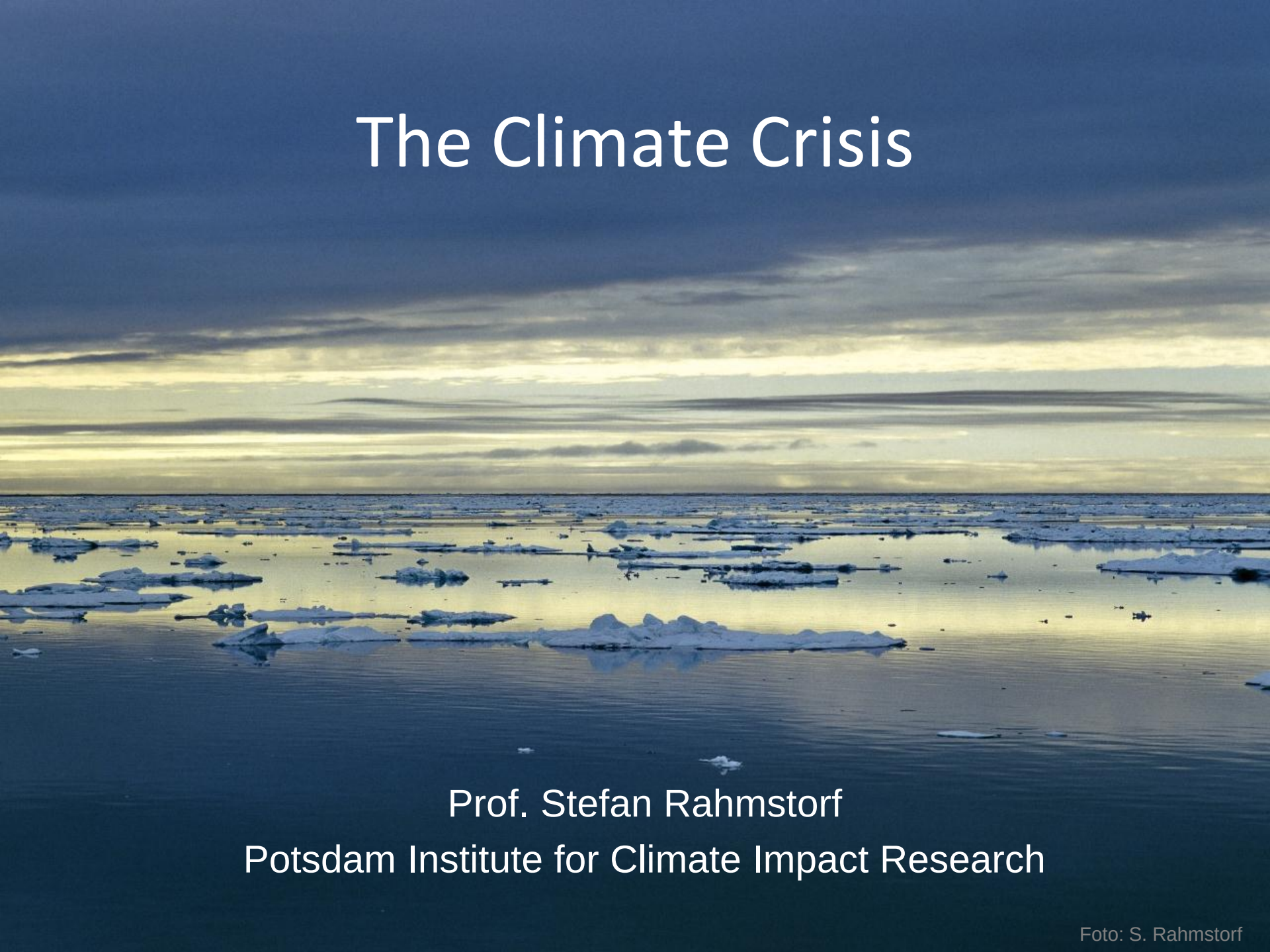
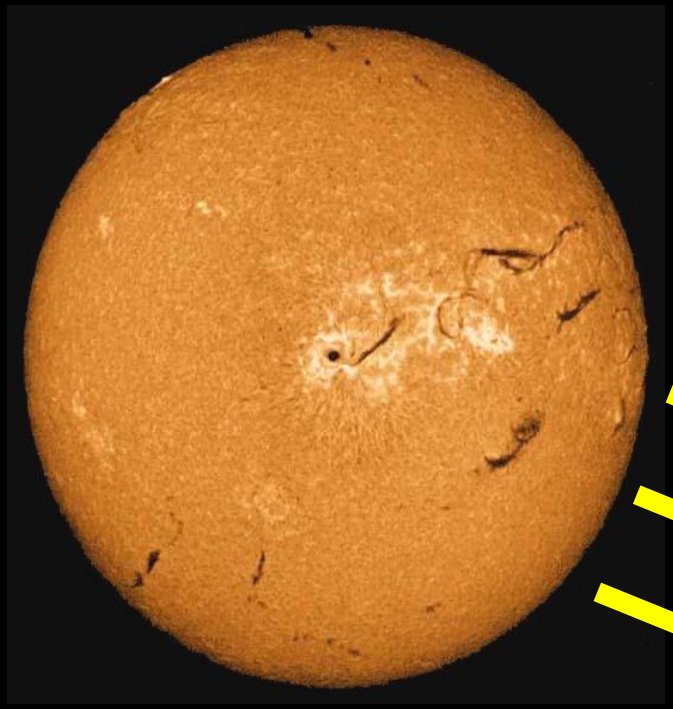
The Climate Crisis

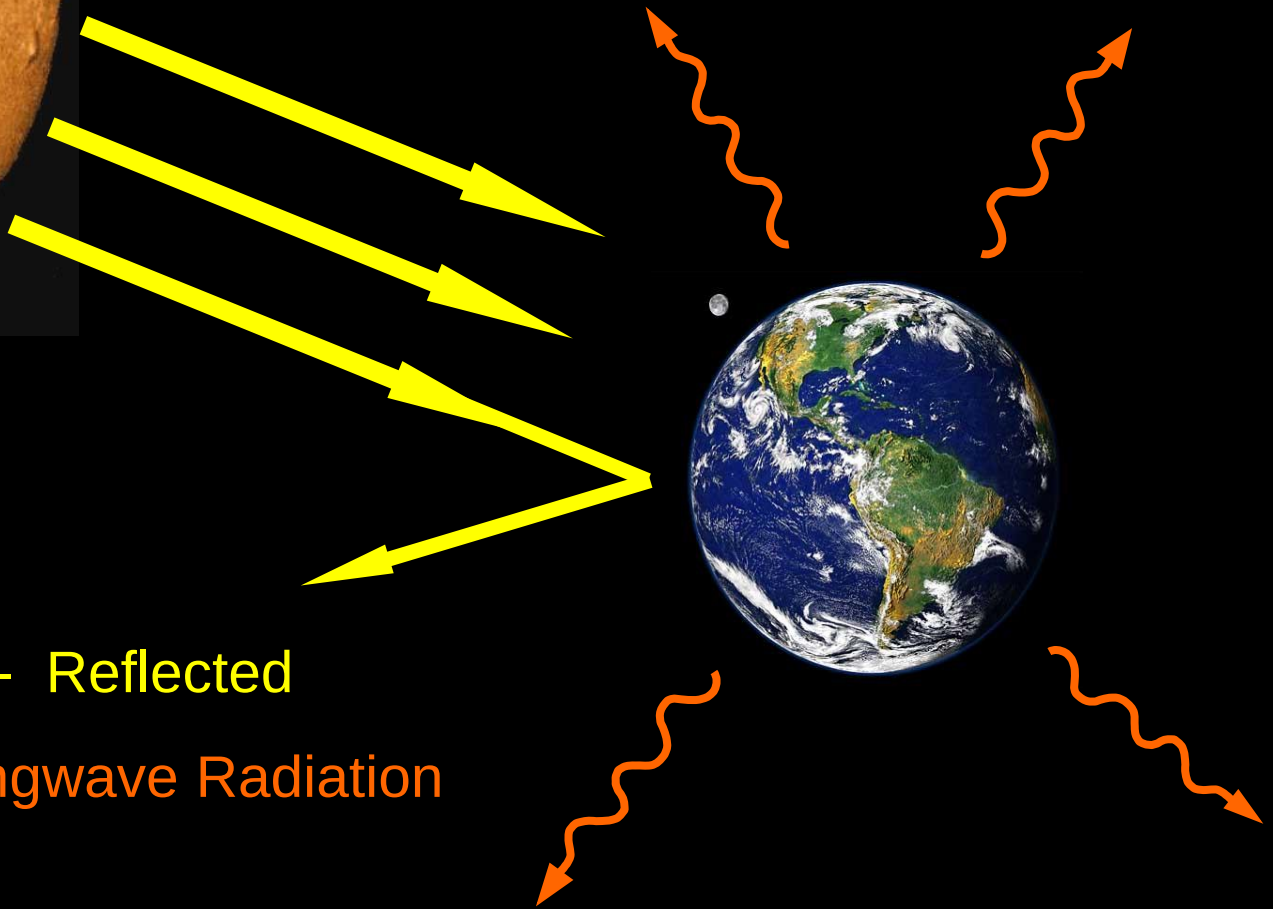


Prof. Stefan Rahmstorf
Potsdam Institute for Climate Impact Research

Foto: S. Rahmstorf

Climate results from an energy balance





Insolation - Reflected

= Longwave Radiation

Alexander von Humboldt, 1843

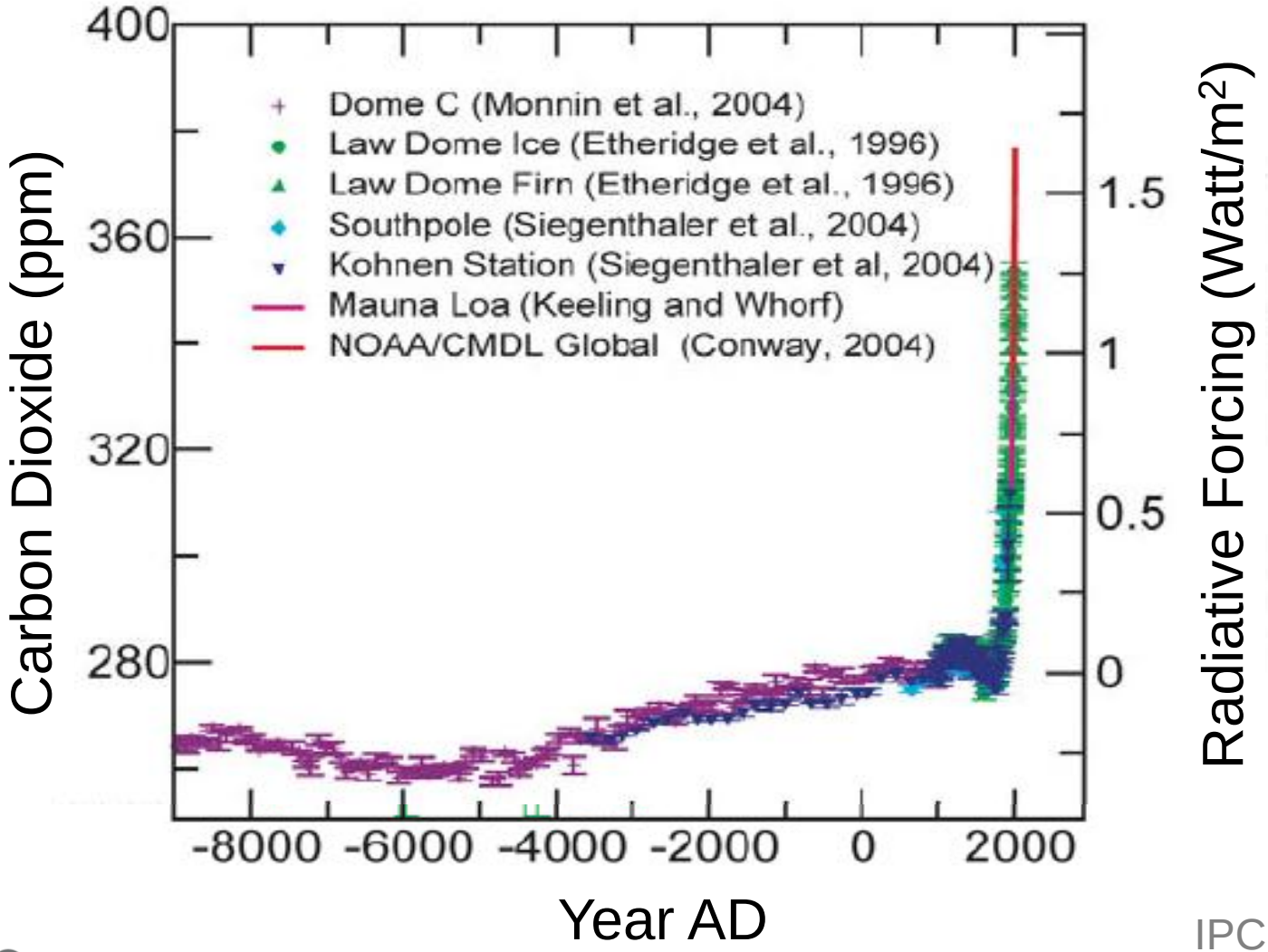
Man changes climate „by cutting forests [...] and by emitting large amounts of steam and gas at the centers of industry"

