
Source: NPS

ECONOMIC IMPACTS OF CLIMATE CHANGE: A REINSURANCE INDUSTRY PERSPECTIVE

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AMS Short Course on Communicating the Costs of Climate Change
20 June 2017

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Agenda

- Insurance, Reinsurance, & Natural Catastrophes
- U.S. Natural Catastrophes Risk in a Warming Climate
- Socioeconomics & U.S. Natural Catastrophe Risk

Insurance, Reinsurance, & Natural Catastrophes

Hurricane Katrina
August 29, 2005

Source: Munich Re

The Role of (Re)Insurance

Providing Recovery Financing and thus Increasing Resilience

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Insurance cover significantly helps economic recovery following a natural catastrophe:

- Academic studies show that a higher level of insurance cover is accompanied by significantly better economic performance following a catastrophe.
- Depending on the type of catastrophe and the level of economic development, insurance cover can even offset the negative indirect effects of natural catastrophes on national economies

- **Martin Melecky and Claudio Raddatz, World Bank (2011):** Higher insurance penetration at an equivalent level of prosperity leads to lower GDP losses and less government debt after natural catastrophes

- **Goetz von Peter, Sebastian von Dahlen and Sweta Saxena (2012):** The higher the share of insured losses to total losses, the more positive GDP performance is following a catastrophe

- **Florian Englmaier, Till Stowasser (2013):** The effect of insurance markets on countries' resilience: particularly in emerging economies, more insurance cover (i.e. increasing the insurance penetration rate) can mitigate the negative economic effects of natural catastrophes

Insurance, Reinsurance, and Natural Catastrophes (1)

Cost to rebuild from fire: $500k

Insurance, Reinsurance, and Natural Catastrophes (2)

Cost to each to rebuild one home from fire: $250k

Insurance, Reinsurance, and Natural Catastrophes (3)

Cost to each to rebuild one home from fire: $50k

Insurance, Reinsurance, and Natural Catastrophes (4)

Cost to each to rebuild:
$5,000

For 1,000 homes:
$500

Thanks to the Law of Large Numbers, insurers have a good understanding of the mean and variance of fire losses to their property portfolio.

As compared to fire, properly insuring homes for severe windstorms is much more difficult.

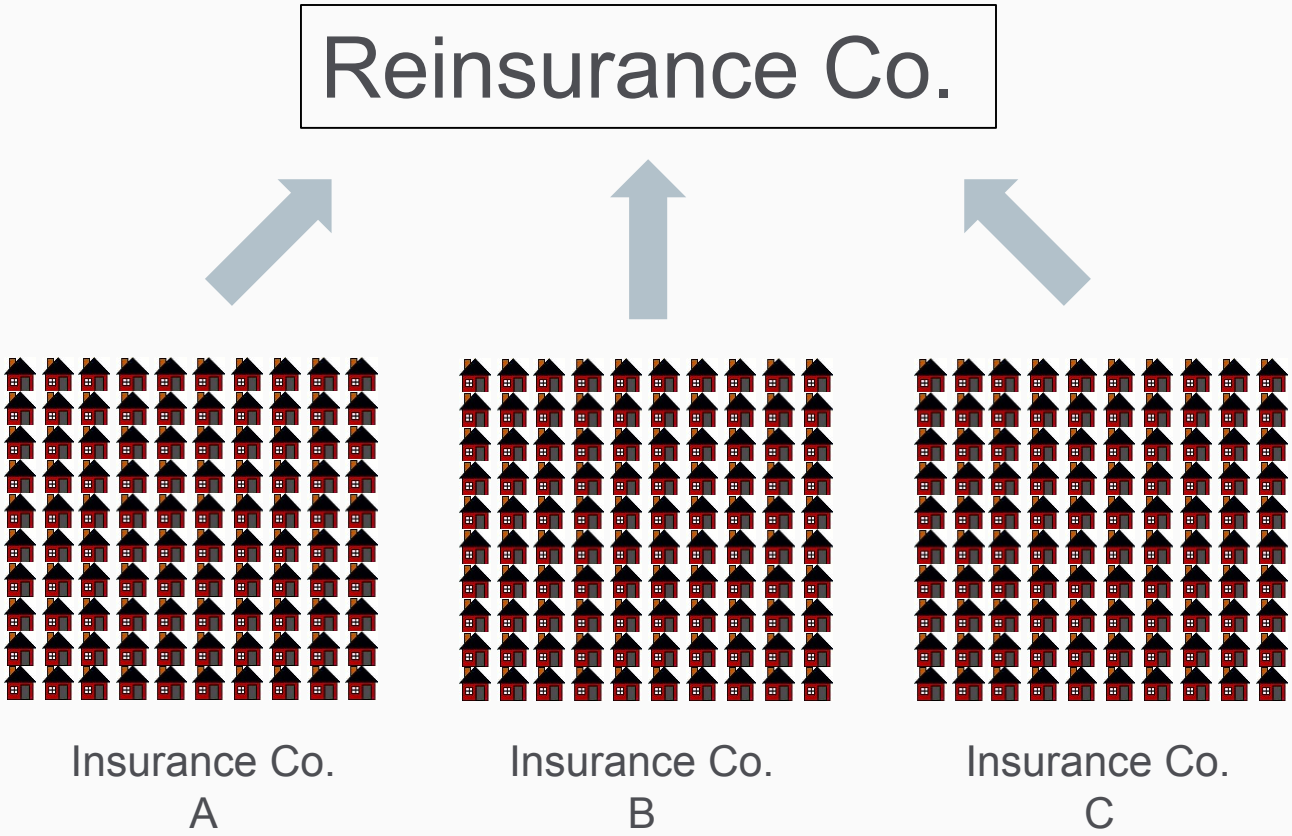
1. Much more likely for multiple locations to be impacted at once.
2. Sparse historical data

Insurance, Reinsurance, and Natural Catastrophes (5)

30 Homes destroyed by a hurricane; $15 million cost to rebuild.

Single event uses up 30 years of premiums!

Insurance, Reinsurance, and Natural Catastrophes (6)



One of the primary functions of reinsurance is to protect insurance companies from catastrophic losses that otherwise might render them insolvent.

Dozens of reinsurers might participate on a contract for a single client – further distributing the financial burden of the event.

(Re)insurance & Climate Change

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- Insurance and reinsurance products are developed and priced based on the past history the peril/product in question. The law of large numbers makes some lines of business very stable.
- For perils where there isn't a large amount of historical data, like natural catastrophes, the industry uses stochastic peril models based on the historical record to fill in the gaps.
- But what if the future climate is not the same as the past?
  - Are natural catastrophe events becoming more frequent?
  - Are natural catastrophe events becoming more intense?
- If so, what is the impact on a one-year insurance contract?

The Costliest Natural Catastrophes Since 1980

In terms of Insured Losses, in Original Dollars

Date	Event	Affected area	Overall losses in US$ m original values	Insured losses in US$ m original values	Fatalities
25-30.8.2005	Hurricane Katrina	United States	125,000	**60,500**	1,720
11.3.2011	Earthquake, tsunami	Japan	210,000	**40,000**	15,880
23-31.10.2012	Hurricane Sandy	Carribean, United States, Canada	68,500	**29,500**	210
6-14.9.2008	Hurricane Ike	Caribbean, United States	38,000	**18,500**	170
23-27.8.1992	Hurricane Andrew	United States	26,500	**17,000**	62
22.2.2011	Earthquake	New Zealand	24,000	**16,500**	185
1.8-15.11.2011	Floods, landslides	Thailand	43,000	**16,000**	813
17.1.1994	Earthquake	United States	44,000	**15,300**	61
19-24.10.2005	Hurricane Wilma	Caribbean, Mexico, United States	22,000	**12,500**	44
June - Sep 2012	Drought	United States	25,000	**12,000**	

Source: Munich Re, NatCatSERVICE, 2017

8 of the top 10 insured losses have occurred in the past 15 years

7 of the top 10 affected the United States

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

NatCatSERVICE

One of the world's largest databases on natural catastrophes

Now searchable online at **natcatservice.munichre.com**!

