
Source: NASA

THE FUTURE OF U.S. WEATHER CATASTROPHES

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AIMU Marine Insurance Day
2 October 2015

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Agenda

- Natural Catastrophes at the start of the 21st Century
- You Are Here: Welcome to Our Changing Climate
- Climate Change Impacts on U.S. Weather Catastrophes

NATURAL CATASTROPHES AT THE START OF THE 21ST CENTURY

Source: Munich Re

Source: Munich Re


Post-Tropical Storm Sandy
October 29, 2012
9 NOV
Source: Munich Re


Joplin EF5 Tornado
May 22, 2011
STOP
Photo: FEMA

The Costliest Natural Catastrophes Since 1980

In terms of Insured Losses, in Original Dollars

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Period	Event	Affected Area	Overall losses	Insured losses	Fatalities
			US$ m, original values		
25-30.8.2005	Hurricane Katrina, storm surge	USA: LA, New Orleans, Slidell; MS, Biloxi, Pascagoula, Waveland, Gulfport	125,000	62,200	1,322
11.3.2011	Earthquake, tsunami	Japan: Honshu, Aomori, Tohoku; Miyagi, Sendai; Fukushima, Mito; Ibaraki; Tochigi, Utsunomiya	210,000	40,000	15,840
24-31.10.2012	Hurricane Sandy, storm surge	Bahamas, Cuba, Dominican Republic, Haiti, Jamaica, Puerto Rico, USA, Canada	65,000	30,000	210
6-14.9.2008	Hurricane Ike	USA, Cuba, Haiti, Dominican Republic, Turks and Caicos Islands, Bahamas	38,000	18,500	170
23-27.8.1992	Hurricane Andrew	USA: FL, Homestead; LA; Bahamas	26,500	17,000	62
1.8-15.11.2011	Floods	Thailand: Phichit, Nakhon Sawan, Phra Nakhon Si Ayuttaya, Pathumthani, Nonthaburi, Bangkok	43,000	16,000	813
June - Sept 2012	Drought, heat wave	USA: Midwest	20,000	15,000-17,000	100
17.1.1994	Earthquake	USA: CA, Northridge, Los Angeles, San Fernando Valley, Ventura, Orange	44,000	15,300	61
7-21.9.2004	Hurricane Ivan	USA, Caribbean, Venezuela, Colombia, Mexico	23,000	13,800	120
22.2.2011	Earthquake	New Zealand: South Island, Canterbury, Christchurch, Lyttelton	16,000	13,000	185

As at: March 2013

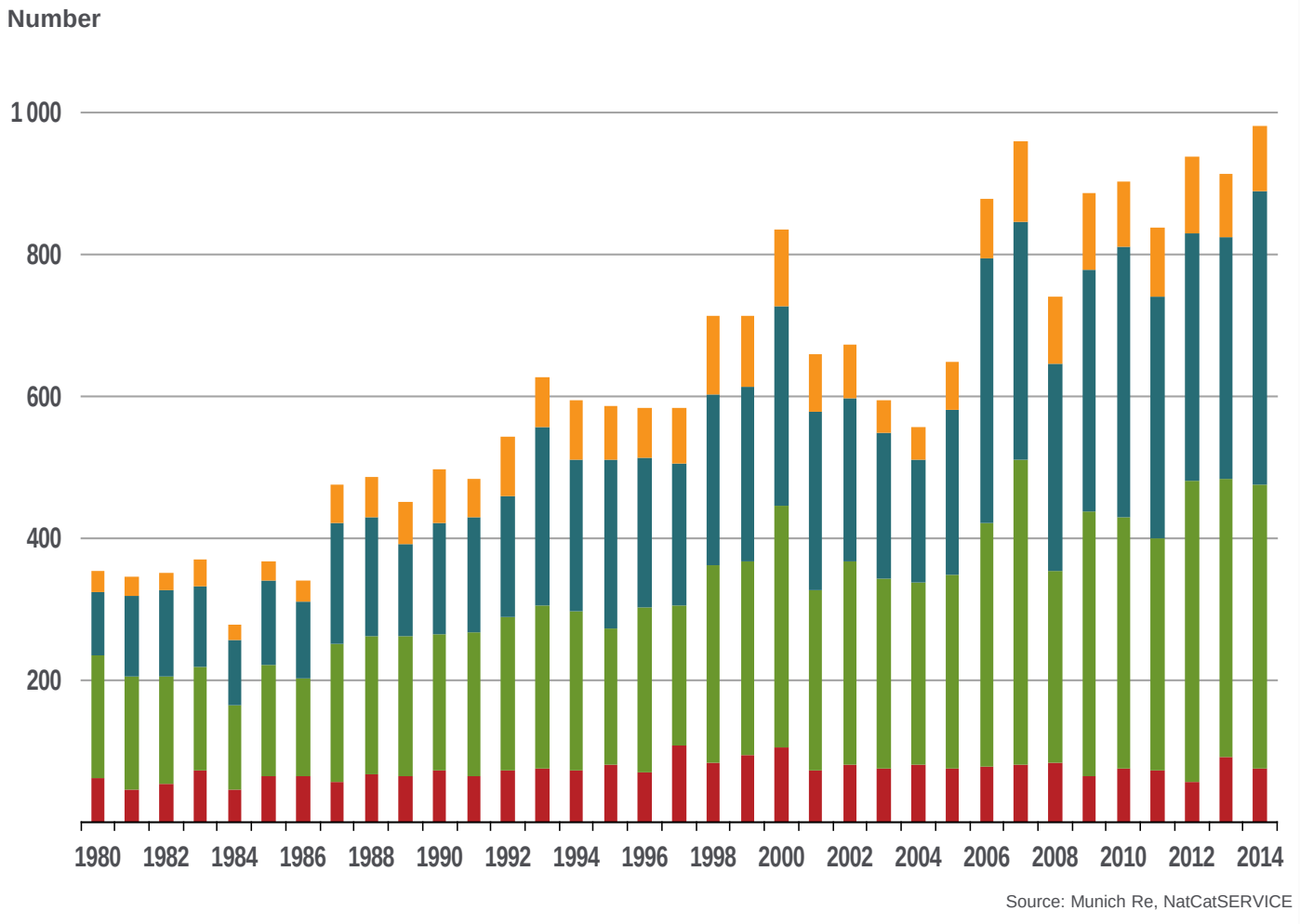
8 of the top 10 insured losses have occurred in the past decade

