

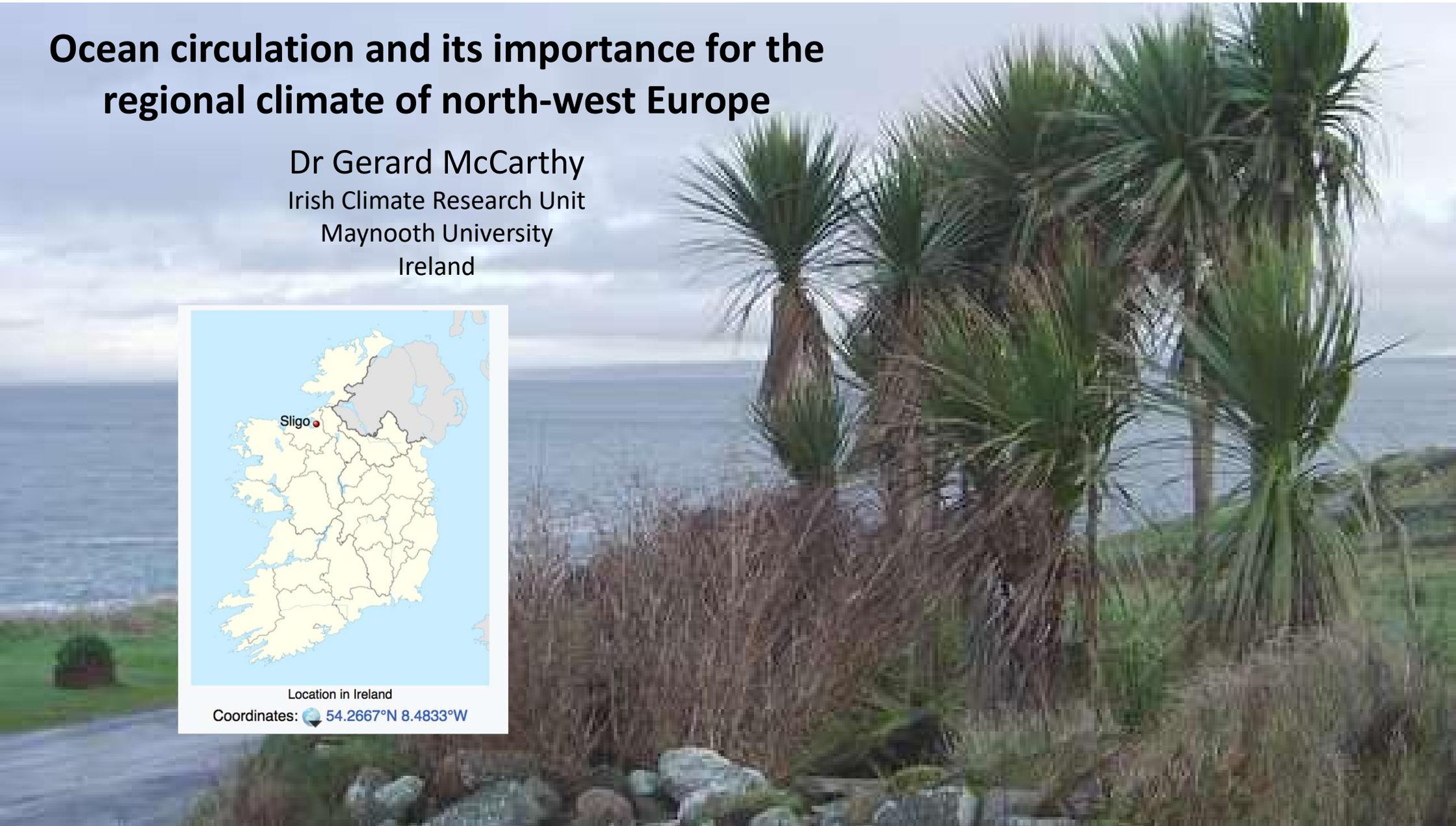
Ocean circulation and its importance for the regional climate of north-west Europe

