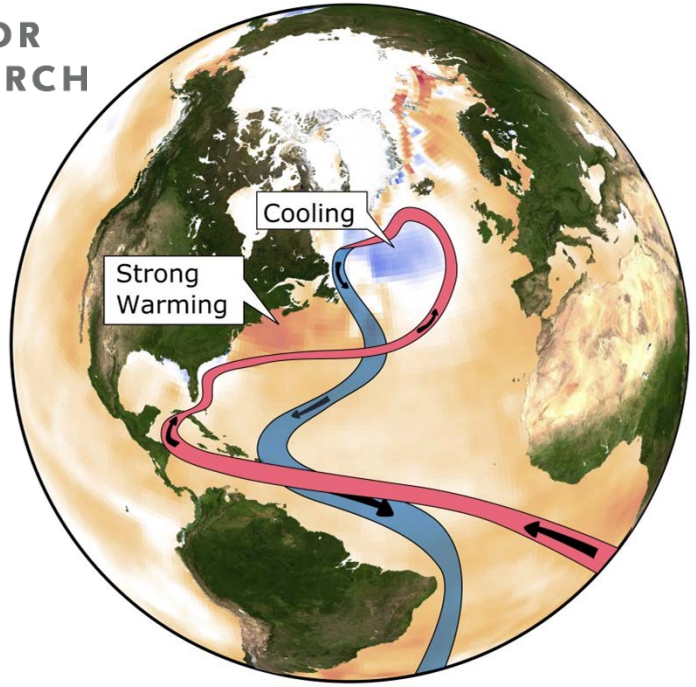
POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

P I K

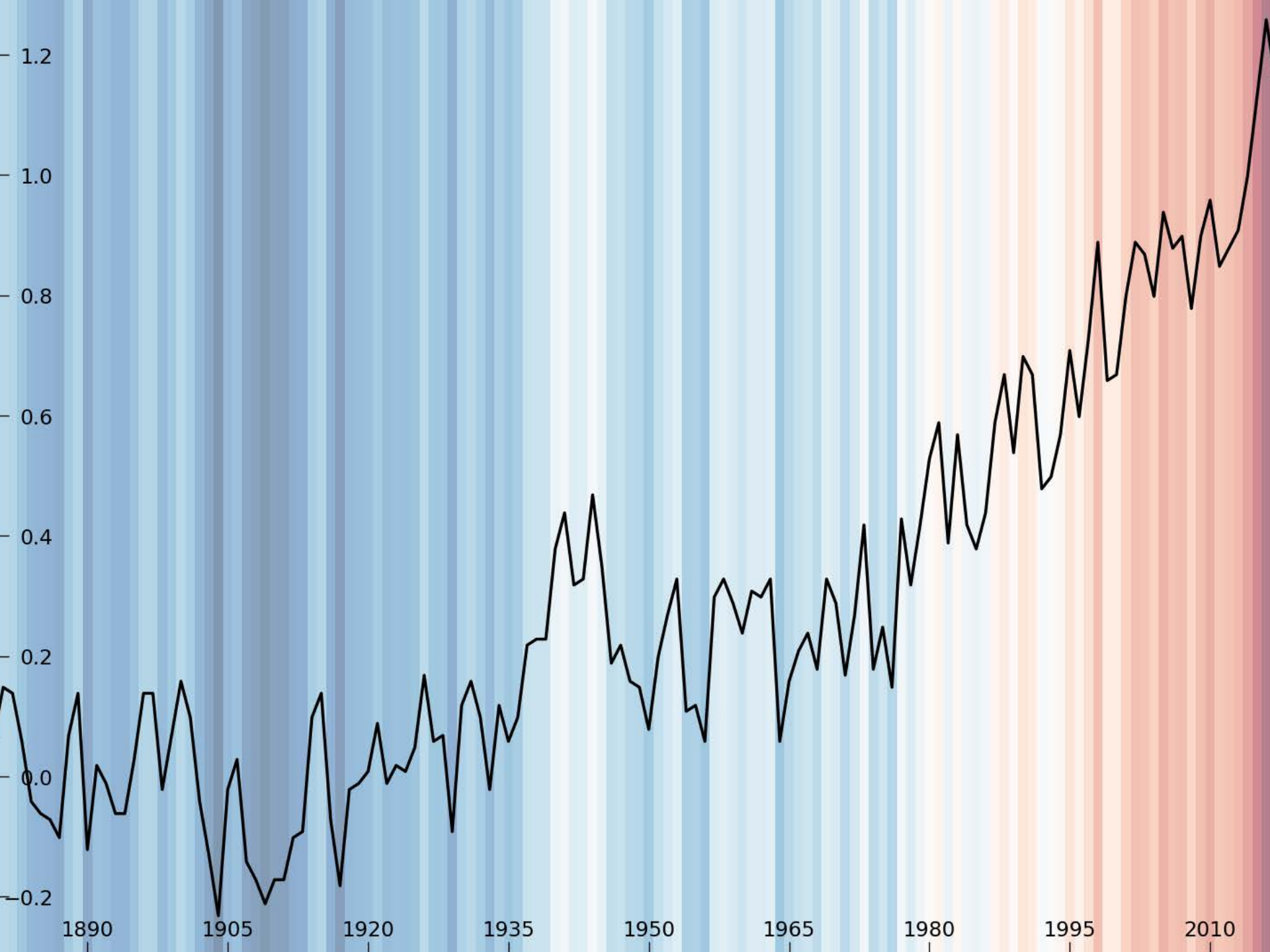
Evidence for a weakening Atlantic Ocean overturning circulation and the potential consequences



Levke Caesar, Stefan Rahmstorf, Alexander Robinson, Vincent Saba, and Georg Feulner

