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UNIVERSITÄT  
BERN

OESCHGER CENTRE  
CLIMATE CHANGE RESEARCH

World Meteorological Organization: Public Science Lecture 2019

# The climate of tomorrow:

## Building the knowledge for Earth Stewardship

**Thomas Stocker**

Physics Institute  
Oeschger Centre for Climate Change Research  
University of Bern, Switzerland

Apollo 8, 24.12.1968

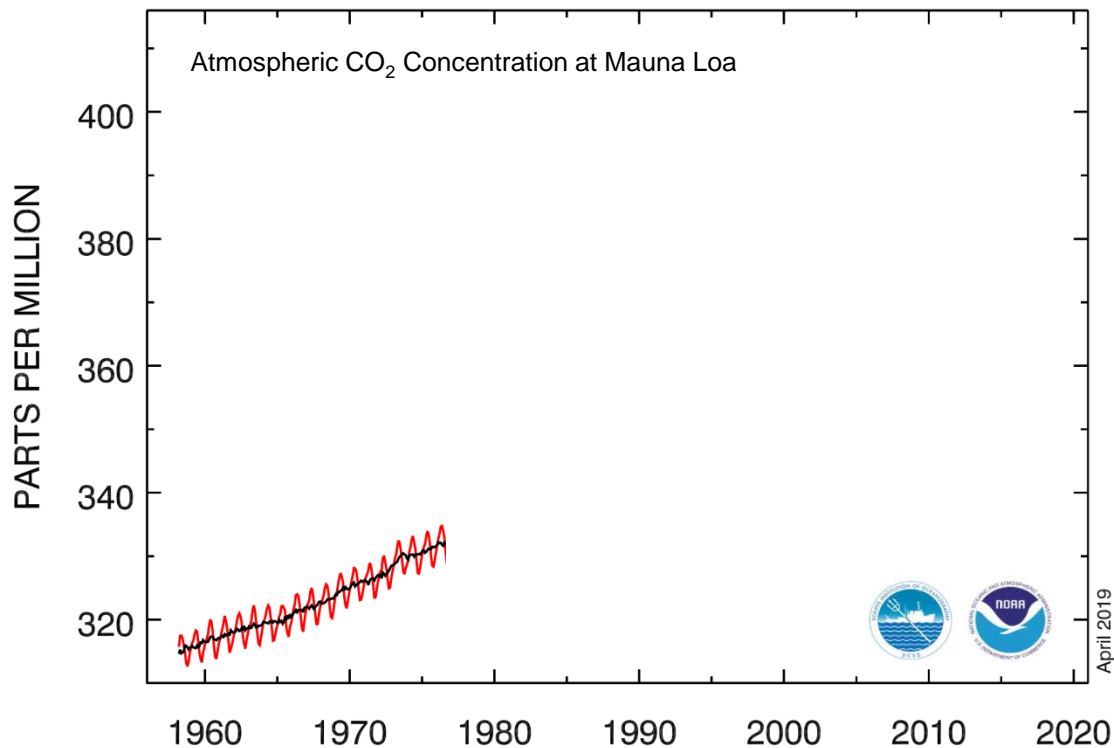




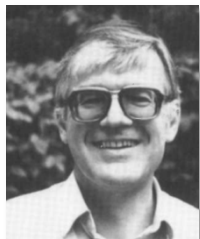
## World Meteorological Organization: Public Science Lecture 2019

1. 40 Years of climate assessment
2. Comprehensive models: the basis for climate assessments
3. Tipping points: Confusion or robust knowledge?
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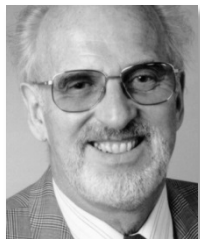
# Earth System Knowledge: Observe and measure



1978



Uli Siegenthaler



Hans Oeschger

## Predicting Future Atmospheric Carbon Dioxide Levels

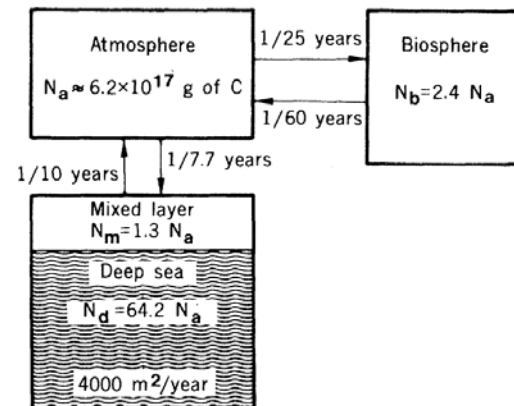
The predictions provide a basis for evaluating the possible impact of the continuing use of fossil fuel.

U. Siegenthaler and H. Oeschger

Since the beginning of industrialization man has been significantly changing the atmospheric carbon dioxide concentration. Until 1974 the fossil fuel CO<sub>2</sub> input into the atmosphere amounted to roughly 21 percent of the preindustrial atmospheric CO<sub>2</sub> content, and as a result the atmospheric CO<sub>2</sub> level increased by about 13 percent. If we continue to exhaust oil and coal reserves at a faster and faster rate, in a few decades the increase of the atmospheric CO<sub>2</sub> concentration will be of the same order of magnitude as the preindustrial CO<sub>2</sub> concentration it-