Dr Gerard McCarthy
Irish Climate Research Unit
Maynooth University
Ireland



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Location in Ireland

Coordinates:  54.2667°N 8.4833°W



Palm Trees in Sligo



SOUTH GEORGIA
Historical and Modern Settlements

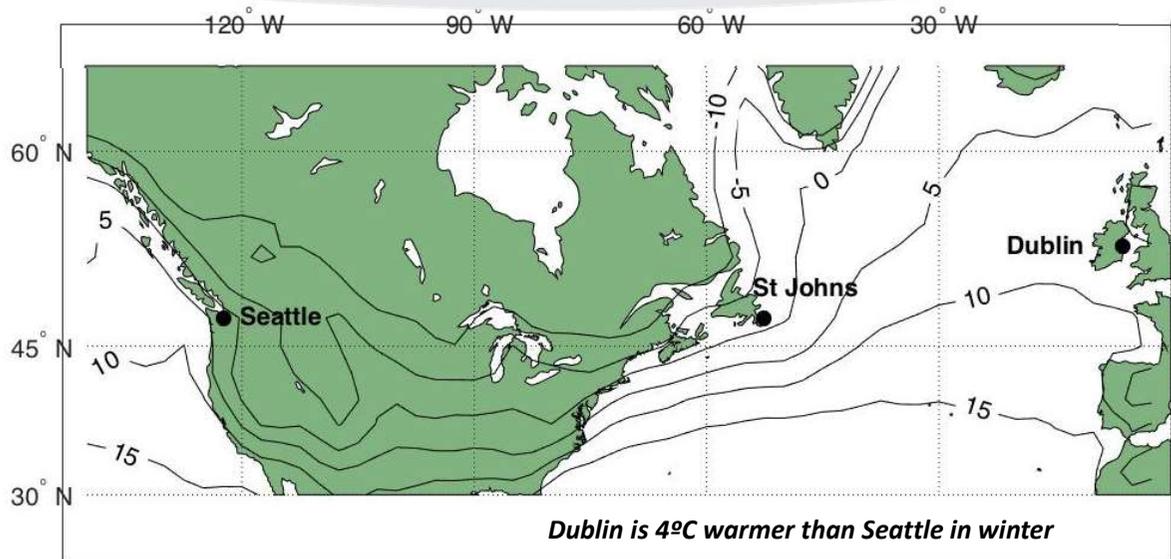
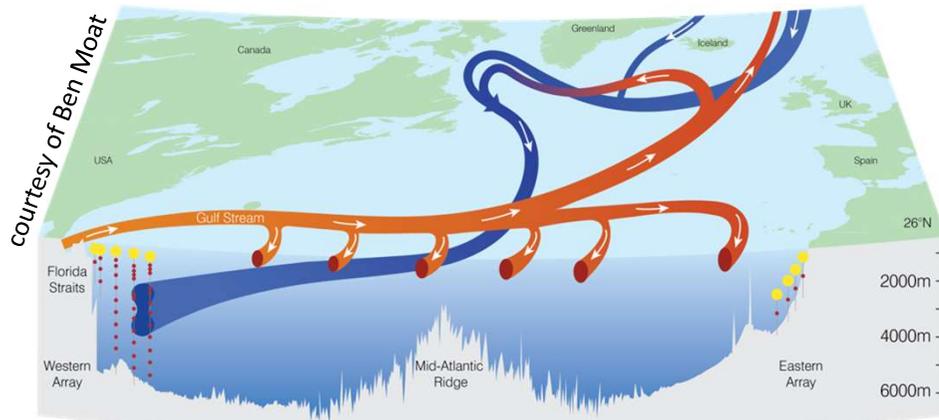
South Georgia settlements

