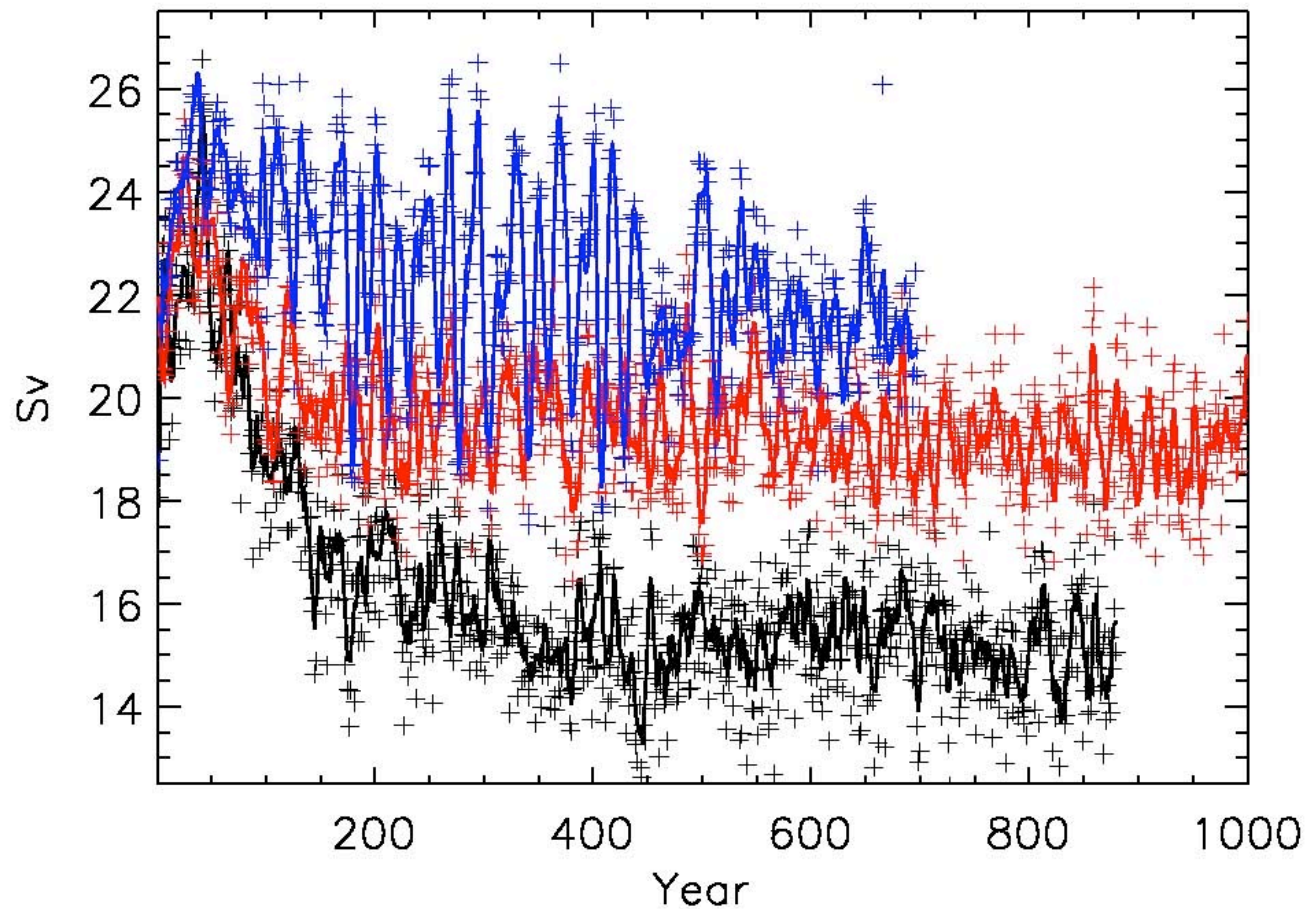


# **MOC Sensitivity to Anthropogenic Climate Forcing in the CCSM: Are There Any Abrupt Surprises?**

**Peter R. Gent**  
**NCAR**

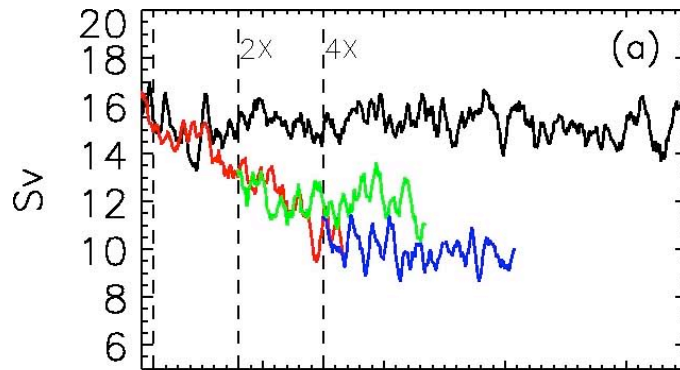
# CCSM3: Present Day Control Runs

## Maximum MOC in North Atlantic

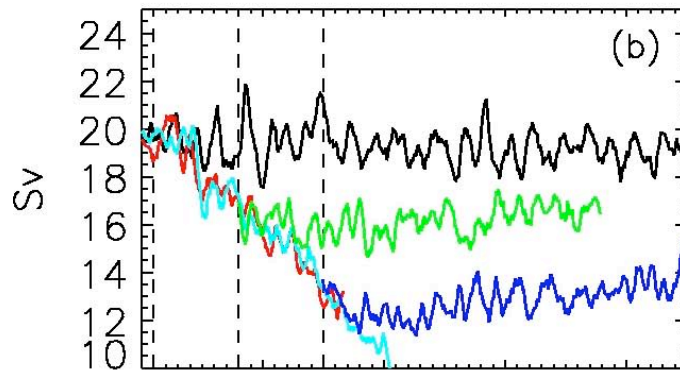


Blue: T85, ×1    Red: T42, ×1    Black: T31, ×3

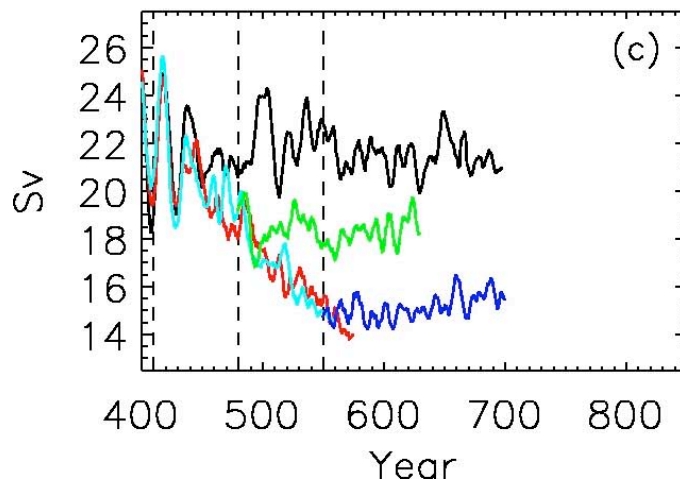
# THC Response to Increasing CO<sub>2</sub>



