The Science Behind Global Warming Liabilities

Mealey's Global Warming Insurance Litigation Conference

San Francisco, California

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Our atmosphere is as thin -- in proportion to the Earth's diameter -- as a film of condensation on a steel ball.

Outline

- The science underlying the current climate change debates
- Is there a scientific consensus that global warming is real?
- What areas are open for debate?
- What is the prognosis for the future?
  - Implications for legal/insurance liability

The Scientific Consensus

Intergovernmental Panel on Climate Change: TAR

1300 Authors; 1100 Reviewers
Unanimously adopted by 100+ nations (including U.S.)

Caribbean: Coral Die-Off

Tanzania: Drought > Blackouts

Greenland: Loss of Sea Ice

Iceland: Retreating Glaciers

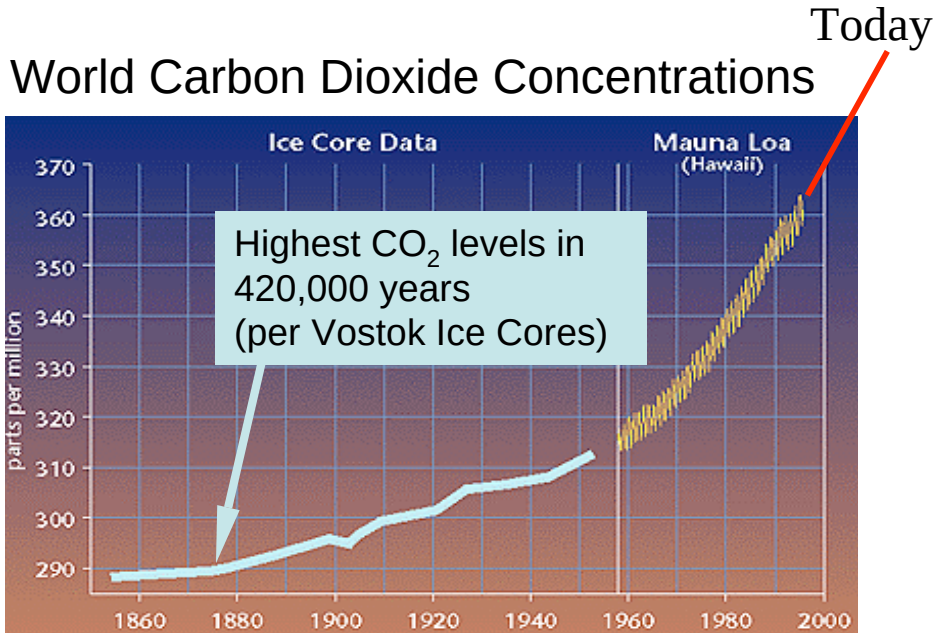
California:
Beetle Super-infestations

The science underlying the current climate change debates

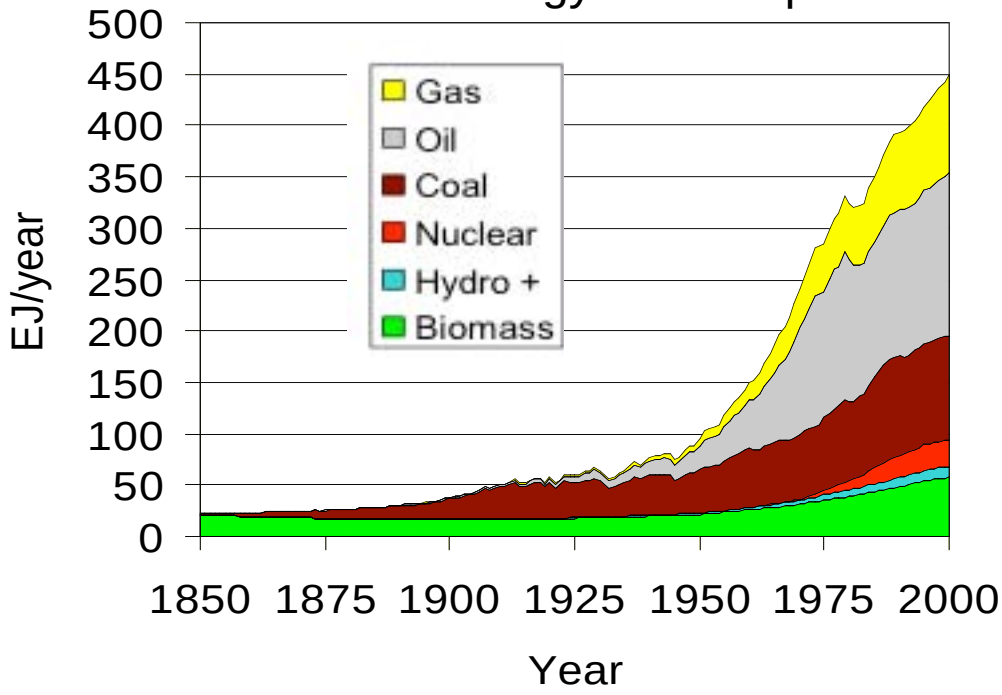
The Primary Human Influence is Fossil Fuels Combustion

(Second is Deforestation)

World Carbon Dioxide Concentrations



World Energy Consumption

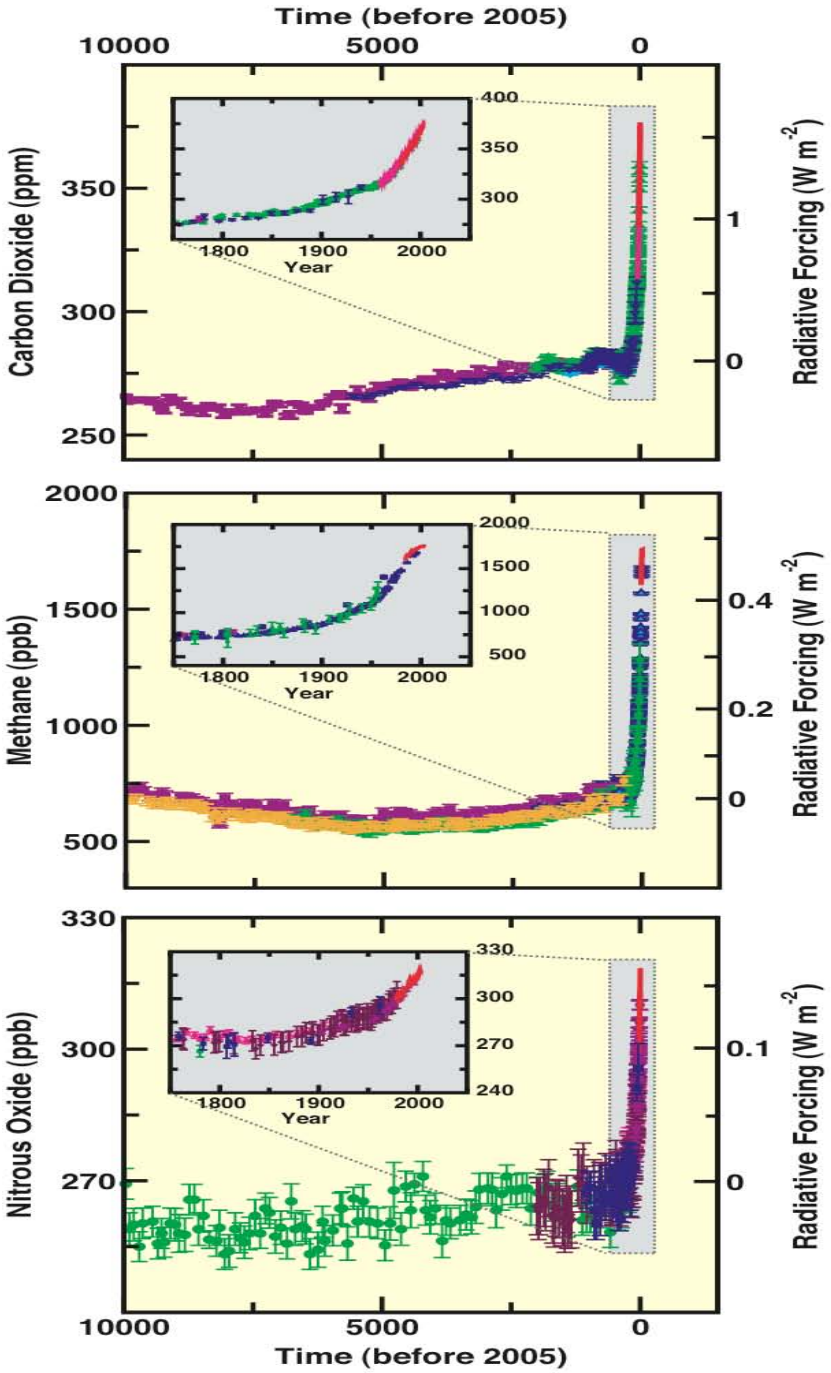


Drivers of Climate Change

CO_2, CH_4 and N_2O Concentrations

- far exceed pre-industrial values
- increased markedly since 1750 due to human activities

Relatively little variation before the industrial era



Deforestation for soy growing in the state of Mato Grosso, Brazil

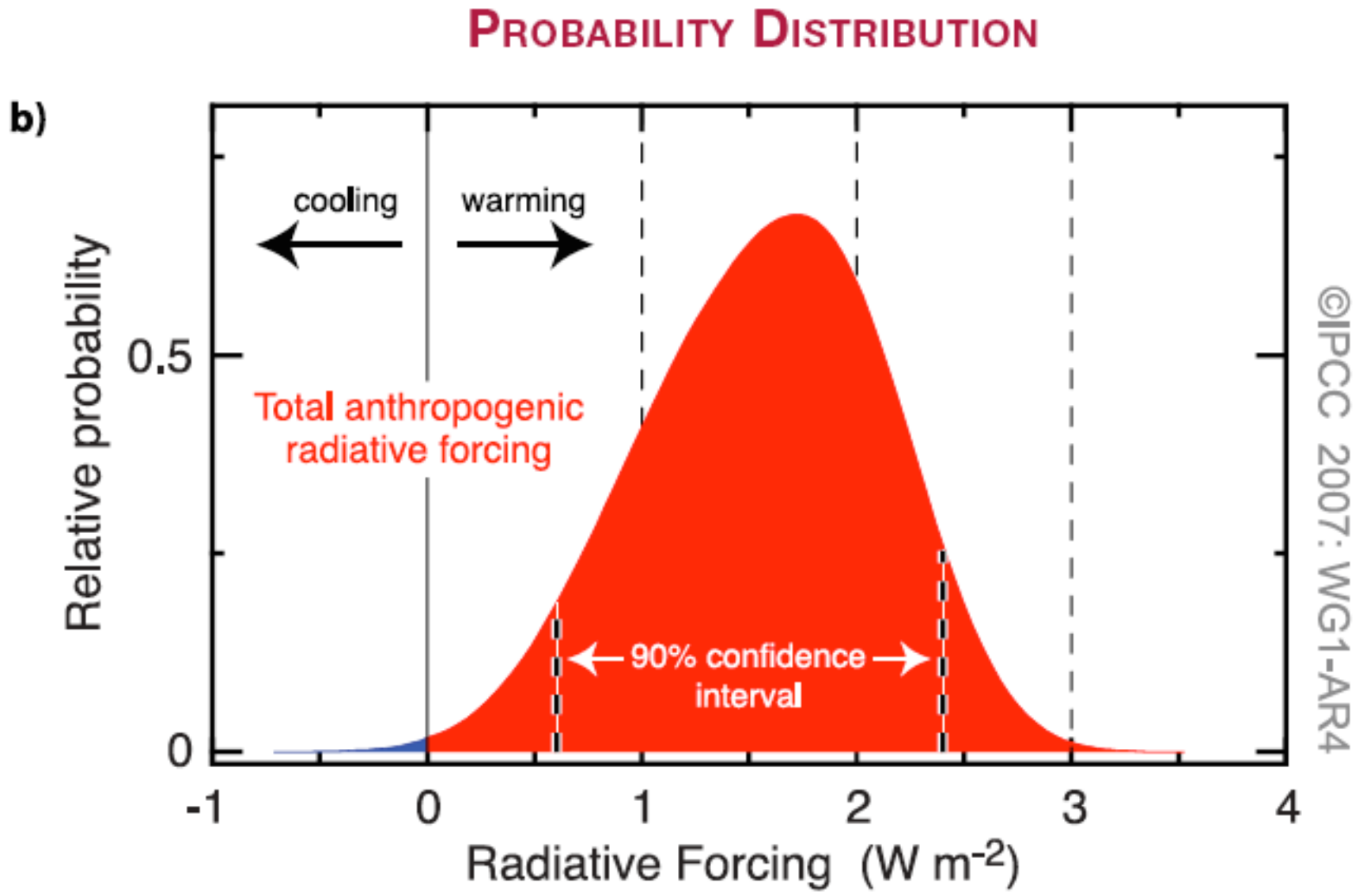
Moutinho and Schwartzman, 2005

IPCC's Latest Characterization of Recent Climate Change

"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level."

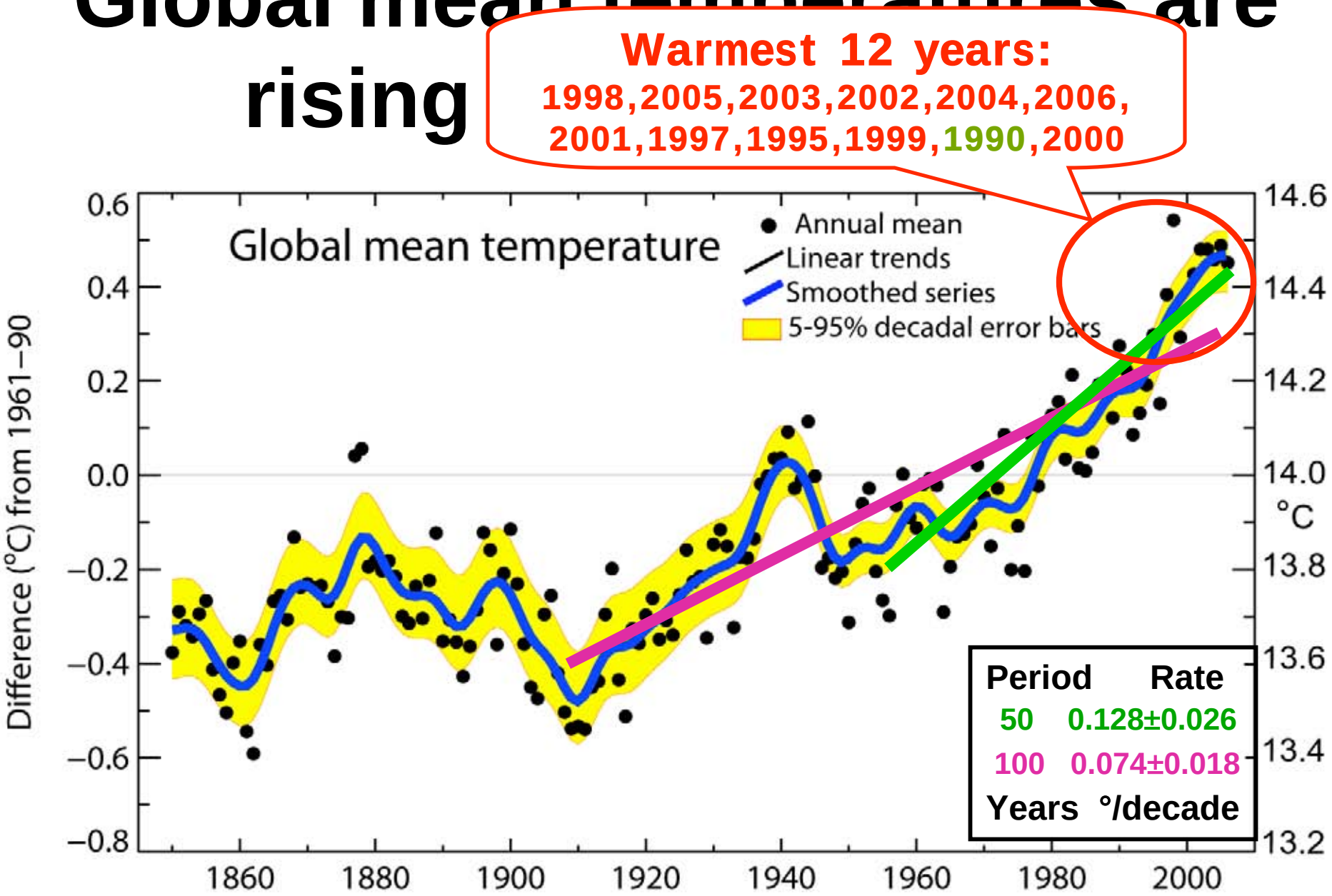
- IPCC Fourth Assessment Report (2007)

Likelihood of Observed Warming



Source: IPCC 4th Assessment (2007)

Global mean temperatures are rising



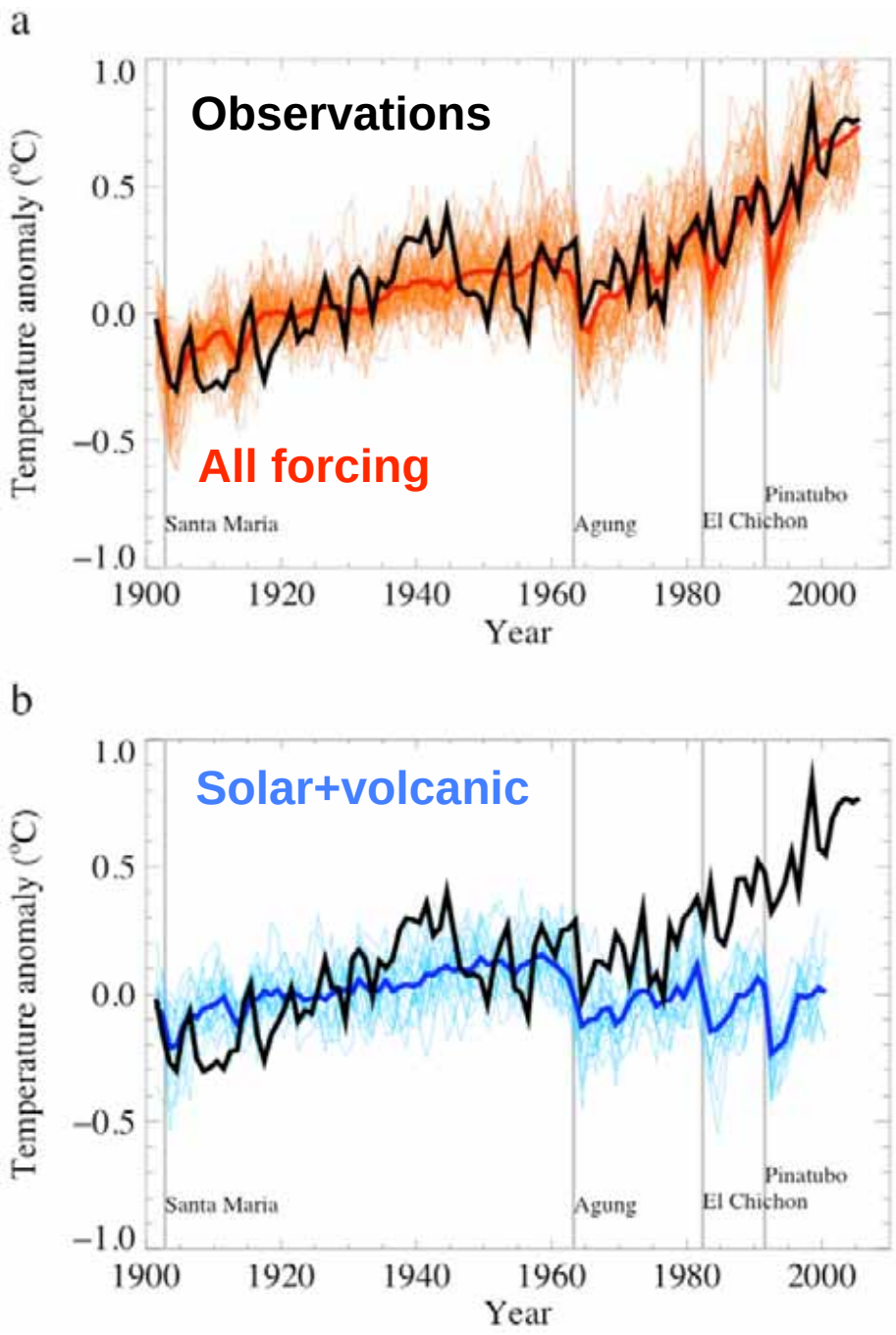
Source: IPCC 4th Assessment (2007)