7 of the top 10 affected the United States

5 of the top 10 were U.S. hurricane events

Loss events worldwide 1980 – 2014

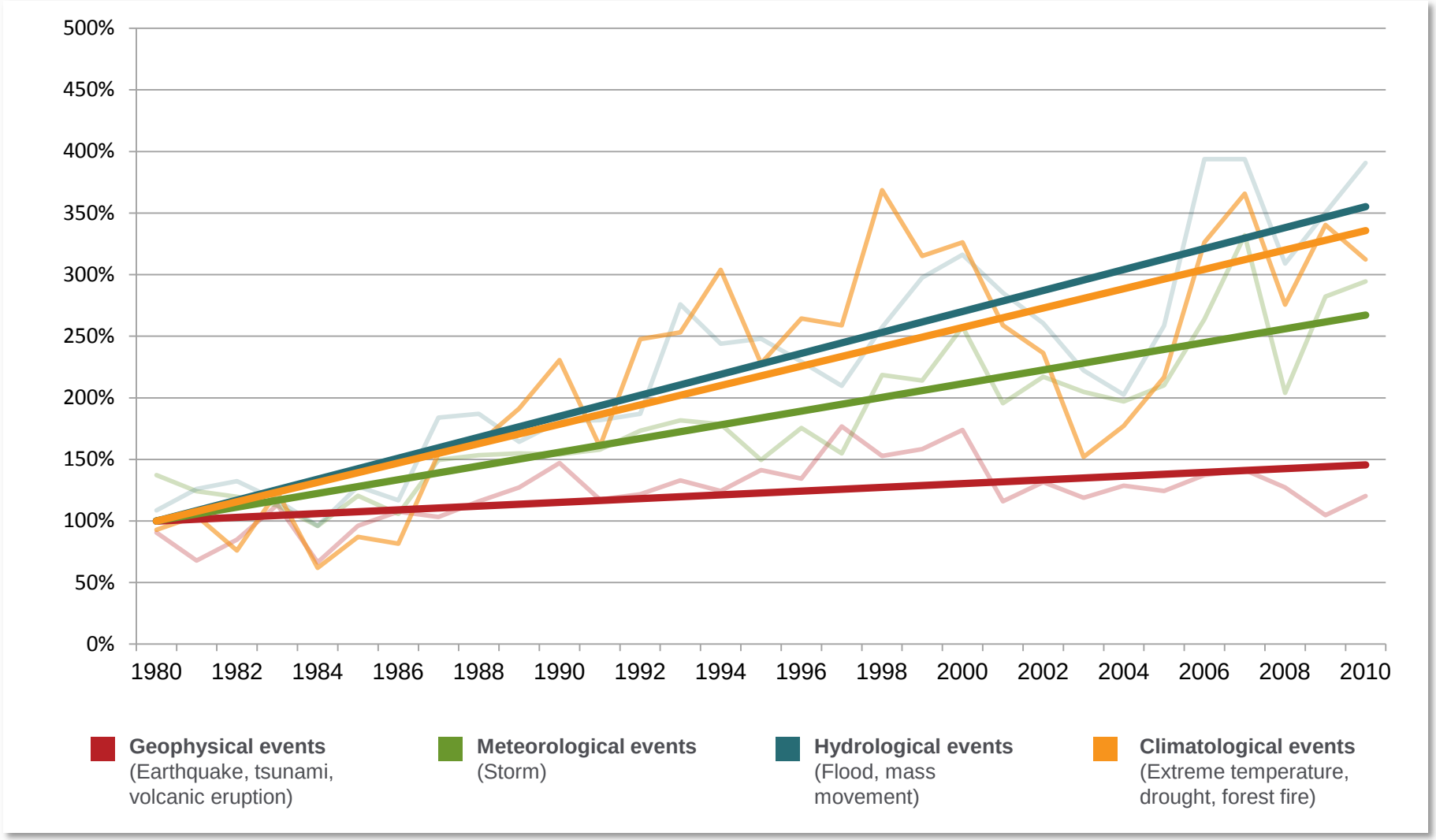
Number of events



Source: Geo Risks Research, NatCatSERVICE – As at January 2015

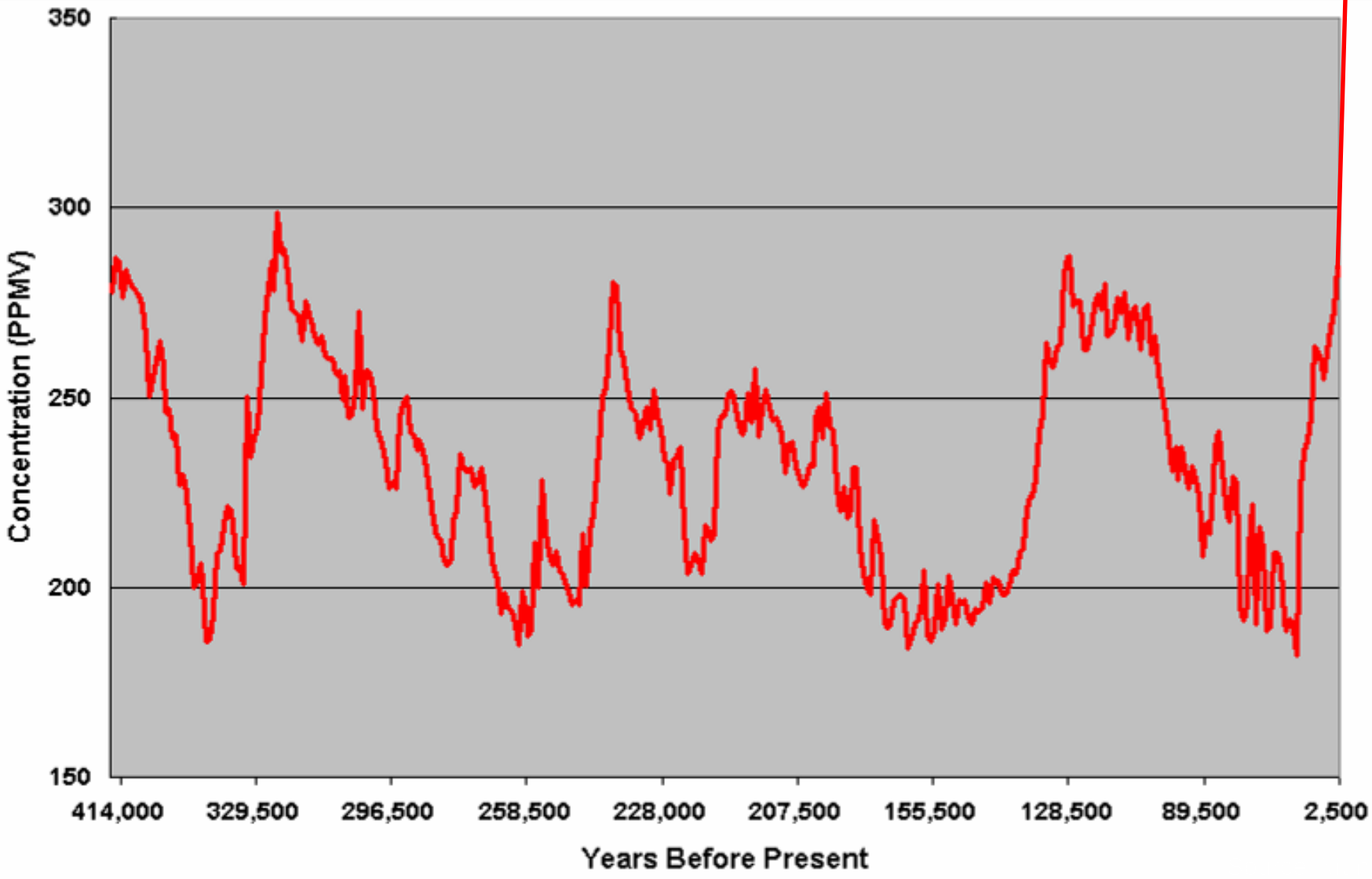
Natural Catastrophes Worldwide 1980 – 2010

Number of events with relative trends



Source: Munich Re NatCat*SERVICE*

YOU ARE HERE:
WELCOME TO OUR CHANGING CLIMATE



Is Our Weather Actually Changing?

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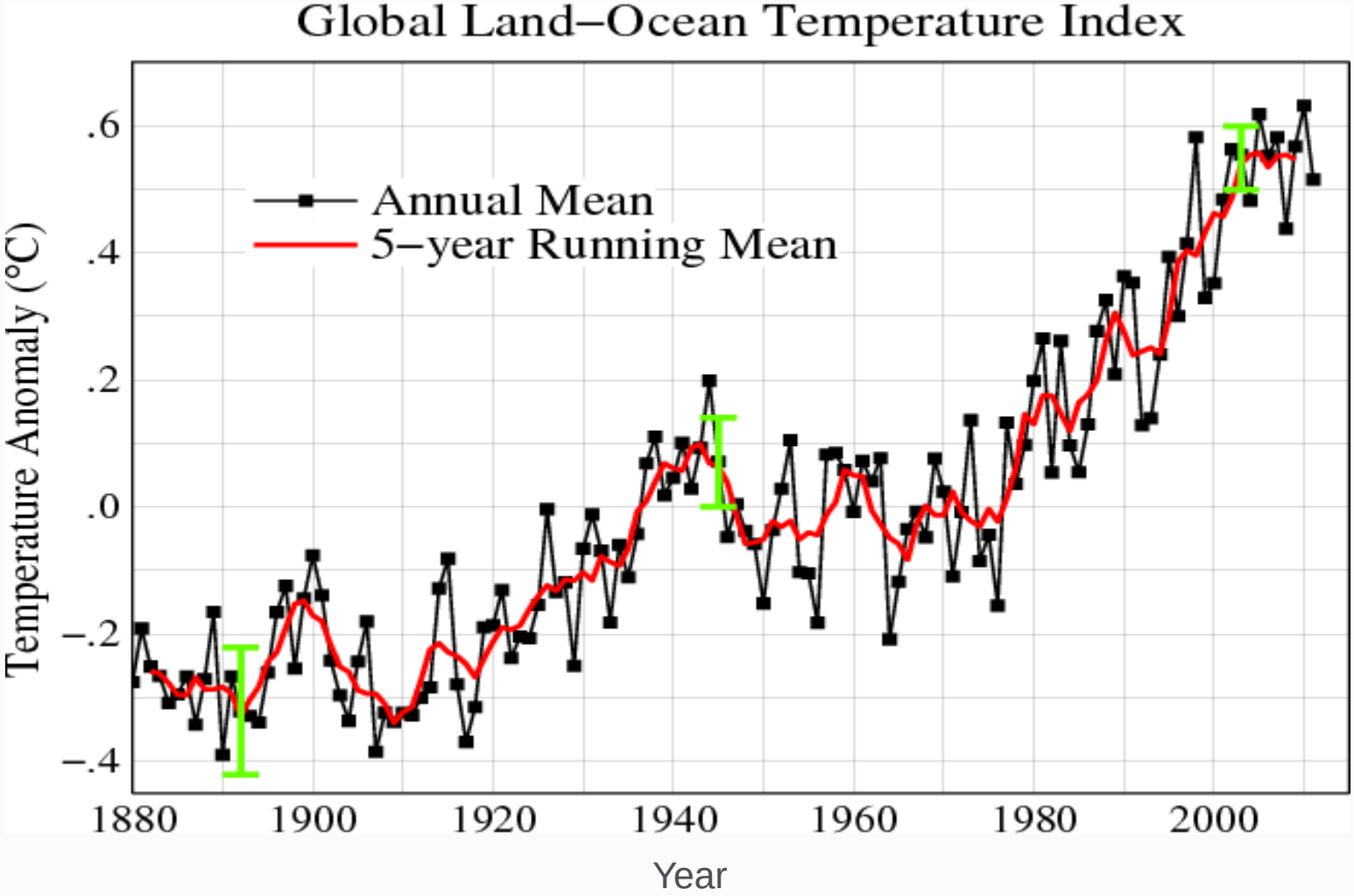
- Long-term weather patterns are always changing.
  - Abrupt changes: Comet/Meteor Impacts, volcanism, etc.
  - Very slow changes: Changes in solar radiation, ice ages, atmospheric chemistry, continental drift, etc.
  - Local land use changes: Deforestation, urban heat islands, etc.
- But there is now an abundance of evidence that human activity is increasing the rate of change.
  - Emissions from human activity are changing atmospheric chemistry.
  - Carbon dioxide and other greenhouse gases prevent excess heat from radiating away from our planet.
  - Biggest impacts are currently seen in the ocean and in polar regions.