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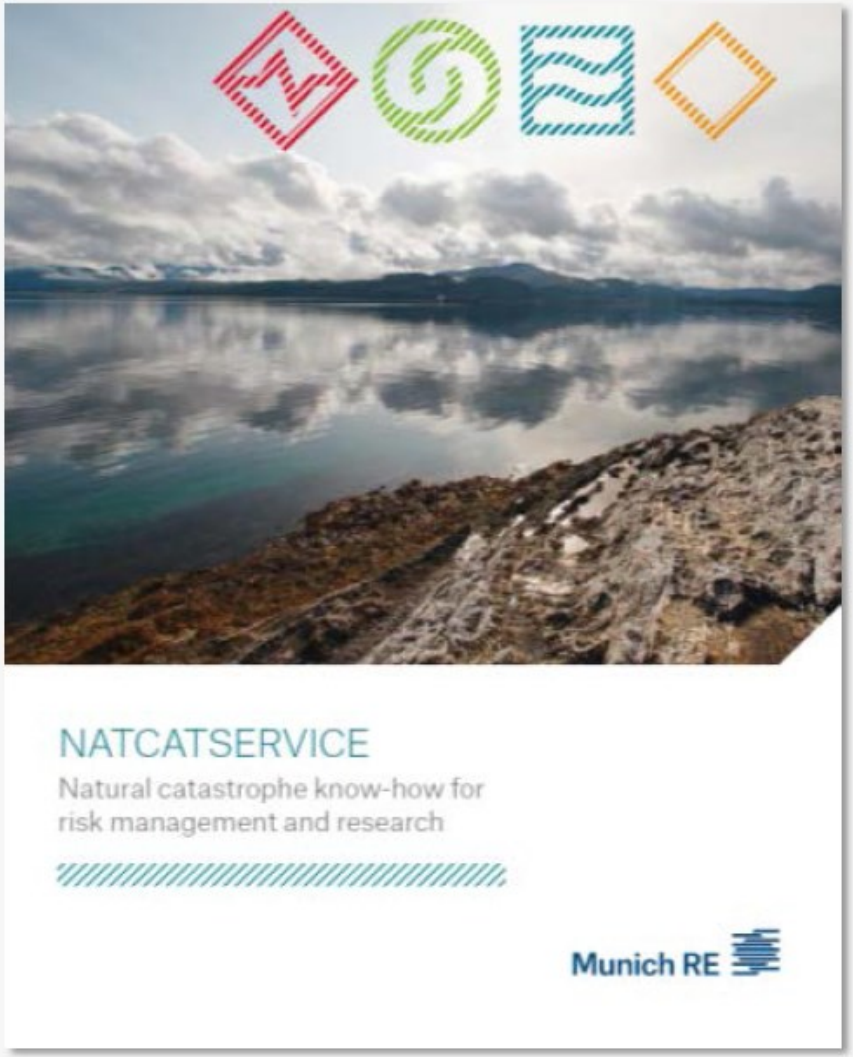
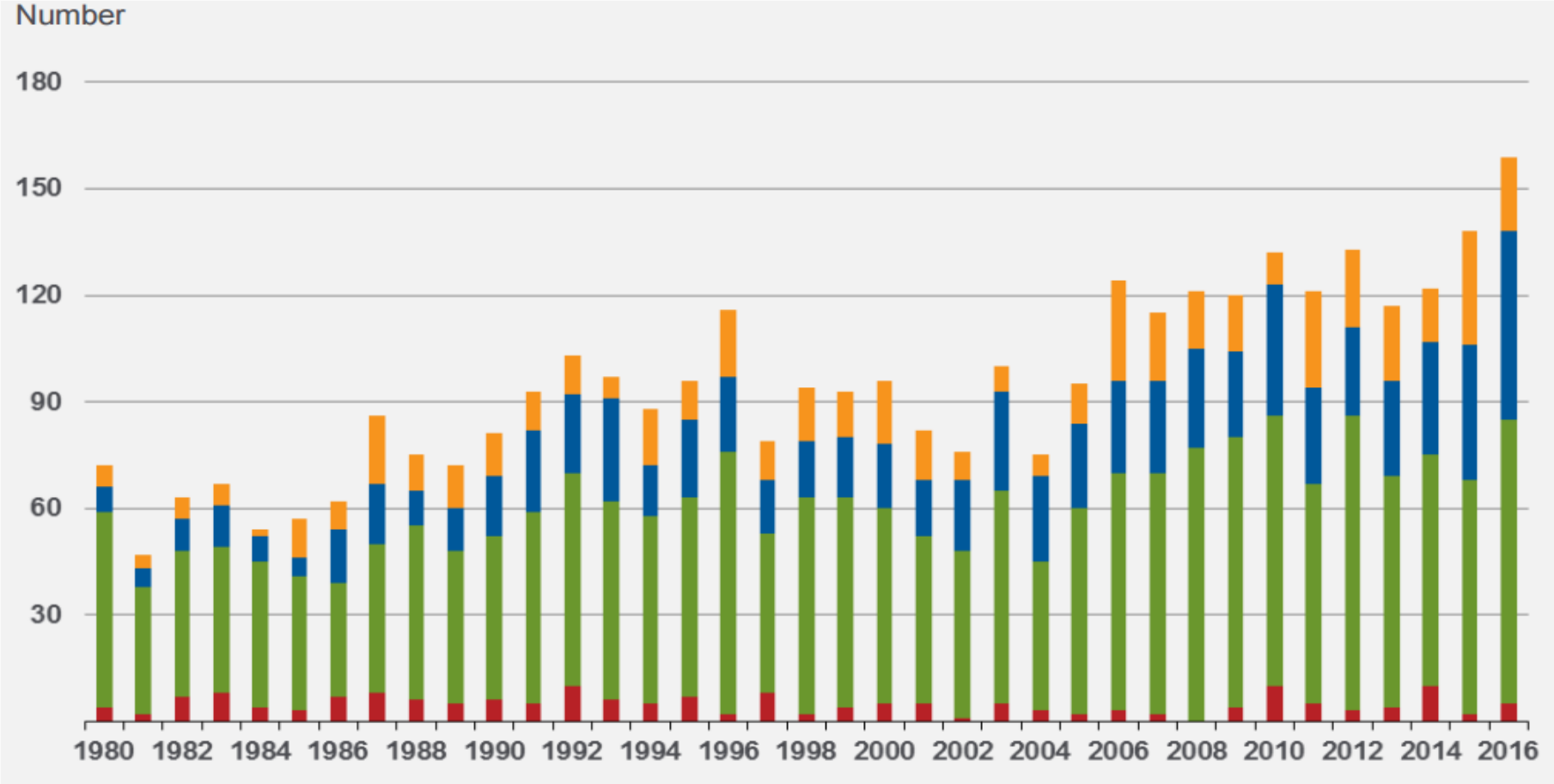


The Database Today

- From 1980 until today all loss events; for USA and selected countries in Europe all loss events since 1970.
- Retrospectively, all great disasters since 1950.
- In addition, all major historical events starting from 79 AD – eruption of Mt. Vesuvius (3,000 historical data sets).
- **Currently ca. 36,000 data sets**

Loss events in North America, 1980 – 2016

Number of relevant* events by peril



Geophysical events (Earthquake, tsunami, volcanic activity)

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

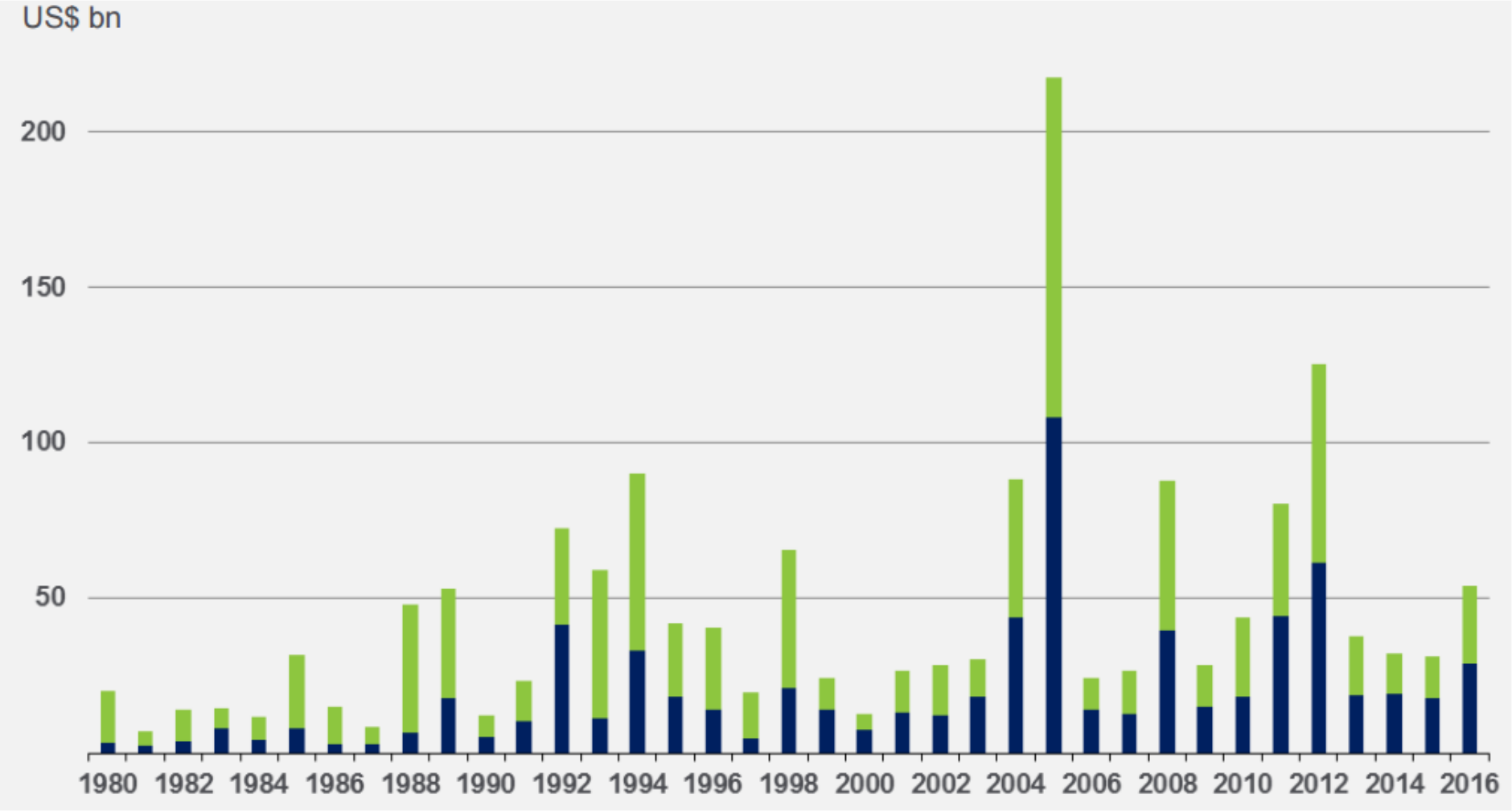
Hydrological events (Flood, mass movement)

Climatological events (Extreme temperature, drought, forest fire)

* Events that have caused at least one fatality or produced normalized losses ≥ US$ 3m.

