Atmospheric and Environmental Research

Climate Change: Is There a New Normal in Insurance Claims?

September 17, 2013
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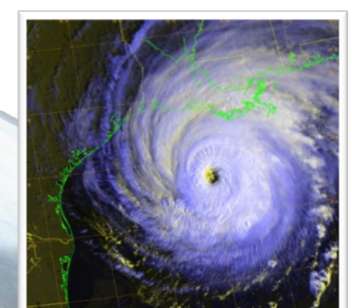
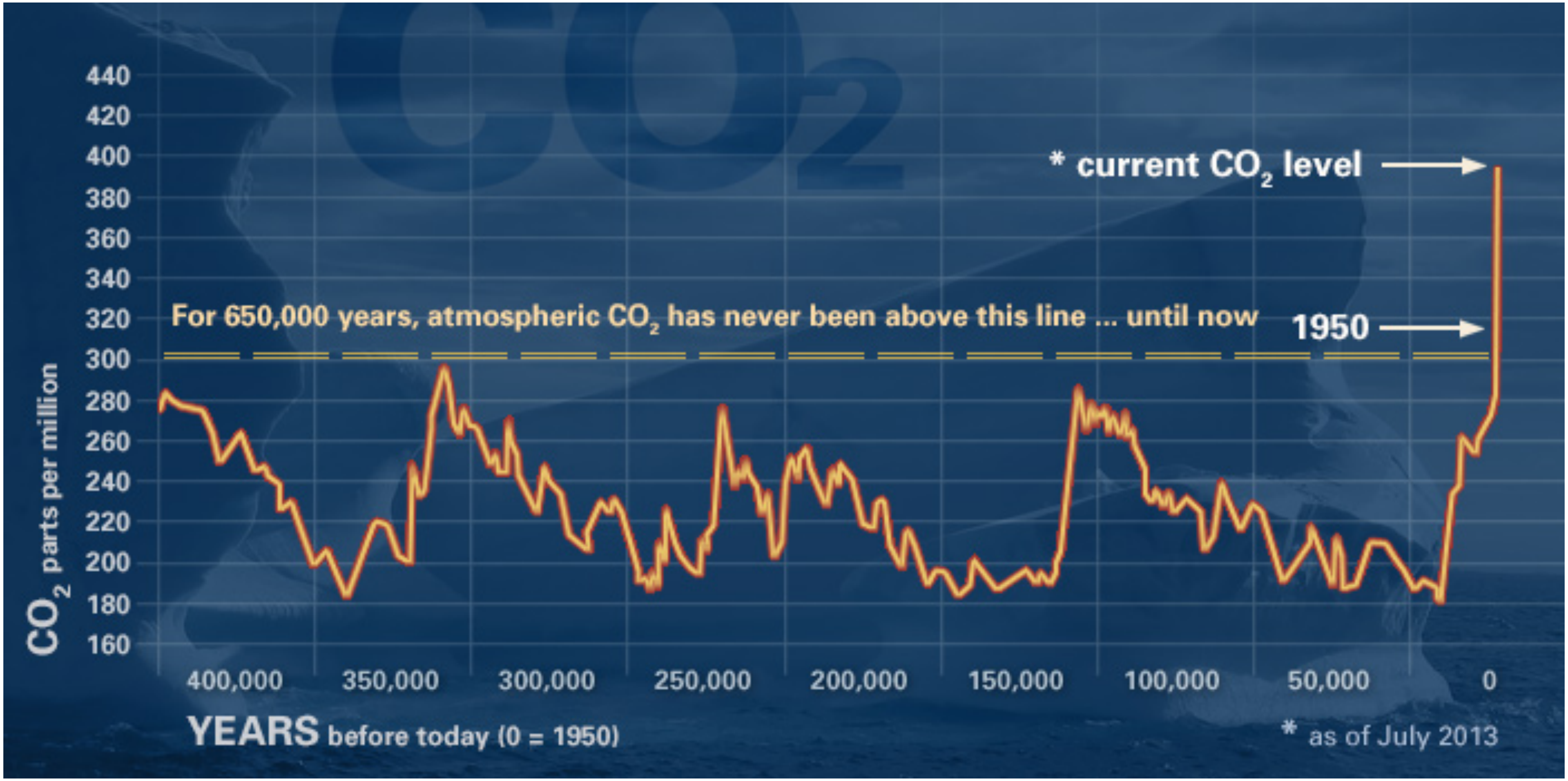


Agenda

- Ways our climate system is changing
  - Temperature patterns
  - Precipitation
  - Sea level
- Changing environmental conditions affecting important perils
  - Severe thunderstorm, extreme rainfall, hurricane, winter storm, wildfire
- How some insurers are preparing and adapting

CO_2 is higher than ever before

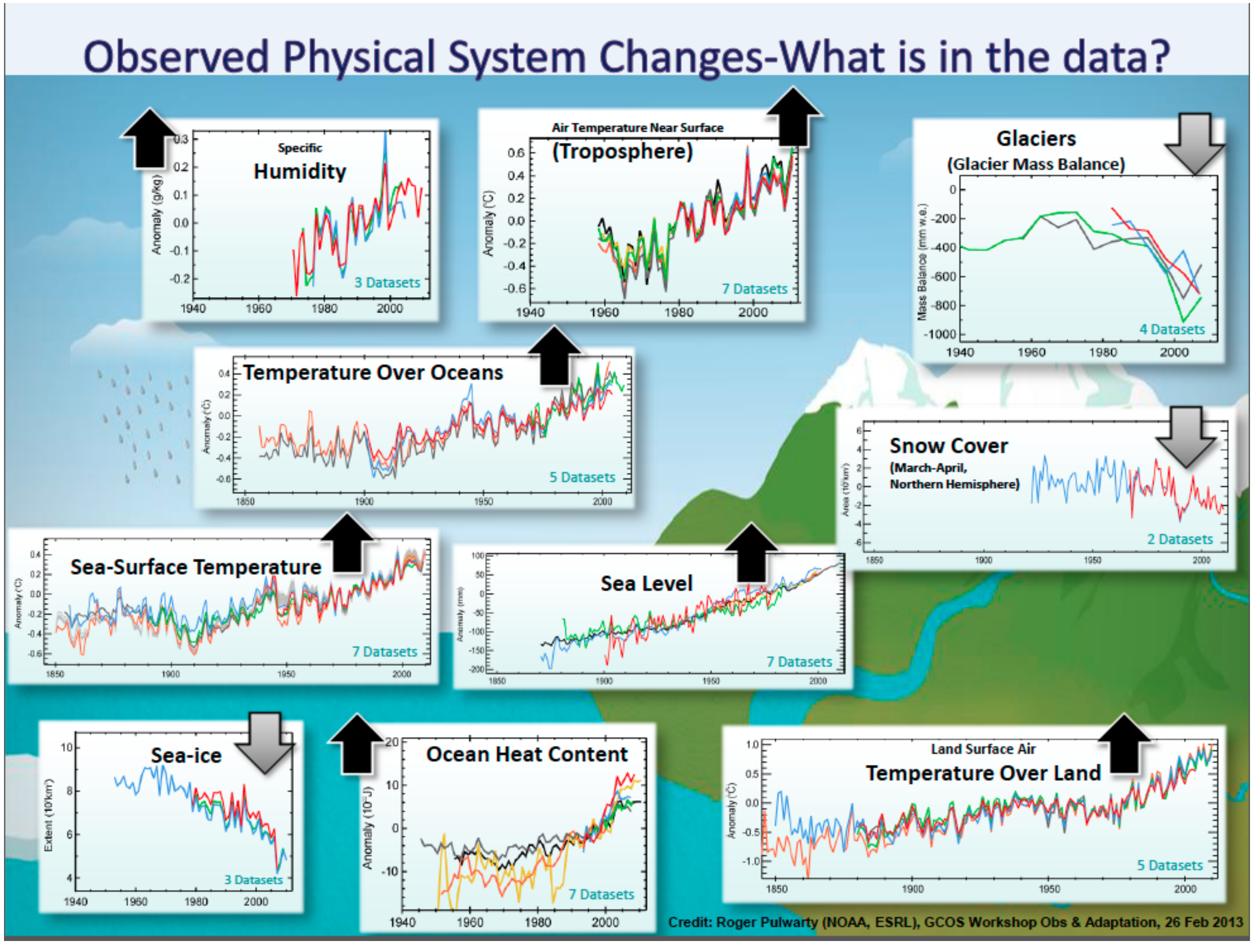


Source: NOAA. Based on atmospheric samples in ice cores and direct measurement (more recently).