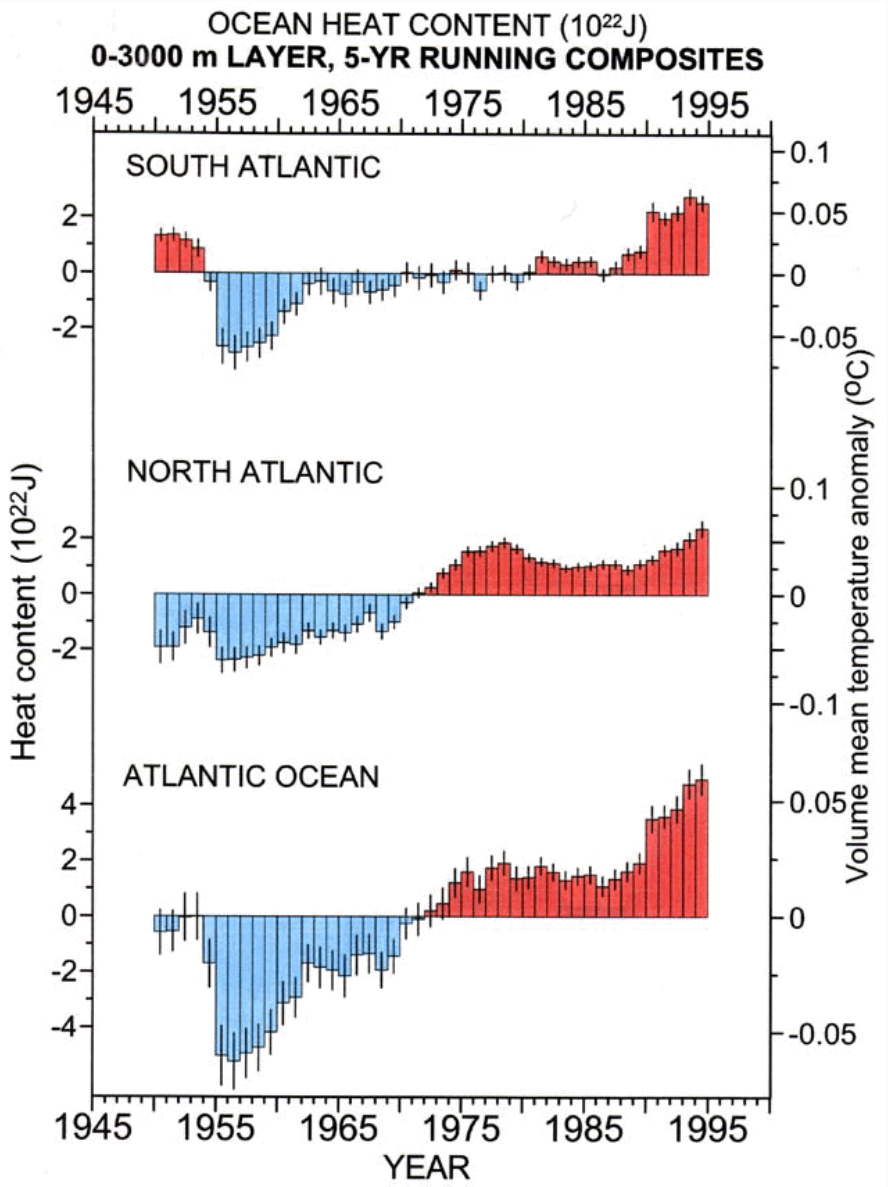
Global Mean Temperature, 1880 - Present



As compared to 1951- 1980 Average

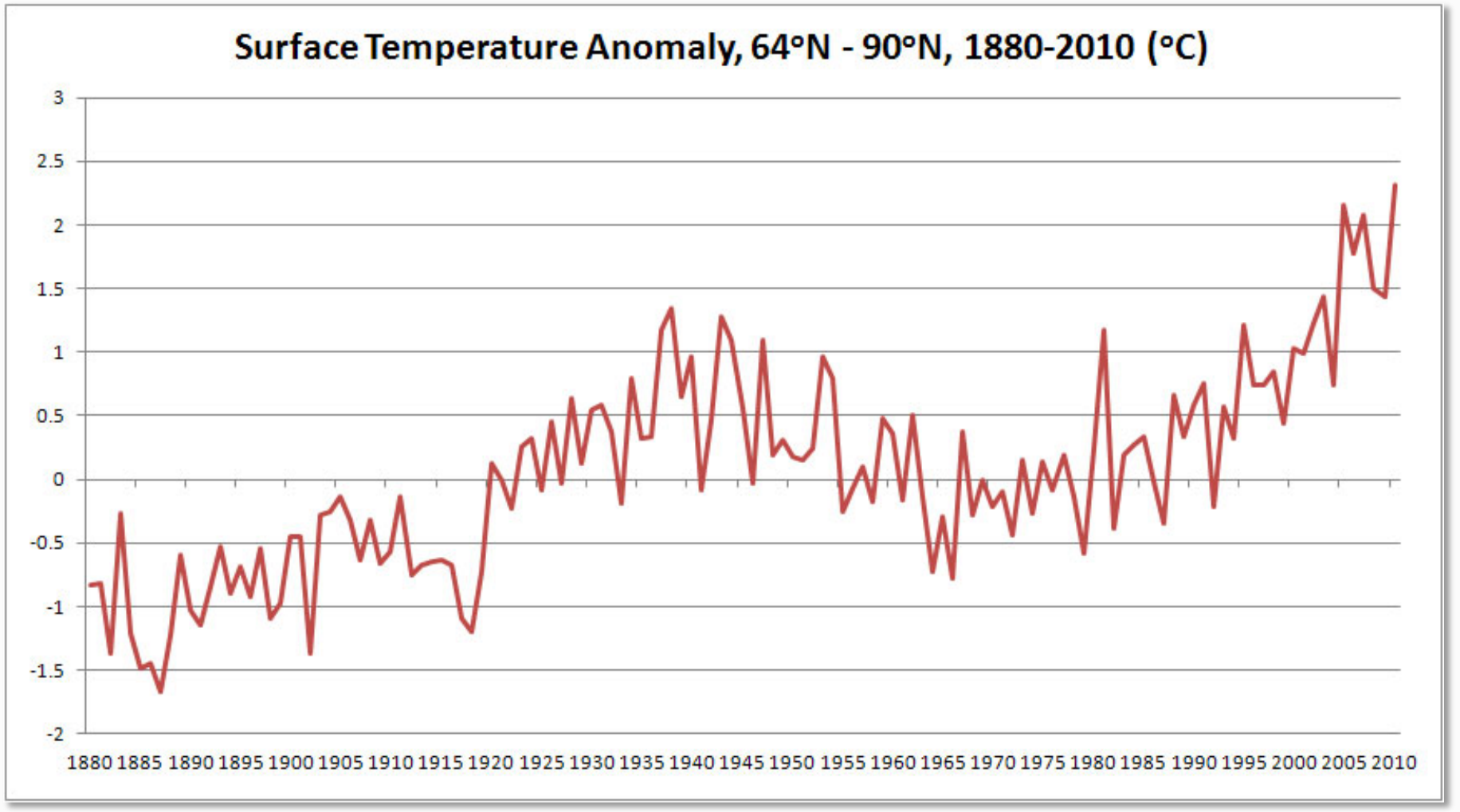
Climate Change and the World's Oceans

- Water is a very good capacitor of heat energy, and most of the excess heat trapped by climate change has gone into our oceans.
- Our oceans have also absorbed significant amounts of excess atmospheric carbon dioxide.
- This creates two big problems:
  - Coral Bleaching
  - Ocean Acidification



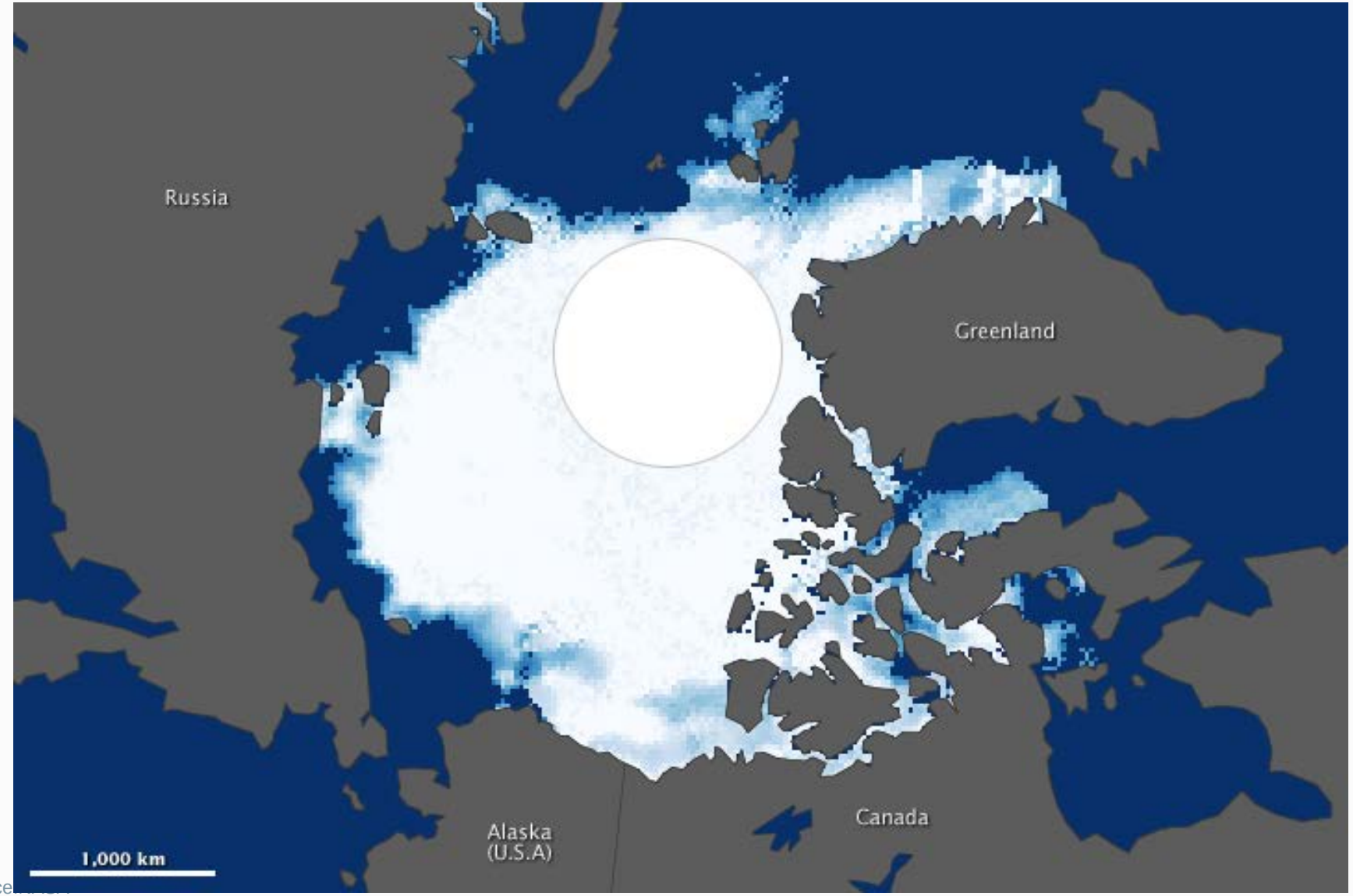
Source: NOAA

Arctic Temperature Anomalies, 1880 - 2010



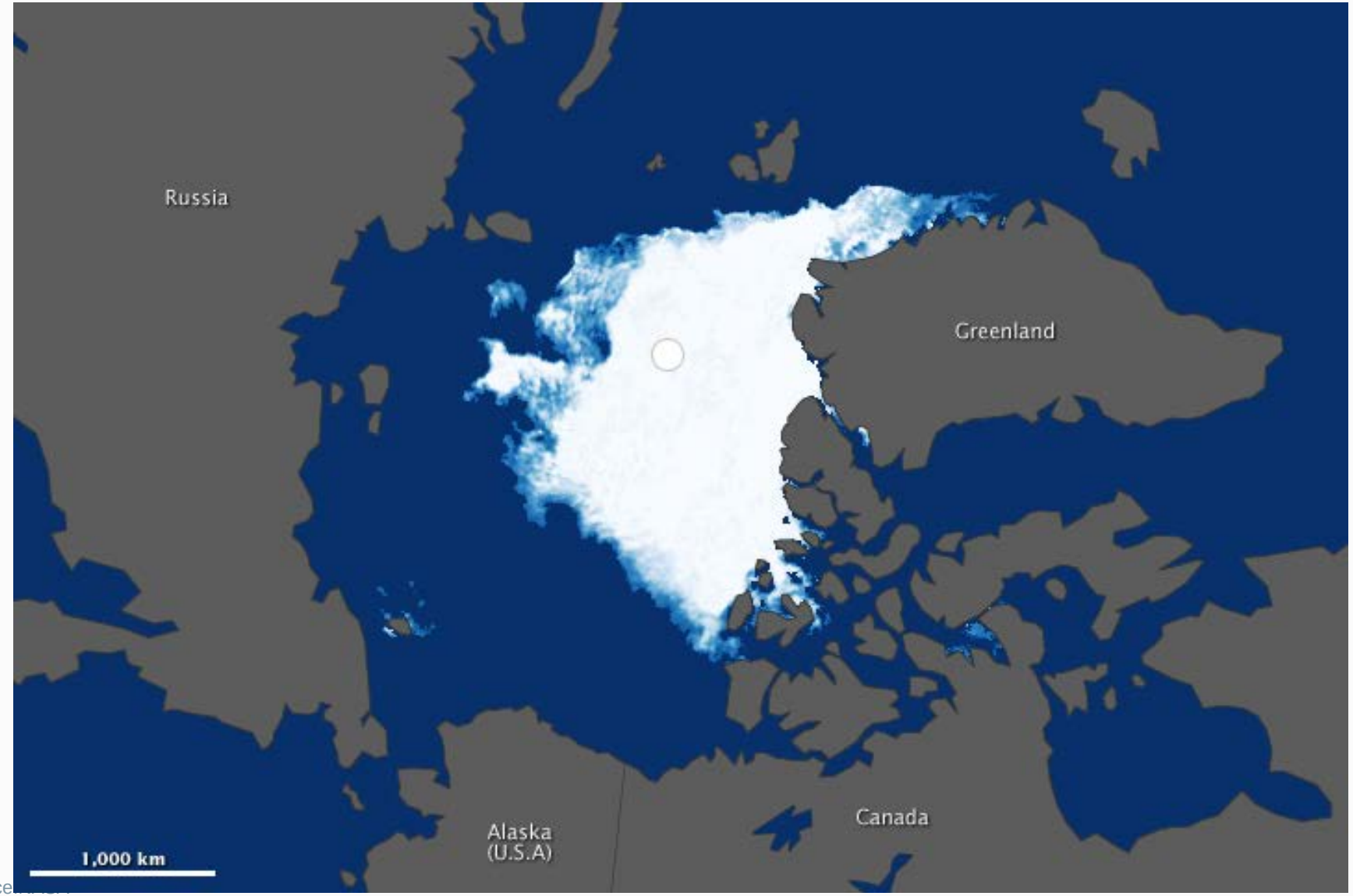
Source:NASA

Changes in Arctic Sea Ice Minimum 1984 vs. 2012



Source:

