Virtual Academy for Sustainability

WBGU
German Advisory Council on Global Change

Lecture 3: Climate Change

Episode 2: Impacts of climate change and mitigation

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World in Transition: A Social Contract for Sustainability *supported by*

DBU
Deutsche Bundesstiftung Umwelt

Lecture 3: Overview

Episode 1: Basic facts about global warming

Episode 2: Impacts of climate change and mitigation

Episode 3: Interview

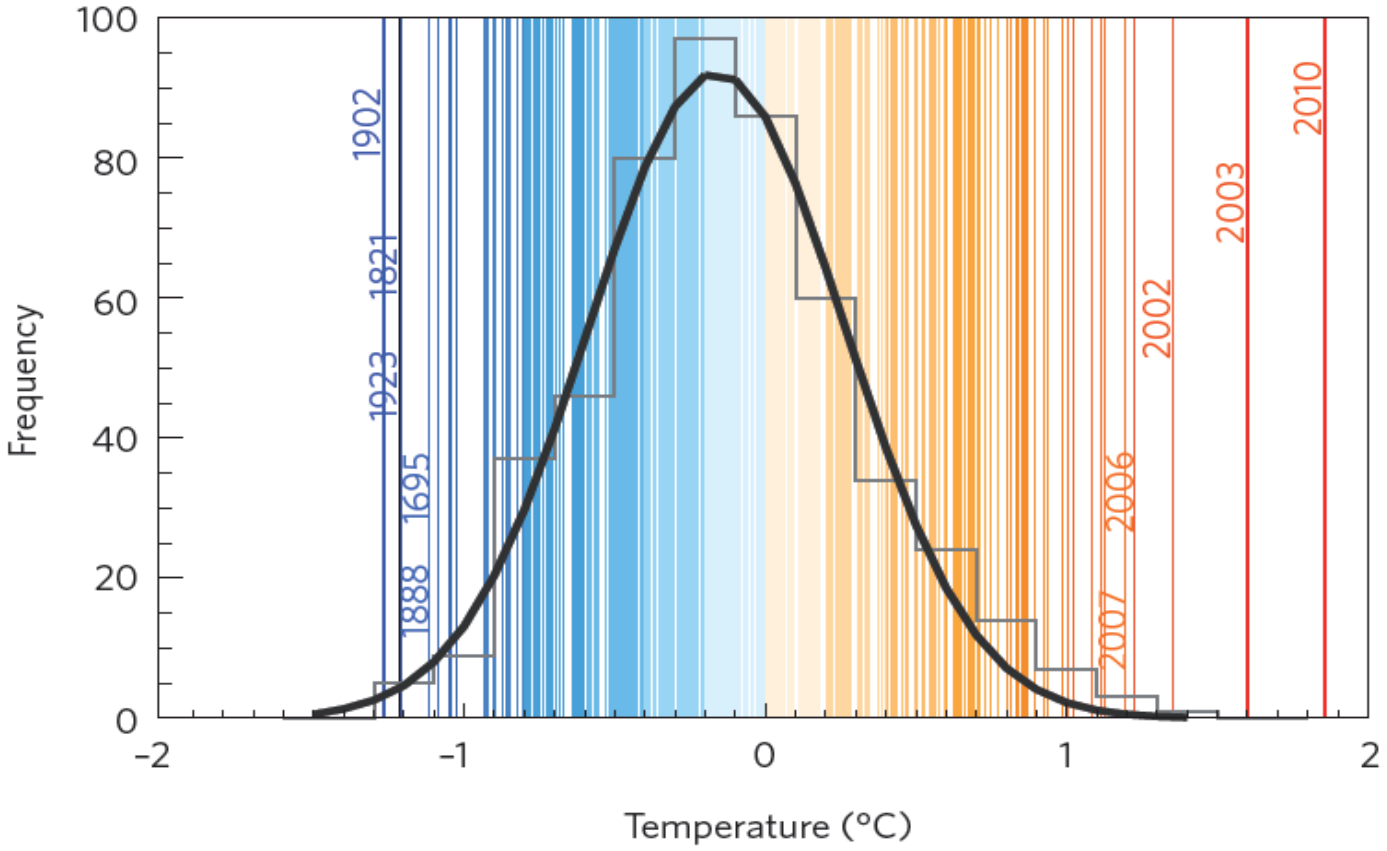
Learning Outcomes

1. Get a basic understanding how global warming affects the incidence of heat waves, droughts and floods.
2. Understand how global warming affects sea-level rise.
3. Understand the 2-degree limit of global climate policy and how quickly emissions need to be reduced to stay below this limit.

Content

- Weather extremes
- Sea level rise
- Mitigating global warming

Heat Waves



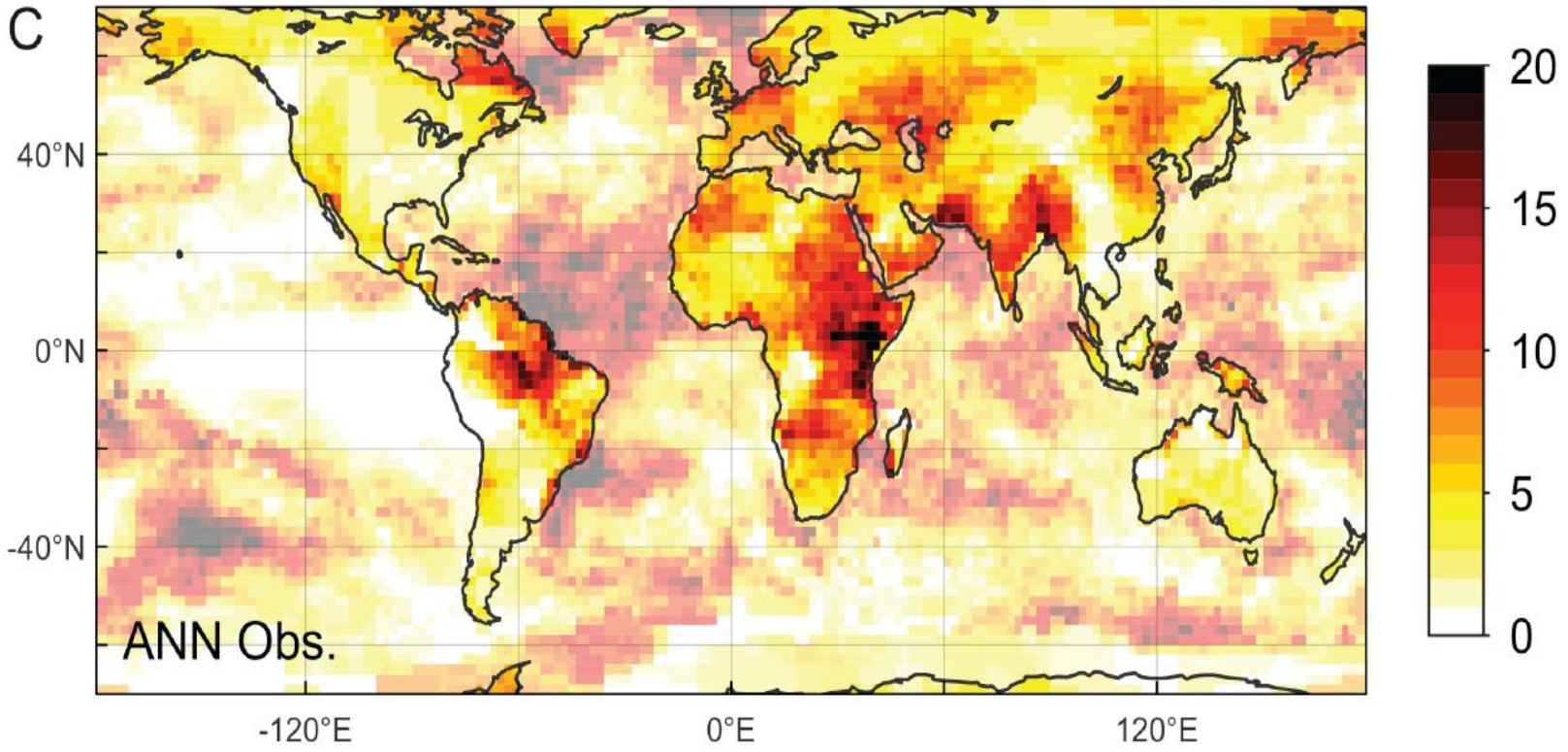
Distribution of European summer temperatures AD 1500 - 2010