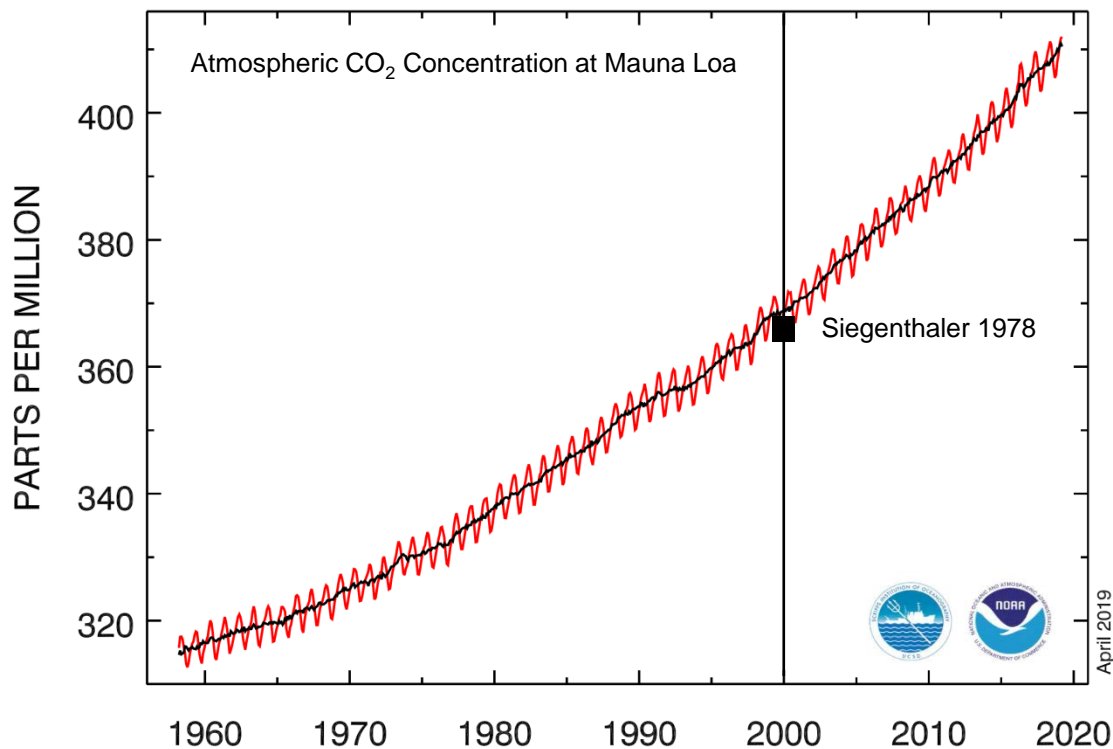
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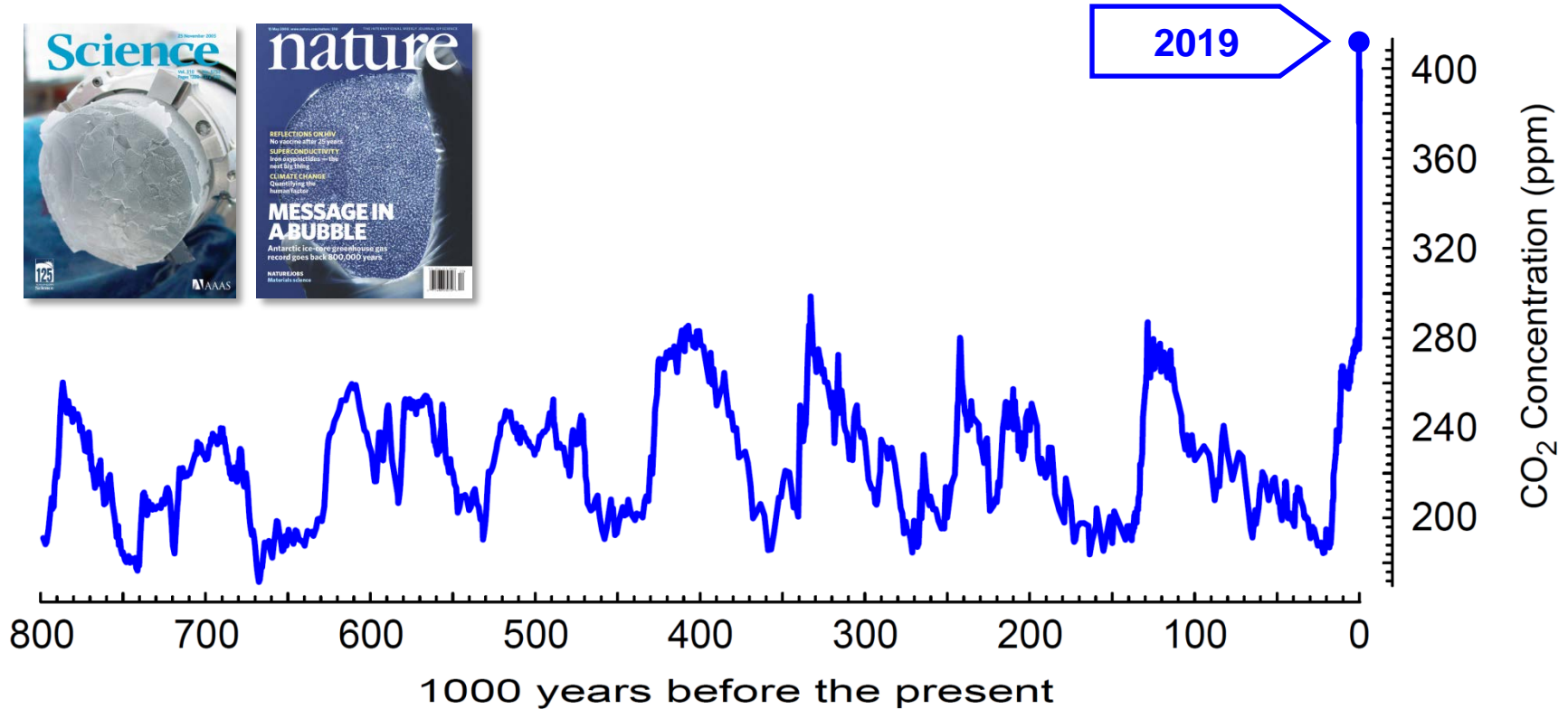
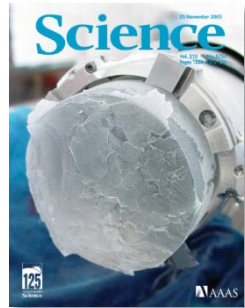


«... a maximum permissible atmospheric CO<sub>2</sub> level might be found which should not be exceeded if the atmospheric radiation balance is not to be disturbed in a **dangerous way**.»

# Earth System Knowledge: ... to policy relevant information



# Earth System Knowledge: ... to policy relevant information



# From science to assessment: The first consensus report



Wallace Broecker



Jule Charney

1975

## **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<sub>2</sub> 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

<sup>18</sup>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<sub>2</sub> 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

1979

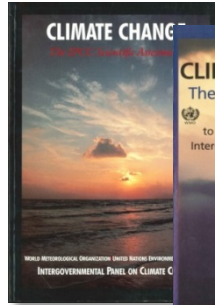
## **Carbon Dioxide and Climate: A Scientific Assessment**

**Report of an Ad Hoc Study Group on Carbon Dioxide and Climate**  
Woods Hole, Massachusetts  
July 23-27, 1979  
to the  
Climate Research Board  
Assembly of Mathematical and Physical Sciences  
National Research Council

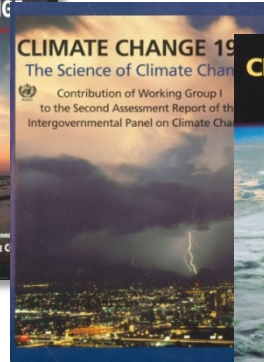
«... Their consensus [of these studies] has been that increasing carbon dioxide will lead to a warmer earth with a different distribution of climatic regimes.»



# A formalized and recognized assessment process: The IPCC



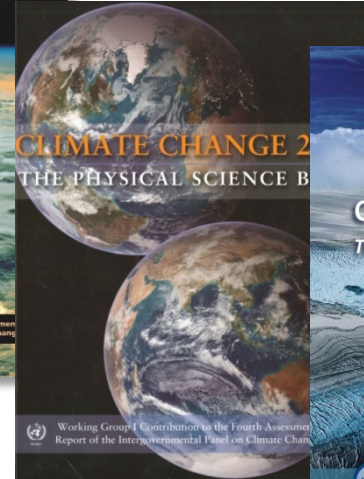
1990



1995



2001



2007



2013

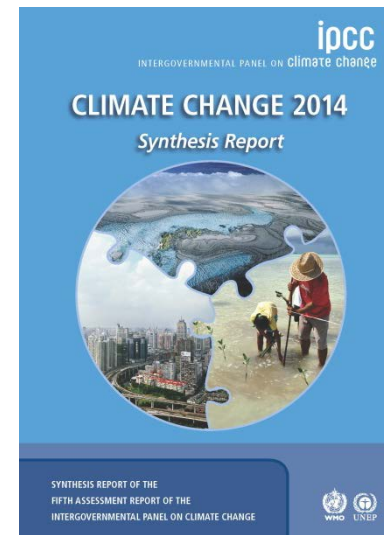
## IPCC Assessments: Understandable, policy-relevant statements

Warming of the climate system is unequivocal.

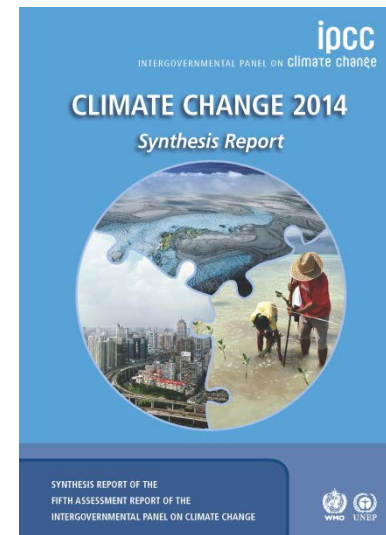
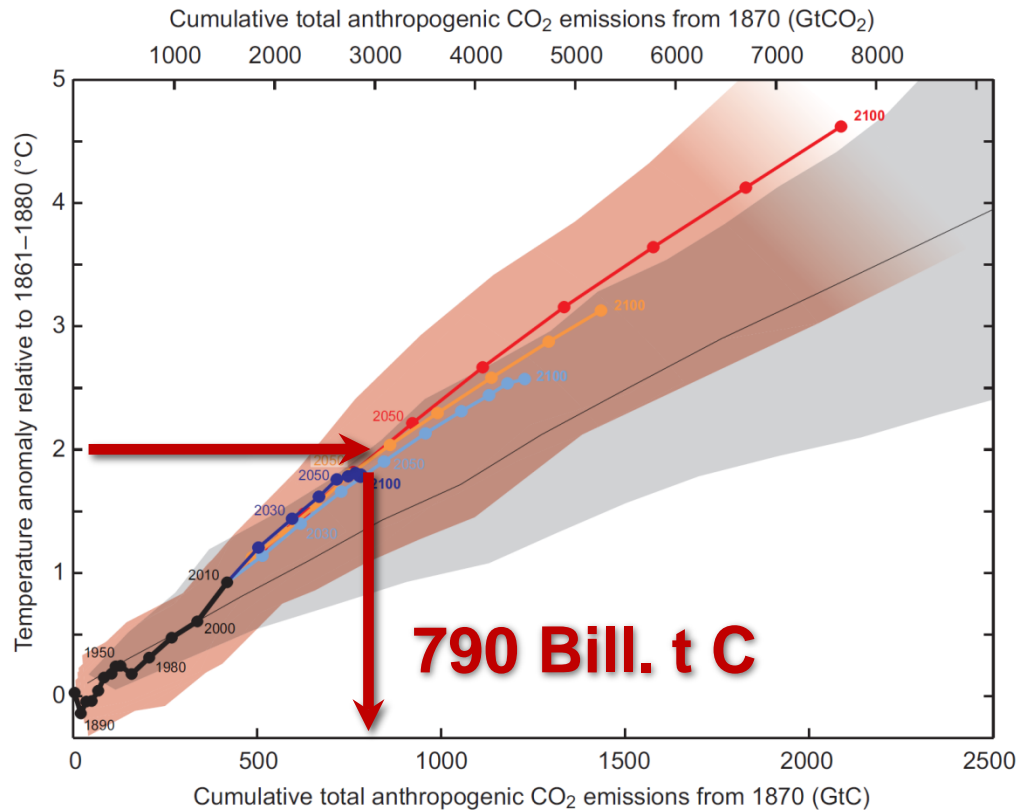
Human influence on the climate system is clear.