Changes in Arctic Sea Ice Minimum 1984 vs. 2012

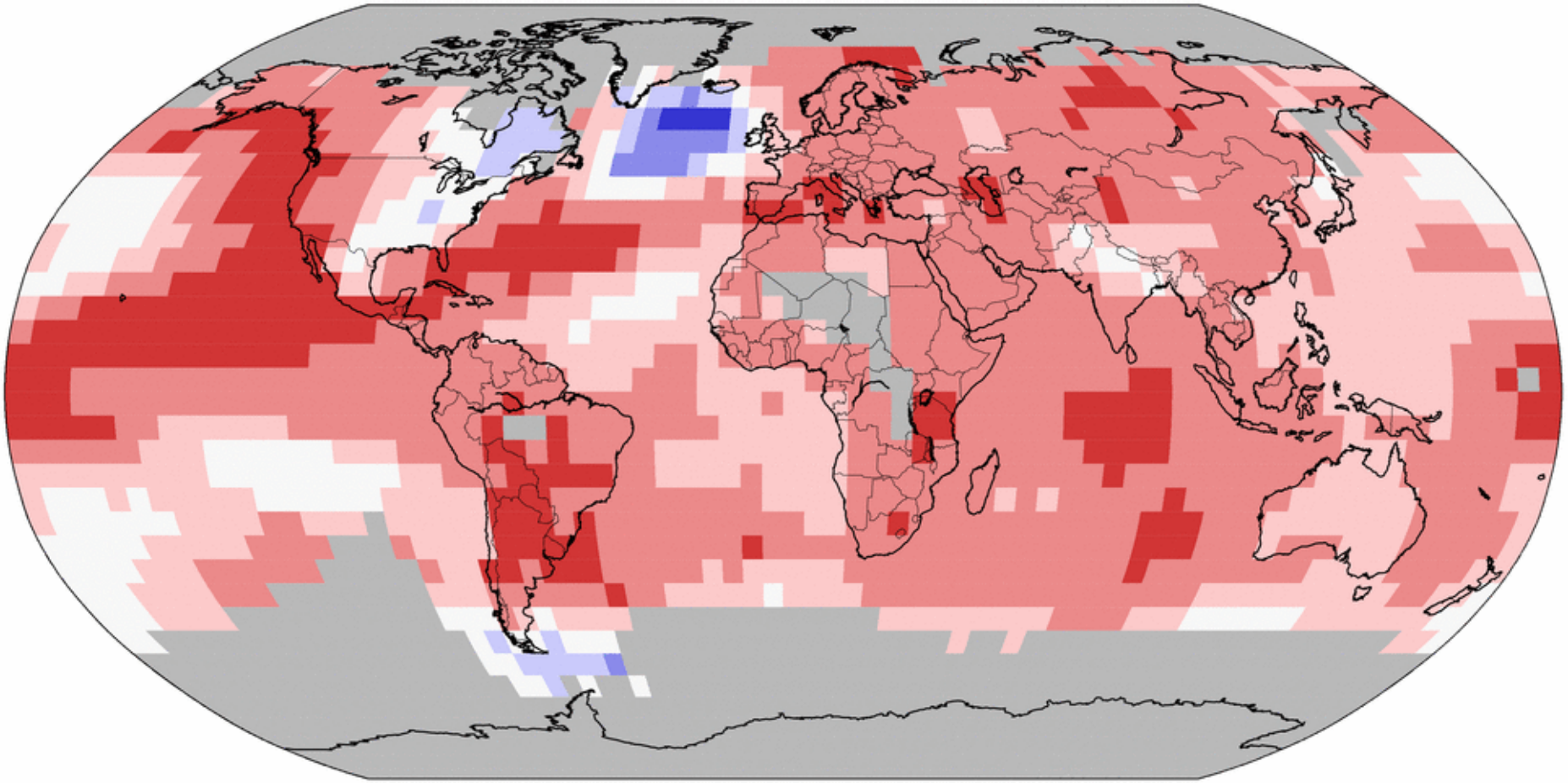


Source:

Land & Ocean Temperature Percentiles Jan–Aug 2015

NOAA's National Centers for Environmental Information

Data Source: GHCN–M version 3.3.0 & ERSST version 4.0.0



Record Coldest | Much Cooler than Average | Cooler than Average | Near Average | Warmer than Average | Much Warmer than Average | Record Warmest

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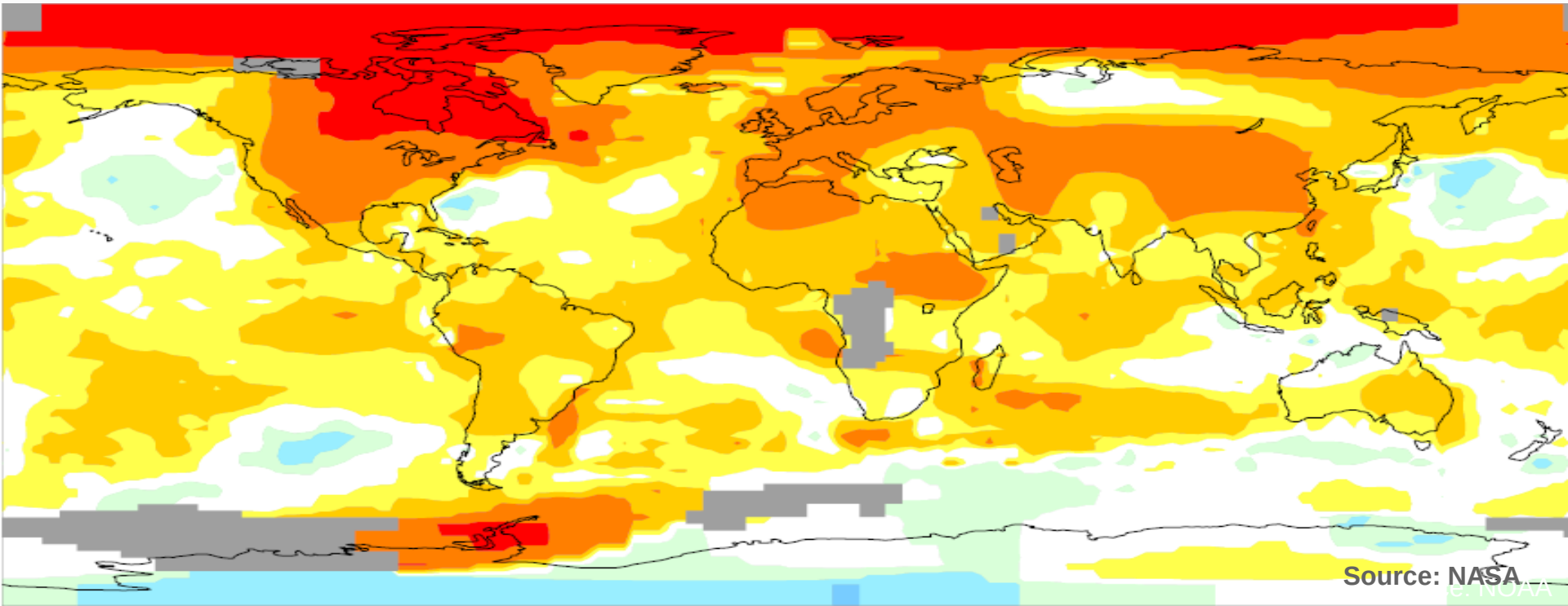
CLIMATE CHANGE IMPACTS ON U.S. WEATHER CATASTROPHES



Source: NASA, NOAA

Climate Change and U.S. Meteorological Perils: General Predictions

The more large-scale the phenomena, the more confident one can be with predicted likelihood and impacts.

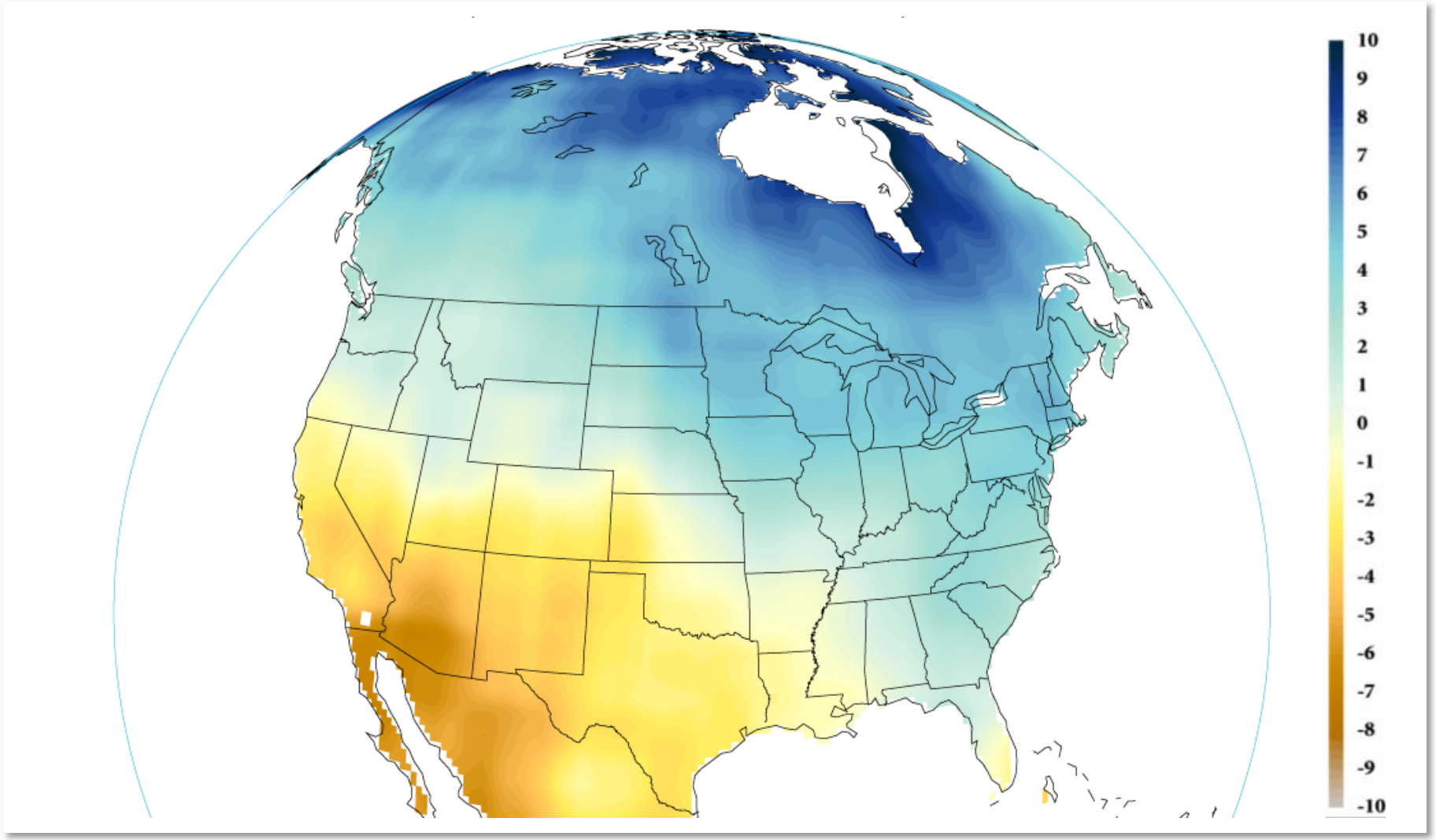
Most confidence
Changes in Hydrological Cycle