Source: Barriopedro et al. 2011

Heat Waves

Observed increase in monthly heat records

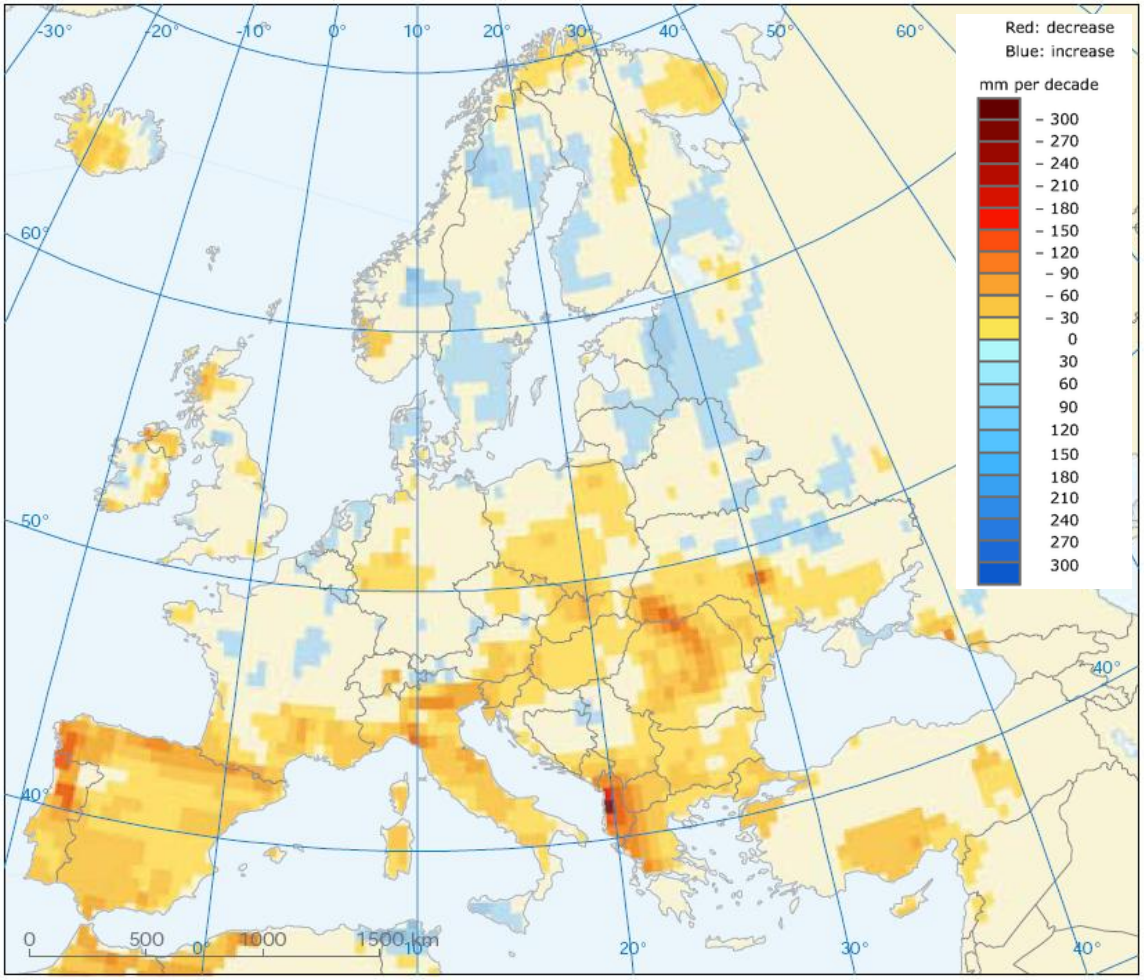
Based on 150.000 time series starting in the year 1880



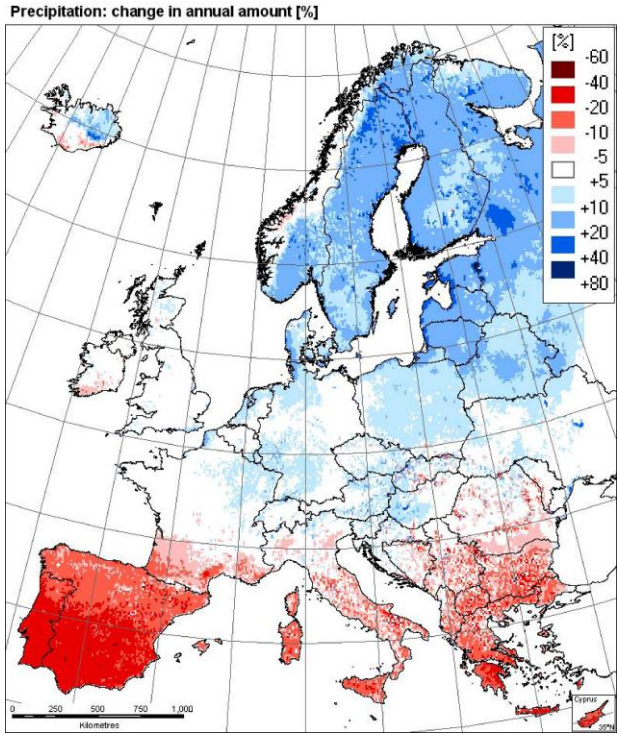
Source: Coumou et al. (submitted)