John Tyndall, 1859

„The atmosphere admits of the entrance of solar heat, but checks its exit; and the result is a tendency to accumulate heat at the surface of the planet.“

John Tyndall

Rising CO2-Concentration

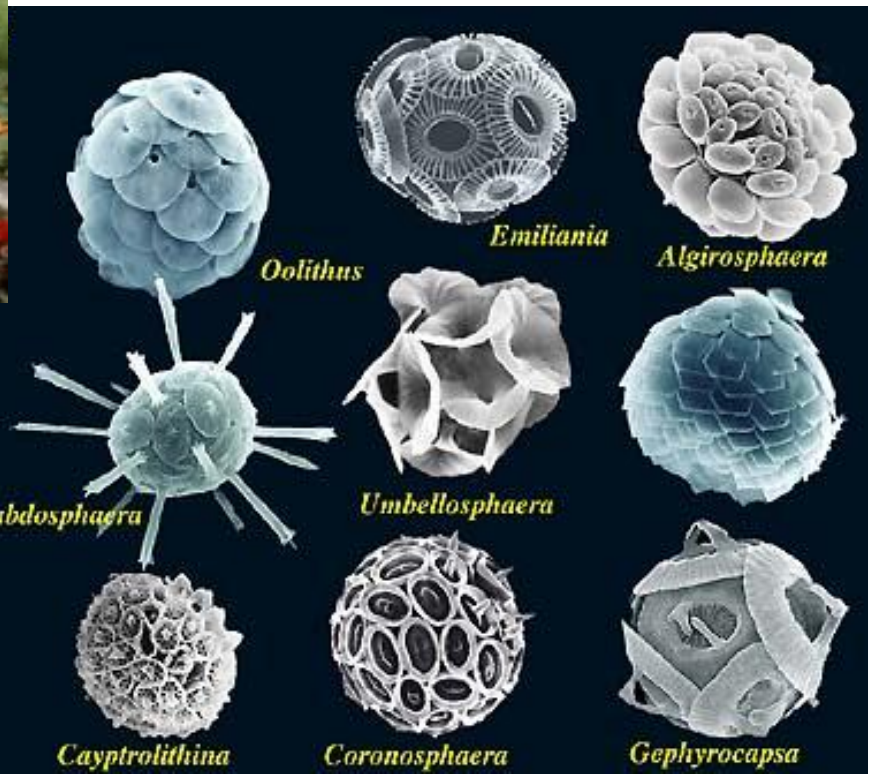


IPCC 2007

Oceans Are Getting More Acidic

- Acidification due to CO_2 is a threat to marine ecosystems

Plankton

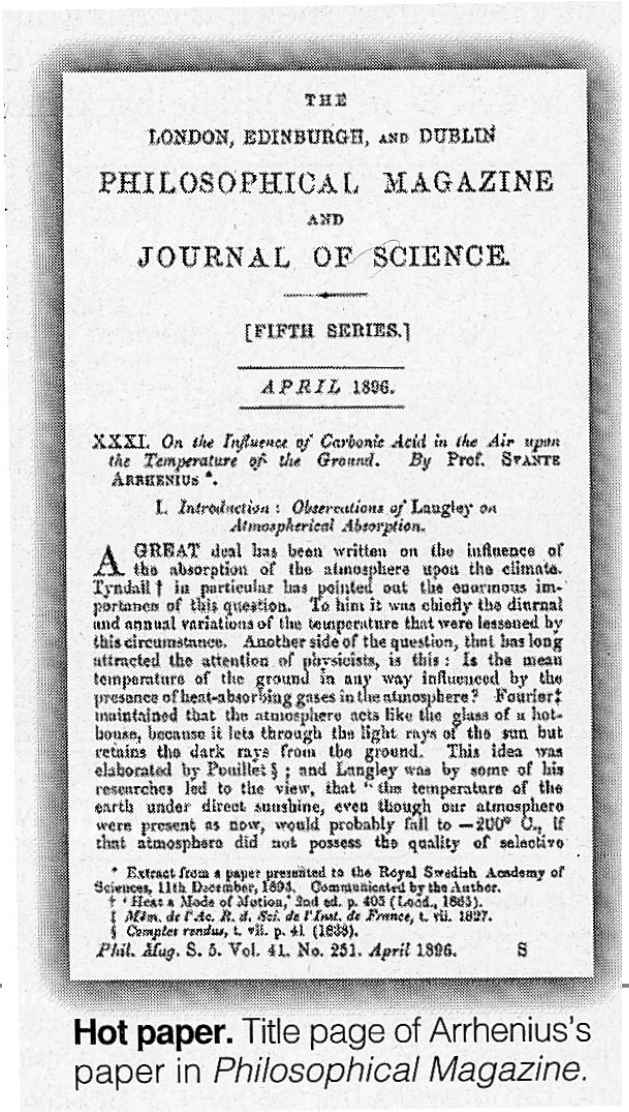


Coral Reefs

Climate Effect of CO2

Arrhenius 1896 (4-6 ºC)

Svante Arrhenius



THE
LONDON, EDINBURGH, AND DUBLIN
PHILOSOPHICAL MAGAZINE
AND
JOURNAL OF SCIENCE.

[FIFTH SERIES.]

APRIL 1896.

XXXI. *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground.* By Prof. SVANTE ARRHENIUS *.

I. *Introduction: Observations of* Langley *on Atmospherical Absorption.*

A GREAT deal has been written on the influence of the absorption of the atmosphere upon the climate. Tyndall † in particular has pointed out the enormous importance of this question. To him it was chiefly the diurnal and annual variations of the temperature that were lessened by this circumstance. Another side of the question, that has long attracted the attention of physicists, is this: Is the mean temperature of the ground in any way influenced by the presence of heat-absorbing gases in the atmosphere? Fourier‡ maintained that the atmosphere acts like the glass of a hot-house, because it lets through the light rays of the sun but retains the dark rays from the ground. This idea was elaborated by Pouillet §; and Langley was by some of his researches led to the view, that "the temperature of the earth under direct sunshine, even though our atmosphere were present as now, would probably fall to −200° C., if that atmosphere did not possess the quality of selective

* Extract from a paper presented to the Royal Swedish Academy of Sciences, 11th December, 1895. Communicated by the Author.
† 'Heat a Mode of Motion,' 2nd ed. p. 405 (Lond., 1863).
‡ *Mém. de l'Ac. R. d. Sci. de l'Inst. de France*, t. vii. 1827.
§ *Comptes rendus*, t. vii. p. 41 (1838).

Phil. Mag. S. 5. Vol. 41. No. 251. *April* 1896. S

Hot paper. Title page of Arrhenius's paper in *Philosophical Magazine*.

Effect of CO_2-doubling:

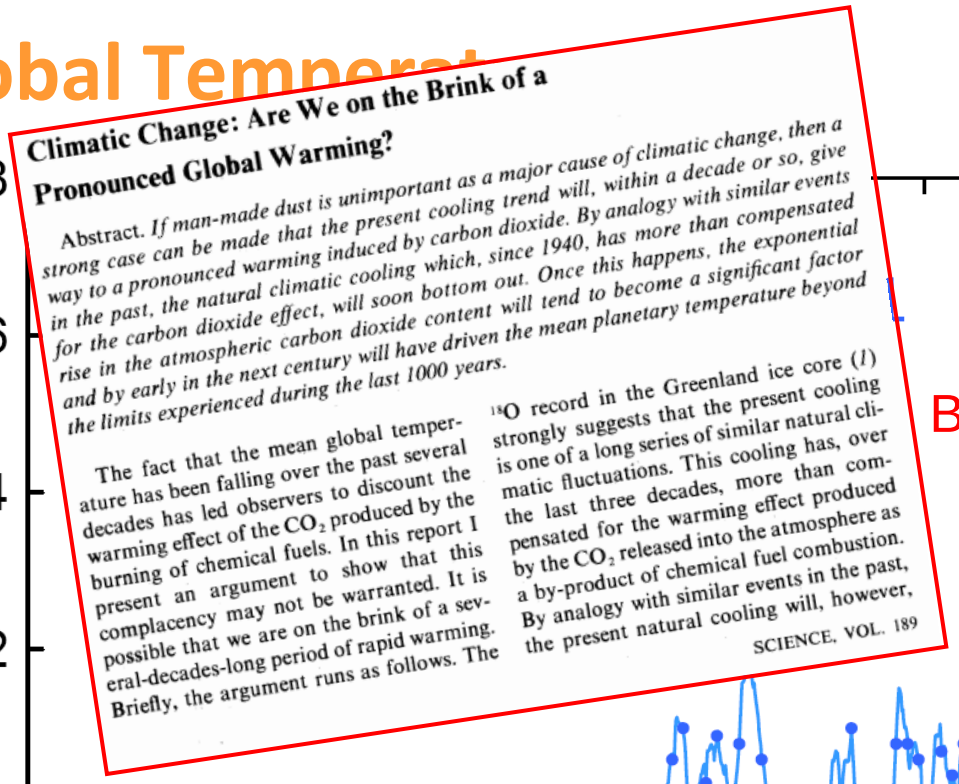
"climate sensitivity"

3 ± 1 ºC

Anthropogenic emissions should have caused 0.7 to 0.9 ºC warming to date

PIK

Global Temperat



Climatic Change: Are We on the Brink of a Pronounced Global Warming?