- Arid regions will tend to become drier (Southern California, Intermountain West and Desert Southwest)
- Wet regions will tend to become wetter (Pacific Northwest, Northern Plains, Midwest, Eastern Seaboard)

Less confidence
Changes in frequency and severity of

- Winter Storms
- Thunderstorms
- Tropical Cyclones

Projected Change in Precipitation, 2021-2040 vs. 1950-2000 (%)



Source: GFDL / NOAA

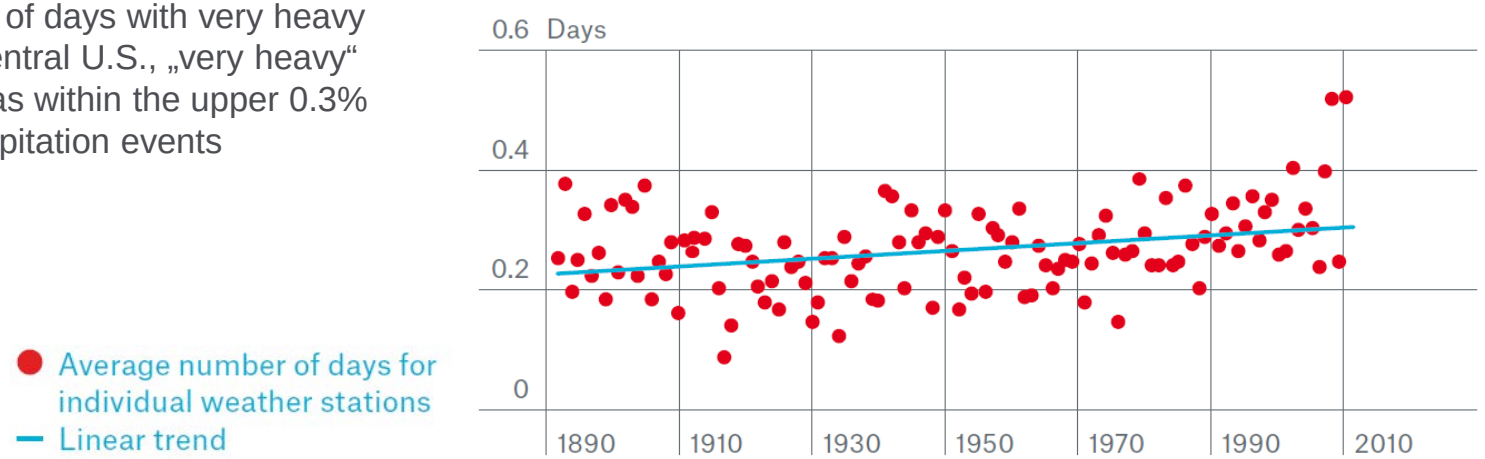
Heavy precipitation in North America

Observed and projected changes

Observed changes

- Increasing frequency and intensity of heavy precipitation events
- Strongest increase in heavy precipitation in the region Midwest and Northeast

Annual number of days with very heavy rainfall in the central U.S., „very heavy“ being defined as within the upper 0.3% of all daily precipitation events



Projected changes

-> Precipitation intensity rise over the contiguous North America

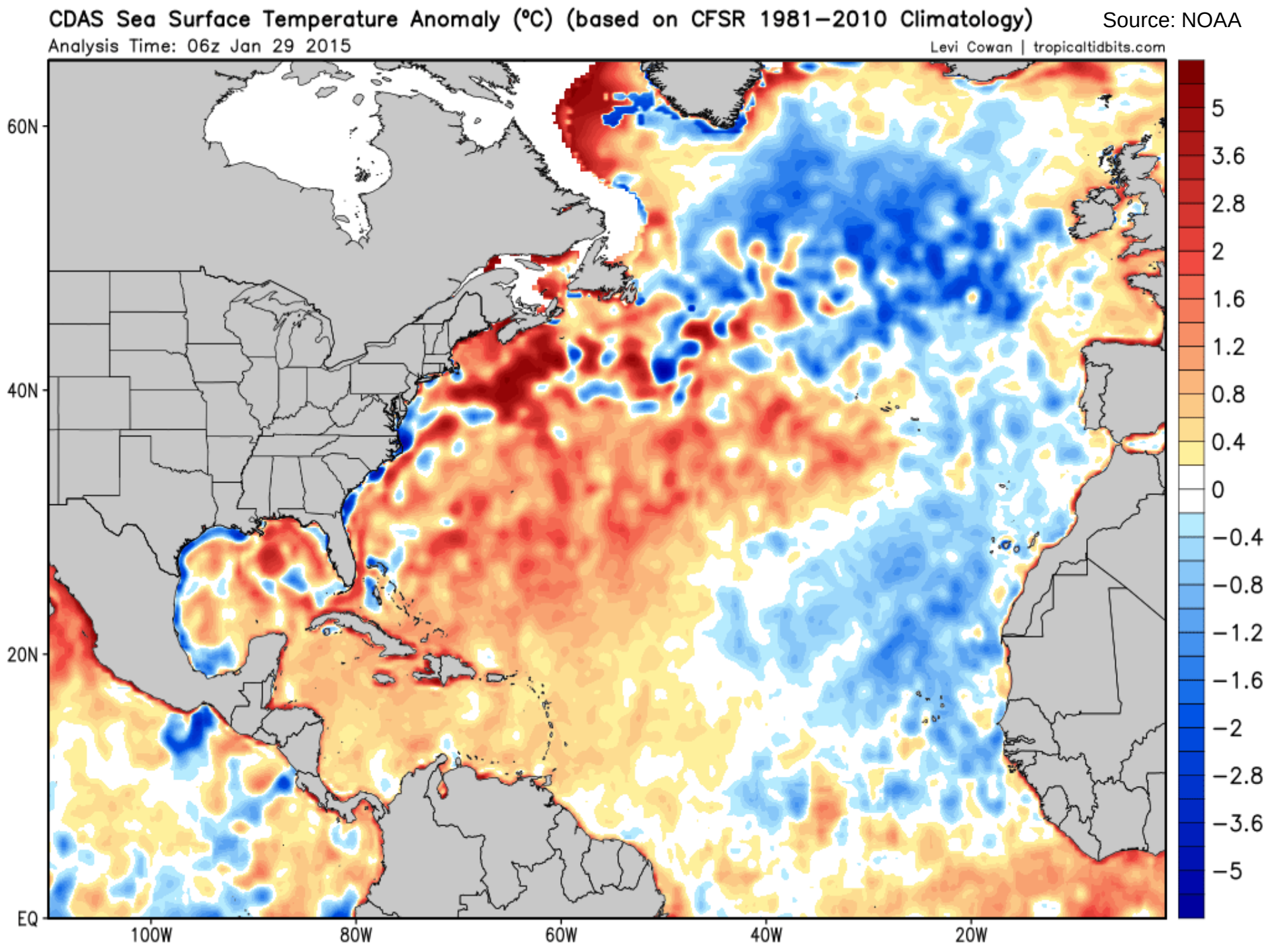
-> Events with extreme precipitation will become more frequent

Source: Munich Re – Severe weather in North America, 2012

Extreme Precipitation Events in the U.S., 2014 - 2015

- Pensacola, Florida: 20” of rain over April 29 & 30
- Detroit, Michigan: 4-6” of rain in in a 4-hour period on August 11.
- Islip, New York: 13” of rain in a single day on August 13.
- Phoenix, Arizona: 4-5” of rain on September 7.
- Buffalo, New York: Over 6 feet of snow over the course of 4 days.
- Northern California: averaged of 2-4” of rain during first week of December.
- Boston,MA: 6’ of snow in 2 weeks

Source: FEMA


CDAS Sea Surface Temperature Anomaly (°C) (based on CFSR 1981–2010 Climatology)
Source: NOAA
Analysis Time: 06z Jan 29 2015
Levi Cowan | tropicaltidbits.com
60N
40N
20N
EQ
100W
80W
60W
40W
20W
5
3.6
2.8
2
1.6
1.2
0.8
0.4
0
−0.4
−0.8
−1.2
−1.6
−2
−2.8
−3.6
−5