Attribution

- Observed changes are consistent with

☑expected responses to forcings

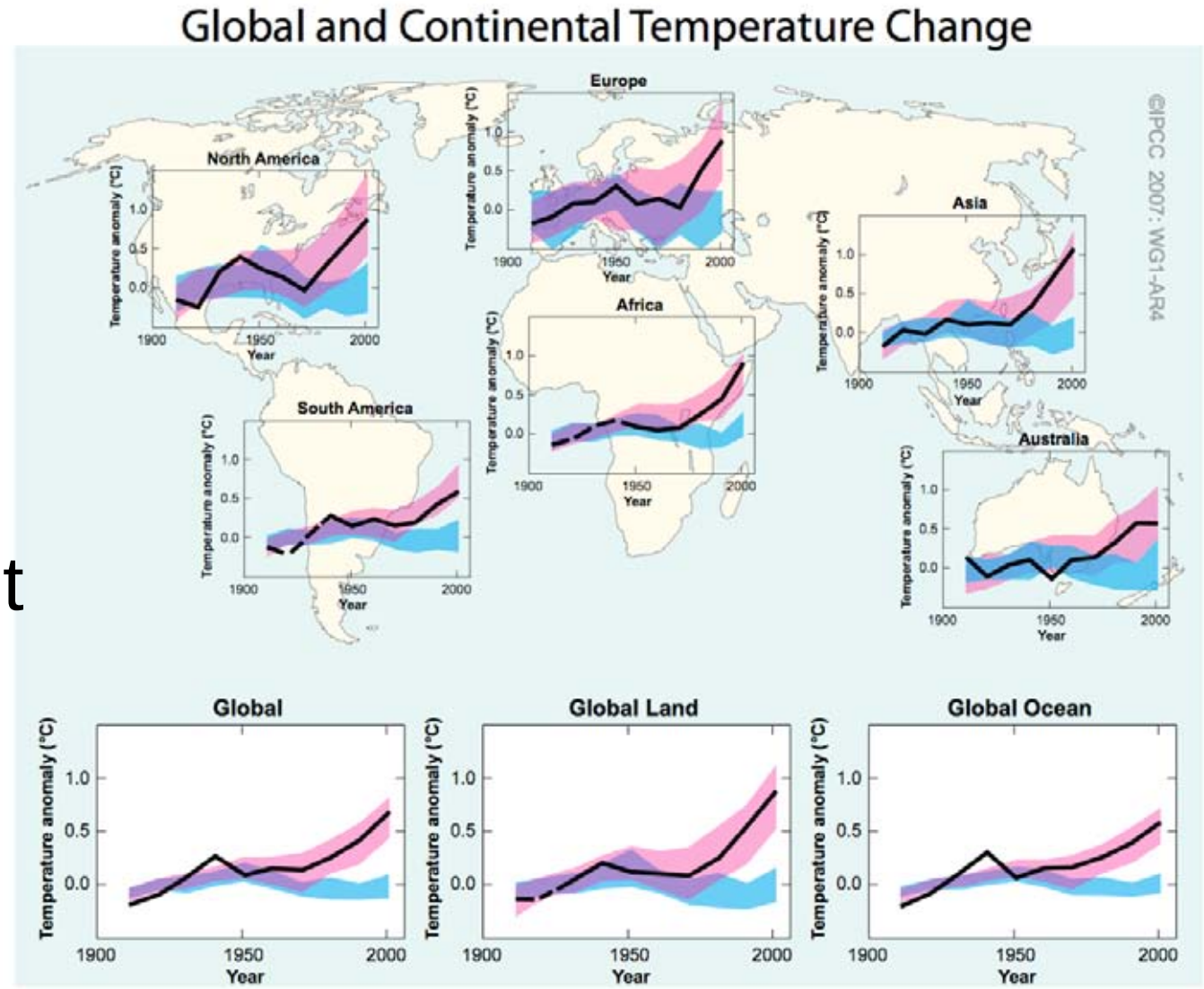
☒inconsistent with alternative explanations



Source: IPCC 4th Assessment (2007)

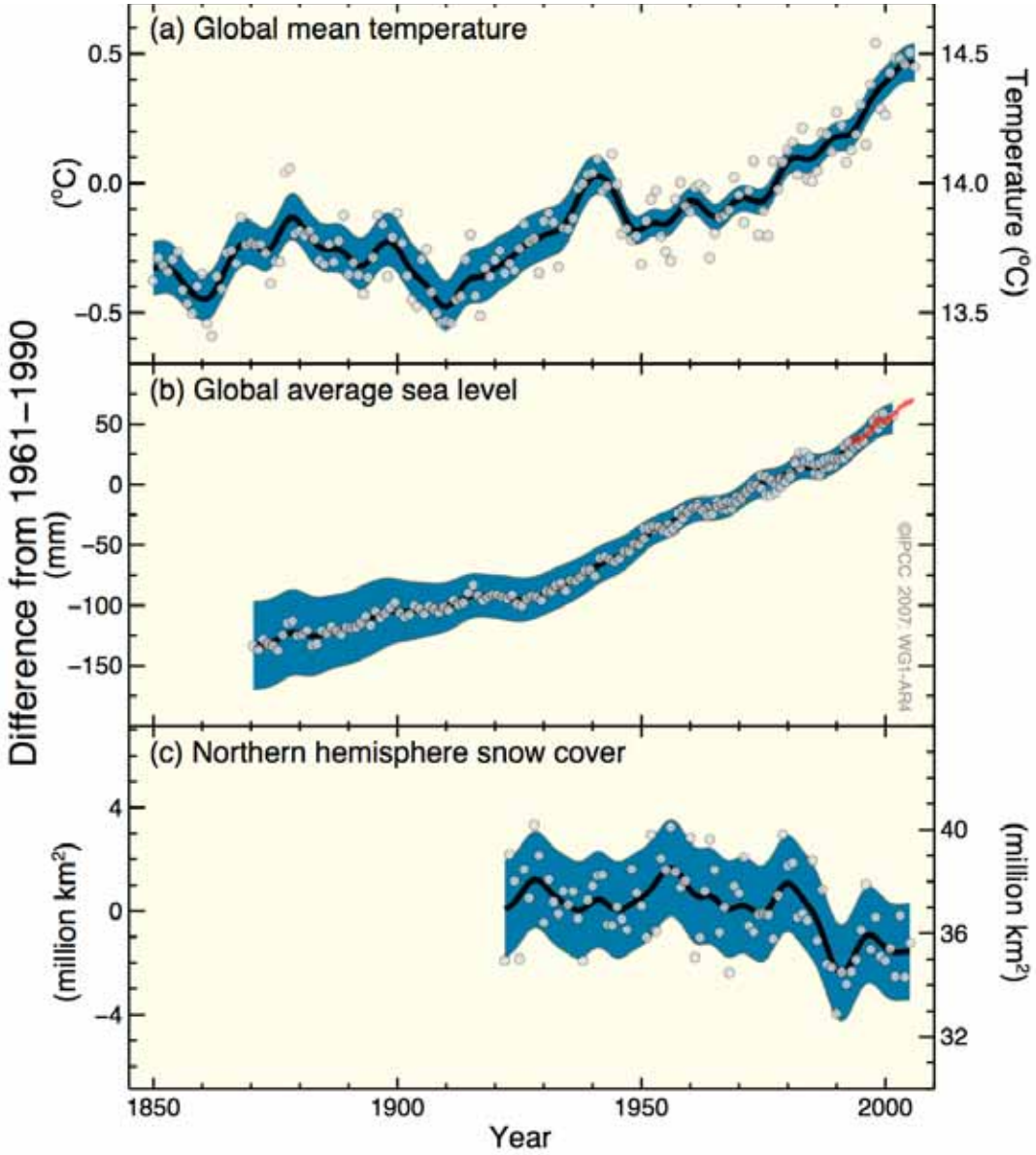
Human Activity is Main Driver of Observed Temperature Changes

Warming shows a significant human contribution over the past 50 years



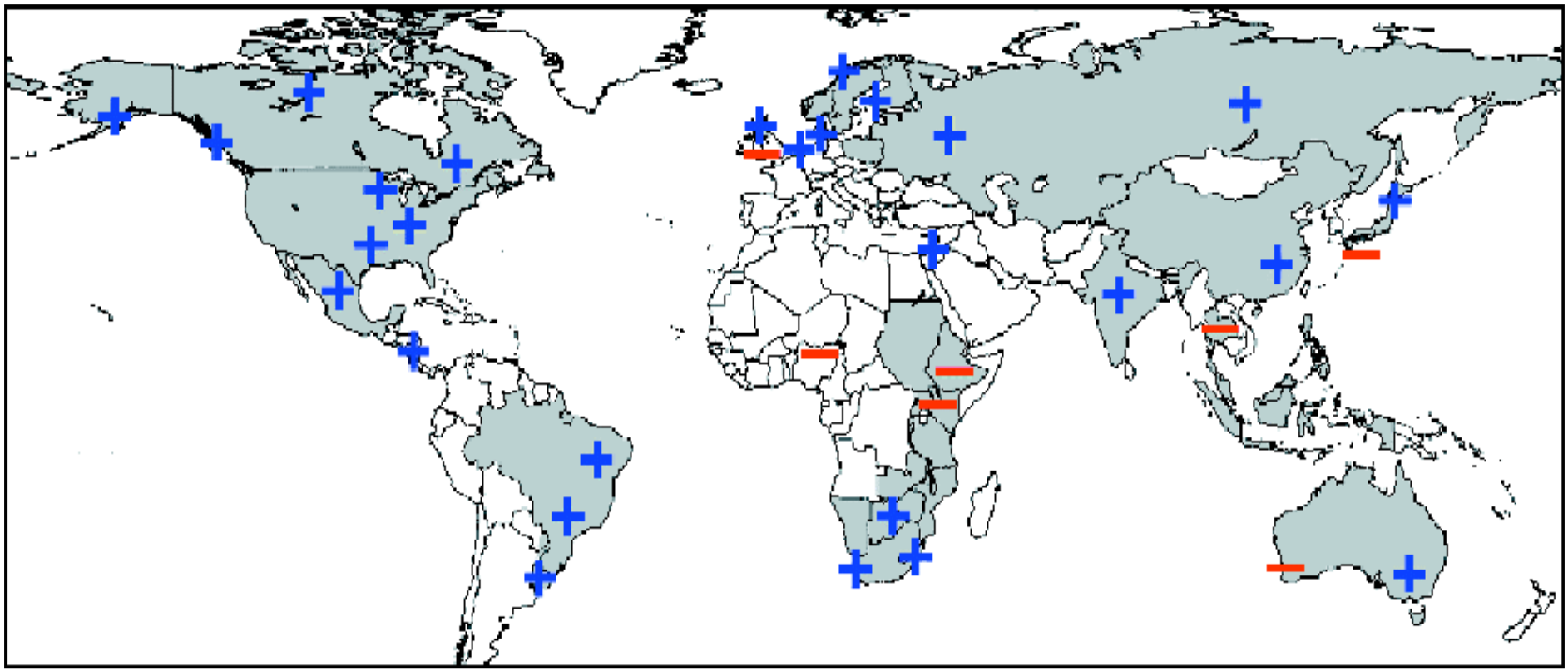
Source: IPCC 4th Assessment (2007)

Fingerprints.... Temperature, Sea Level, Snow



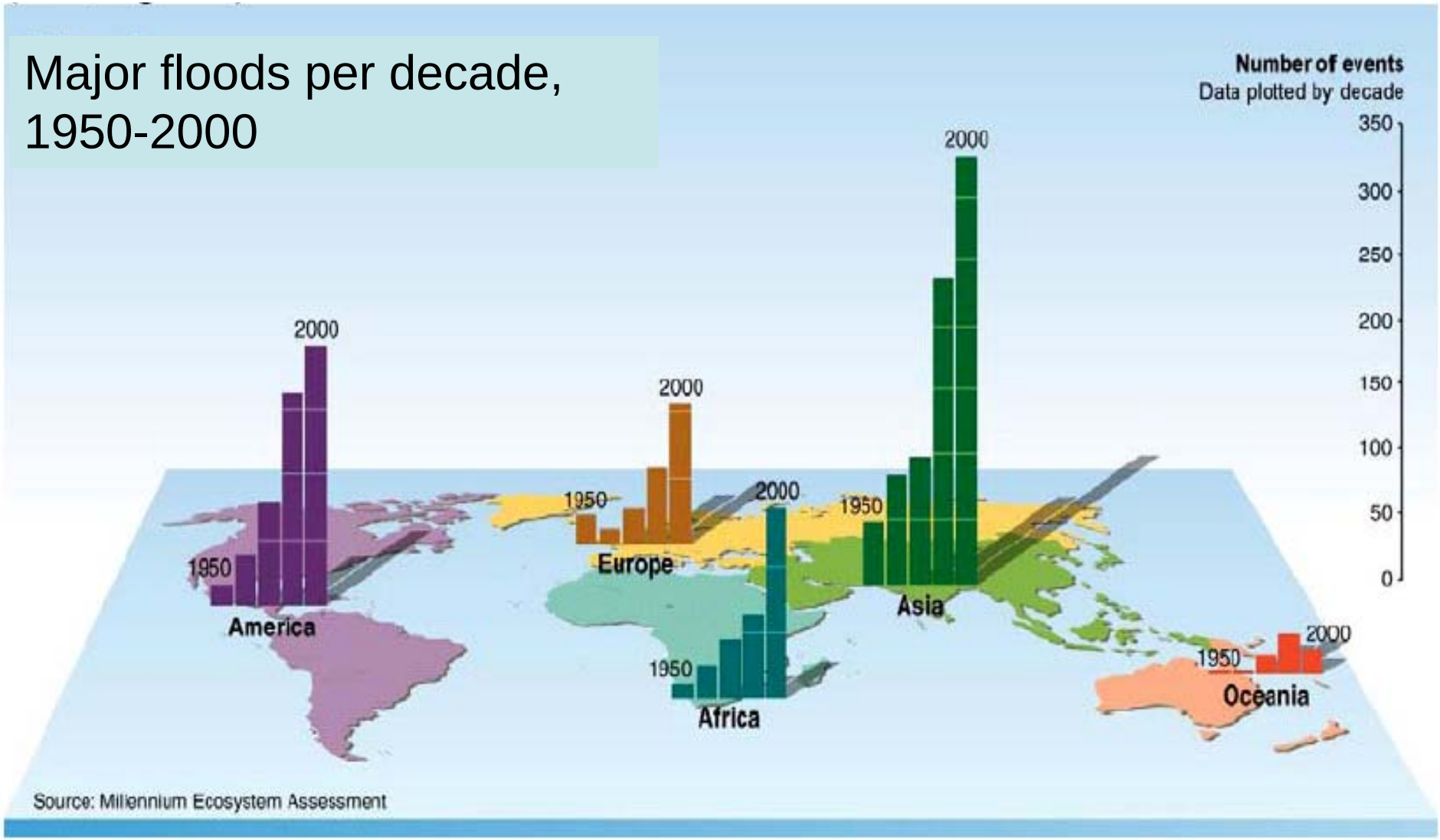
Source: IPCC 4th Assessment (2007)

Fingerprints.... Torrential Rain



Source: IPCC 4th Assessment (2007)

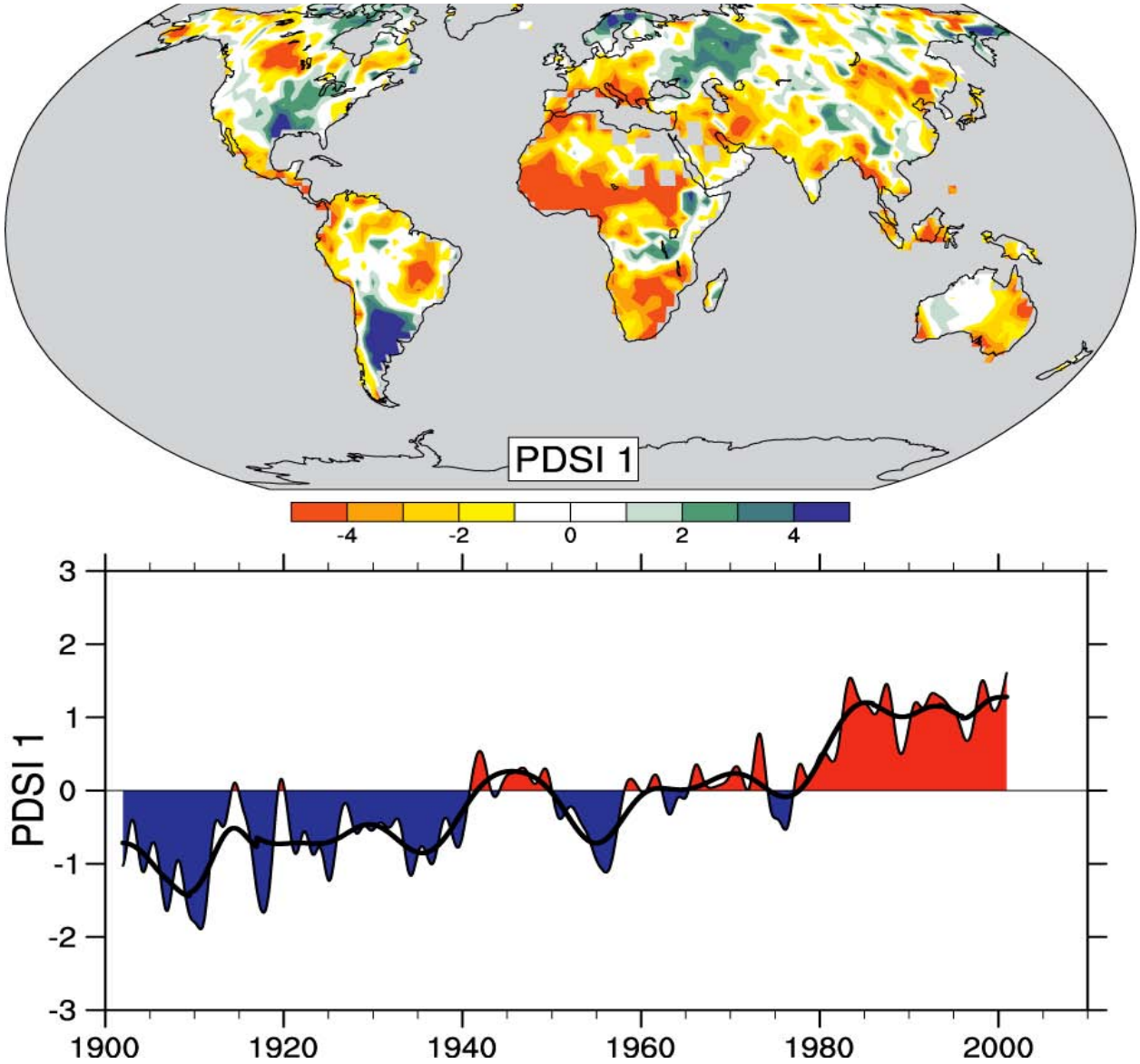
Fingerprints.... Floods



There's a consistent 50-year upward trend in every region except Oceania.