Abstract. *If man-made dust is unimportant as a major cause of climatic change, then a strong case can be made that the present cooling trend will, within a decade or so, give way to a pronounced warming induced by carbon dioxide. By analogy with similar events in the past, the natural climatic cooling which, since 1940, has more than compensated for the carbon dioxide effect, will soon bottom out. Once this happens, the exponential rise in the atmospheric carbon dioxide content will tend to become a significant factor and by early in the next century will have driven the mean planetary temperature beyond the limits experienced during the last 1000 years.*

The fact that the mean global temperature has been falling over the past several decades has led observers to discount the warming effect of the CO_2 produced by the burning of chemical fuels. In this report I present an argument to show that this complacency may not be warranted. It is possible that we are on the brink of a several-decades-long period of rapid warming. Briefly, the argument runs as follows. The ^{18}O record in the Greenland ice core (*1*) strongly suggests that the present cooling is one of a long series of similar natural climatic fluctuations. This cooling has, over the last three decades, more than compensated for the warming effect produced by the CO_2 released into the atmosphere as a by-product of chemical fuel combustion. By analogy with similar events in the past, the present natural cooling will, however,

SCIENCE, VOL. 189

El Niño →

Broecker 1975

Pinatubo

Temperature Anomaly (°C)

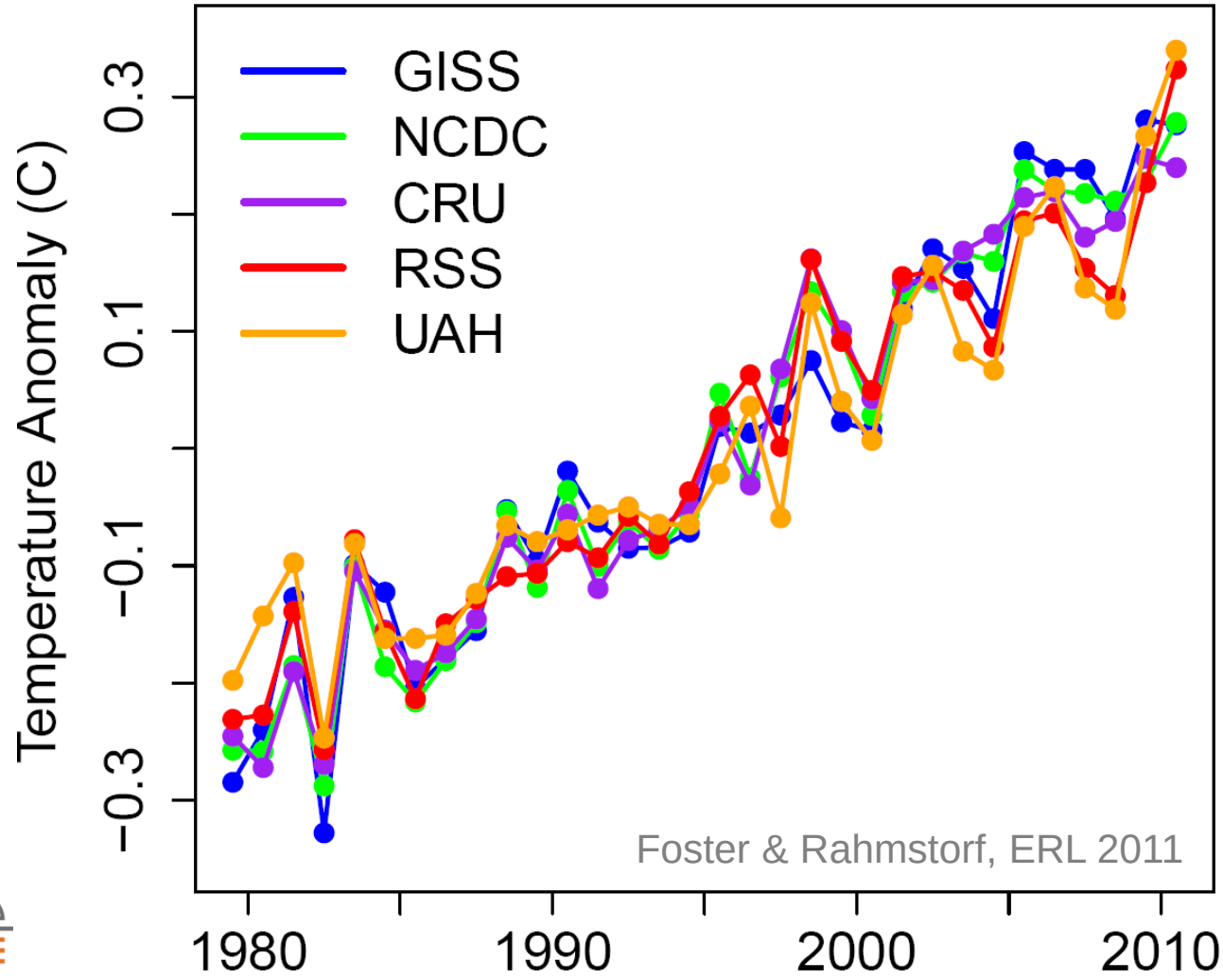
0.8
0.6
0.4
0.2
0
-0.2
-0.4

1880 1900 1920 1940 1960 1980 2000 2020

Year

Global Temperature Series

- **With effect of El Niño, Volcanos und solar activity removed**



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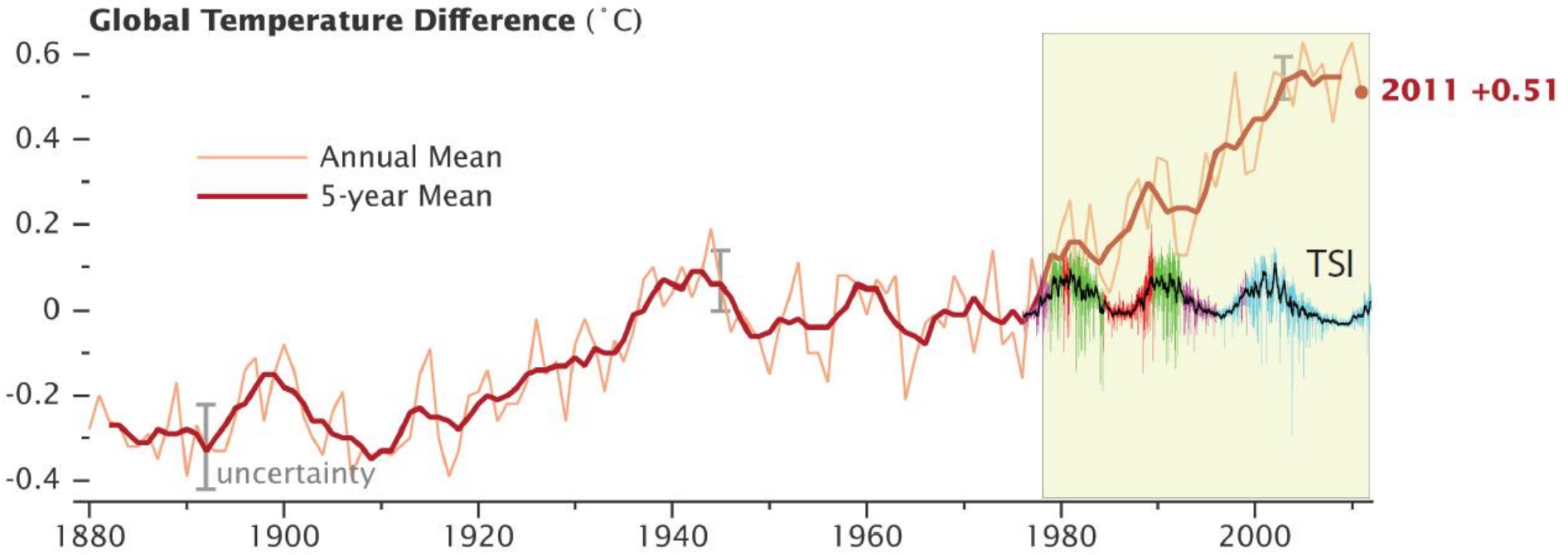
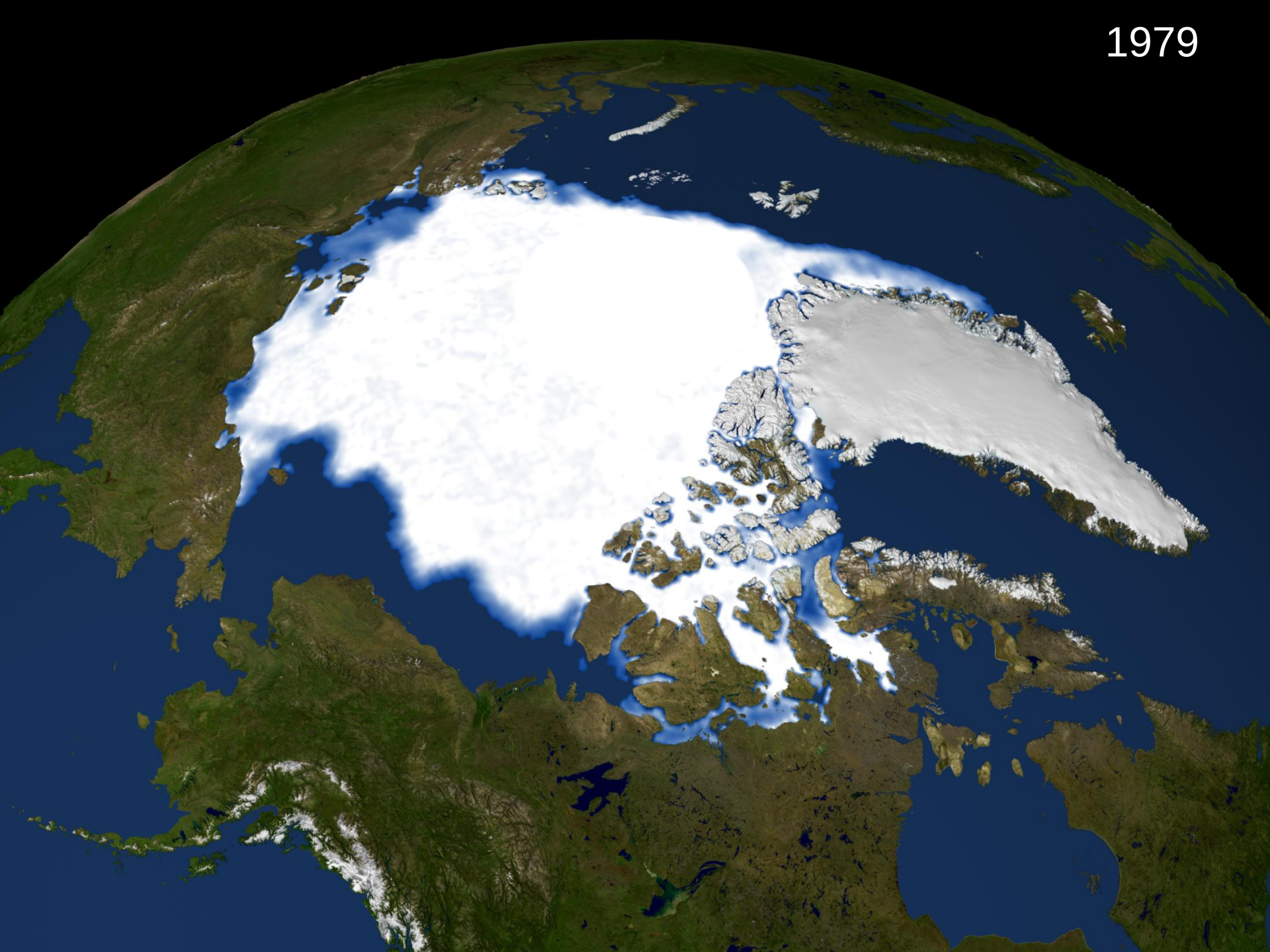
Solar Luminosity and Global Temperature

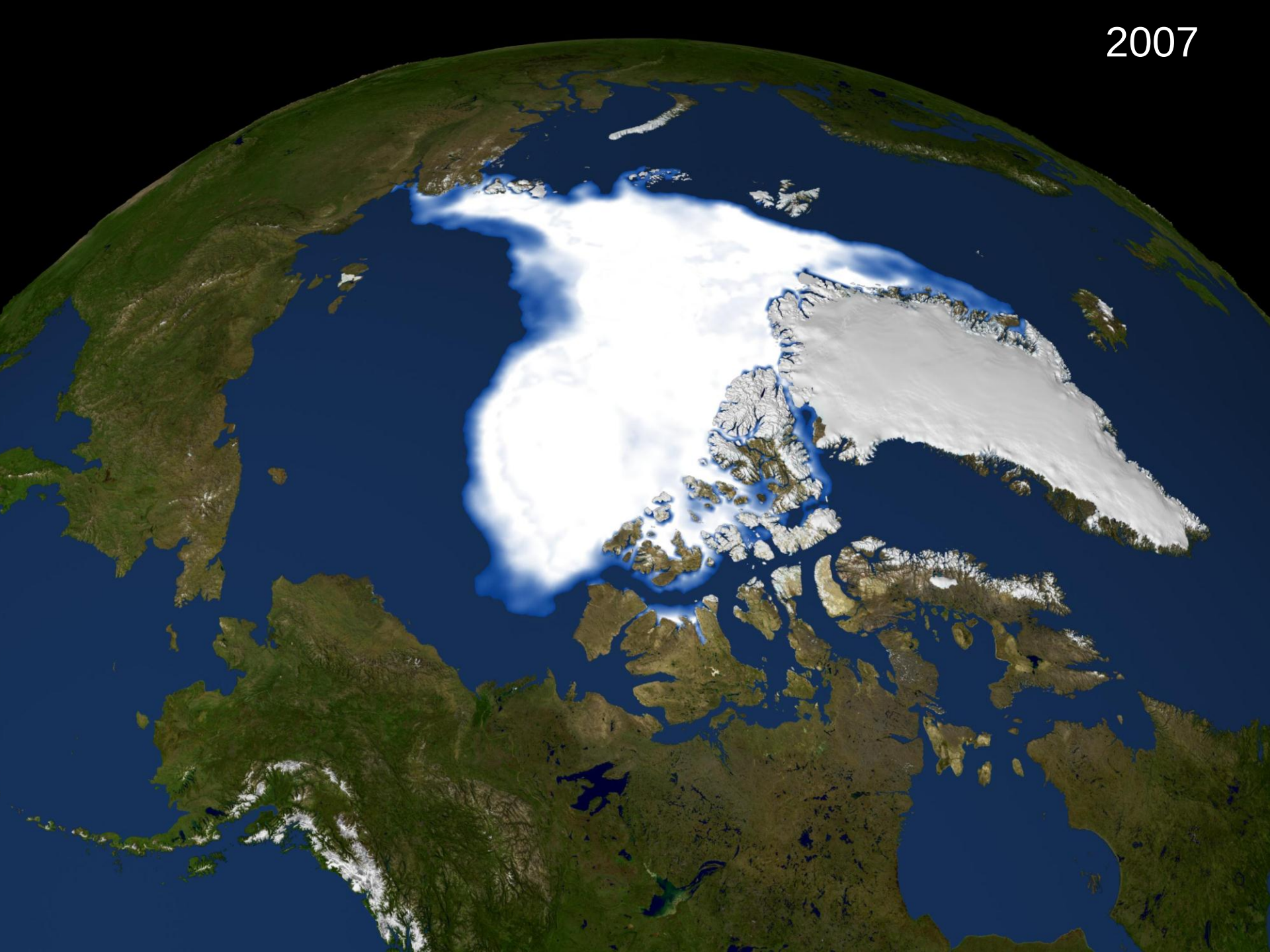
- **Amplitude of solar effect: ± 0.04 °C**