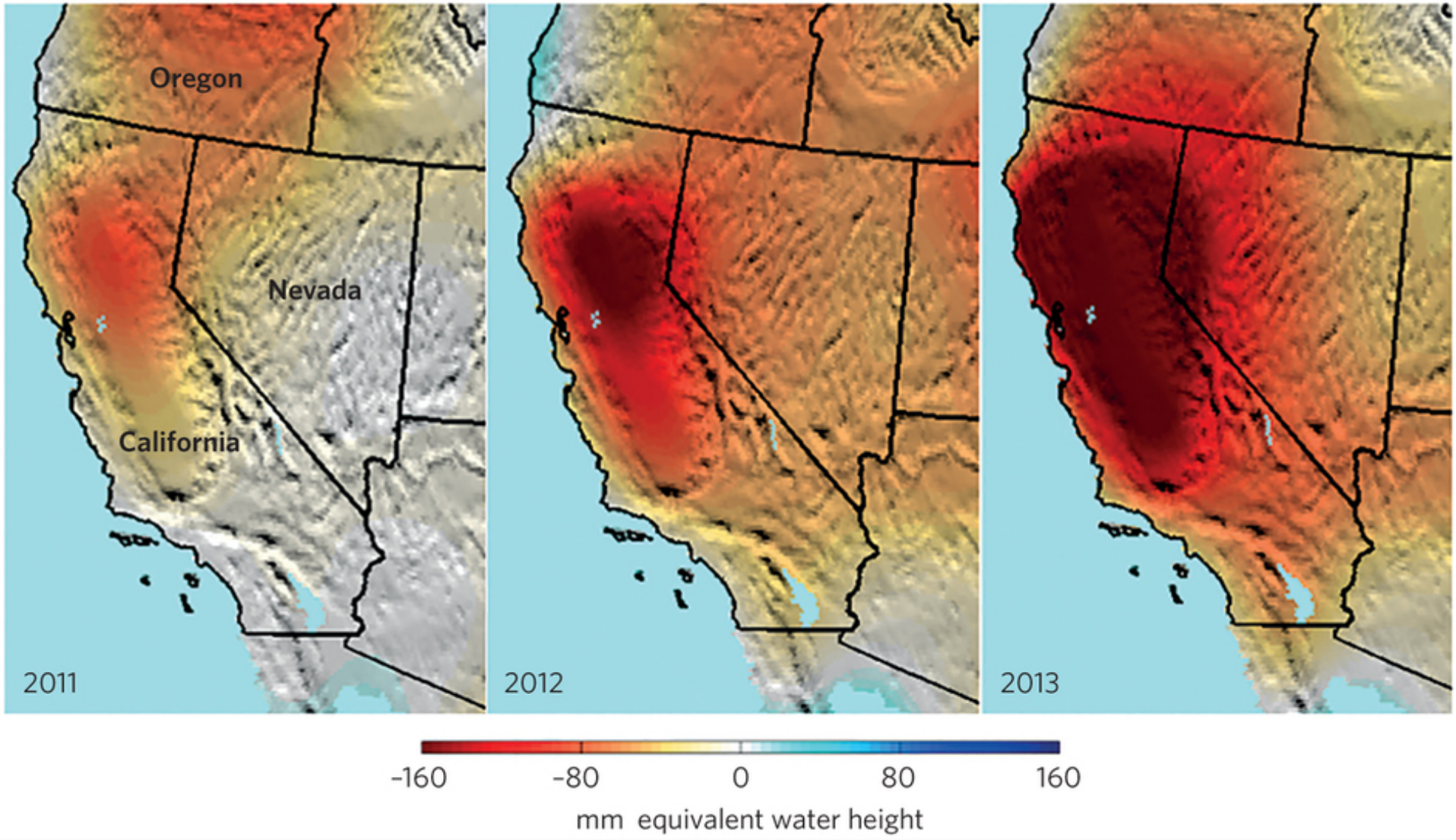
Climate Change, Socioeconomic Trends, and Flooding

Urban and suburban sprawl has created problems for severe flood potential across the United States

- Reduction or modification of natural drainage patterns
- Development of flood plains
- Potential for levee failures

Source: Munich Re

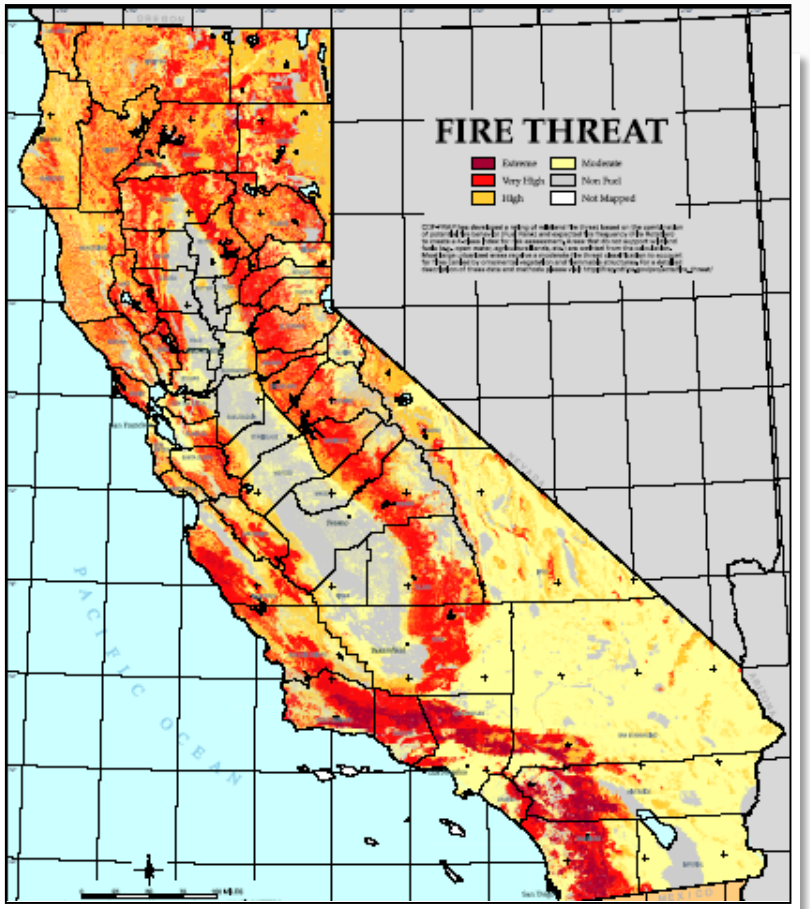
The 2010s Great California Drought



Source: NASA/JPL

Climate Change, Socioeconomic Trends, and Drought

- Physical property damage:
  - Agriculture (plants and livestock)
  - Wildfires & Suburban Sprawl



- Business Interruption potential:
  - Electric power generation
    - Hydroelectric
    - Nuclear
  - Resource reduction
    - Lack of sufficient water for commercial, agricultural, or industrial use
    - Limited electricity due to shutdowns of hydro and nuclear facilities

Source: California Division of Forestry

U.S. Thunderstorm Loss Trends

Annual Totals 1980 – 2014

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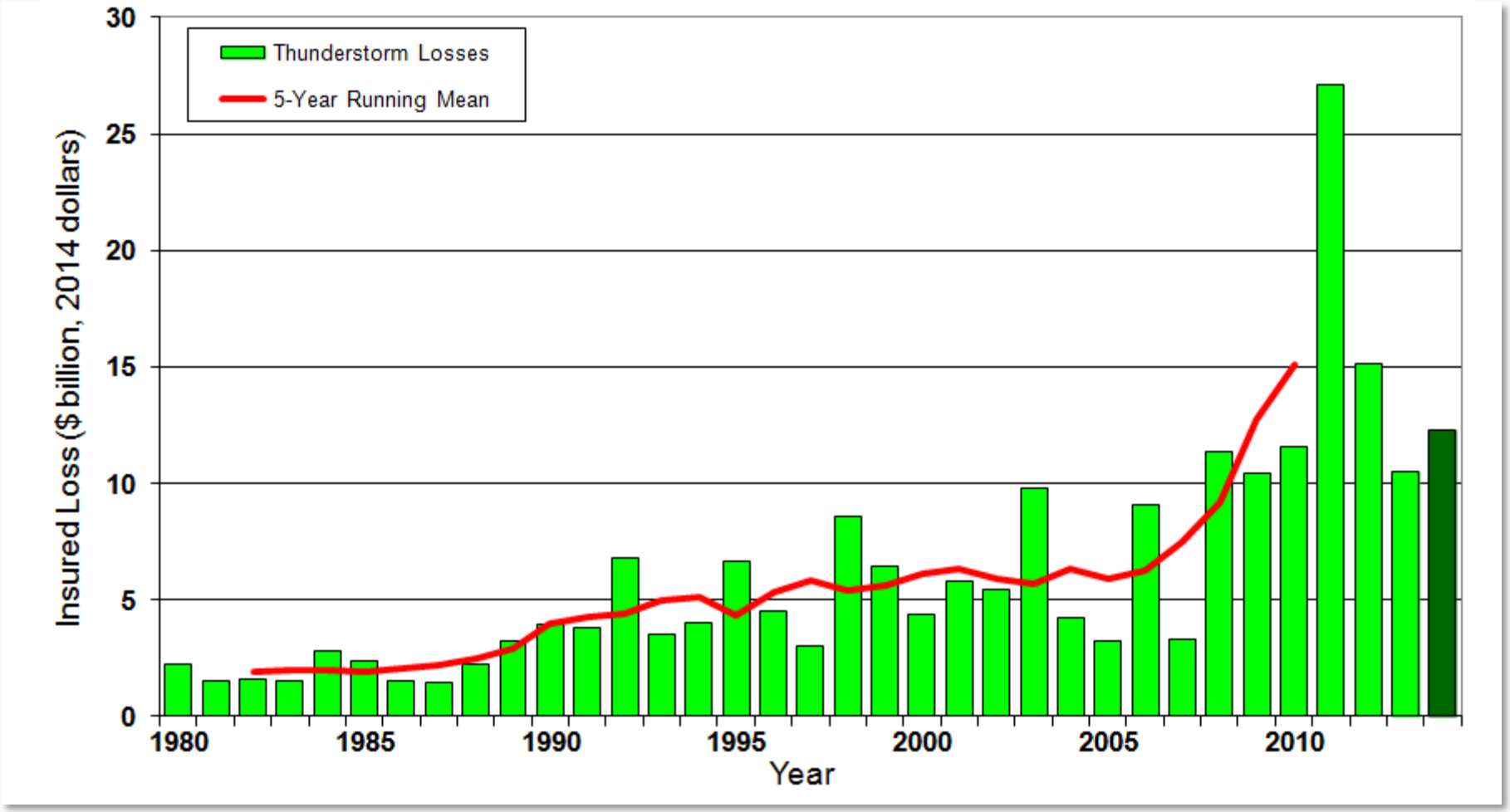
Average thunderstorm losses have increased sevenfold since 1980.



Source: Property Claims Service
MR NatCat*SERVICE*

Thunderstorms and Climate Change

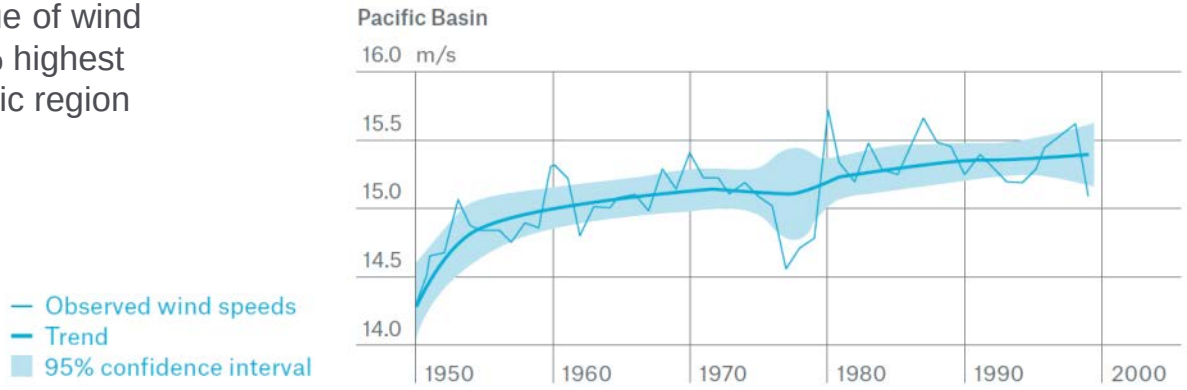
- Due to the small-scale, localized nature of severe thunderstorms and their associated hazards, it is hard to tell what impact climate change will have on these storms.
- Increased atmospheric moisture and heat will likely increase the number of days per year that severe thunderstorms are possible in certain areas of the globe.
- Some studies already indicating more large hail events over past 50 years; unclear if naturally driven change or influence by human activity.
- Socioeconomic factors will likely dominate thunderstorm loss potential for the foreseeable future.

