Studies of the AMOC strength in future and paleo simulations with the Community Earth System Model (CESM1 and CCSM4)

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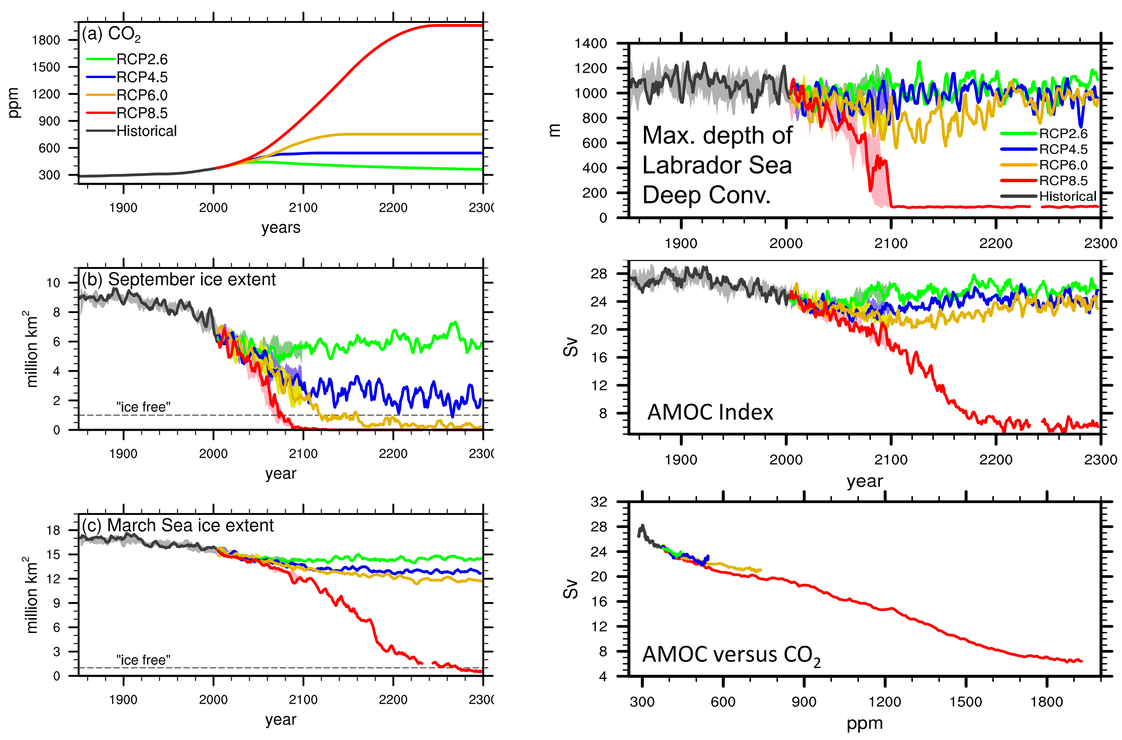
AMOC in CCSM4-CMIP5 simulations to 2300

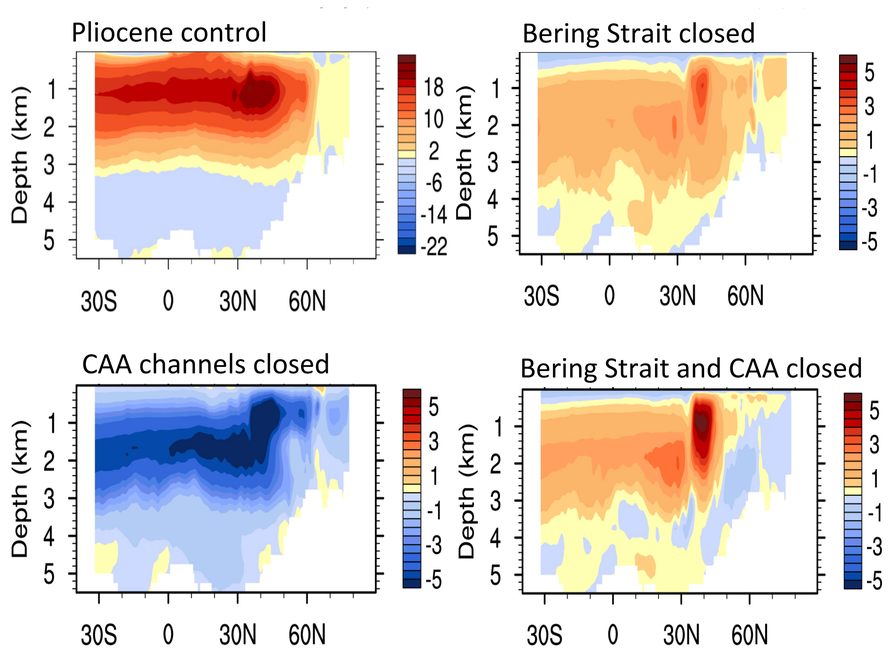
Based on Jahn and Holland (2013)



In the extended CCSM4-CMIP5 RCP simulations to the year 2300, the maximum strength of the AMOC decreases proportionally to the applied CO_2 forcing in all RCP scenarios, irrespective of the rate of change of the CO_2 forcing. This weakening of the AMOC is caused by a reduction or shut down of North Atlantic (NA) deep convection due to surface freshening. In the Labrador Sea, the surface freshening is caused by a strongly increased liquid freshwater export from the Arctic through Fram Strait, which is largely due to the decrease in the Arctic sea ice cover, and hence of the solid freshwater export. In the extended RCP8.5 scenario, all NA deep convection in the CCSM4 ceases by 2145 due to this freshening, which leads to a 72% (18 Sv) decrease of the MOC strength by the end of the simulation in 2300, which persists for several 100 years. A temporary reduction in AMOC strength is also observed for the RCP2.6, RCP4.5, and RCP6.0 while the CO_2 increases. However, the AMOC strength in these simulations recovers within one to three decades after the CO_2 forcing decreases or stabilizes and the salinity anomalies are flushed out of the deep convection regions.