Continued emissions of greenhouse gases  
will cause further warming.

Limiting climate change would require substantial and  
sustained reductions of greenhouse gas emissions.



# IPCC Assessments: Numbers conveyed in compelling diagrams





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## Conclusion 1

- ❖ The scientific assessments of the IPCC are the **foundation of the UNFCCC and the Paris Agreement**.
- ❖ The pace of assessments and political and public **expectations have increased** considerably.
- ❖ This constitutes a **growing burden on the scientists** and the scientific community. Risks must be managed appropriately.



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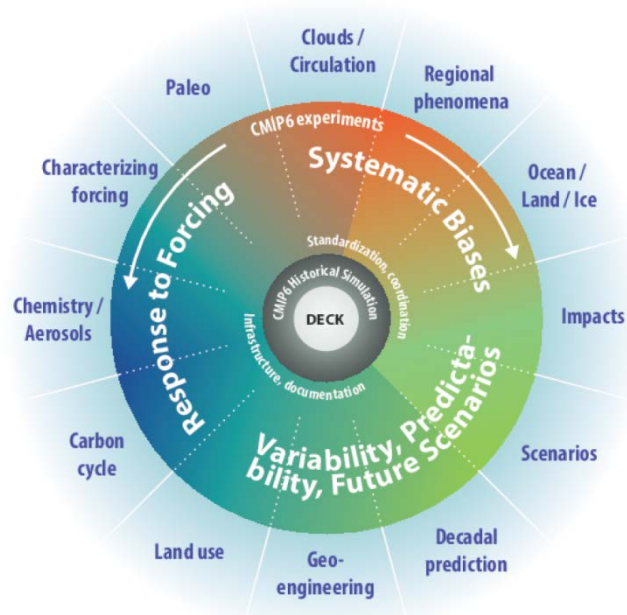
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4. Geoengineering: Dangerous interference!

# World Climate Research Program: The driving force behind IPCC numbers



## Coupled Modelling Intercomparison Project Phase 6

- ❖ common standards, metrics
- ❖ analysis tools: ESMValTool
- ❖ entry card for participation
- ❖ forcing data sets
- ❖ **23 endorsed MIPs**