Coordinates:  54°16'53.4"S 36°30'28.8"W



Glaciers in Grytviken

The AMOC: a critical component of climate

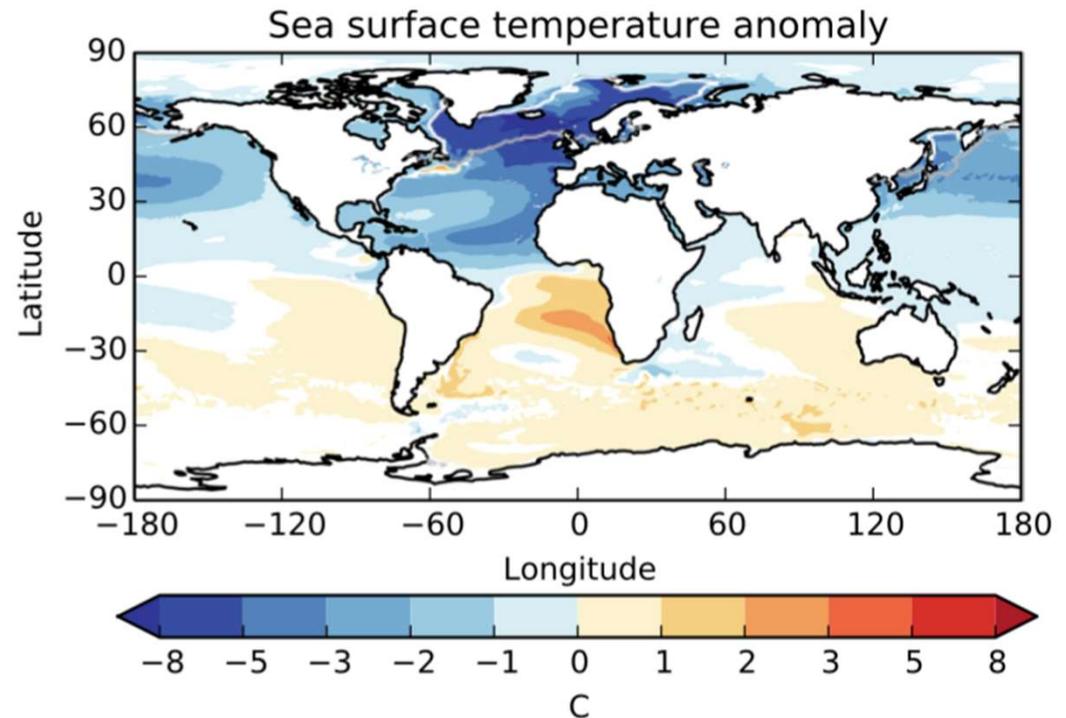
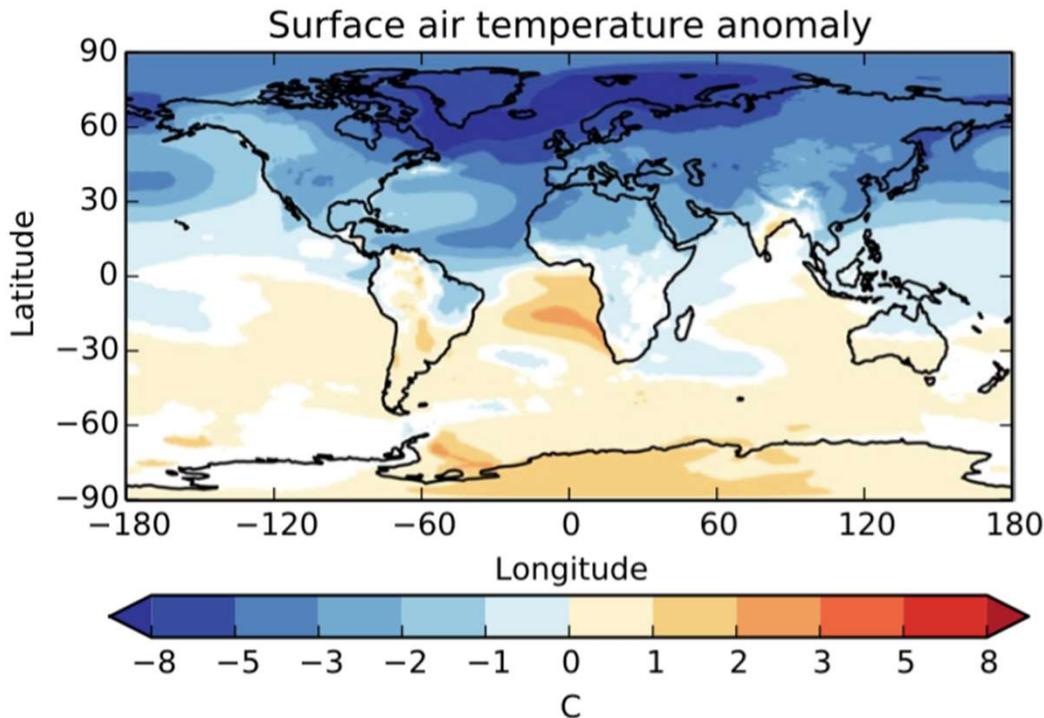


McCarthy et al. (2015), The influence of ocean variations on the climate of Ireland, *Weather*, 70(8), 242-245.

The Atlantic Meridional Overturning Circulation (AMOC):

- a system of currents
 - carrying warm, shallow water northwards and
 - returning cold, deep water
-
- A mechanism of the climate system in redistributing heat globally
-
- Not just “a fan assisted storage heater” (Ellett, 1993, *Weather*) and, in fact, more like “a byword for climate change” (J. Karstensen)