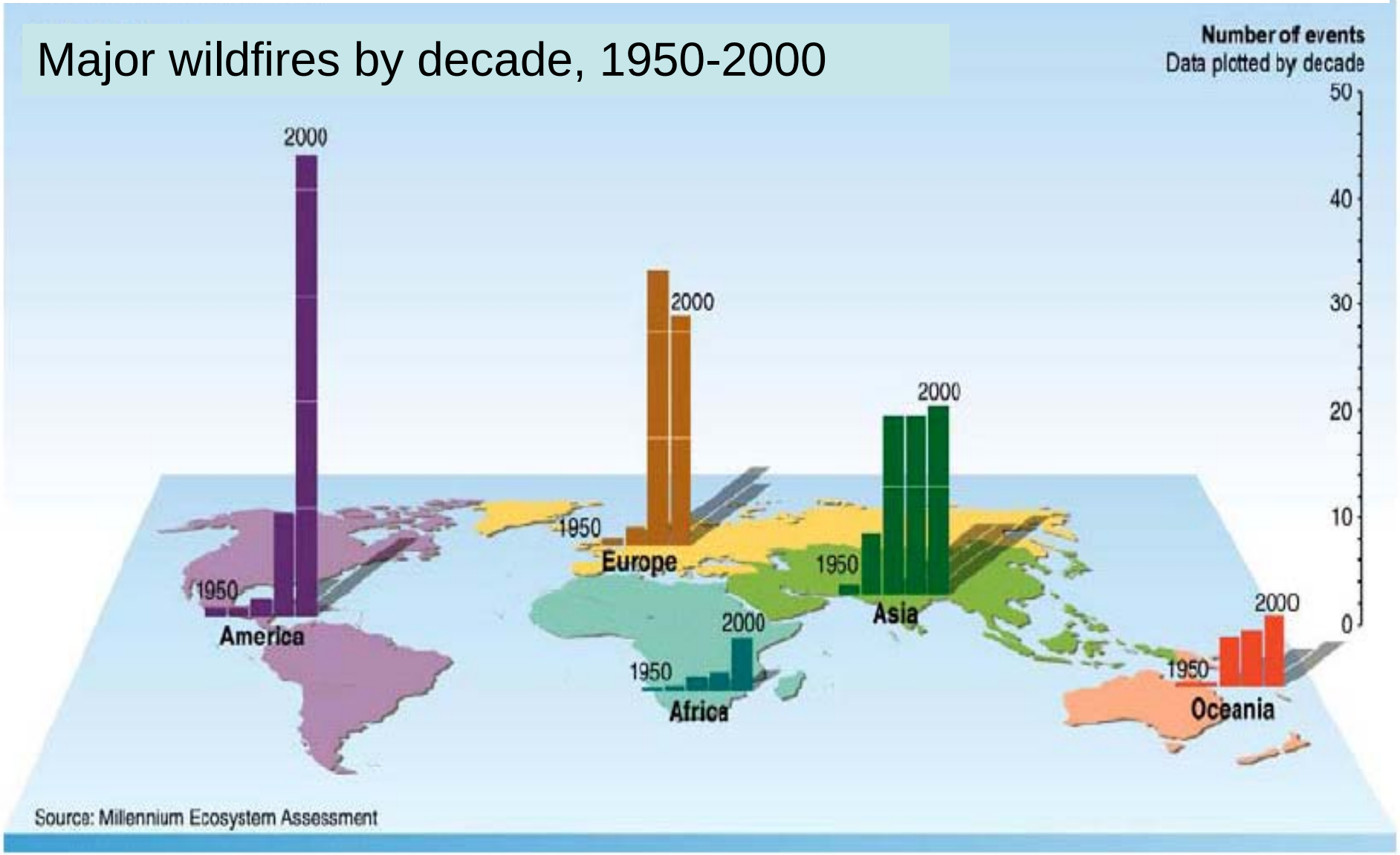
Fingerprints.... Drought

Change in Palmer Drought Severity Index (PDSI) for 1900 to 2002



Source: IPCC 4th Assessment (2007)

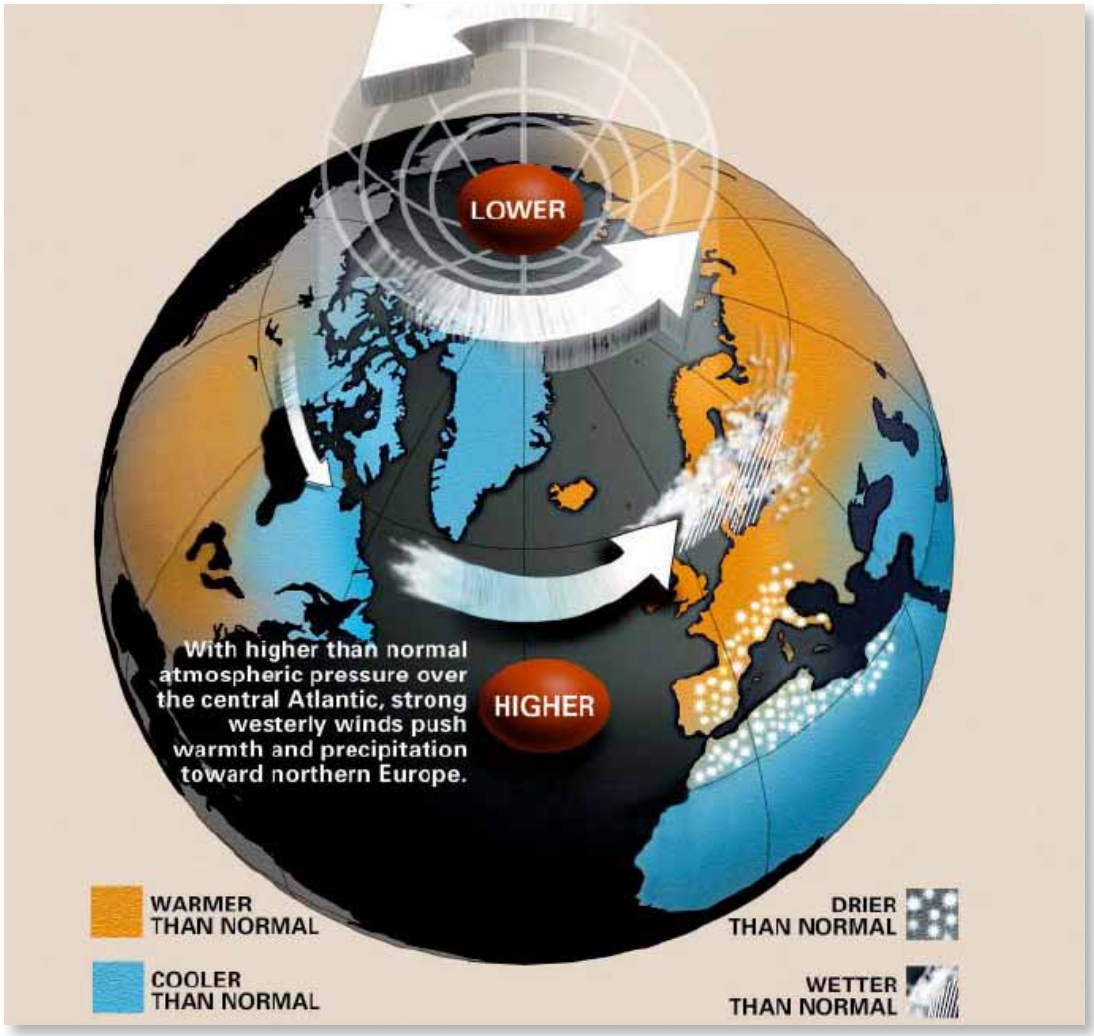
Fingerprints.... Wildfire



The trend has been sharply upward everywhere.

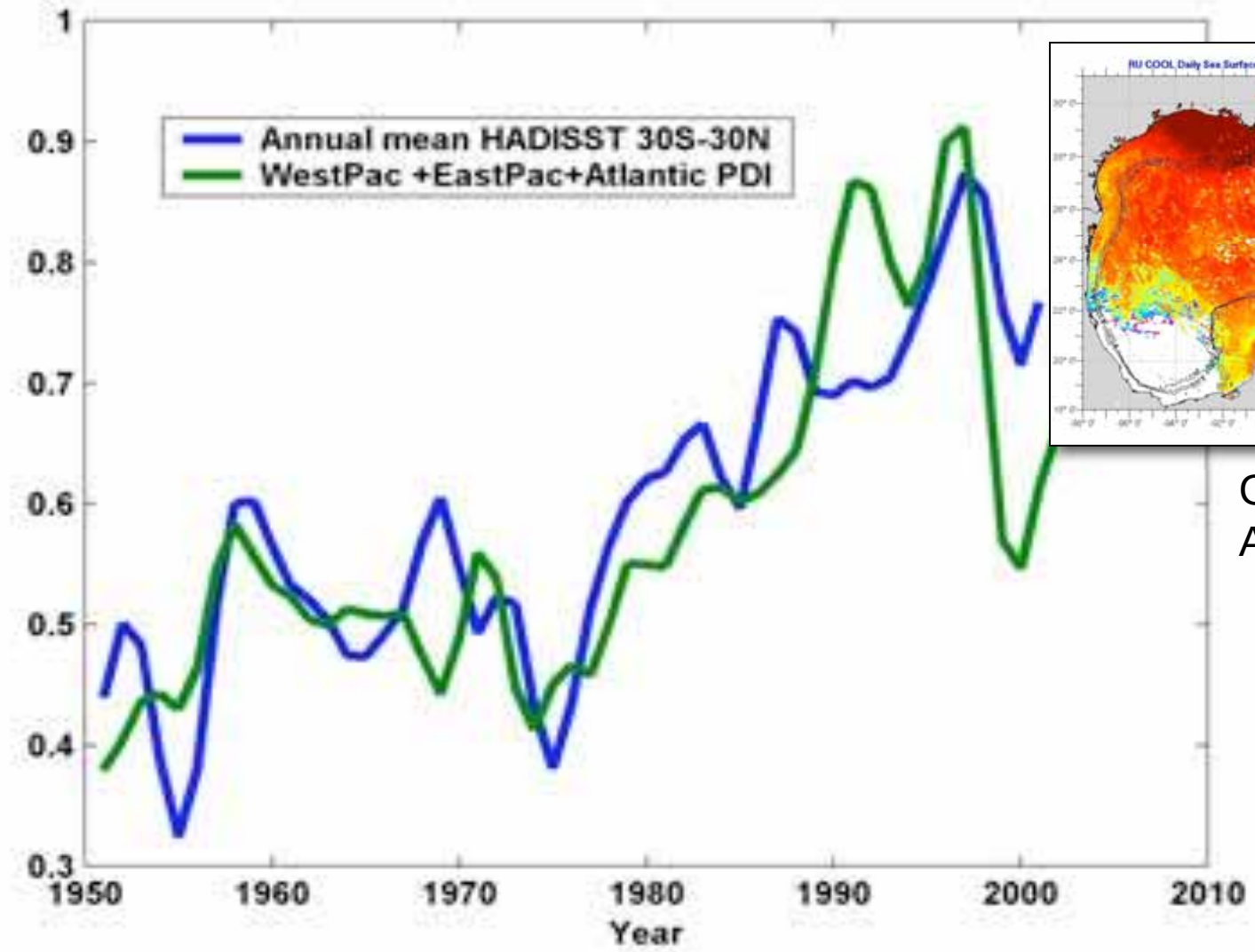
Fingerprints.... Storms

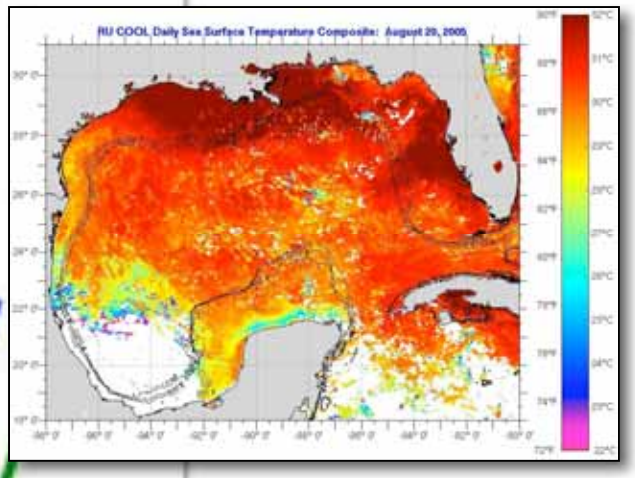
- Climate change is affecting storm tracks, winds and temperature patterns
- Anthropogenic forcing has likely contributed



Source: IPCC 4th Assessment (2007)

Fingerprints.... Storms and Sea-surface Temp



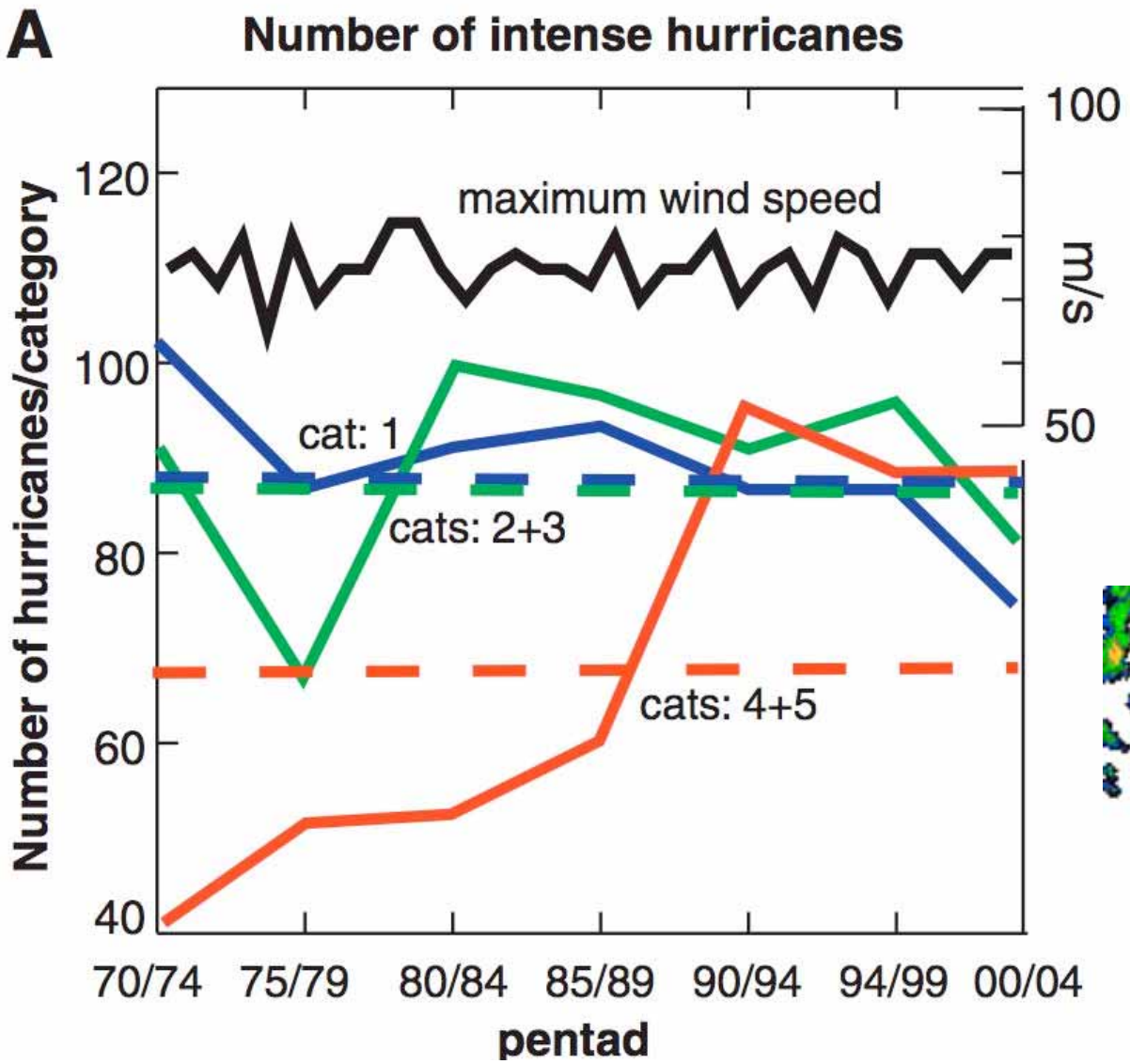


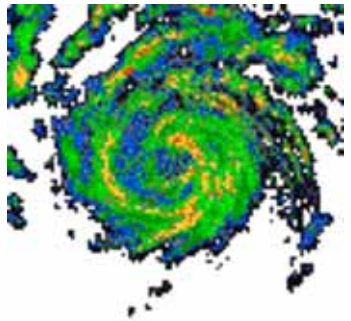
Gulf of Mexico SST, August 2005

Total power released by tropical cyclones (green) has increased along with sea surface temperatures (blue).