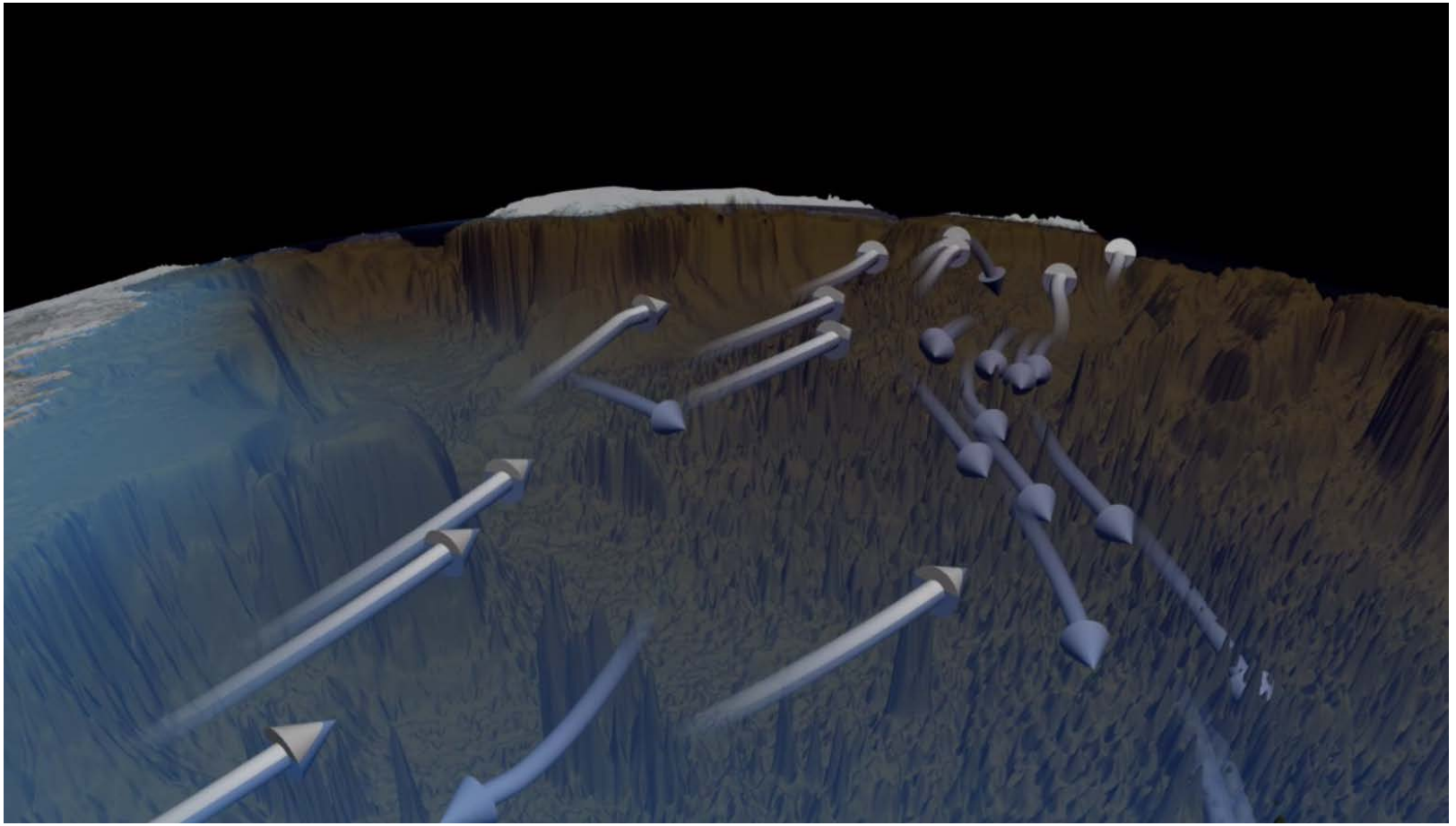
European Environmental Bureau - 2018 ANNUAL CONFERENCE

Leibniz Association


1.2
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
1890
1905
1920
1935
1950
1965
1980
1995
2010

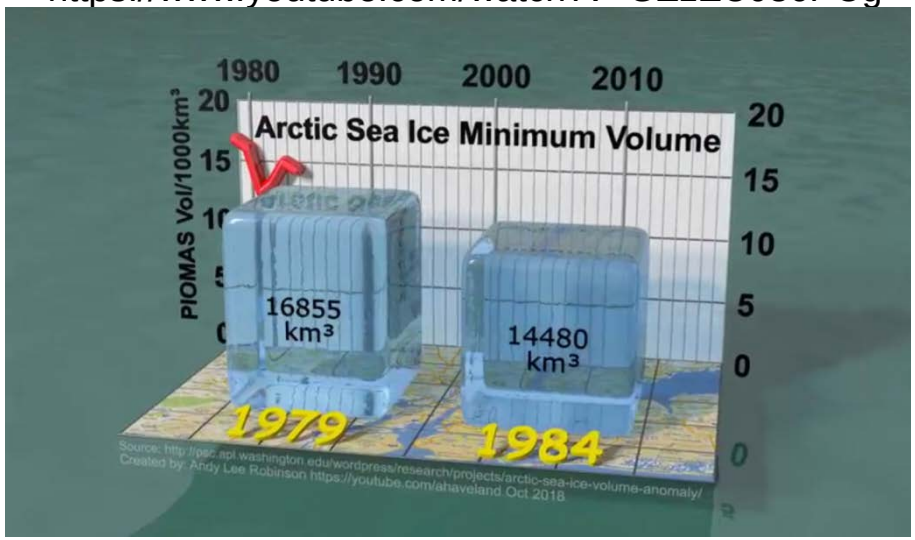
Meet Europe's heating system

https://pmm.nasa.gov/education/videos/thermohaline-circulation-great-ocean-conveyor-belt



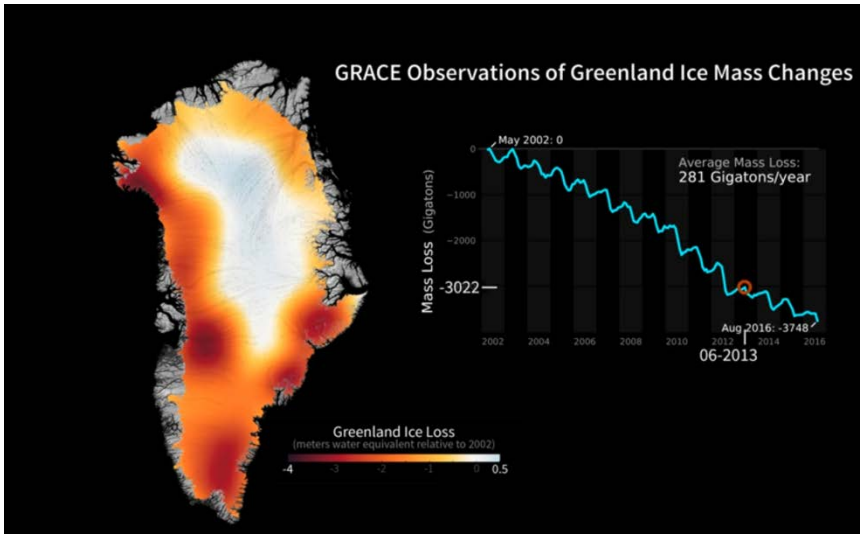
Why a warmer world leads to an AMOC slow down