T31, x3



T42, x1



T85, x1

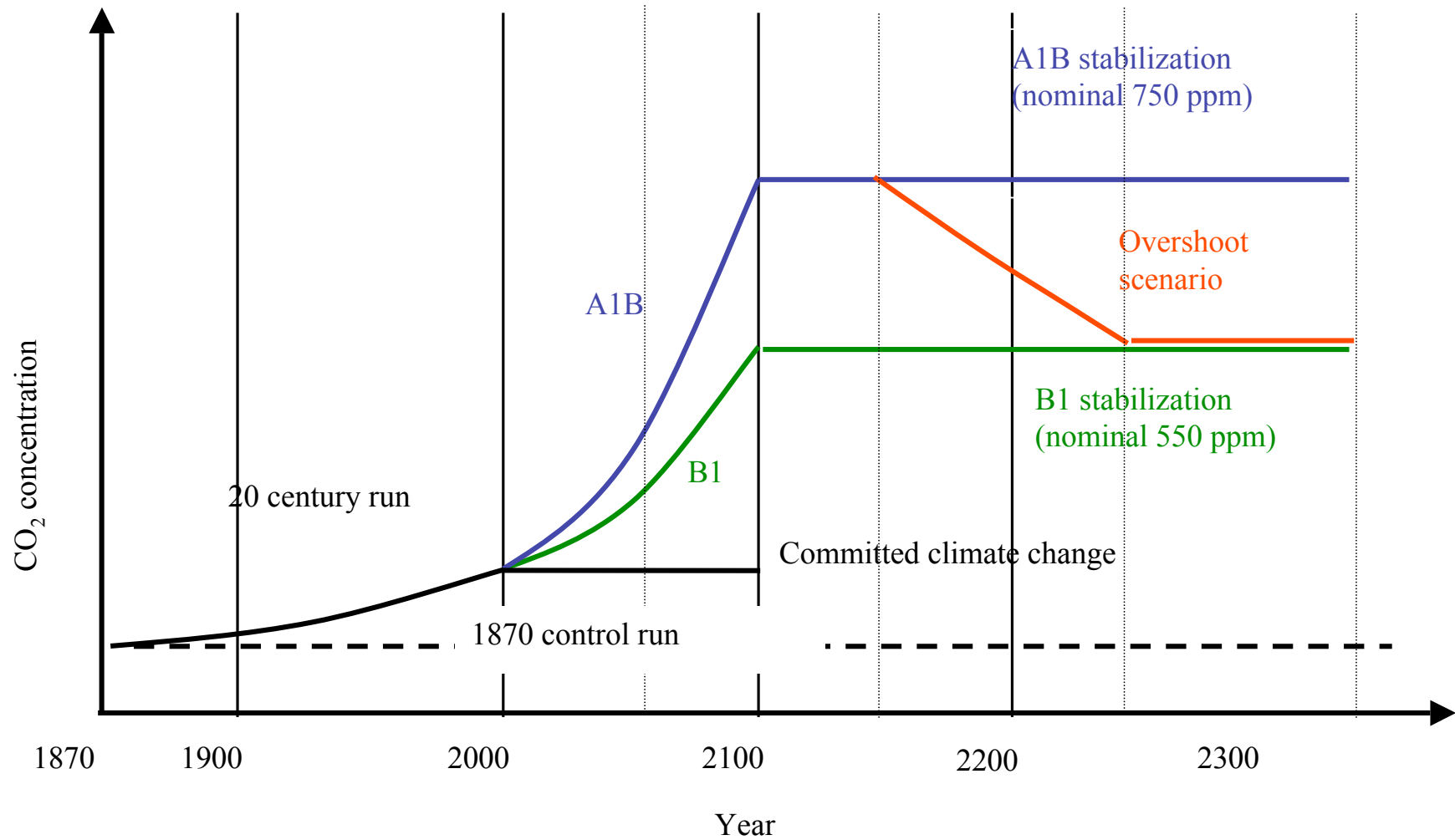
Control: Black

1% CO<sub>2</sub> Run: Red, Cyan

2 × CO<sub>2</sub>: Green

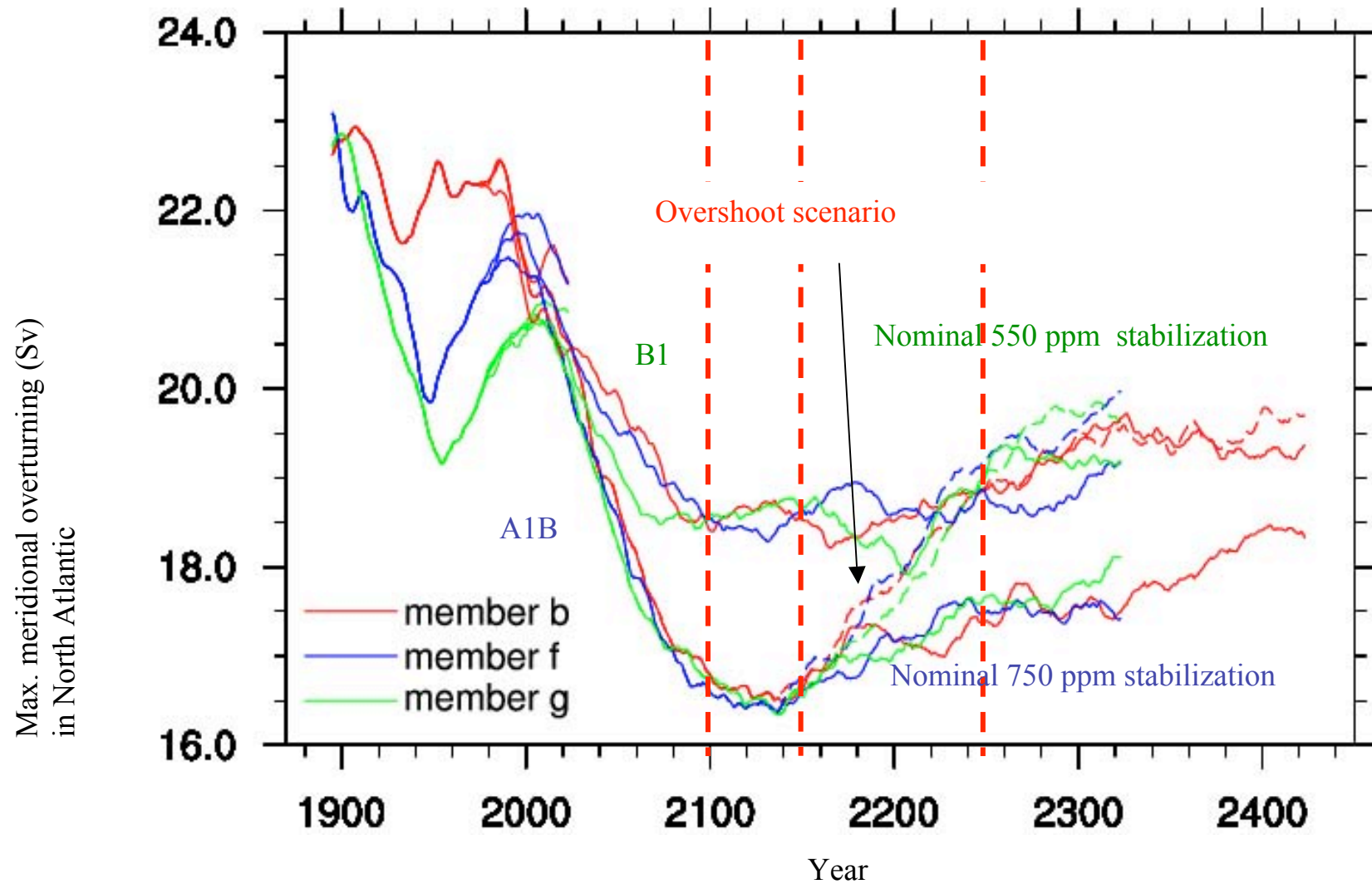
4 × CO<sub>2</sub>: Blue

# Future Scenario Runs Using CCSM3

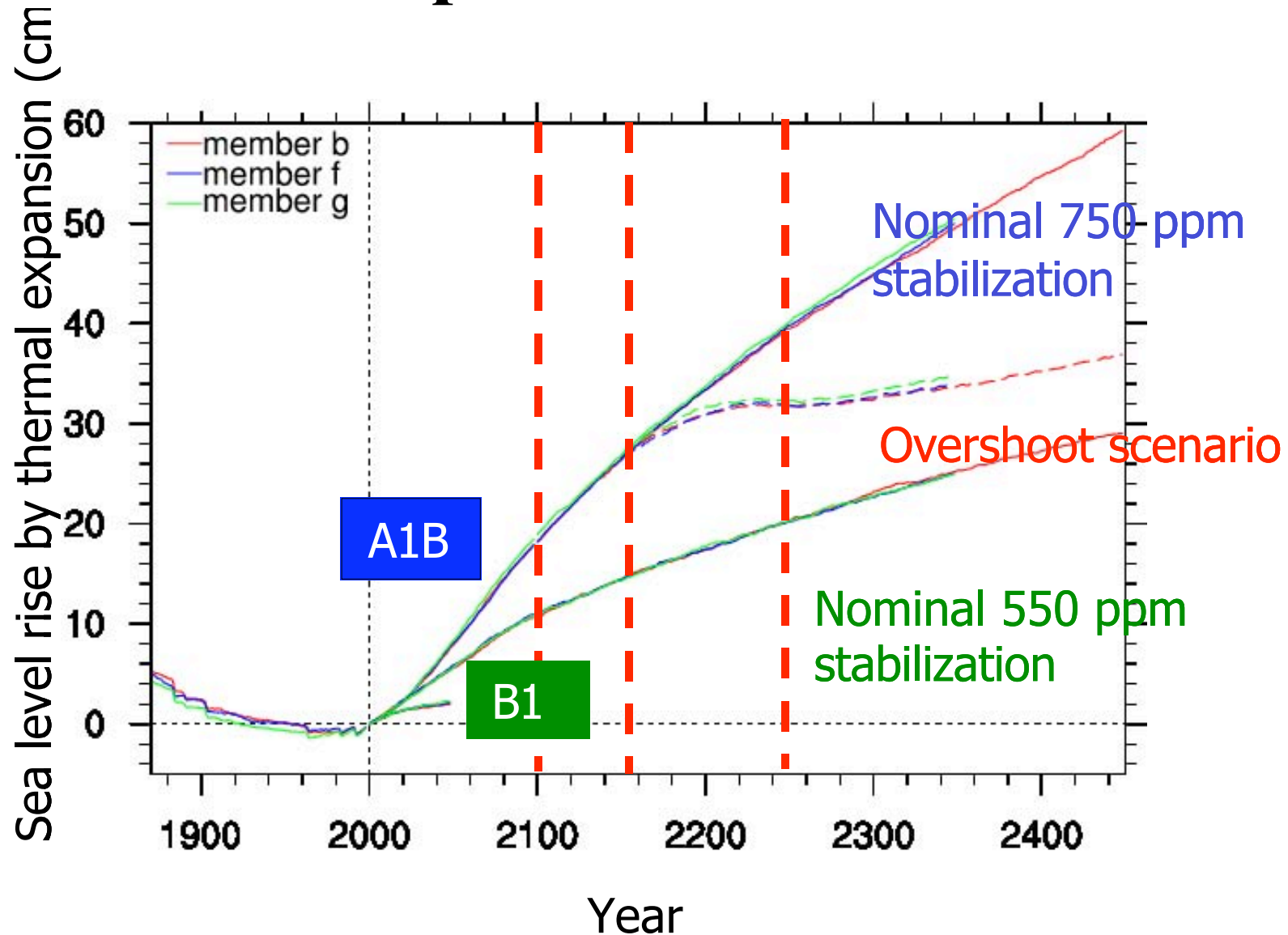




# MOC Response to Future Scenarios



# Sea Level Response to Future Scenarios



# Summary

- Gradual changes in anthropogenic forcing  
⇒ Gradual changes in North Atlantic MOC
- THC reductions, but no collapses
- THC strength appears to be simply related to the stability of the water column
- Both in deep water formation regions and in the overall North Atlantic MOC



## UK News

# Global warming may freeze out British Isles

## Conference warns of acid seas and 50-50 chance of halt to Gulf stream

Paul Brown

The chance of the Gulf stream, which brings warm waters around the British Isles, being halted, reducing temperatures by more than 5C, is now more than 50%, a scientific conference on climate change was told last week.

The conference, called by Tony Blair to inform world leaders about the urgency of reducing carbon dioxide emissions, was told of new research findings showing that climate change was speeding up and would be worse than hitherto expected.

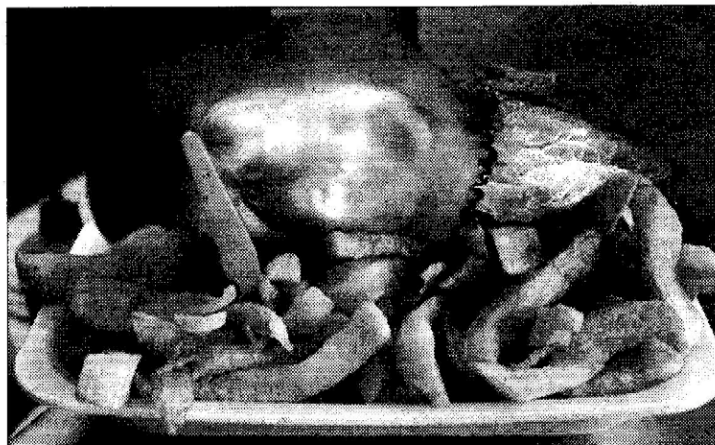