Loss events in North America, 1980 – 2016

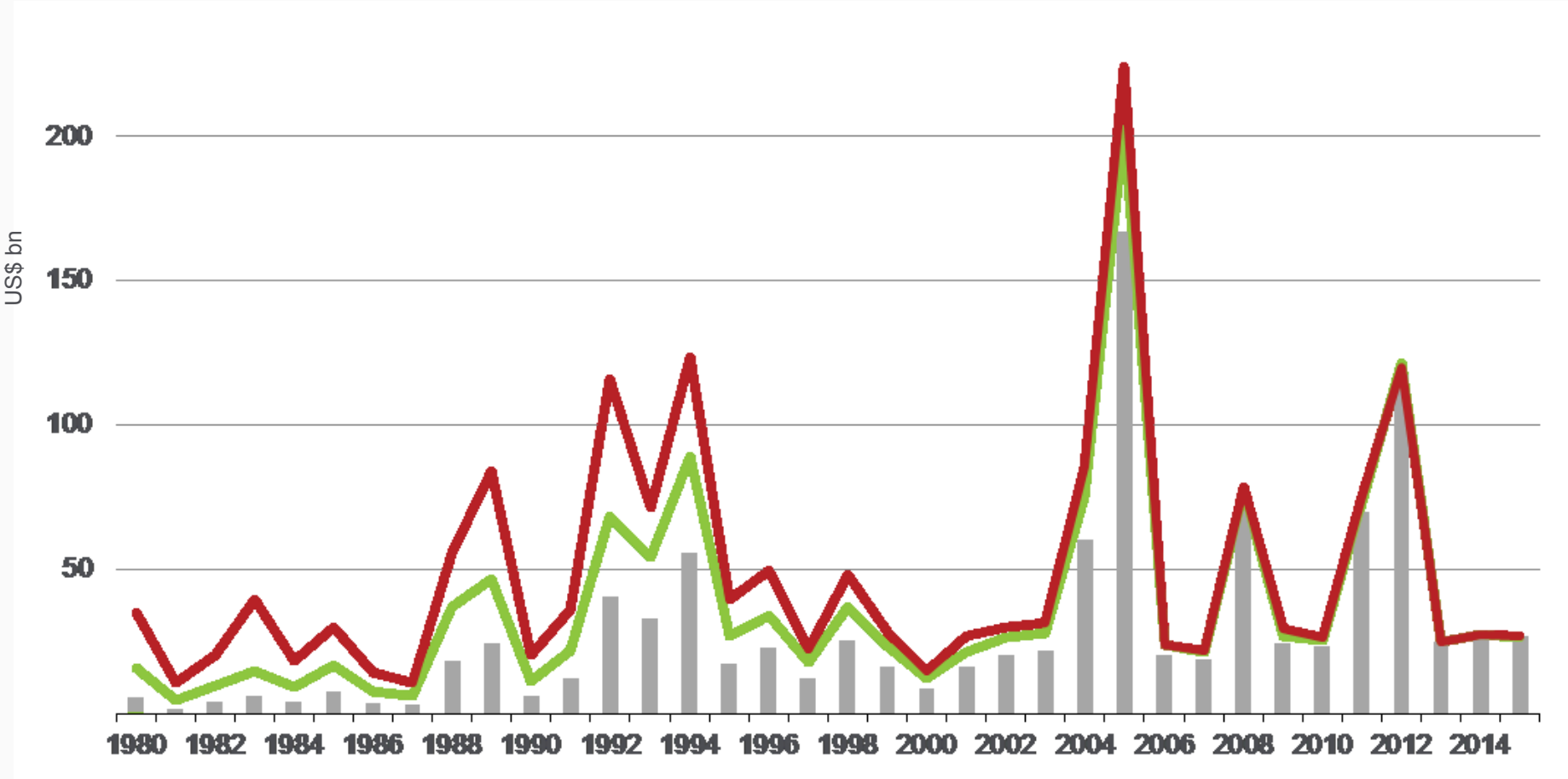
Overall and Insured Losses



Inflation adjusted via country-specific consumer price index and consideration of exchange rate fluctuations between local currency and US$. .