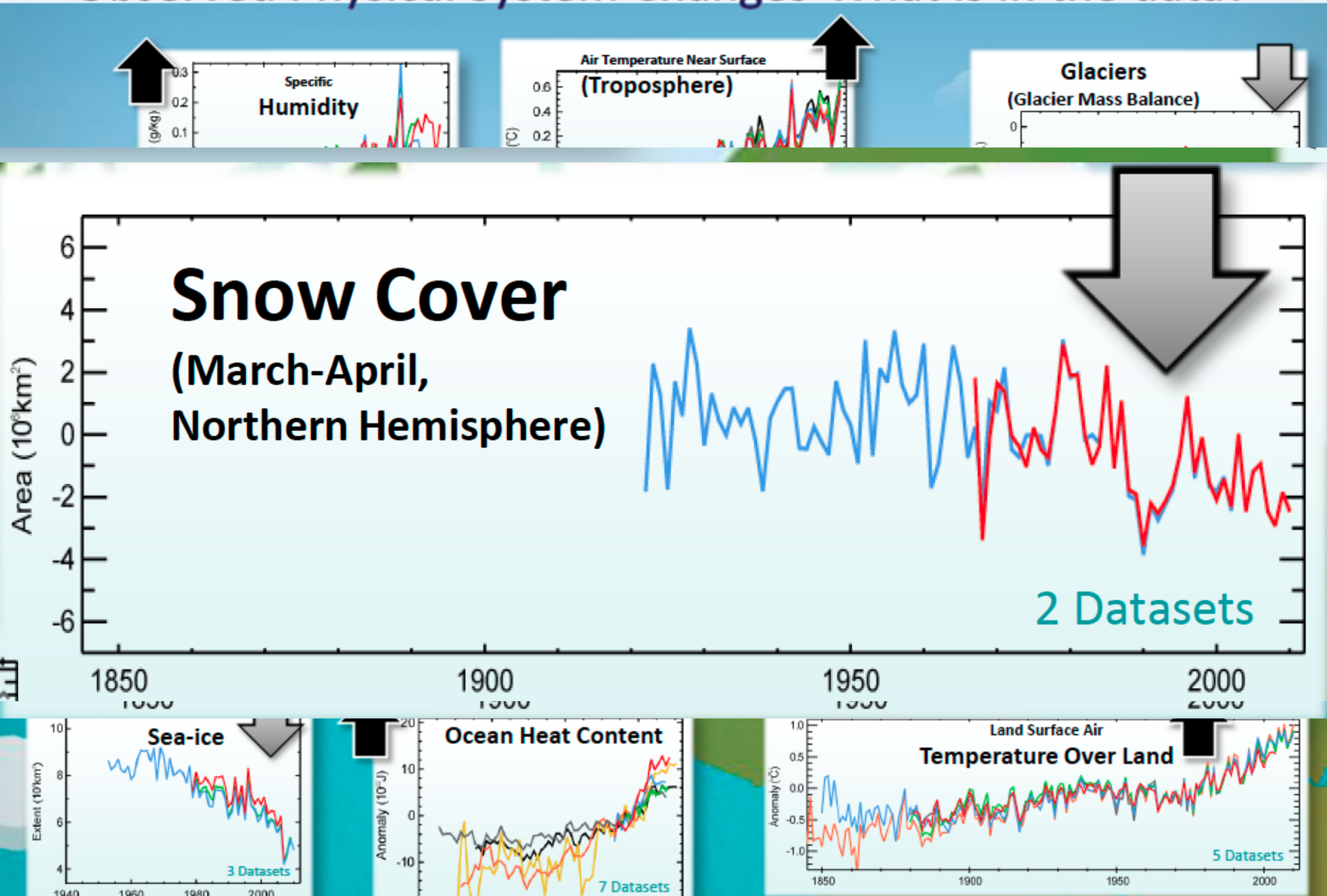
Trends in global climate

Current results presented at a June 5th, 2013 meeting of the UN Framework Convention on Climate Change (Bonn, Germany).

Next IPCC reports coming out late September 2013 through 2014



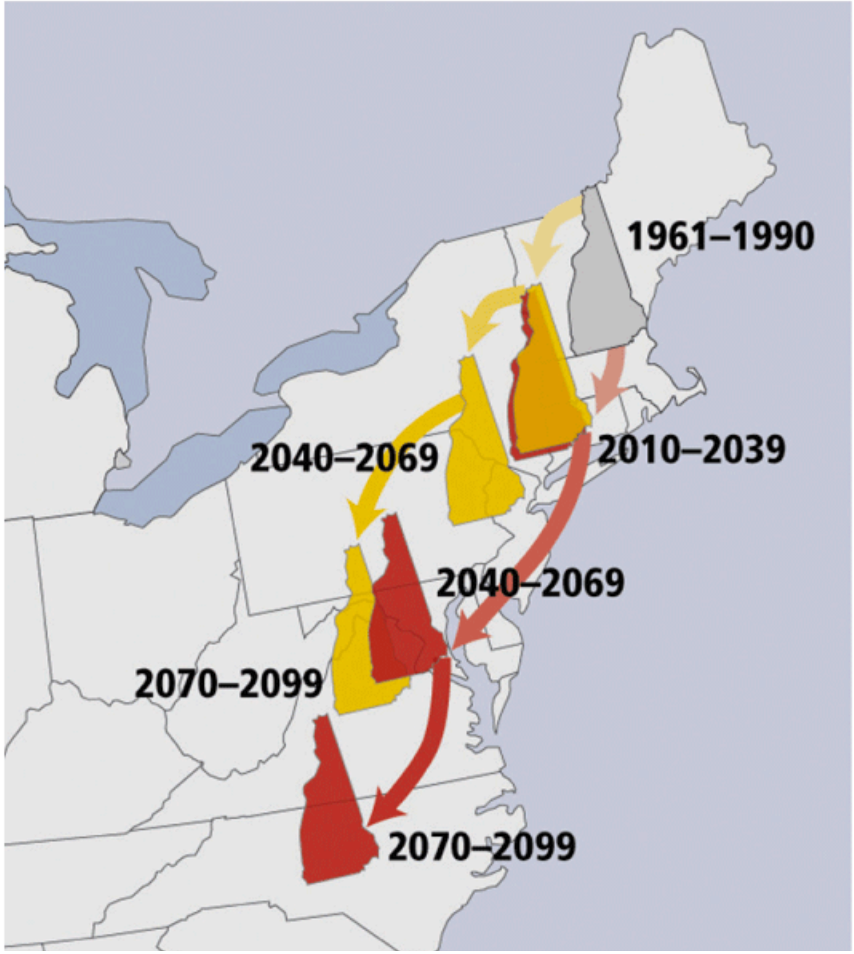
Observed Physical System Changes-What is in the data?



Credit: Roger Pulwarty (NOAA, ESRL), GCOS Workshop Obs & Adaptation, 26 Feb 2013

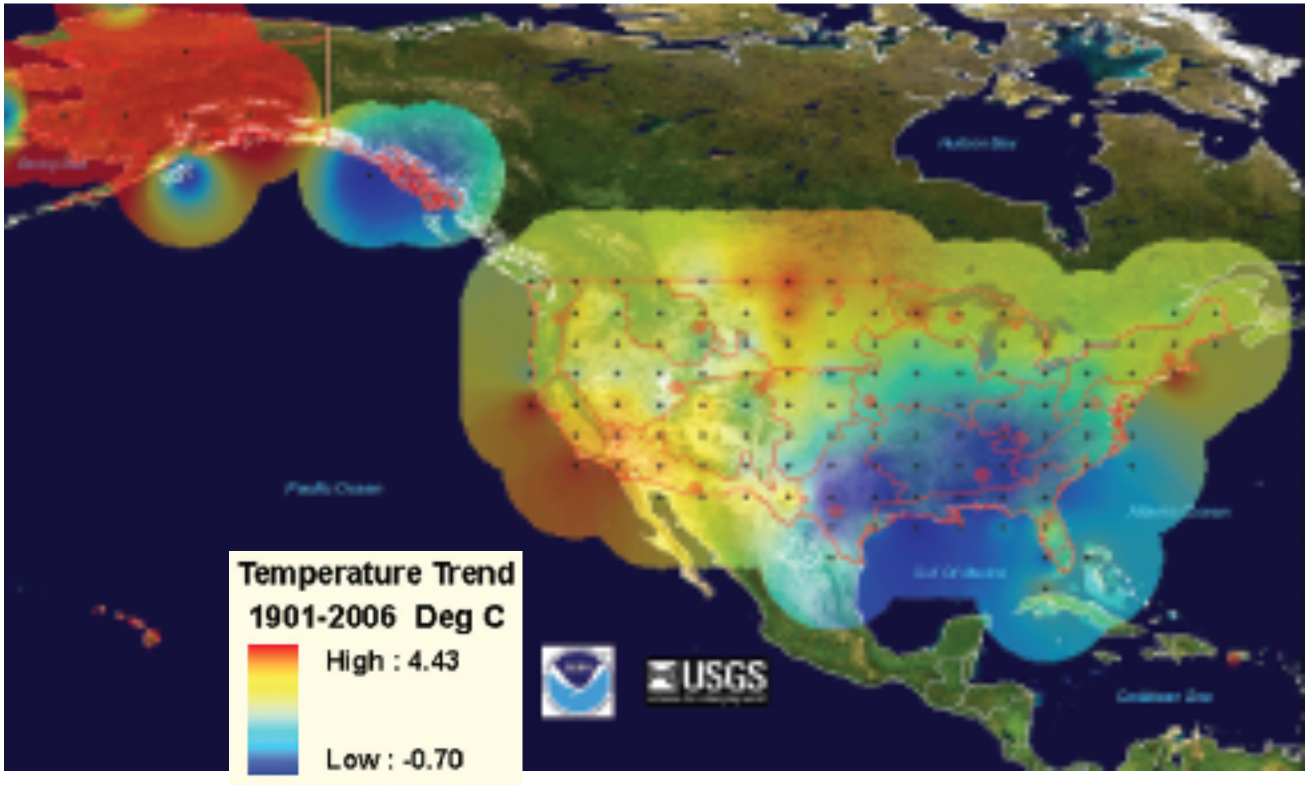
Regional climate shifts

Climate on the move: changing summers in New Hampshire[12]



Footnotes:
[12]U.S. Global Climate Change Program (2009), B1 & A1FI emissions scenarios