https://www.youtube.com/watch?v=GZzEUJ86PCg

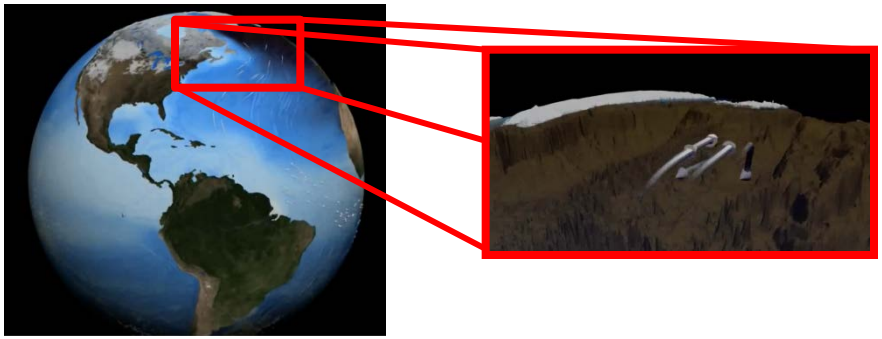


Arctic sea ice loss

https://www.youtube.com/watch?v=ZVWXC_j7Dqs

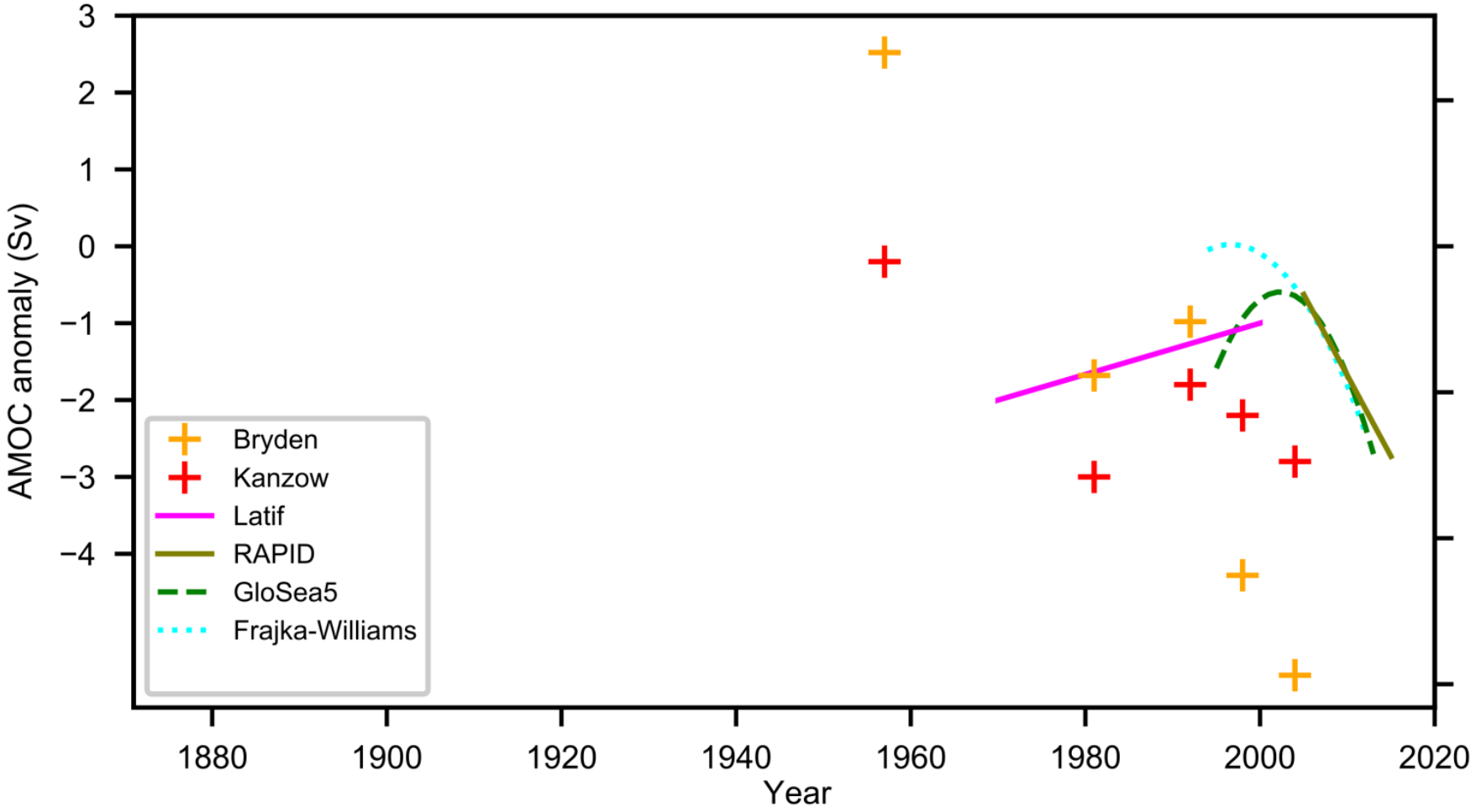


Greenland ice loss



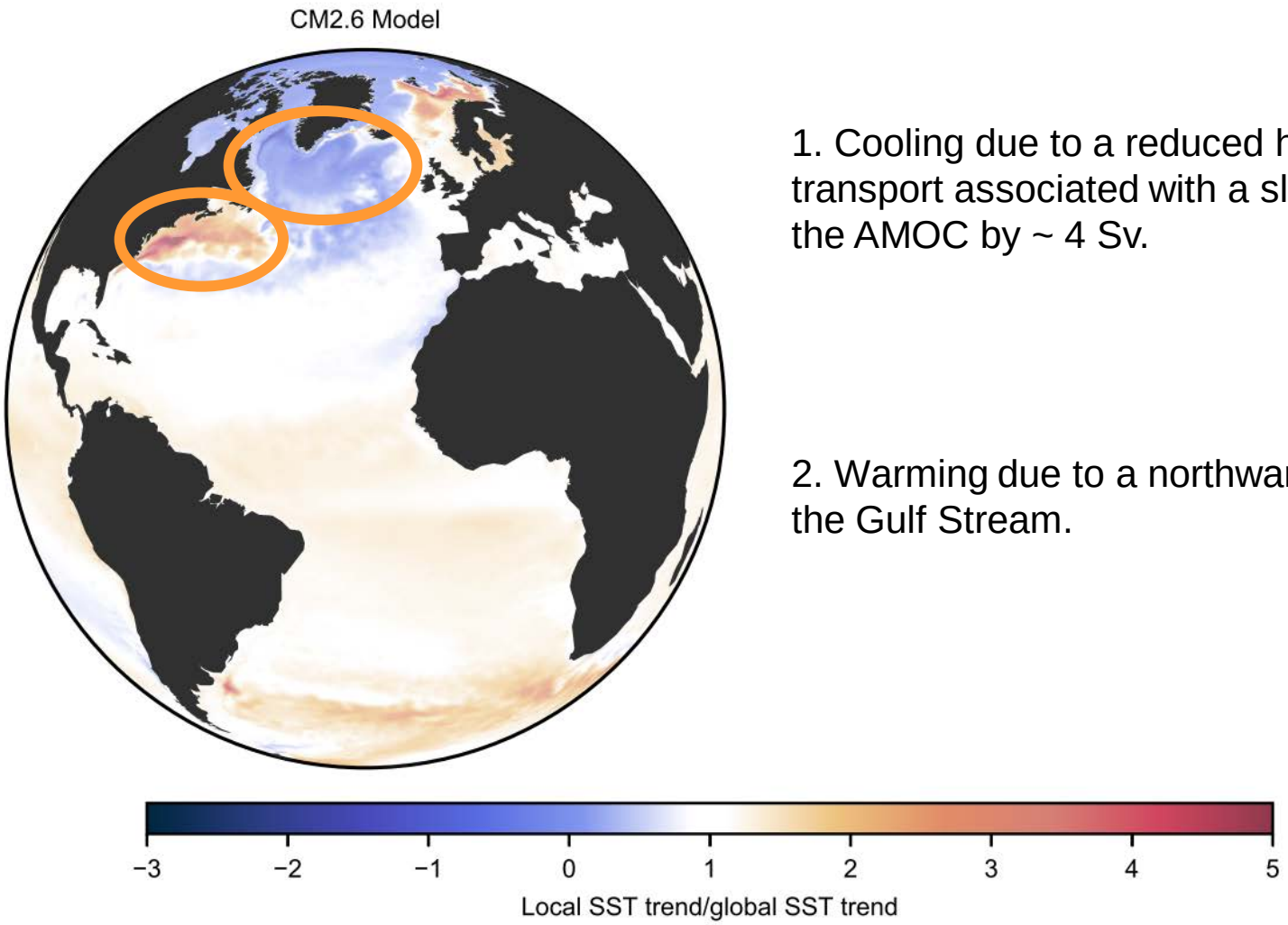
Dilution of water hinders the formation of deep water and with that the driver of the overturning circulation.

Evolution of the AMOC has been controversial



Bryden et al., Nature (2005)