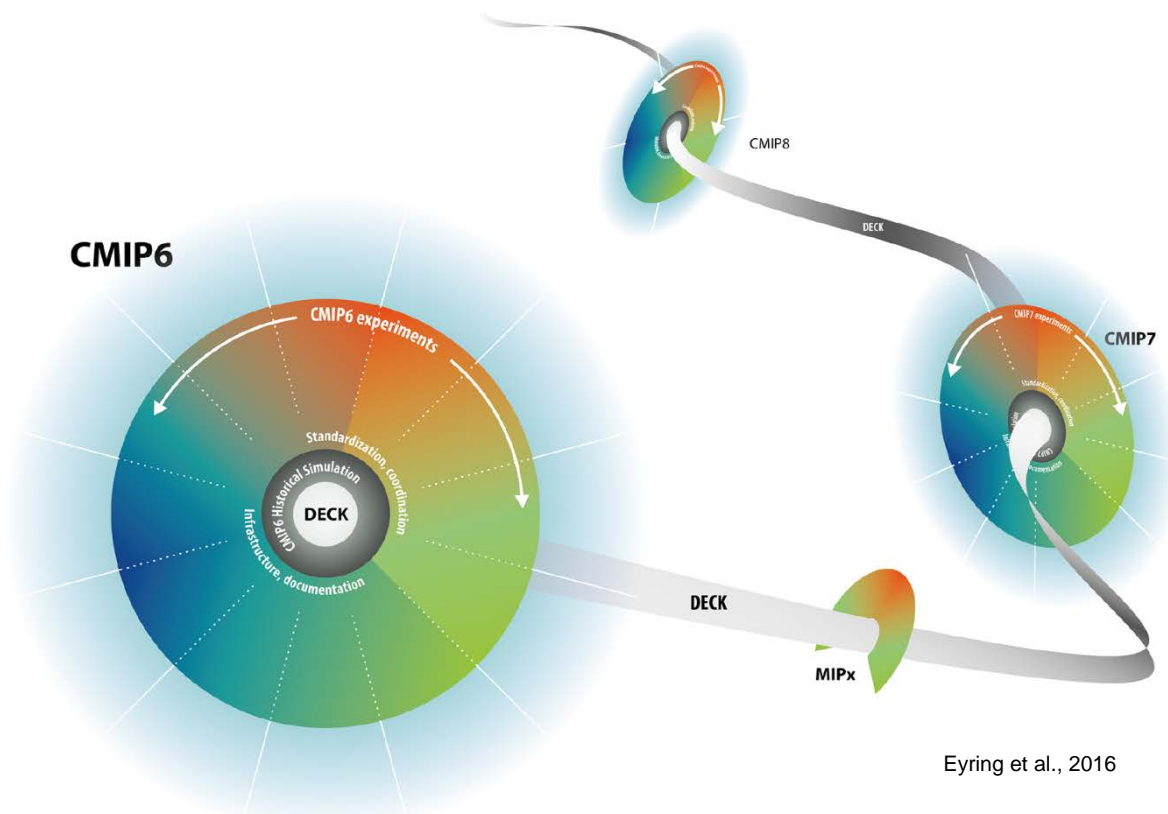




# World Climate Research Program: The driving force behind IPCC numbers

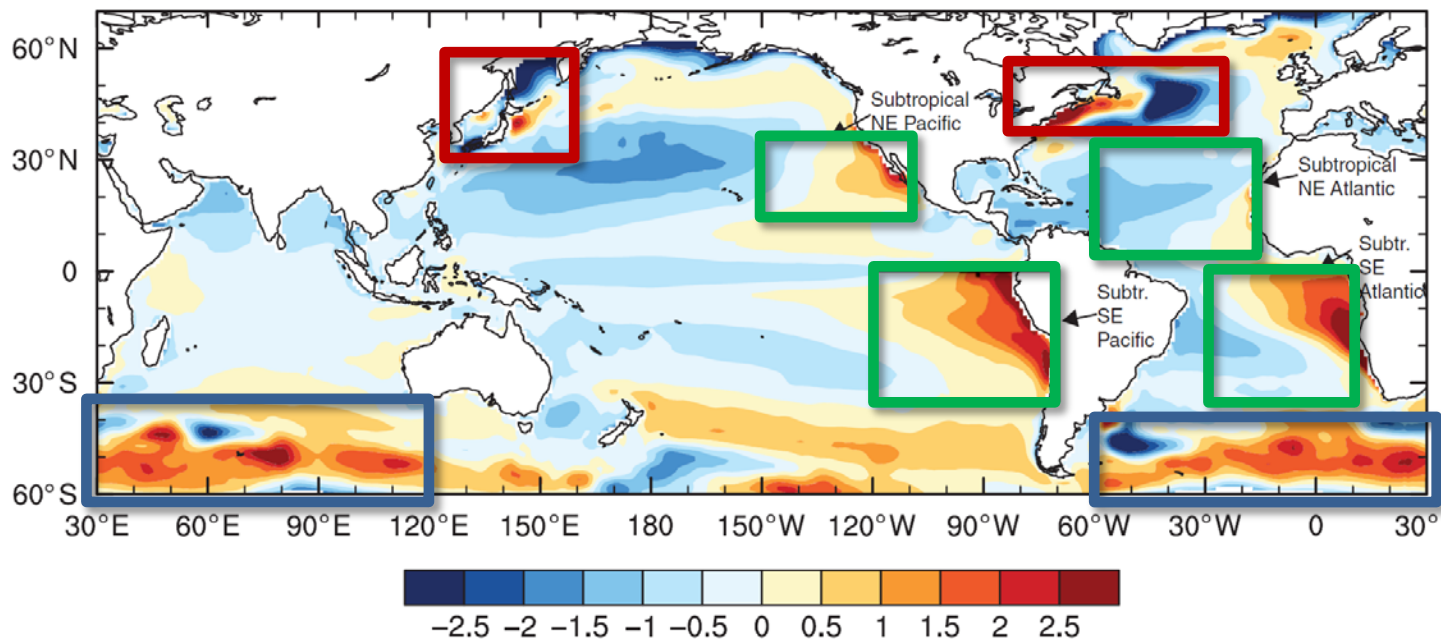


- ❖ common standards, metrics
- ❖ analysis tools: ESMValTool
- ❖ entry card for participation
- ❖ forcing data sets
- ❖ **23 endorsed MIPs**



## Systematic climate model biases persist in key regions

Annual mean SST error in CMIP5 ensemble (degC)



**Western boundary currents**

**Subtropical upwelling zones**

**Southern Ocean**





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## Conclusion 2

- ❖ Climate change **scenario calculations** have become "**near-operational**" but are still carried out at research centres.
- ❖ Comprehensive global climate models **must reach the next level of realism**. This requires continued development and evaluation.
- ❖ **Seamless climate prediction** is an emerging effort that needs an institutional home.



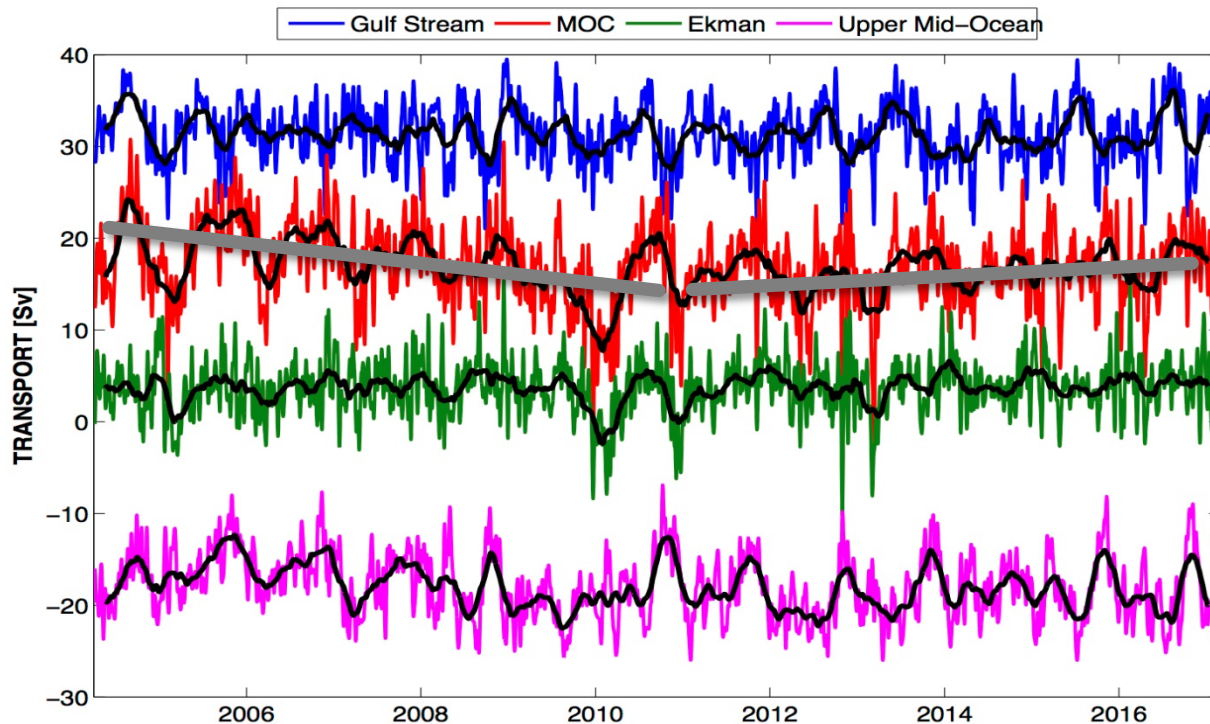
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# Tipping points: Observations are short, understanding is emerging



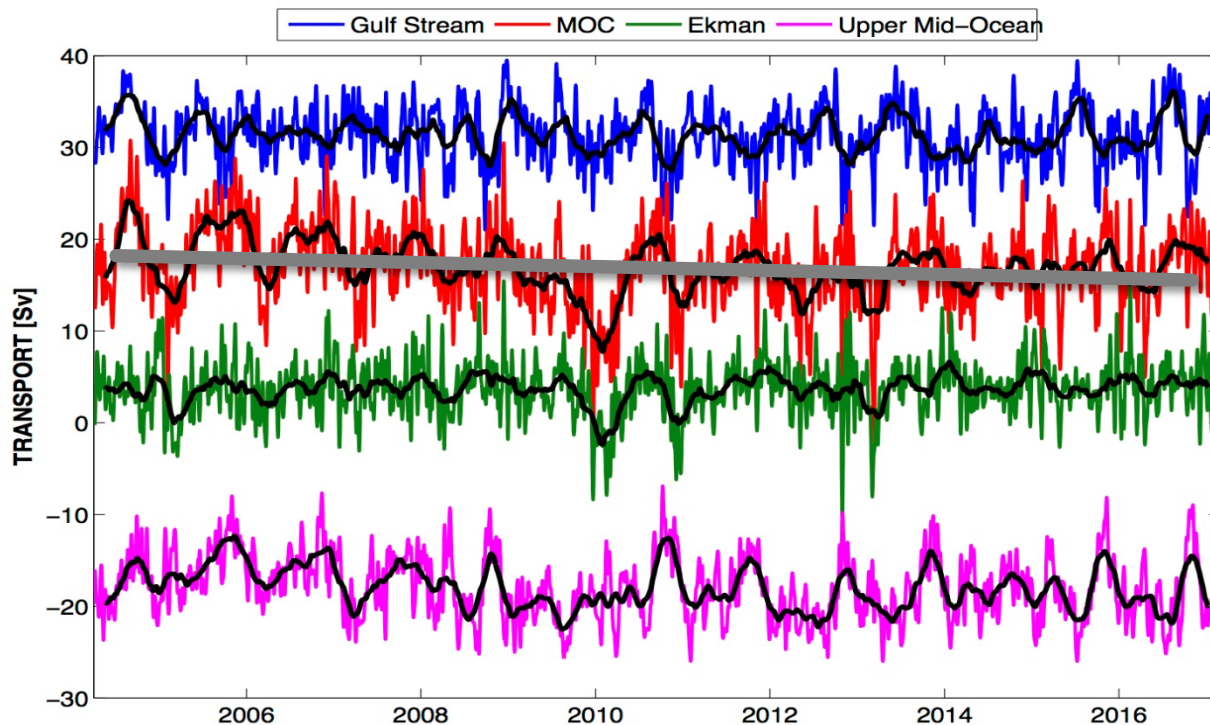
Trend or  
no trend ?