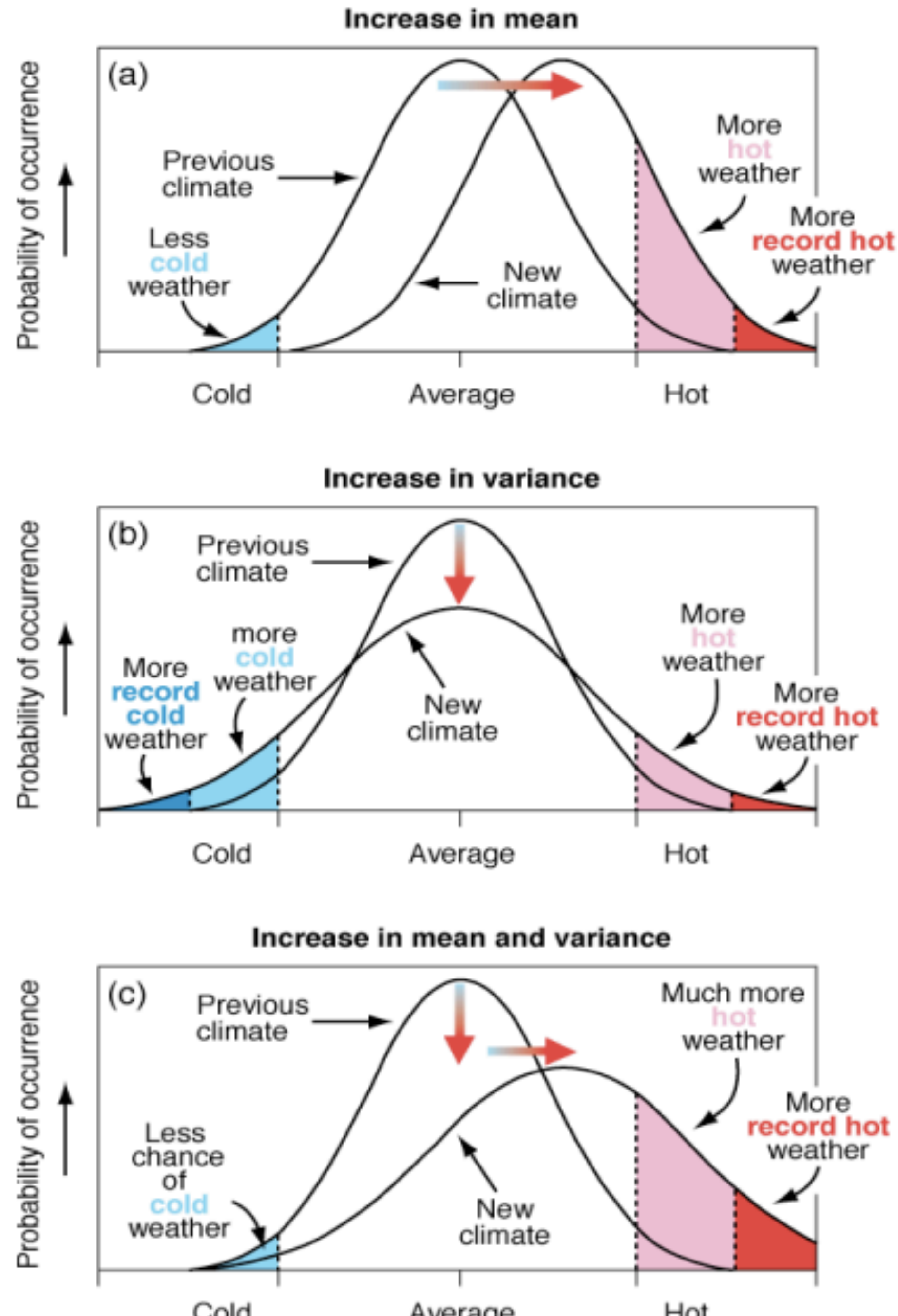
Temperature trends



Temperature changes over the past century from weather stations with complete, consistent, and high quality records. NOAA's National Climate Data Centers and the U.S. Geological Survey.
Source: U.S. Climate Change Science Program Systhesis and Assessment Product 4.3*, The Effect of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States*

Illustration of Climate Change Impacts

- Potential changes in the mean distribution[9]
- Potential changes in the variance of the distribution
- Potential joint changes, resulting in skewed distribution



Footnotes:
[9]Folland et. al (2001), Observed Climate Variability and Change

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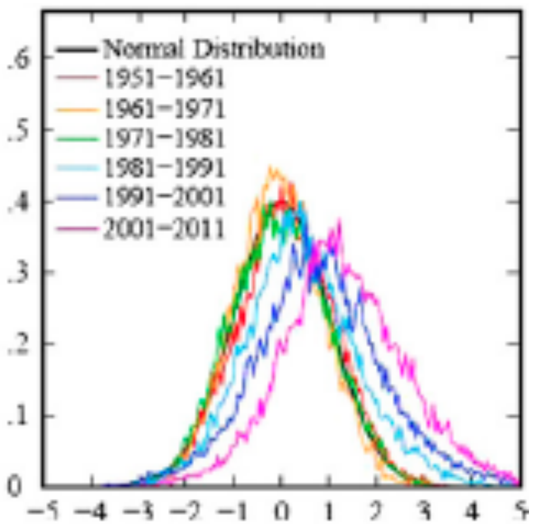
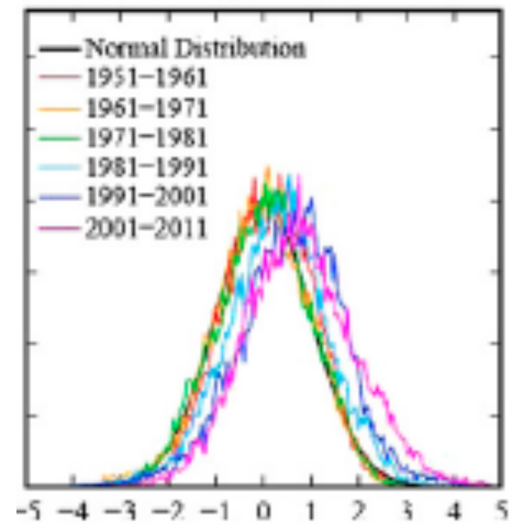
Temperature changes in the Northern Hemisphere

Northern Hemisphere, Summer



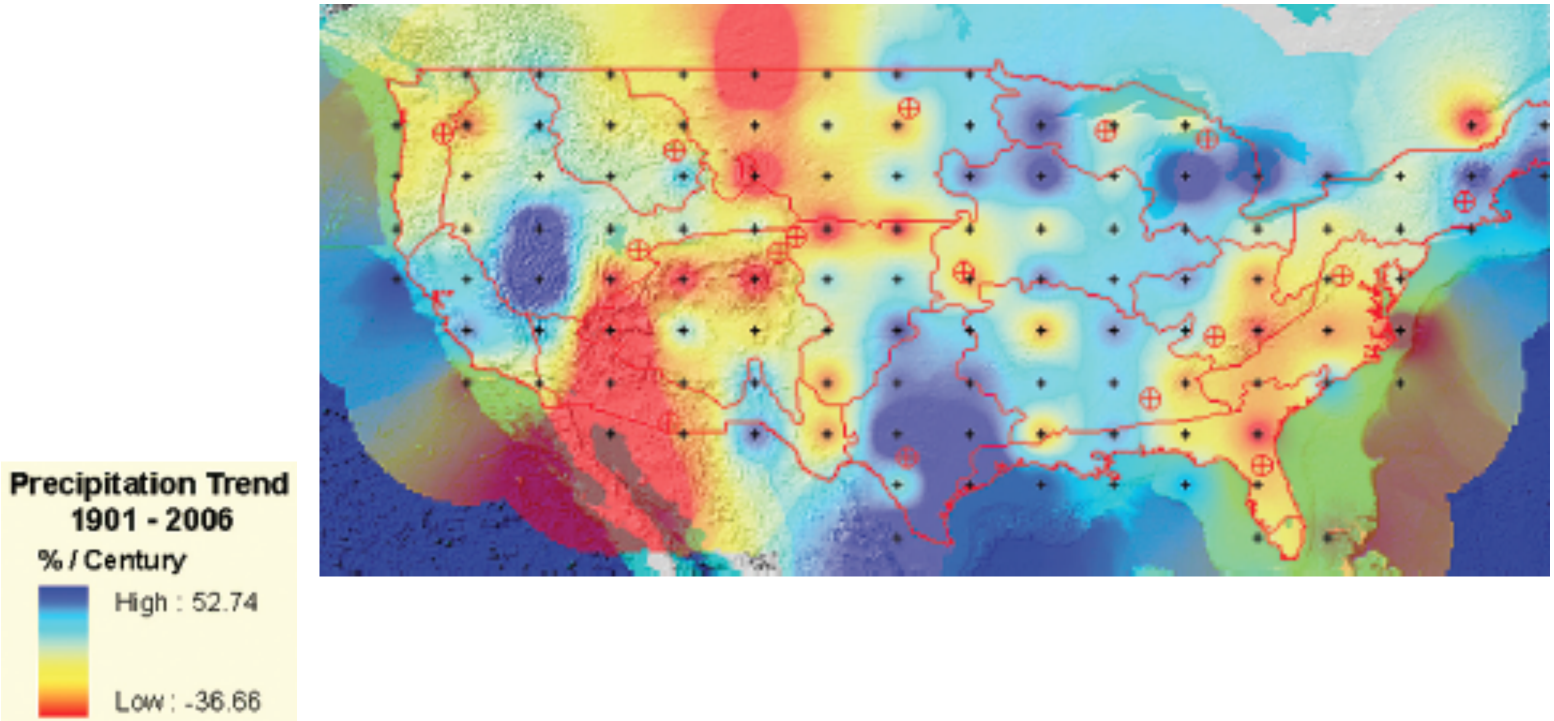
Northern Hemisphere, Winter



Mean is shifted warmer, but perhaps more importantly, the distribution is wider, i.e. variability is increased.