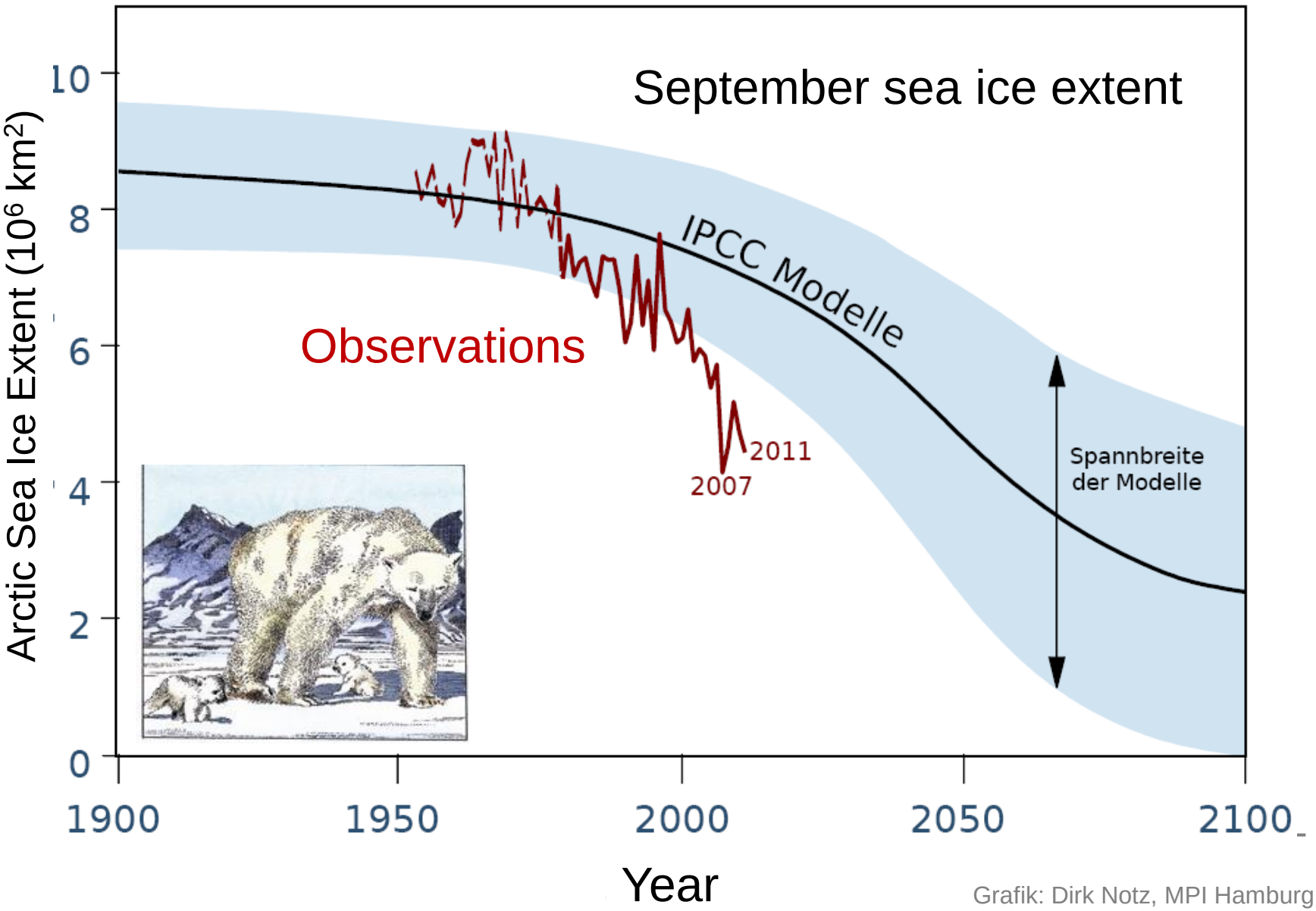
http://www.giss.nasa.gov/research/news/20120119/ Claus Fröhlich


