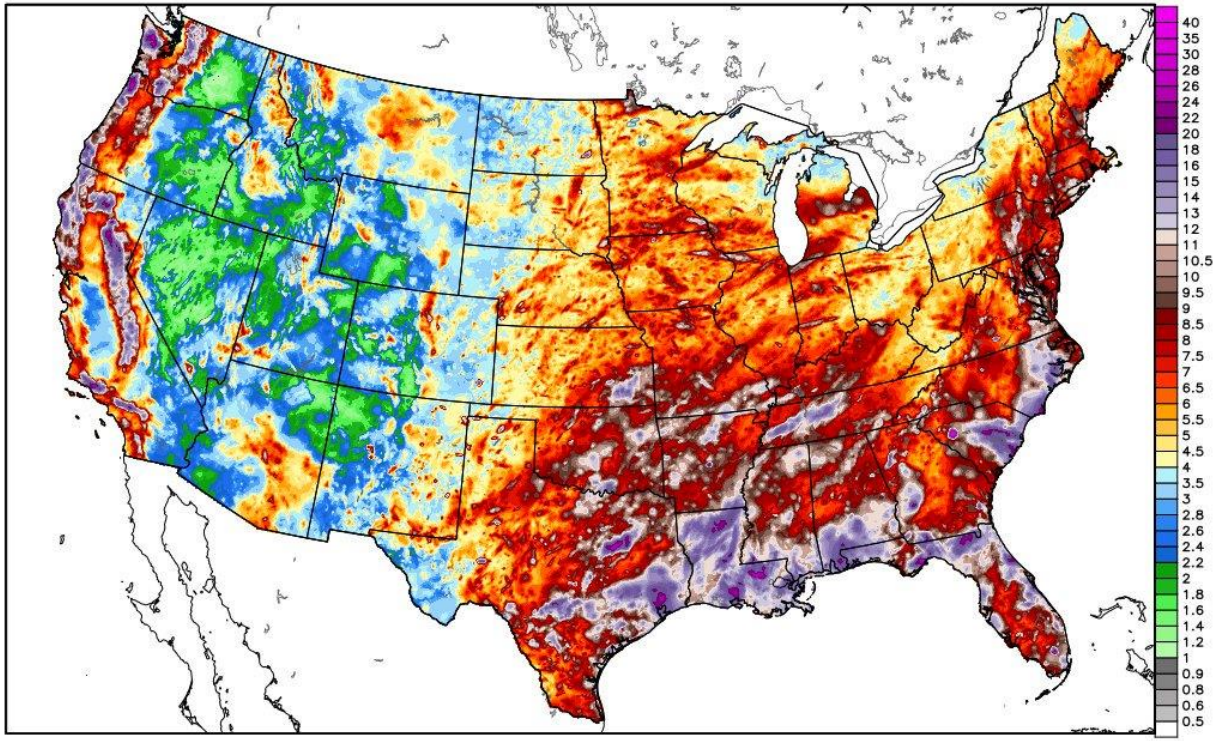
What is the expected maximum rainfall?

PRISM Maximum 5–day Precipitation Total
January 1, 1981 – August 28, 2017 12z



Data Ownership: PRISM Climate Group, Oregon State University | 1405x621 0.042° x 0.042°

PRISM Maximum 3–day Precipitation Total
January 1, 1981 – August 15, 2016 12z



Data Ownership: PRISM Climate Group, Oregon State University | 1405x621 0.042° x 0.042°

Source: RyanMaue