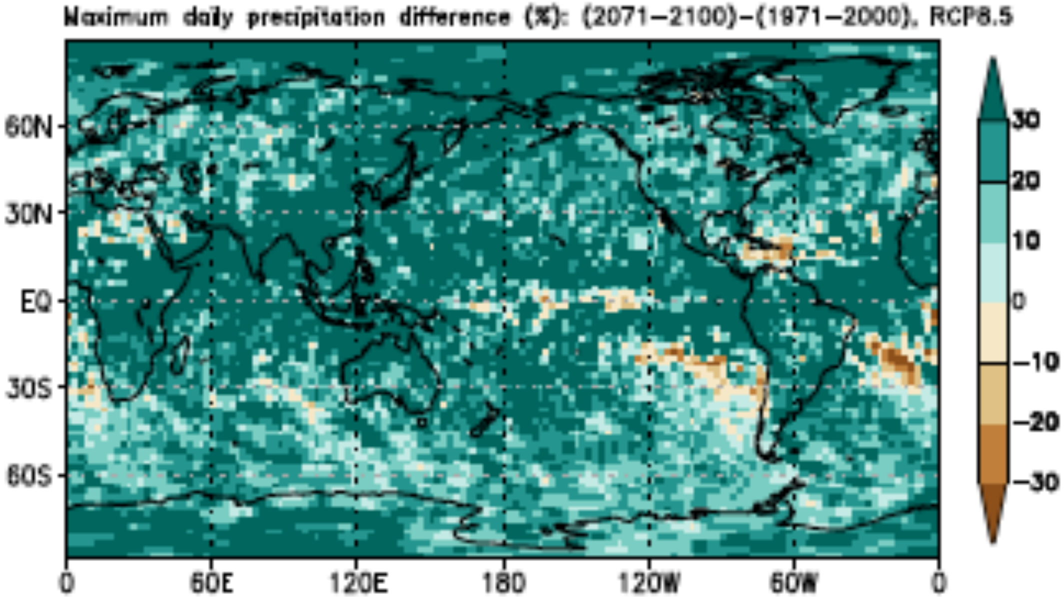
Hansen et al. 2012

Precipitation trends



Precipitation changes over the past century from weather stations with complete, consistent, and high quality records. NOAA's National Climate Data Centers and the U.S. Geological Survey.
Source: U.S. Climate Change Science Program Systhesis and Assessment Product 4.3*, The Effect of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States*

Extreme precipitation events



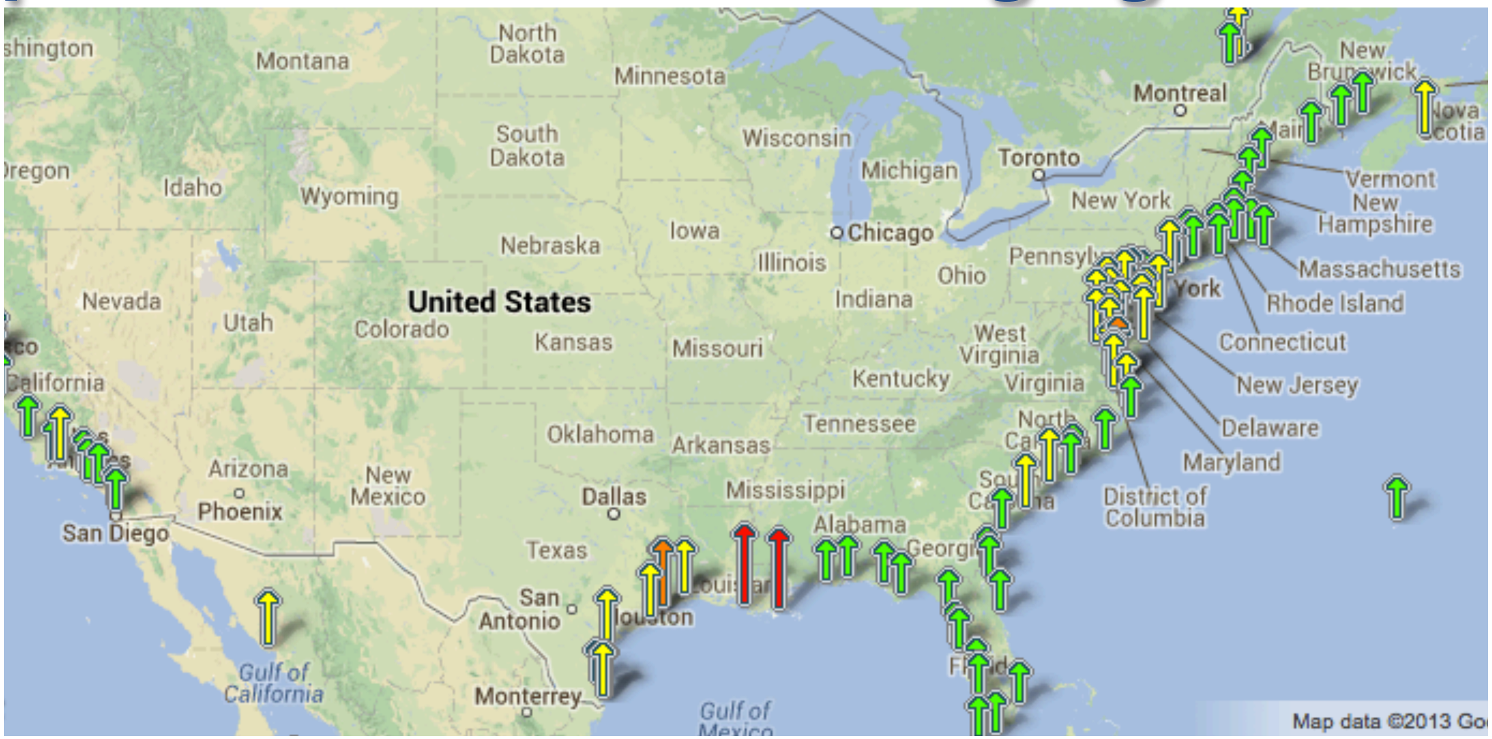
Possible explanations:

1) Saturation water vapor temperature increases with temperature, so more available moisture in each event
2) Warming-induced increase of the convective season, leading to more events

Changes in the 30-year return period maximum daily precipitation increase by 10-30%

Kunkel et al. 2013

Sea level rise will make hurricanes and tropical storms more damaging



Sea Level Trends
mm/yr (feet/century)

15 to 21 (5 to 7)	6 to 9 (2 to 3)	-3 to 0 (-1 to 0)	-12 to -9 (-4 to -3)
12 to 15 (4 to 5)	3 to 6 (1 to 2)	-6 to -3 (-2 to -1)	-15 to -12 (-5 to -4)
9 to 12 (3 to 4)	0 to 3 (0 to 1)	-9 to -6 (-3 to -2)	-18 to -15 (-6 to -5)

NOAA: Sea Levels Online

Coastal cities at highest risk

1. Guangzhou
2. Miami
3. New York
4. New Orleans
5. Mumbai
6. Nagoya
7. Tampa
8. Boston
9. Shenzen
10. Osaka

(Items 1–4:) 43% of forecast total global losses

Stephane Hallegatte and the OECD, 2013
Study incorporates existing coastal defenses

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Summary of global trends

- The earth is warming – the climate is shifting.
- The world's atmosphere is "wetter" and more energetic.
- The water cycle is more intense.
  - more floods and possibly more droughts
- Event "tails" seem to be growing.
- There are regional winners and losers as the climate moves.

Global Climate Change: Recent Impacts

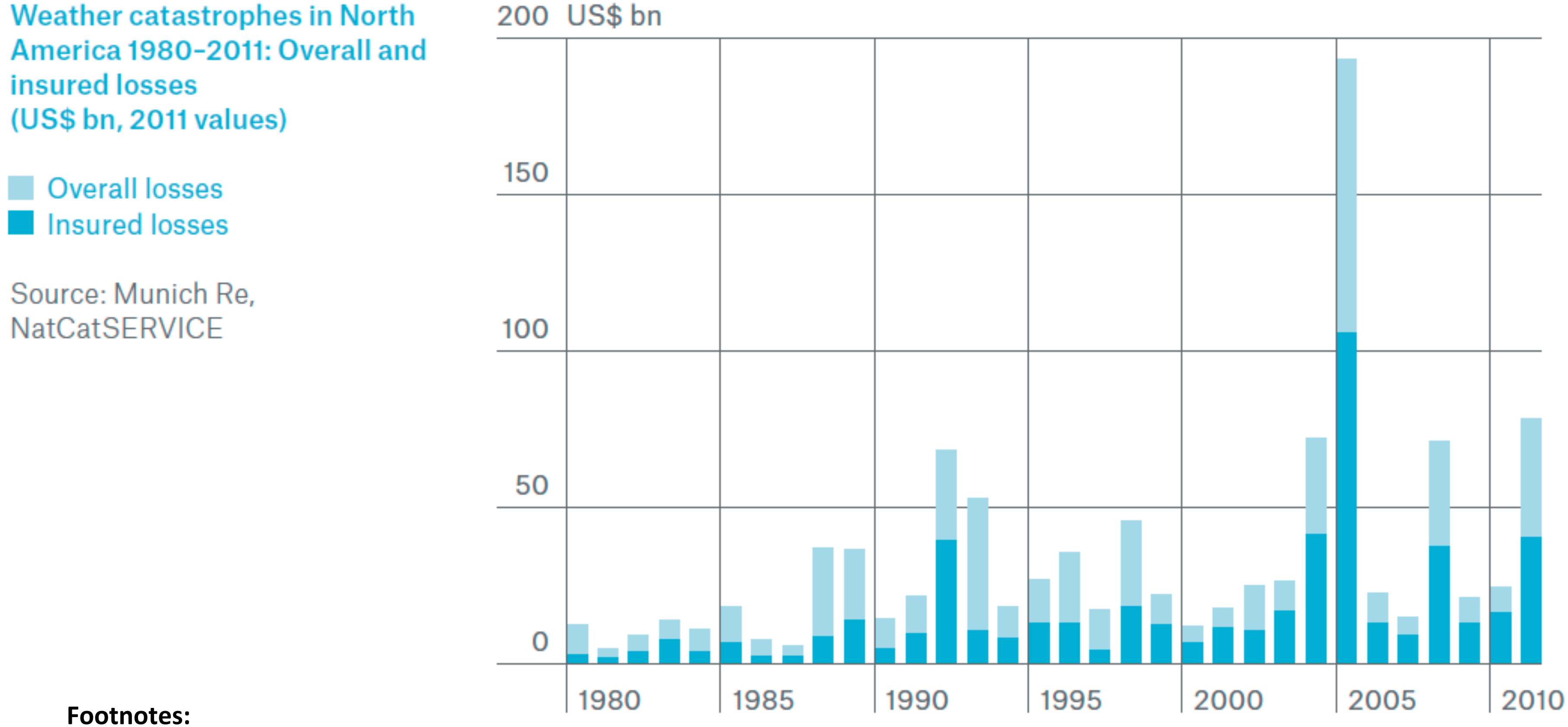
Phenomena	Likelihood that trend occurred in the late 20th century
Cold days, cold nights, and frost less frequent over land areas	Very likely
More frequent hot days and nights	Very likely
Heat waves more frequent over most land areas	Likely
Increased incidence of extreme high sea level	Likely
Global area affects by drought has increased (since 1970s)	Likely in some regions
Increase in intense tropical cyclone activity in North Atlantic (since 1970)	Likely in some regions