Only five years ago the scientists on the UN's Intergovernmental Panel on Climate Change were confident that Antarctica's vast ice sheets were so cold that they would not begin to melt for centuries, even if the climate changed elsewhere. The conference, in Exeter, was told that "the giant is awakening", and areas of the ice-bound continent melting, causing faster sea-level rise than expected.

For western Europe and North America the most worrying find-

ing revealed at the conference was the potential collapse of the current known popularly as the Gulf stream and to oceanographers as the Atlantic thermohaline circulation (THC). The melting of Greenland and Arctic ice and additional fresh water from rainfall is threatening to shut down the current completely.

Mike Schlesinger, from the climate research group at the University of Illinois, said a 3C rise in temperature this century, which is well within current predictions, would lead to a 45% chance of the Gulf stream halting by the end of this century and a 70% chance by 2200. But he said that some sophisticated climate models showed the current halting with as little as a 2C to 2.5C rise in temperatures — "and that is what you could call dangerous climate change".

The current, which carries 1 million billion watts of heat — a "petawatt" — from the tropics past Scotland and northwards to the Arctic is known to be weakening by about 10%, but the chance of it being switched off



**Jellyfish and chips: on the menu in a generation** Photograph: Phil Noble/PA

completely by climate change was previously considered remote. Professor Schlesinger said that even if politicians imposed stringent carbon taxes to reduce emissions there was still a greater than one in four chance of the current being turned off.

Figures from the Hadley Centre for Climate Change given at the meeting showed that in some places in the North Atlantic the temperature might drop as much as 10C, and over the UK Atlantic coast it would

be about 5C, causing a winter freeze-up.

Earlier in the week scientists warned of a newly discovered threat to mankind, which will wipe out coral and many species of fish and other sea life.

Extra carbon dioxide in the air is not only spurring climate change, but also making the oceans more acidic — endangering the marine life that helps to remove carbon dioxide from the atmosphere.

So alarmed have marine scientists become about this that special briefings have been held for government departments. The head of science at Plymouth Marine Laboratory, Carol Turley, warned of a "potentially gigantic" problem for the world.

