

State of the Climate Debate

Judith Curry

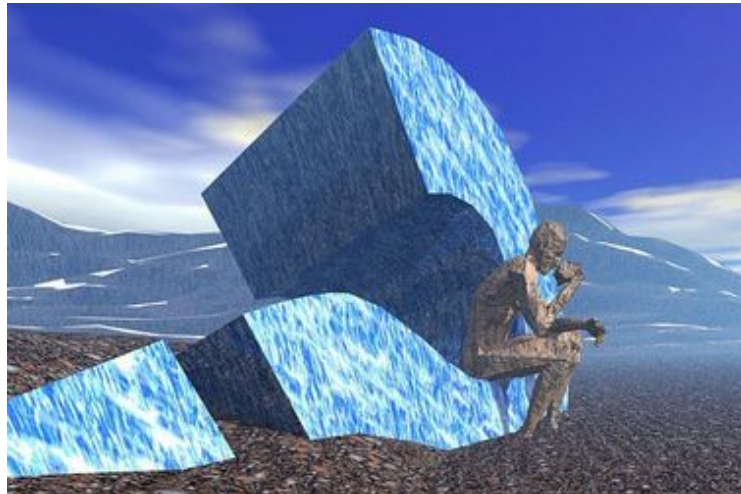
Georgia Institute of Technology

Climate Forecast Applications Network

Confusion

• Uncertainty

• Disagreement



Agreement:

- Surface temperatures have increased since 1880
- Humans are adding carbon dioxide to the atmosphere
- Carbon dioxide and other greenhouse gases have a warming effect on the planet

Disagreement:

- **Whether the warming since 1950 has been dominated by human causes**
- **How much the planet will warm in the 21st century**
- Whether warming is 'dangerous'
- Whether we can afford to radically reduce CO₂ emissions, and whether reduction will improve the climate



Extraterrestrial Factors

Solar
Output

Earth-Sun
Geometry

Interstellar
Dust

Volcanic
Emissions

Mountain
Building

Continental
Drift

Atmosphere/Ocean
Heat Exchange

Atmospheric
Composition

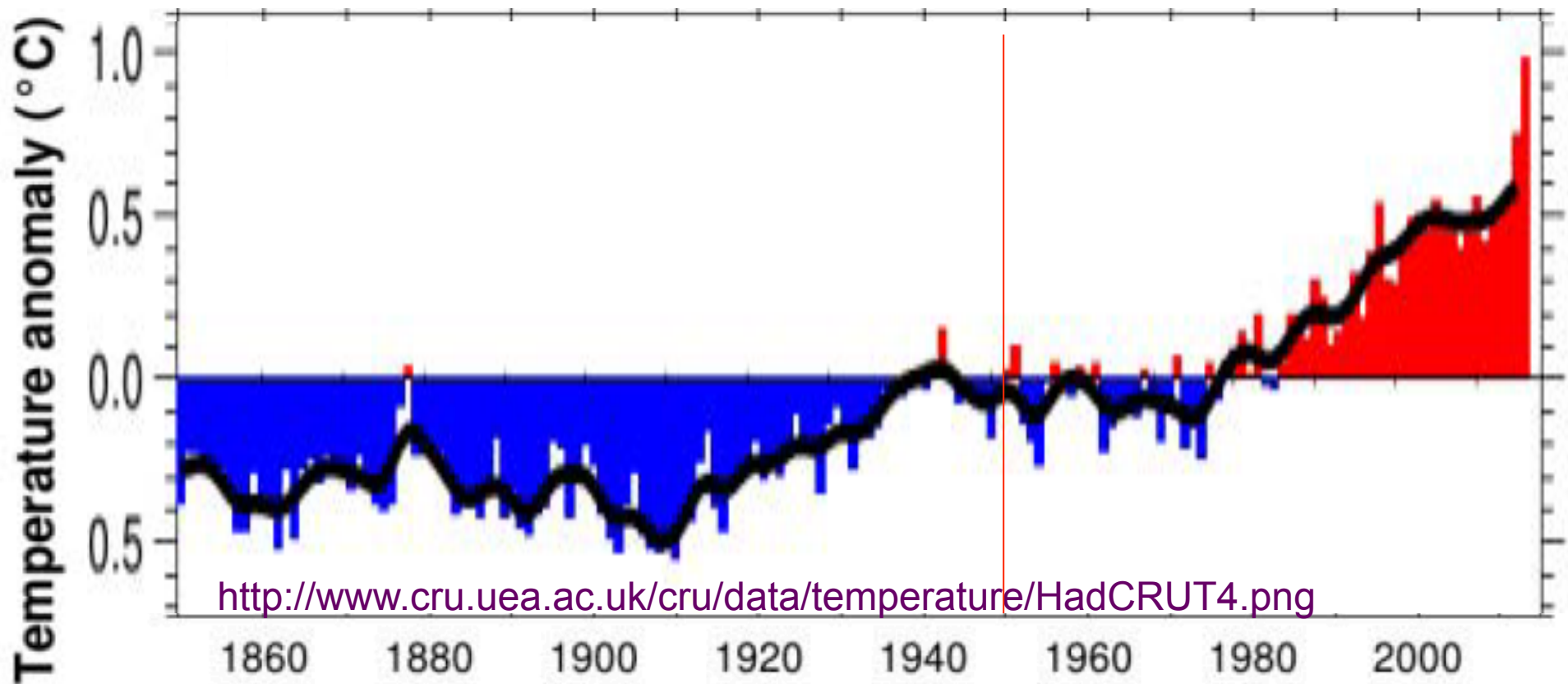
Atmospheric
Reflectivity

Surface
Reflectivity

**Earth's
Climate**

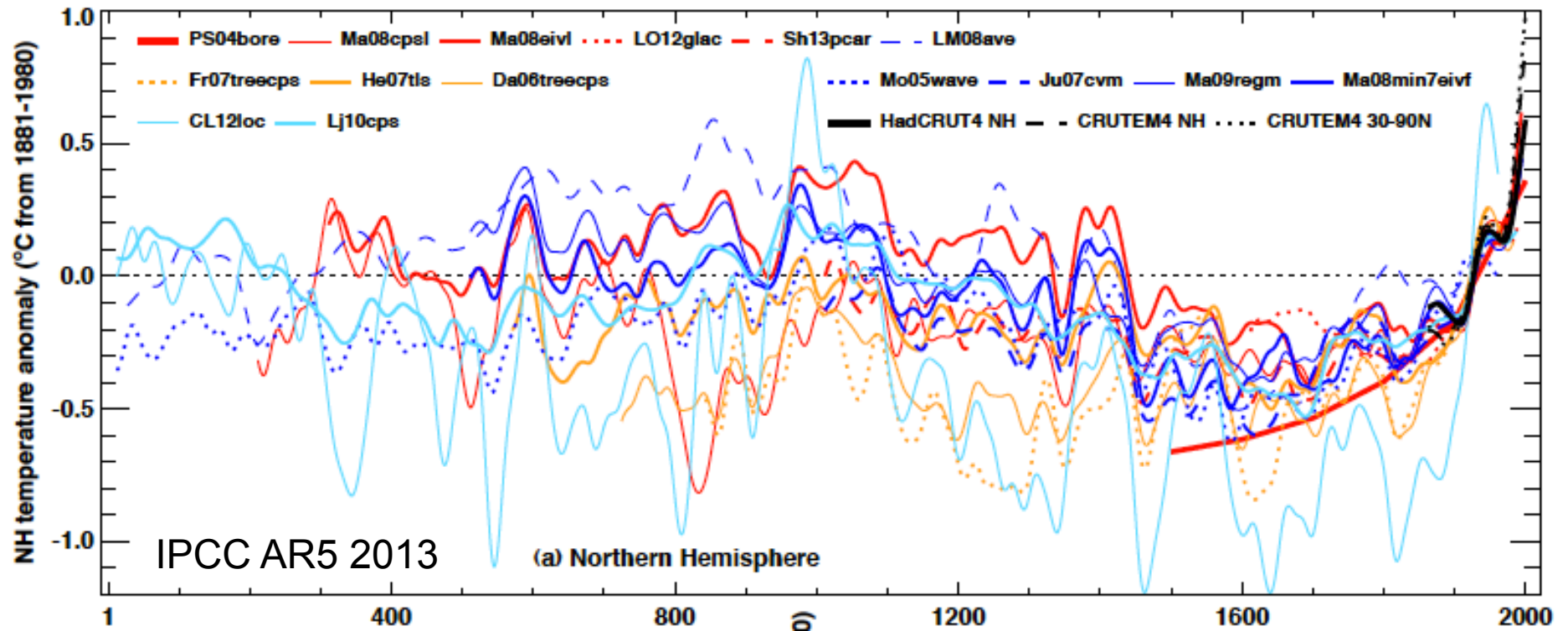
Ocean, Atmosphere, and Land Factors

Global surface temperature anomaly



IPCC AR5: *It is **extremely likely** that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by [humans]. The best estimate of the human induced contribution is similar to the observed warming over this period.*