Climate.nasa.gov/effects; adapted from IPCC 2007 Summary for Policymakers

Increasing trend in losses[5]

5 of the last 9 years: > 40 bn US$

Weather catastrophes in North America 1980–2011: Overall and insured losses (US$ bn, 2011 values)



Source: Munich Re, NatCatSERVICE

Footnotes:
[5]Munich Re Natcat Service

Example Emerging Risk Definitions

- Lloyds[1]: An issue that is perceived to be potentially significant but which may not be fully understood or allowed for in insurance terms and conditions, pricing, reserving or capital setting
- PWC[2]: Those large scale events or circumstances beyond one's direct capacity to control, that impact in ways difficult to imagine today
- S&P[3]: May appear slowly, are difficult to identify, and represent an idea more than existing circumstances. They often result from changes in the political, legal, market or physical environment, but the link between cause and effect is not proven

Footnotes:
[1]Lloyds Emerging Risk Reports (2013)
[2]Price Waterhouse Coopers (2009), Exploring Emerging Risks
[3]Standard & Poors (2007), Summary of S&P's ERM Evaluation Process

Emerging Risk Definitions in Practice

1. Completely new risks that have never been seen before[4]
2. Previously known risks that are evolving in unexpected ways with unanticipated consequences

Characteristics:

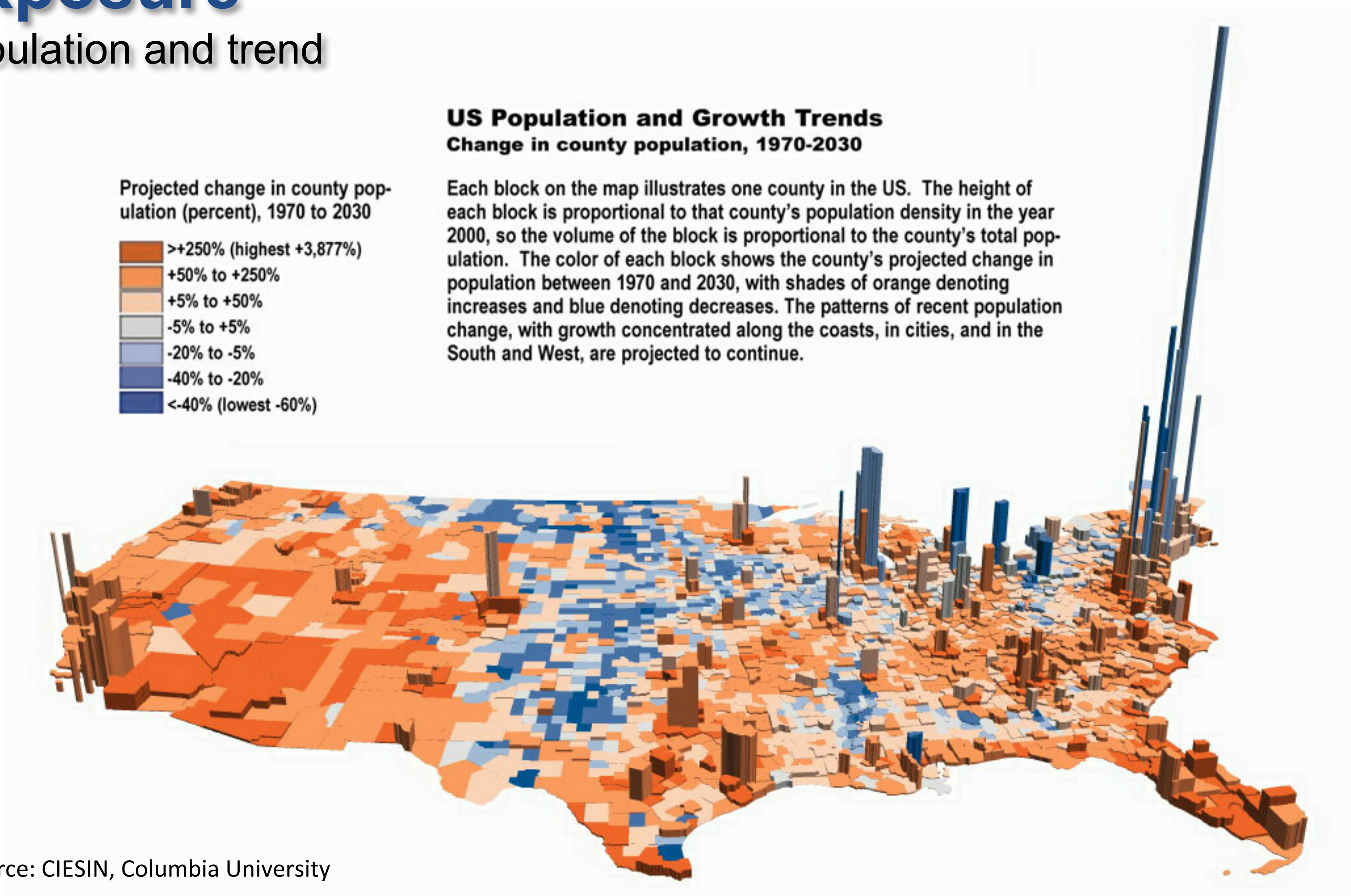
- Significance may be uncertain, not well understood
- Difficult to quantify due to lack of data and/or volatility
- Consequences and implications can be ambiguous
- Interactions and interconnectedness with other risks can be complex
- May be systemic, outside of organizational control

Footnotes:

[4] Woerner (2011) Buckeye Annual Continuing Education presentation

Exposure

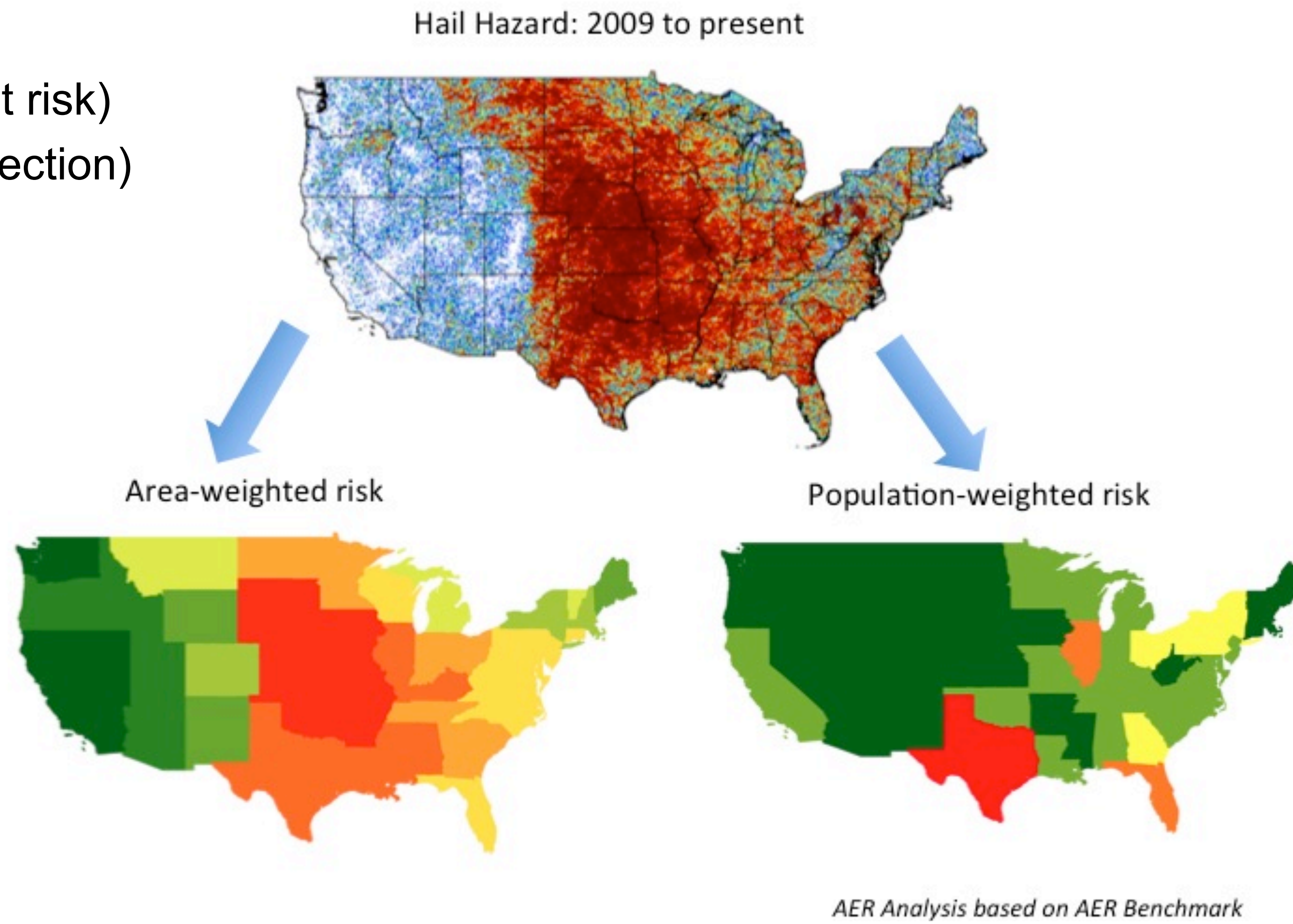
Population and trend



Source: CIESIN, Columbia University

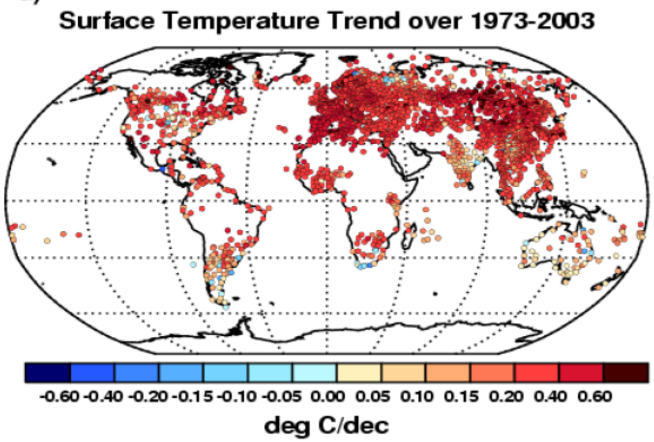
Risk profile for weather losses

Hazard (perils)
Exposure (value at risk)
Vulnerability (protection)