Changes in Precipitation

Observations: trend 1961-2006



Model simulation



Southern Europe
Is drying out

Source: EEA 2008

Heat Raises Fire Risk

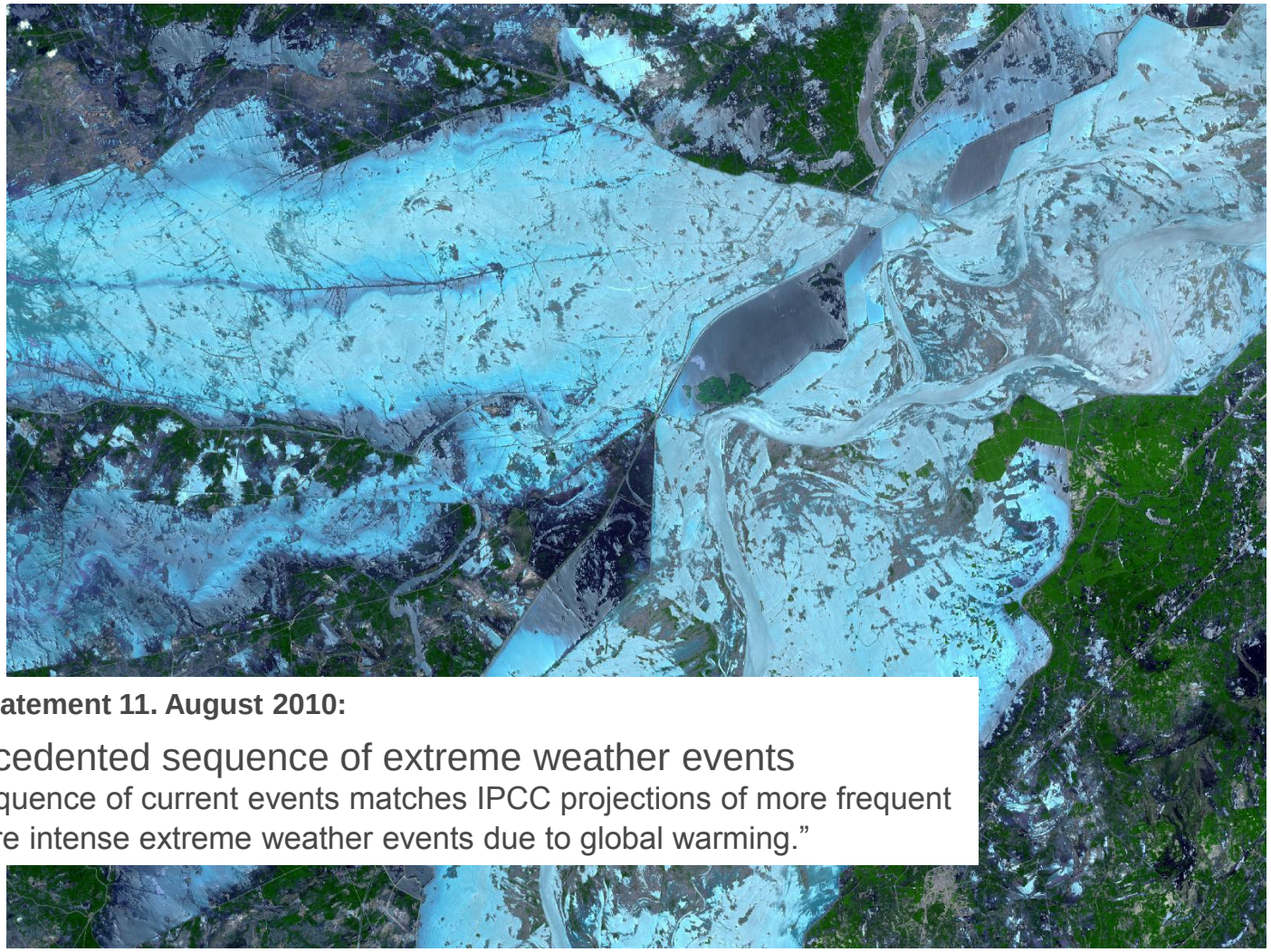
Forest fires in Greece, August 2007

Source: MODIS Rapid Response Project, NASA Goddard Space Flight Center

Heat Raises Fire Risk

Australian newspaper headline about the “Black Saturday” bushfires in February 2009

Pakistan Flood Disaster 2010



WMO-Statement 11. August 2010:

Unprecedented sequence of extreme weather events

“The sequence of current events matches IPCC projections of more frequent and more intense extreme weather events due to global warming.”

Source: NASA

Weather Extremes

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 Delaware[2]. The period from January to October was the wettest on record for several northeastern states, with wet soils contributing to the severe flooding when Hurricane Irene hit the region in August. During spring, the southern United States had been hit by the worst recorded tornado outbreak in history: April saw 753 tornadoes, beating the previous monthly record of 542 (from May 2003) by a large margin[3]. Other regions in the world were affected by extreme weather in 2011 as well: rainfall records were set in Australia, Japan and Korea, whereas the Yangtze Basin in China experienced record drought[4]. In western Europe, spring was exceptionally hot and dry, setting records in several countries (Table 1)[5].

But 2011 was not unique: the past decade as a whole has seen an exceptional number of unprecedented extreme weather events, some causing major human suffering and economic damages[6] (Table 1 and Fig. 1). In August 2010, the World Meteorological Organization issued a statement on the "unprecedented sequence of extreme weather events", stating that it "matches Intergovernmental Panel on Climate Change (IPCC) projections of more frequent and more intense extreme weather events due to global warming". The Moscow heatwave and Pakistan flooding that year illustrated how destructive extreme weather can be to societies: the death toll in Moscow has been estimated at 11,000 and drought caused grain-harvest losses of 30%, leading the Russian government to ban wheat exports. At the same time Pakistan was hit by the worst flooding in its history, which affected approximately one-fifth of its total land area and 20 million people[7].

Simple physical considerations

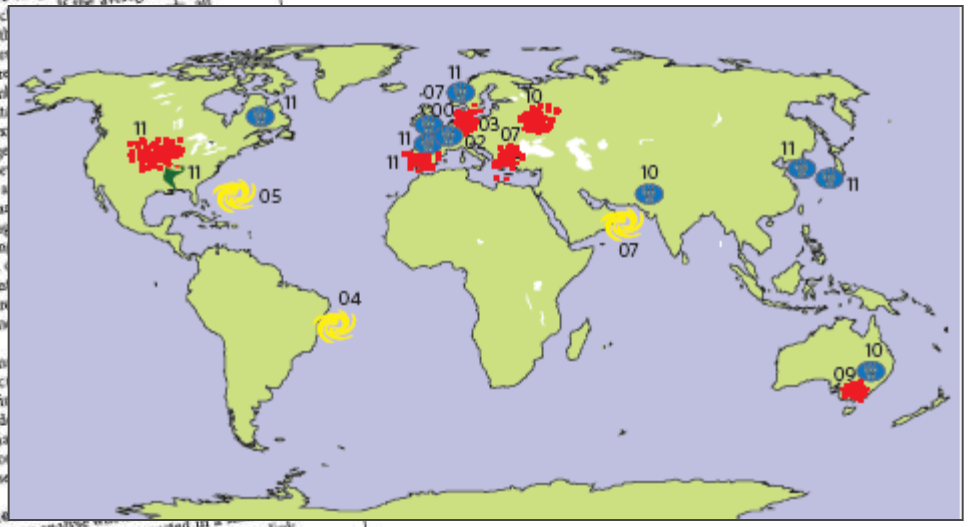
For some types of extreme, there are simple physical reasons why they would increase in a warming c… of the average temper-ature rises, then obviously so will t… else remaining equal. Cold extremes… ability distribution for temperature… warmer conditions, the total num… will increase[8]. That is fundament… extreme is always based on past ex… moves us out of the familiar range…

Warming will lead to more e… drying, increasing the intensity … air can also be expected to exhau… hold more moisture. According… tion, for each 1 °C of warmin… water vapour, which may rain … atmospheric moisture conten… to drive storms. Furthermor… storms increases with warm… remaining equal.

Such simple physical con… tain weather extremes to inc… are not sufficient to make fu… remain equal and a more d… detect whether extremes ha… required. For an attributio… ling approaches can be use…