Loss events in the U.S. 1980 – 2015

Overall losses: nominal, inflation adjusted, and normalized



Normalized Losses

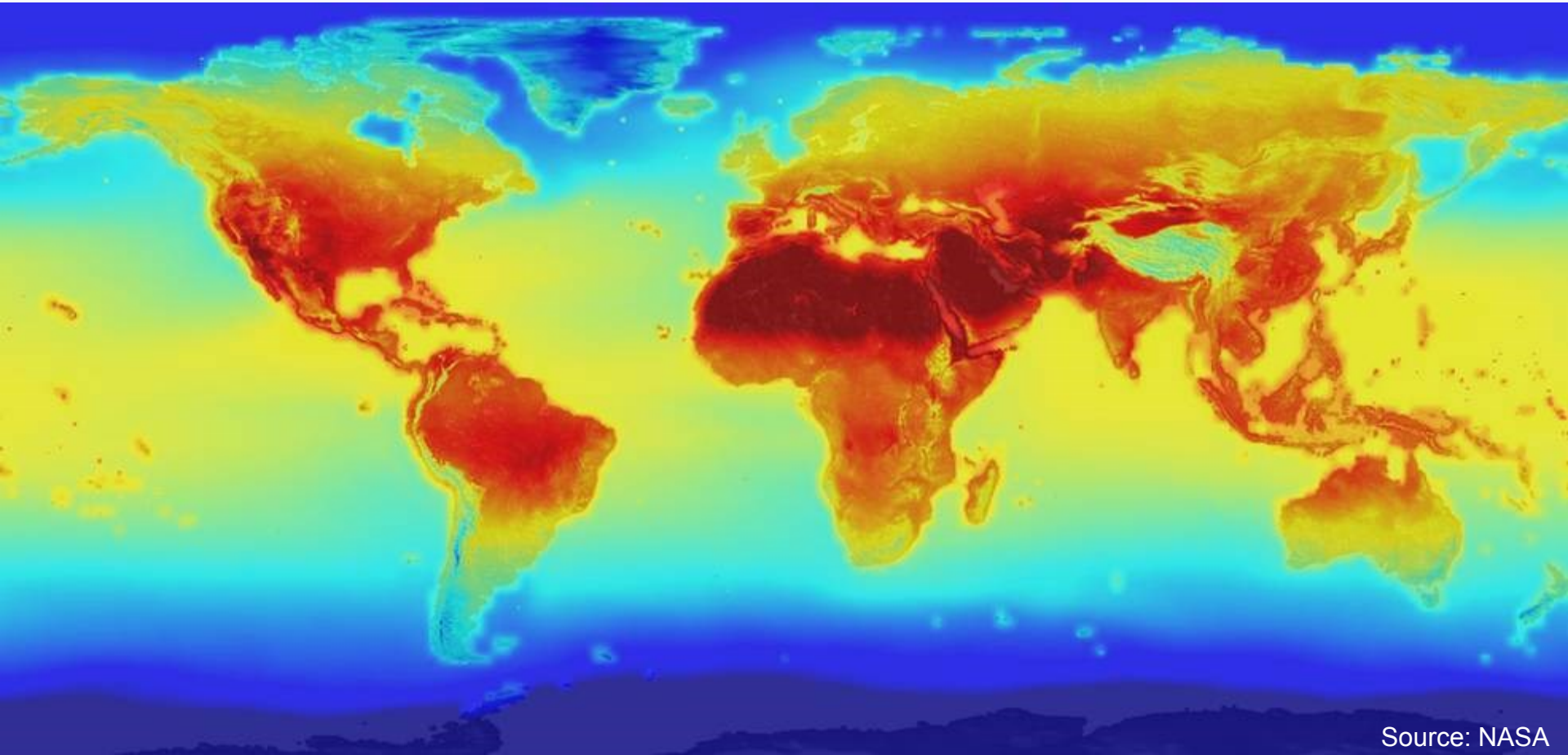
Inflation-Adjusted Losses

Nominal Losses

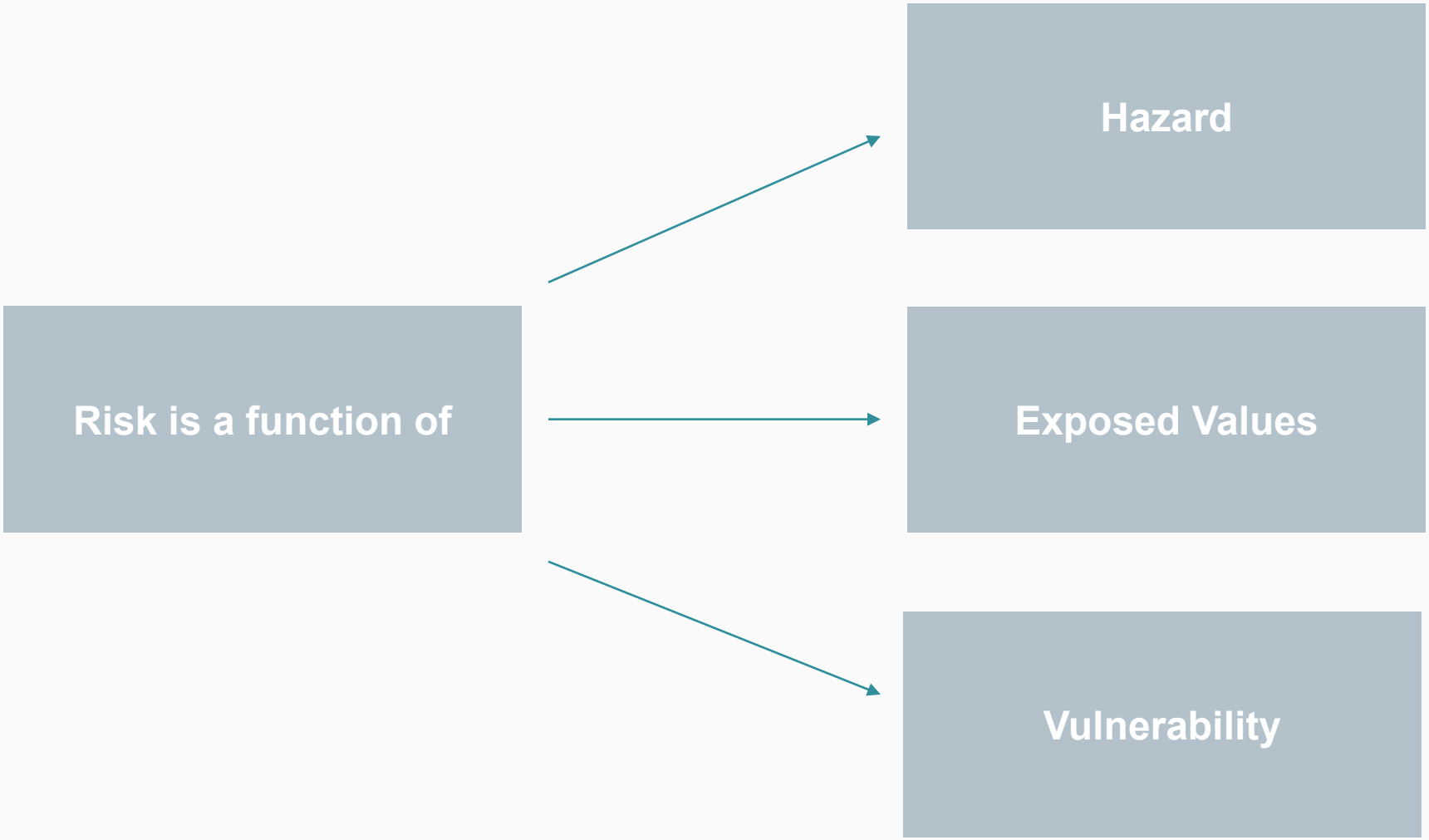
Inflation adjusted via country specific consumer price index.

Normalization via local GDP developments.

U.S. Natural Catastrophe Risk in a Warming Climate



Factors Influencing Natural Catastrophe Risk



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

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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)

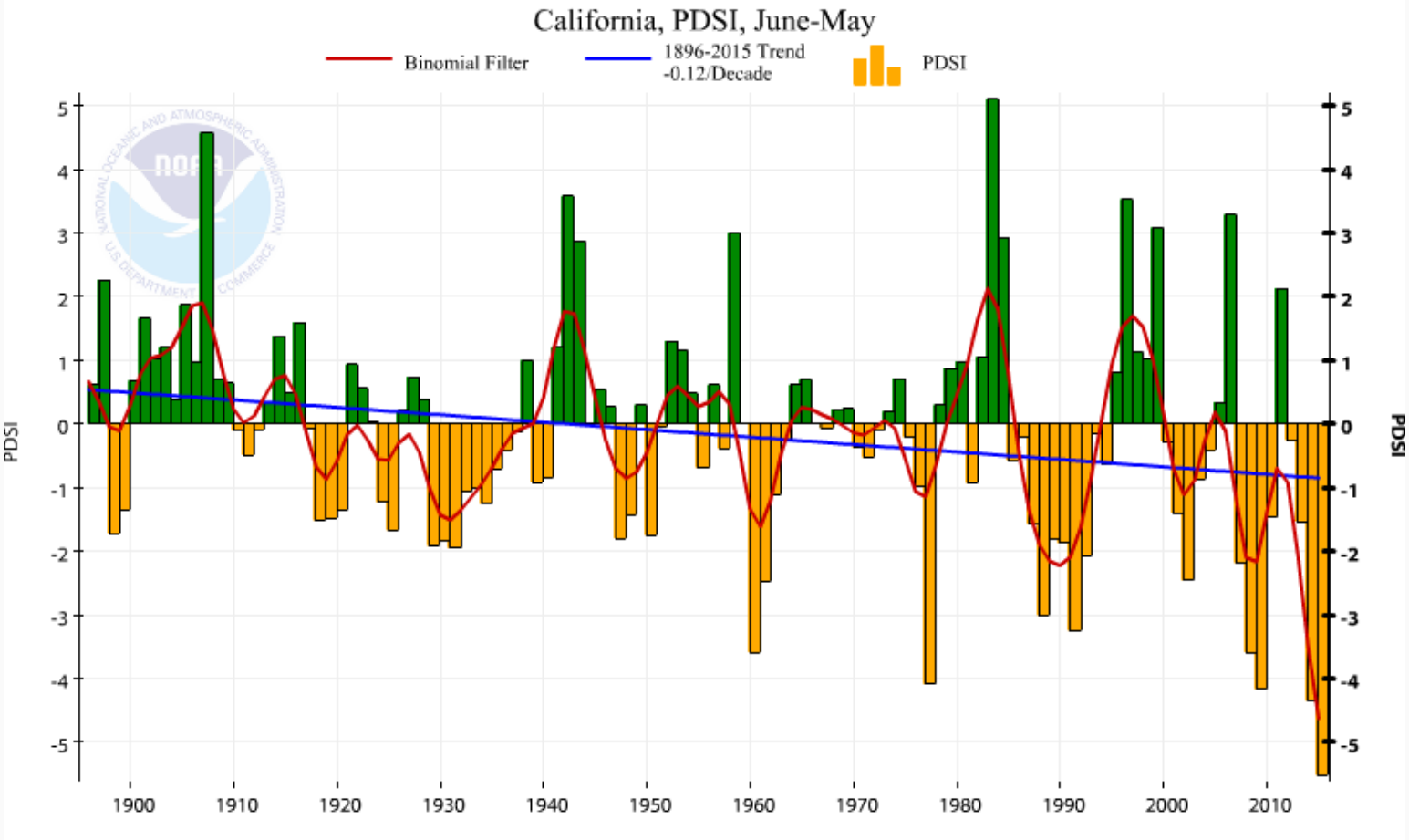
Less confidence
Changes in frequency and severity of

- Winter Storms
- Thunderstorms
- Tropical Cyclones

California Palmer Drought Severity Index (PDSI)

June-May 12 Month Periods Ending May 2015

Most Severe Drought Conditions in California Over the Past 12 Months in History



Impact of California Drought on Agriculture and Land Subsidence

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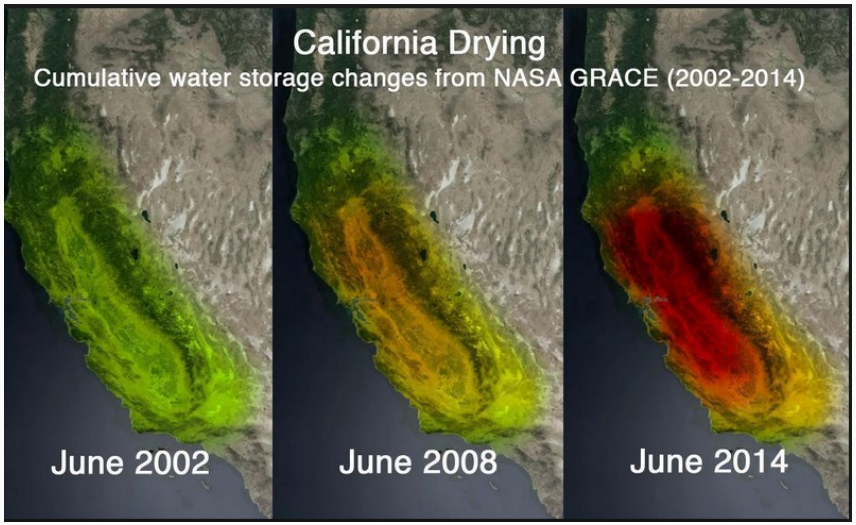
Agricultural Losses for 2015 Expected to be $2.7 Billion in Economic Loss – An Increase of $500 Million Over 2014