Source: Kerry Emanuel, *Nature*, 2005

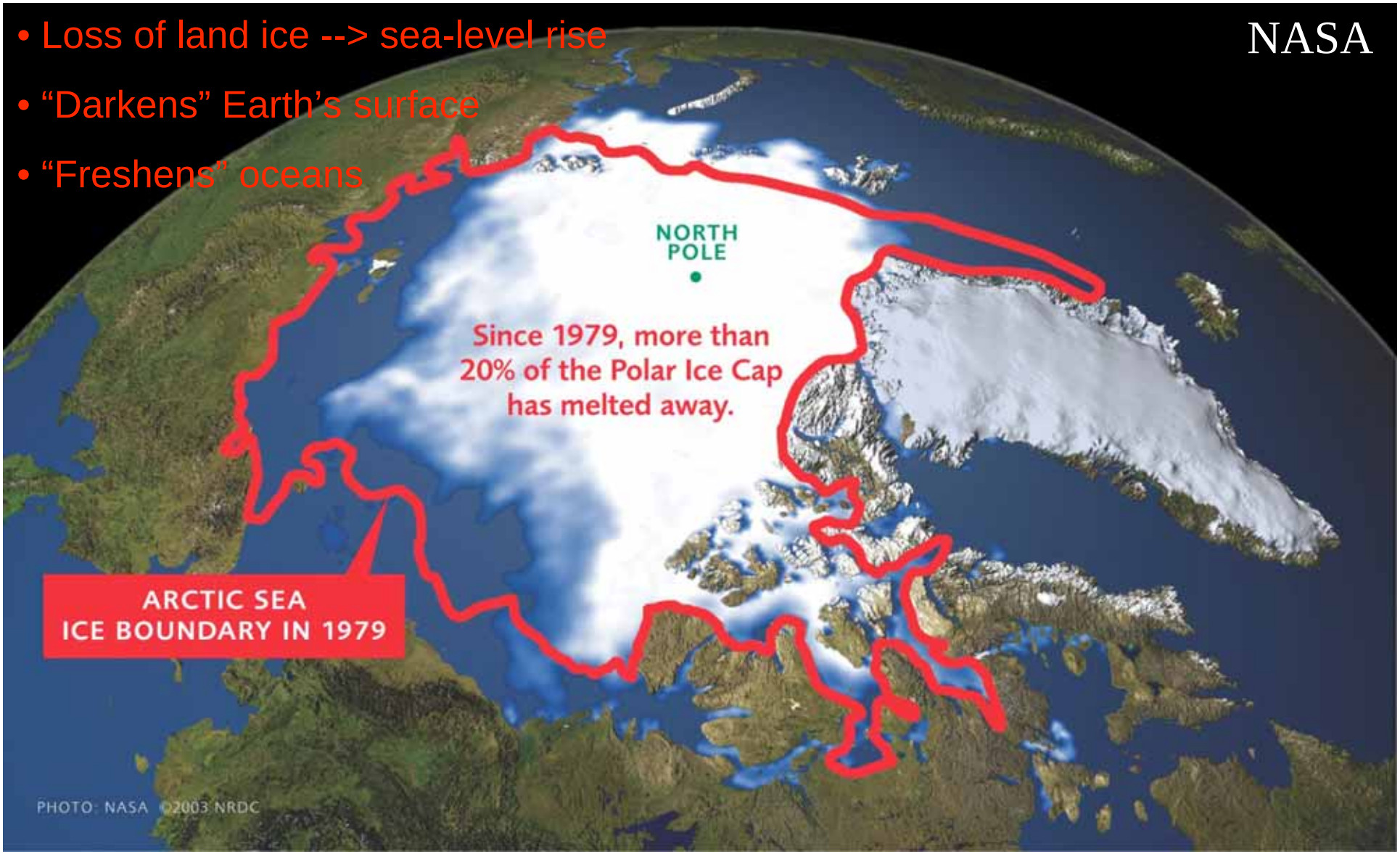
Fingerprints.... Cat 4-5 Hurricanes/Cyclones





Source: Webster, et al., *Science*, 2005

Fingerprints: Loss of Ice & Snow Cover (Summer -7.4% per decade)

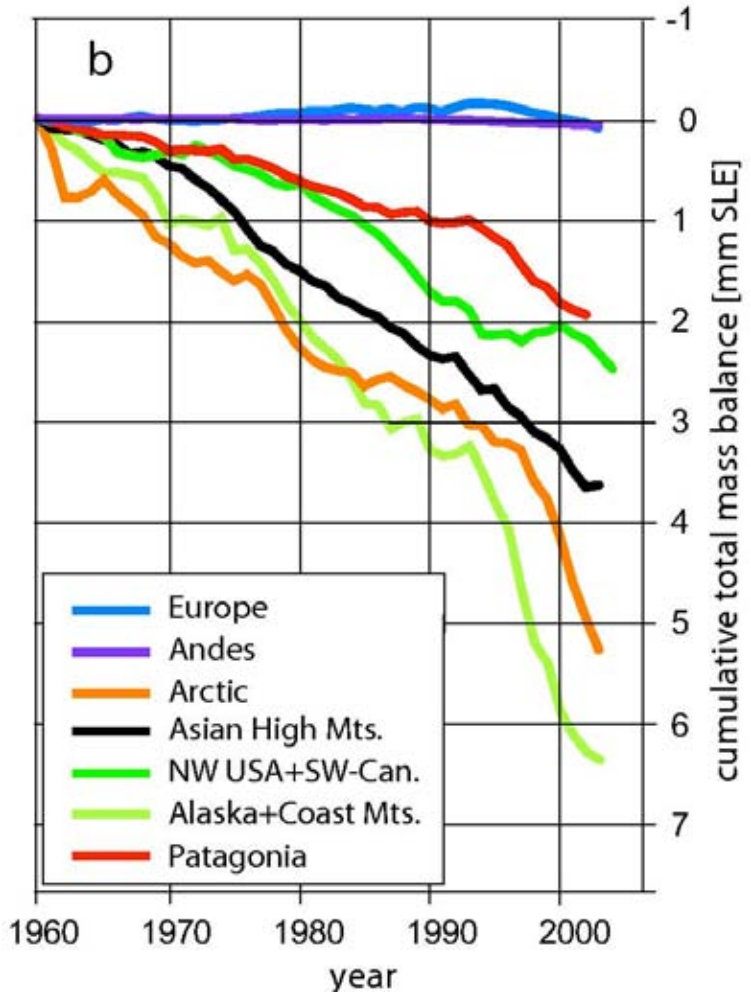


Harvard Expedition to North Pole

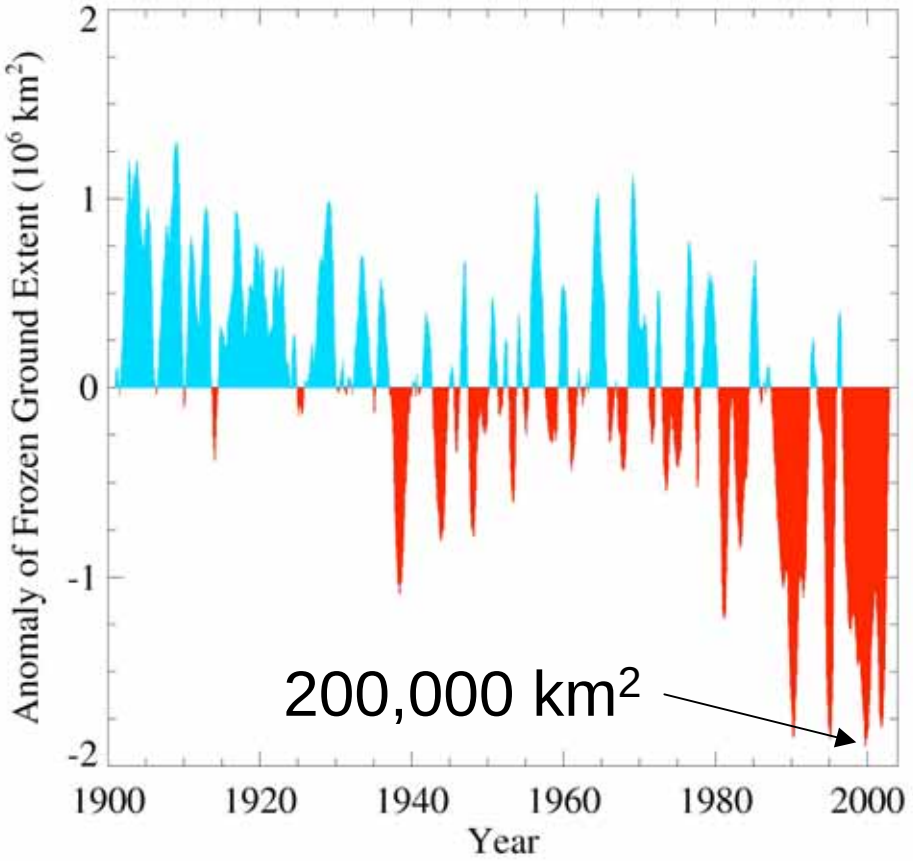
Source: James McCarthy, Harvard

Fingerprints ... Permafrost Disintegration

Fingerprints ... Glaciers & frozen ground are receding



Accelerating since early 1990s



Area of seasonally frozen ground in NH has decreased by 7% from 1901 to 2002

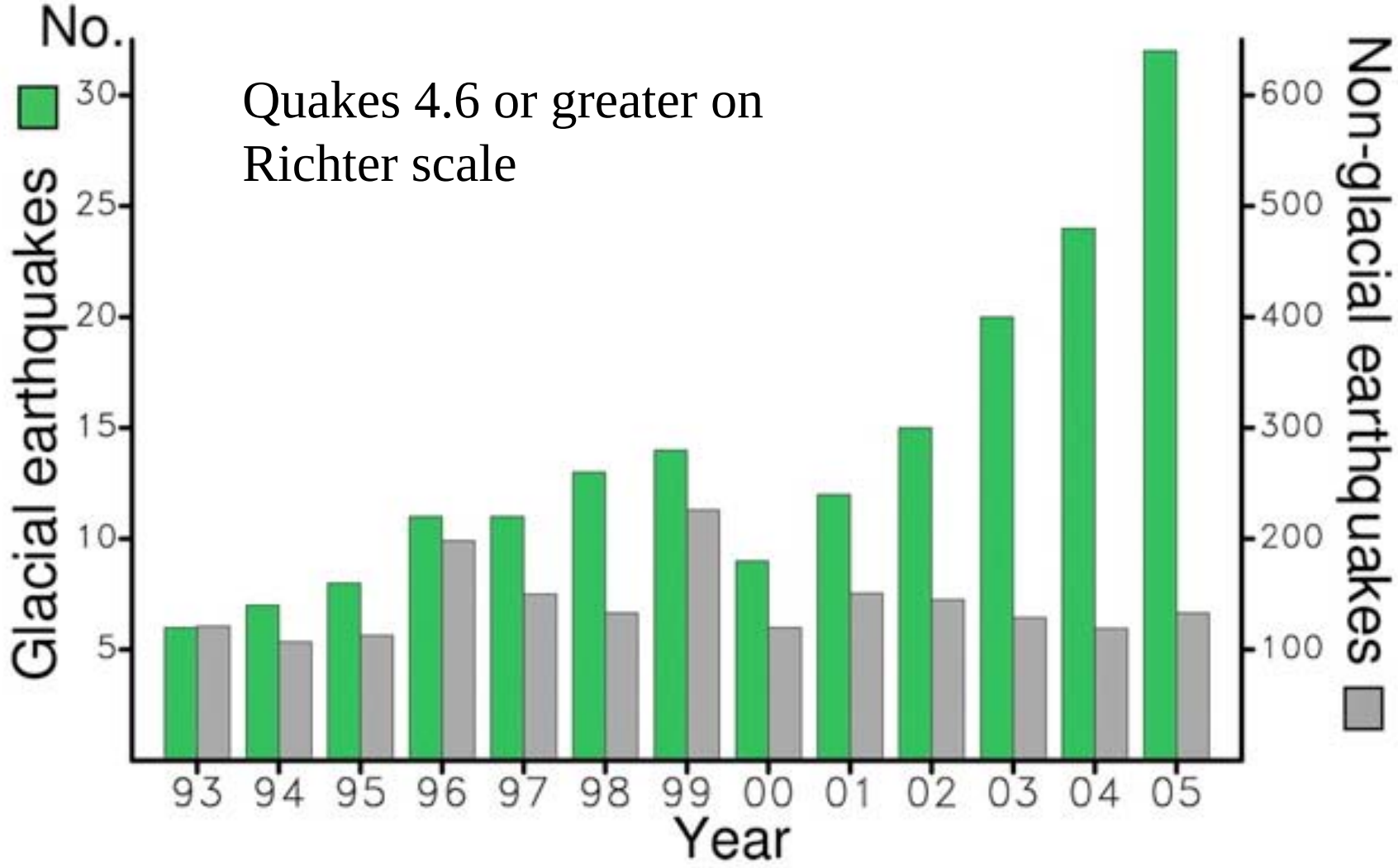
Source: IPCC 4th Assessment (2007)

Consumer Reports on Glaciers

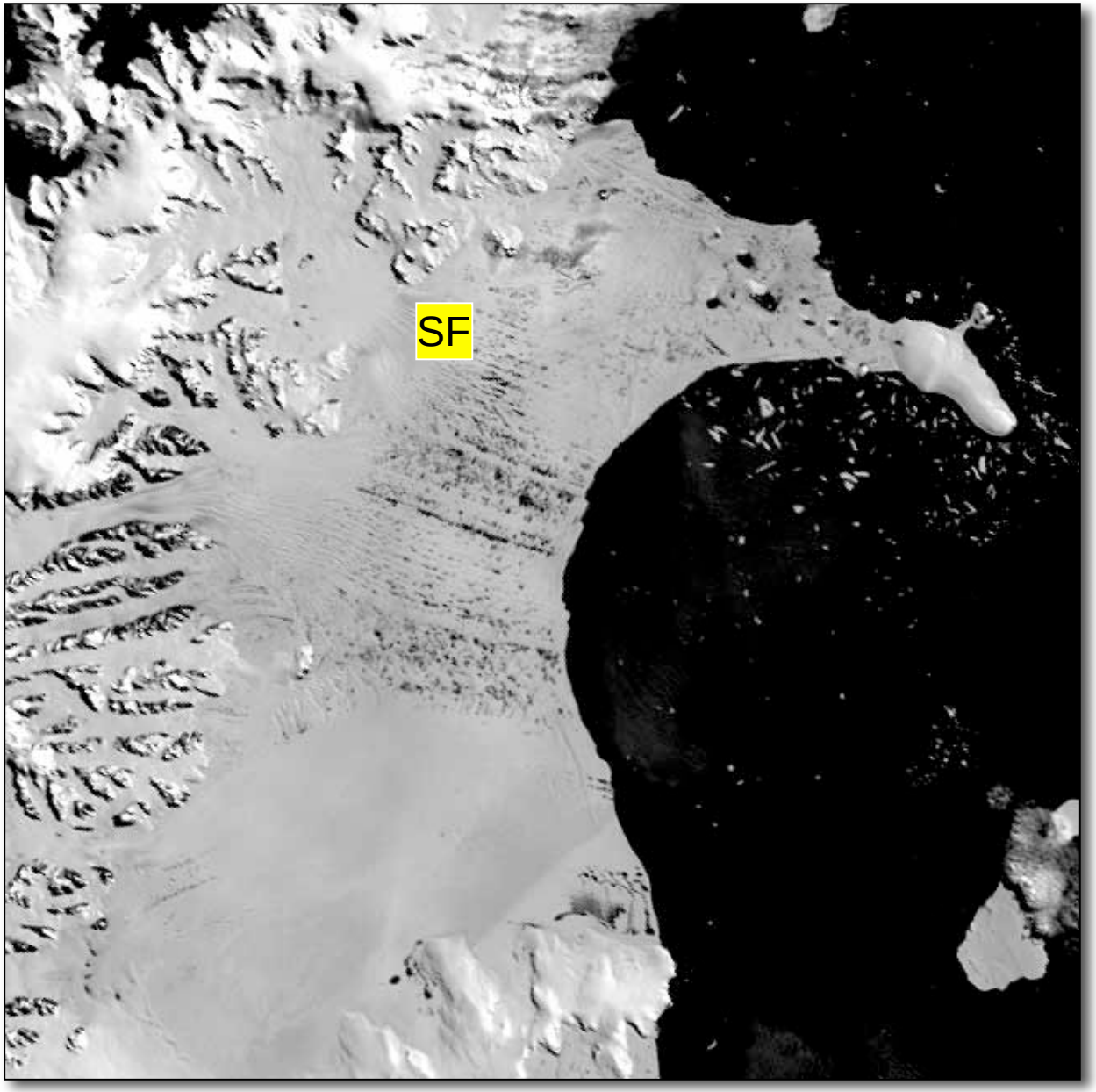
MELTING AWAY Photographs taken from Mount Gould, in Montana's Glacier National Park, show that Grinnell Glacier is in retreat.

1938 Photo by T.J. Hileman, Glacier National Park Archives; 1981 Photo by Carl Key, USGS; 2006 Photo by Karen Holzer, USGS.

Fingerprints ... Glacial Earthquakes

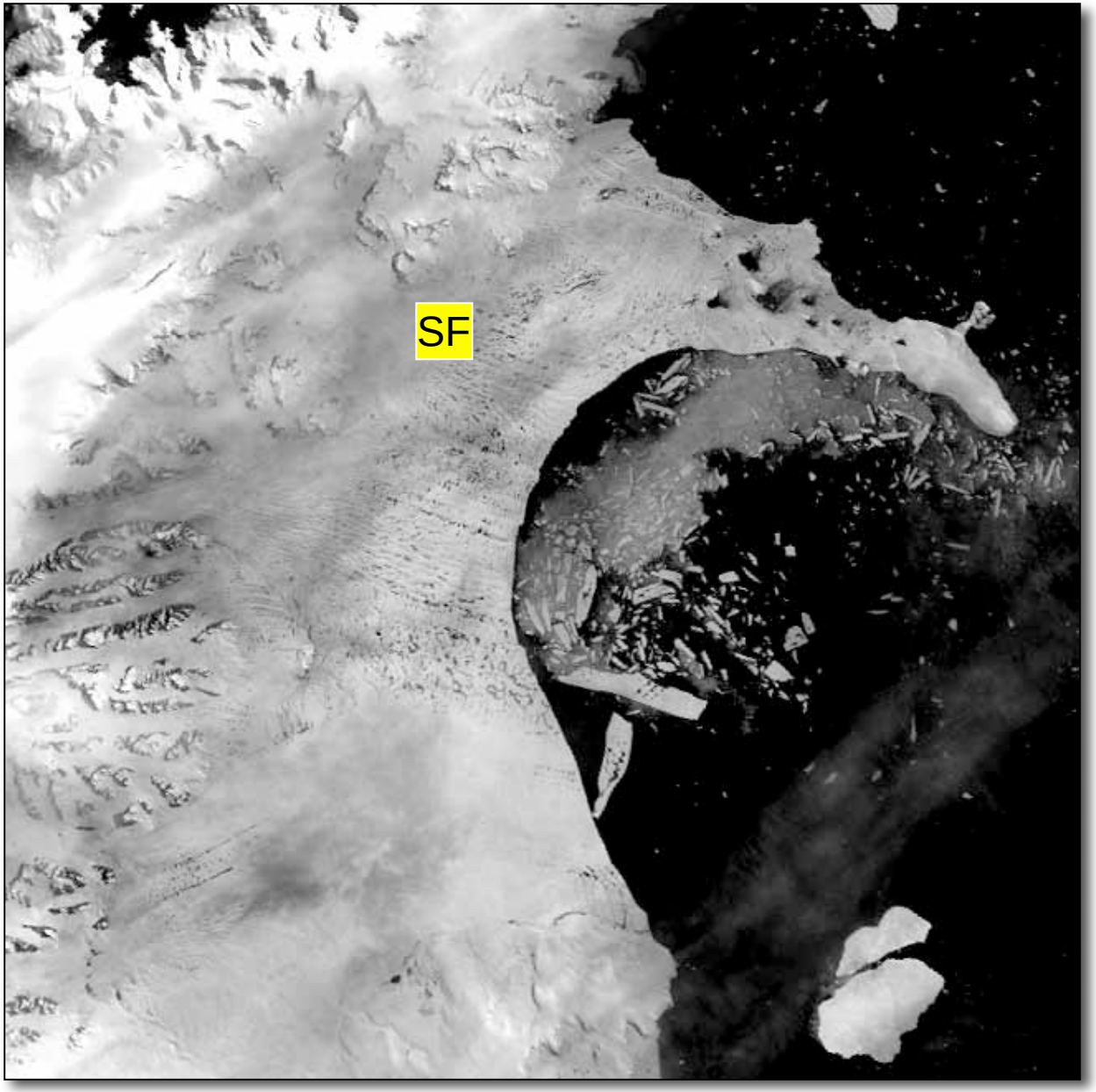


Larsen-B Ice Sheet
Image NASA
©2006 Google
Pointer 87°32'33.79" S 86°21'17.38" E
Streaming 100%
Eye alt 8466.64 km