The AMOC: a byword for climate change

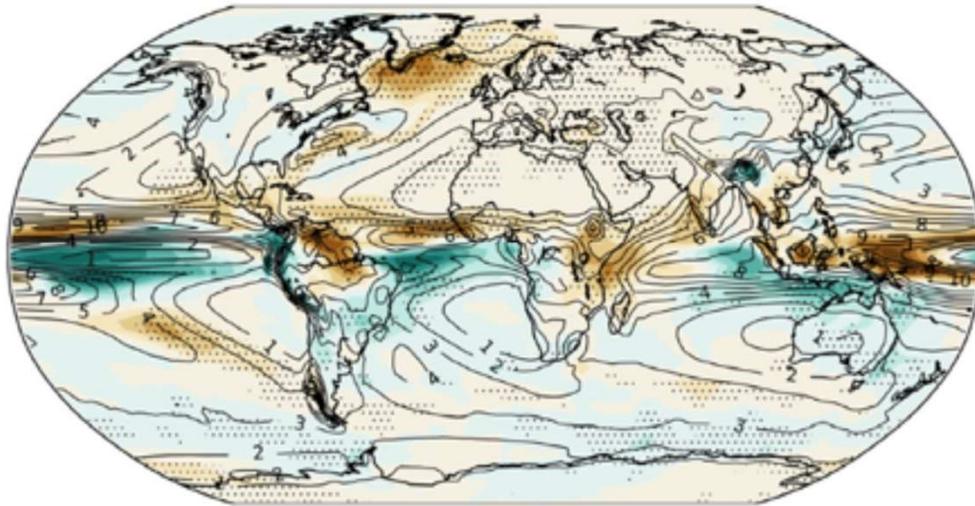


A collapse of the AMOC would lead to cooling throughout the Northern Hemisphere and most extremely in northwest Europe

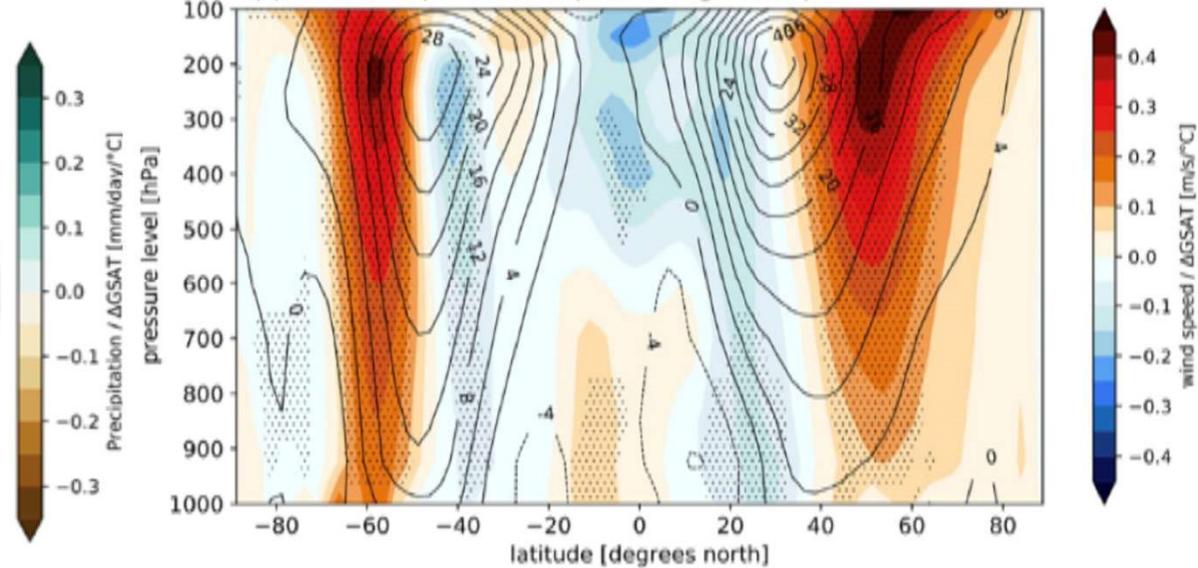
Jackson et al. (2015), Global and European climate impacts of a slowdown of the AMOC in a high resolution GCM, *Clim. Dyn.*, 45(11-12), 3299-3316.

The AMOC: a byword for climate change

(c) Difference (precipitation change)



(c) Difference (zonal wind speed change in DJF)