Mueller Glacier


1979

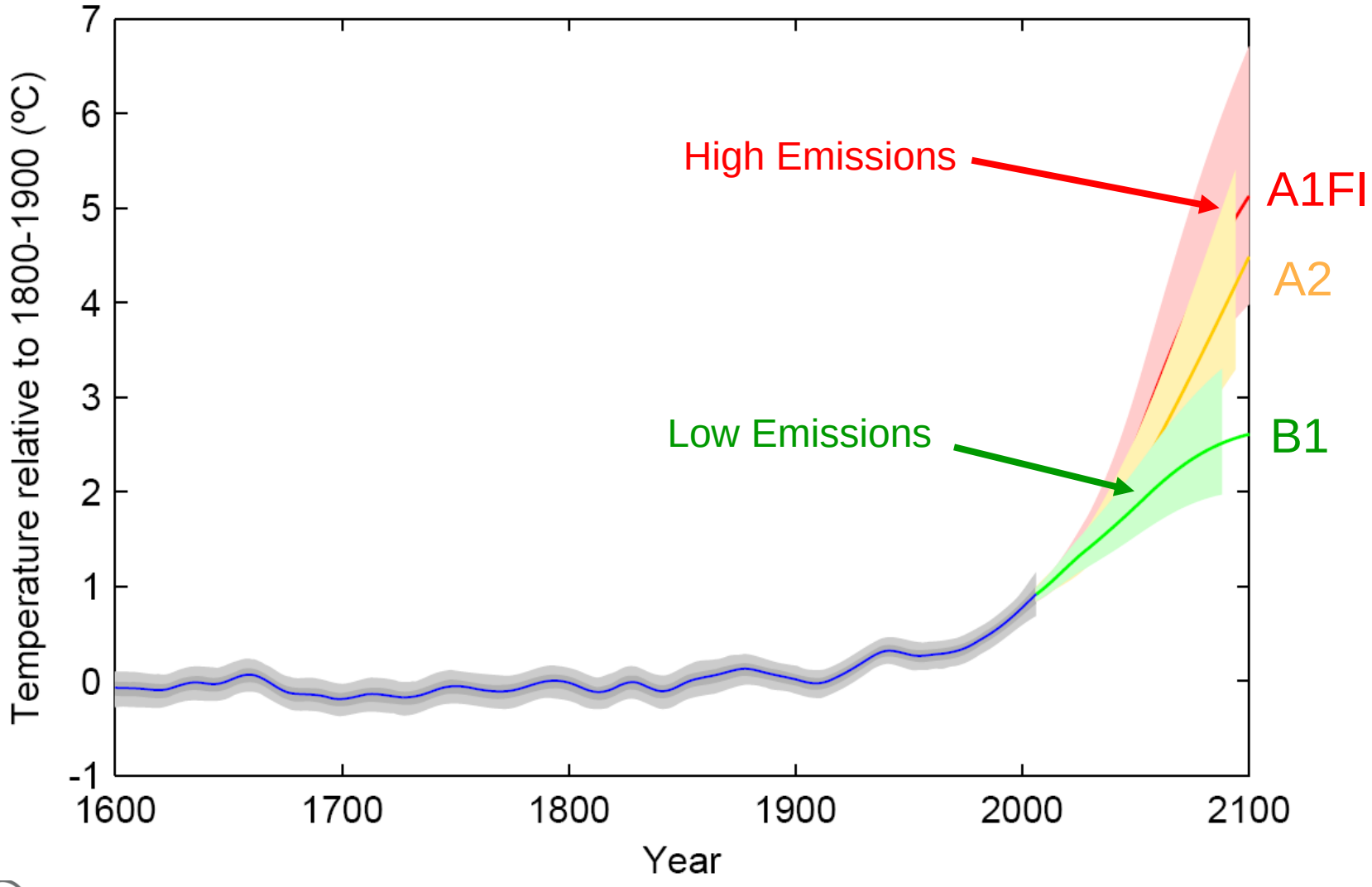

2007

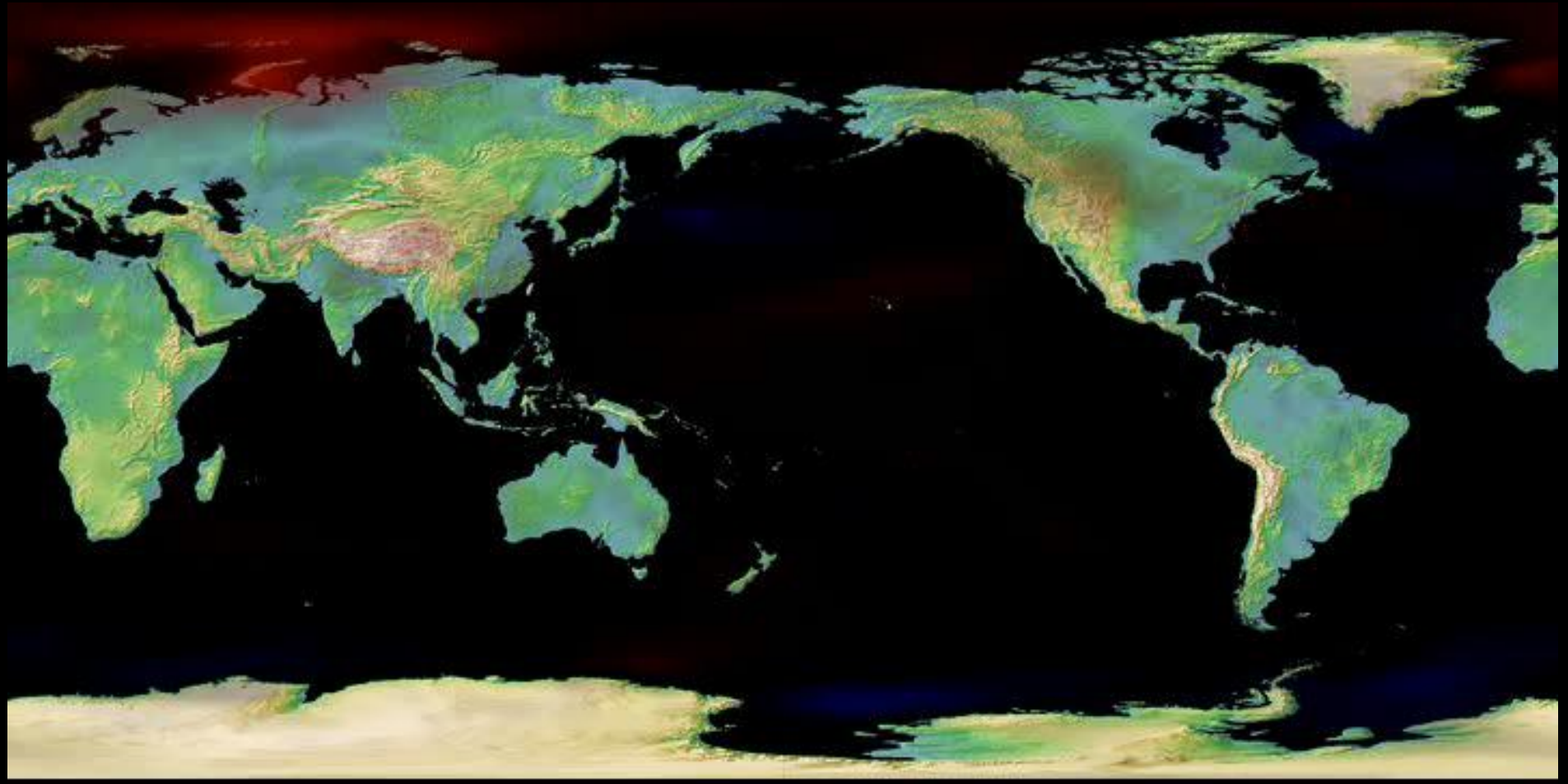
Loss of Arctic Sea Ice Cover



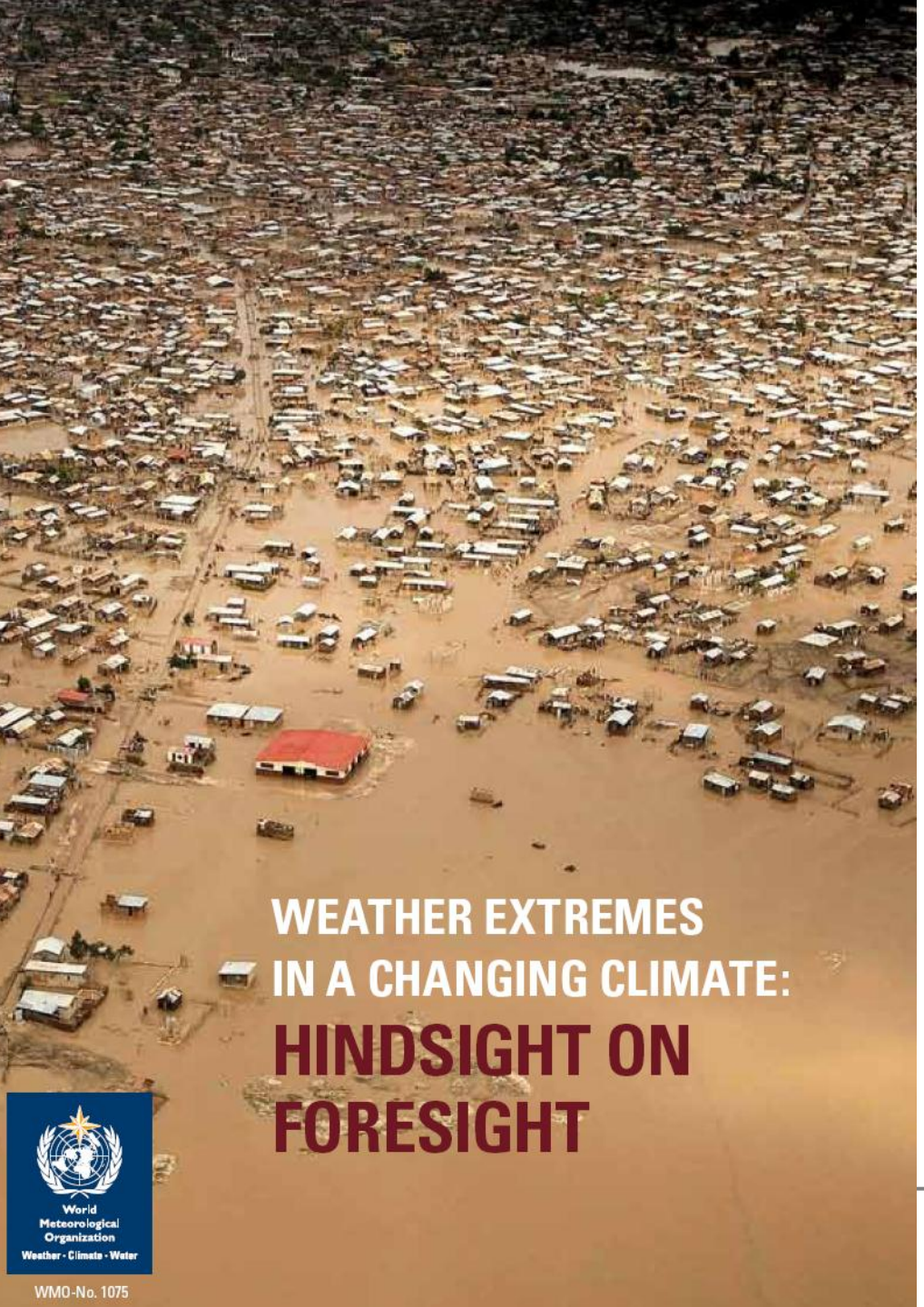
Grafik: Dirk Notz, MPI Hamburg

The Next 100 Years





Computeranimation: Earth Simulator, Japan



The decade 2001–2010 was the warmest ever recorded. The decade was marked by numerous weather and climate extremes, unique in strength and impact.

(WMO 2011)

Nature Climate Change, March 2012:

nature climate change

PERSPECTIVE

PUBLISHED ONLINE: 25 MARCH 2012 | DOI: 10.1038/NCLIMATE1452

A decade of weather extremes

Dim Coumou and Stefan Rahmstorf*

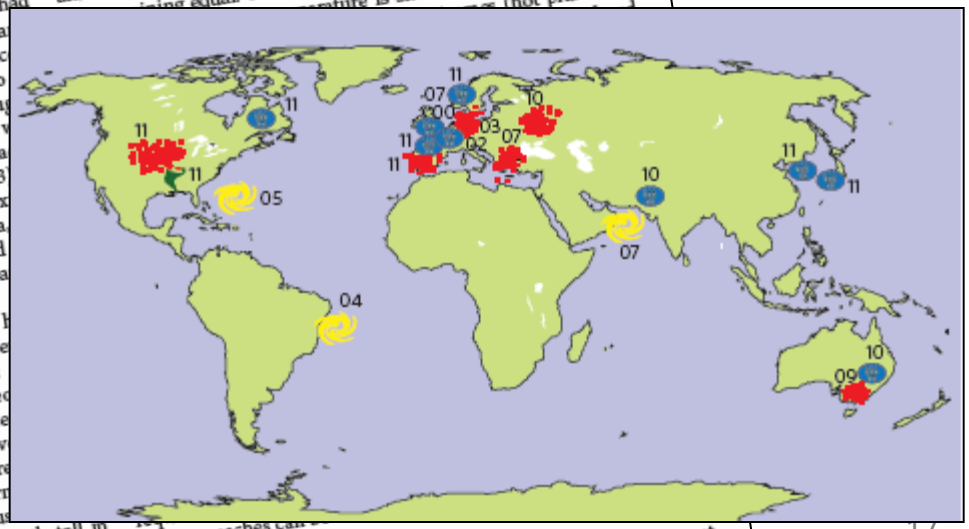
The ostensibly large number of recent extreme weather events has triggered intensive discussions, both in- and outside the scientific community, on whether they are related to global warming. Here, we review the evidence and argue that for some types of extreme — notably heatwaves, but also precipitation extremes — there is now strong evidence linking specific events or an increase in their numbers to the human influence on climate. For other types of extreme, such as storms, the available evidence is less conclusive, but based on observed trends and basic physical concepts it is nevertheless plausible to expect an increase.

For the United States, 2011 was a year of extreme weather, with 14 events that caused losses in excess of US$1 billion each[1]. The US National Oceanic and Atmospheric Administration spoke of "a year seemingly full of weather extremes" after July had set new monthly heat records for Texas, Oklahoma and Delawa... The period from January to October was the wettest on rec... for several northeastern states, with wet soils contributing to severe flooding when Hurricane Irene hit the region in Au... During spring, the southern United States had been hit by the ... recorded tornado outbreak in history: April saw 753 torna... beating the previous monthly record of 542 (from May 2003) ... large margin[3]. Other regions in the world were affected by ex... weather in 2011 as well: rainfall records were set in Australia, ... and Korea, whereas the Yangtze Basin in China experienced ... drought[4]. In western Europe, spring was exceptionally hot a... setting records in several countries (Table 1)[1].

But 2011 was not unique: the past decade as a whole h... an exceptional number of unprecedented extreme weathe... some causing major human suffering and economic ... (Table 1 and Fig. 1). In August 2010, the World Meteo... Organization issued a statement on the "unprecedented se... extreme weather events", stating that it "matches Intergov... Panel on Climate Change (IPCC) projections of more fre... more intense extreme weather events due to global warr... Moscow heatwave and Pakistan flooding that year illus... destructive extreme weather can be to societies: the death toll in ... estimated at 11,000 and drought caused grain- ... government to ban wheat ... flooding in ...

Simple physical considerations

For some types of extreme, there are simple physical reasons why they would increase in a warming climate. If the average temperature rises, then obviously so will the number of heat records, all ... equal. Cold extremes will decrease, but if the prob- ... ature is shifted unchanged towards ... (hot plus cold) ...

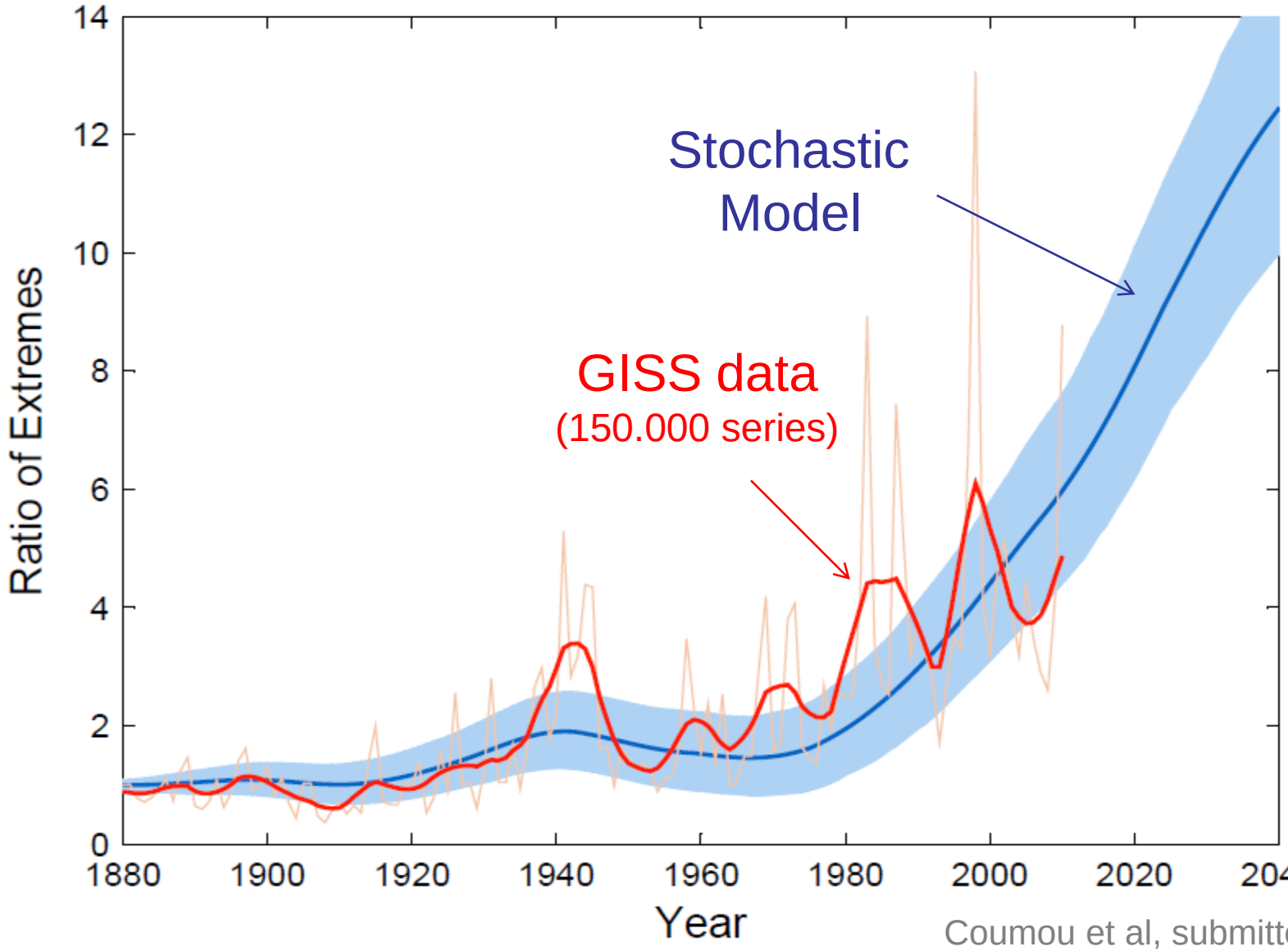


... ling approaches can ...