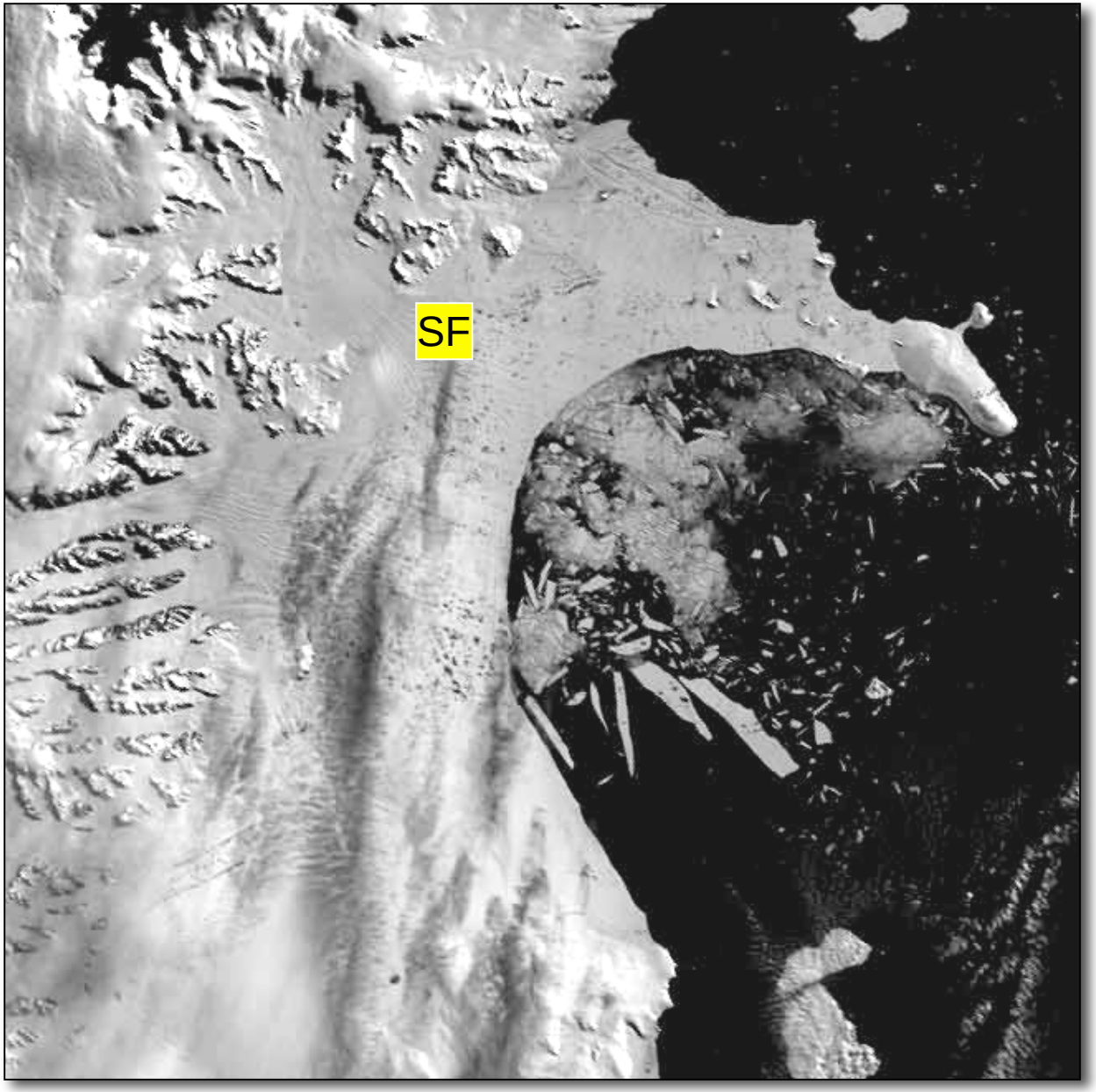


Jan 31
2002

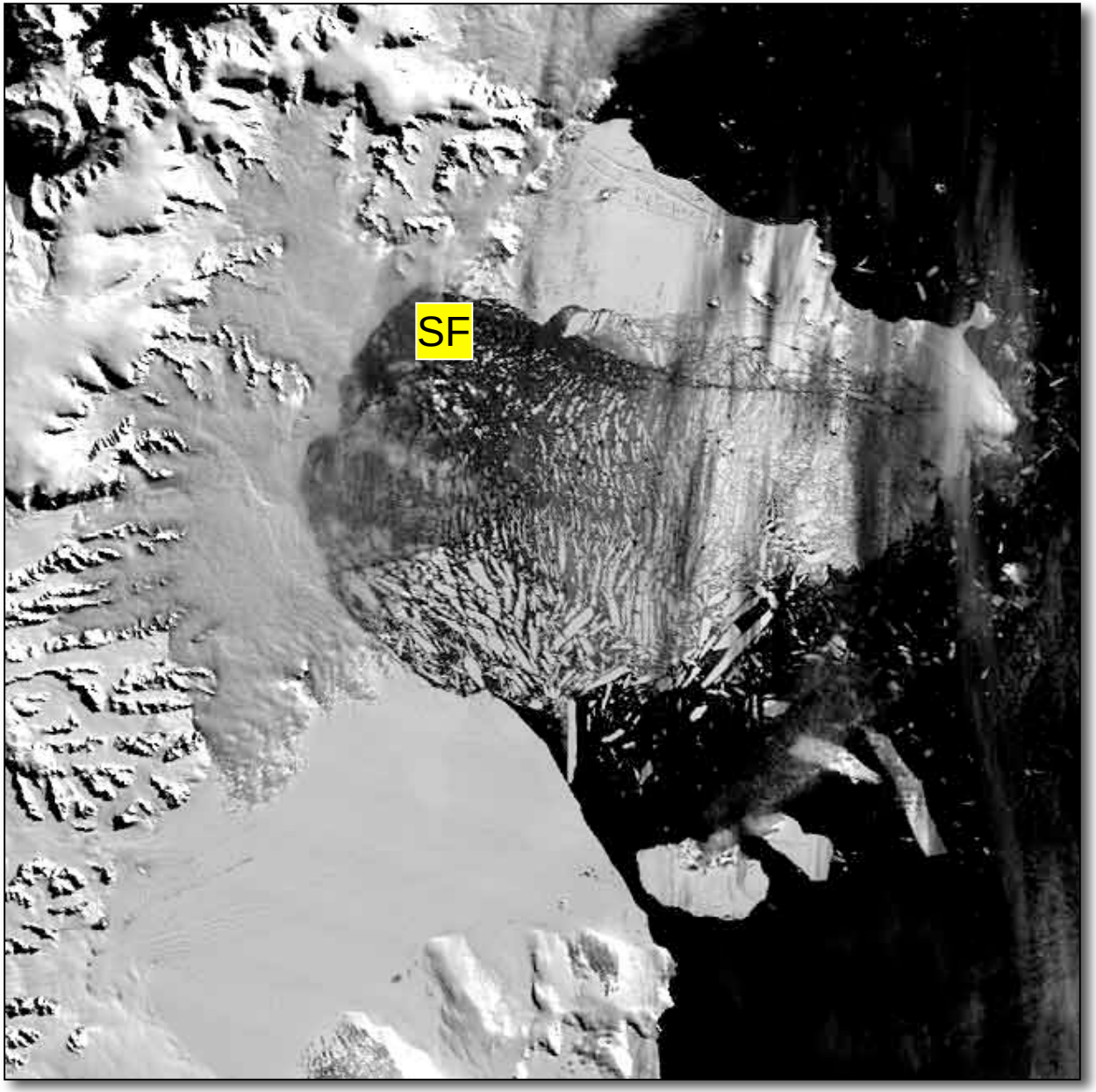
Larsen B
Ice Shelf



Feb 17



Feb 23



March 5

1255 square miles [24x San Francisco]

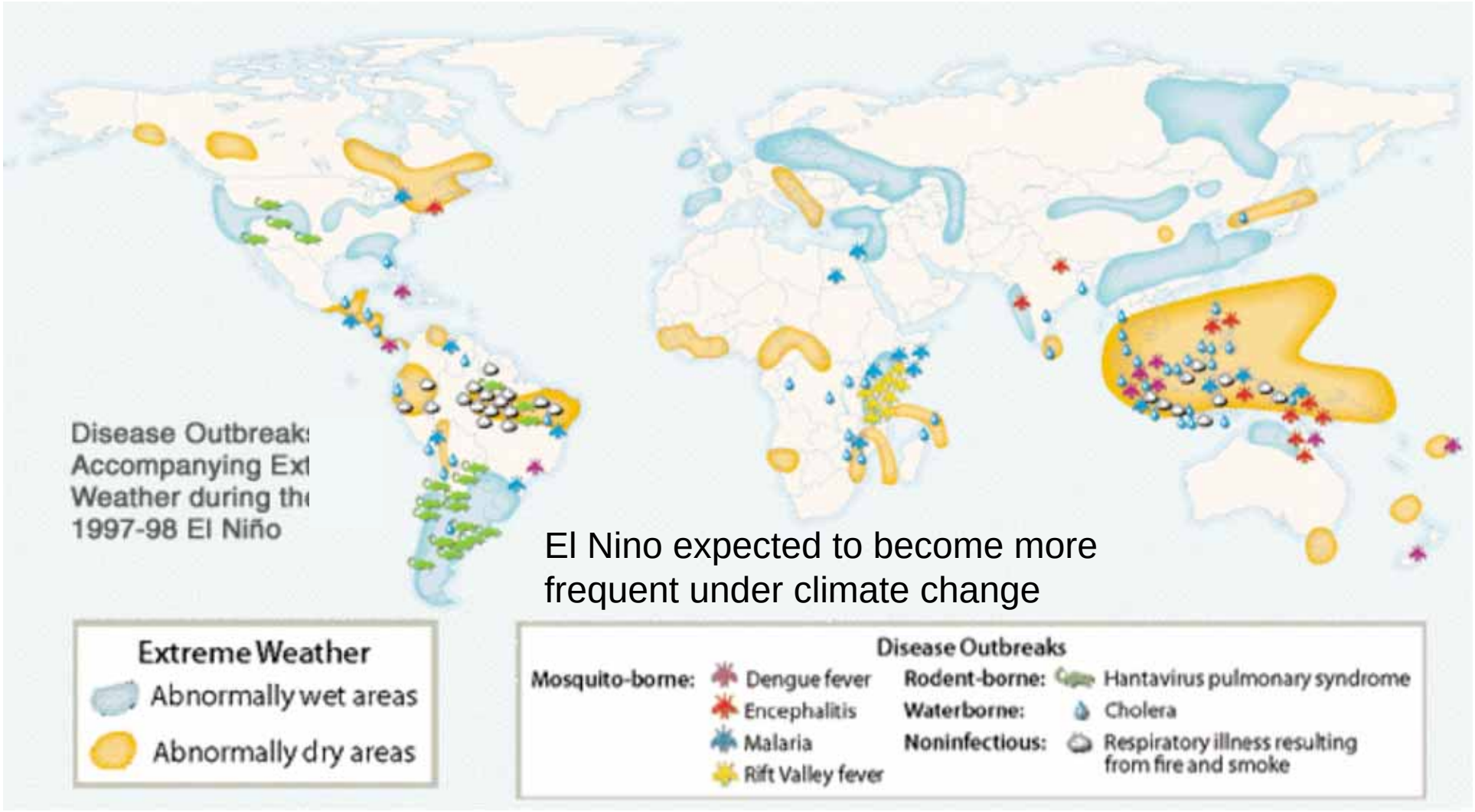
650 feet thick [4.3 Lake Tahoes]

720 billion tons

Subsequent 8x increse in outflow glacier speed

Photo Credit/Crédit photographique: Dan Crosbie

Correlation of Disease Clusters with the 1997-1998 El Nino Weather Extremes



Source: Epstein, Harvard Medical School, *Science*

World Health Organization estimates climate change already causing ≥150,000 premature deaths/yr in 2000

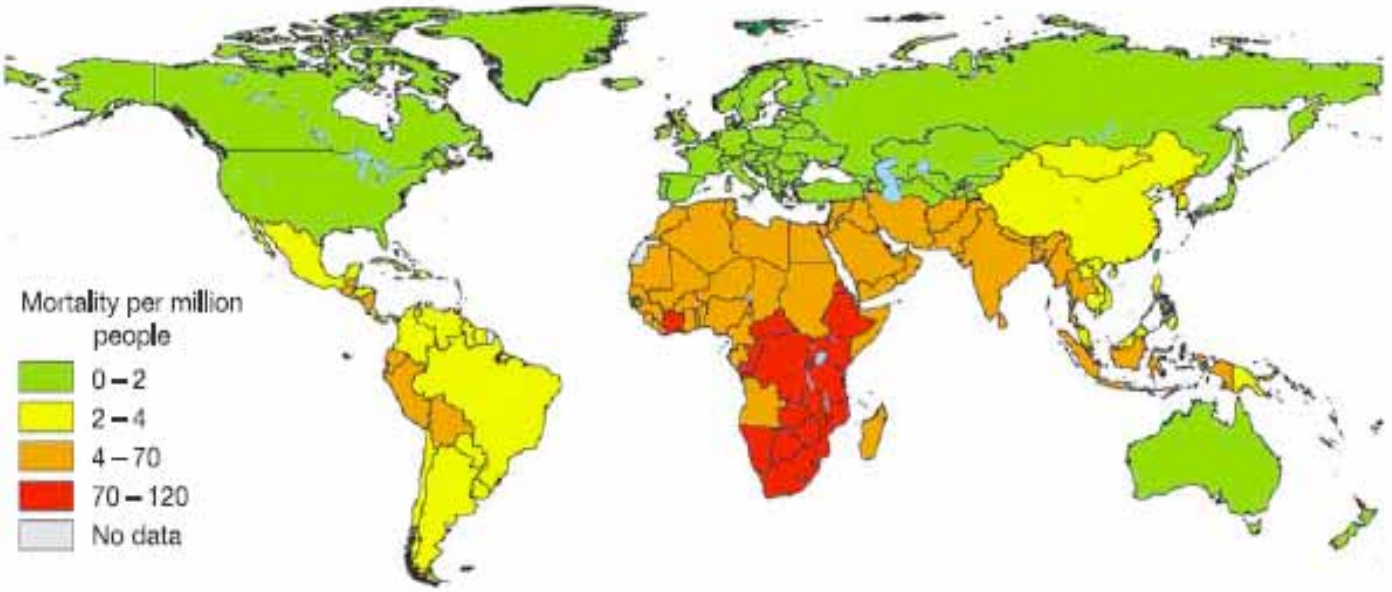
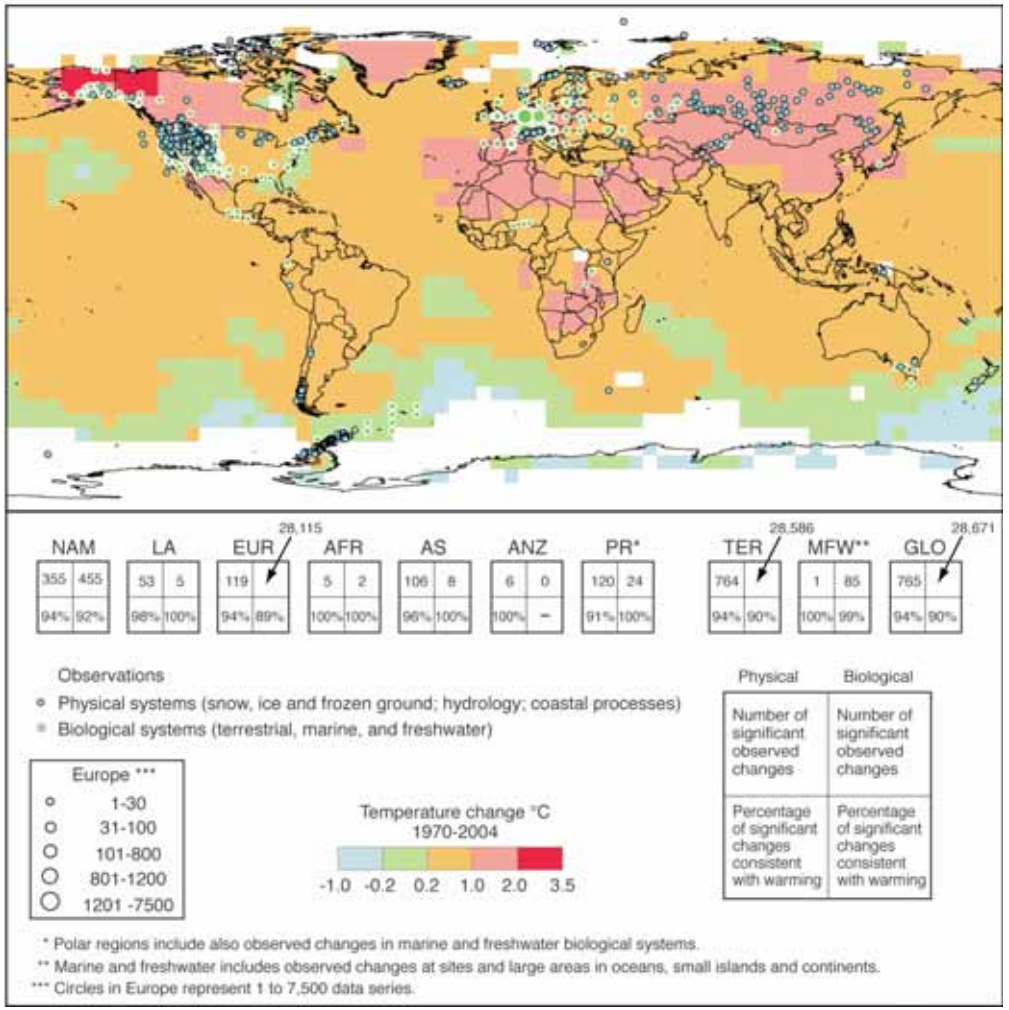


Figure 2 | WHO estimated mortality (per million people) attributable to climate change by the year 2000. The IPCC 'business as usual' greenhouse gas emissions scenario, 'IS92a' and the HadCM2 GCM of the UK Hadley Centre were used to estimate climate changes relative to 'baseline' 1961–1990 levels of greenhouse gases and associated climate conditions. Existing quantitative studies of climate–health relationships were used to estimate relative changes in a range of climate-sensitive health outcomes including: cardiovascular diseases, diarrhoea, malaria, inland and coastal flooding, and malnutrition, for the years 2000 to 2030. This is only a partial list of potential health outcomes, and there are significant uncertainties in all of the underlying models. These estimates should therefore be considered as a conservative, approximate, estimate of the health burden of climate change. Even so, the total mortality due to anthropogenic climate change by 2000 is estimated to be at least 150,000 people per year. Details on the methodology are contained in ref. 57.

Overwhelming Correlations
Synthesis of Scientific Literature on Observed Changes 1970-2004

- 577 studies reviewed
- 765 observed physical changes (94% consistent with warming)
- 28,671 observed biological changes (90% consistent with warming)



Source: IPCC 4th Assessment (2007)

Is there a scientific consensus that global warming is real?

Consensus

- **Yes** - we've been working on this for over a century
- Note: consensus FOLLOWS the facts; consensus itself is not evidence of climate change
- Consensus, is about like that for:
  - Human evolution
  - Health consequences of tobacco smoke
- You can quibble with specific cases, but not with the systematic pattern
- No satisfactory alternate theory has been advanced

What areas are open for debate?