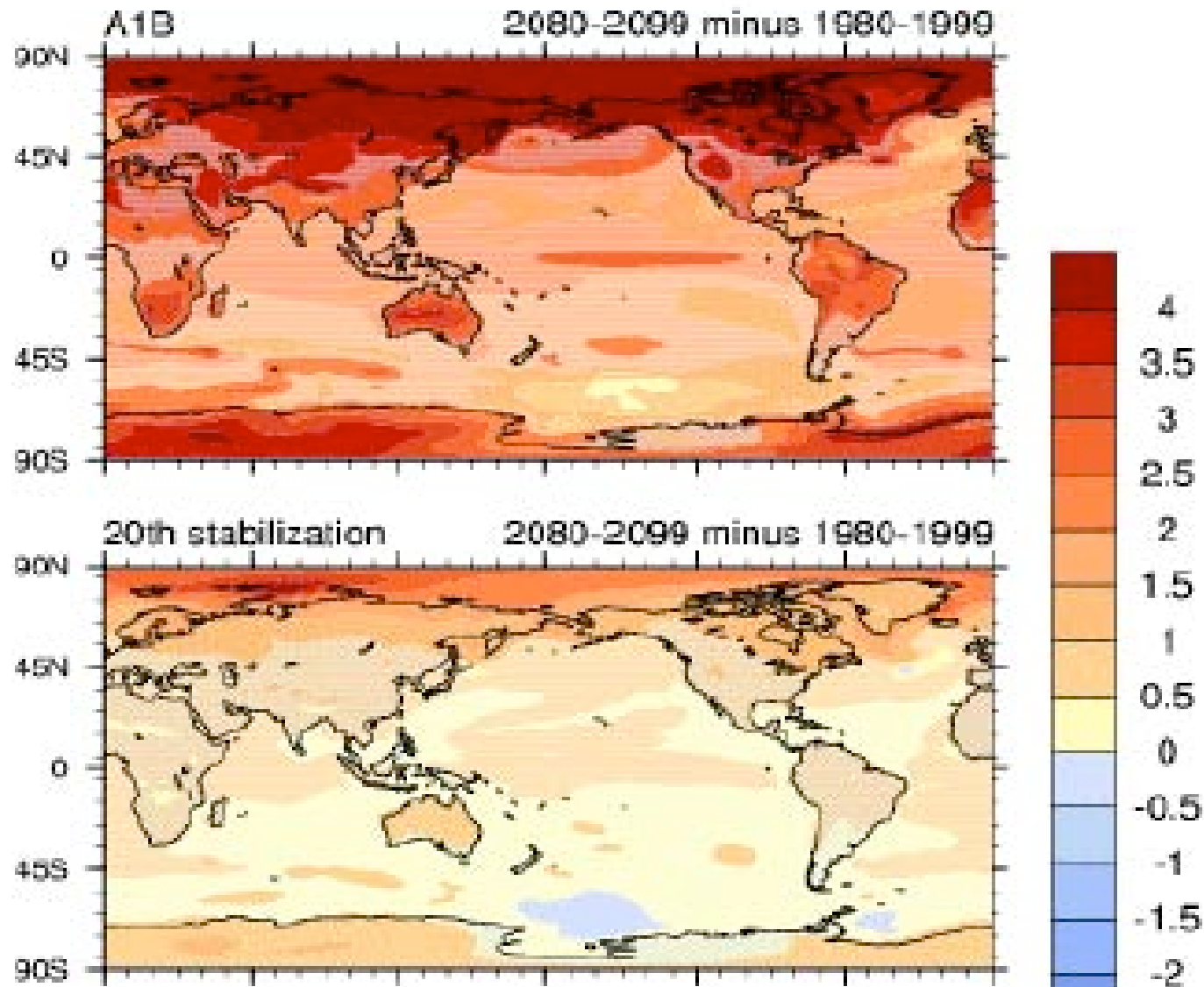
"It is very urgent to warn people what is happening," she said. "Many of the species we rely on to eat, like cod, will disappear. In cartoon form, you could say people should prepare to change their tastes and switch from cod and chips to jellyfish and chips. The whole composition of life in the oceans will change."

Although the phenomenon is caused by excess carbon dioxide in the atmosphere, it is not a "global warming" problem but a simple chemical reaction between air and sea. Carbon dioxide mixed with water produces carbonic acid, which is making the alkaline oceans more acidic.

"Scientists did not look at this problem because everyone assumed that the chemical composition of the sea was constant. But this change is O-level chemistry and we missed it," said Dr Turley. The oceans' vital role in limiting CO<sub>2</sub> levels in the air will have to be reassessed in light of the findings.