Drought Impact	Loss Quantity
Water Supply	
Surface water reduction	8.7 million acre-feet
Groundwater pumping increase	6.2 million acre-feet
Net water shortage	2.5 million acre-feet
Statewide Costs	
Crop revenue loss	$856 million
Additional groundwater pumping cost	$595 million
Livestock revenue loss	$100 million
Dairy revenue loss	$250 million
Total direct agricultural costs	**$1.8 billion**
Total statewide economic cost	**$2.7 billion**
Total job losses	**18,600**

Groundwater Pumping has Helped Limit Agricultural Losses During Recent Droughts, But Is Being Utilized at Unsustainable Levels



Howitt et al. 2015. "Preliminary Analysis: 2015 Drought Economic Impact Study." UC Davis Center for Watershed Sciences. 9p https://watershed.ucdavis.edu/files/biblio/2015Drought_PrelimAnalysis.pdf

Credit: NASA/JPL-Caltech/University of California, Irvine

How Climate Change is Altering Drought Risk

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

- 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

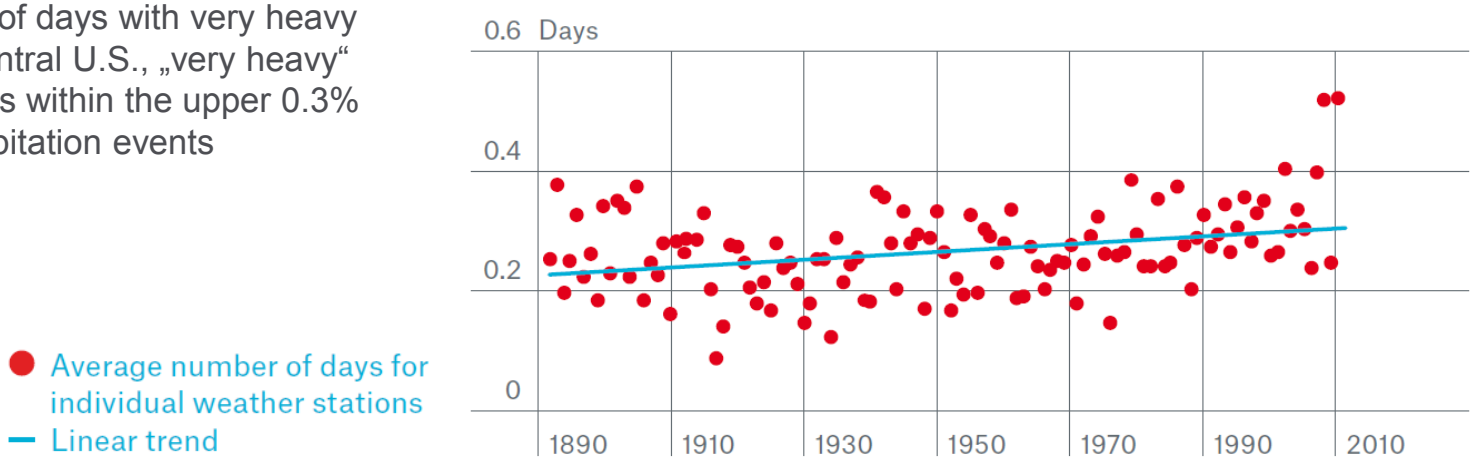
Heavy precipitation in North America

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

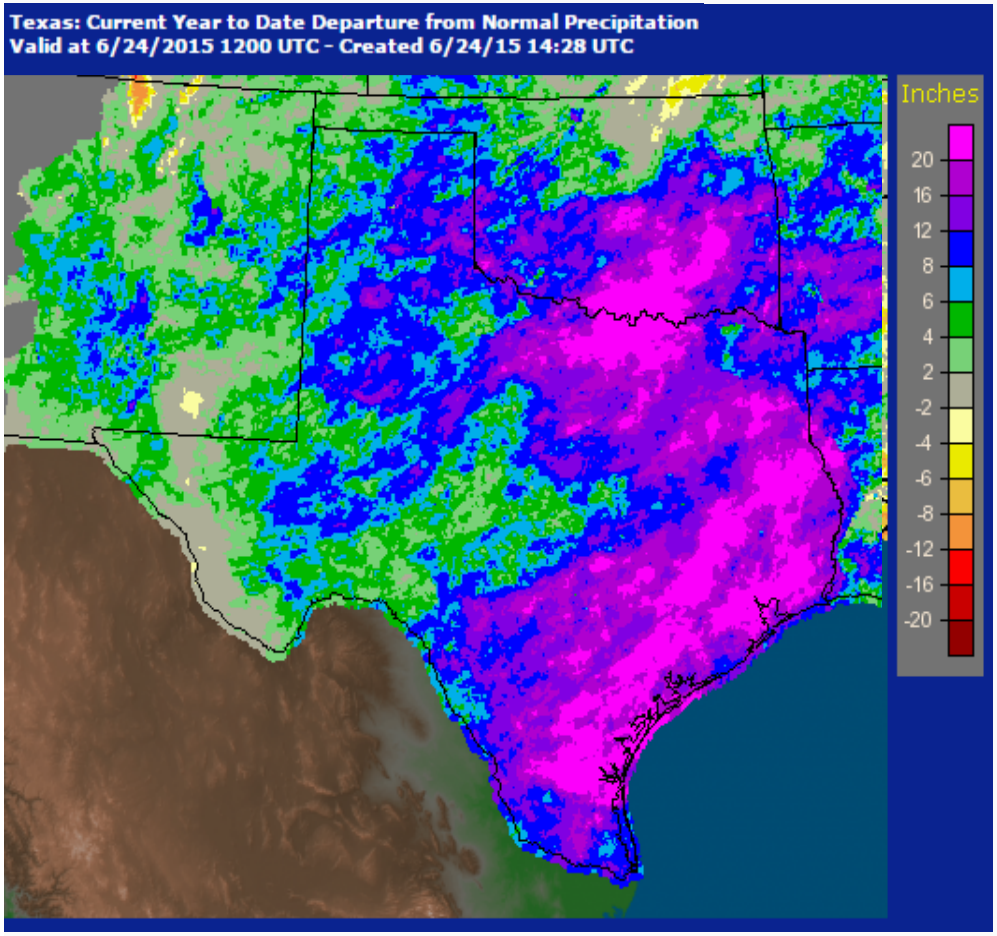
-> Precipitation intensity rise over the contiguous North America

-> Events with extreme precipitation will become more frequent

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

Selected Extreme Precipitation / Flash Flood Events in the U.S., 2014 - 2016

- Pensacola, Florida: 20” of rain over April 29 & 30 2014
- Detroit, Michigan: 4-6” of rain in in a 4-hour period on August 11 2014.
- Islip, New York: 13” of rain in a single day on August 13, 2014.
- Phoenix, Arizona: 4-5” of rain on September 7, 2014.
- Texas/Oklahoma: Large region of 20+” in May 2015
- Houston: 17”+ on April 19, 2016.
- West Virginia: 8-10+ in 12 hours on June 23, 2016
- Ellicott City, Maryland & Princeton, NJ: 6” in 2 hours on July 30, 2016
- Central Louisiana: 10-20”+ of rain over 2 days, August 12-13 2016.