Open Questions

- Not the existence of human-induced climate change, or lack thereof, but rather:
  - How much?
  - How fast?
  - How gradual/abrupt?
  - Feedbacks
    - Positive
    - Negative
  - Geography of impacts
  - Gaps in models (especially cryosphere)
  - Society's ability to adapt
  - Attribution of *Impacts*

Positive proof of global warming.
18th Century
1900
1950
1970
1980
1990
2006

Climate Contrarians: An Endangered Species

Source: Krispy Creme

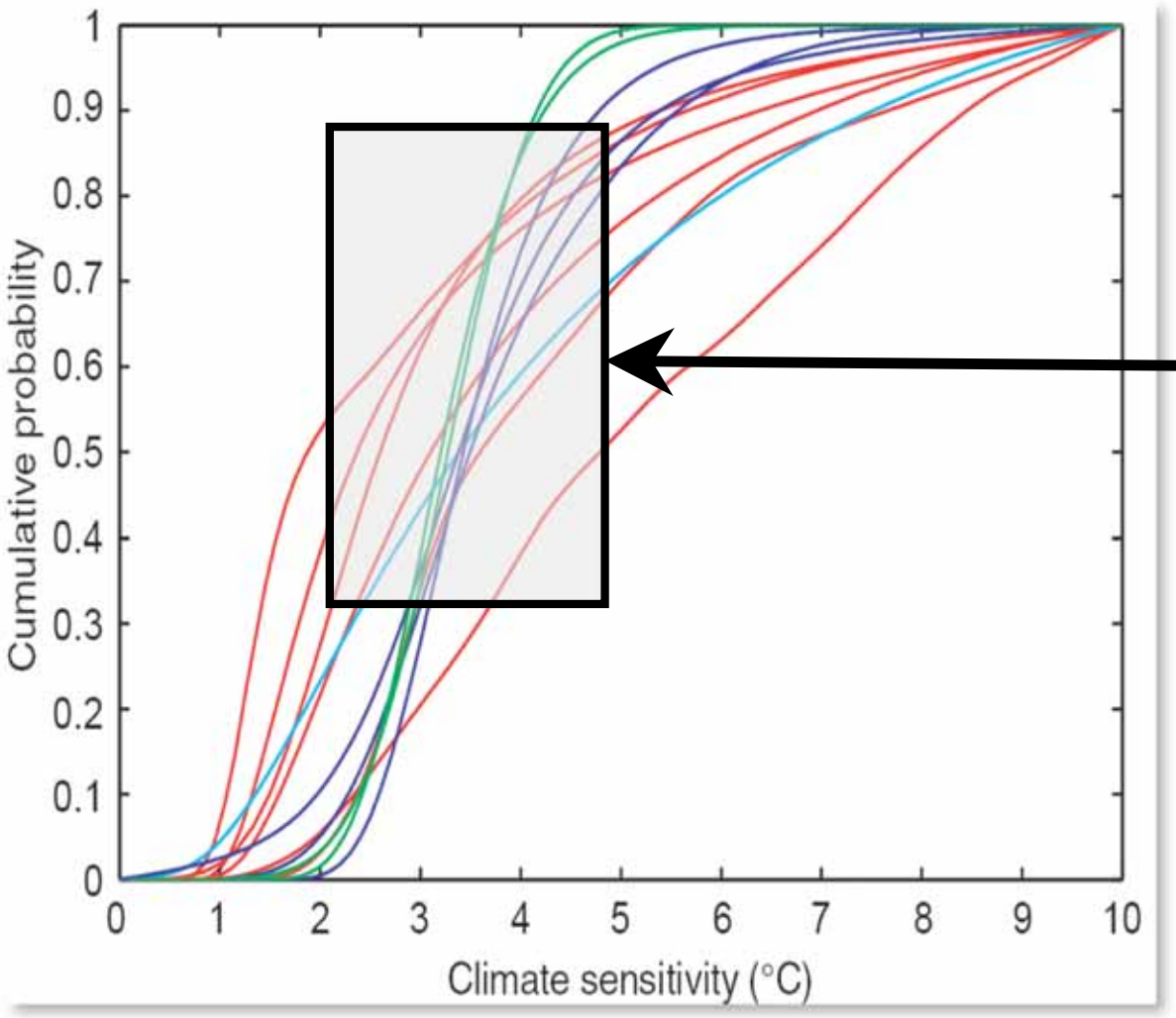
Contrarians

- Cherry-picking
  - point to the one glacier that is holding its own rather than the 99 that are receding
  - comparing isolated Medieval Warming in one area to current warming in virtually all regions of world
- Red Herrings
  - The earth has been warm before
    - Pre-civilization
    - Sea-level was 80 feet higher
    - Oh, and by the way, for different reasons
- Lack of data or models equated with disproof
- Personal attacks
- Egoism
- Self-censorship

What is the prognosis for the future?

Equilibrium Climate Sensitivity

Surface warming following a sustained doubling of CO_2 concentrations



Best estimate 3°C;

likely 2-4.5°C

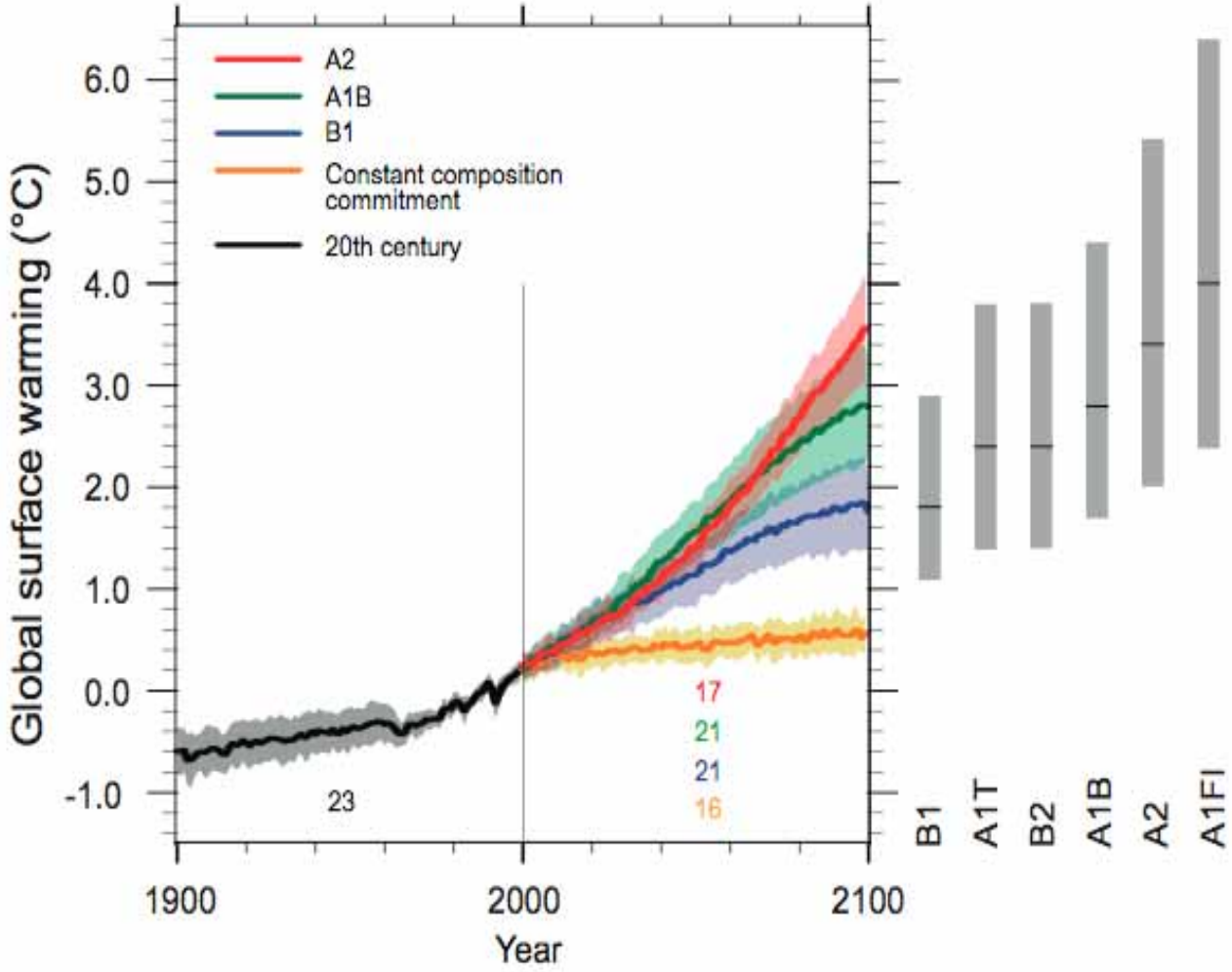
very unlikely less than 1.5°C

Higher values not ruled out

Source: IPCC 4th Assessment (2007)

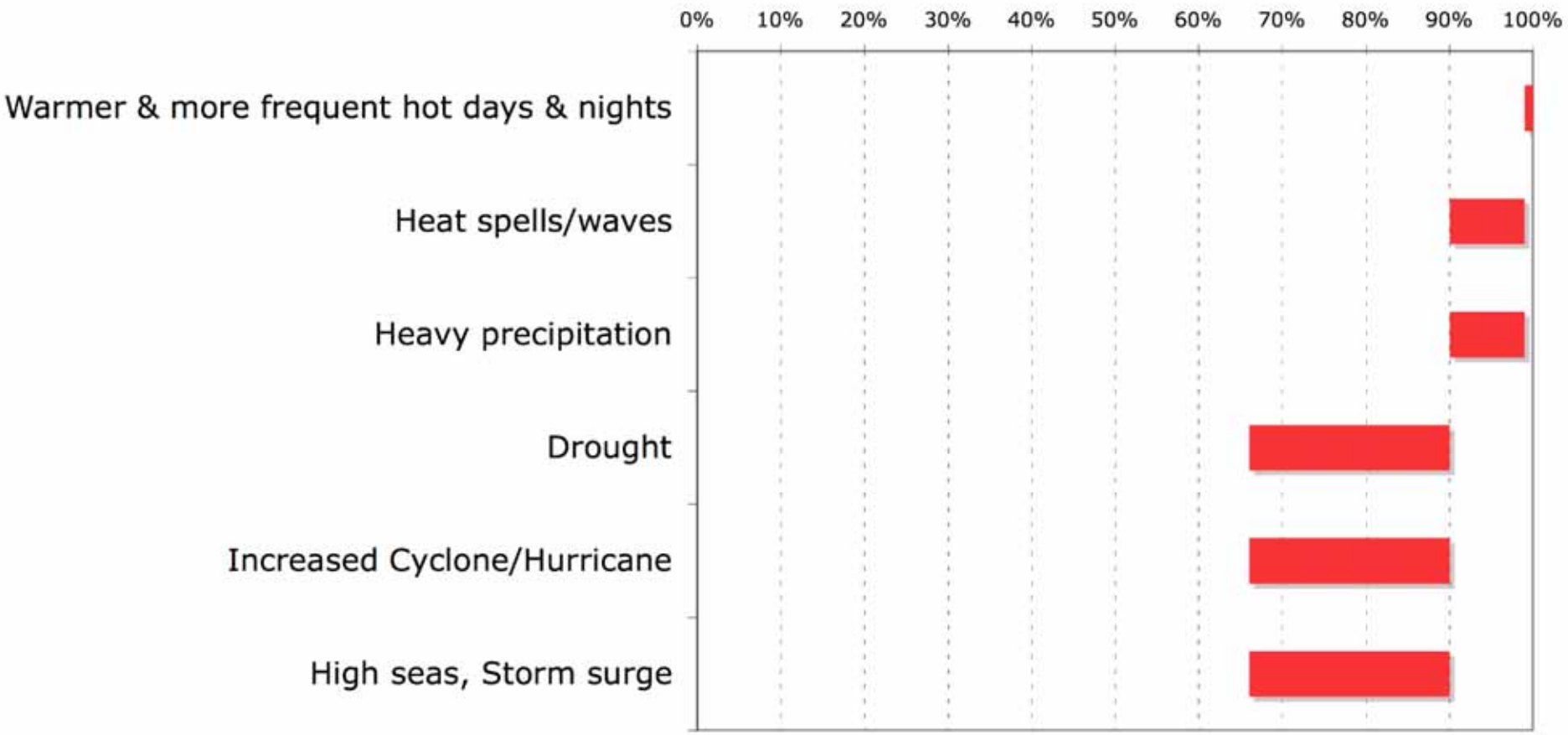
IPCC (2007) Projections of Future Changes in Climate

Best estimate for low scenario (B1) is 1.8°C (*likely* range is 1.1°C to 2.9°C), and for high scenario (A1FI) is 4.0°C (*likely* range is 2.4°C to 6.4°C).



Source: IPCC 4th Assessment (2007)

IPCC (2007) Likelihood of Future Events



Source: IPCC 4th Assessment (2007)

Impacts of Future Events @ 3-5ºC warming (IPCC 2007)

Water	• **Decreasing availability** • **100's of millions of people exposed to increased stress**
Ecosystems	• **Significant extinctions** • **Widespread coral mortality** • **Change in species range**
Food	• **Impacts on subsistence farmers and fishing** • **Decreased productivity of cereal crops**
Coasts	• **Millions more people experience coastal flooding** • **~30% of coastal wetlands lost**
Health	• **Increased malnutrition, diarrhoeal, cardio-respiratory, and infectious disease** • **Rising morbidity & mortality: heat waves, flood, droughts** • **Changed disease distributions** • **Substantial burden on health services**

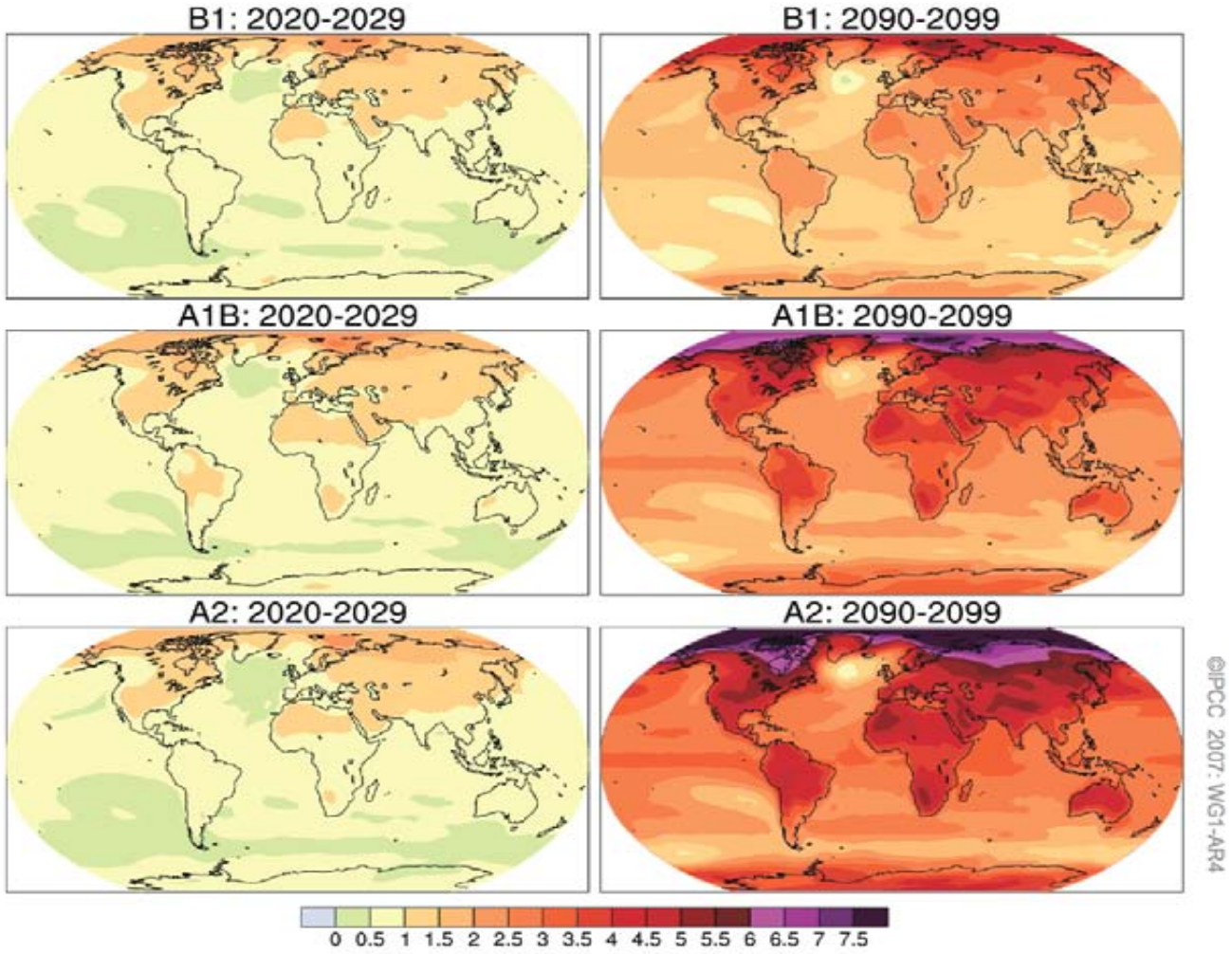
Source: IPCC 4th Assessment (2007)

IPCC (2007) Projections of Future Changes in Climate

Projected warming in 21st century expected to be:

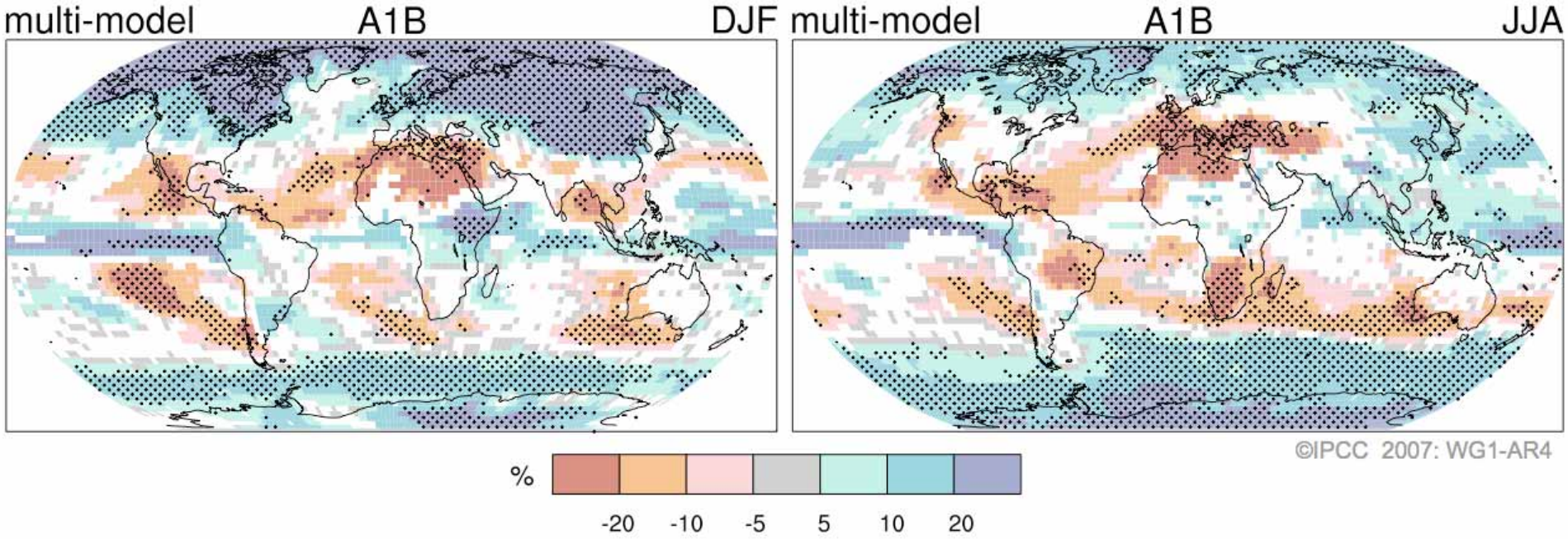
> Greatest over land
and at most high northern latitudes