Kanzow et al., J Clim (2006)
Latif et al., J Climate (2005)
Frajka-Williams, GRL (2015)
Jackson et al, Nature GS (2015)
Robson et al. Nature GS (2014)

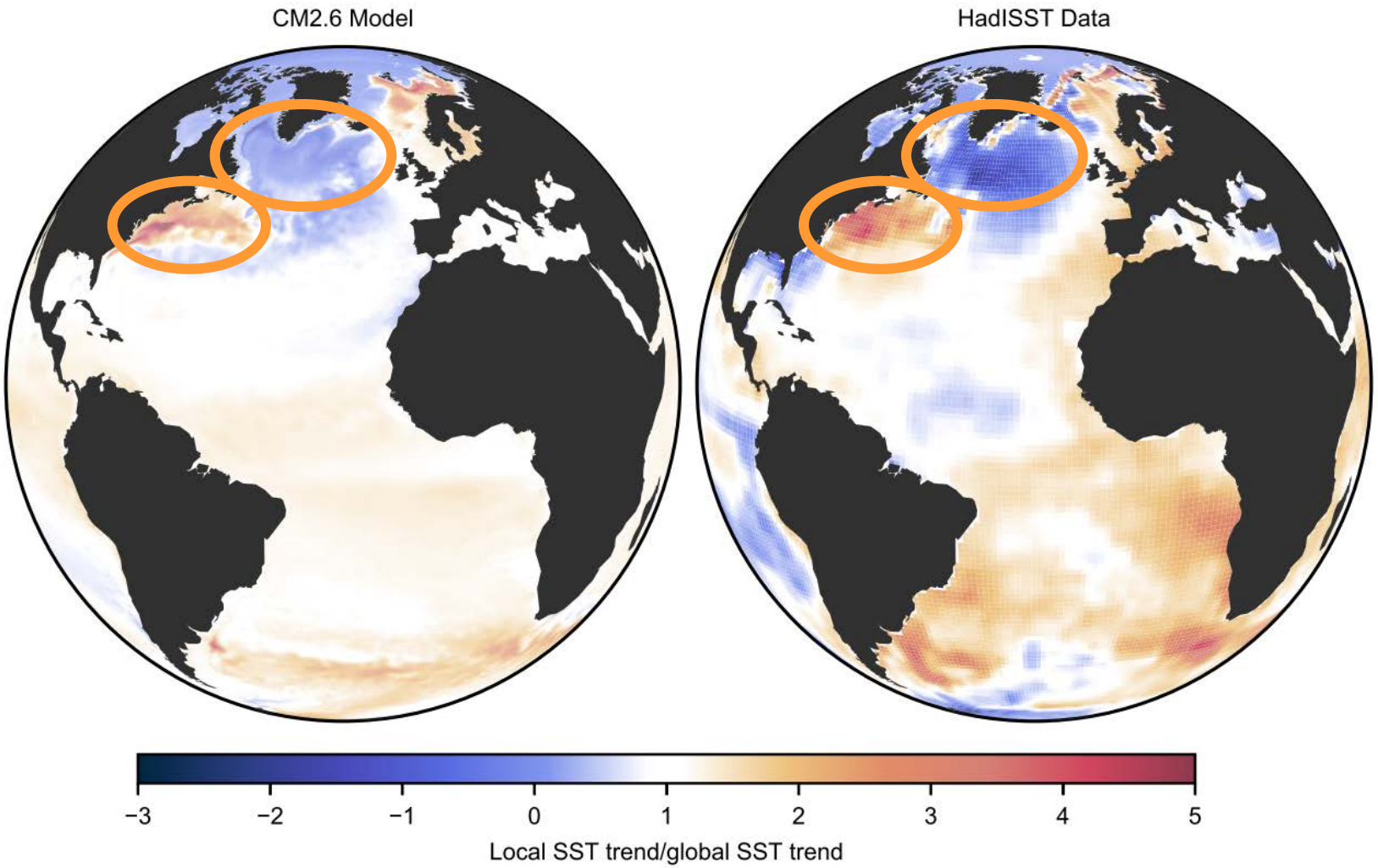
SST trend shows fingerprint of AMOC slowdown…



1. Cooling due to a reduced heat transport associated with a slowdown of the AMOC by ~ 4 Sv.

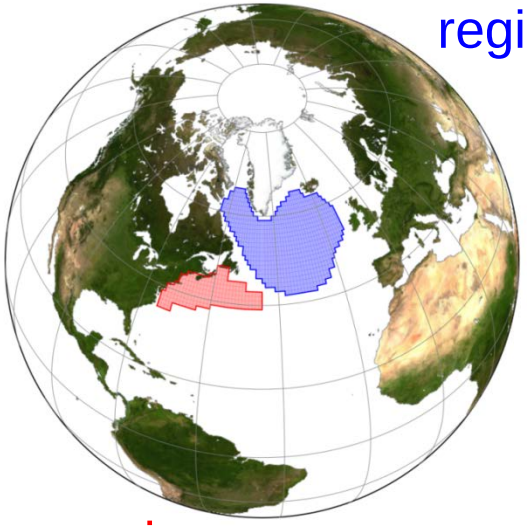
2. Warming due to a northward shift of the Gulf Stream.