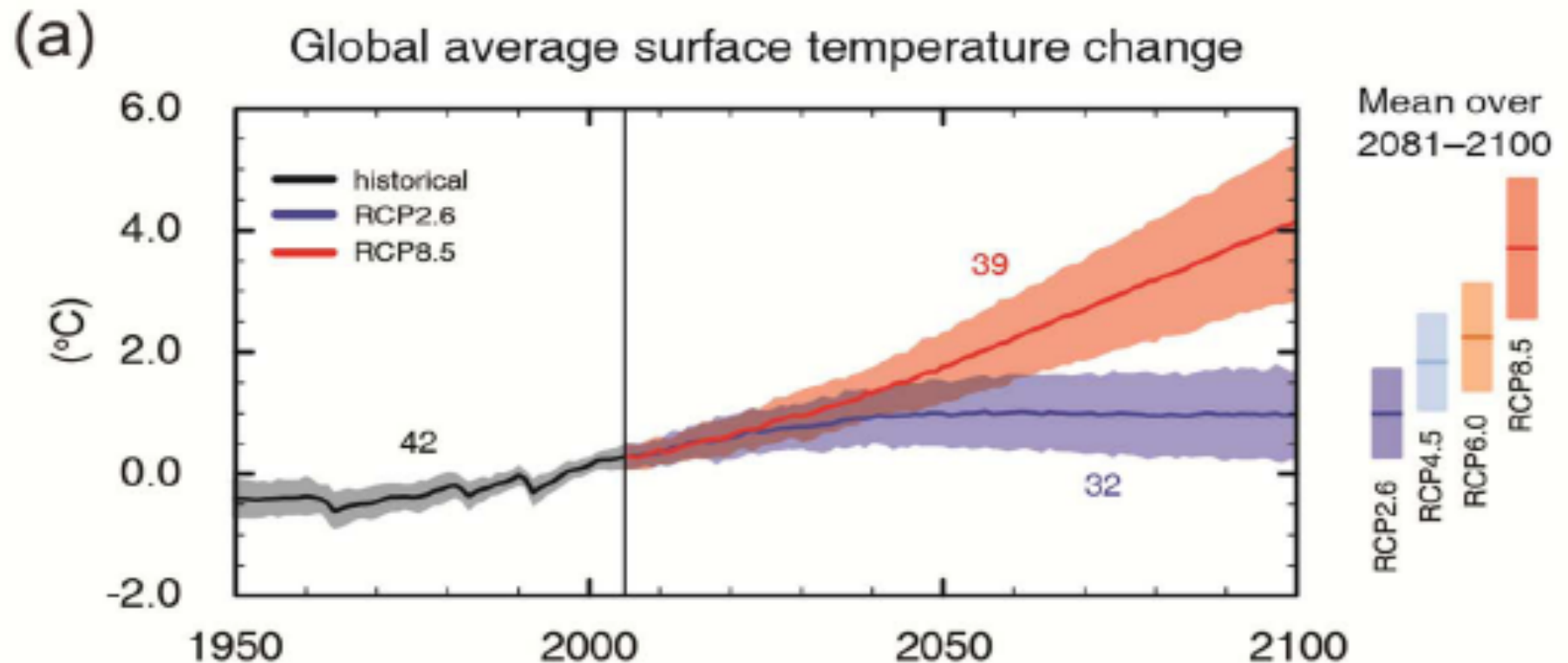
Northern Hemisphere paleoclimate surface temperature reconstructions



Temperatures have been warming for the past 200-400 years; only the warming since 1950 is being attributed to humans

Implications for the future:

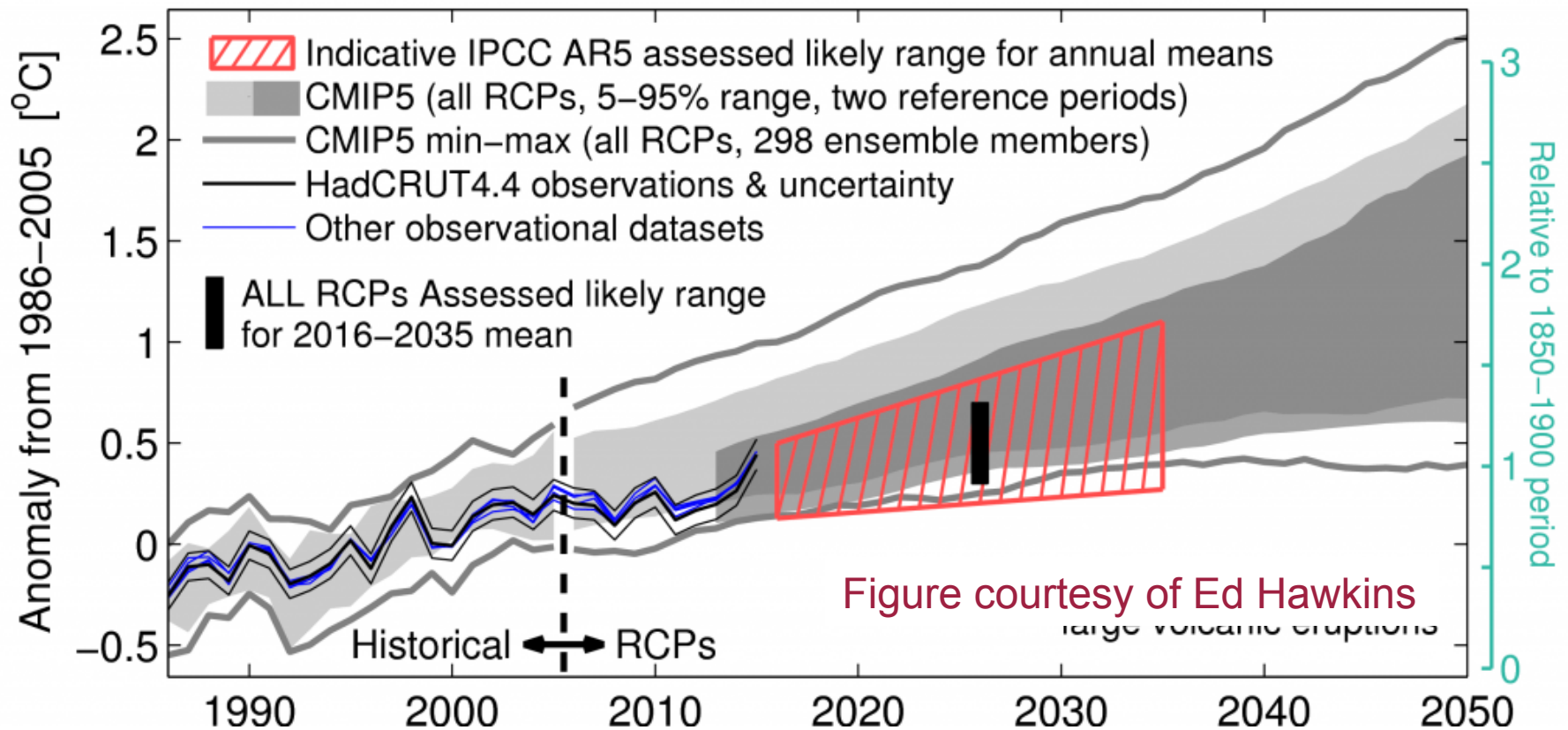
I. Consensus IPCC view



The amount of warming depends on the emission of greenhouse gases

Growing divergence: models vs observations

CMIP5 near-term global temperature projections: updated from IPCC AR5 Fig. 11.25



Growing divergence: models vs observations

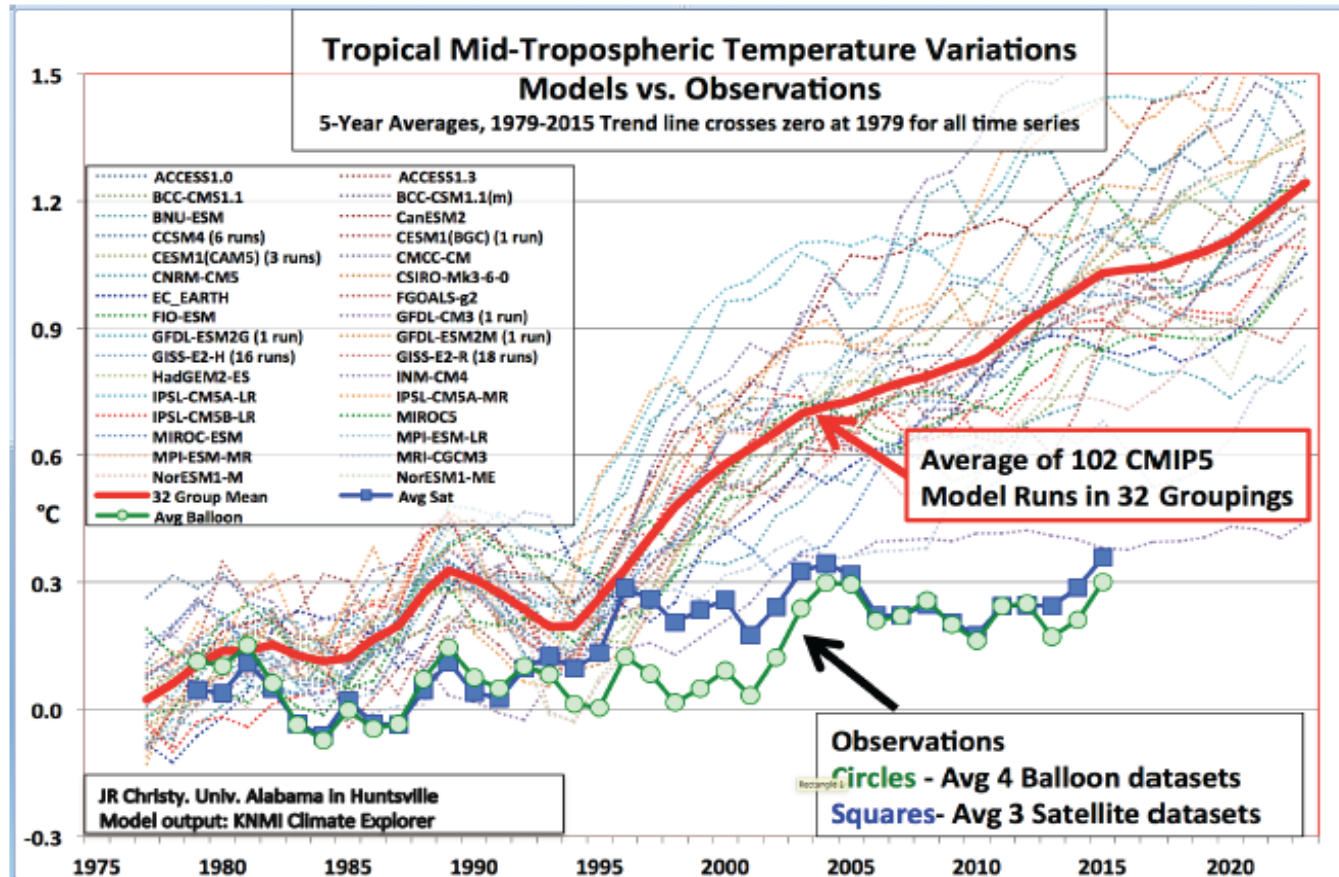


Figure courtesy John Christy

- Are climate models too sensitive to greenhouse forcing?
- Is modeled natural climate variability inadequate?
- Are model projections of 21st century warming too high?