> Least over the Southern Ocean and parts of the North Atlantic Ocean



Source: IPCC 4th Assessment (2007)

IPCC (2007) Projections of Future Changes in Precipitation

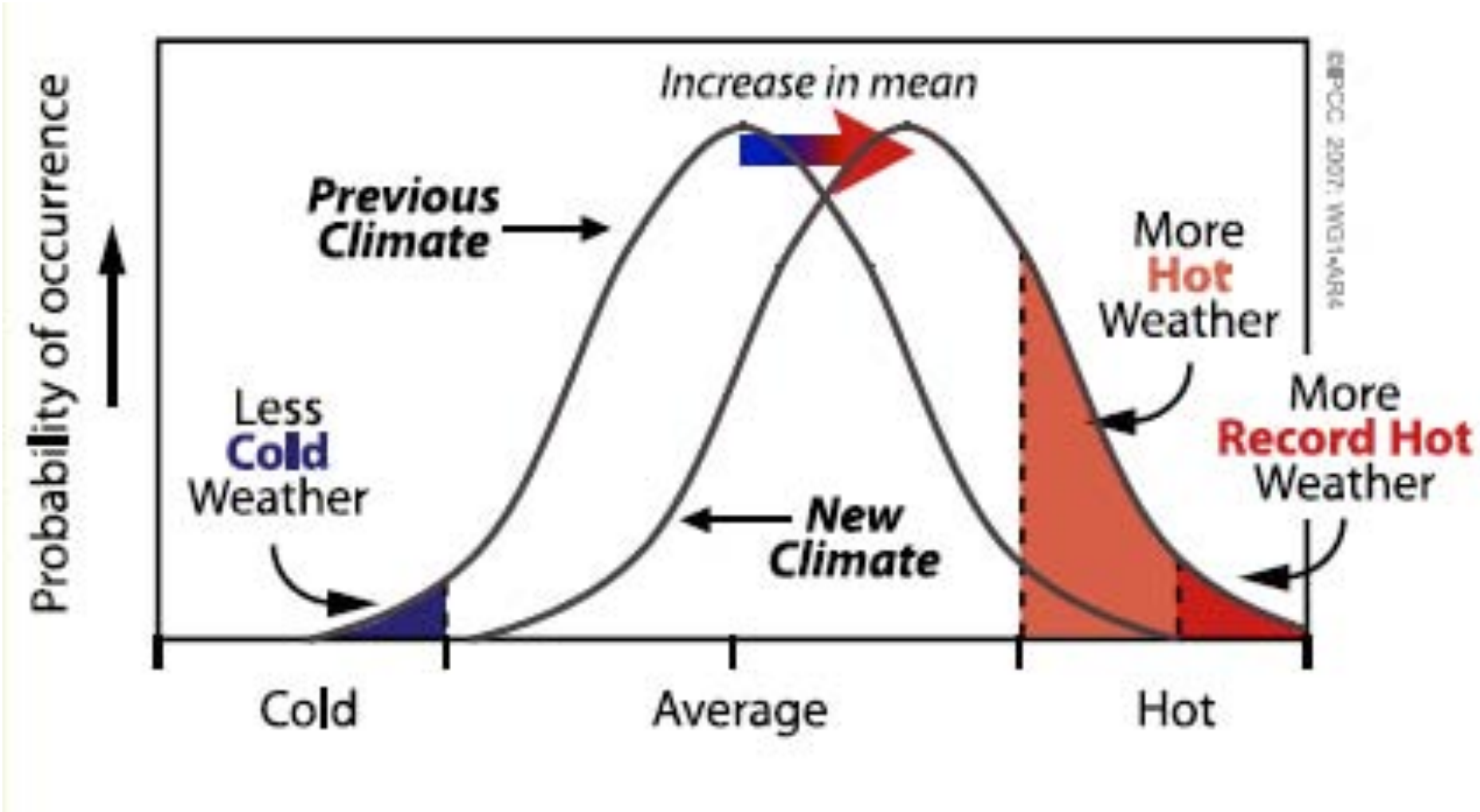


Precipitation increases *very likely* in high latitudes

Decreases *likely* in most subtropical land regions

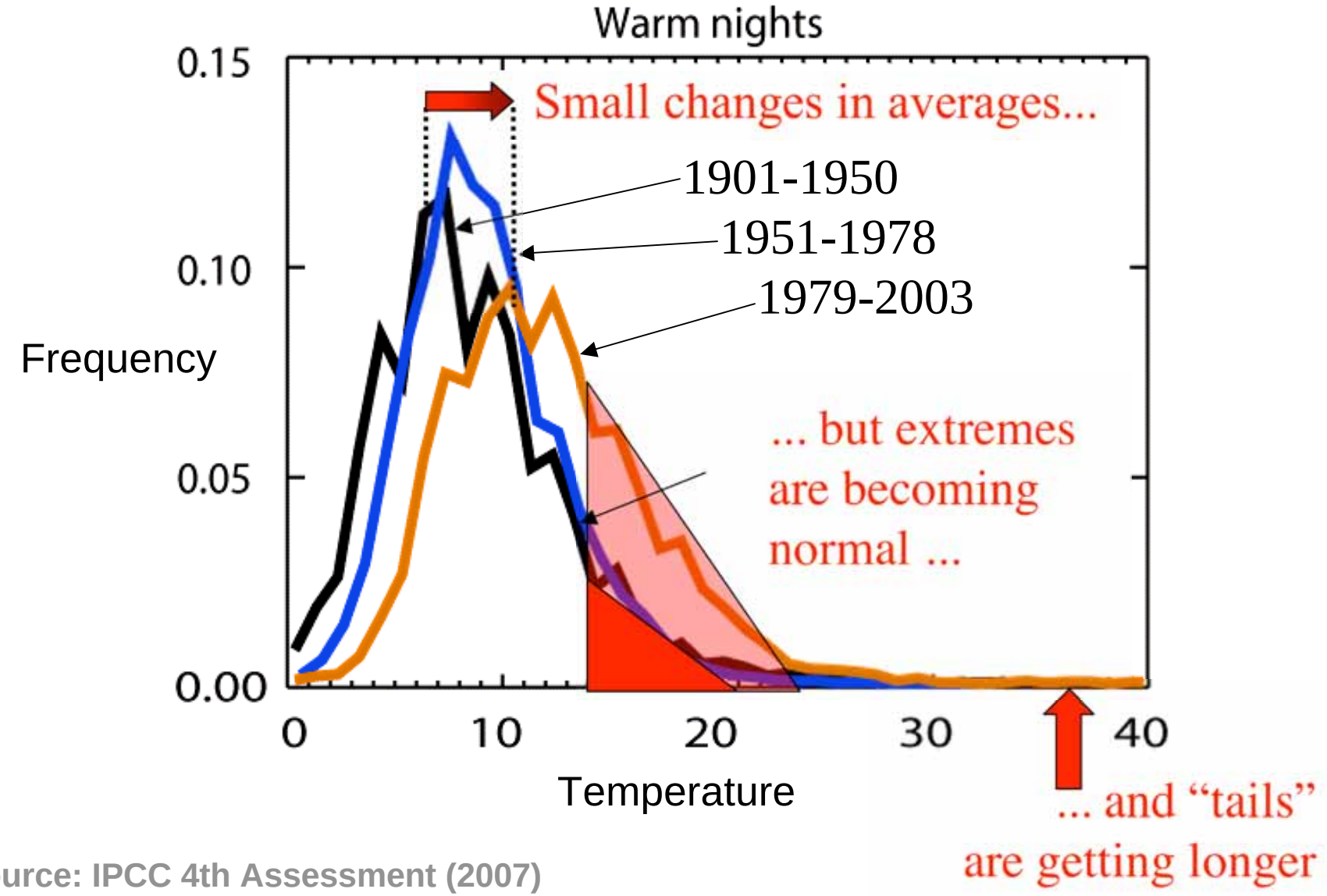
Source: IPCC 4th Assessment (2007)

Changes in Averages vs. Extremes



Source: IPCC 4th Assessment (2007)

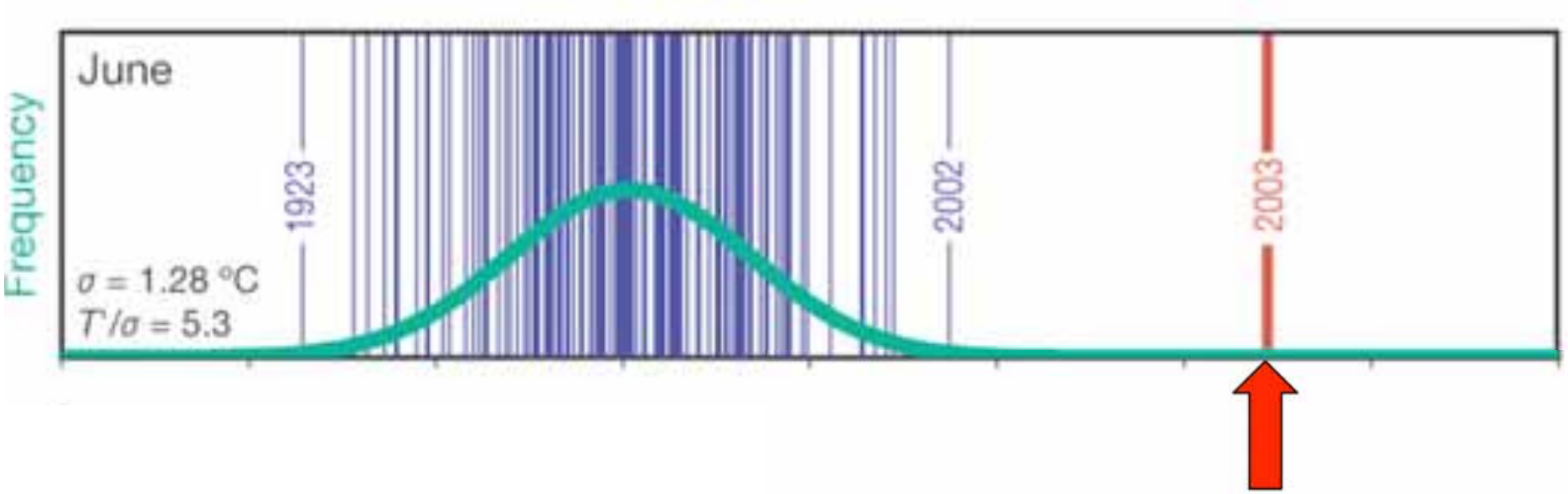
Extremes Shift *More* Than Avg's.



Source: IPCC 4th Assessment (2007)

Rare Extremes Cause Most of the Damages & Insured Losses

The European heat wave of Summer 2003



Event was "six-sigmas" outside of norm.
16°F above average in France and Germany
was a 1-in-10,000 event to 1-in-46,000 event

Source: Schar et al, *Nature*, v. 427, 2004.

Small-scale, Indirect Events and Consequences Often Overlooked

Greater combined impacts than CATs in an average year

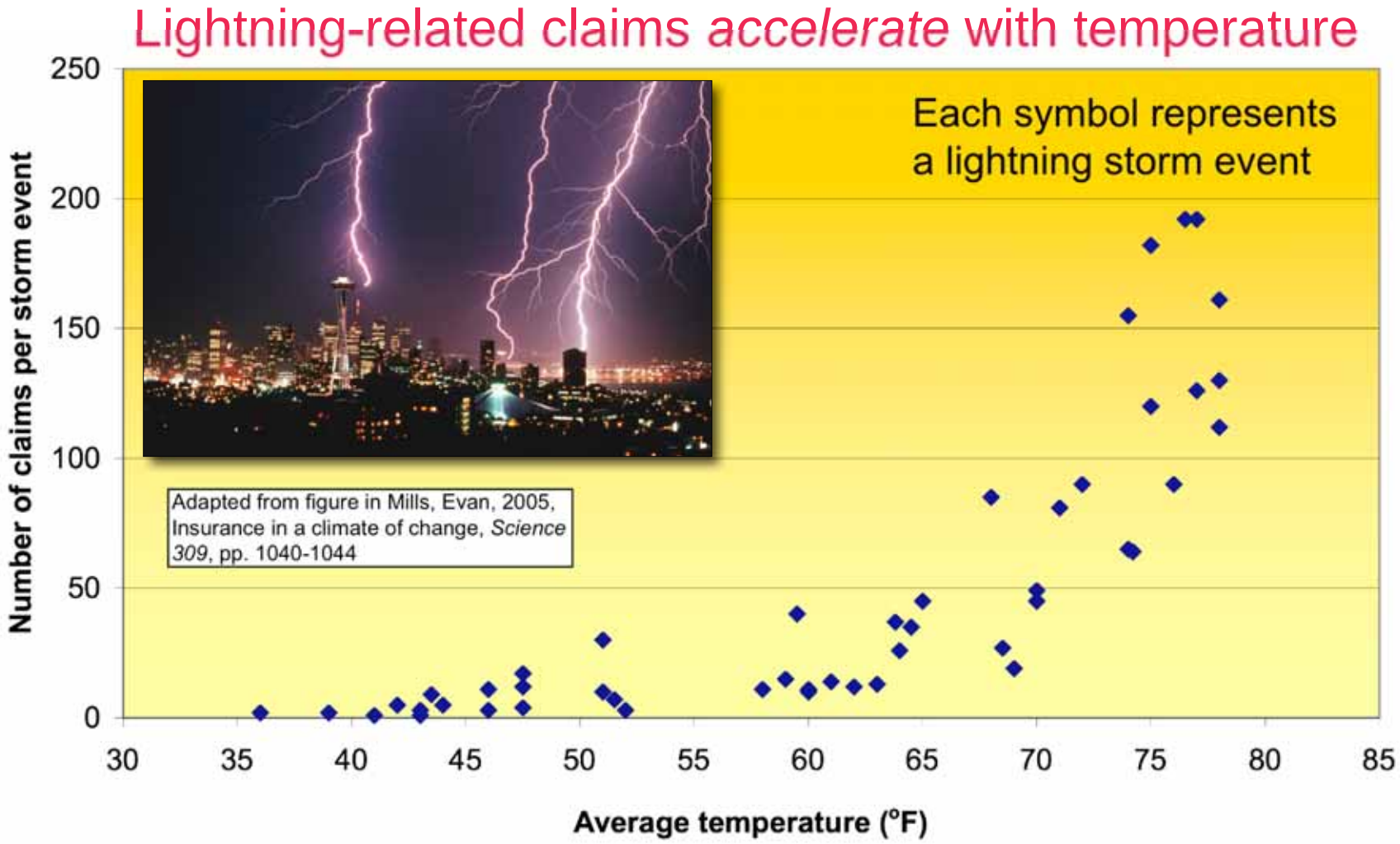
Events

- Drought
- Hail
- Heat waves
- Ice Storms
- Lightning
- Sea-level rise
- Thunderstorms
- Tornados
- Torrential rains
- Wildfire
- Winterstorms

Consequences

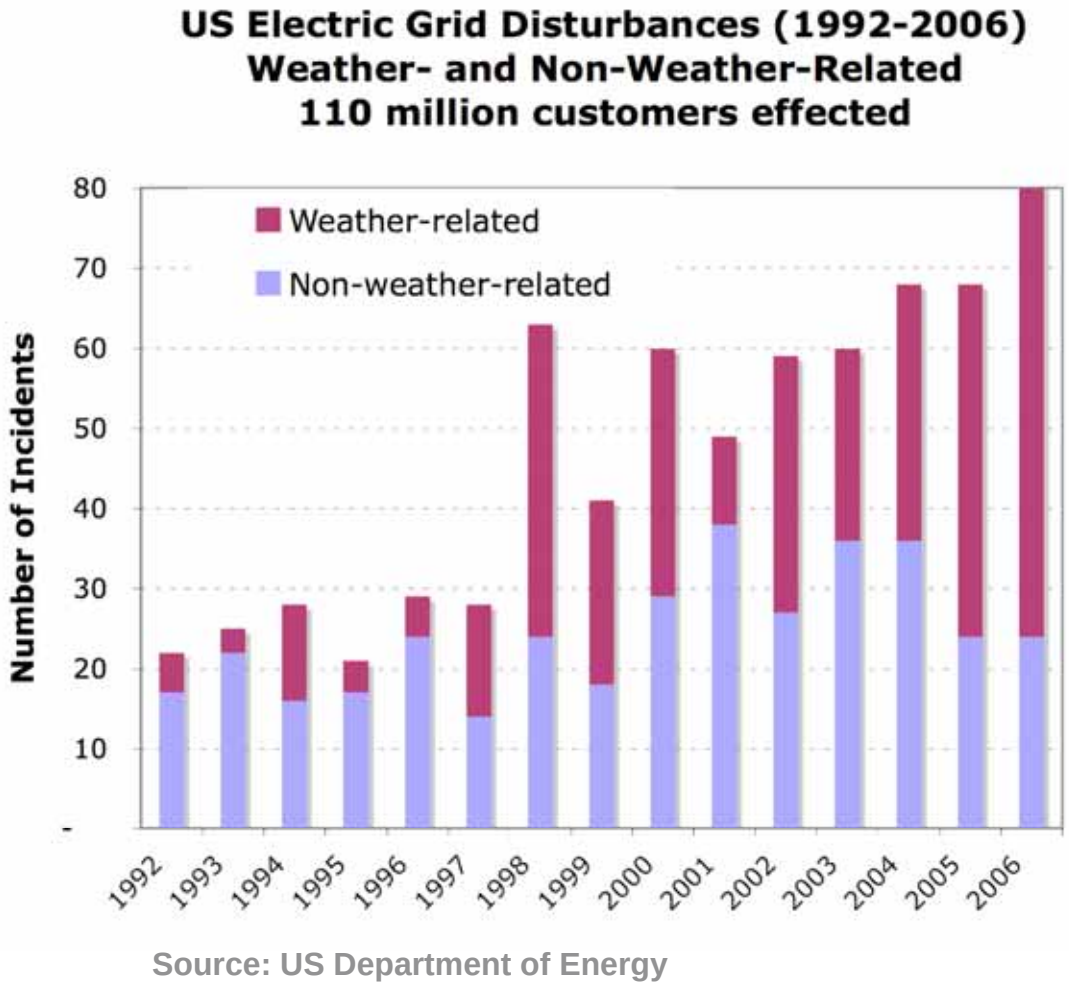
- Blackouts
- Coastal erosion
- Crop/fishery damages
- Equipment breakdown
- Eroded air quality
- Eroded water quality
- Flooding
- Health impacts
- Mudslides
- Property loss
- Sinkholes/Subsidence
- Weather-related vehicle accidents

Temperature-Related Insurance Loss Experience



Source: Hartford Steam Boiler Inspection and Insurance Co.