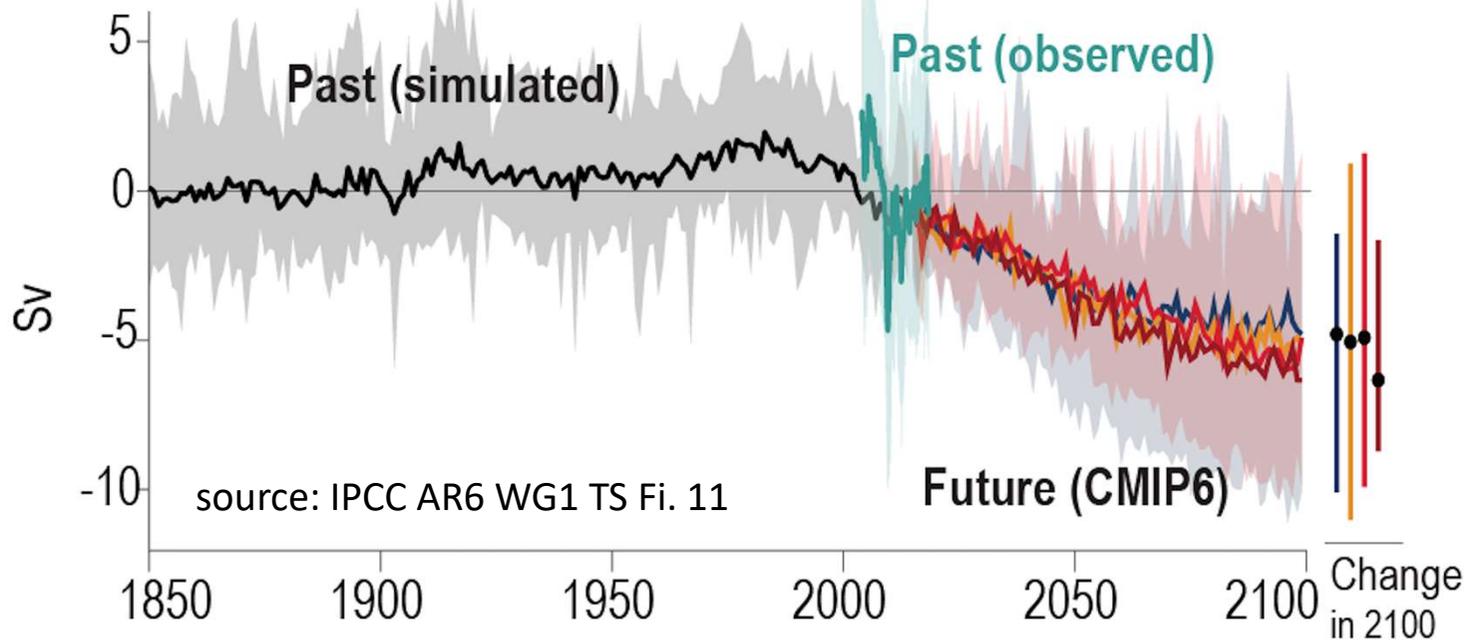


Future climates with a large AMOC slowdown have a southward displacement of the ITCZ and a poleward shift of the mid-latitude jet—a drier, stormier future for northwestern Europe

Bellomo, K., Angeloni, M., Corti, S., & von Hardenberg, J. (2021). Future climate change shaped by inter-model differences in Atlantic meridional overturning circulation response. *Nature Communications*, 12(1), 1-10.

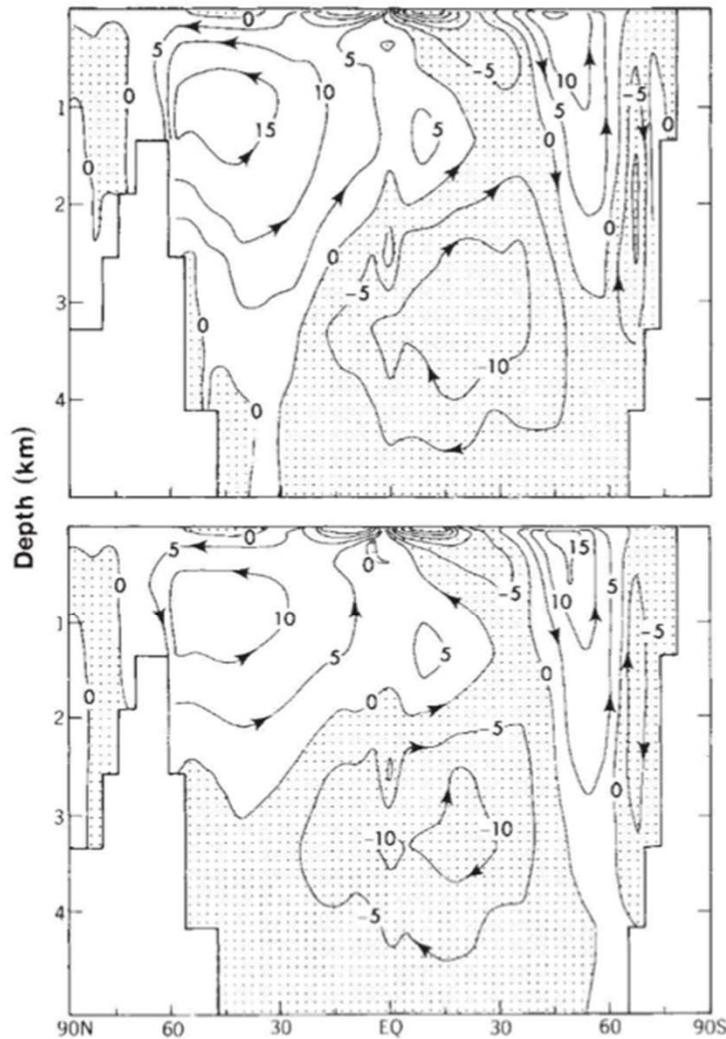
The AMOC will weaken

(b) Atlantic Meridional Overturning Circulation (AMOC)



The IPCC AR6 reports that the AMOC is *very likely* to decline in the 21st century

The AMOC will weaken



- from 1985: “A fourfold increase in atmospheric CO₂ causes a warming sufficiently intense to produce a partial collapse of the thermohaline circulation of the ocean.” Bryan K, Spelman MJ (1985) J Geophys Res
- (fig. on left) 30% weakening of overturning in response to a 1% per year Co₂ increase over a 100 year integration. Stouffer, R. J., Manabe, S., & Bryan, K. (1989). Nature, 342(6250), 660-662

FIG. 4 Streamlines of zonal-mean meridional oceanic circulation (in Sverdrups) averaged over the seventh decade (that is, years 61–70) of the experiment. Top, the control integration with constant CO₂; bottom, the integration in which atmospheric CO₂ concentration is increased with the rate of 1% yr⁻¹.