# Tipping points: Observations are short, understanding is emerging

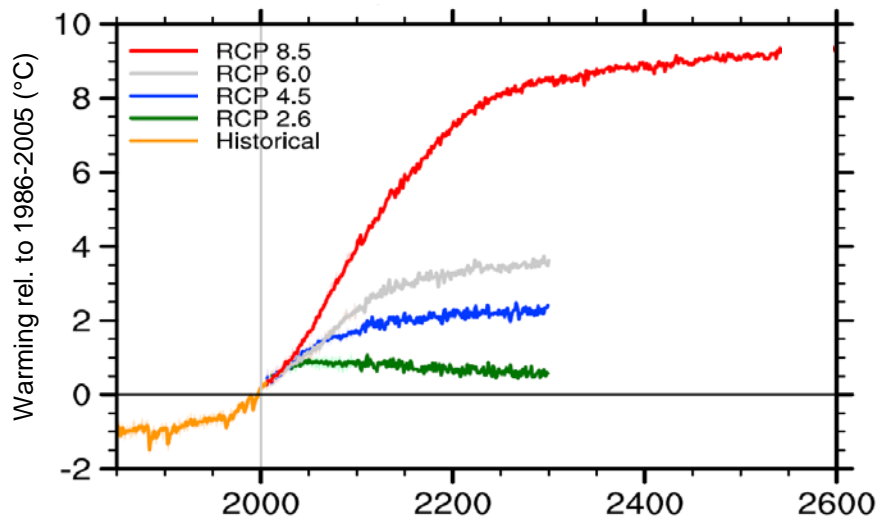


Trend or  
no trend ?

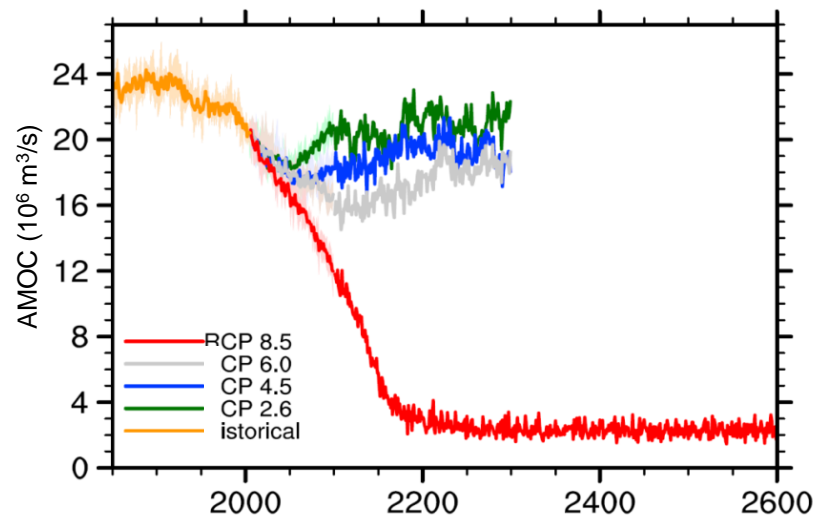


# Tipping points: Observations are short, understanding is emerging

Global mean surface temperature change

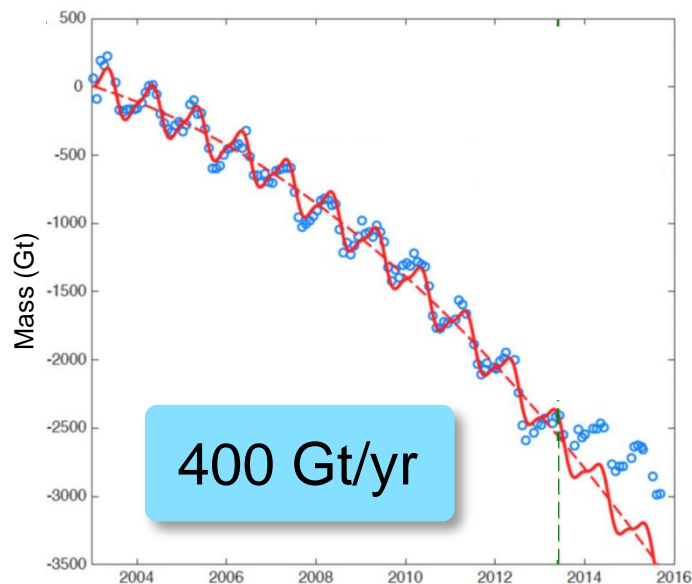


Maximum AMOC (40°N-80°N)



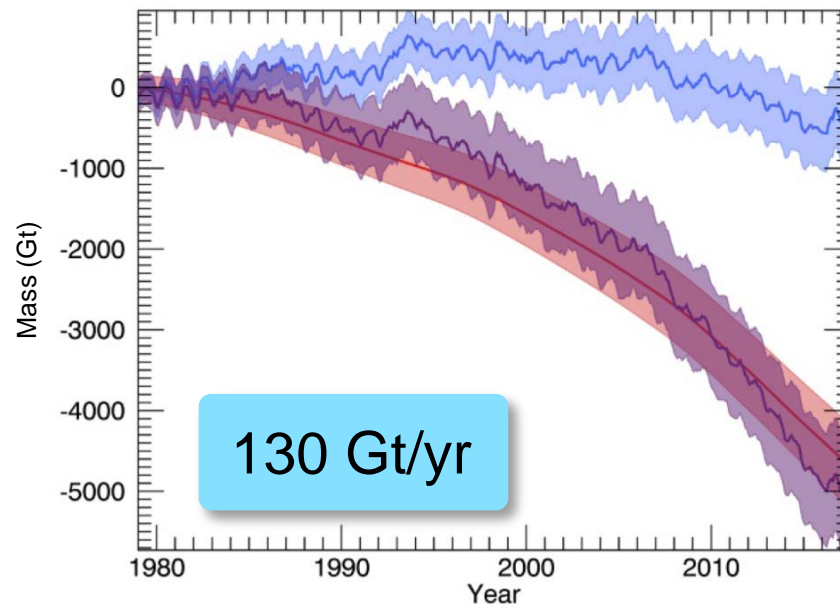
Tipping points: Observations are short, understanding is emerging

## Greenland (GRACE)



Bevis et al., 2019

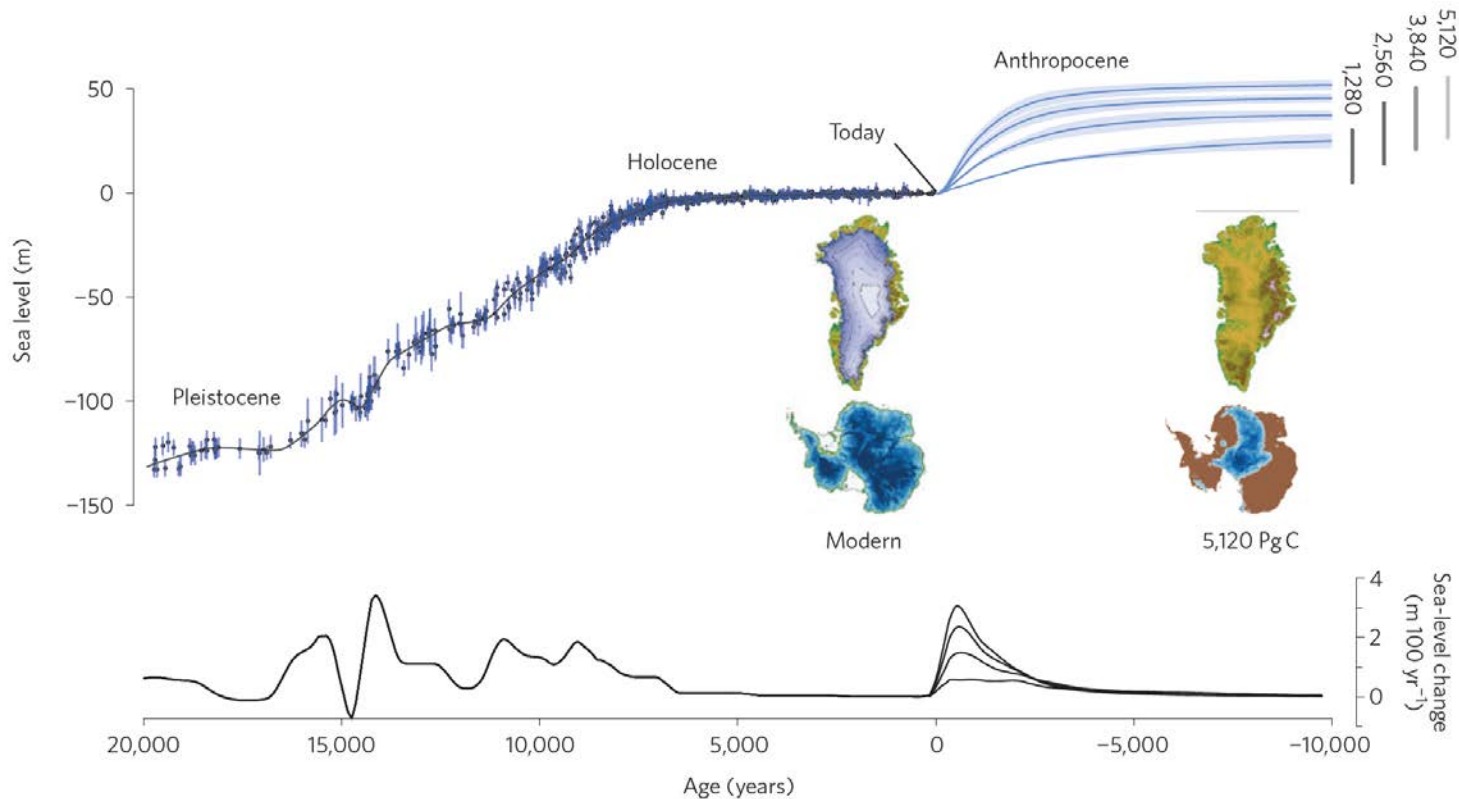
## Antarctica (various)