Implications for the future:

II. View emphasizing natural variability

- The 'pause' will continue at least another decade (into the 2030's?); El Ninos weak and infrequent
- Climate models are too sensitive to human forcing; 21st century warming will be on the low end of IPCC projections (or even below)
- Solar variations & volcanoes: wild card. Most are predicting solar cooling in the near term
- Can't rule out unforeseen surprises



Implications for utility regulators

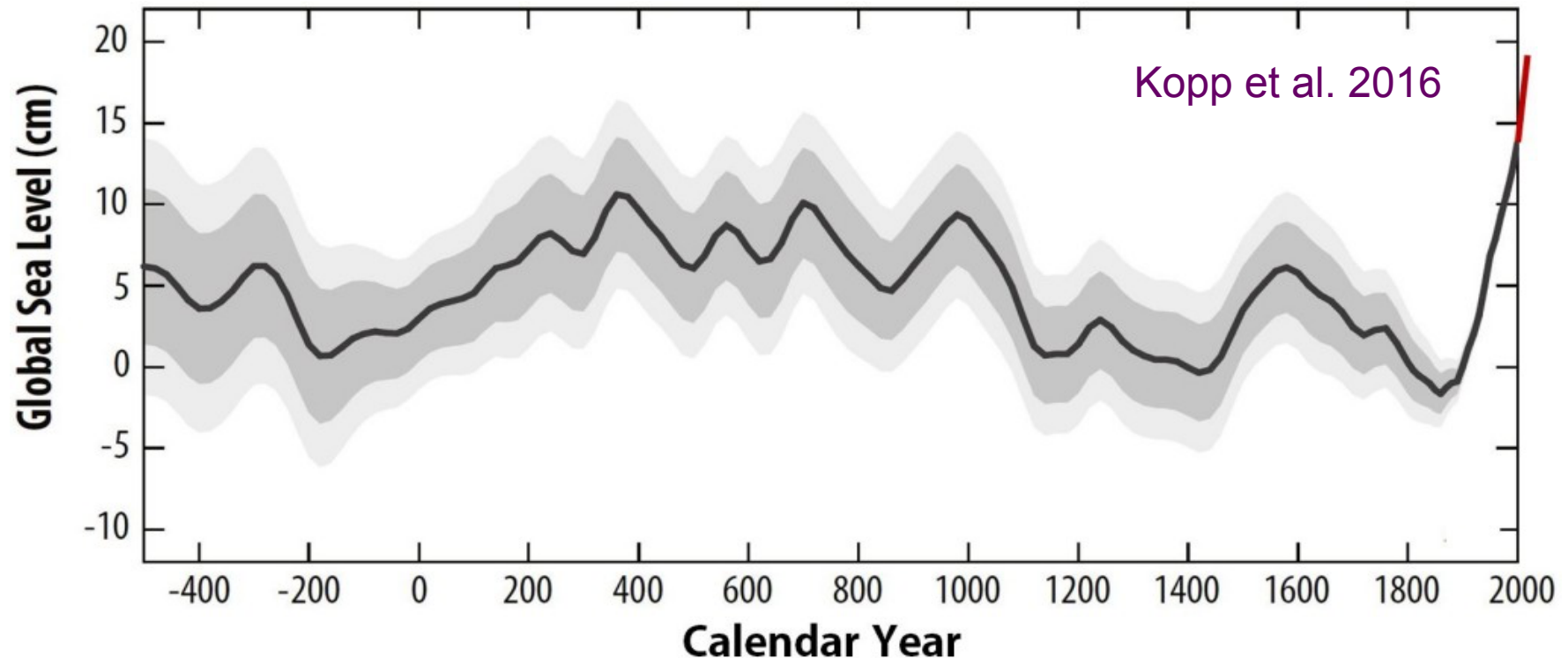
- There is a great deal of uncertainty in our understanding of what has caused the 20th century warming and how the 21st century climate might evolve.
- We have oversimplified both the climate change problem and its solution

News Item #1

*“Oceans rising faster than
anytime in the last 2,800
years, scientists calculate”*

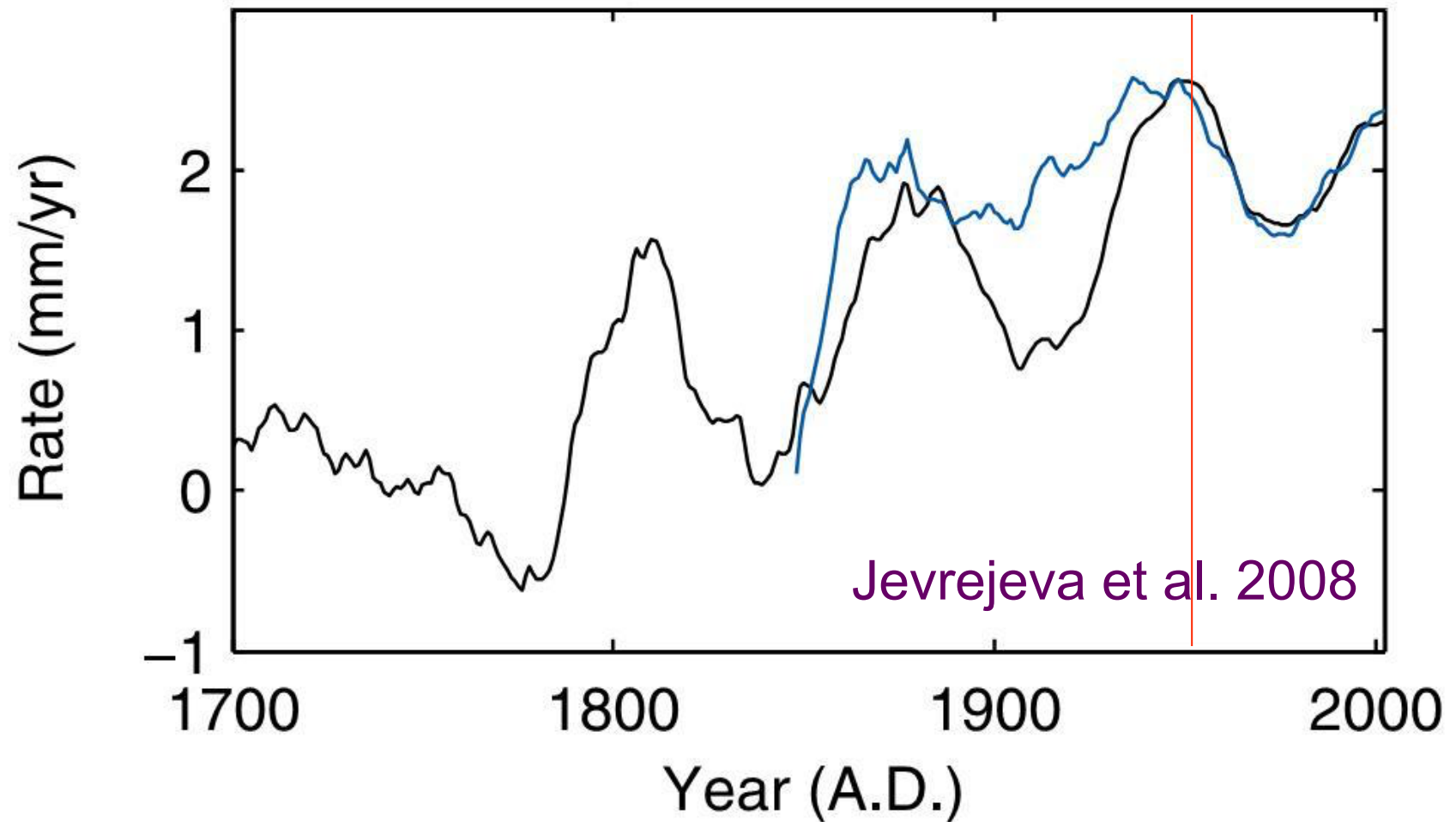
New York Times, 2/23/16

“A significant global sea level acceleration began in the 19th century and yielded a 20th century rise that is extremely likely to be faster than during any of the previous 27 centuries”

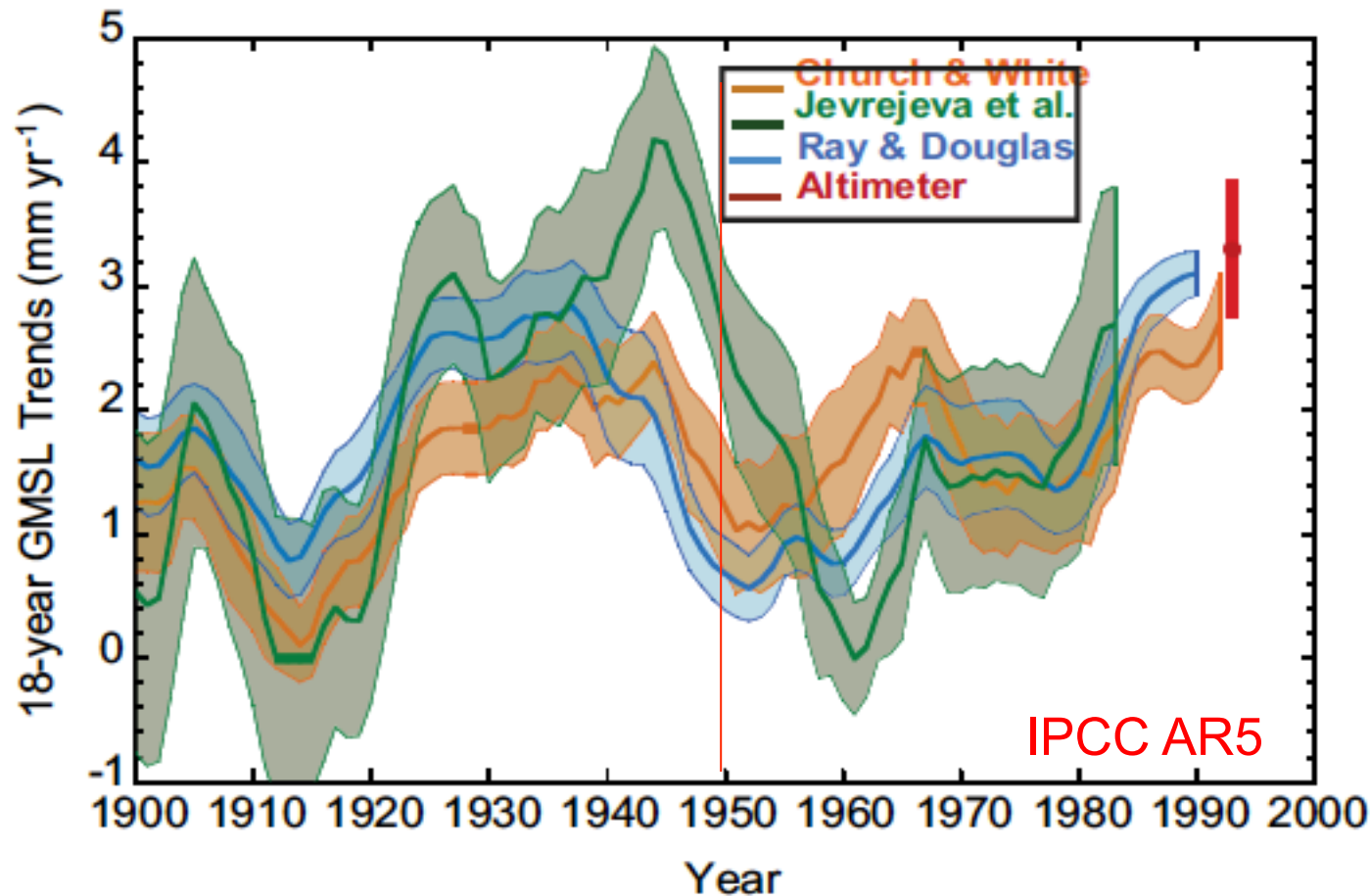


Comment: the temporal resolution of this analysis is insufficient to resolve periods of less than 50 years

Recent global sea level rise acceleration started over 200 years ago



Is the IPCC's sea level rise conclusion justified?