… that is also found in observational data!

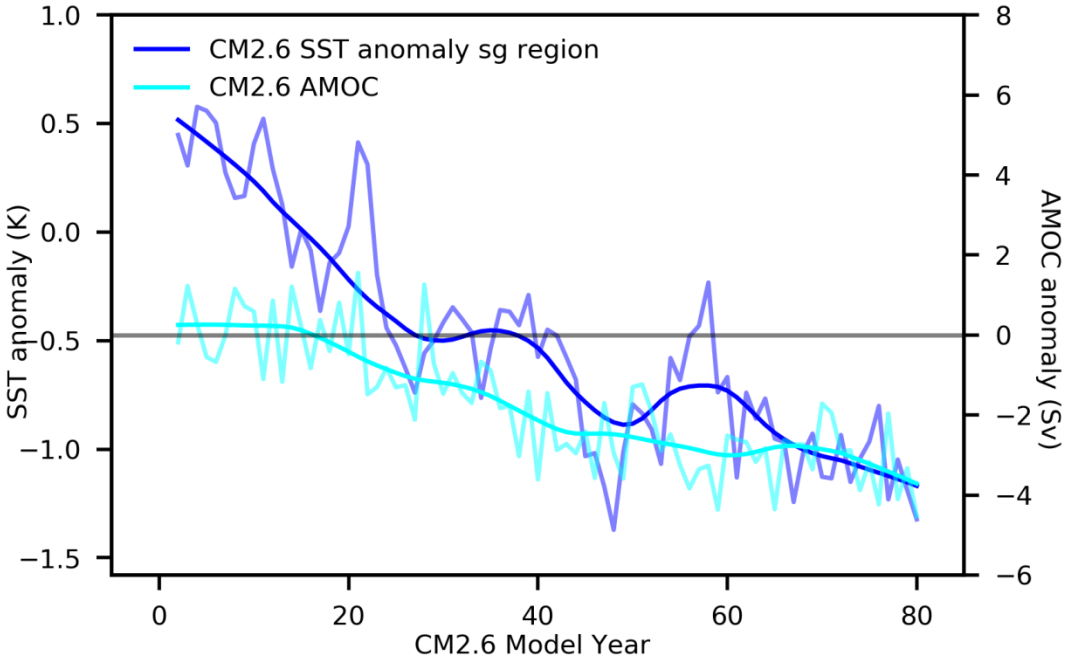


Extracting the AMOC evolution from the SST pattern

subpolar gyre region

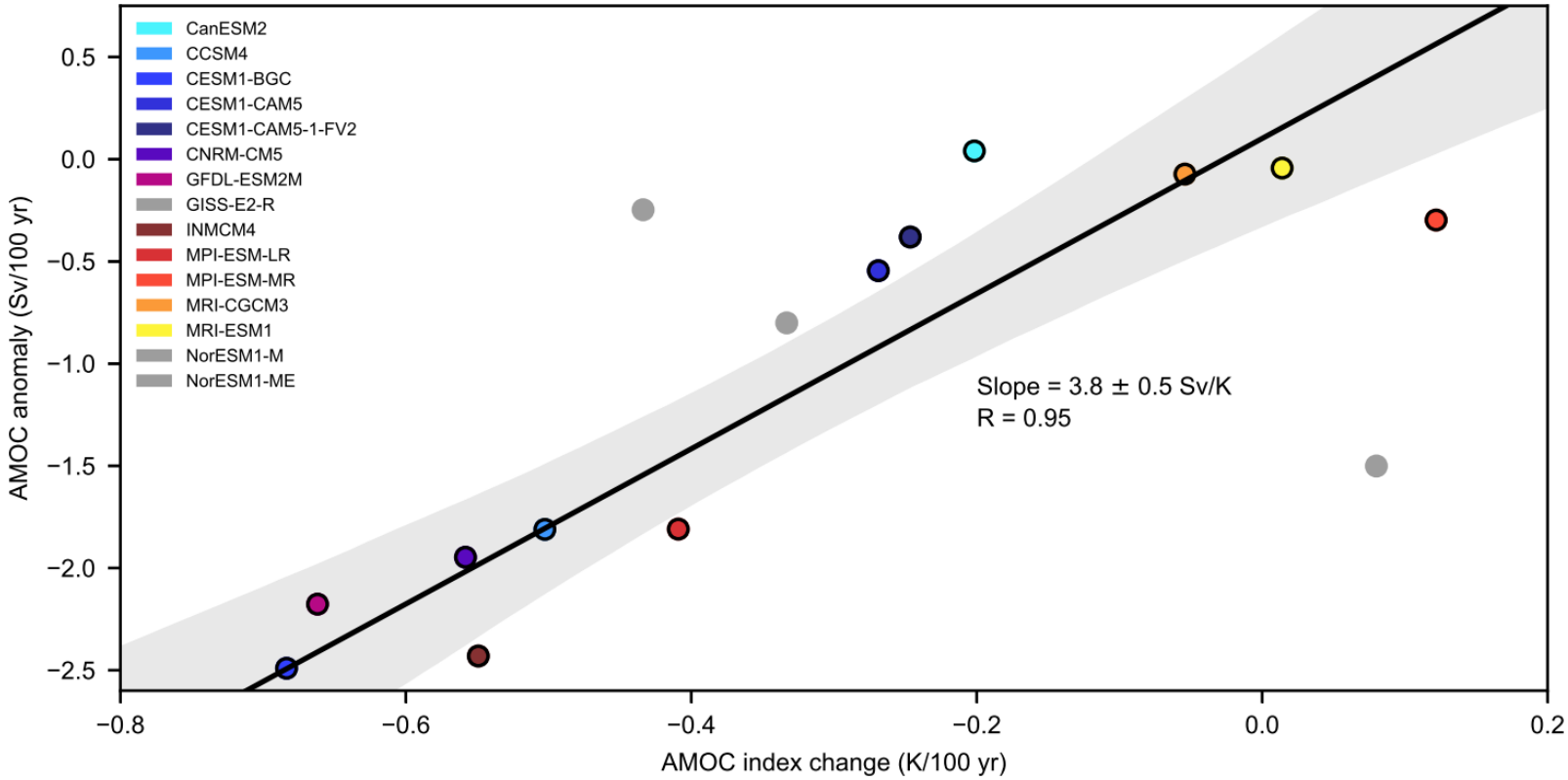


Gulf-Stream region



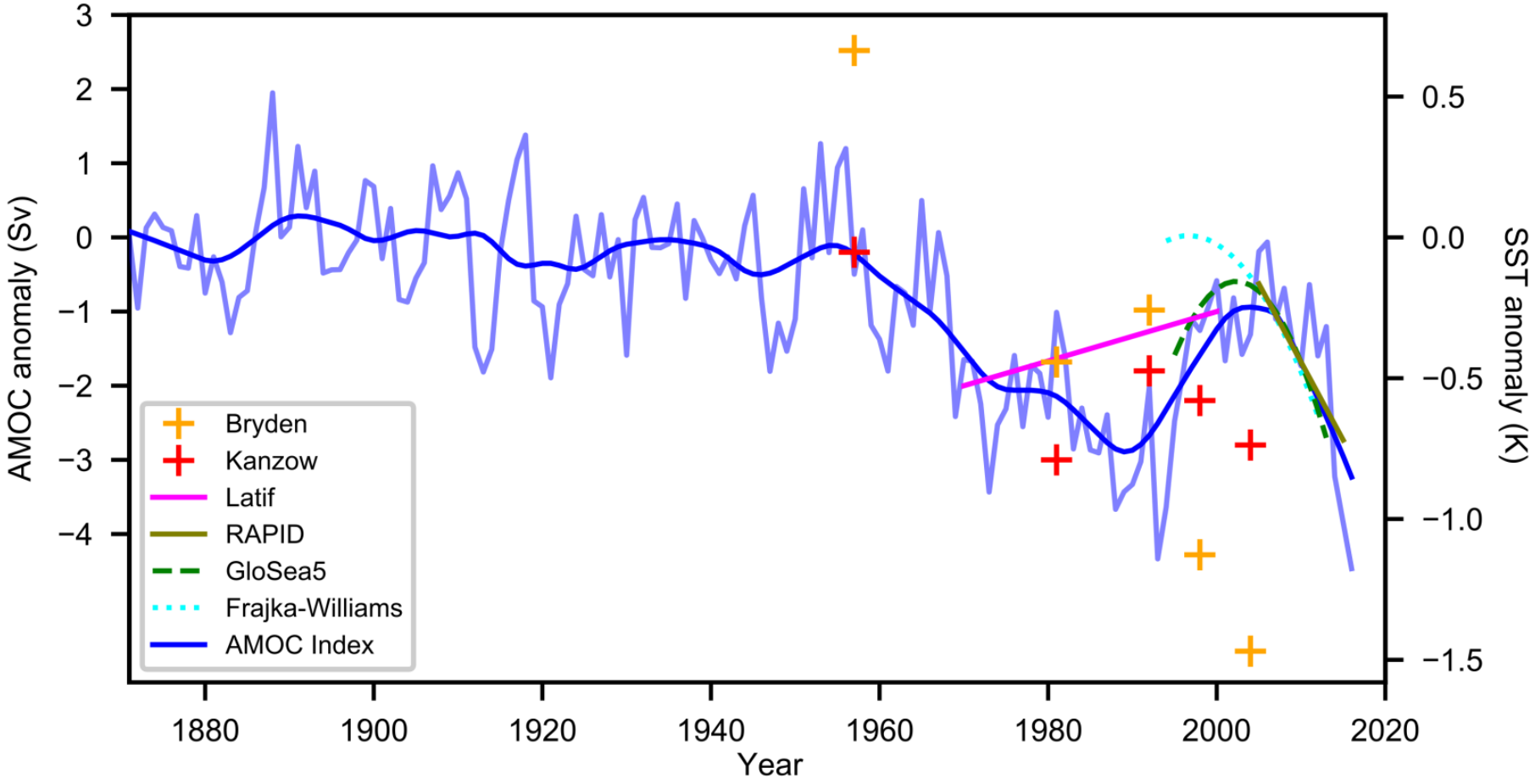
Definition of the AMOC index: $I_{AMOC} = SST_{sg} - SST_{globe}$

Correlation between AMOC index and strength