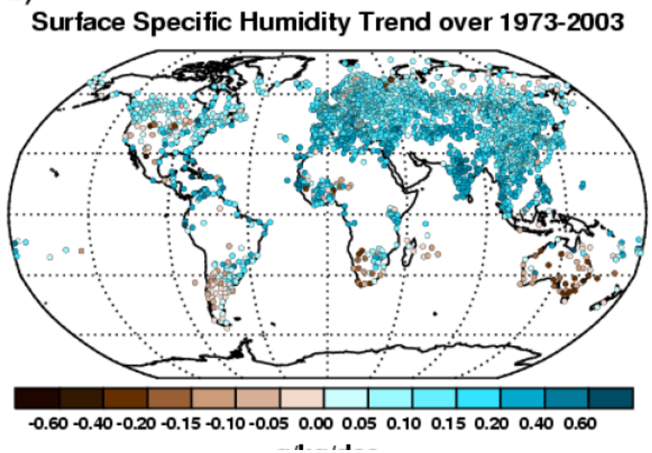


Observed changes in physical parameters

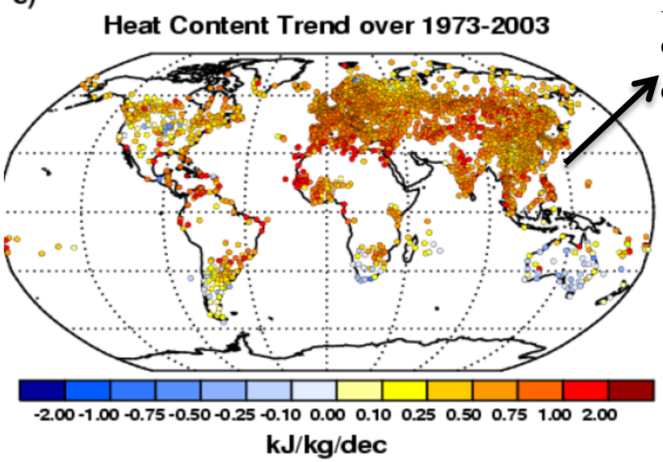
a)



b)



c)



Heat content (includes moisture) has increased over much of the globe with some areas of decrease (e.g., Australia).

Trends in Various Quantities:

Specific Humidity over Land: 0.11 g/kg/decade
Land surface temperature: 0.291 K/decade
Ocean surface temperature: 0.125 K/decade
Upper ocean heat content: 3.7e20 J/decade
Latent heat: 270 J/decade
Enthalpy: 300 J/decade
Kinetic Energy: -0.63 J/decade

Peterson et al. (2011)

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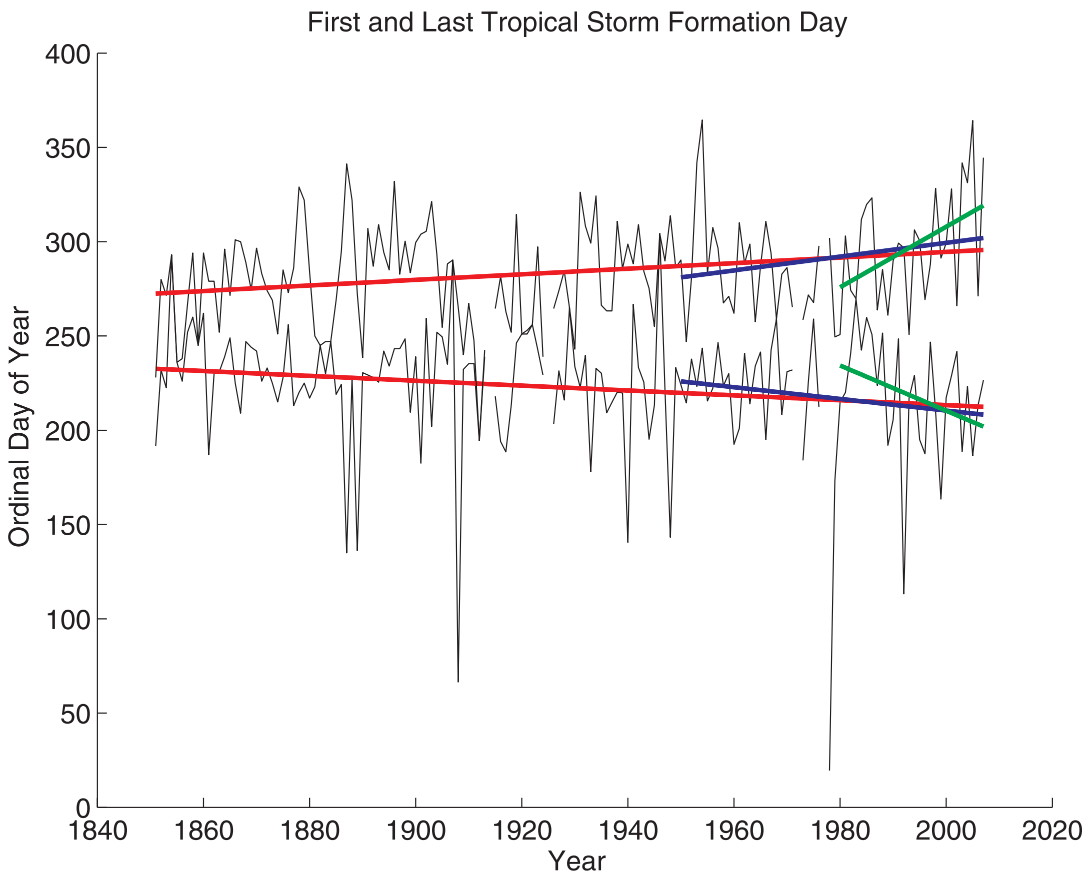
Example of physical changes affecting severe weather in North America

- Global weather patterns transport heat and moisture
  - Energy balance
- Jet stream driven by temperature gradient between poles and mid-latitudes
  - Faster in winter when gradient is strongest
- Temperature gradient is decreasing
  - Arctic is warming faster than mid-latitudes
- Jet stream speed decreases
  - Instability: more "kinks"
  - Weather patterns stay in place longer
- Position of jet stream indicates which areas are affected by severe convective storms, i.e. hail and tornados

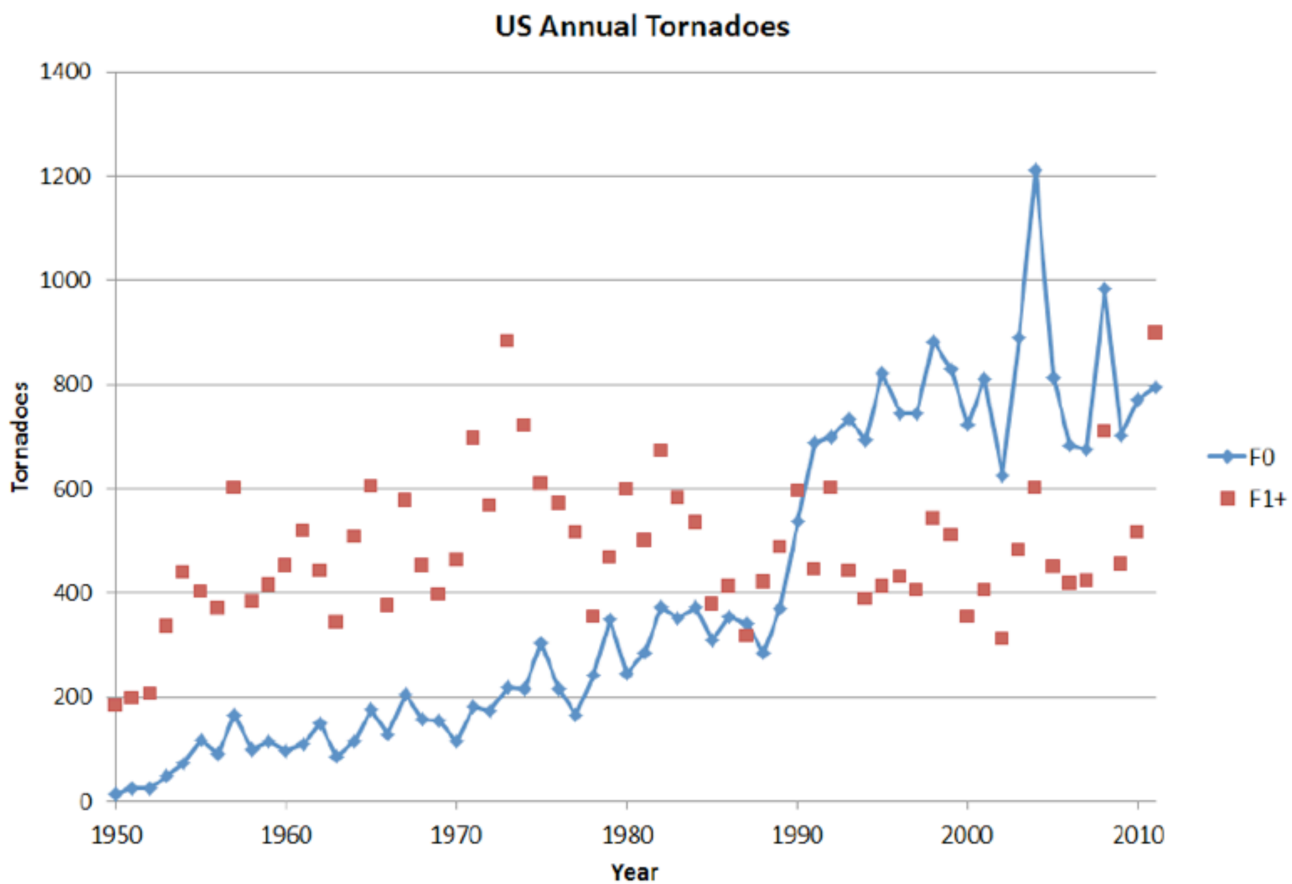
Broadening tails

Trends in North Atlantic hurricane season



Kossin (2008), Is the North Atlantic hurricane season getting longer?