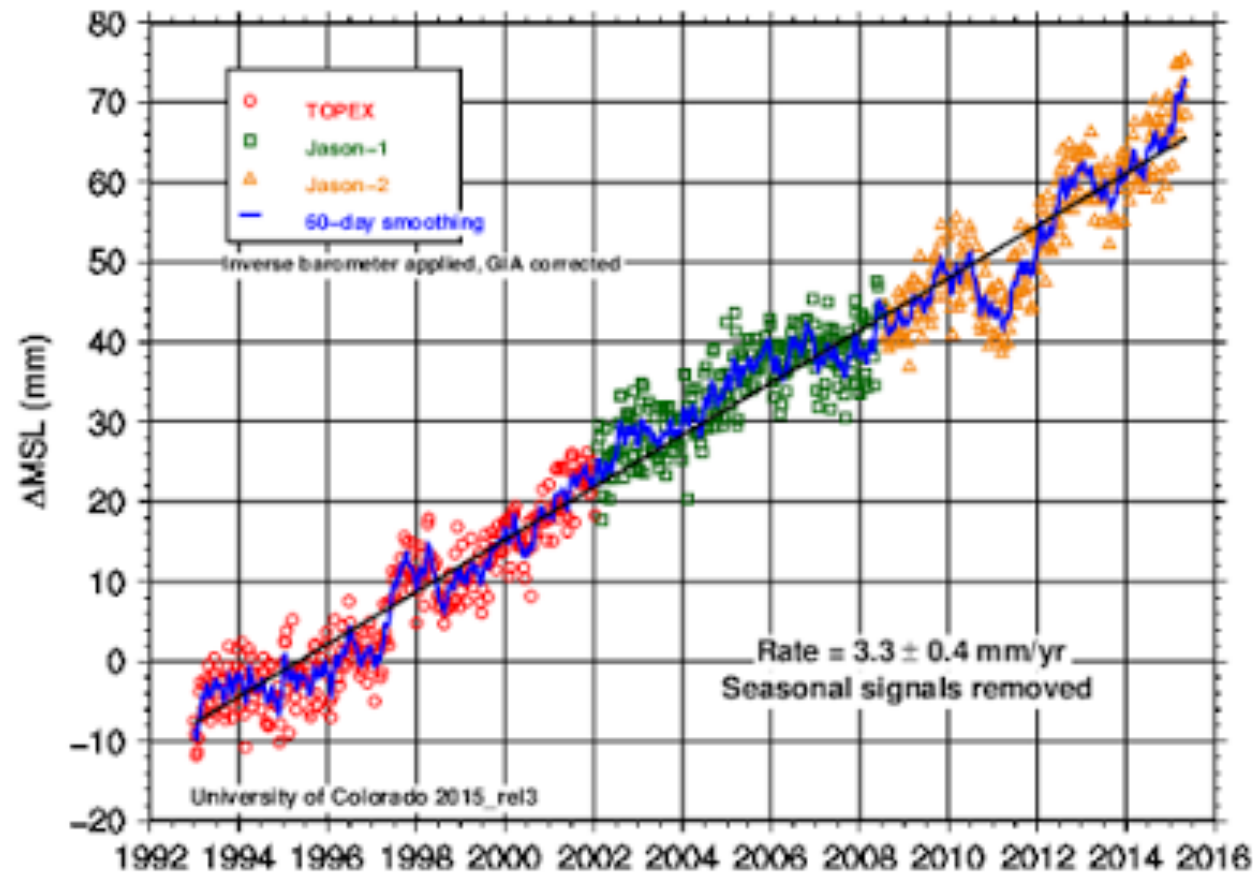


IPCC AR5: “Since the early 1970’s, glacier mass loss and ocean thermal expansion from warming together explain about 75% of the observed global sea level rise (high confidence)”

2015_rel3: Global Mean Sea Level Time Series (seasonal signals removed)

Edited: 2015-07-23

Shai



Data from satellite altimeters available since 1993.
Interannual variability from El Nino and La Nina

News Item #2

*“Torrid 2015 Set a
Record: Hottest
Year Ever”*

New York Times, 1/21/16

Global surface temperature anomalies

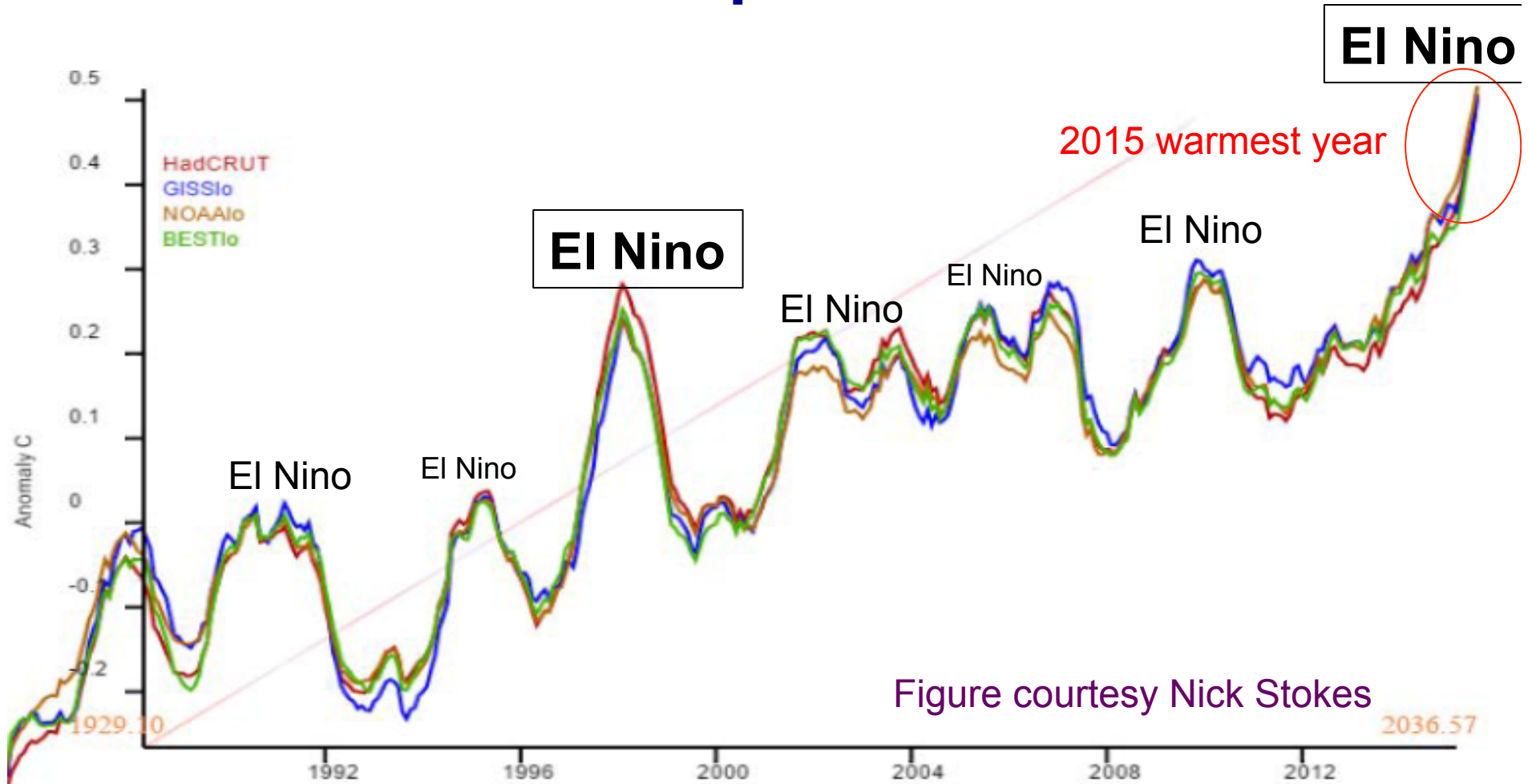
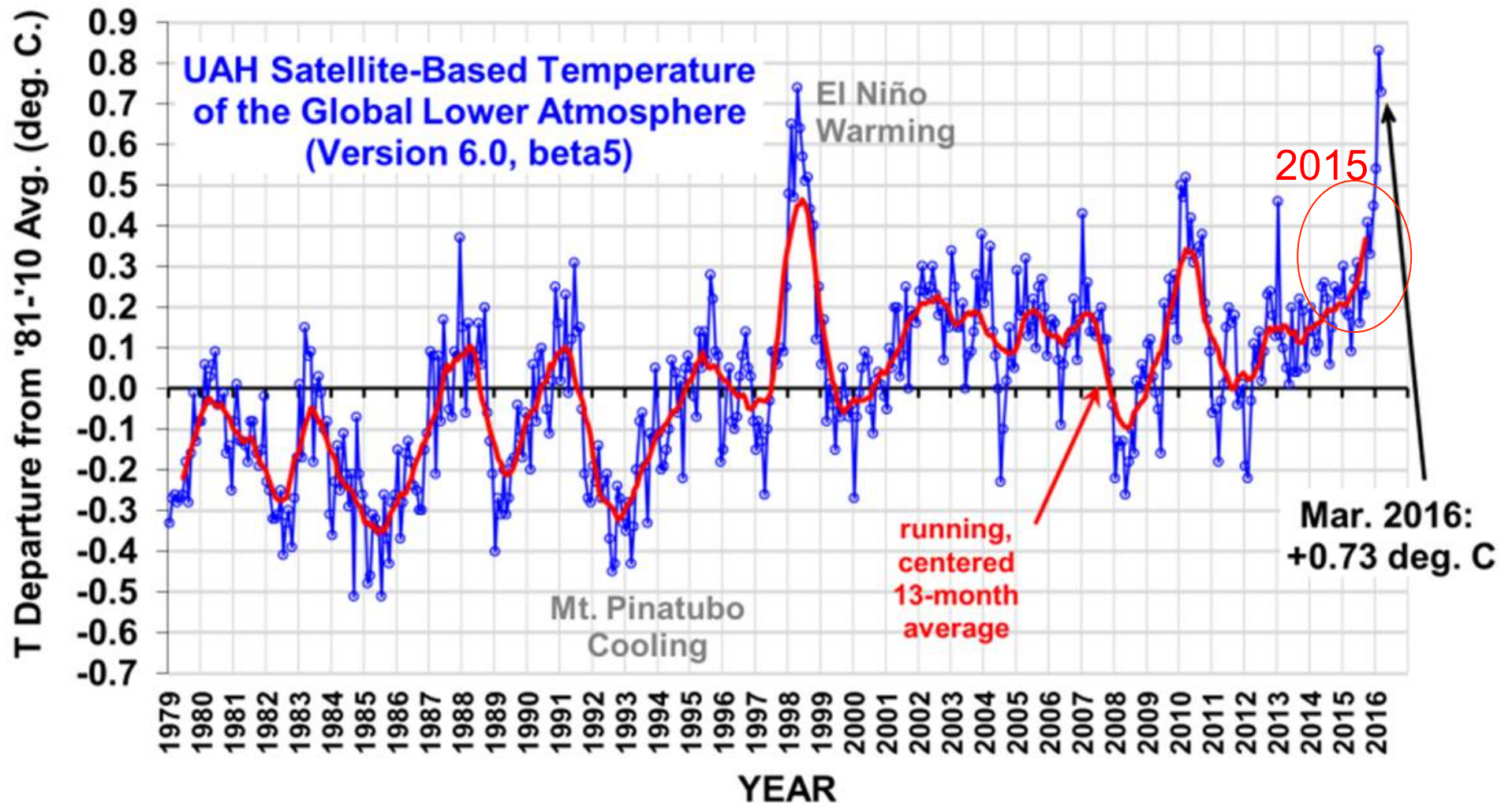