Climate crisis

Gulf Stream could collapse as early as 2025, study suggests

A collapse would bring catastrophic climate impacts but scientists disagree over the new analysis



Online attention



- 3812 tweeters
- 49 blogs
- 5 Facebook pages
- 636 news outlets
- 22 Redditors
- 1 Video uploaders
- 4 Wikipedia page
- 148 Mendeley

This article is in the 99th percentile (ranked 7th) of the 255,265 tracked articles of a similar age in all journals and the 99th percentile (ranked 1st) of the 1,624 tracked articles of a similar age in *Nature Communications*

A study in summer 2023 by Ditlevsen and Ditlevsen found the AMOC could collapse by the end of the century, sparking a flurry of media articles.

Ditlevsen, P., & Ditlevsen, S. (2023). Warning of a forthcoming collapse of the Atlantic meridional overturning circulation. *Nature Communications*, 14(1), 1-12.

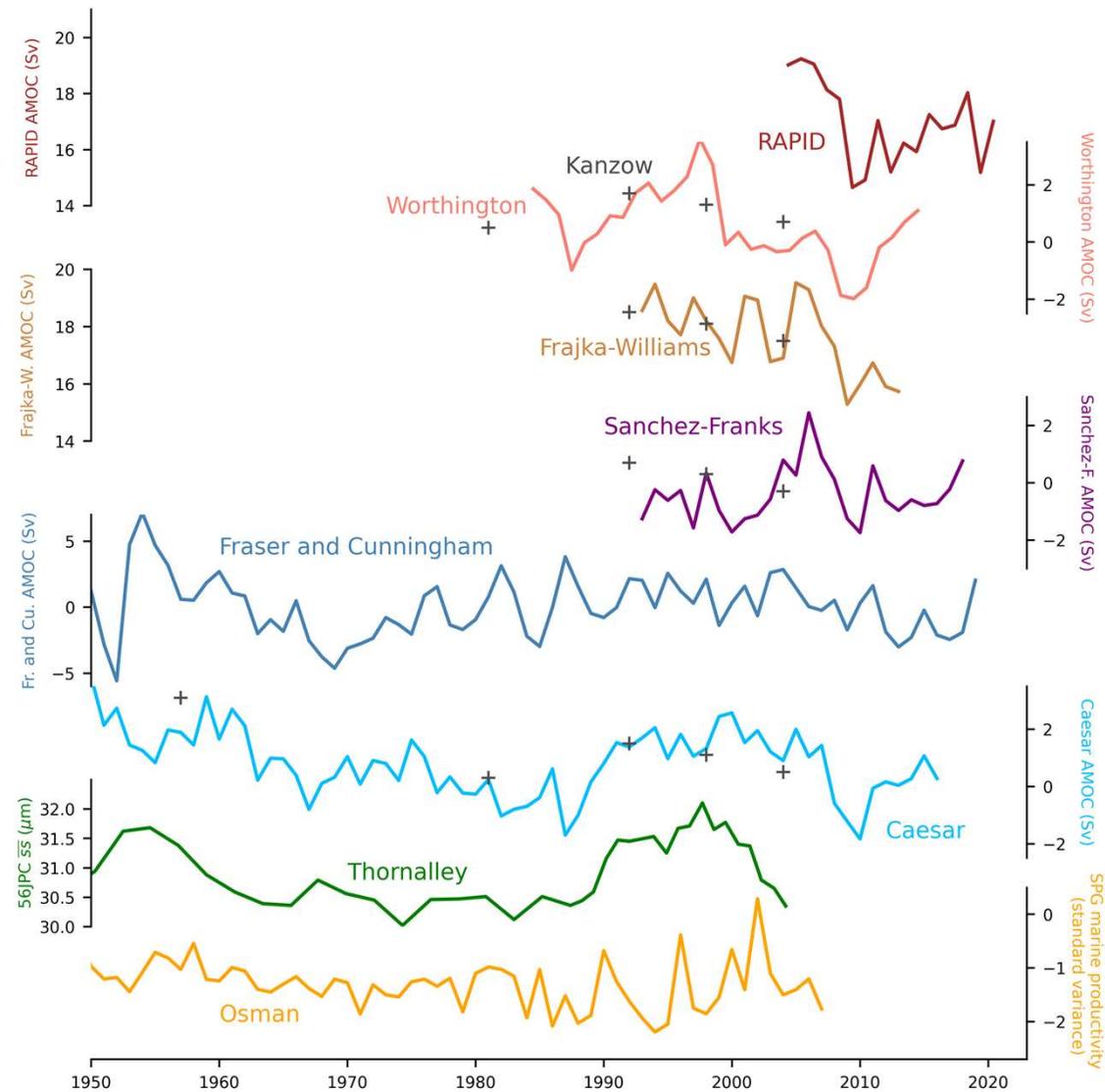
Observations agree...