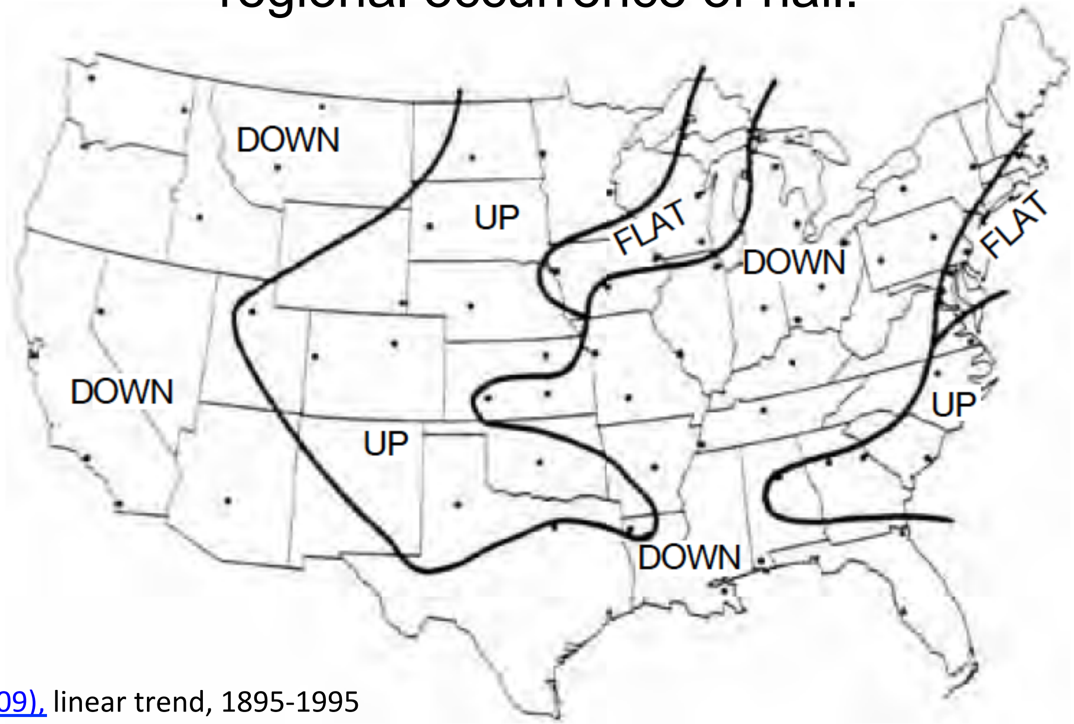
Severe Weather Trends: Tornado



Brooks et al. (2012), 26th SLS Conference

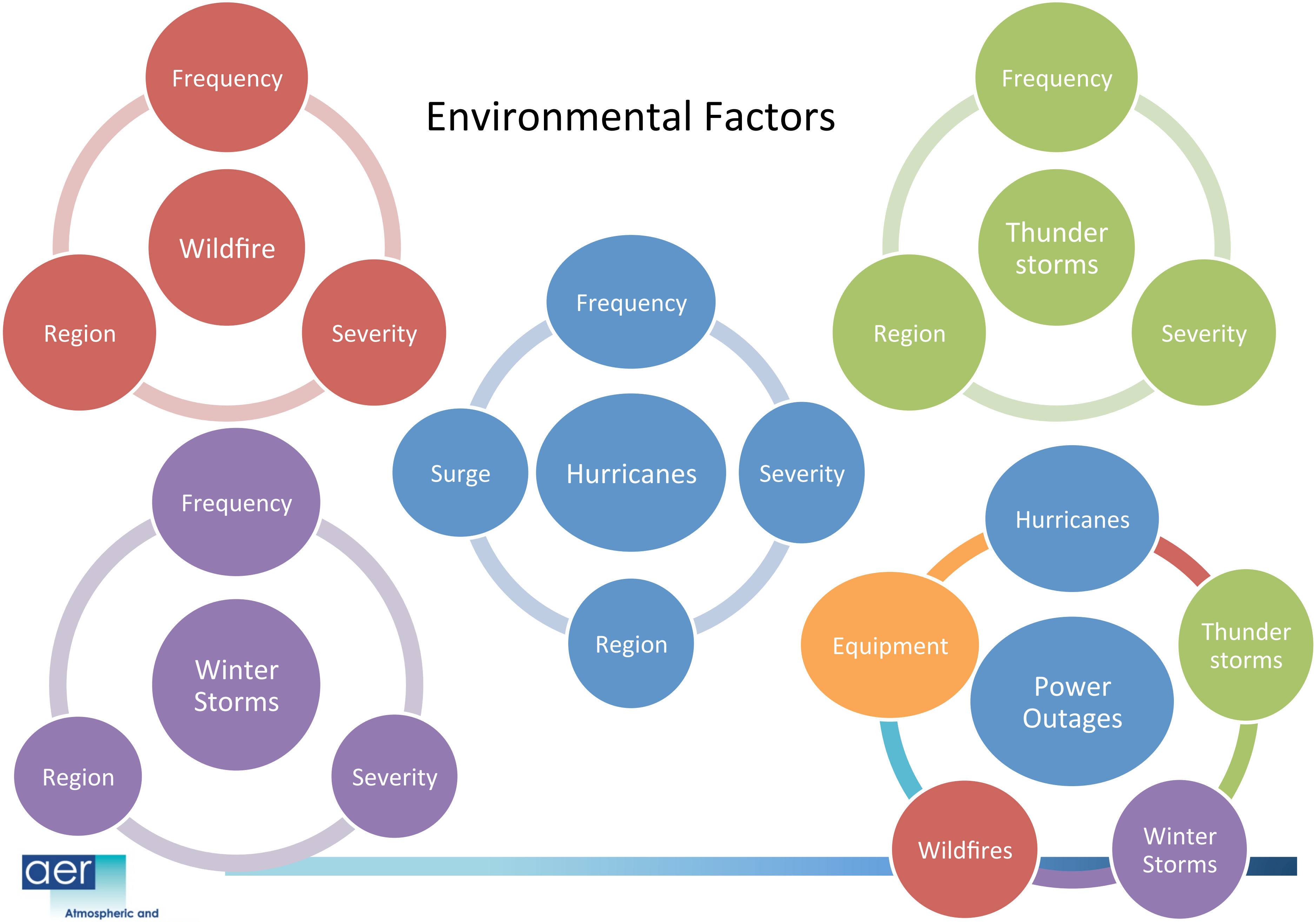
Severe Weather Trends: Hail

Some evidence of changes in regional occurrence of hail.



Footnotes:
[Changnon et al. (2009),](#) linear trend, 1895-1995

Environmental Factors

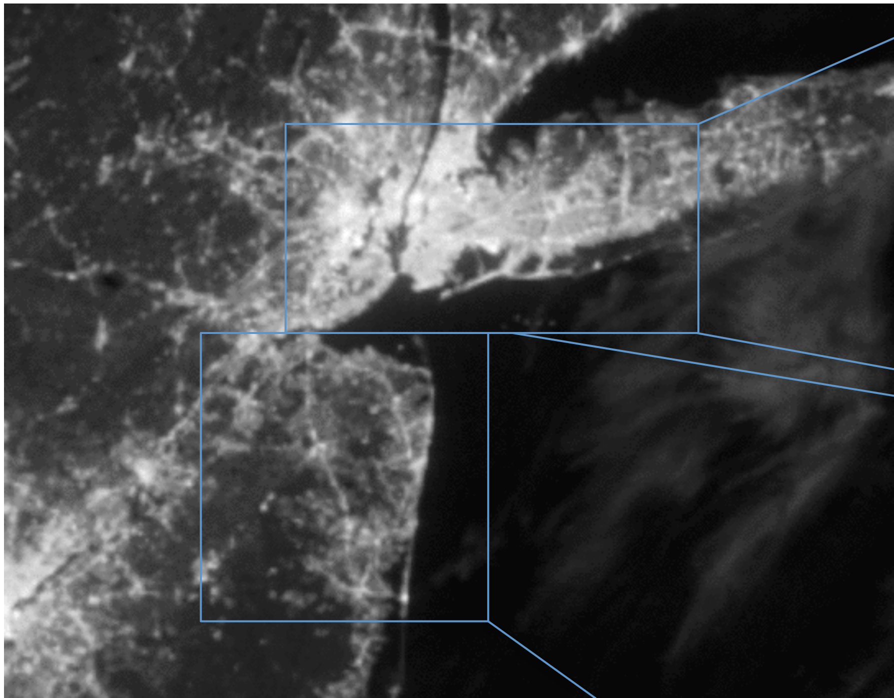


Power Outage as an Emerging Risk

- CRO Forum – in 2012 identified blackouts as an emerging risk
- Blackouts expected to increase in *both* frequency and severity (U.S. DOE report, *Insurance as a Risk Management Instrument for Energy Infrastructure Security and Resilience*, March 2013)
- Aging infrastructure, increasing interconnectedness, climate change-driven increases in heat waves, floods, and possibly severe thunderstorms, winter storms and hurricanes

Power Outage Analysis
from satellite nighttime light imagery

Alternating Pre/Post-Storm Views



AER Analysis:
Areas of most significant outage

Statistics for Blackouts in the U.S.