Figure courtesy Nick Stokes

2015 was striking as 'warmest year,' since there had been very little warming after 1998

Lower atmospheric temperatures from satellite



2015 was not the warmest year in the satellite data set, Although there is a large spike for Feb 2016 from El Nino

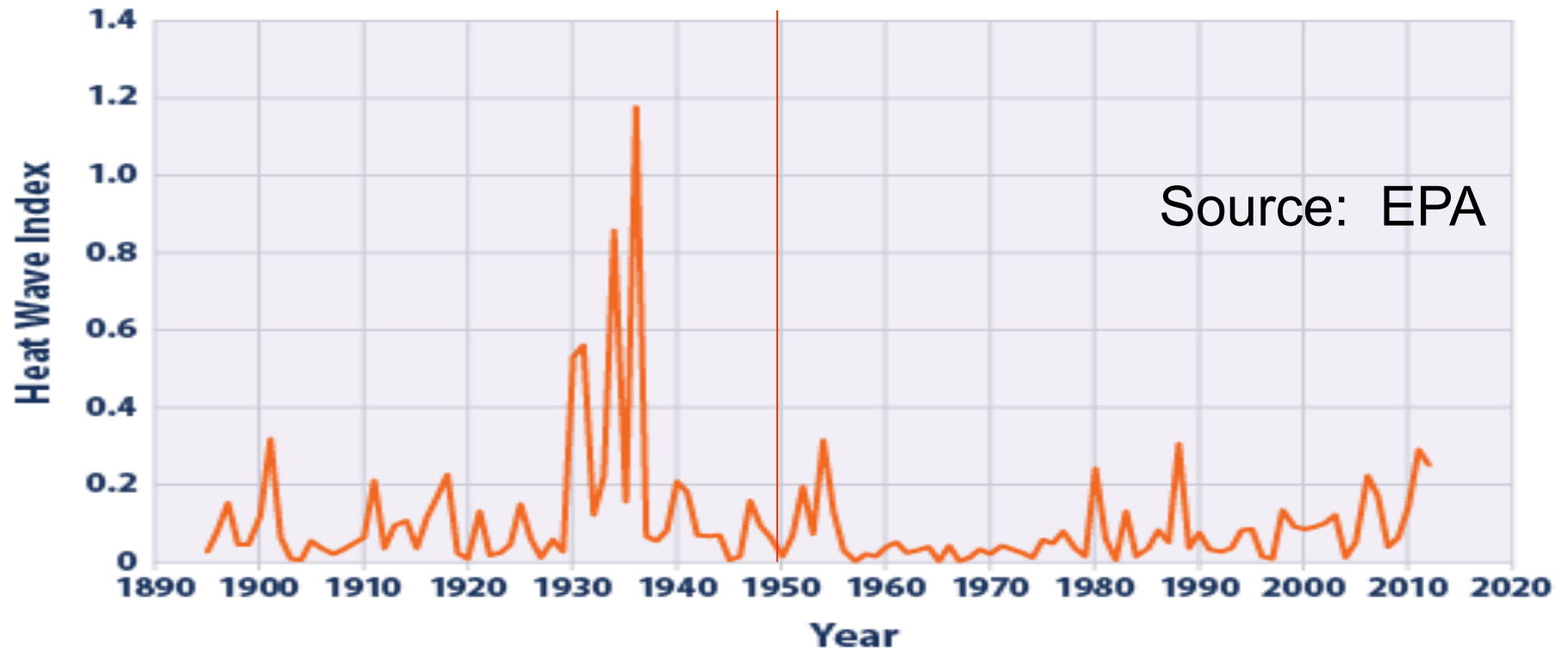
News Item #3

*“Some Extreme
Weather Events
Linked to Climate
Change”*

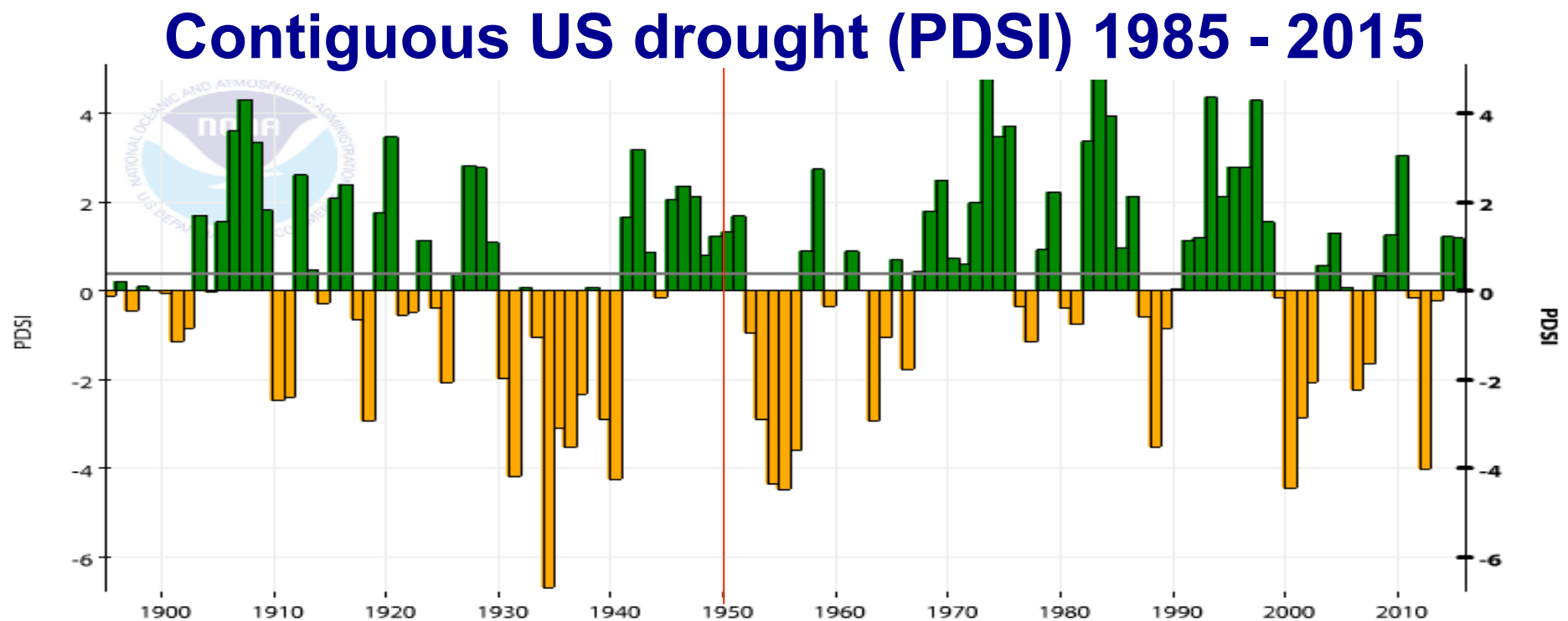
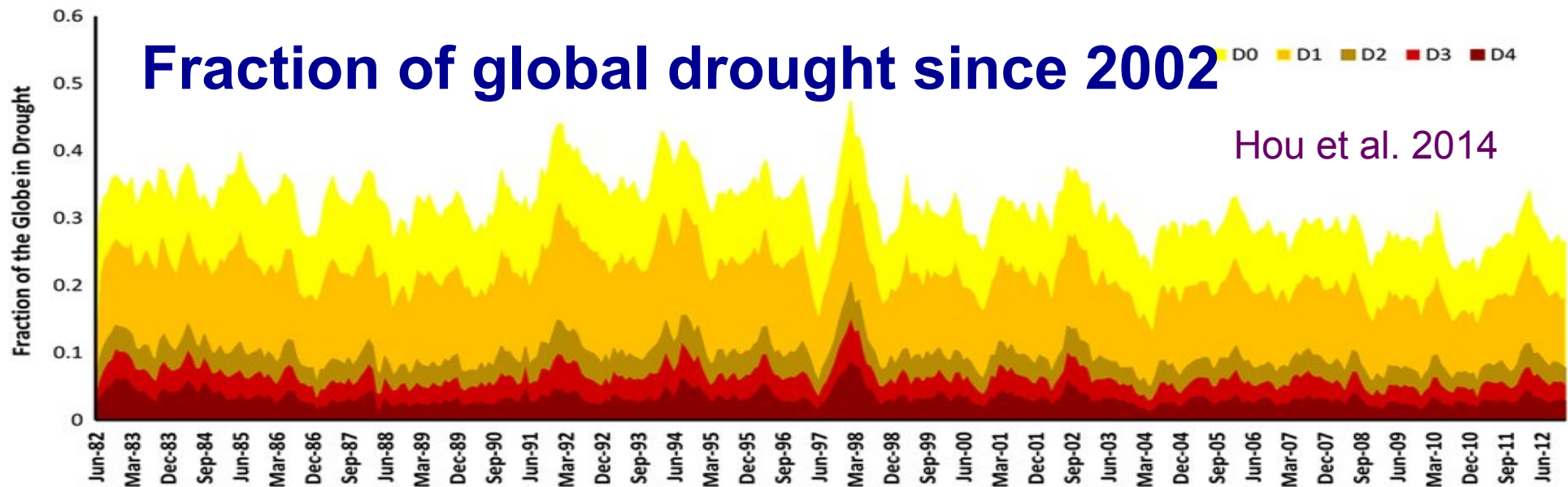
National Academy of Sciences, March 2016