Rignot et al., 2019



# Tipping points: Observations are short, understanding is emerging





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### Conclusion 3

- ❖ Our understanding of **tipping points in the Earth System** is rapidly growing. Observational capability is crucial.
- ❖ Because of its high policy relevance there is a **confusion of messages**. An authoritative assessment would be timely.
- ❖ An **IPCC Special Report on Tipping Points in the Earth System** should be requested and scoped.

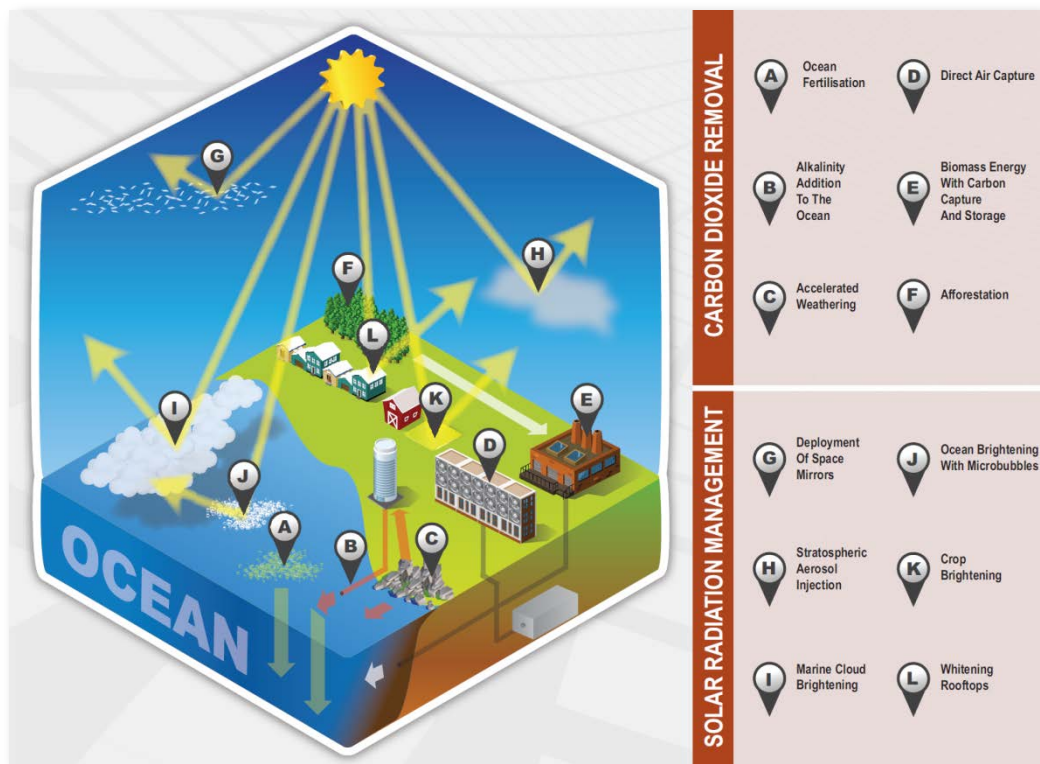