There is good agreement between direct observations, instrumental reconstructions, and instrumental proxies since the 1980s

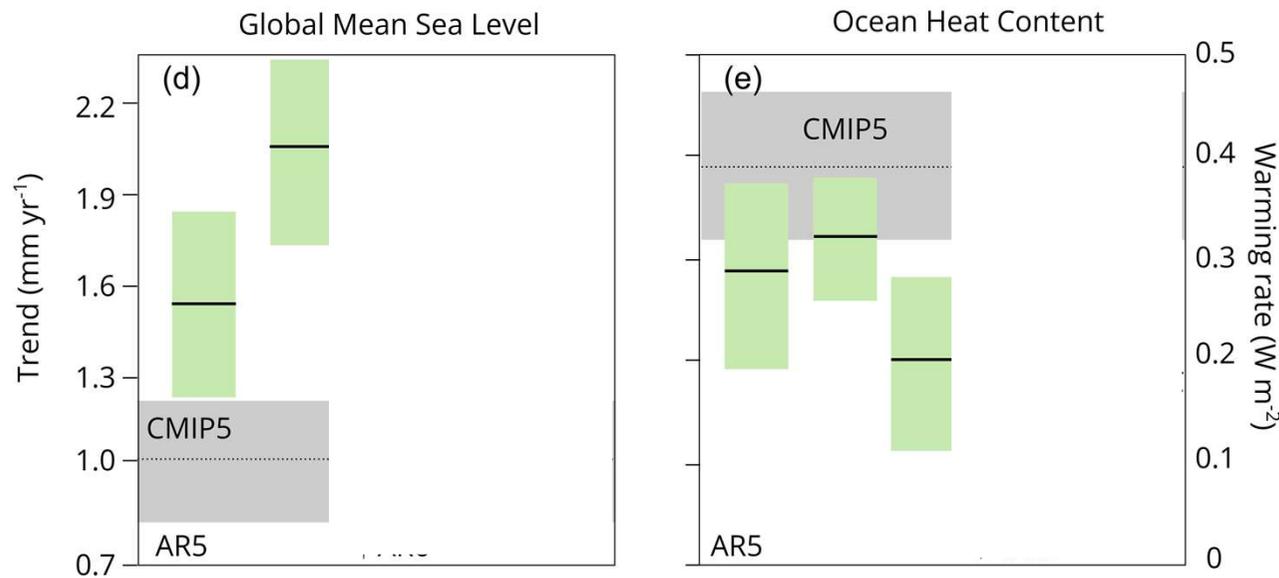
A majority of paleo proxies and instrumental proxies agree in the 20th century

Figure from McCarthy and Caesar, "Can we trust projections of AMOC weakening based on climate models that can't reproduce the past?" accepted to Phil Trans A

see also: Jackson, Laura C., et al. "The evolution of the North Atlantic meridional overturning circulation since 1980." *Nature Reviews Earth & Environment* 3.4 (2022): 241-254.