US Annual Heat Wave Index, 1895-2012

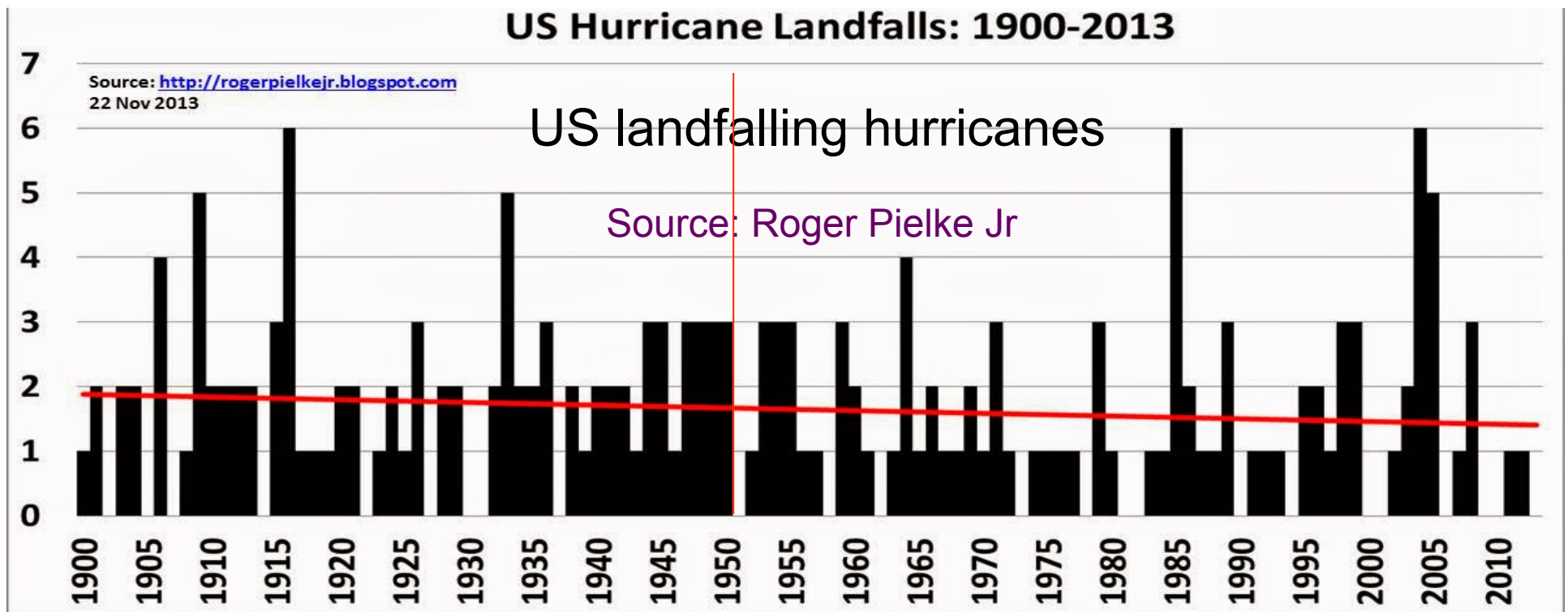
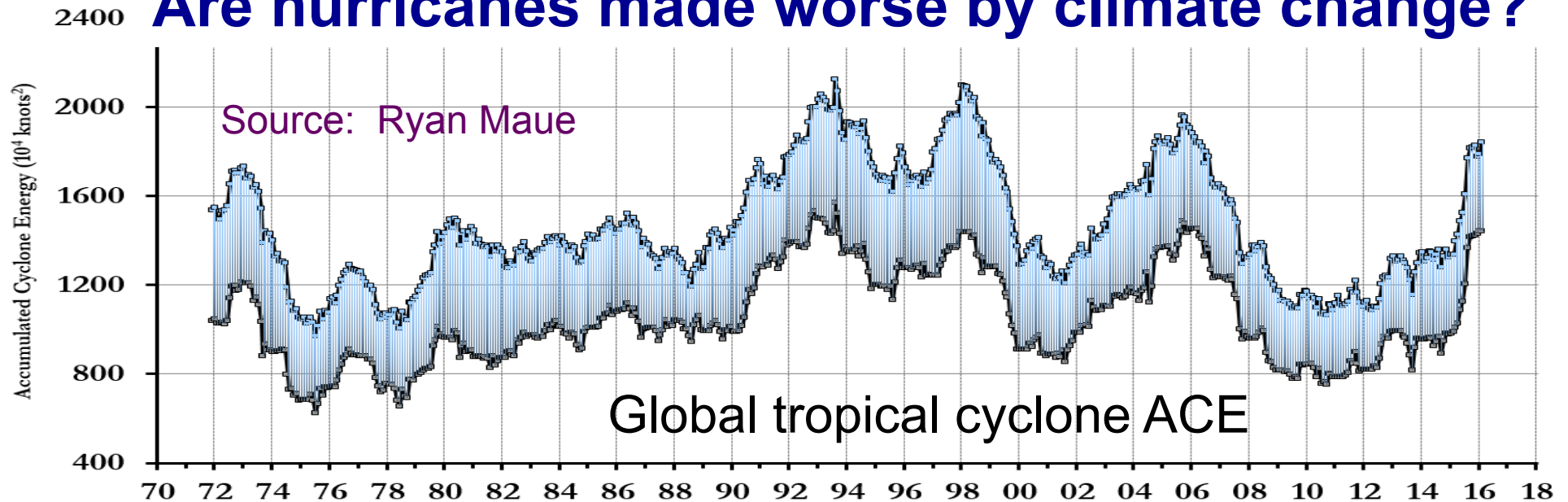
Figure 1. U.S. Annual Heat Wave Index, 1895–2012



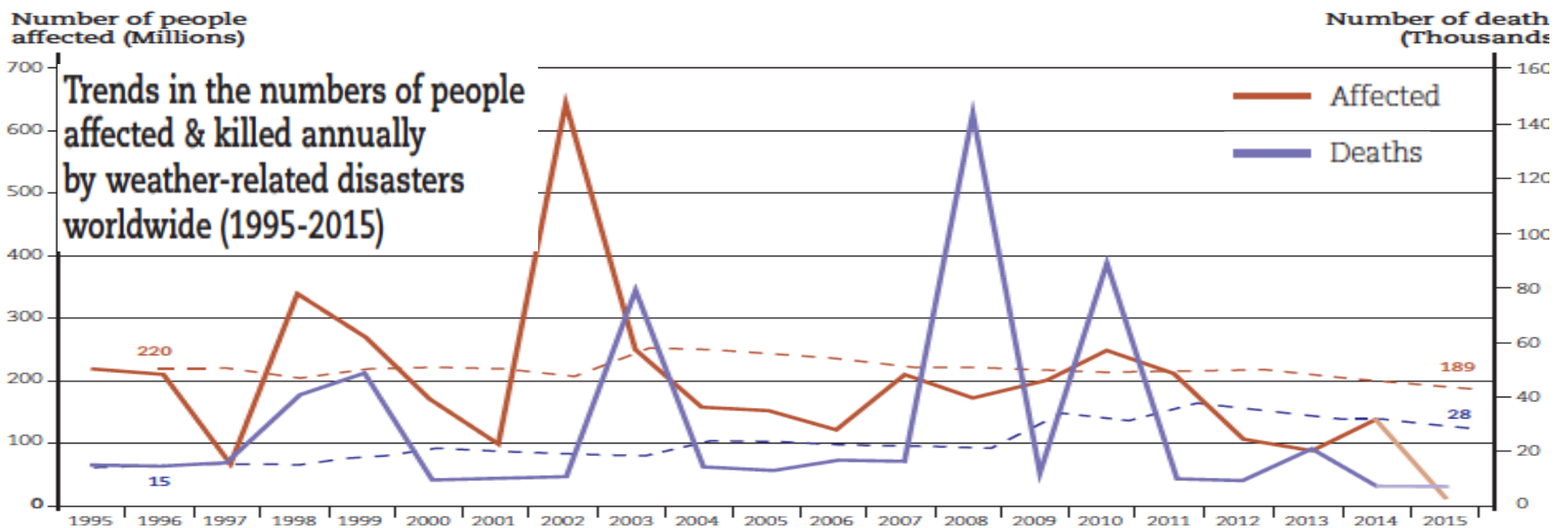
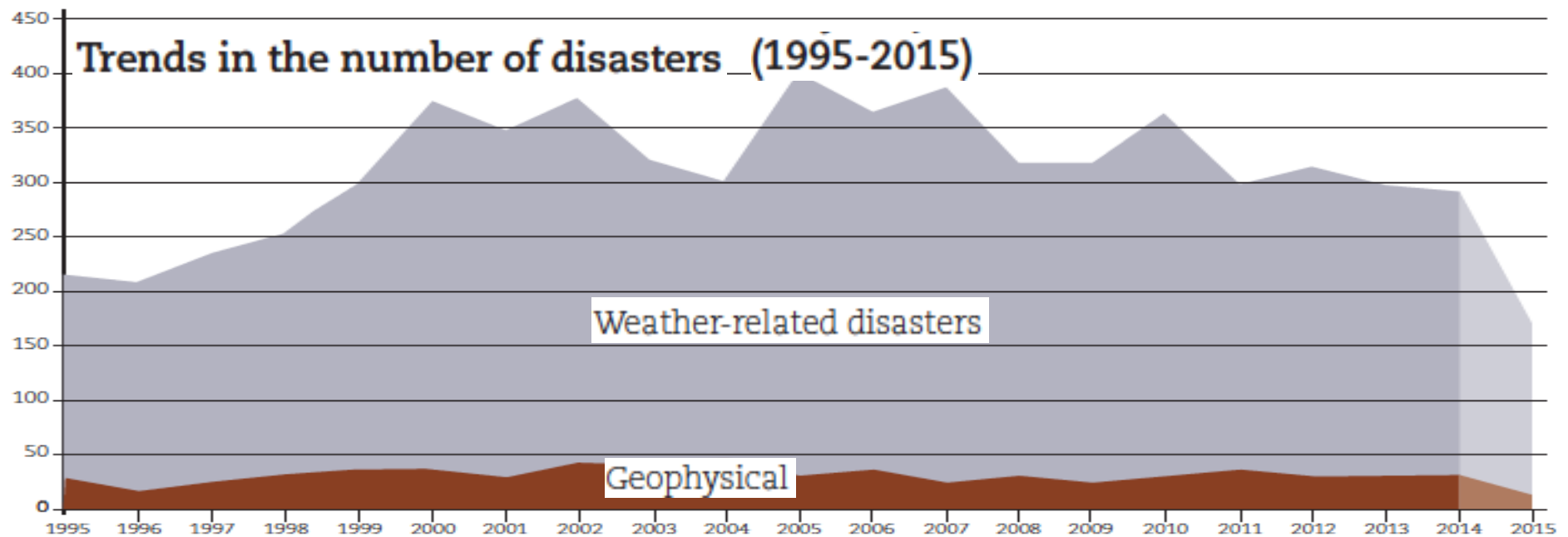
“It is *likely* that the frequency of heat waves has increased in large parts of Europe, Asia and Australia”. (since 1950)
IPCC AR5



Are hurricanes made worse by climate change?