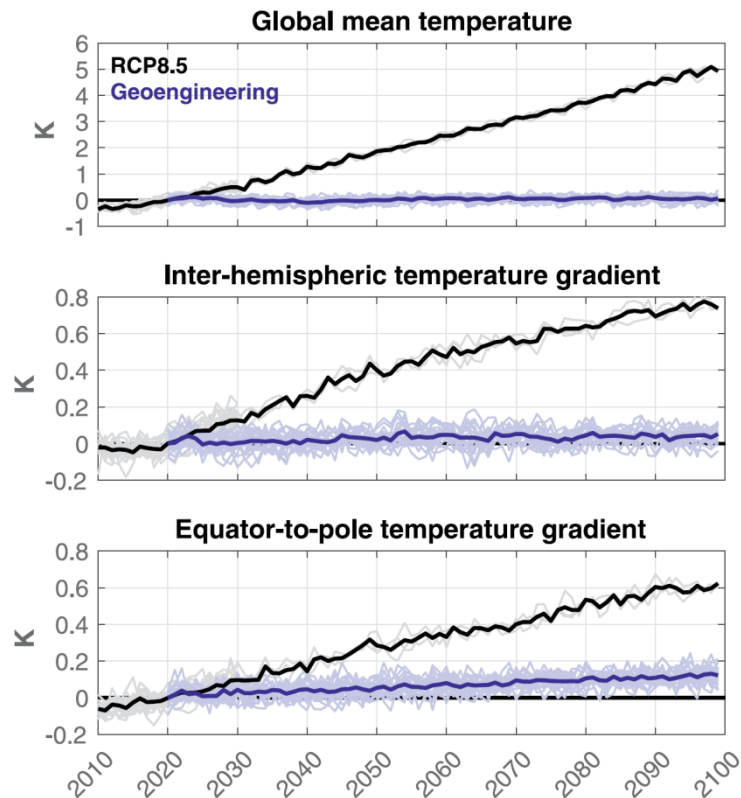
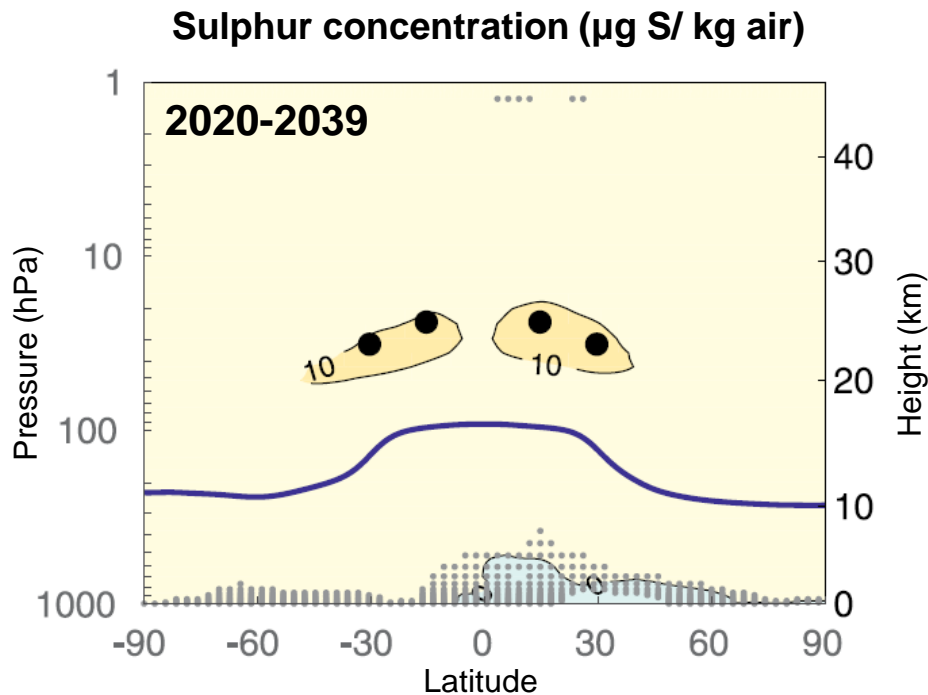
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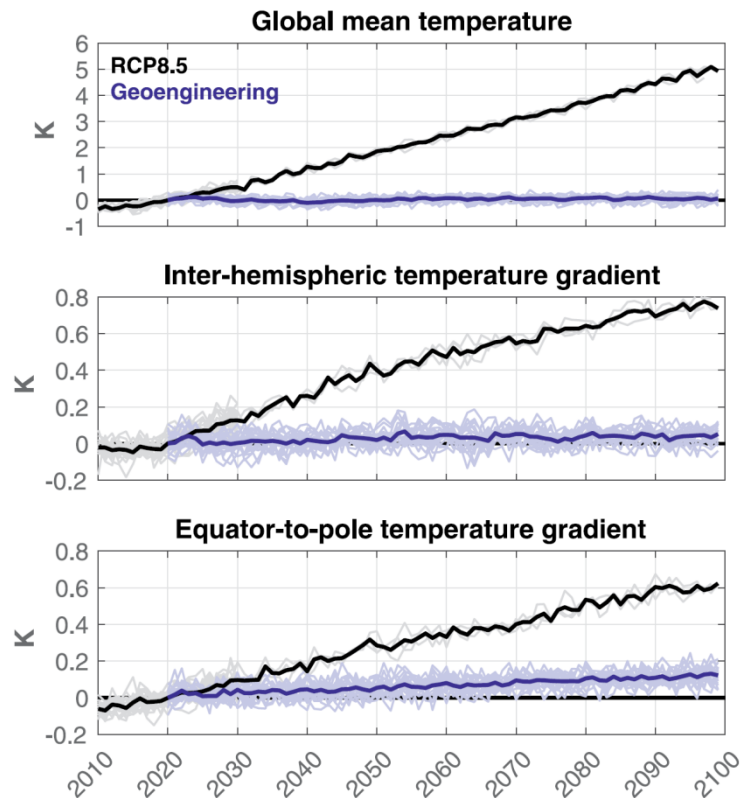
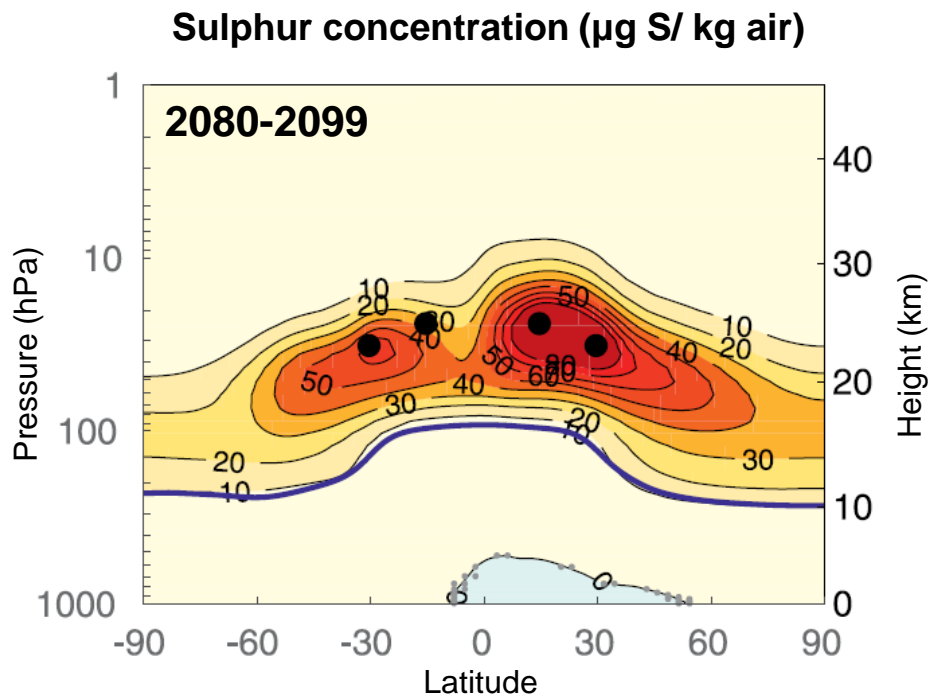
# Geoengineering: A new type of dangerous interference



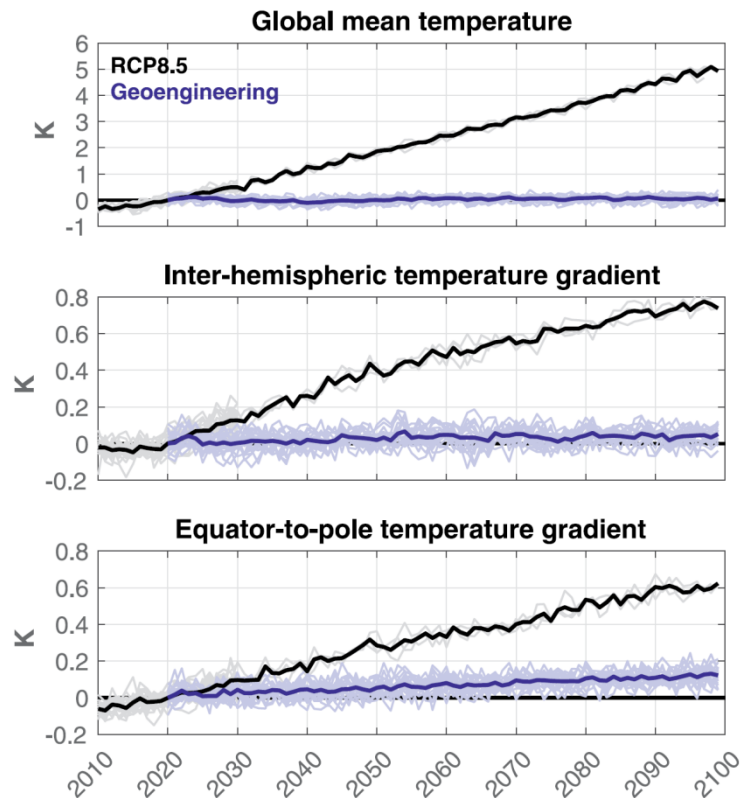
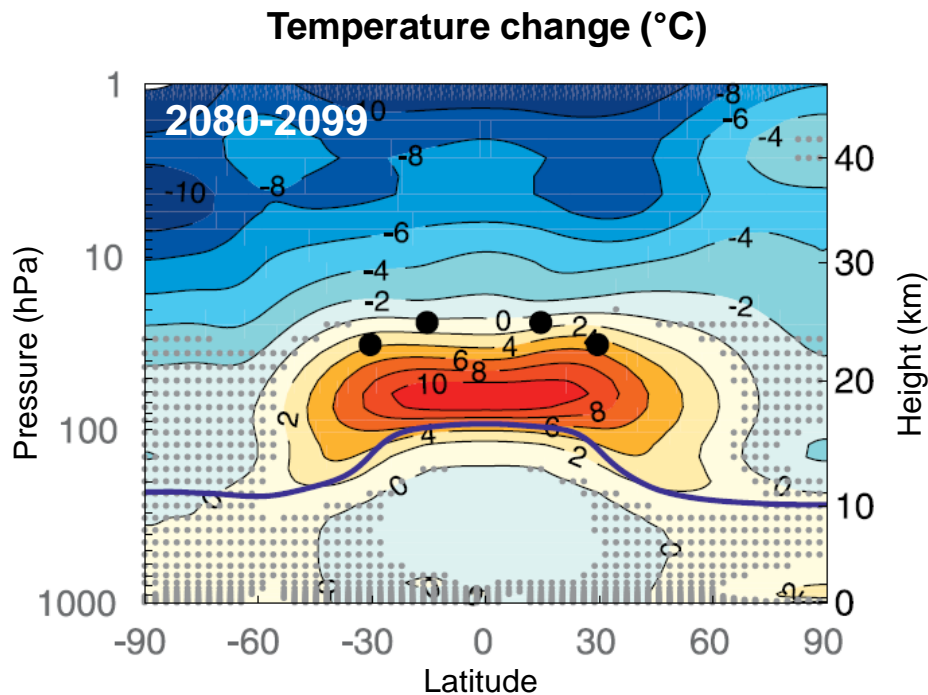
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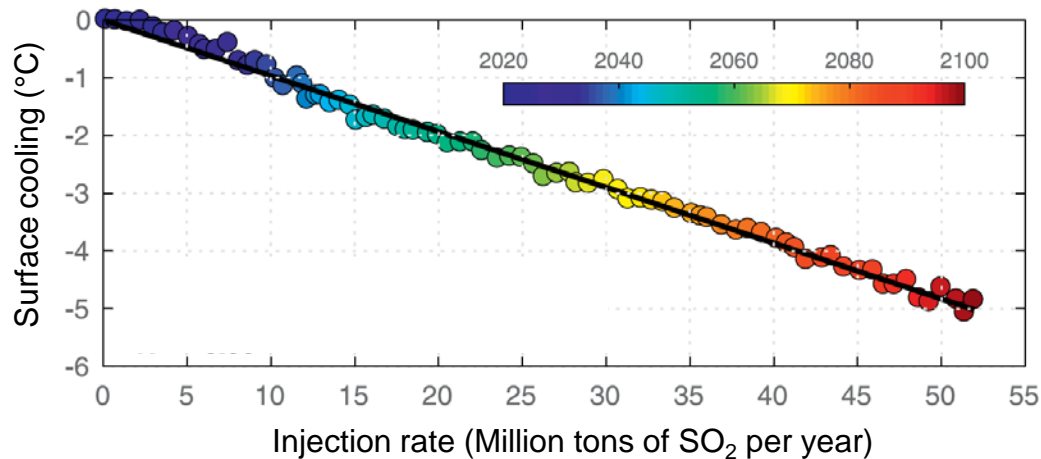
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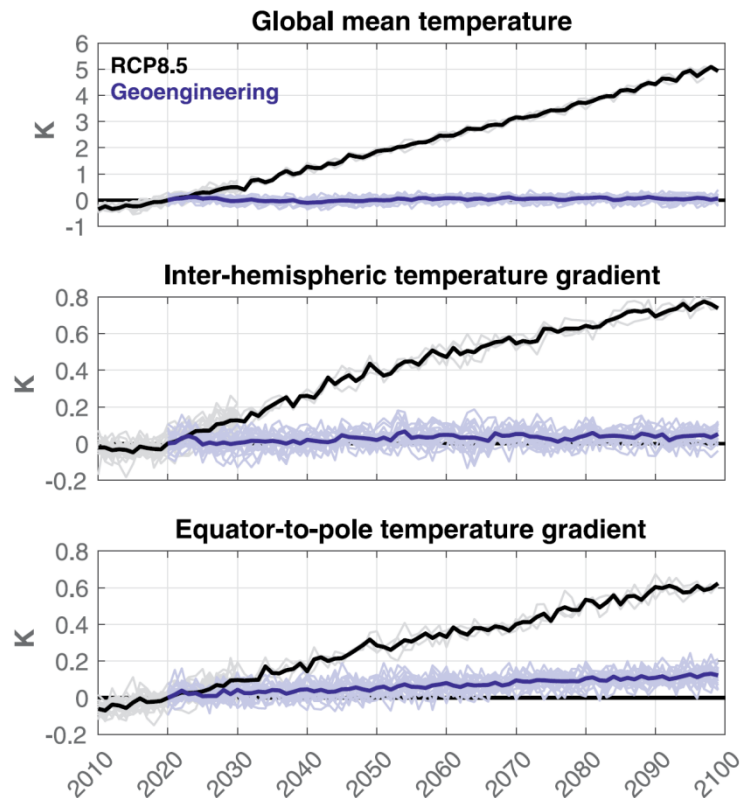