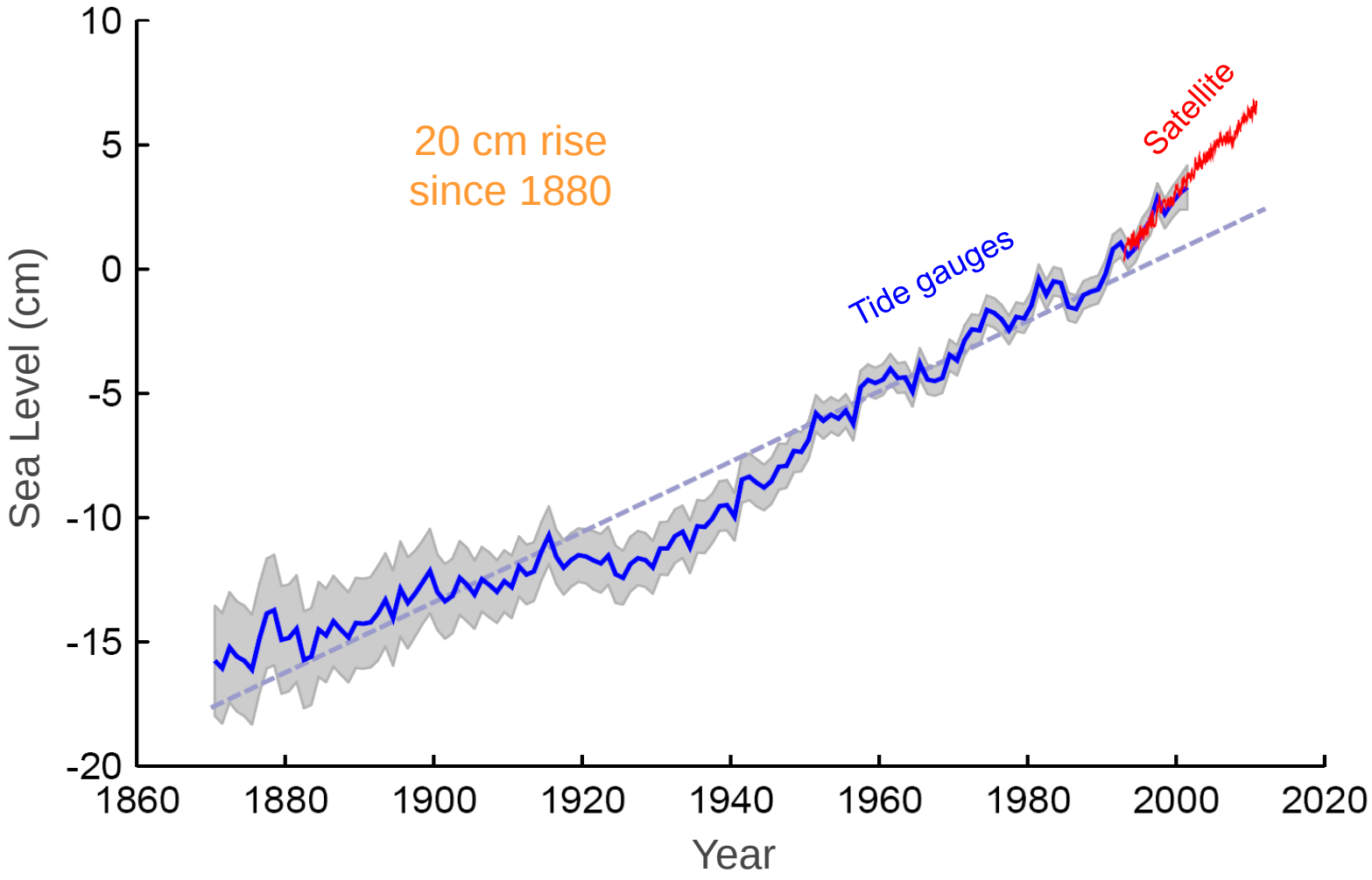
Statistics and the dete…

Using statistics, scientists can analyse … extreme events is significantly larger than expected in a … (that is, unchanging) climate. Statistical methods thus may link extremes to an observed climatic trend, but this does not address the question of whether this trend is anthropogenic or caused by natural factors. Extreme-event statistics are challenging: extremes …, and often cannot be assumed to be …



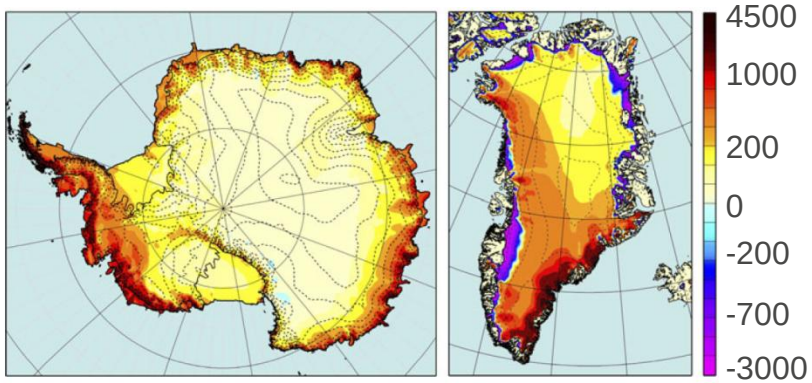
Source: Coumou and Rahmstorf 2012

Sea Level Rise



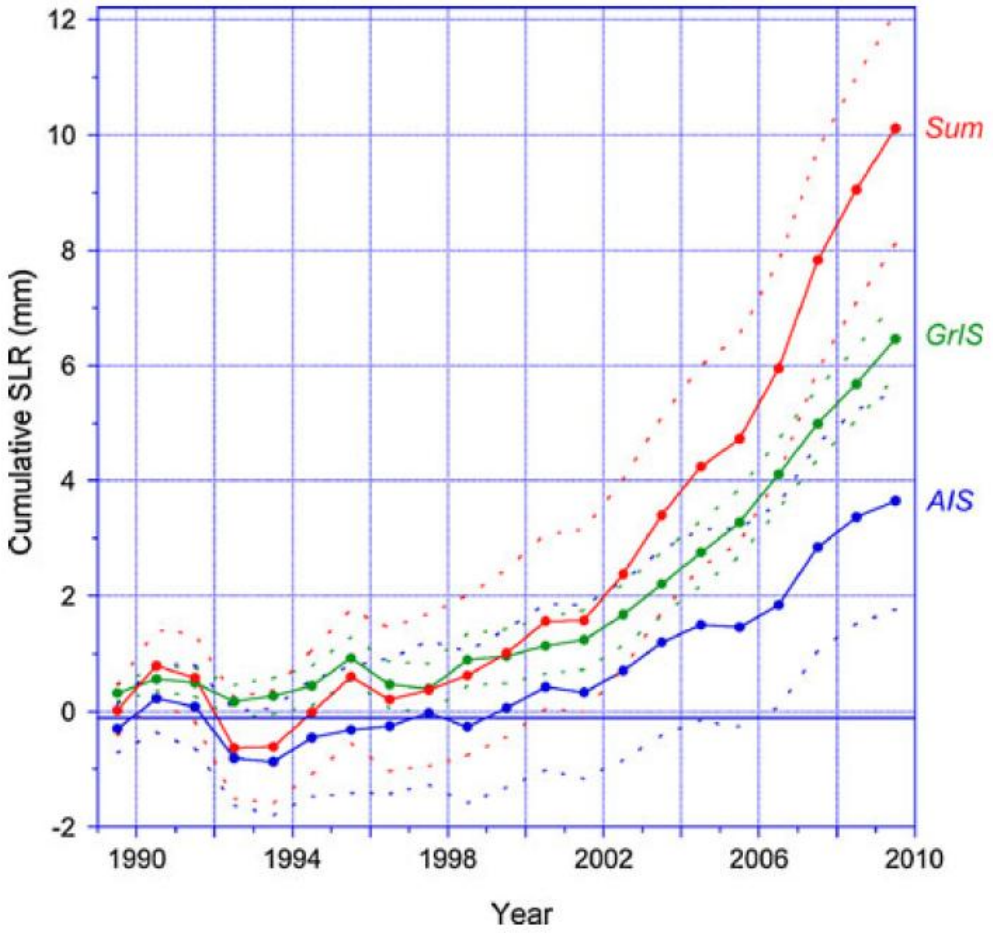
Data: Gauges: Church & White 2006; Satellite: AVISO