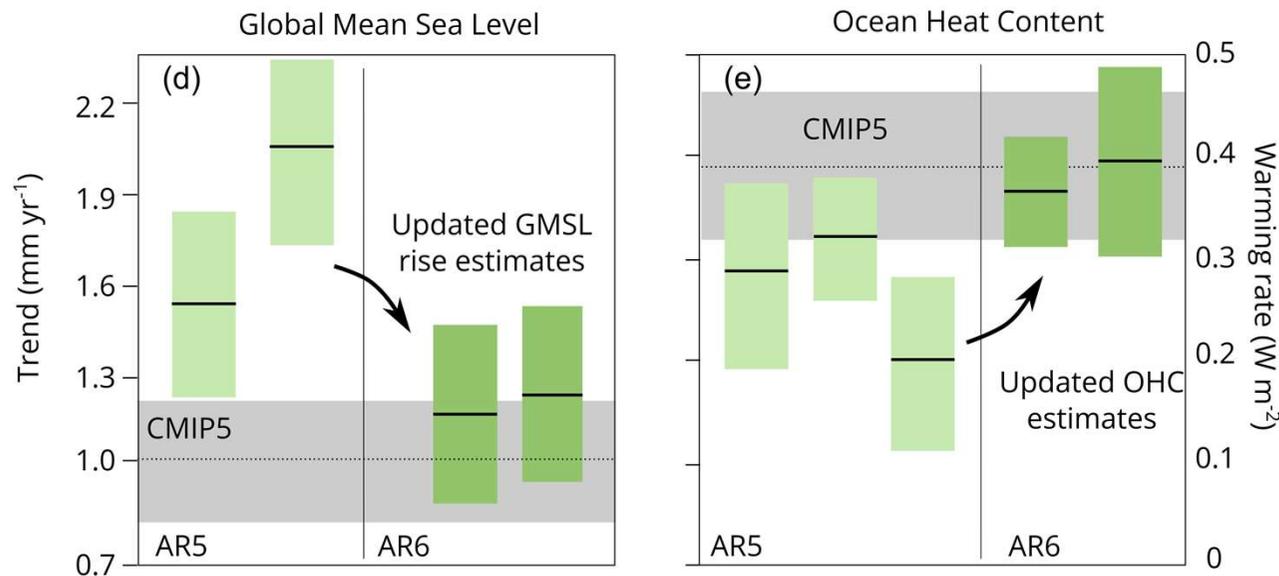
Climate Models are good at many things



In AR5, estimates of global mean sea level rise and ocean heat content change did not fall within the model envelope

McCarthy, G. D. & Caesar, L. Can we trust projections of AMOC weakening based on climate models that can't reproduce the past? *Philos. Trans. R. Soc. A Math. Phys. Eng. Sci.* (2023).

Climate Models are good at many things

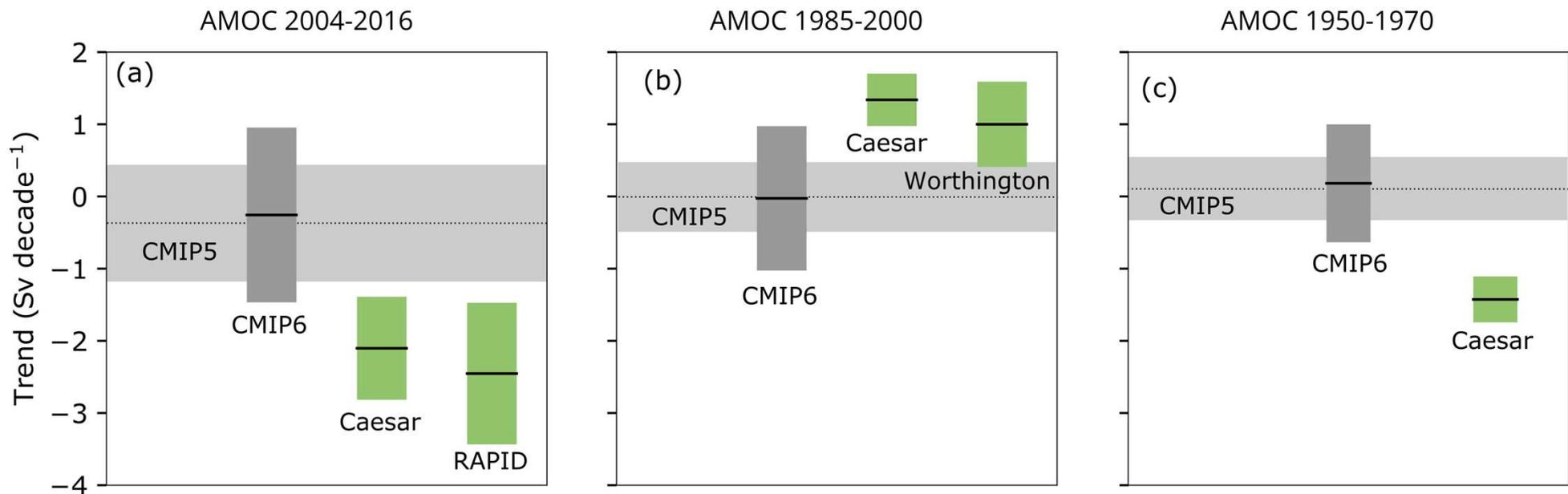


In AR5, estimates of global mean sea level rise and ocean heat content change did not fall within the model envelope

But improvements to the **observational** estimates improved agreement

McCarthy, G. D. & Caesar, L. Can we trust projections of AMOC weakening based on climate models that can't reproduce the past? *Philos. Trans. R. Soc. A Math. Phys. Eng. Sci.* (2023).

Climate Models are good at many things ...but need to be supported by observations



McCarthy, G. D. & Caesar, L. Can we trust projections of AMOC weakening based on climate models that can't reproduce the past? *Philos. Trans. R. Soc. A Math. Phys. Eng. Sci.* (2023).