Human Cost of Weather Related Disasters - UNISDR



News Item #4

“Ancient trees
emerge from frozen
forest ‘tomb’”

Juneau Empire, 9/13/13

“Retreat of the Mendenhall Glacier reveals the remains of trees which grew more than 2,000 years ago.”

“A subglacial exposure of undisturbed vegetation has been found below cold-based glacier Longyearben. Dating demonstrates that the study site was covered by the advancing glacier no later than 1104 yrs BP. Before that, the site was ice- free for at least 800 years and possibly much longer.” (Humlum et al. 2004)

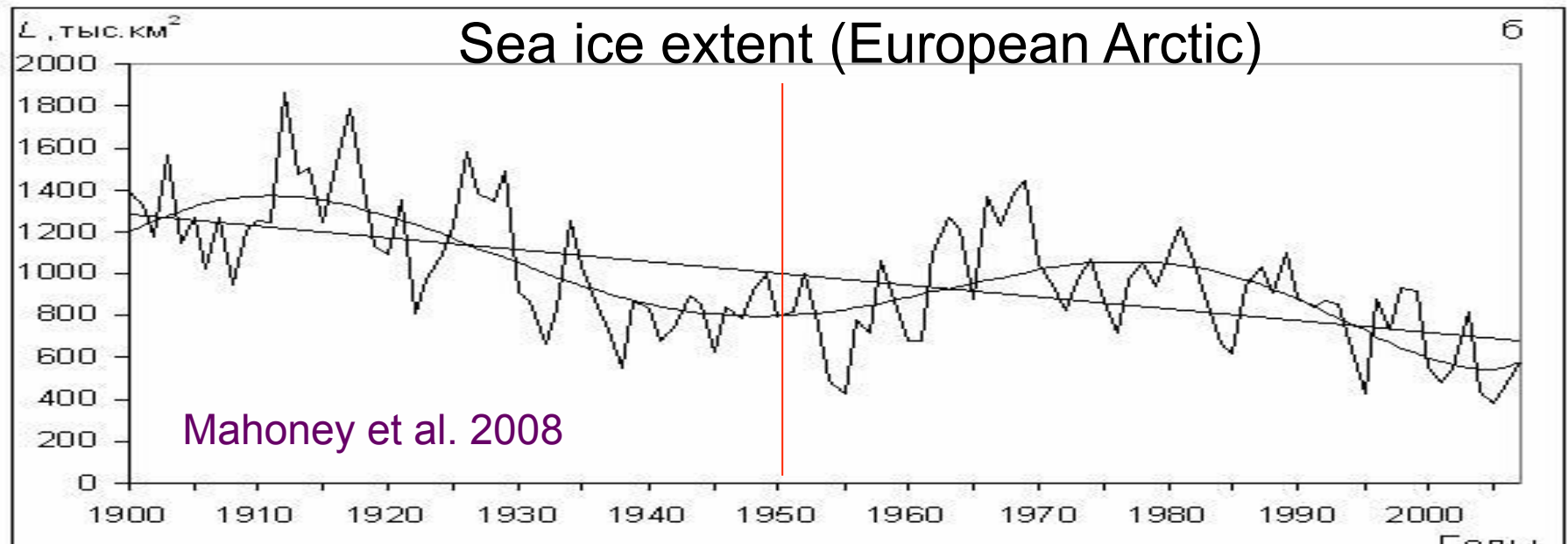
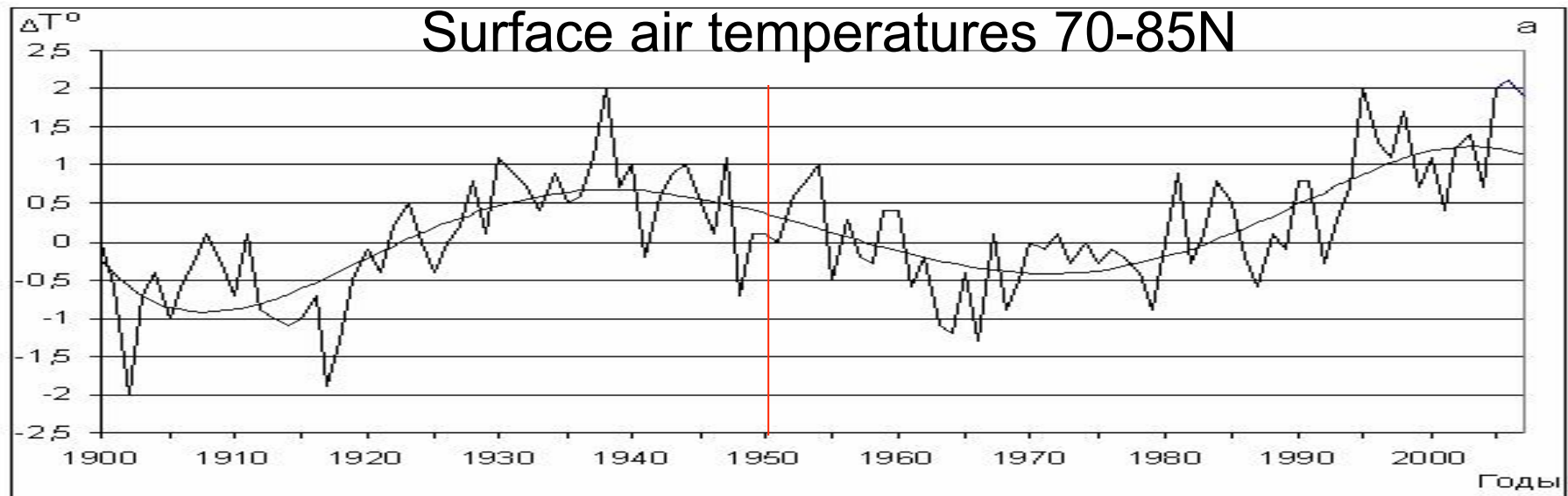
Green Alps theory: Hannibal was able to cross the Alps since it coincided with a period when the glaciers were in severe recession (218 BC)

Hannibal's crossing of the Alps

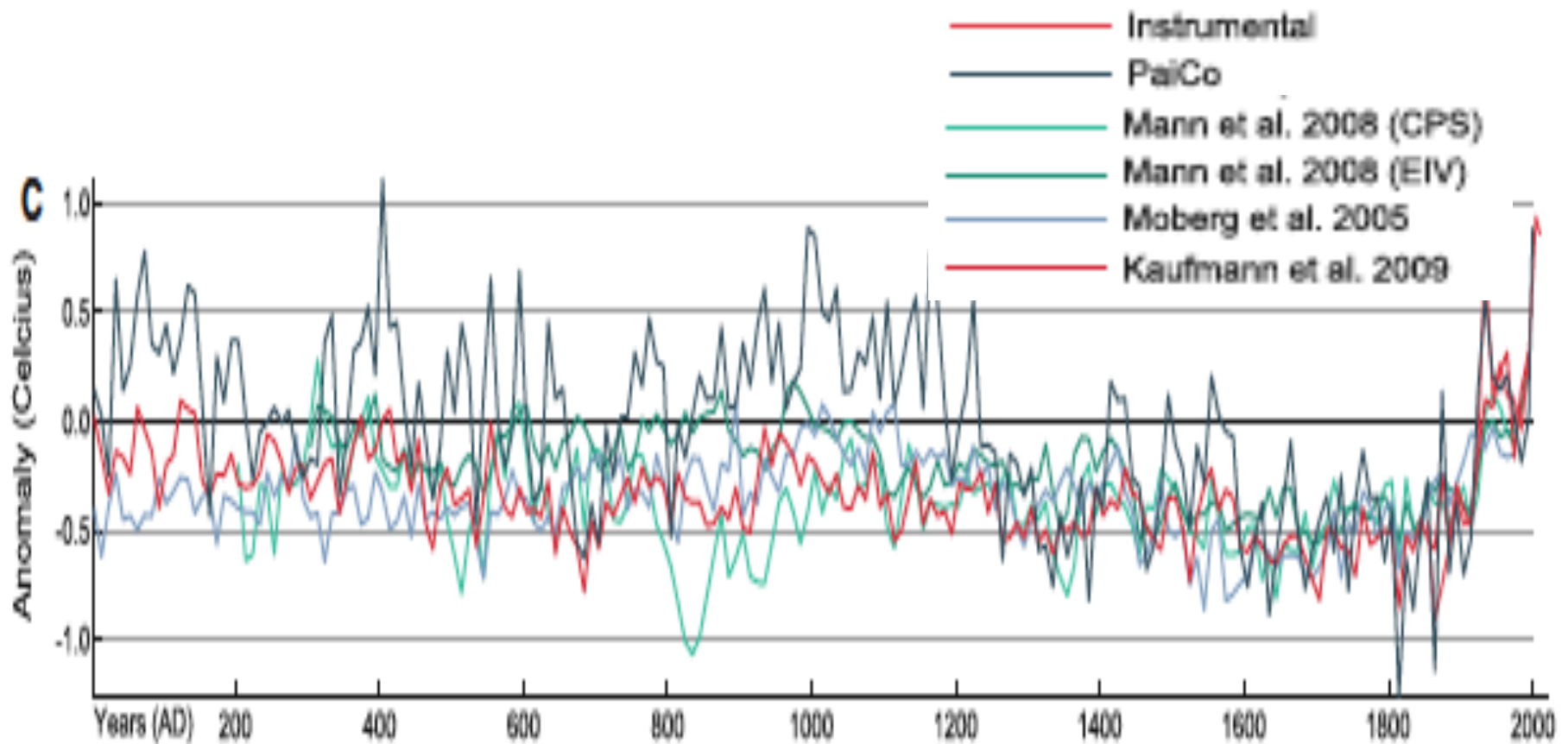


https://en.wikipedia.org/wiki/File:Hannibal_route_of_invasion-en.svg

“Arctic temperature anomalies in the 1930s were apparently as large as those in the 1990s and 2000s. There is still considerable discussion of the ultimate causes of the warm anomalies in the 1920s and 1930s.” (IPCC AR5)



IPCC AR5: “A recent multi-proxy 2000-year Arctic temperature reconstruction shows that temperatures during the first centuries were comparable or even higher than during the 20th century (Hanhijärvi et al., 2013; PAGES 2k Consortium, 2013).”