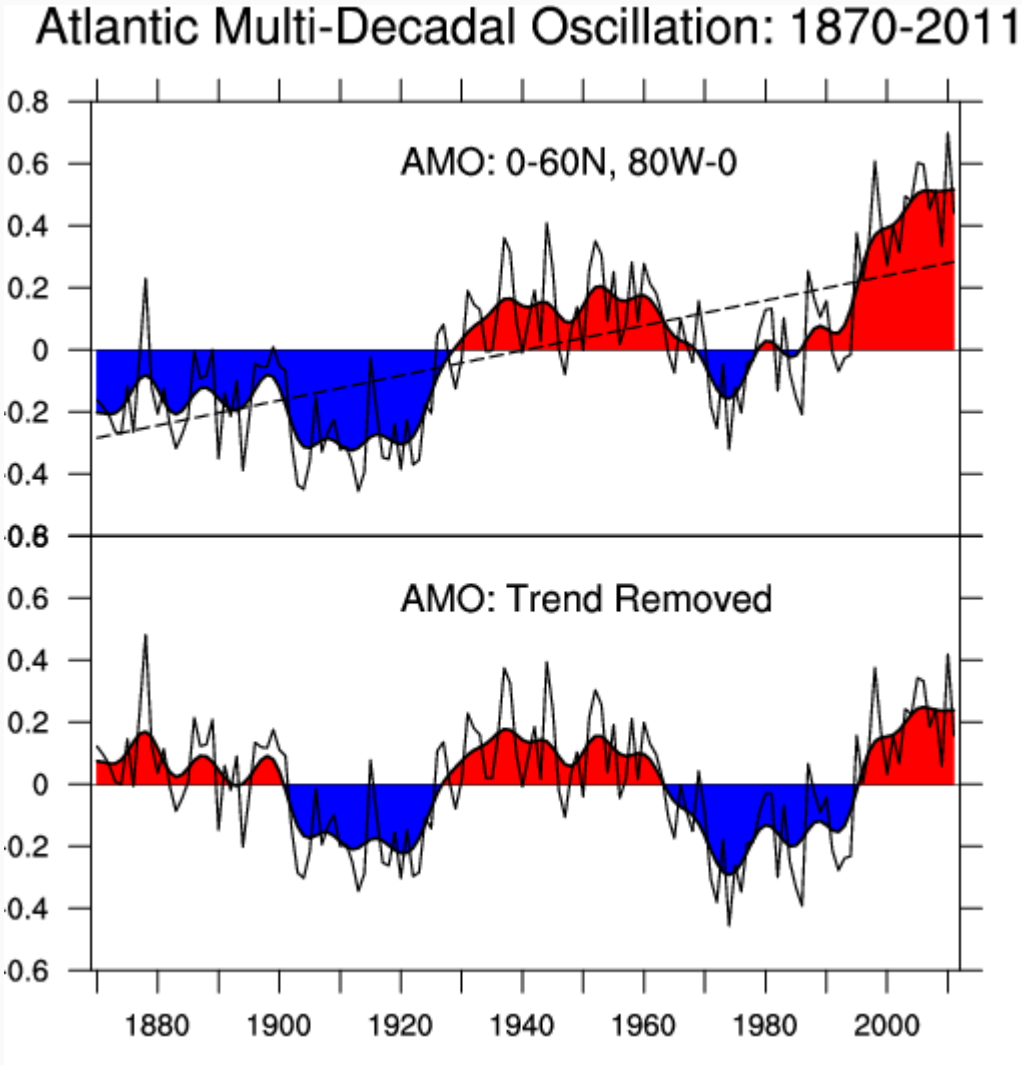


Source: NOAA

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.

Increased oceanic heat content can provide more “fuel” for hurricanes and allow them to become more intense – but only if other atmospheric conditions are conducive for Intensification.



Source: NOAA

Atlantic TC Variability by Atlantic Multidecadal Oscillation (AMO)

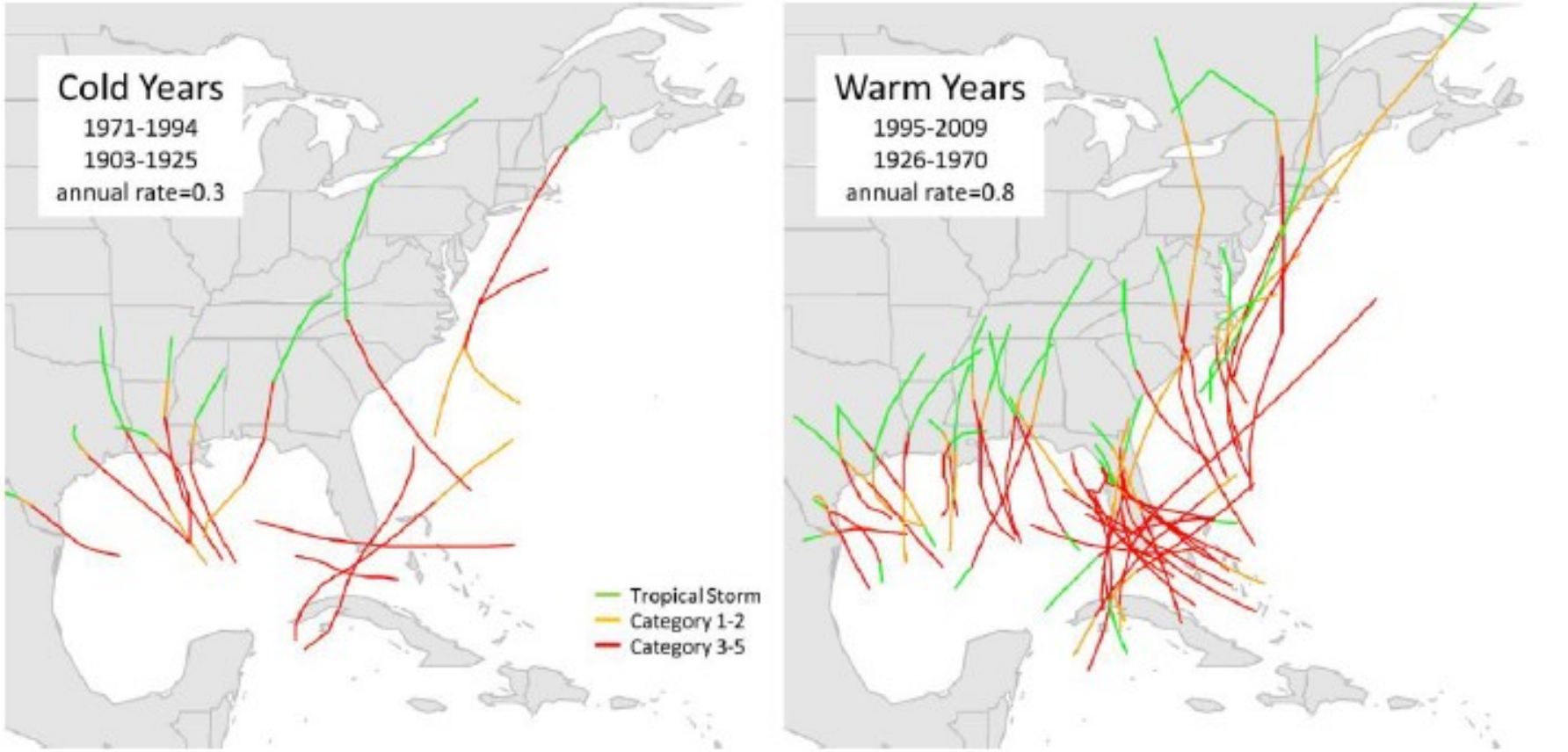


Figure 4: Tracks of major U.S. landfalling hurricanes in cold phases (left) and warm phases (right) of the AMO (Following Goldenberg et al. 2001)

Over the past 115 years, the U.S. has seen twice as many major hurricane landfalls during AMO warm conditions than cold.

Source: Goldenberg, S. B. et al., 2001: The Recent Increase in Atlantic Hurricane Activity: Causes & Implications. *Science* **293**, 474.

Atlantic TC Variability by ENSO State

1900-2013	Atlantic Basin			U.S. Landfalls		
	Tropical Storms & Hurricanes	All Hurricanes	Major Hurricanes	Tropical Storms & Hurricanes	All Hurricanes	Major Hurricanes
El Niño	8.8	4.7	1.9	2.5	0.9	0.2
Neutral	11.5	6.9	3.0	3.5	1.7	0.6
La Niña	12.1	6.6	2.9	3.4	1.7	0.6

All hurricanes:

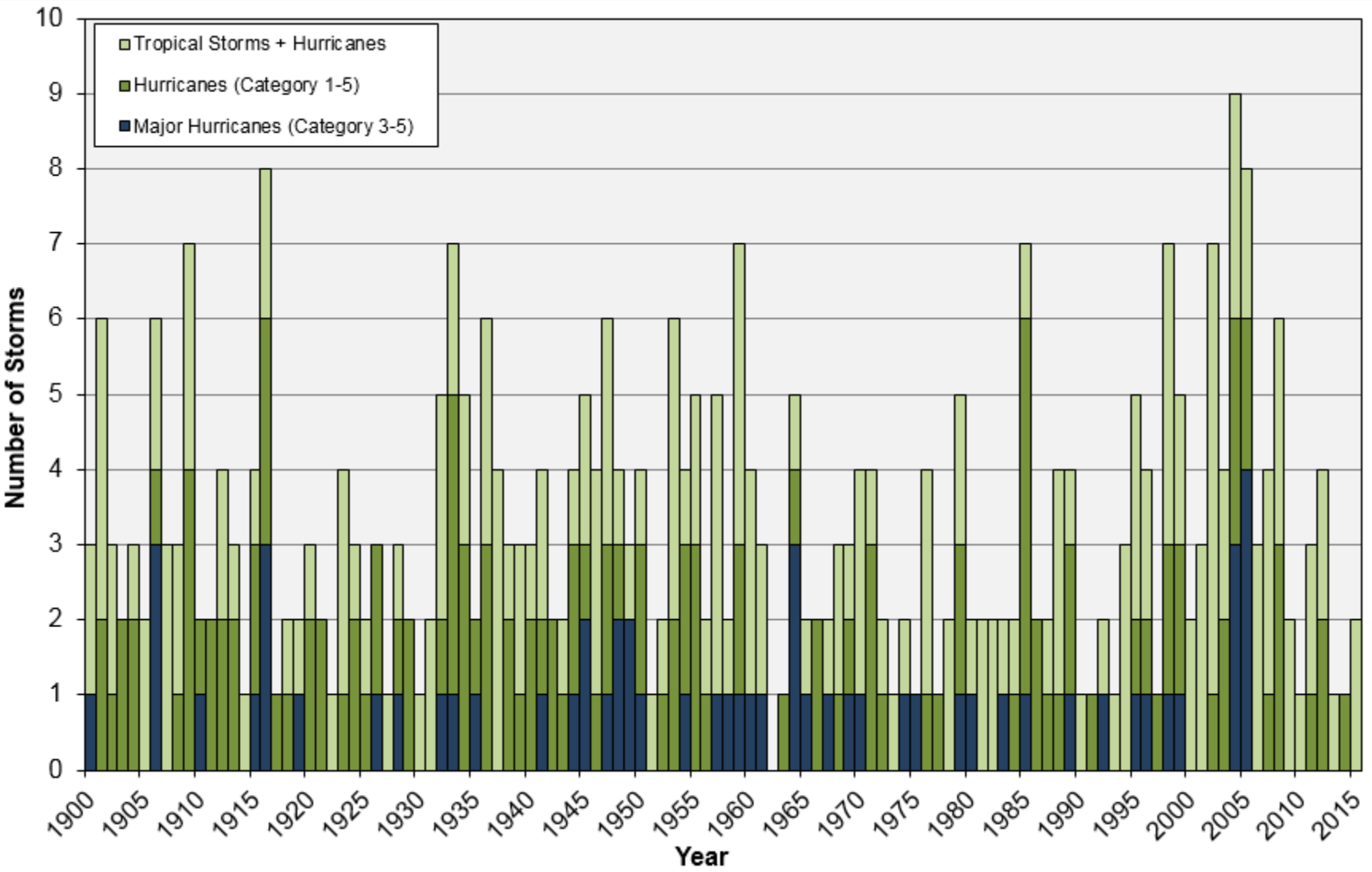
- El Niño: 30% reduction in basin-wide activity
- El Niño: 50% reduction in landfalls
- La Niña: No change from Neutral