Winter Storms and Climate Change

Observed changes

- Winter storm activity is affected by the ENSO-phases
- No long-term trend in frequency has emerged from 1950 onwards
- Number of storms with high wind speeds is increasing while weaker storms are declining (especially for storms originating in the Pacific)

Extreme wind speeds, i.e. the value of wind speed that demarcates the top 5% highest wind speeds per year for the Pacific region (20°-70°N, 130°E-112.5°W)



Projected changes

-> No general increase in the frequency of winter storms

-> Intensity of the winter storms increase

Source: Munich Re – Severe weather in North America, 2012

Climate Change & Hurricanes

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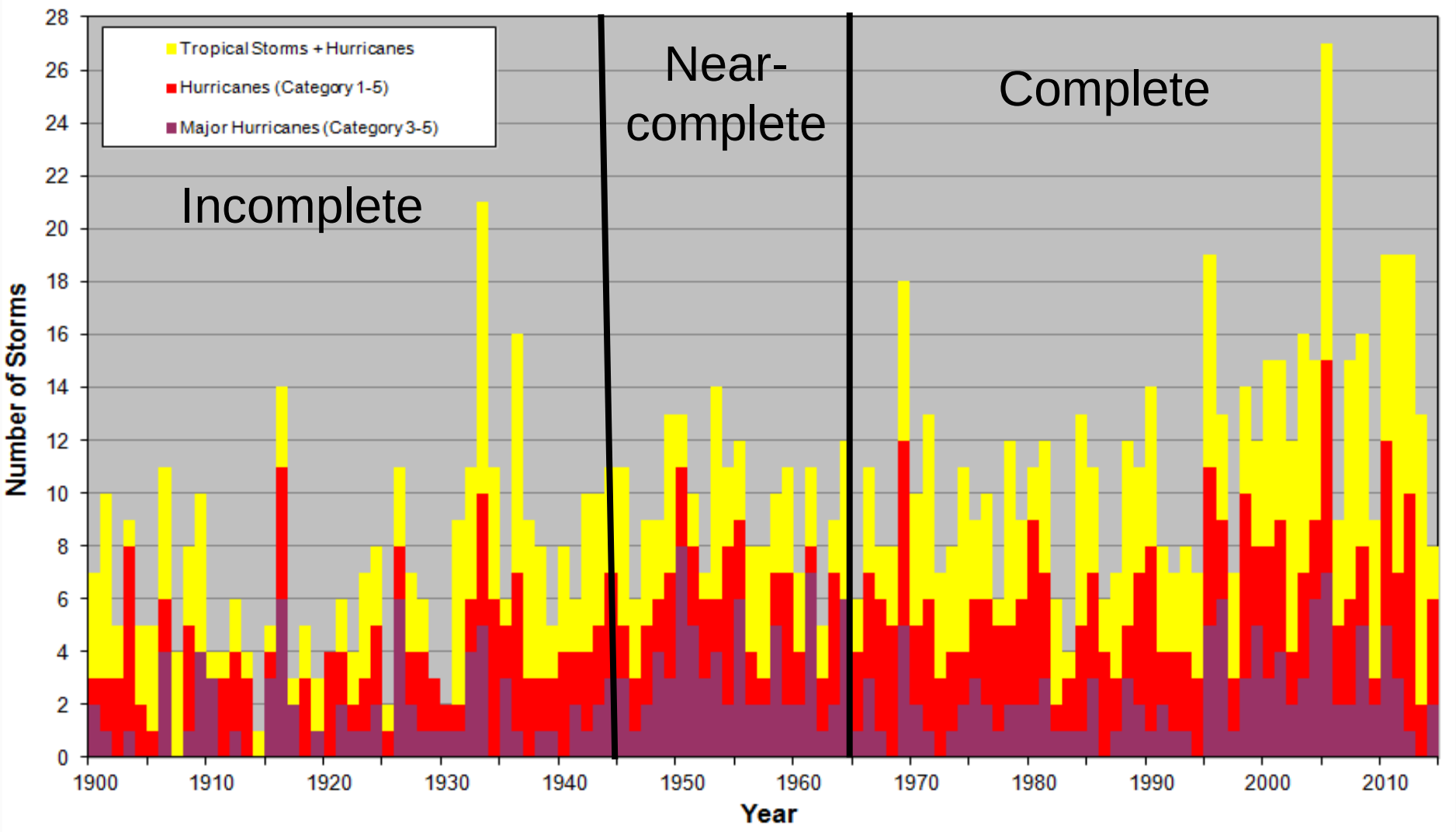
In 2004 & 2005, there were two groups of thought in scientific community:

Increased sea surface temperatures, caused at least in part by anthropogenic activities, is leading to an increase in intense tropical cyclones worldwide as compared to historic activity, particularly in the Atlantic.

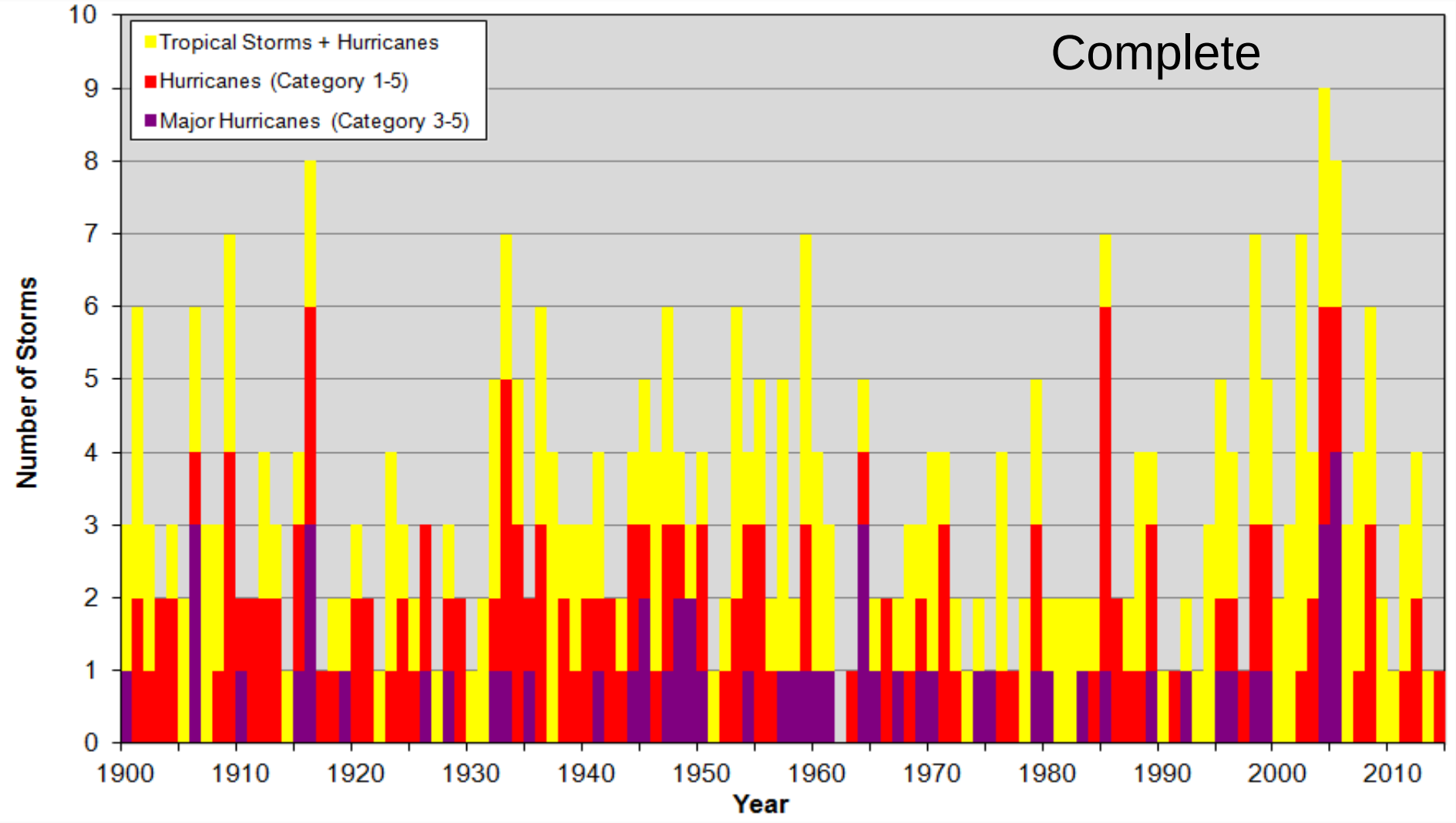
Tropical cyclone data is poor or sparse as you go back in time, making it difficult to compare current and past frequency and intensity levels. Recent increase in frequency and intensity of storms in the Atlantic due to natural variability.