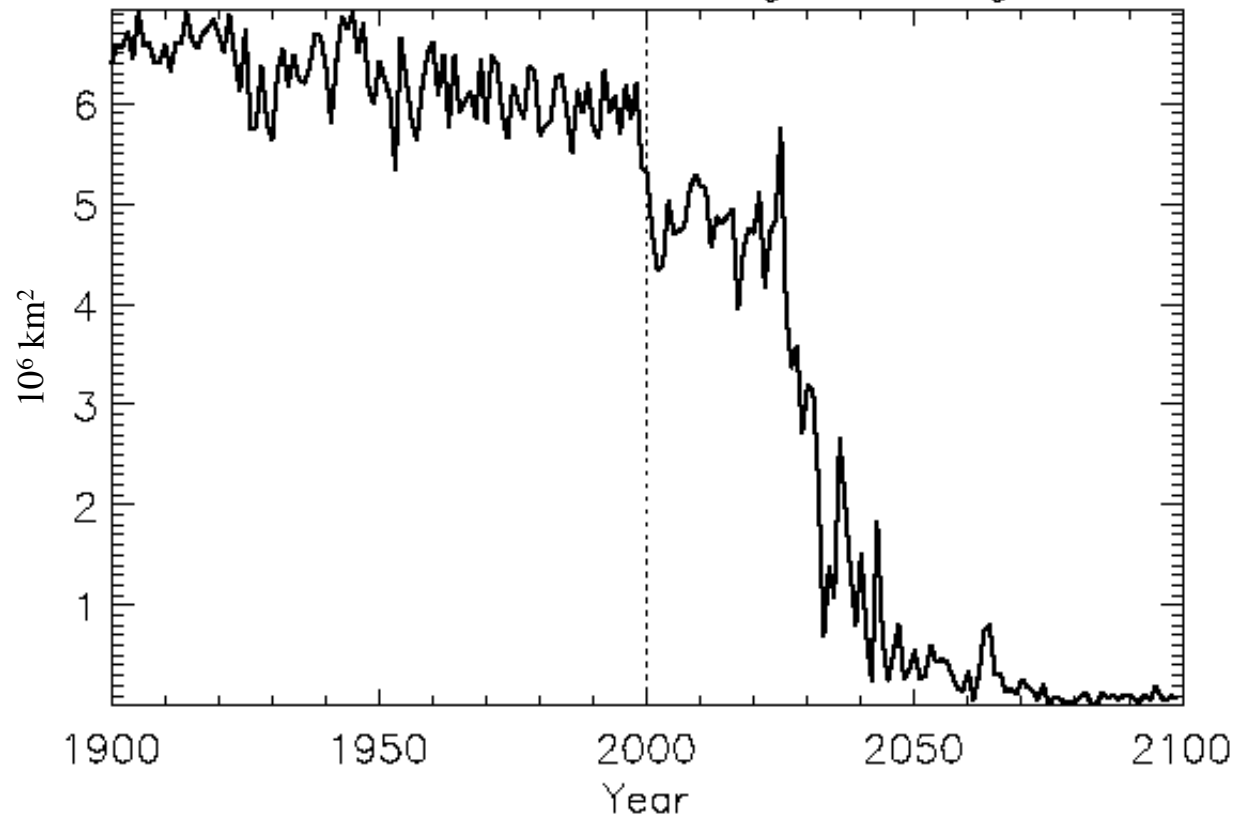
## surface air temperature



By end of 21st century SAT consistently warms in all scenarios

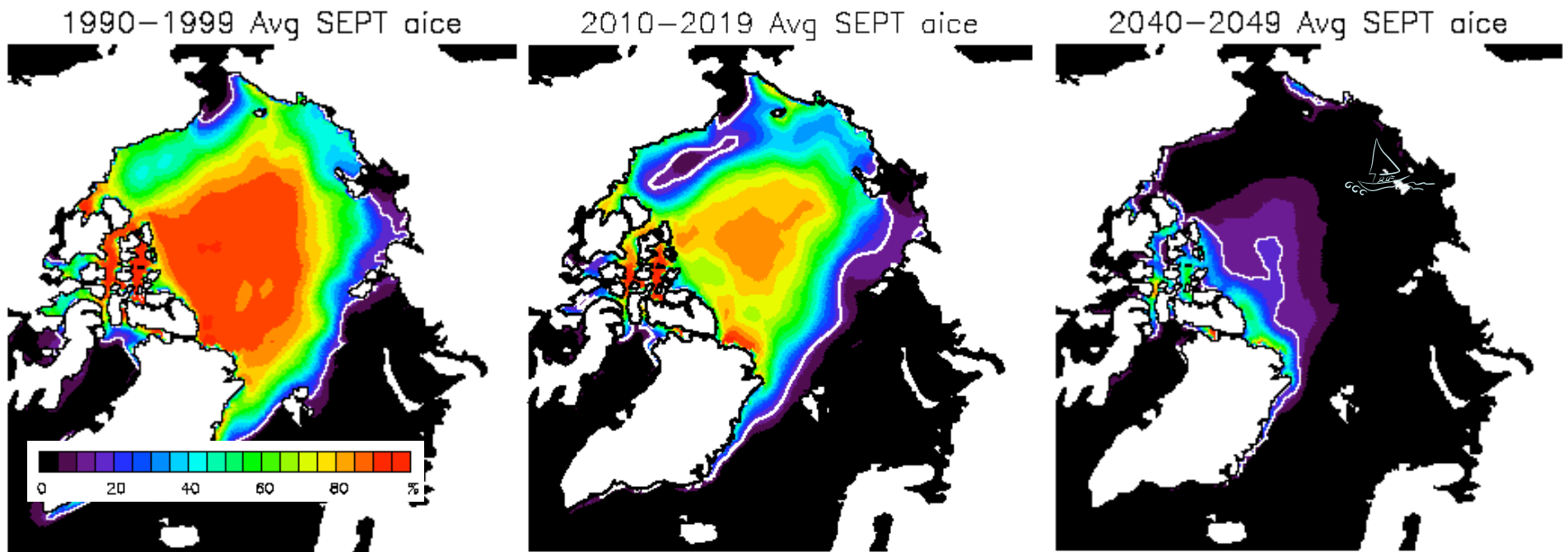
# Abrupt transitions in Sea Ice

September ice extent timeseries



Although forcing is gradual, abrupt transitions in sea ice do occur in some simulations.