Statistics and the detection problem

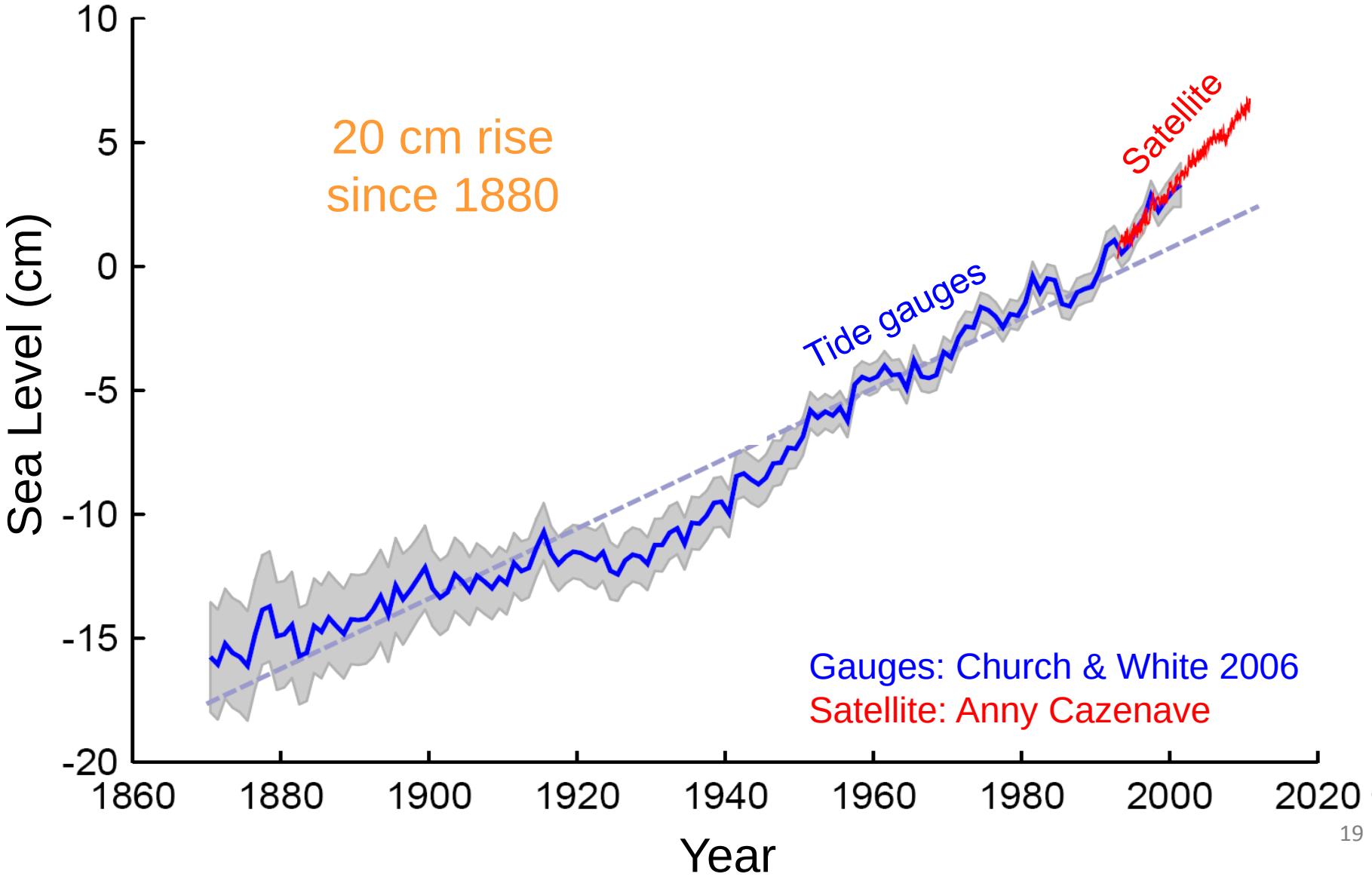
... statistics, scientists can analyse whether the number of recent ... ficantly larger than expected in a stationary ... methods thus may link ...