# Geoengineering: A new type of dangerous interference

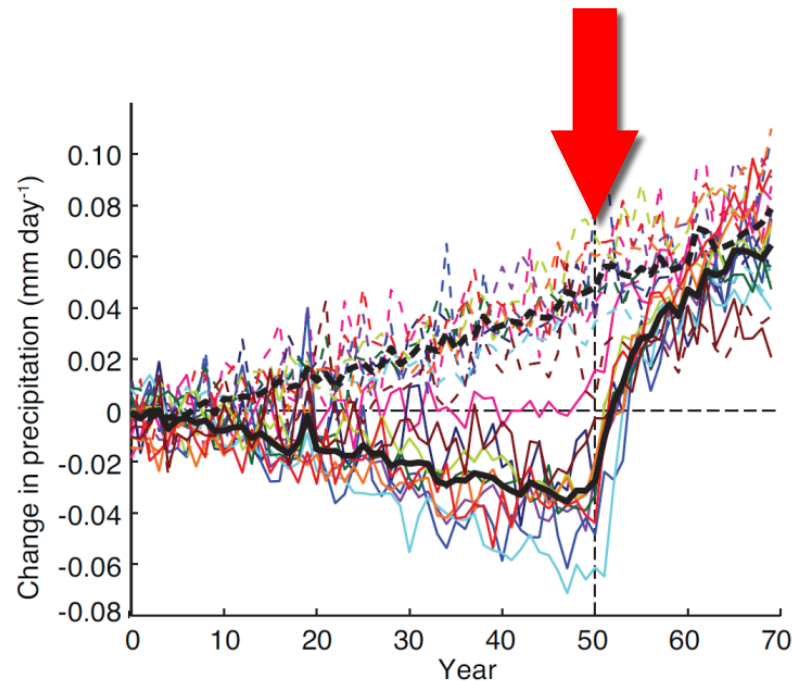
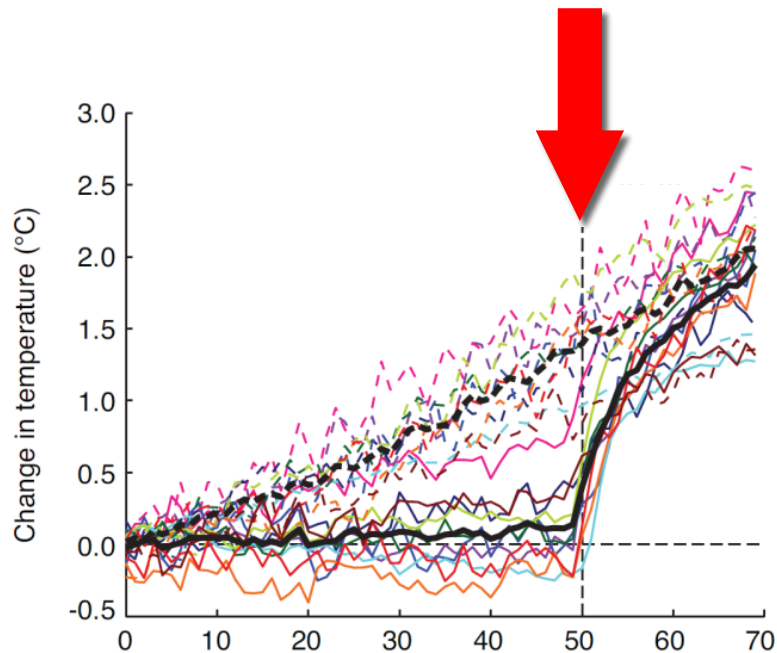


Continuous cooling implies growing  
commitment to increasing aerosol injection

**10 Million tons of  $\text{SO}_2$  per  $^{\circ}\text{C}$**



## The Termination Problem







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## Conclusion 4

- ❖ Geoengineering, in particular solar radiation management, bears **risks that are global, unknown and unquantified**.
- ❖ **Stratosphere-resolving physical-chemical models** are essential to quantify the risks and unintended impacts.
- ❖ **Geoengineering may** constitute dangerous anthropogenic interference with the climate system and **threaten Earth Stewardship**.





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## Closing Remarks

- ❖ Robust climate assessments need **more and stable resources**. Extensive scenario computations must be institutionalized.
- ❖ Climate models **must reach the next level of realism** to enable **seamless climate prediction**.
- ❖ Knowledge on **Tipping Points** requires a **timely scientific assessment**. An **IPCC Special Report** should be requested.
- ❖ Geoengineering may itself constitute ***dangerous anthropogenic interference with the climate system***.