- CMIP5 models are consistent in their relationship between AMOC index and AMOC strength
- On long time scales the AMOC variation explains 89% of the variance in the AMOC index.

AMOC has already weakened under global warming



Bryden et al., Nature (2005)
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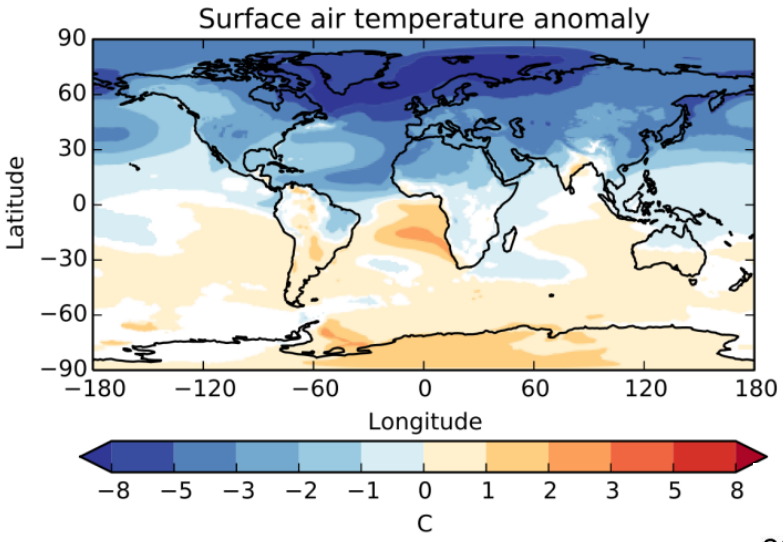
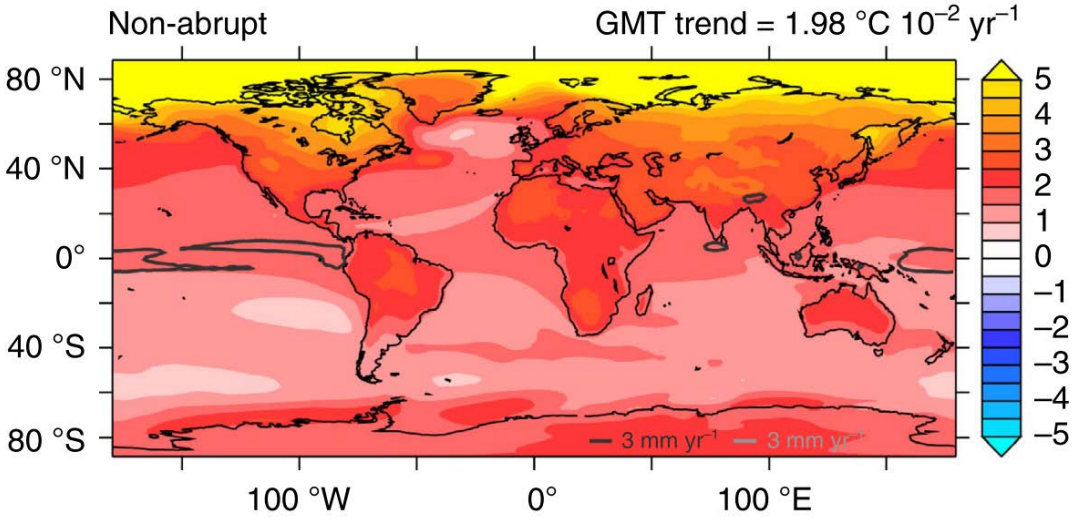
Jackson et al, Nature GS (2015)
Robson et al. Nature GS (2014)