Pliocene AMOC response to Arctic gateway closures in the CCSM4

Based on Otto-Bliesner et al. (in preparation)



Change in the AMOC (Sv) compared to the Pliocene control simulation (upper left) for Pliocene experiments with closed Arctic gateways.

The Pliocene sensitivity simulations show that closures of the Bering Strait (BS) and Canadian Archipelago (CAA) channels in the Arctic strongly influence the AMOC, by changing the freshwater transport and the freshwater pathways into and out of the Arctic Ocean and from the Arctic Ocean to the Labrador Sea.

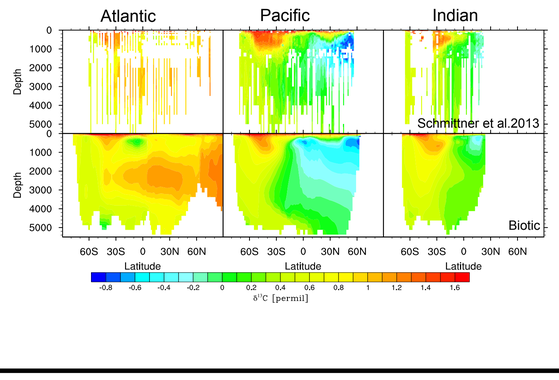
While a closed BS leads to a strengthened AMOC due to strongly reduced Arctic freshwater input and export, a closed CAA leads to a weakening of the AMOC, as all freshwater export is rerouted through Fram Strait, increasing the stratification in the GIN and Lab Seas. When both BS and the CAA channels are closed, a Pliocene land configuration suggested by Dowsett et al. (2016), the net result is a much stronger AMOC and a much improved simulation of the proxy-indicated warm SSTs across the North Atlantic. This AMOC strengthening occurs despite a larger freshwater export through Fram Strait than in the control (as the CAA is closed), as the overall Arctic freshwater export is reduced (as BS is closed), leading to a saltier Labrador Sea with enhanced deep convection.

Carbon isotopes in the ocean model of CESM1

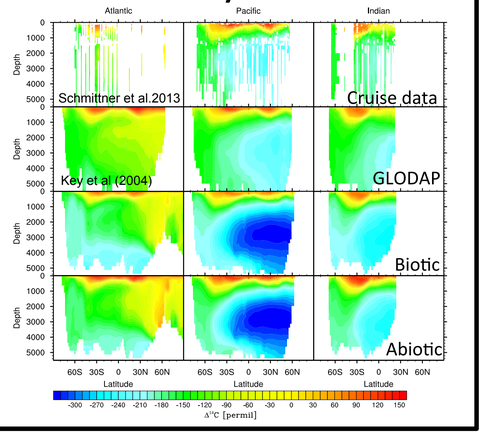
Based on Jahn et al. (2015)

Carbon isotopes (^{13}C and ^{14}C) were added to the ocean model (POP2) of the CESM1, in order to allow more direct comparisons with present-day carbon isotope data and paleo proxies based on marine carbon isotopes ($\delta^{13}C$ and radiocarbon). We are currently spinning-up a LGM simulations including the new carbon isotopes, in addition to also newly added water isotopes.

Present-day $\delta^{13}C$

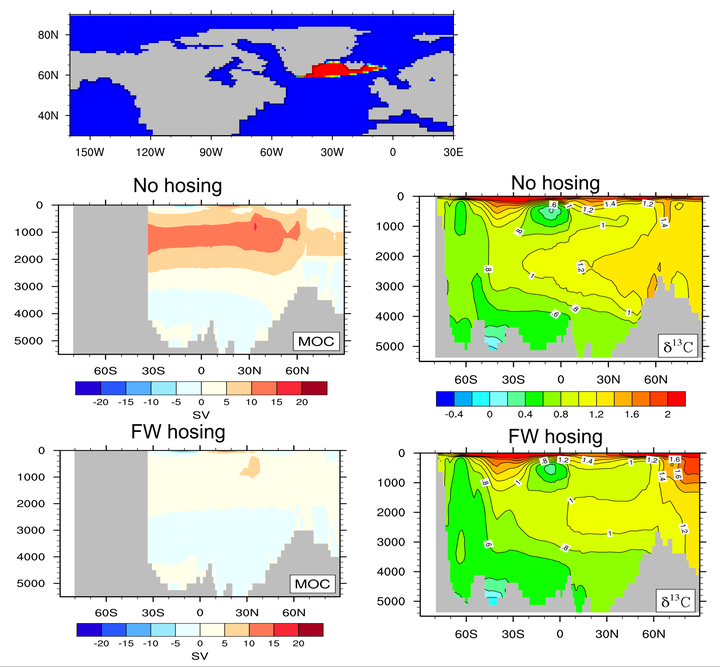


Present-day radiocarbon



Freshwater hosing experiments in CESM1

Jahn, A., preliminary results



Freshwater hosing experiments (of 0.25 Sv per year, in red shaded area) were used to study the $\delta^{13}C$ response to a AMOC shutdown. The simulated $\delta^{13}C$ shows a shallowing of higher values of $\delta^{13}C$ for the shut-down AMOC state, in general qualitative agreement with paleo reconstructions for the LGM (Oppo and Curry 2012)

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