U.S. Wholesale Power Outages



Source: US Department of Energy

U.S. total cost: ~$80B/year

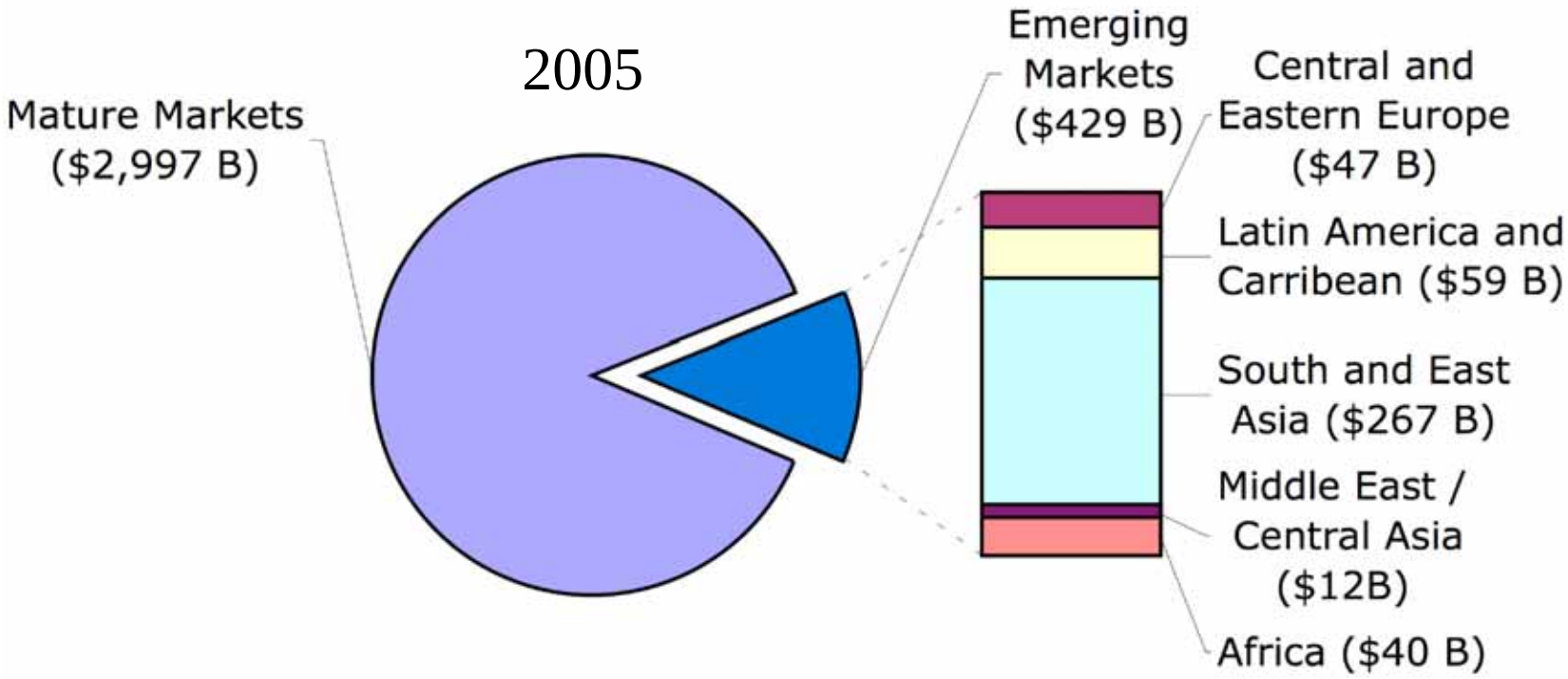
Current insured portion unknown: most are below ISO/PCS threshold for being "worth" counting

RMS Scenario: $2.7B for NY

Power outages were a factor in slowness of draining New Orleans following Hurricane Katrina. Also important for contingent business interruption.

$3.4 *Trillion* World Insurance Market

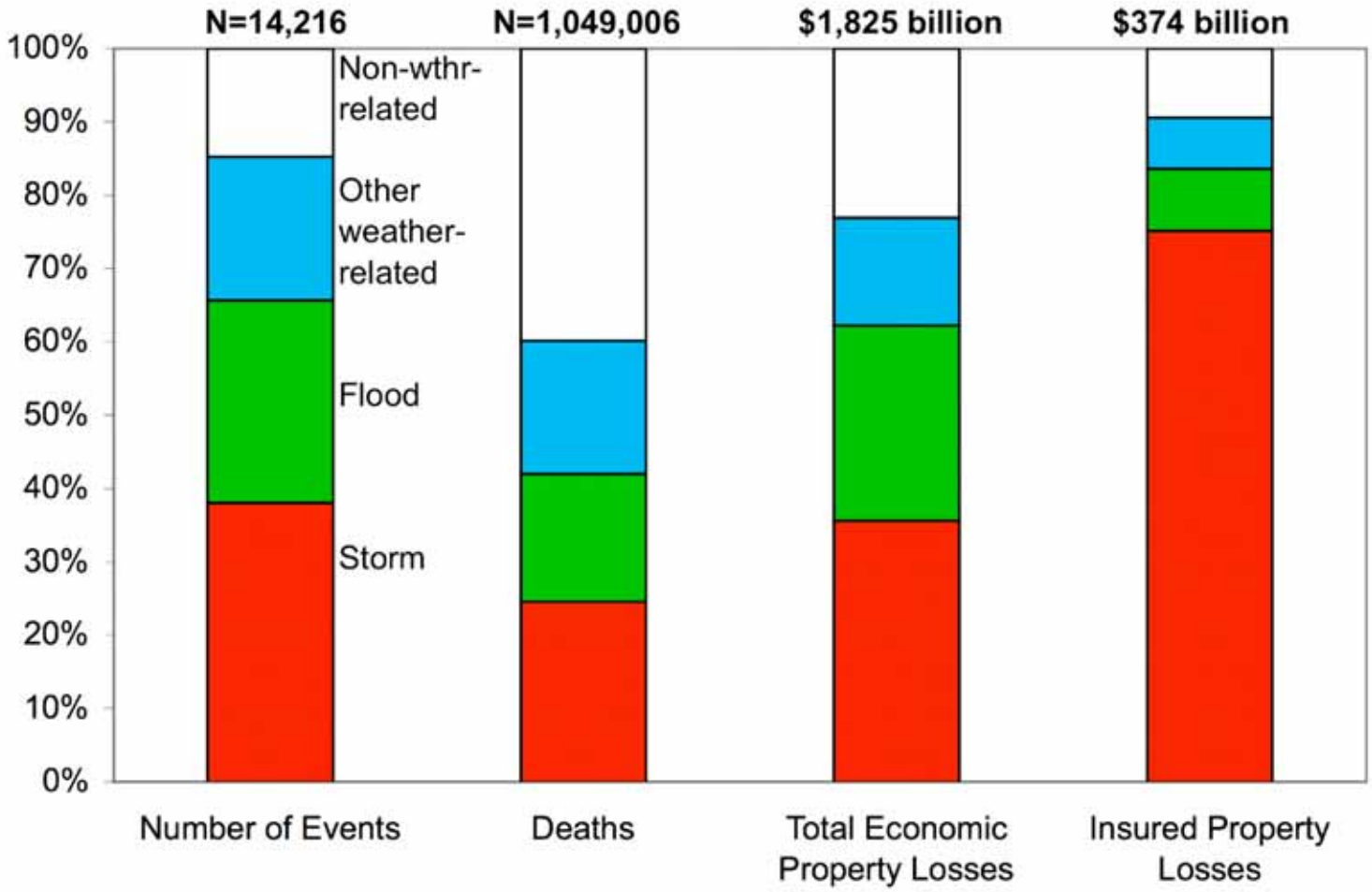
- World's biggest industry; important to economic development
- Large employer
- Major player in financial markets
- Enormous political influence



Source: Swiss Re, Sigma No. 5/2005

Disasters Look Different Through an Insurance "Lens"

Aggregate Global Impacts: 1980-2004

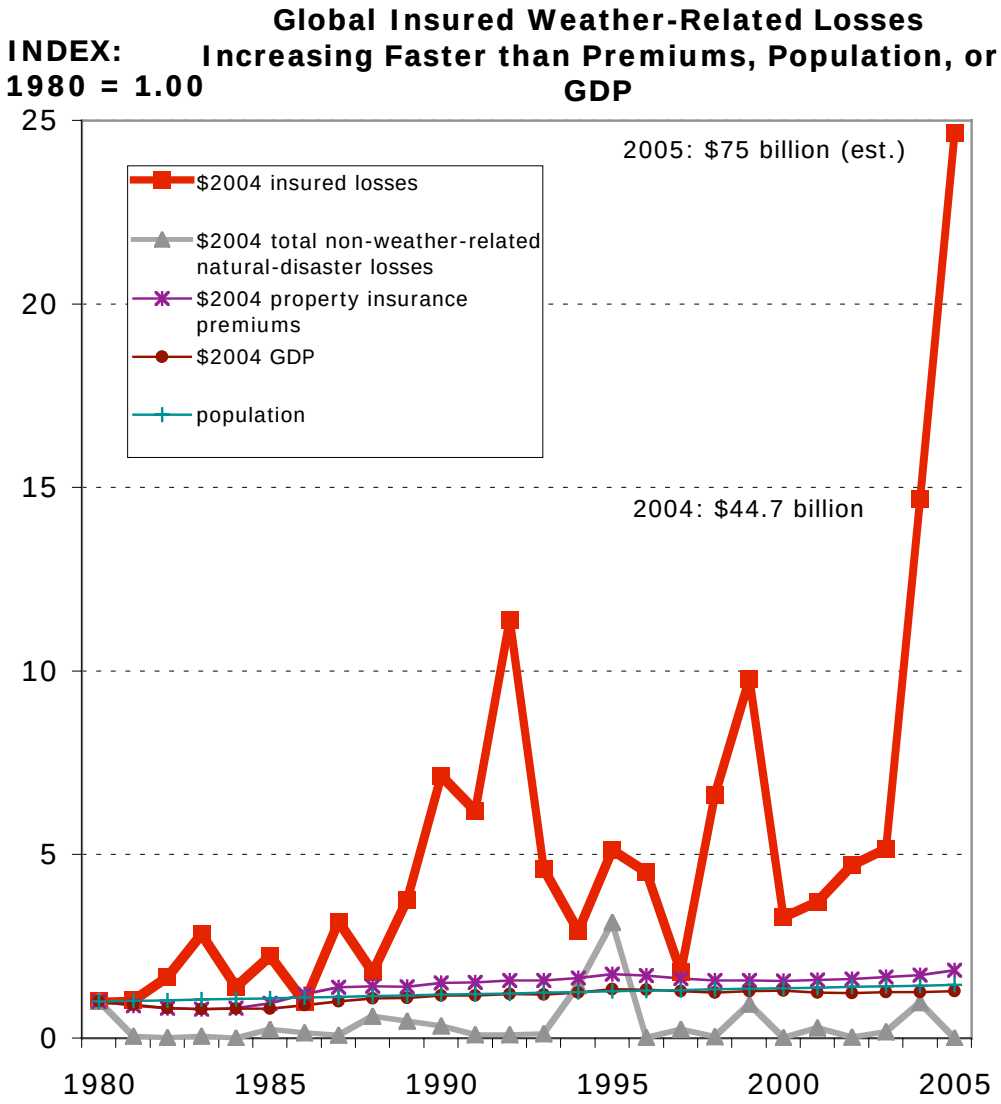


Source: E. Mills Science 309, 1040 -1044 (2005)

Uncertainty: **Physical ➡ Financial**

Non-climate factors play a role, but…

- Trends *consistent* with observed change
- Why are non-weather losses level?
- Would have been even worse without prevention efforts

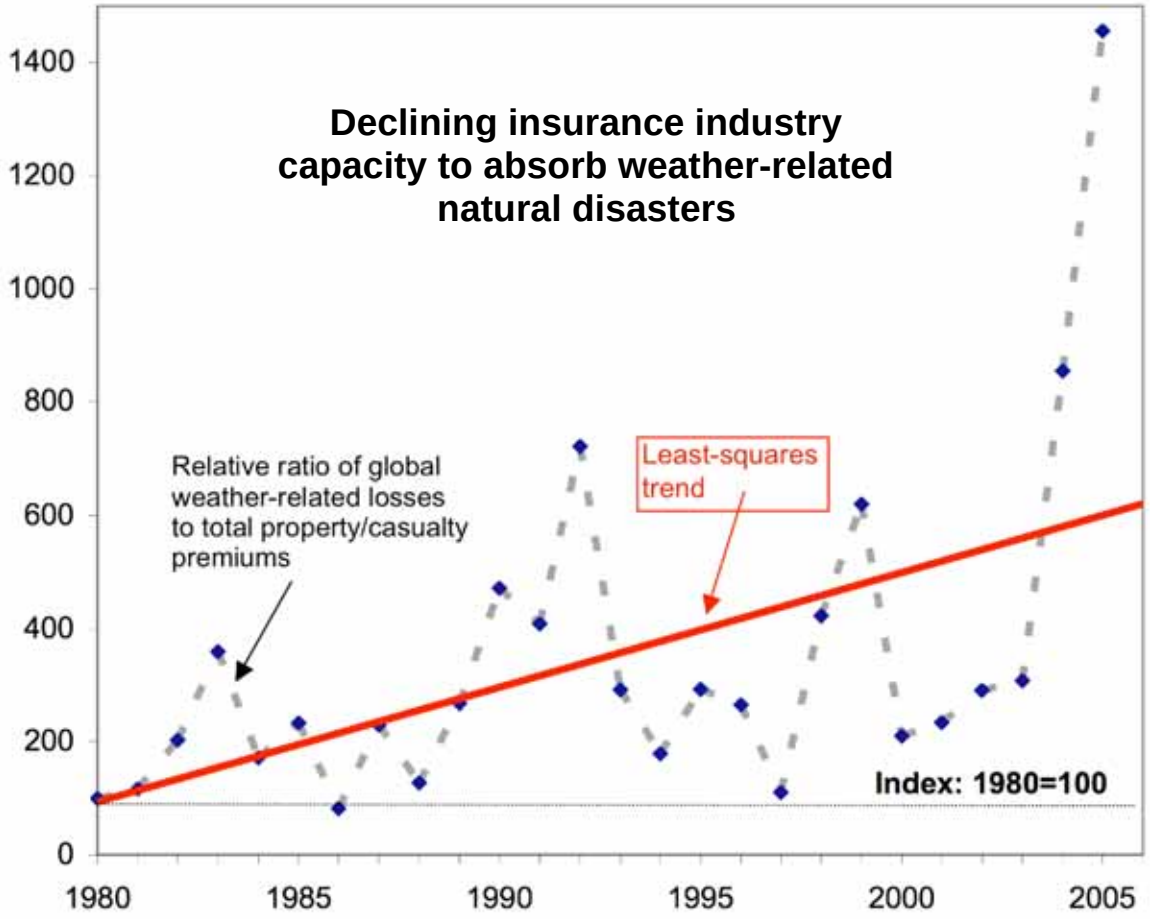


Notes: All economic values inflation-adkusted to 2004 levels. Losses from Munich Re NatCat Service; premiums from Swiss Re, *Sigma*. Values for 2005 are LBNL estimates.

Source: E. Mills Science 309, 1040 -1044 (2005)

Risk is OK
Volatility & Uncertainty is Not

The ratio of losses to premium revenues is increasing



Source: E. Mills Science 309, 1040 -1044 (2005)

Insurance & Legal Consequences

- Property damage
- Mold/moisture
- Forest products
- Agricultural losses
- Fisheries
- Business interruption
- Roadway

- Injury
- Infectious diseases
- Heat stress
- Respiratory
- Pollutant releases
- Food poisoning
- Mental health
- Nutrition/water

- Products
- Negligence
- Nuisance
- Fiduciary
- Tort / BI
- Environmental
- Roadway liability insurance

Risks Also Associated with Responses *to* Climate Change

- Emissions reductions: supply- and demand-side
  - Green buildings
  - Nuclear power
  - Hydrogen energy
  - Renewable energy
  - Carbon capture & storage
- Comparative risk assessments needed

Carbon Capture & Storage (CCS)

- Lake Nyos - 1986 (Cameroon): Natural CO_2 leak killed 1800 people, 3500 farm animals

Climate Change Liability: A Rapidly Emerging Issue

New IPCC Report has reduces uncertainties

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June 3, 2007, 5:13 pm

What Insurers Should Do About Climate Change

Getty Images

Insurers are likely to soon take a leadership role in reducing the risks of climate change as companies become more liable for damage related to it. The authors of a study jointly published by the Stanford Environmental Law Journal and the Stanford Journal of International Law sketch out several ways that companies who disproportionately contribute to global warming could be held responsible for its damage as the science of global warming becomes clearer.

The most common example is owners of property damaged by a warmer world's extreme weather suing companies that disproportionately emitted greenhouse gases. As well as paying out on insurance covering such liability claims, insurers will have to pay for several kinds of damage related to global warming, the authors say. They'll have to pay for car crashes on wet roads and ski resorts that insure themselves against warm winters short on snow.

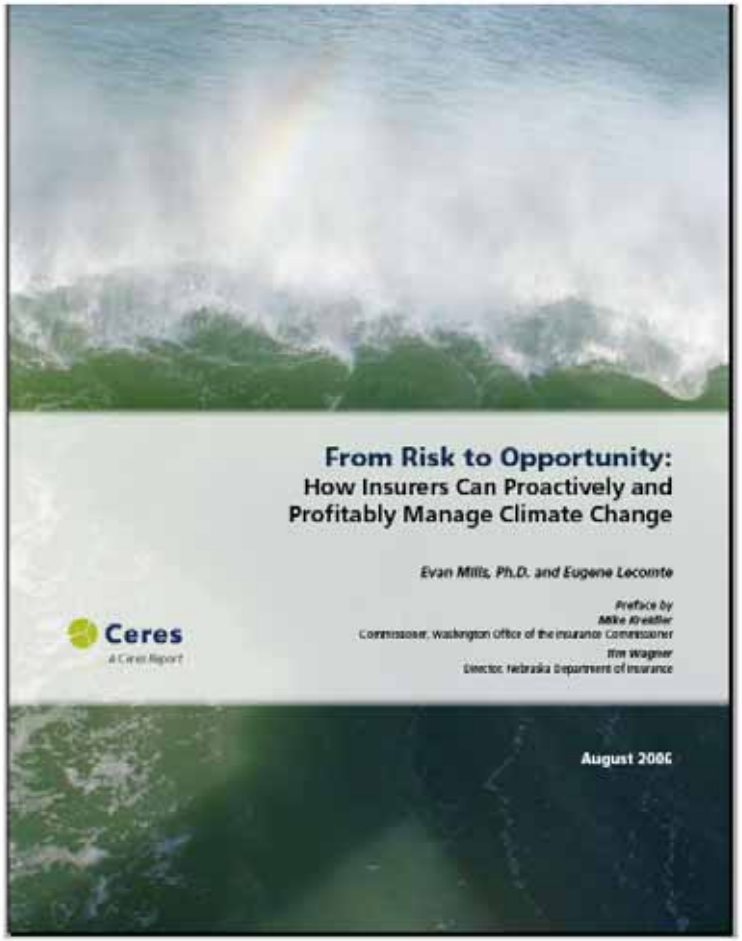
"The insurance industry, perhaps more than any other institution, has the power to set the stage for enduring and significant contributions to solving the problem of global climate change," say environmental consultant Christina Ross, government scientist Evan Mills and environmental-law expert Sean B. Hecht.

From Risk ⟹ to Opportunity

The insurance sector has a key role to play in helping to mitigate the effects of climate change … and by developing new products and solutions that can support emerging greenhouse-gas and renewable energy markets.

- Marsh & McLennan

New Report:
~220 examples; ~120 insurers
[*modest* beginnings]



Thank You

http://insurance.lbl.gov

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