News Item #3

The Paris Climate Talks: Three Reactions

- Dr. Judith Curry
- Dr. Joe Casola
- Commissioner Brian Kalk, PhD

Concerns about the Paris Agreement

In-country legal, political & economic issues – nonbinding agreement and voluntary compliance by developing countries insures that emissions will continue to rise

Technical feasibility: no known technologies that are feasible, economic and scalable to substantially reduce CO₂ emissions from power, transportation, agriculture, cement on the timescale of a few decades

Confounding factors:

- Global population increase
- Bringing grid electricity to undeveloped countries (esp Africa)
- Rapid economic development in developing and undeveloped countries

Can we limit the warming to 2°C?

Yes, if the climate sensitivity is at lower end of estimates
(emissions reductions will make little difference)

No, if natural climate variability is dominating the warming
(emissions reductions will make little difference)

If the IPCC climate model projections are correct: even
dramatic reductions in carbon dioxide emissions would have
little impact on temperatures in the 21st century.

Paris Agreement: costs/benefits

Assuming that the IPCC climate model projections are correct:

- First round commitments (by 2025-2030, continued to 2100) are estimated to cost \$1 trillion per year, to prevent a maximum of 0.2°C warming by 2100
- Much deeper reductions that are currently committed to by 2050 would prevent less than 1°C of warming by 2100.
- Current commitments fall far short of keeping the warming below 2°C from pre-industrial
- Future commitments and later implementation will have less impact on 21st century temperatures owing to thermal inertia in the climate system

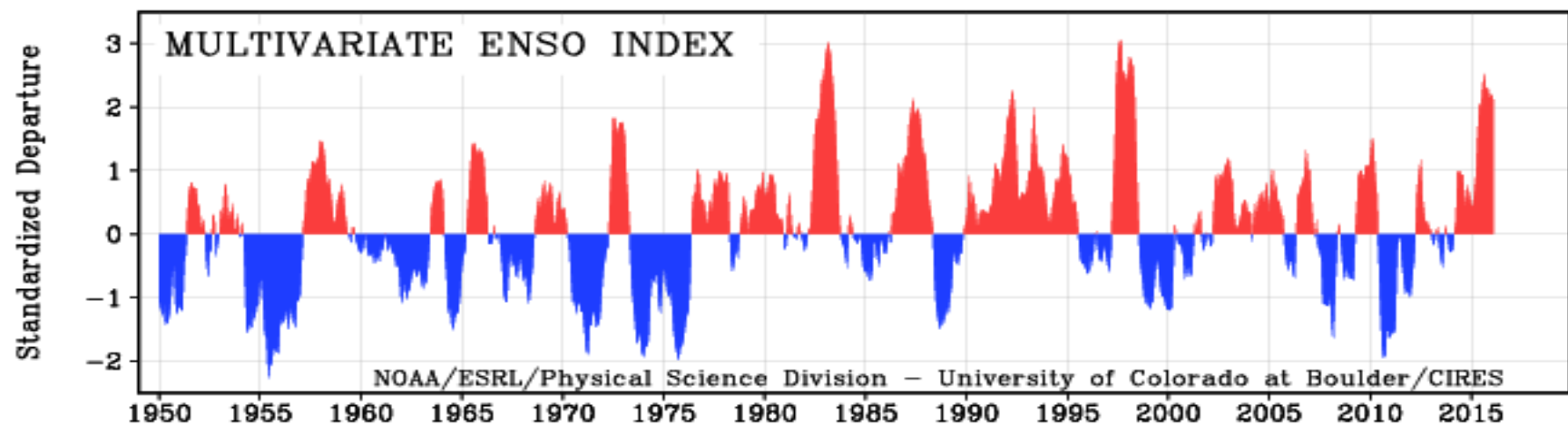
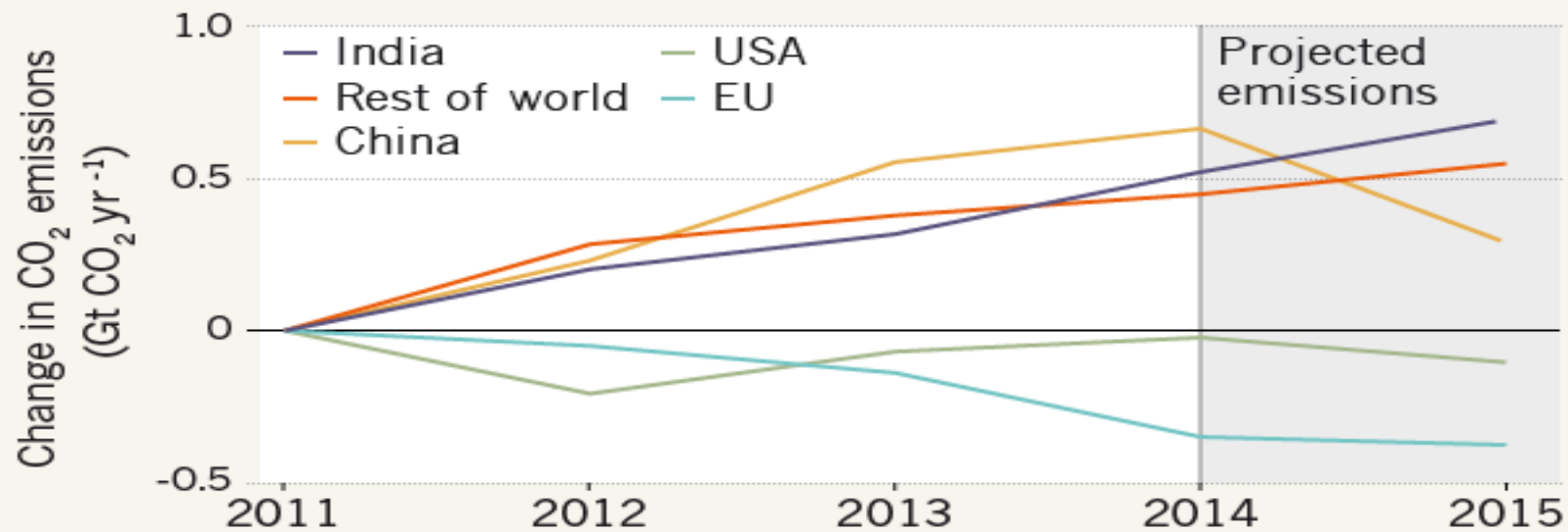
Climate change conundrum

- There is increasing evidence that the threat from global warming is overstated
- However, if the threat is not overstated, there are major shortfalls in current and proposed solutions.

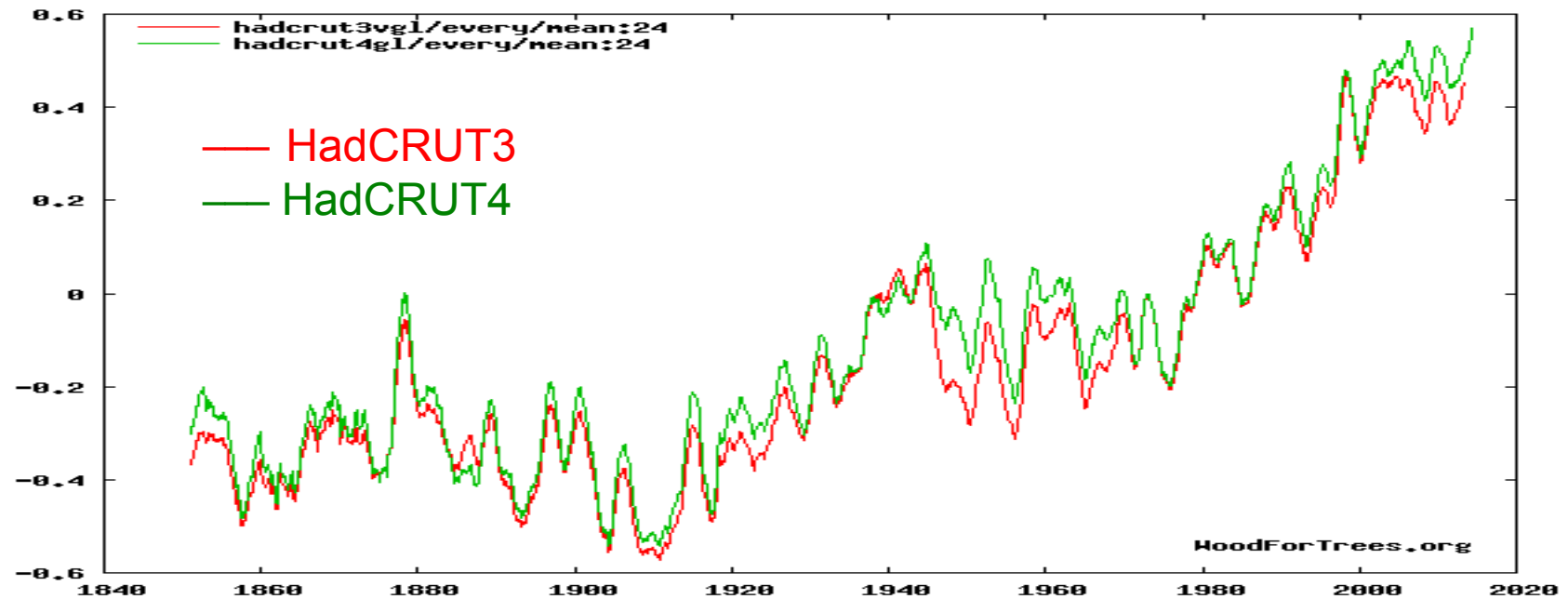


SLOWING DOWN

Global carbon dioxide emissions are poised to dip in 2015, largely due to a notable decrease in China's output.



Recent adjustments to the HadCRUT data set



Global temperatures from ECMWF reanalysis