# Sea Ice Conditions

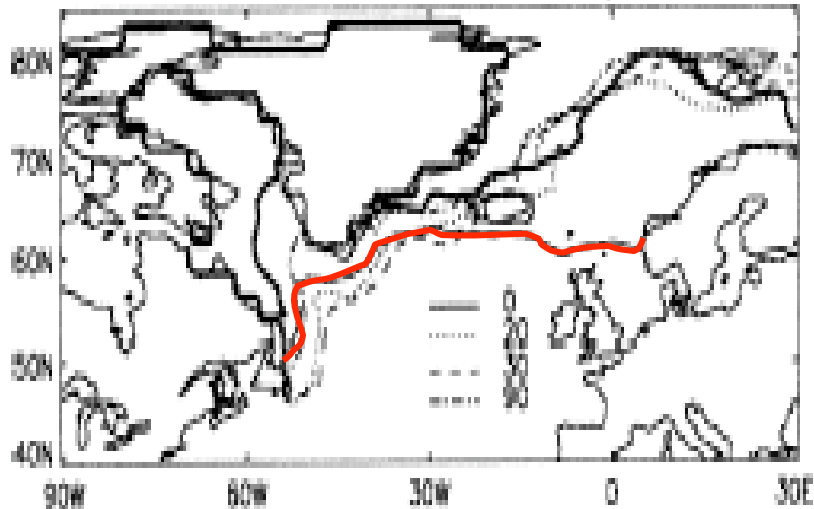




# Simulated abrupt transitions in sea ice

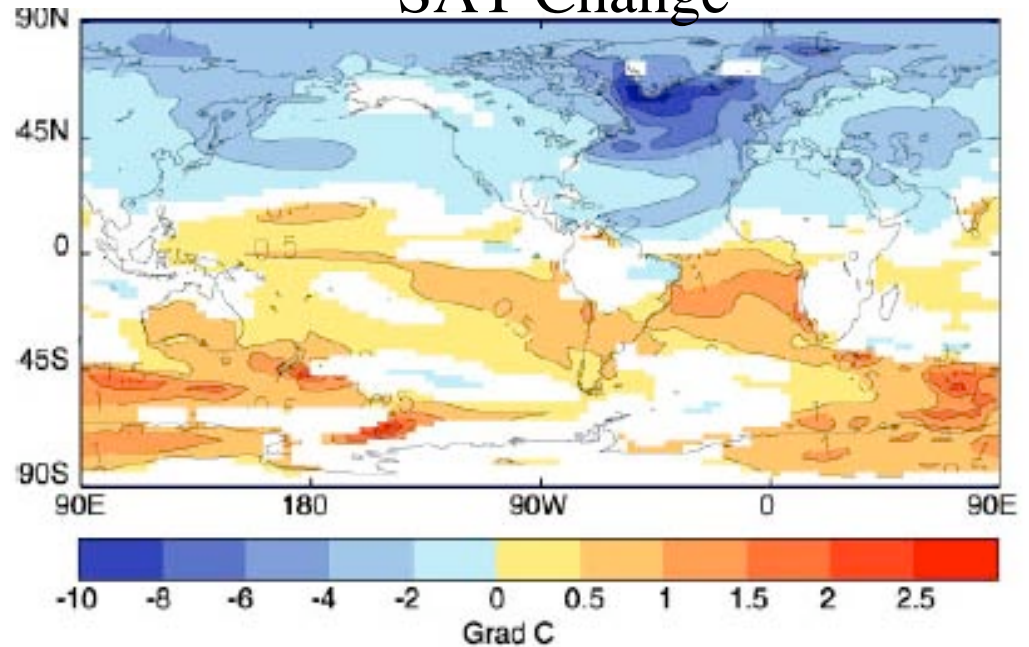
abrupt forcing (freshwater hosing) can result in abrupt ice changes

Sea ice change



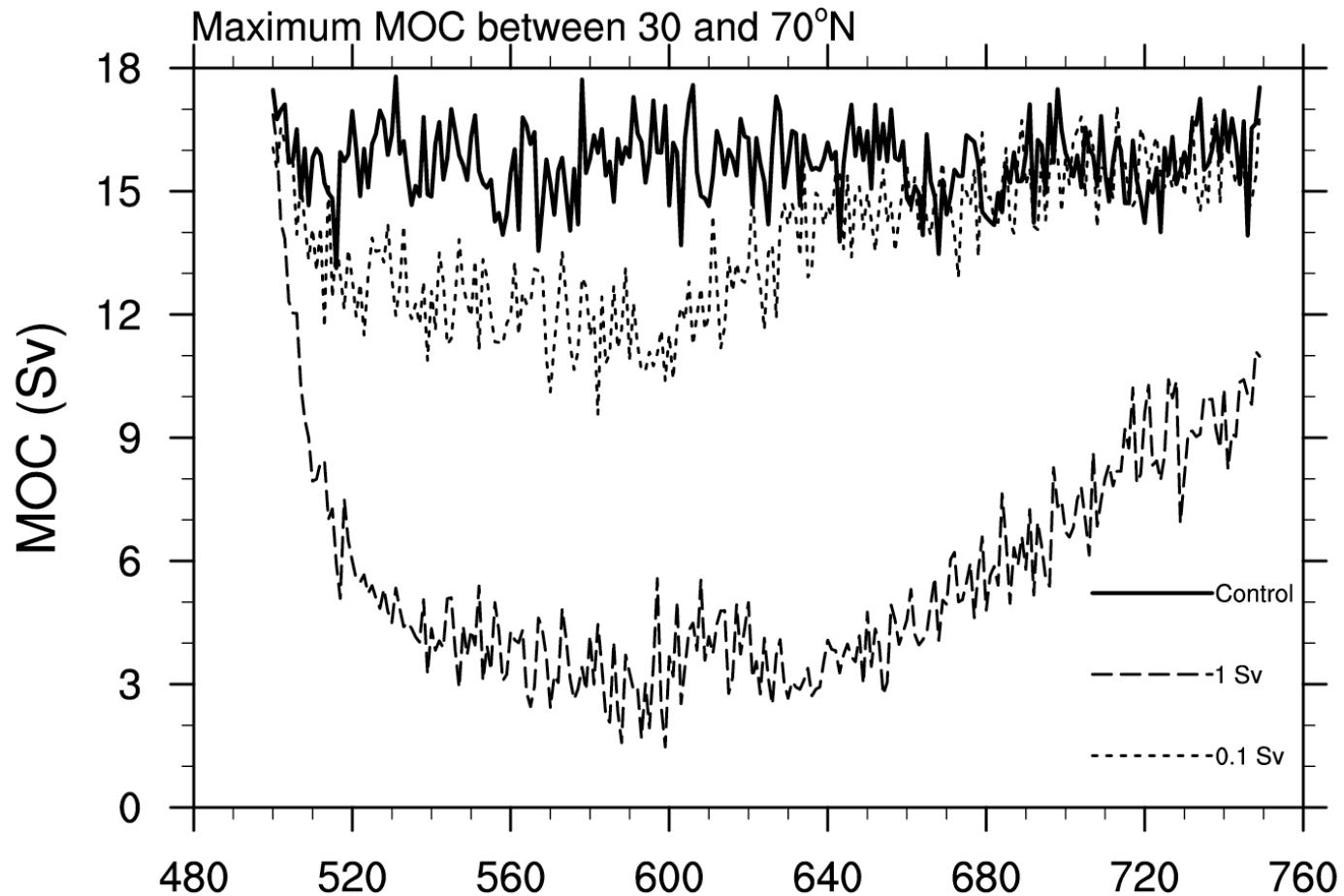
(From Vellinga and Wood, 2002;  
Vellinga et al, 2002)