Widespread cooling throughout the North Atlantic and northern hemisphere following a large AMOC reduction



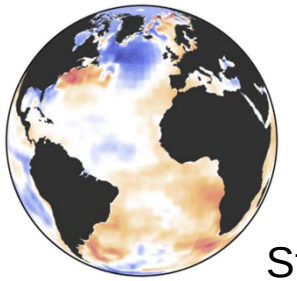
Temperature response to an AMOC collapse without increased greenhouse gas concentrations.

Temperature trend over the 21st century under the RCP4.5 scenario.



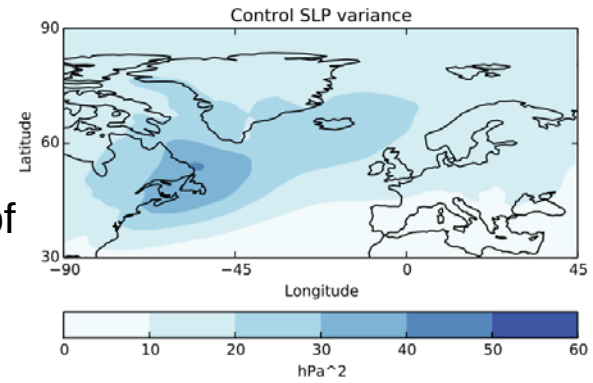
Jackson et al., Clim- Dyn. (2015)
Sgubin et al., Nature Com. (2017)
Drijfhout, Sci. Rep. (2015)

Consequences of the temperature response

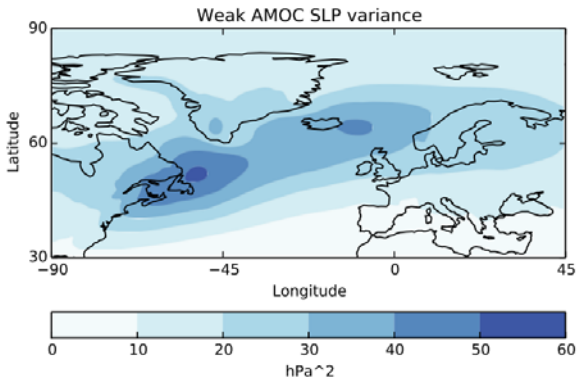


Strengthening of North Atlantic storm tracks.

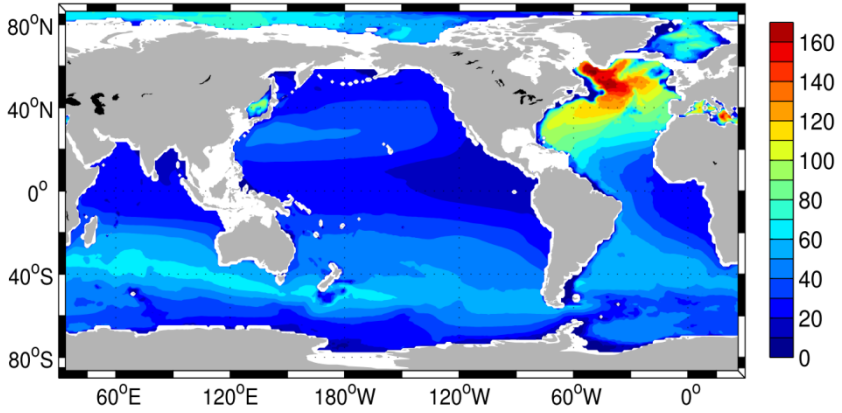
Normal AMOC



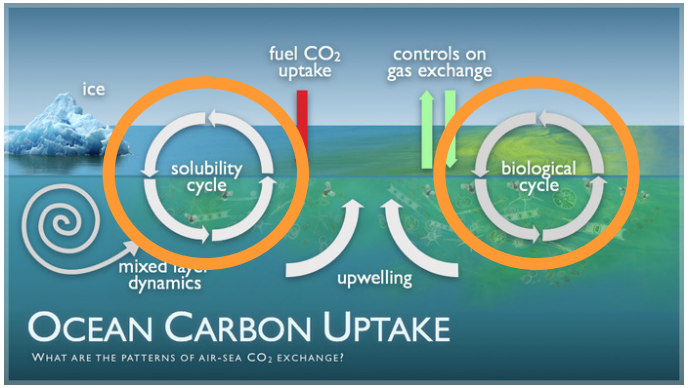
weak AMOC



Oceanic CO_2 uptake in 2010 (in $mol\ m^{-2}$)