	% of events	Mean size in MW	Mean size in customers
Earthquake	0.8	1,408	375,900
Tornado	2.8	367	115,439
Hurricane/Tropical Storm	4.2	1,309	782,695
Ice Storm	5	1,152	343,448
Lightning	11.3	270	70,944
Wind/Rain	14.8	793	185,199
Other cold weather	5.5	542	150,255
Fire	5.2	431	111,244
Intentional attack	1.6	340	24,572
Supply shortage	5.3	341	138,957
Other external cause	4.8	710	246,071
Equipment Failure	29.7	379	57,140
Operator Error	10.1	489	105,322
Voltage reduction	7.7	153	212,900
Volunteer reduction	5.9	190	134,543

Source: *Trends in the History of Large Blackouts in the United States*. http://www.uvm.edu/~phines/publications/

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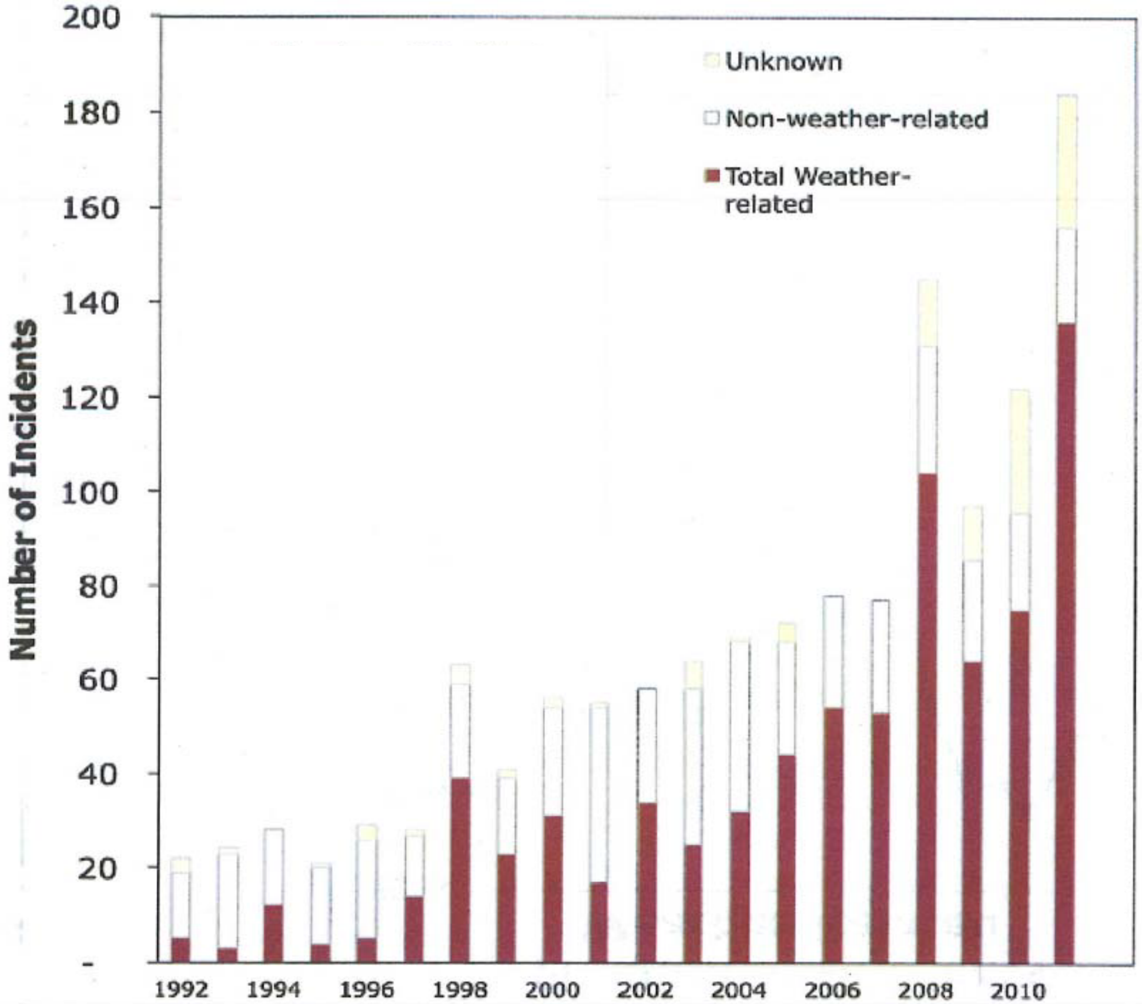
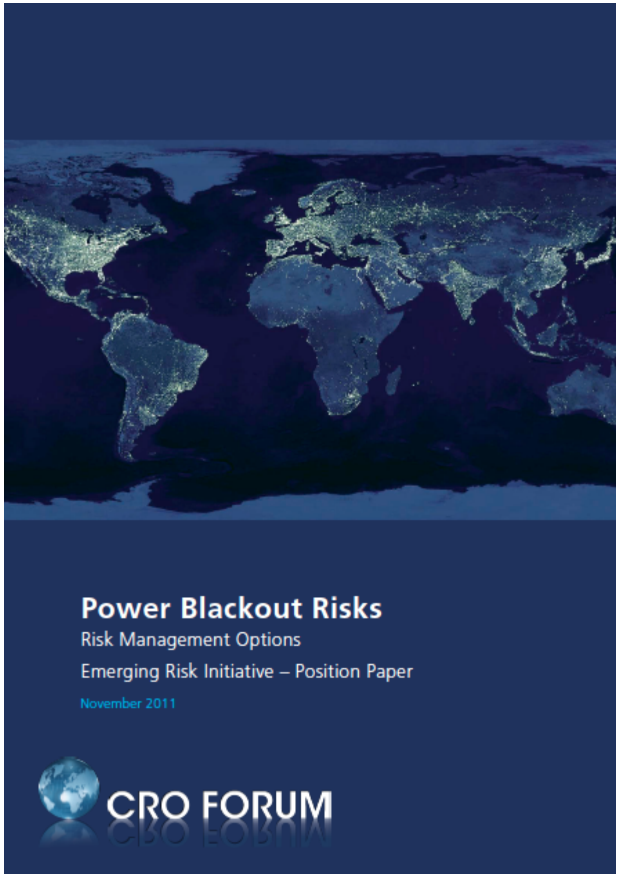
Number of Significant US Weather-Related Grid Disturbances is Rising



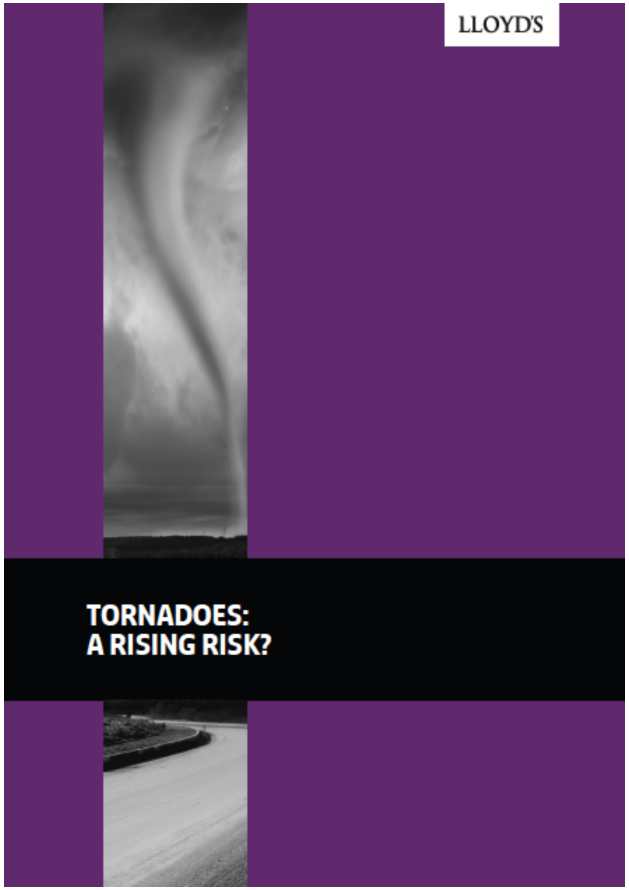
Source: Electric Grid Disruptions and Extreme Weather, 2012, Campbell

How is the insurance industry responding?

A couple of examples:



Organization to increase awareness



Targeted research

Preparation and Adaptation

- Understand
  - Emerging risk research
- Model
  - Cat models focused on insured losses, but what about Cat response planning?
    - "Maximum probable claim event"
    - Real-time resource allocation
  - Perils not covered by current Cat models
    - Power outage
    - Water back-up
- Who is going to pay for increased costs?
  - Median household income is flat
- Mitigation and efficiency

Global Climate Change: Future Trends

Phenomena	Likelihood of trend
Contraction of snow cover areas, increased thaw in permafrost regions, decrease in sea ice extent	Virtually certain
Increased frequency of hot extremes, heat waves, and heavy precipitation	Very likely to occur
Increase in tropical cyclone intensity	Likely to occur
Precipitation increases in high latitudes	Very likely to occur
Precipitation decreases in subtropical land regions	Very likely to occur
Decreased water resources in many semi-arid areas, including western U.S. and Mediterranean basin	High confidence

Climate.nasa.gov/effects; adapted from IPCC 2007 Summary for Policymakers

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