Major hurricanes:

- El Niño: 33% drop in basin-wide activity
- El Niño: Factor of 3 reduction in landfalls
- La Niña: No change from neutral; 200% increase in landfalls as compared to El Niño

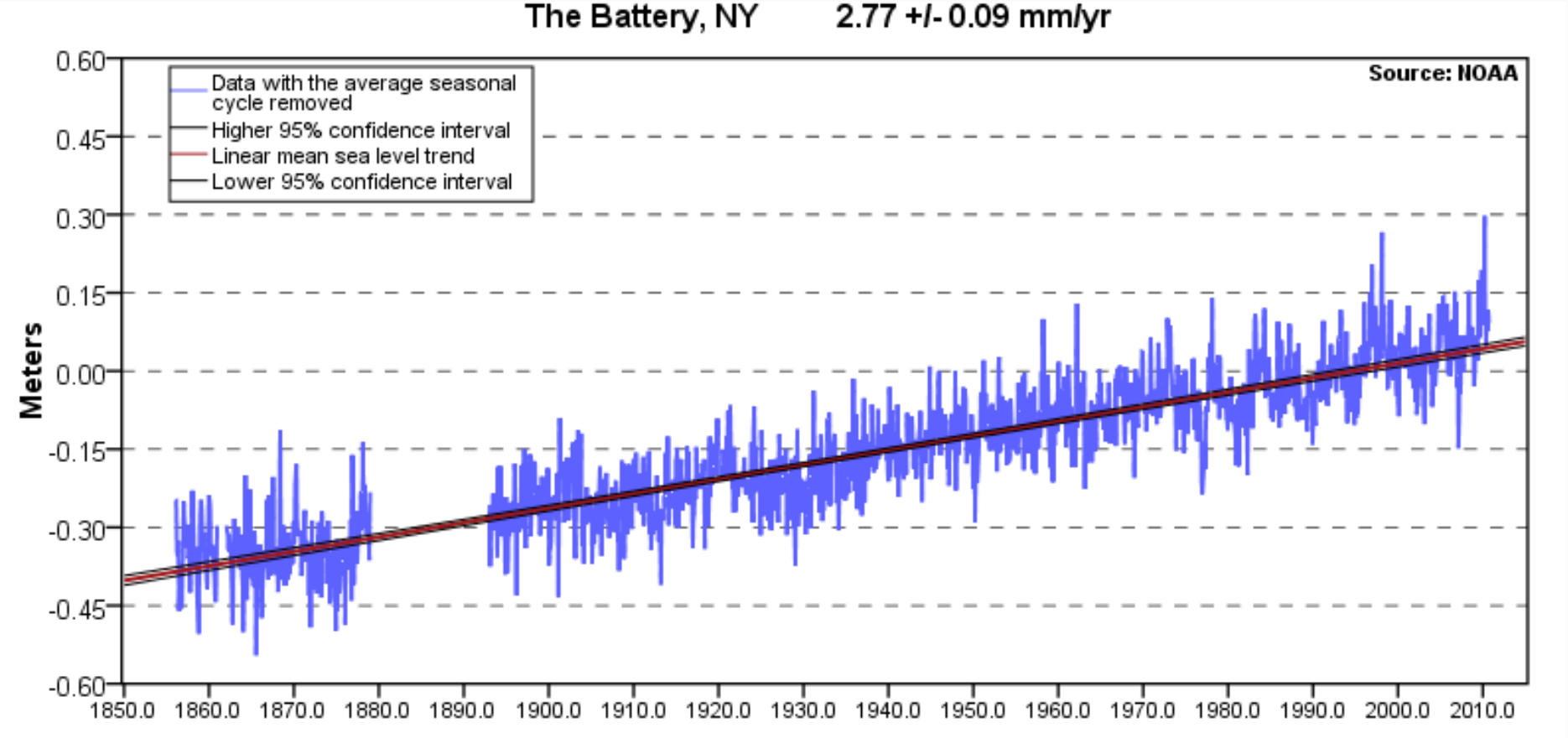
Data NOAA; Table: Munich Re America, Inc.

Annual Number of U.S. Landfalling Tropical Cyclones (TCs), 1900 – 2015



Source: Munich Re

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.

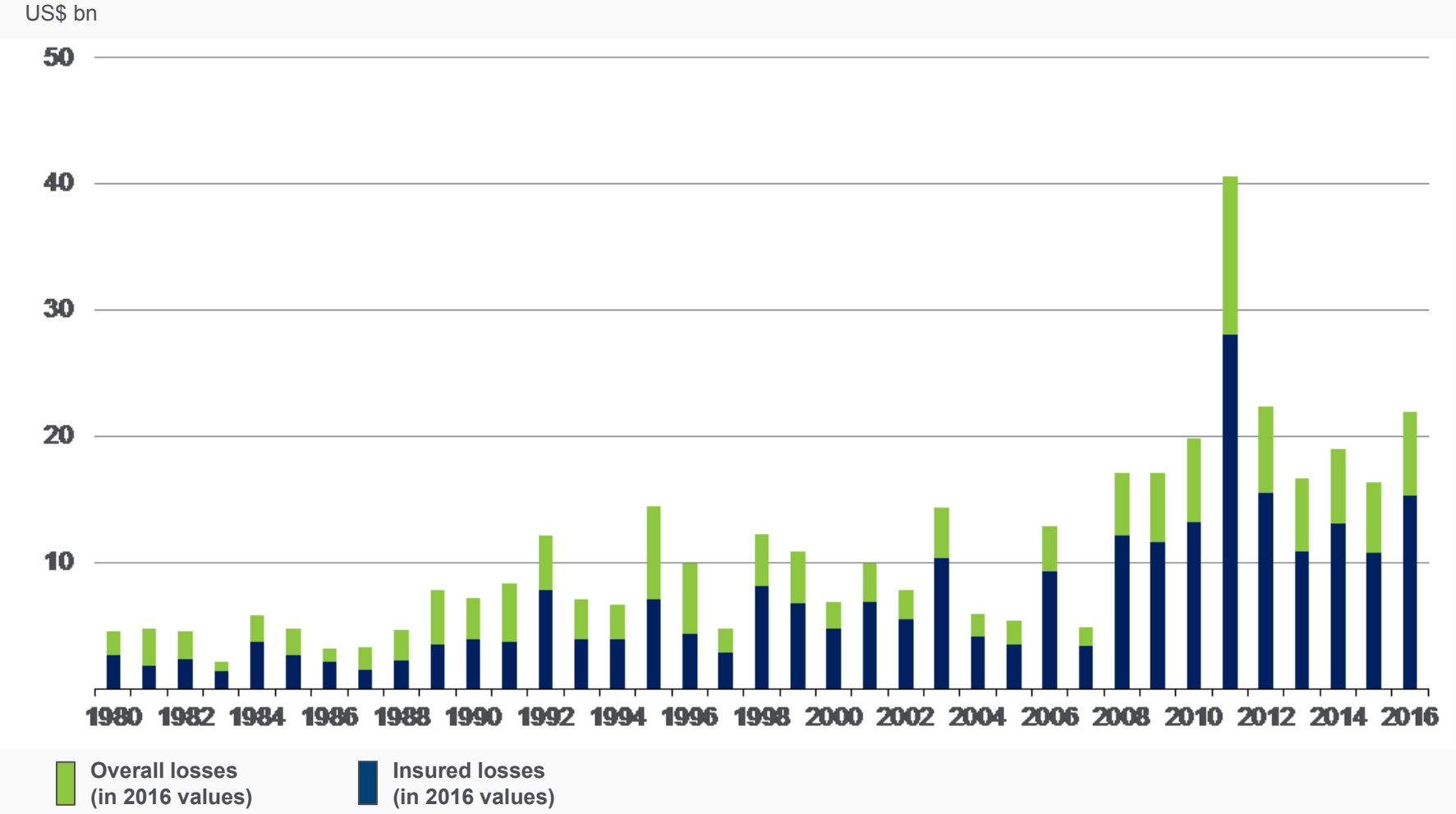
Source: NOAA

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.