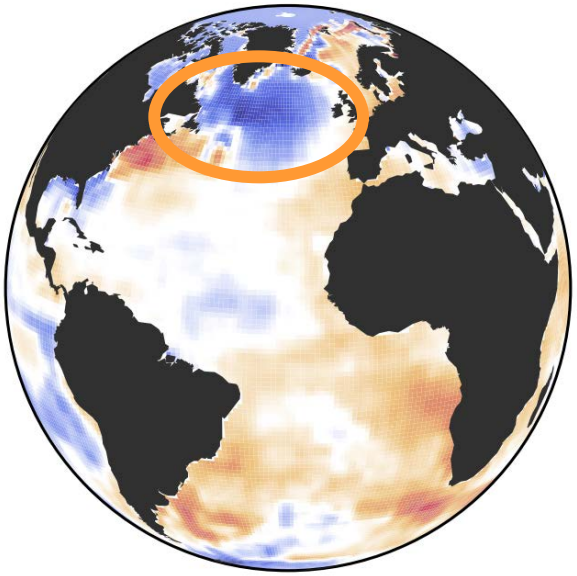


Changes under weakened AMOC



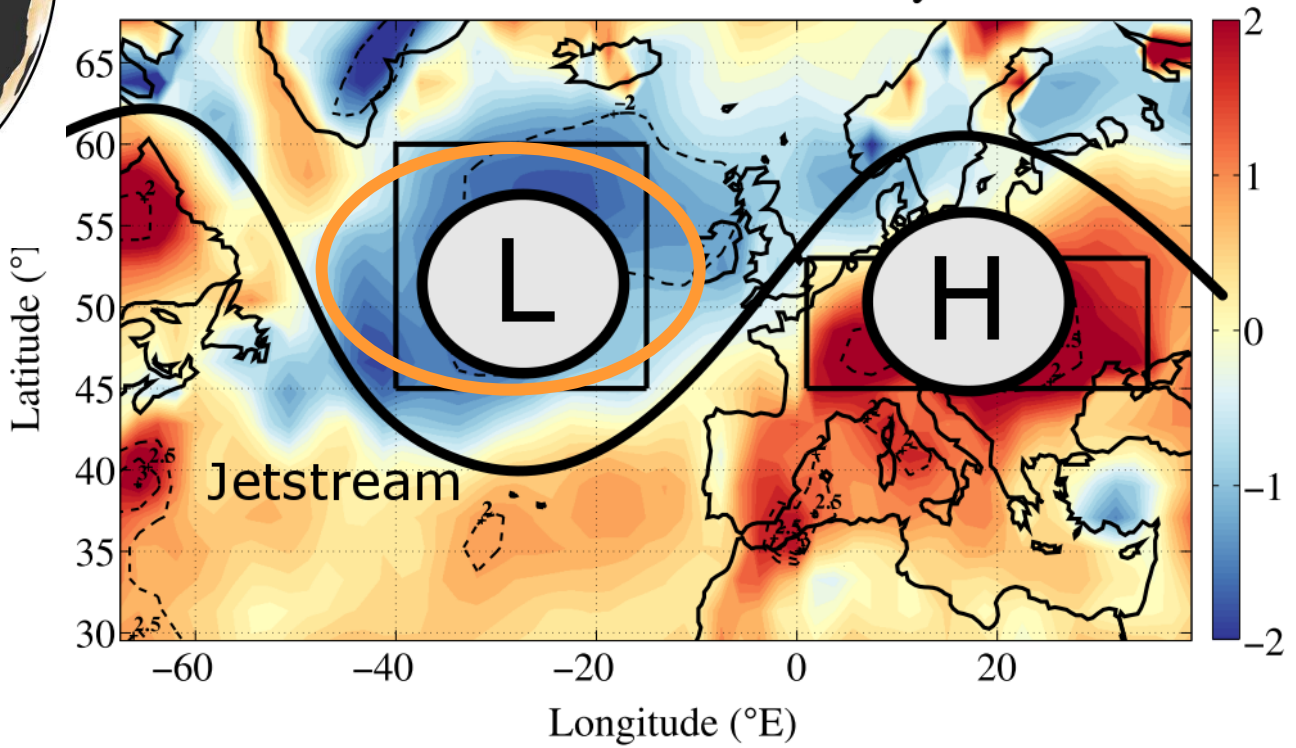
Jackson et al., Clim- Dyn. (2015)
Brayshaw et al.,J Climate (2009)
Khatiwala et al., Biogeos. (2013)
Schmittner, Nature (2005)

Linking the cold blob to European heat waves



Long-term trend in sea surface temperatures

Summer 2015:
Tmax and SST anomaly

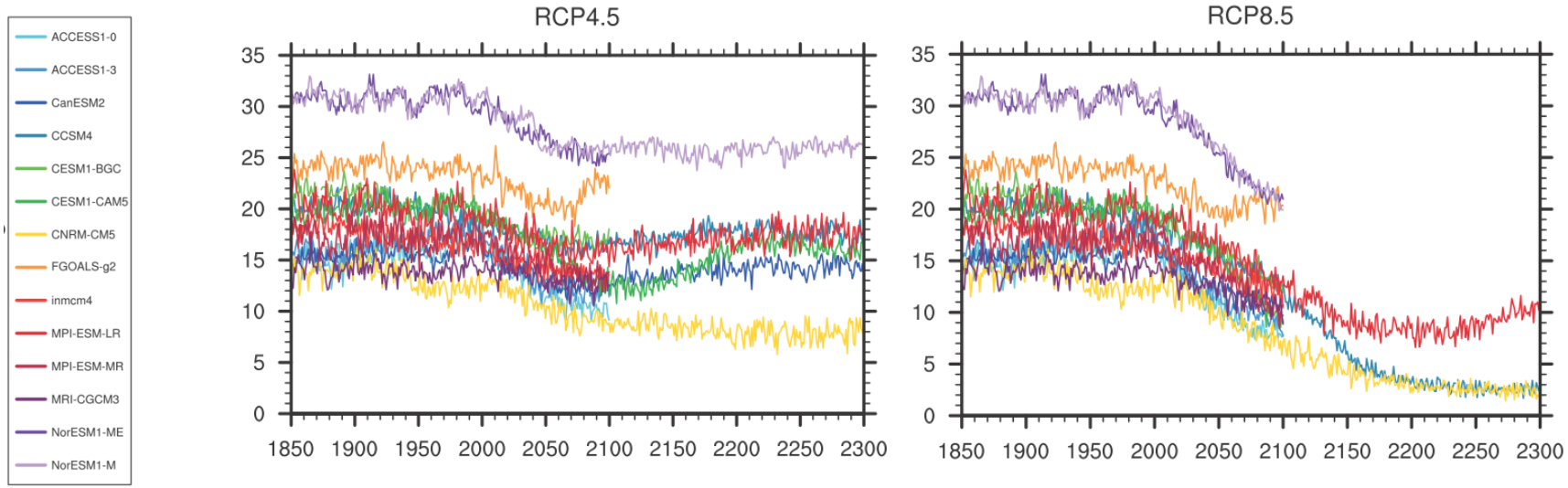


Duchez et al., Environ. Res. Lett.. (2016)
Caesar et al., Nature (2018)

What about the future?

IPCC:

"It is very likely that the Atlantic Meridional Overturning Circulation (AMOC) will weaken over the 21st century but it is very unlikely that the AMOC will undergo an abrupt transition or collapse in the 21st century."



Thank you for you attention!