Annual Number of Atlantic Tropical Cyclones, 1900 – 2014



Source: Munich Re

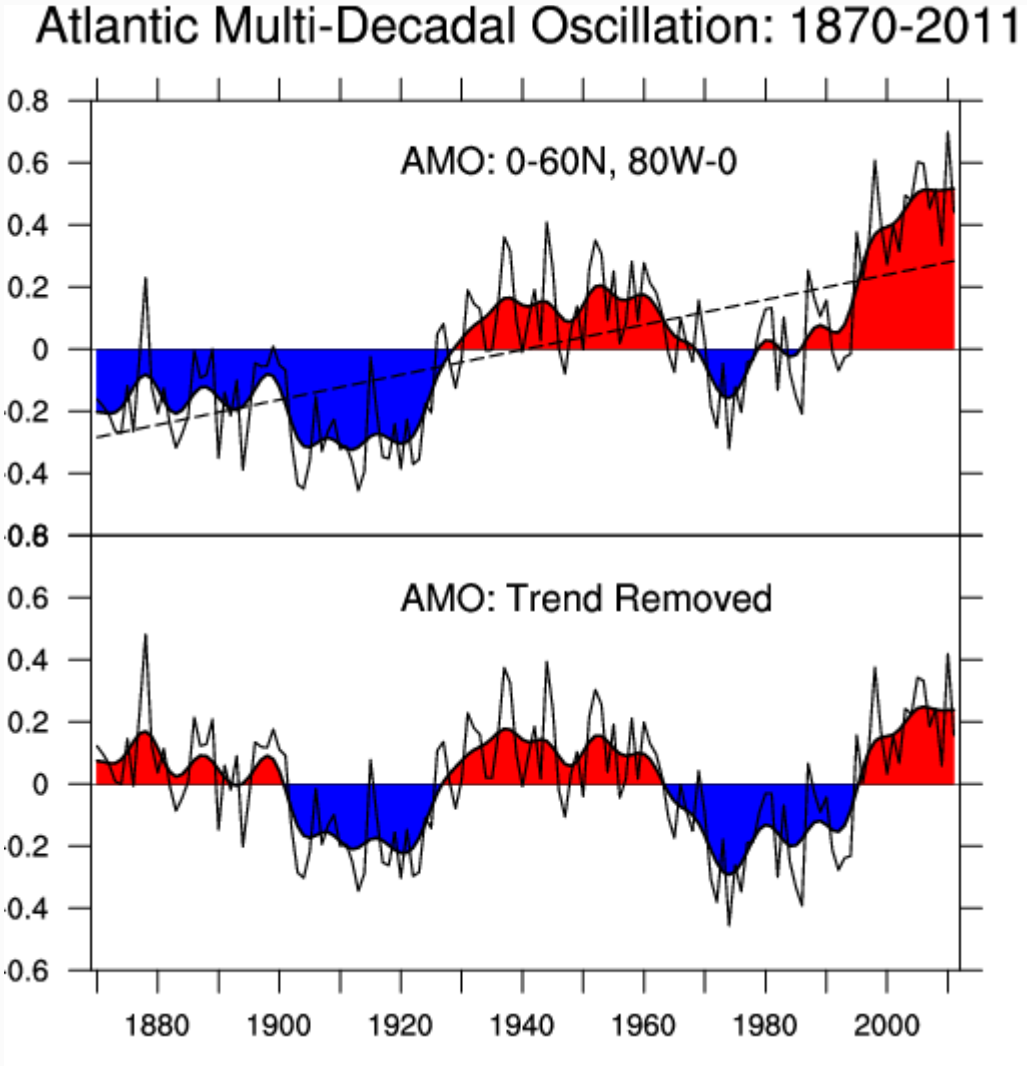
Annual Number of U.S. Landfalling Tropical Cyclones, 1900 – 2014



Source: Munich Re

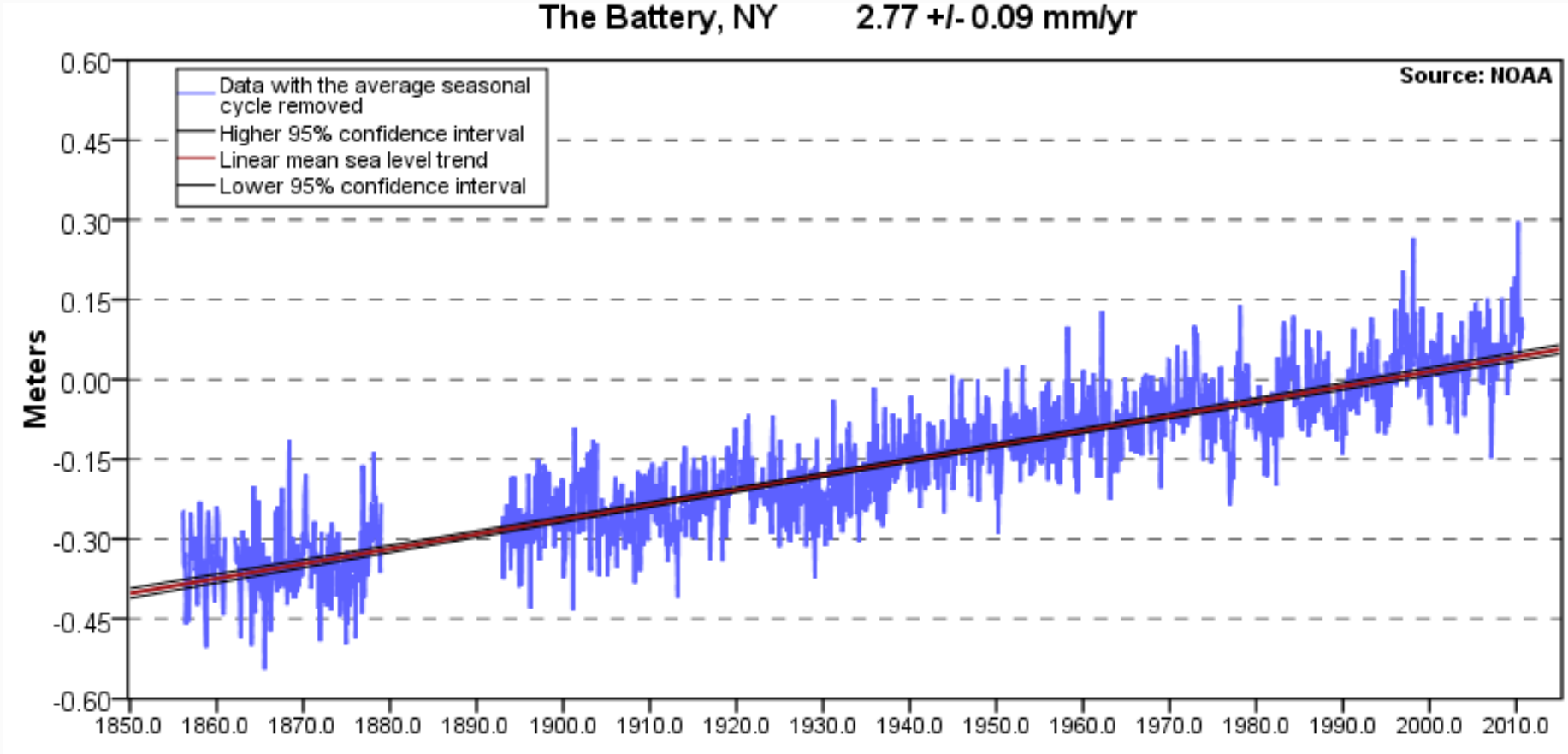
Impact of Oceanic Heat Increase on Atlantic Hurricane Climate

Ocean warming has led to an apparent linear increasing trend in the decadal-scale AMO cycle.



Source: NOAA

Impact of Sea Level Rise on Hurricane Impacts



Sea level rise will make damage from future storm surge events worse, even if there is no change in the hazard itself.

Source: NOAA

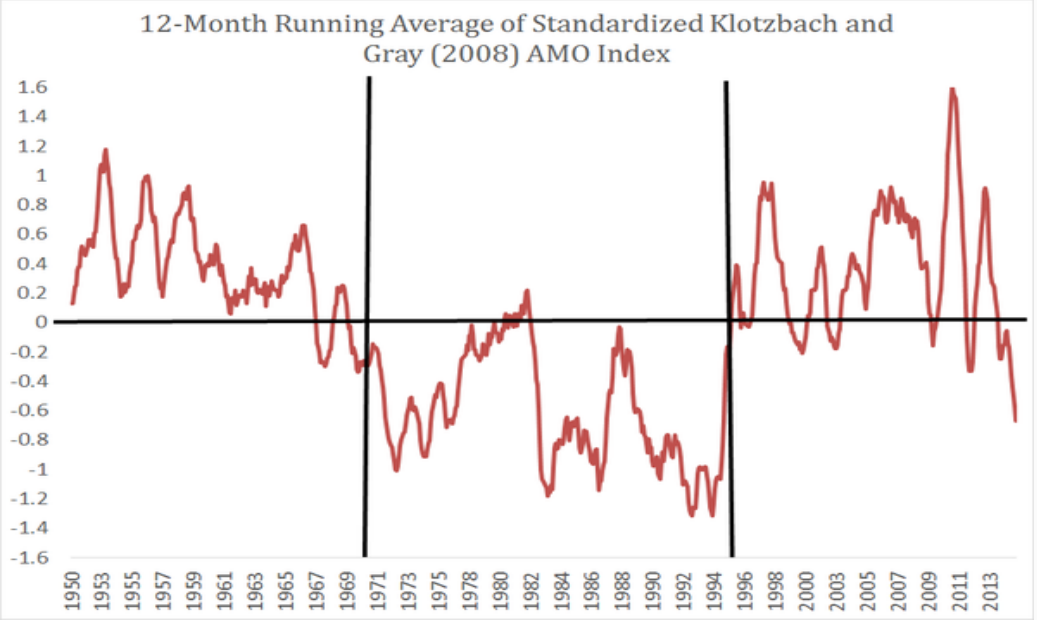
Lessons from Sandy:
Impact to Marine Industry

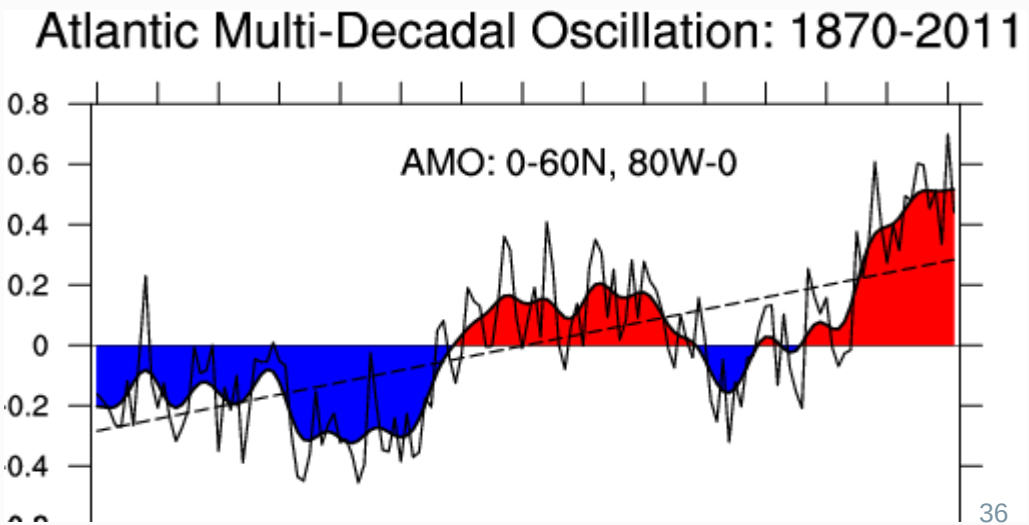
- Yacht & Marinas
  - Haul-outs caused more damage than proper mooring in place
  - Pilings too short
  - Cost to build to code may be significant
- Port Accumulations
  - Exposed to significant storm surge
  - Lag in reporting ongoing
- Warehouses
  - Flood maps are inaccurate - location and aggregation issues
  - How cargo is stored matters

Atlantic Hurricane Outlook for Next 10–20 Years

- Is the current 20-year AMO warm phase ongoing? Or is it ending / already ended?

- Can the historical record still be relied upon to forecast future activity?
  - Future cold phases of AMO cycle may not be as strong as in the past, diminishing its negative influence on hurricane development.
  - Latest modeling studies indicate no major increase in number of storms developing
  - Increase in major hurricane landfalls / fewer weaker hurricanes
  - Increase of quantity of storms making landfall is less certain






Source: NASA

THANK YOU! ANY QUESTIONS?

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Source: NASA

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