SAT Change

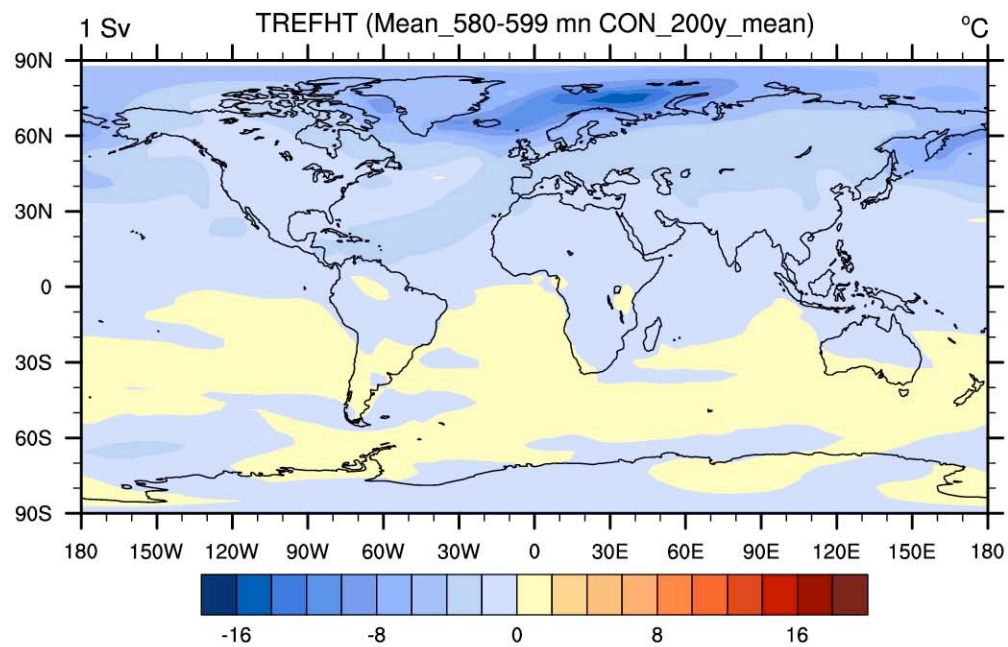
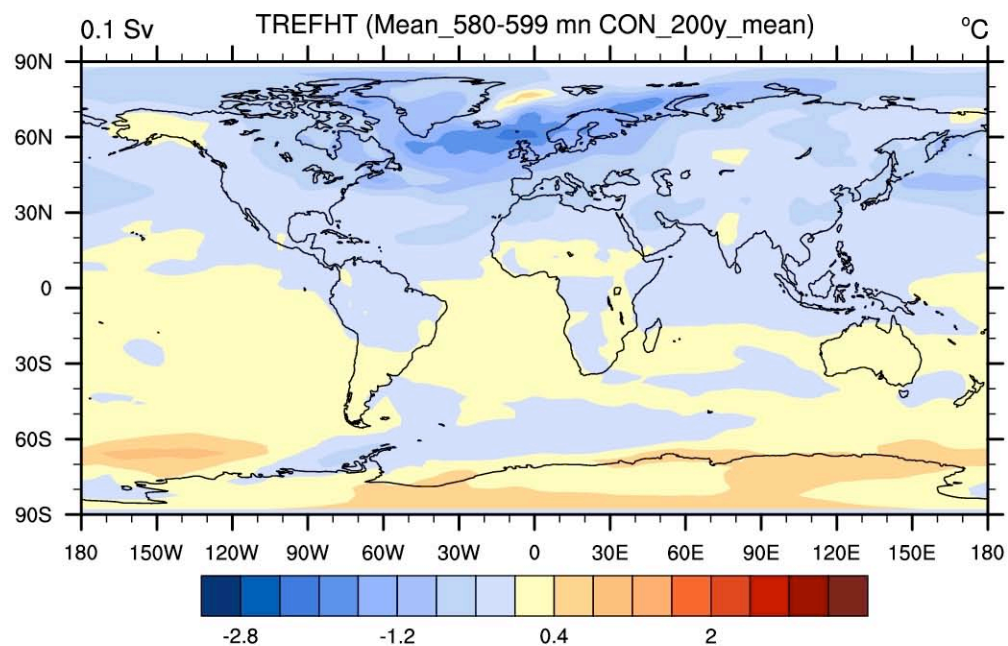


- Sea ice changes amplify climate response
- Global teleconnections can result
- Longevity of these changes are an issue

# N. Atlantic Fresh Water Input Expts. (CCSM2)



## Maximum surface temperature change





# Conclusions

- THC reductions due to anthropogenic forcing
- Europe always warms in future scenarios
- Abrupt sea ice changes in one A1B ensemble member
- Abrupt MOC changes are caused by abrupt fresh water additions in the North Atlantic
- Europe most often cools in these expts.

# Abrupt transitions in future climate scenarios?

- Relatively gradual forcing.
- Relatively gradual response in global air temperature