Increase in Number of Record-warm Months

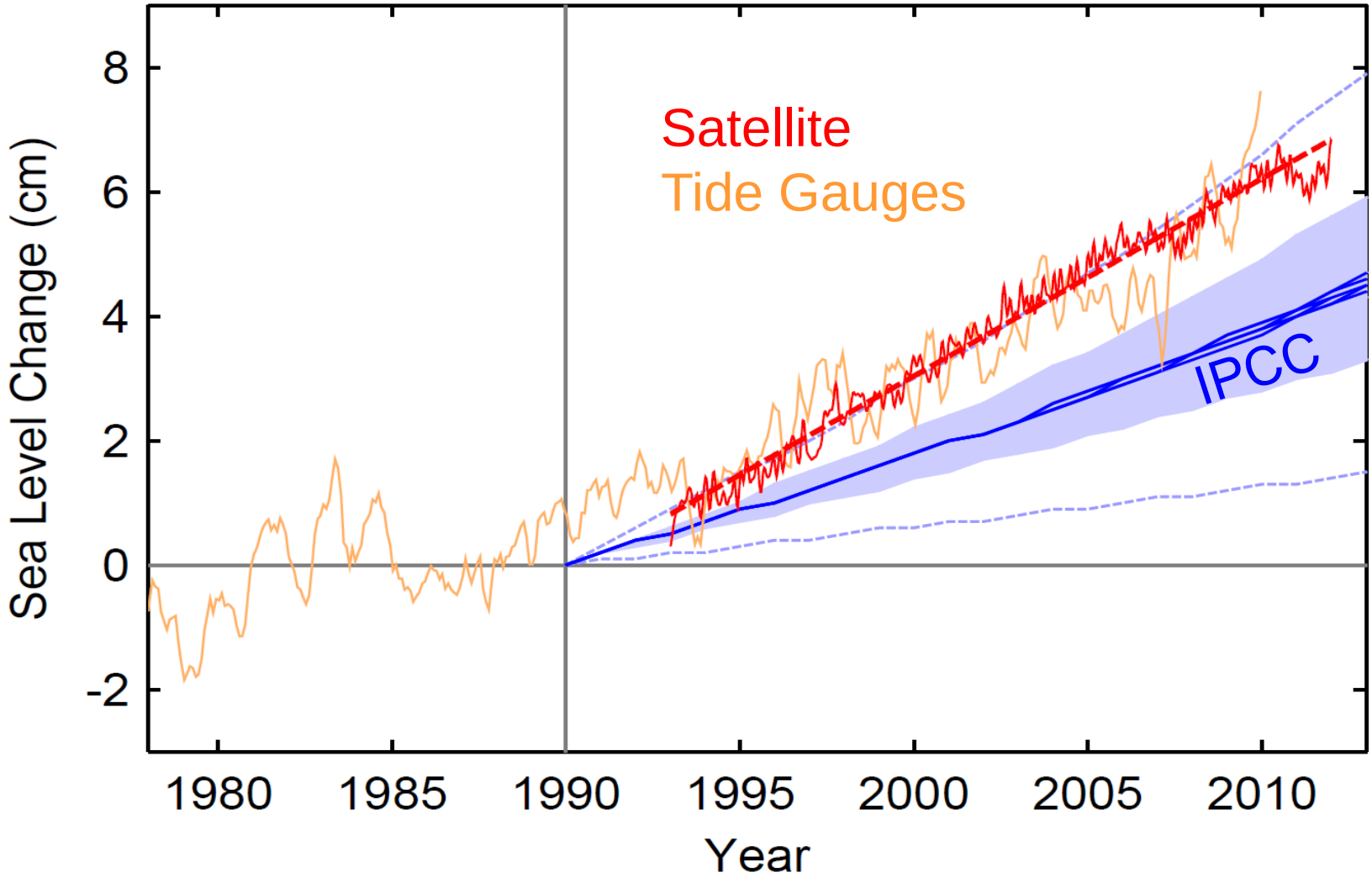


Coumou et al, submitted

Sea Level Rise

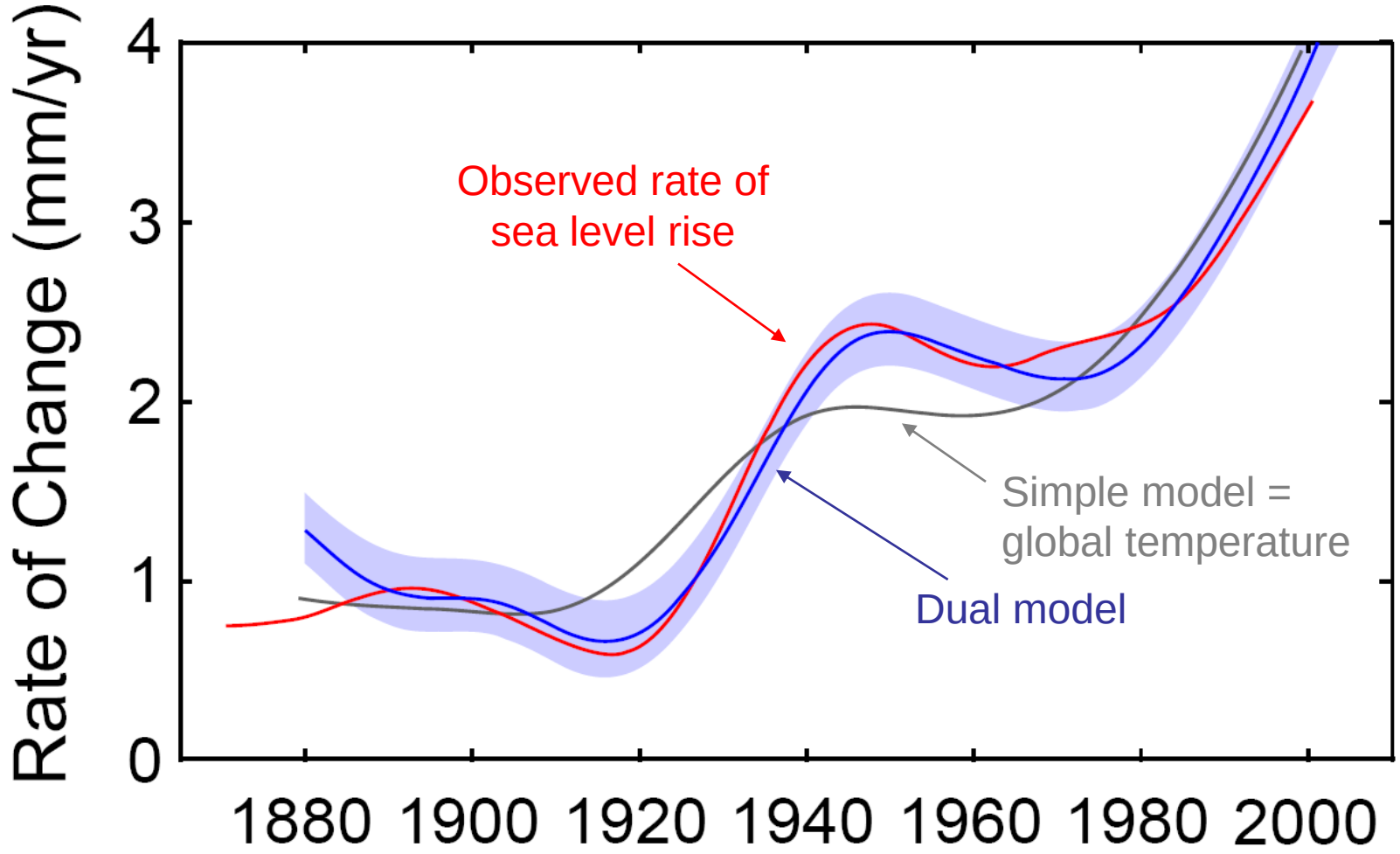


Global Sea Level Rising Faster Than Expected



PIK

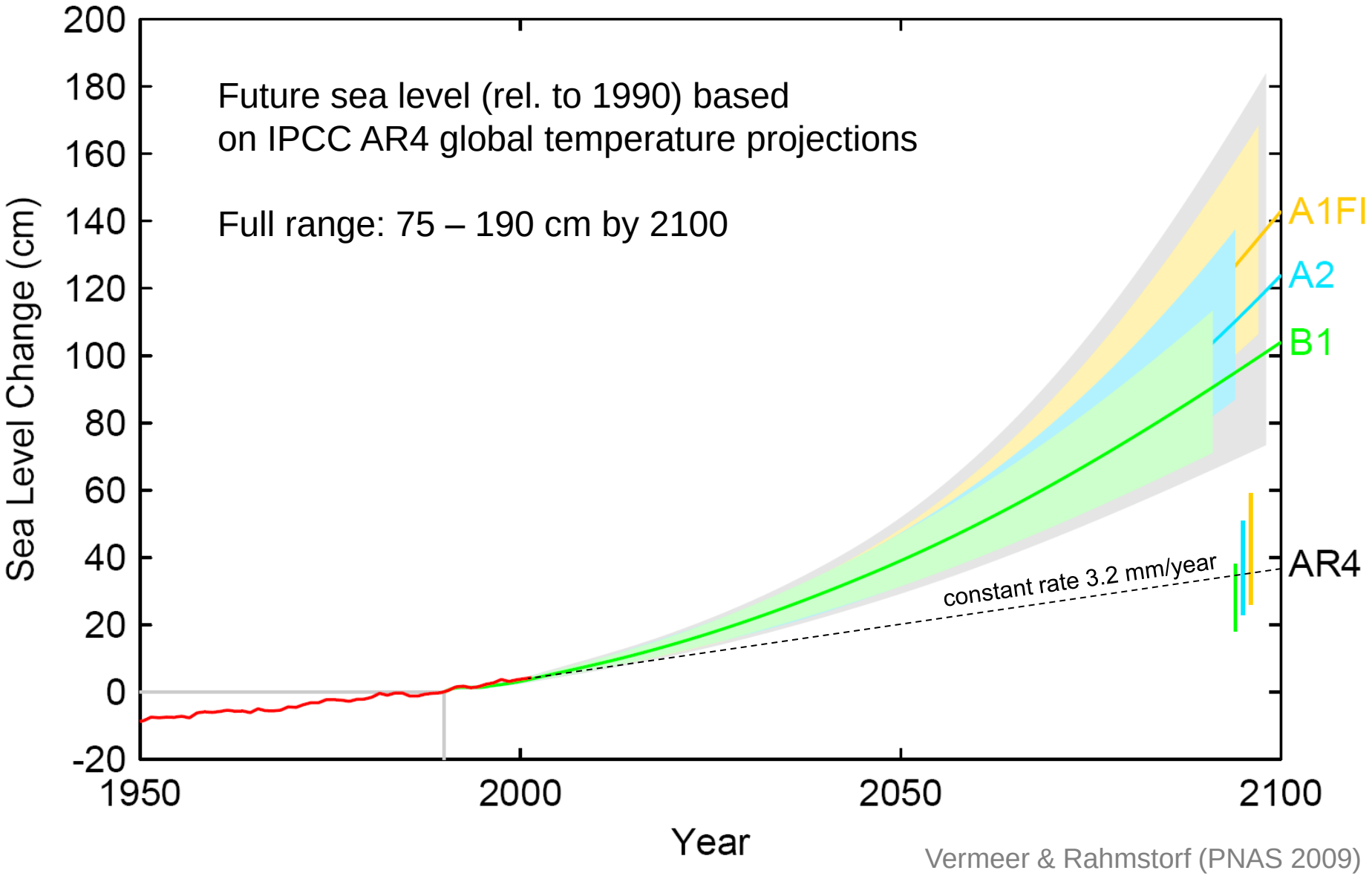
Rate of SLR and Global Temperature



Data: Church & White sea level with Chao reservoir correction
NASA GISS global mean temperature

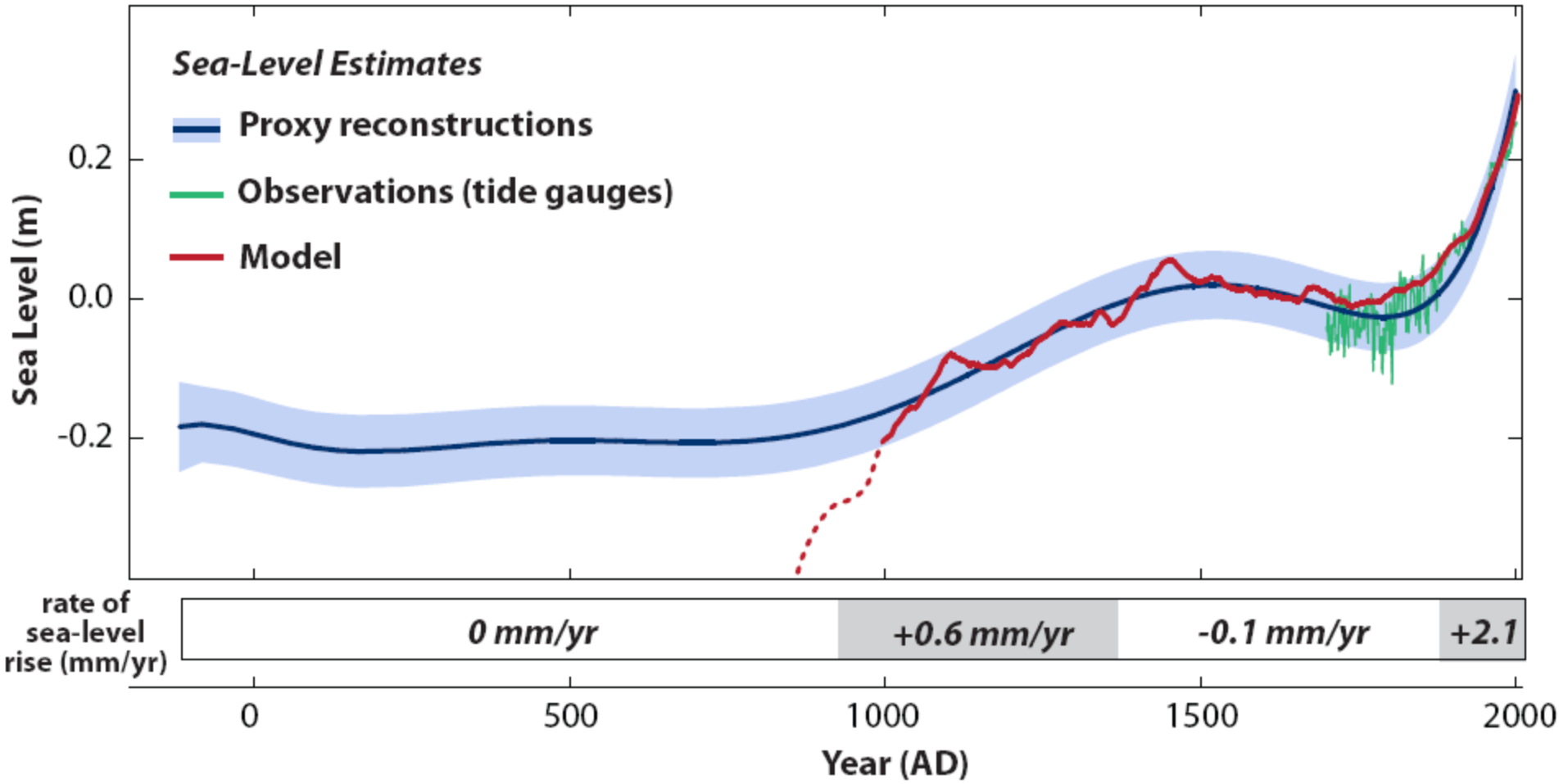
Vermeer & Rahmstorf (PNAS 2009)

Semi-Empirical Projections



Vermeer & Rahmstorf (PNAS 2009)