Ice Sheet Contributions to Sea Level



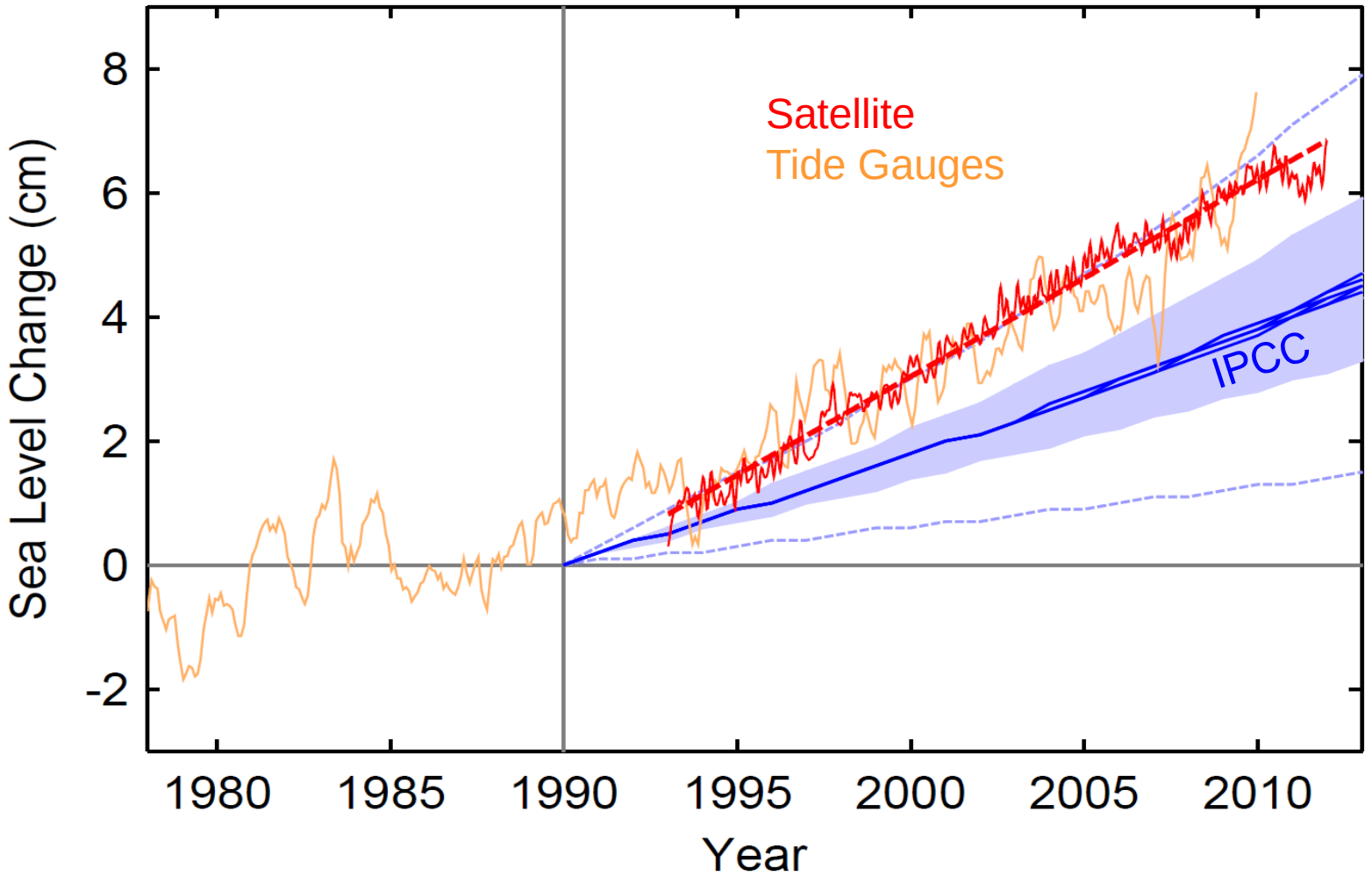
Source: ?