Convective storm events* in the U.S. 1980 – 2016

Overall and insured losses

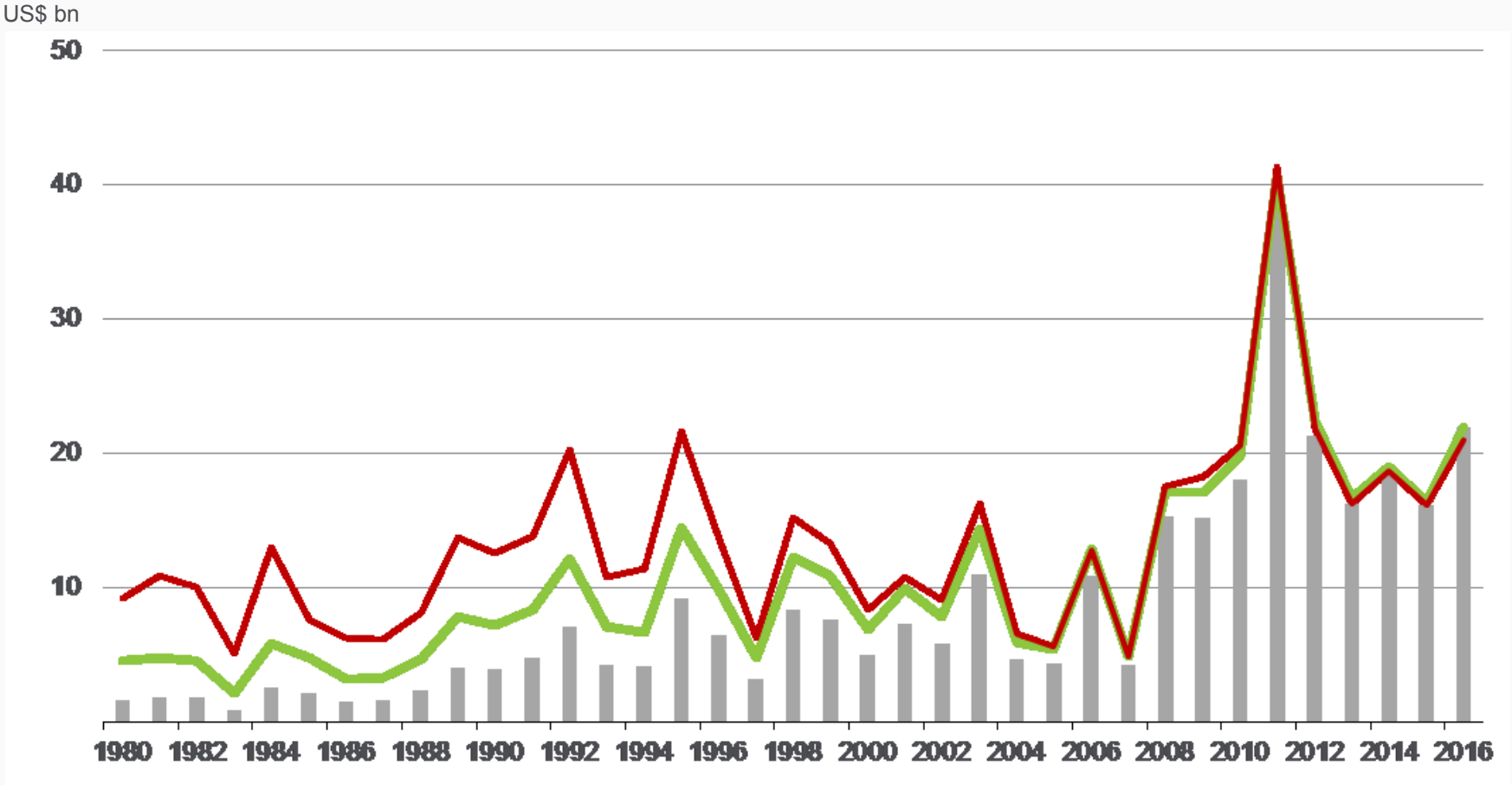


Inflation adjusted via country-specific consumer price index.

*(incl. severe storm, hail, tornado, lightning, flash flood)

Convective storm events* in the U.S. 1980 – 2016

Overall losses: nominal, inflation adjusted, and normalized



Normalized Losses

Inflation-Adjusted Losses

Nominal Losses

Inflation adjusted via country-specific consumer price index.

Normalization via local GDP developments measured in US$.

*(incl. severe storm, hail, tornado, lightning, flash flood)

Socioeconomics & U.S. Natural Catastrophe Risk

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Socioeconomic Factors Increasing Thunderstorm Losses: Urban and Suburban Sprawl

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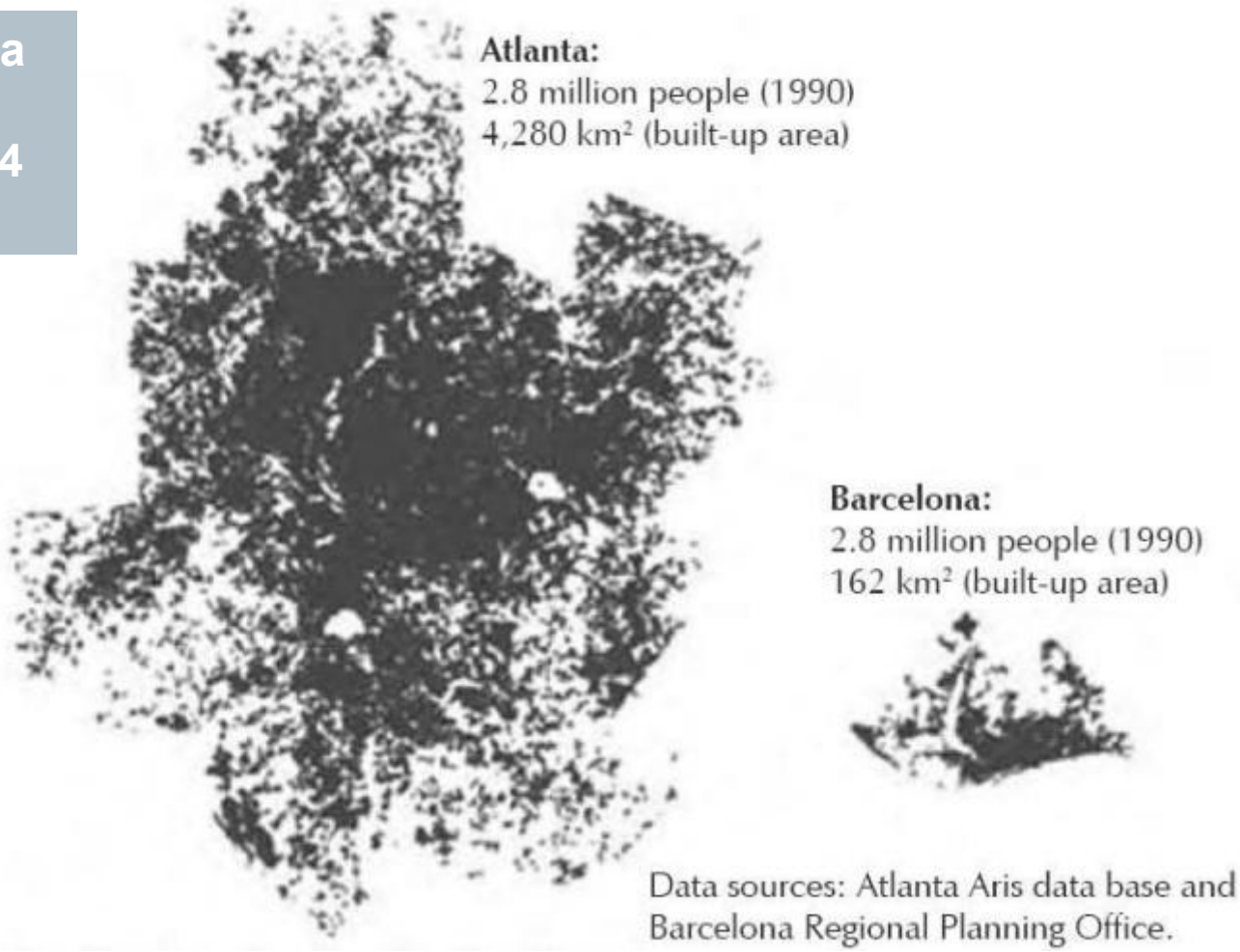
The Built-up areas of Atlanta and Barcelona represented at the same scale

Current Atlanta Metro Population: 5.4 million



Socioeconomic Factors Increasing Nat Cat Losses: Building Age / Construction Quality

Links to Institute For Business & Home Safety Videos Shown:

https://www.youtube.com/watch?v=itv3XFe-IEI

https://www.youtube.com/watch?v=L9ngIY_fzgg

https://www.youtube.com/user/ibhsdotorg/featured

Key Messages

- The (re)insurance industry is very concerned about climate change, particularly in regard to how it may change the frequency and severity of meteorological natural catastrophes.
- Both economic & insured property losses due to natural catastrophes have been risen dramatically over the past 35 years.
- Uncertainties around our understanding and observations of natural catastrophes makes it exceedingly difficult to attribute these trends to anthropogenic warming (if such a link exists).
- Socioeconomic factors dominate insurance industry loss trends from Natural Catastrophes.
- **Our buildings can't withstand today's severe weather, let alone the potential for more frequent and/or more severe catastrophes in a future climate.**

THANK YOU! ANY QUESTIONS?

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