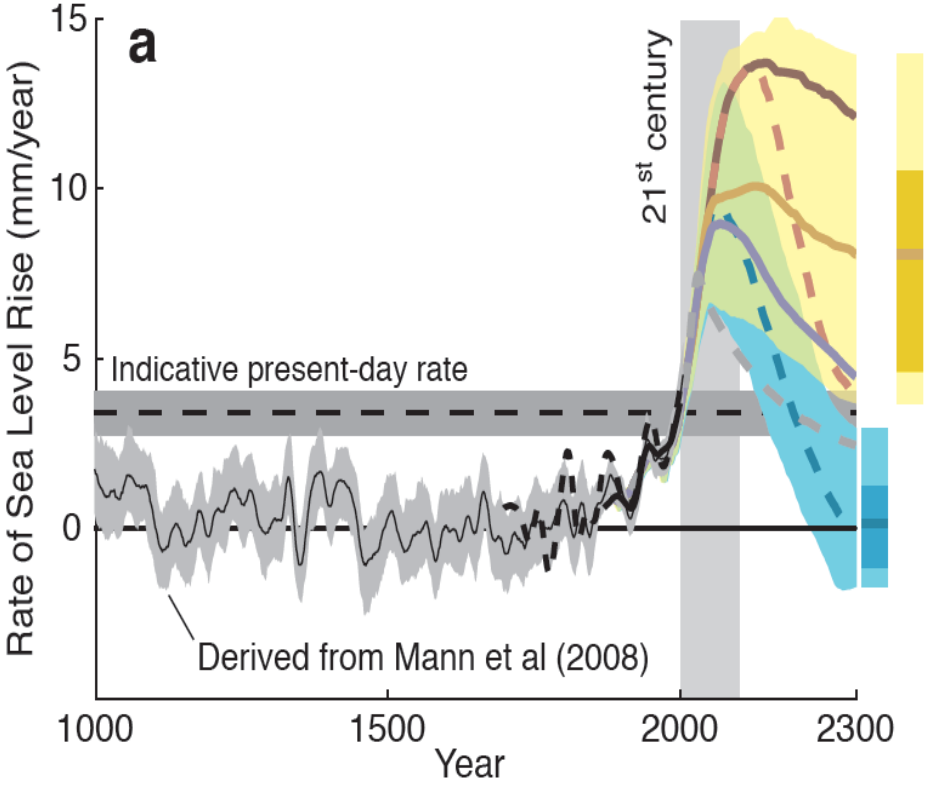
2000 Years of Sea Level



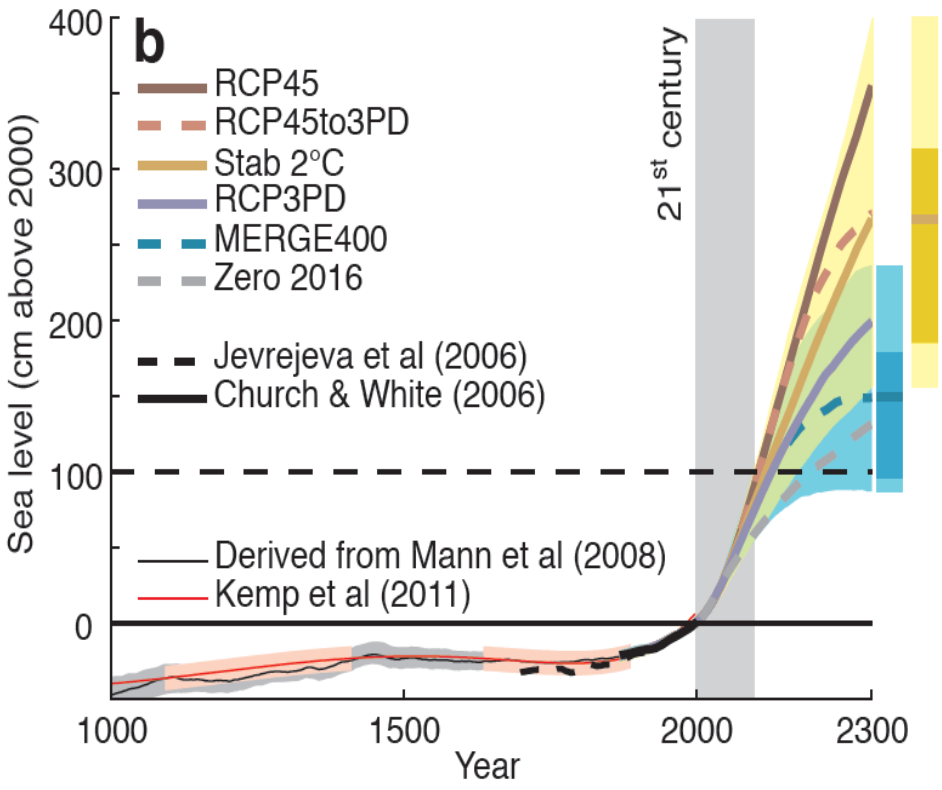
Kemp et al. PNAS 2011

Multi-Century Projections

Rate of Rise



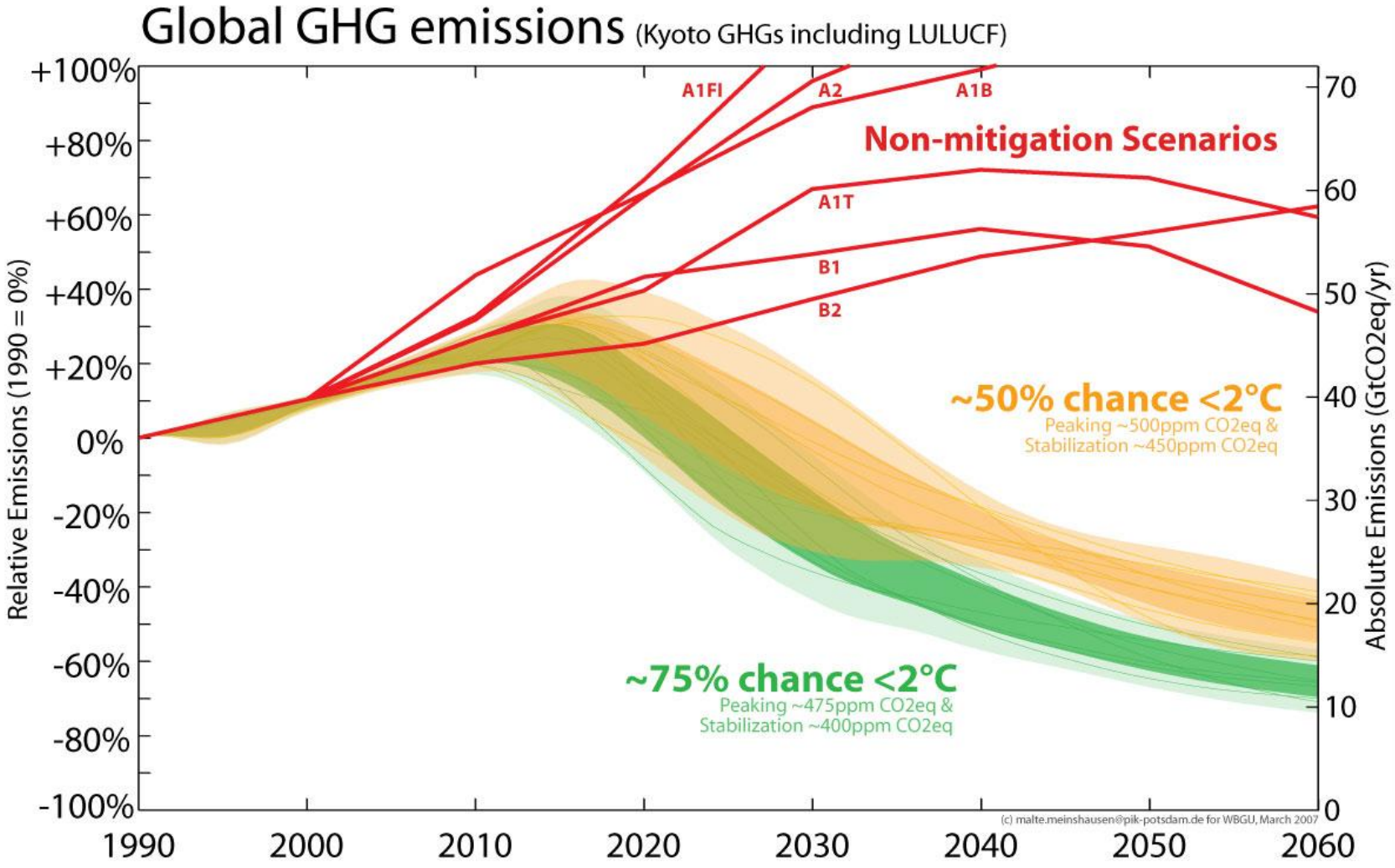
Sea Level



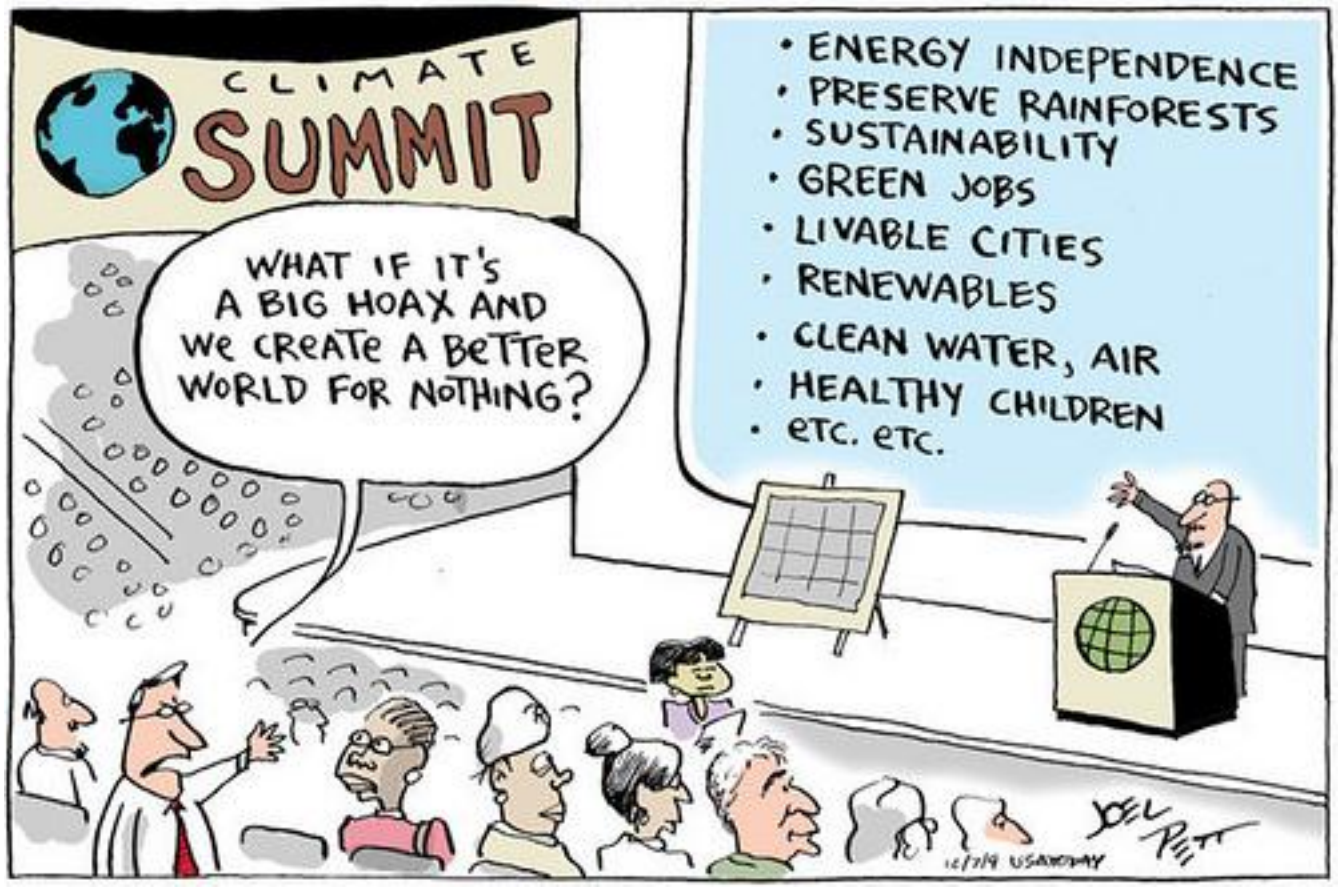
PIK

Schaeffer et al. (Nature CC in press)

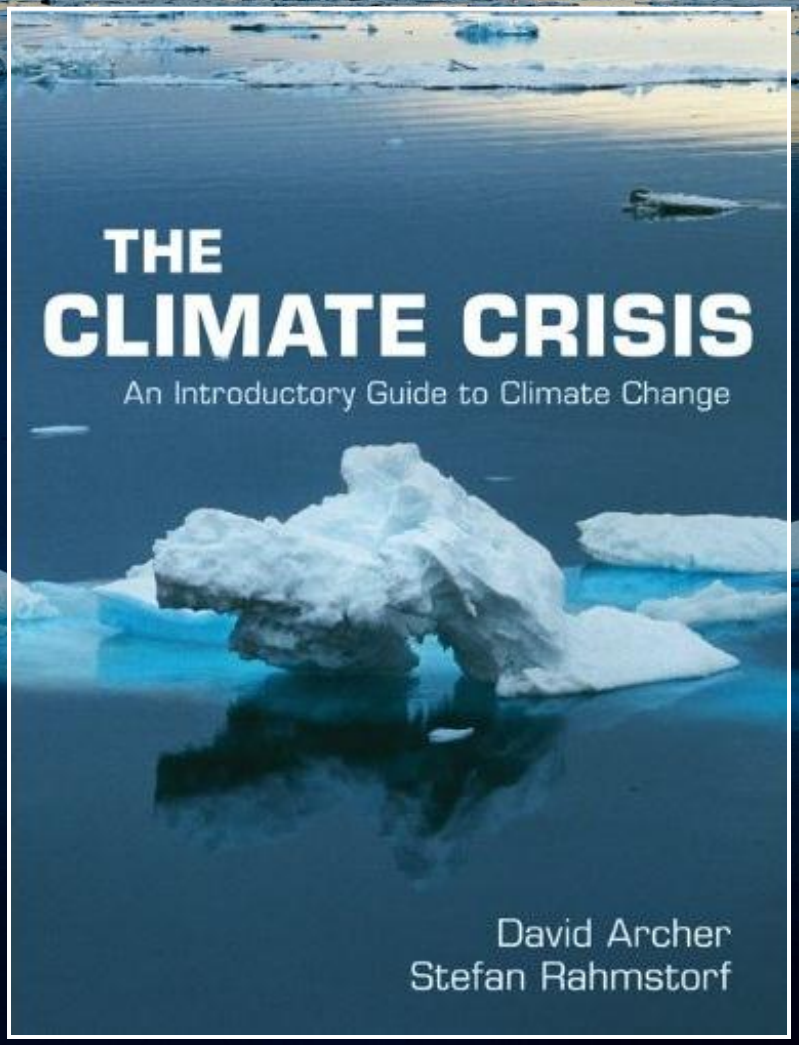
What Can We Do?



Graph: Malte Meinshausen


CLIMATE
SUMMIT
WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?
• ENERGY INDEPENDENCE
• PRESERVE RAINFORESTS
• SUSTAINABILITY
• GREEN JOBS
• LIVABLE CITIES
• RENEWABLES
• CLEAN WATER, AIR
• HEALTHY CHILDREN
• ETC. ETC.

Thank you for your attention!



Cambridge University Press 2010

photo ©SR