Photo: Ian Joughin



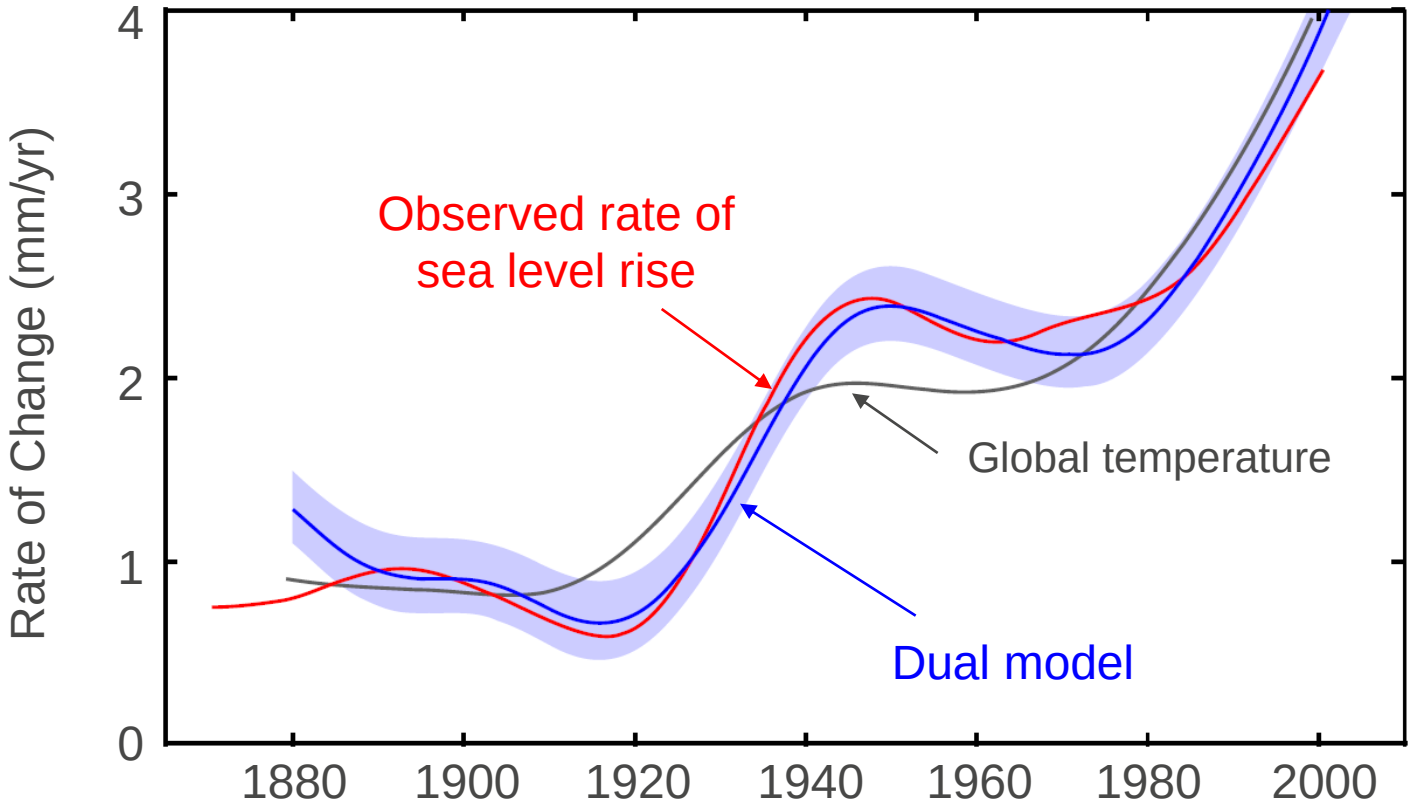
Source: Van den Broeke et al. 2011

Rising Faster Than Expected



Source: Rahmstorf et al., submitted

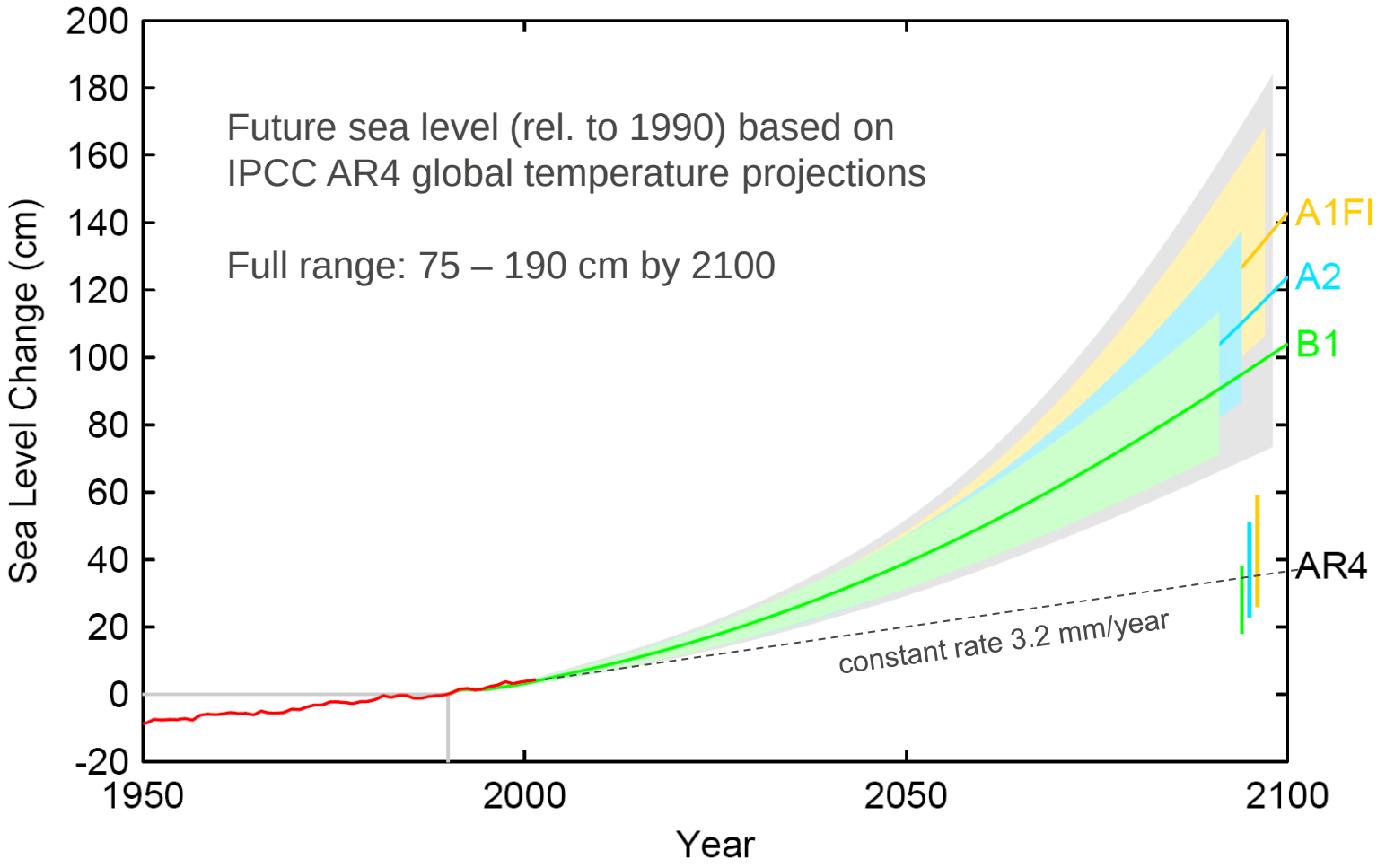
Sea-Level Rise and Global Temperature



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

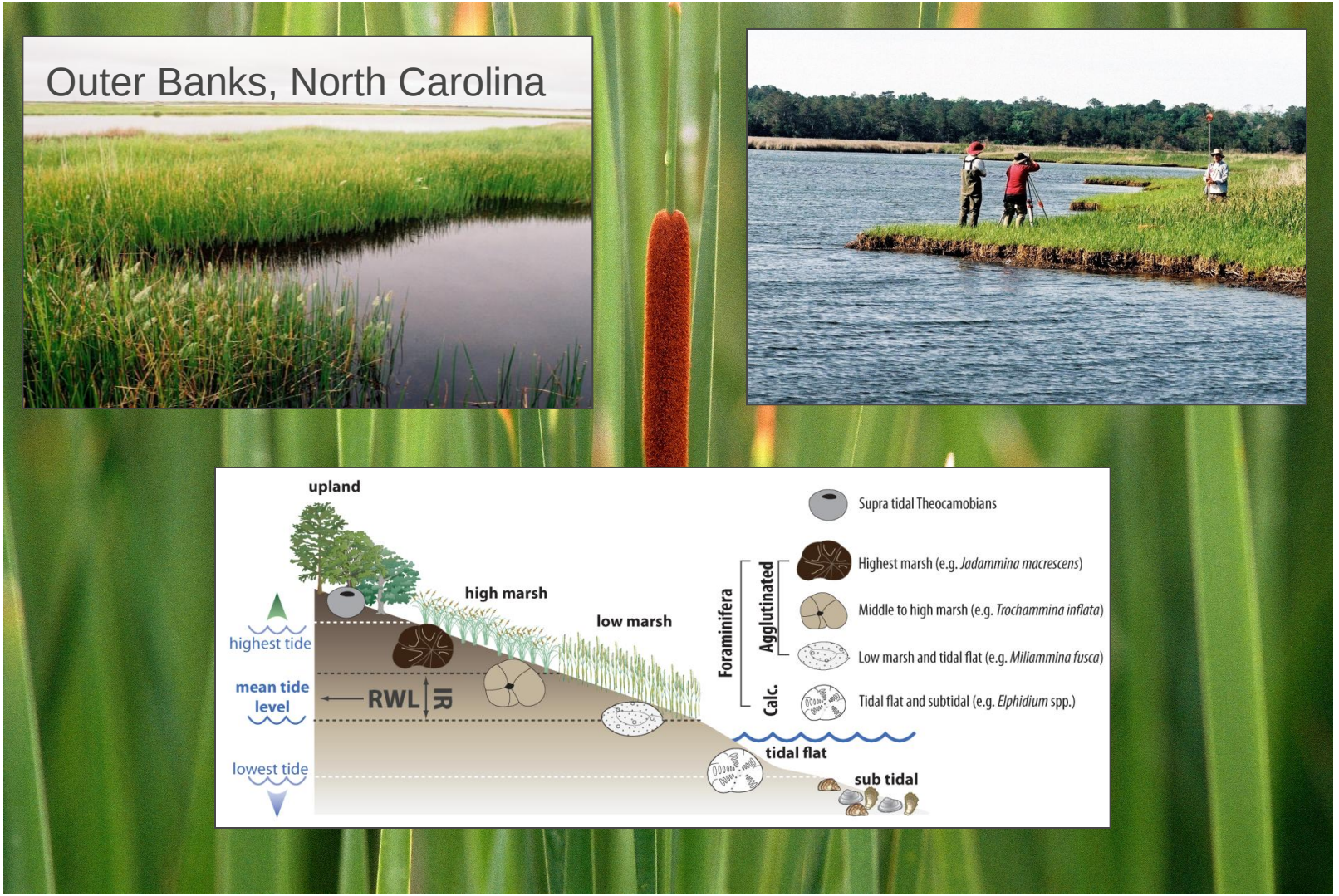
Source: Vermeer and Rahmstorf 2009

Sea Level Projections



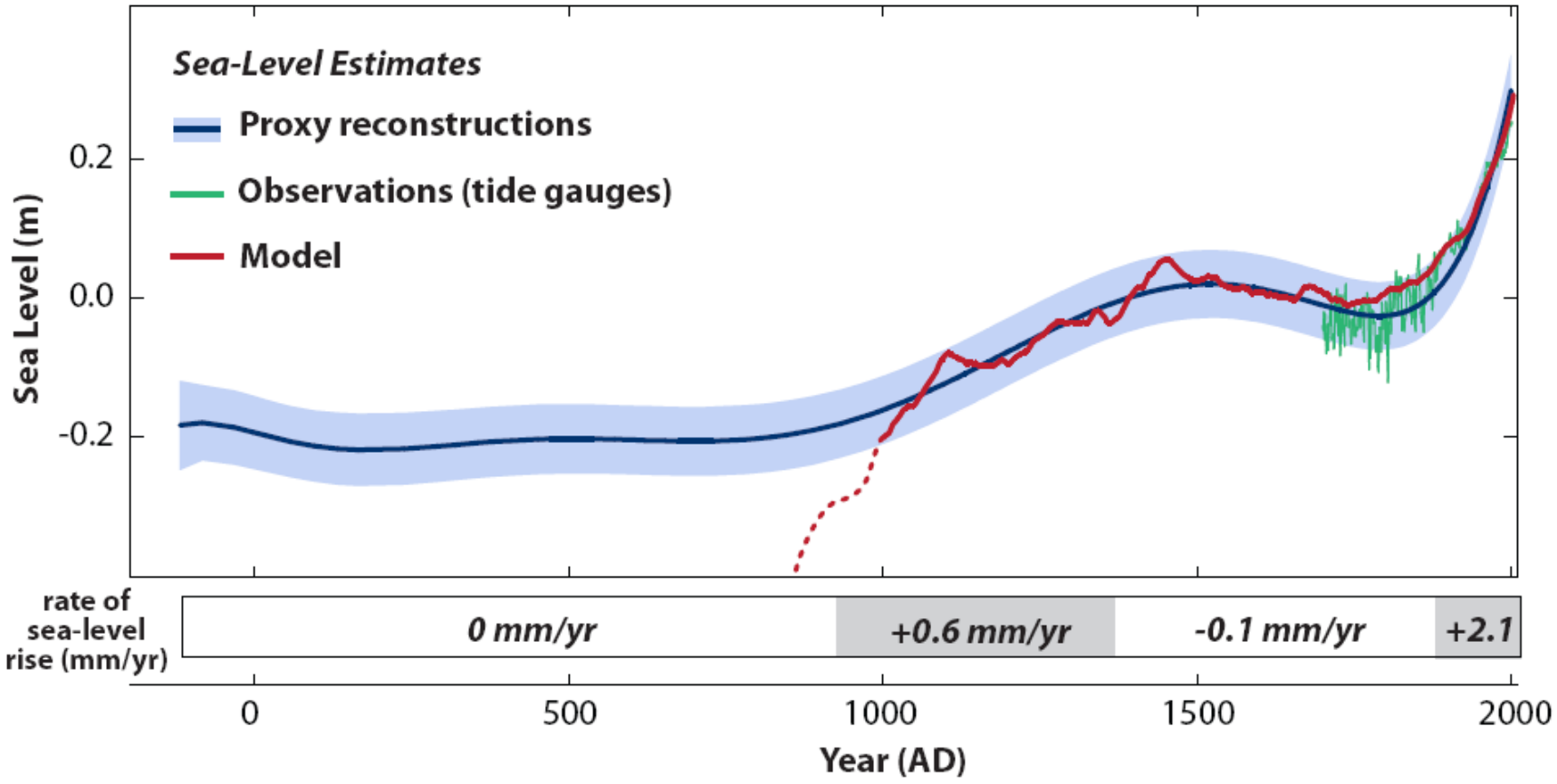
Source: Vermeer and Rahmstorf 2009

Reconstructing Past Sea Level



Fotos: S. Rahmstorf

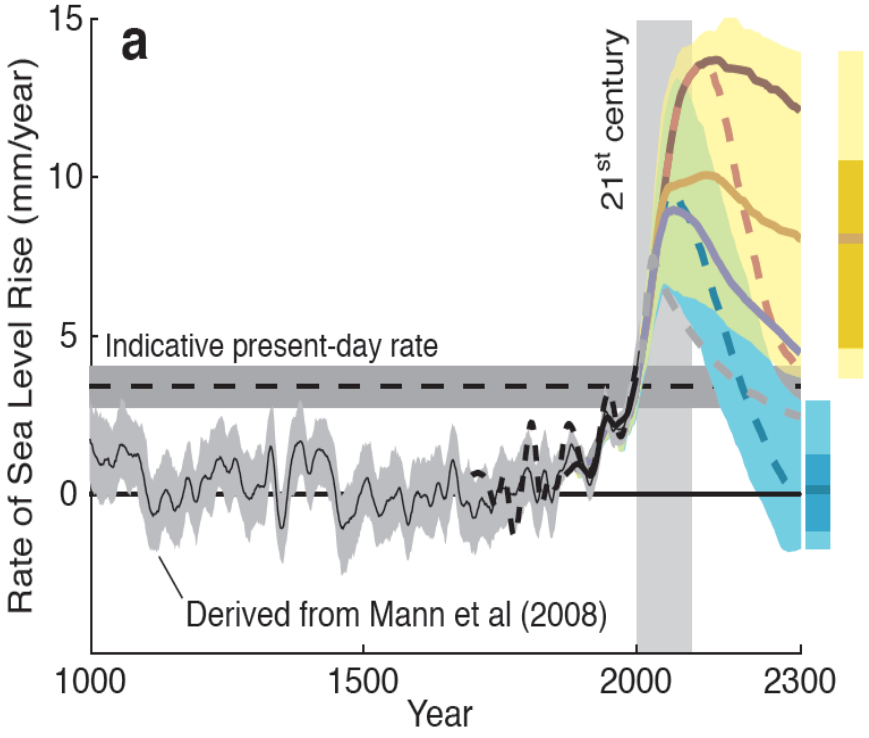
2000 Years of Sea Level



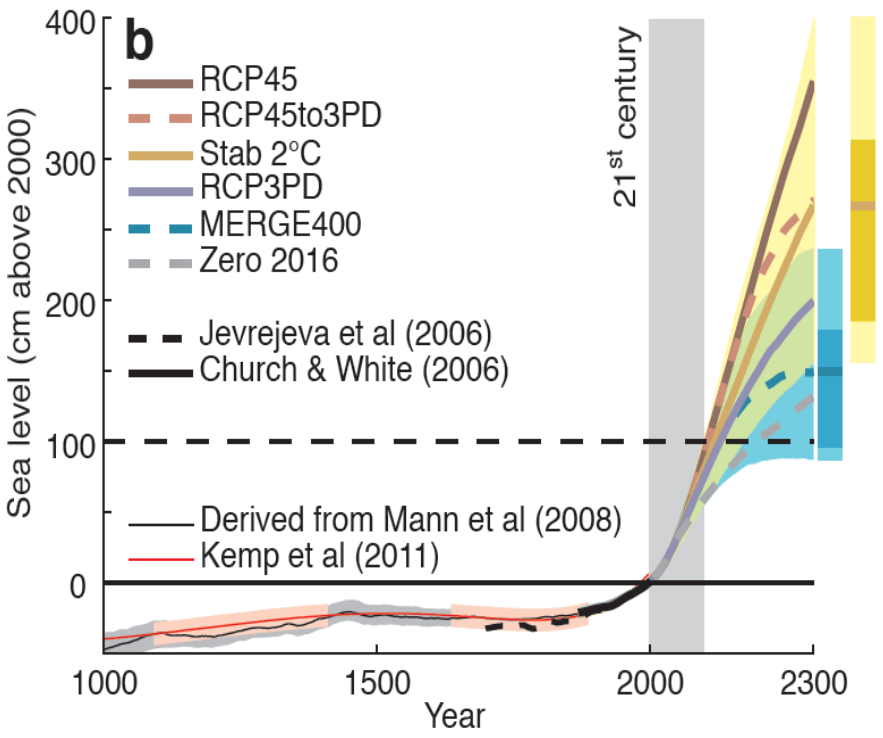
Source: Kemp et al. 2011

Multi-Century Projections

Rate of Rise

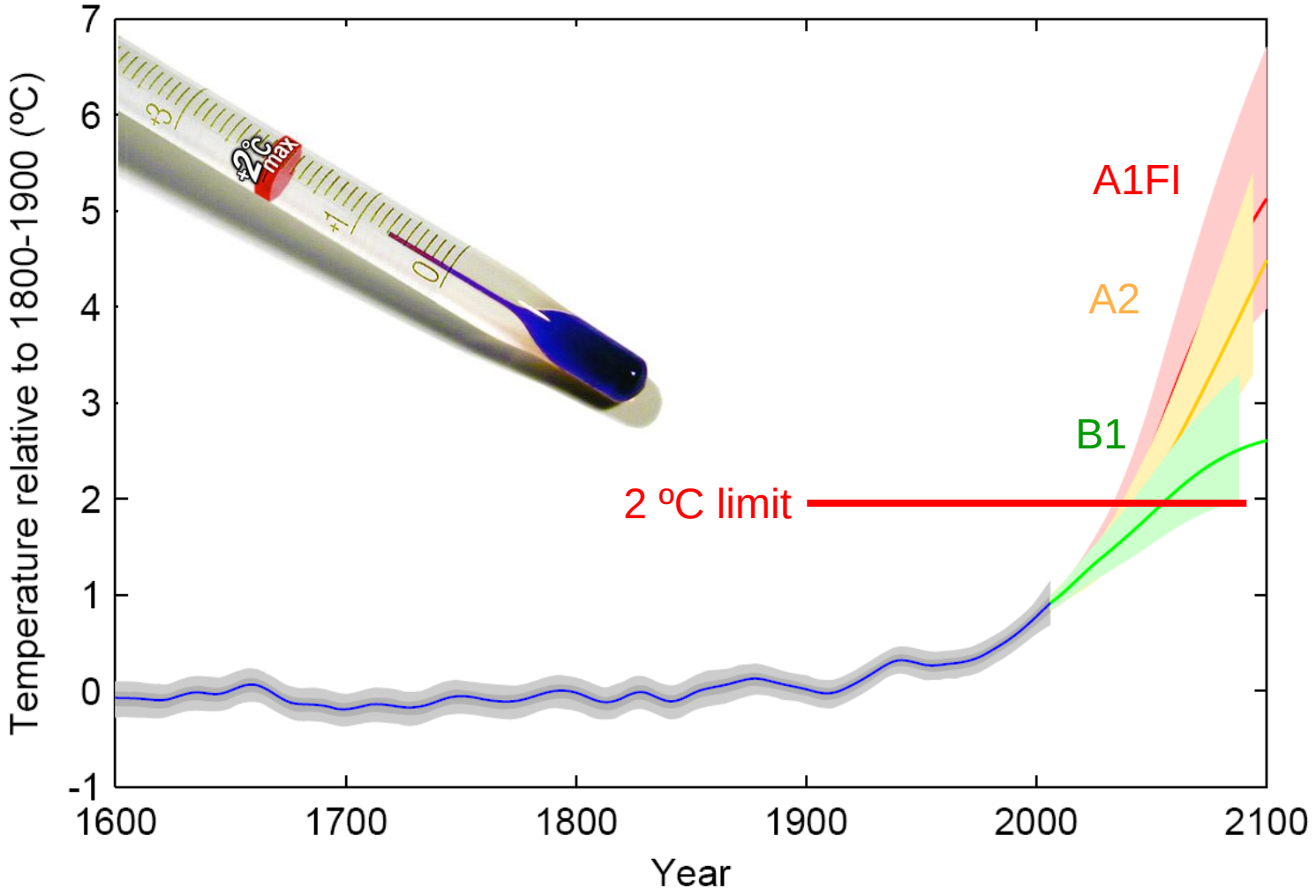


Sea Level

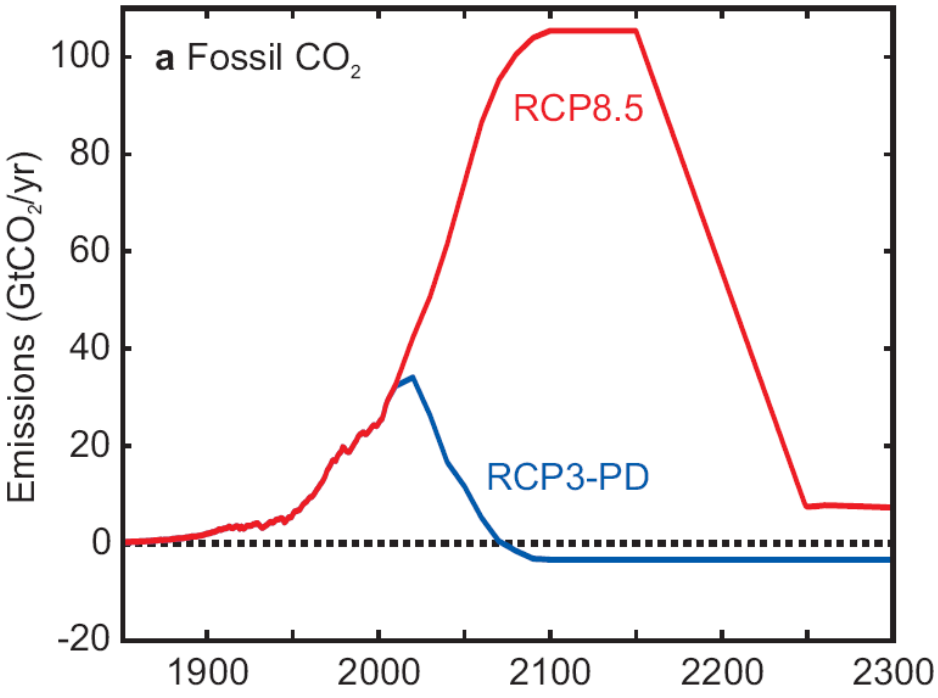


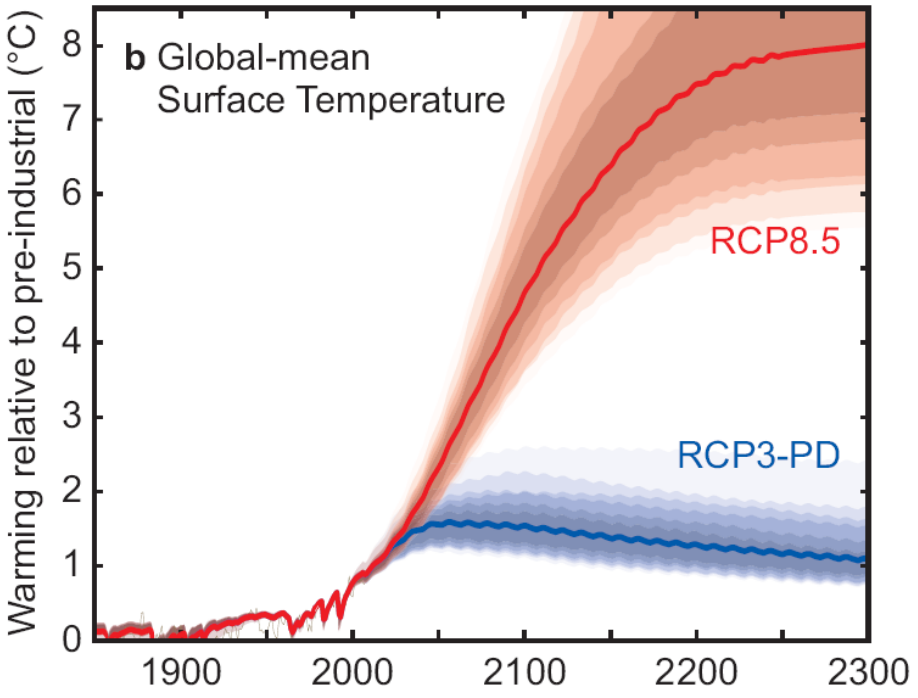
Source: Schaeffer et al. 2012

The 2 ºC Limit



Two Futures





Source: Meinshausen et al. 2011

- To stay below 2ºC with probability 75% we can still emit 700 Gt CO2 until 2050.
- At current rate we will have used up this budget in 20 years.

Exercises for Self Study

1. Find out what is known scientifically about climate change impacts in your country or region. A good starting point is volume 2 of the IPCC 4th assessment report, found at www.ipcc.ch, which has regional chapters. A much shorter, illustrated summary of the main findings of this report is provided in the book The Climate Crisis (David Archer and Stefan Rahmstorf, Cambridge University Press 2010). Scientific articles can be found e.g. by using the search engine google scholar.

2. Keep informed about current developments by reading the monthly State of the Climate reports compiled by the National Oceanic and Atmospheric Administration at http://www.ncdc.noaa.gov/sotc/

Exercises for Self Study

3. Get informed about „tipping points“, where irreversible, large-scale changes in the Earth system might be triggered. (A good starting point is the review paper „Tipping elements in the Earth‘s climate system“, by Lenton et al., PNAS 2008.)

4. Find out what targets and strategy your government has to reduce greenhouse gas emissions. Do you find the strategy adequate? Which concrete steps have been taken to implement it?

References

Basic reading:

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