Polona Itkin, Michael Karcher and Rüdiger Gerdes

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

# Is weaker Arctic sea ice changing the Atlantic water circulation?

## How can it be?

The Arctic sea ice is getting weaker and more mobile [1]. The sea ice conditions at the Atlantic Water (AW) gateways to the Arctic and also in the central Arctic are changing. Can this bear consequences for the mid-depth properties and circulations?

We attempt to mimic two sea ice strength modes, prior and during the climate change, in a sensitivity study where we compare two sea ice-ocean model simulations.

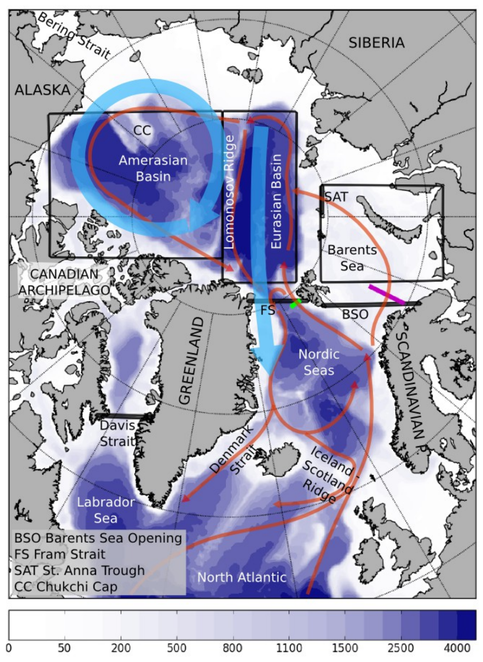



Figure 1: model domain and Arctic ocean surface (blue) and mid-depth circulation (red arrows)

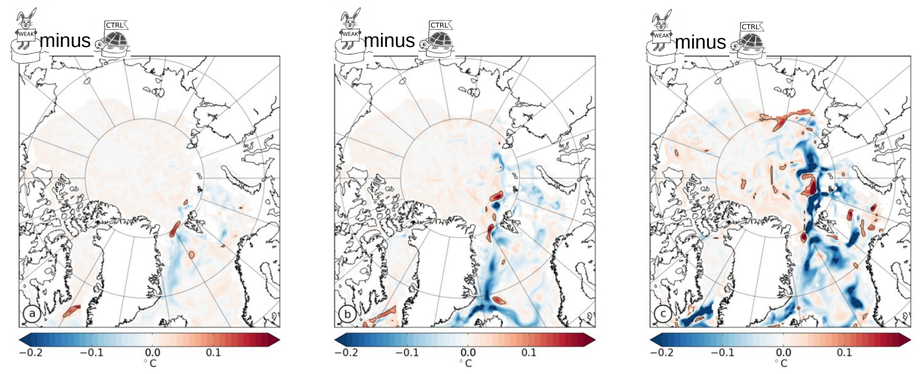



Figure 5: AWL temperature difference development during: a - 1st, b- 2nd and c - 4th year. The signal spreads from the Barents Sea and Nordic Seas to the Eurasian Basin through St. Anna Trough, Fram Strait and strait between Svalbard and Franz-Josef Land.

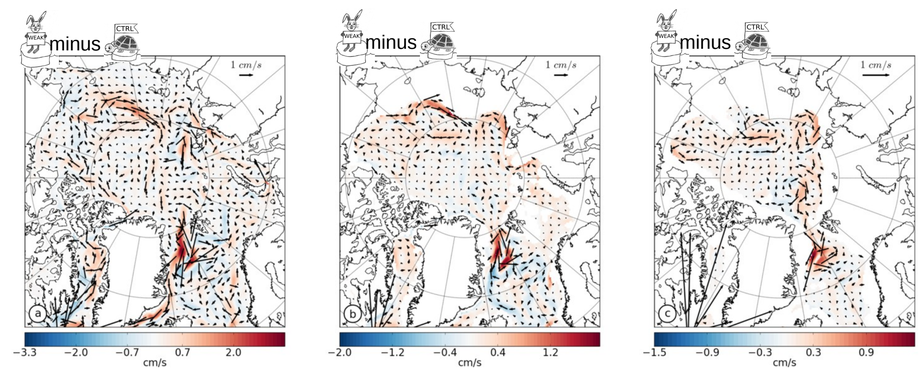


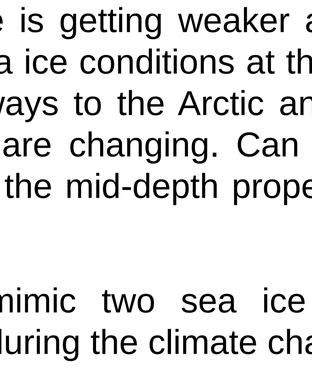

Figure 6: Speed and velocity differences in: a – surface layer (0-100m) , b – upper AWL (170-700m), c – lower AWL (700-1200m). The enhanced anticyclonic gyre is hampers the cyclonic circulation of the AWL.

## Experiment setup

MITgcm ocean model [2] coupled to to sea ice model [3] with linear free surface, C-grid, ¼° horizontal grid spacing, 36 vertical layers, z* [4], volume river runoff, 100 years spinup with CORE 1 climatology and atmospheric forcing CORE2 (1948-2007). We are comparing:

control run (CTRL):

P* = 27500 N/m$^2$




weak ice run (WEAK):

P* = 15000 N/m$^2$



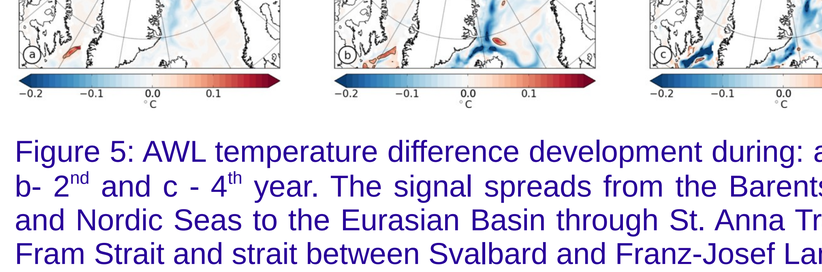




Figure 7:The mid-depth circulation changes are reflected in the volume flux balance of the Arctic straits: Fram Strait (solid), Barents Sea Opening (dash) and Davis Strait (dot).

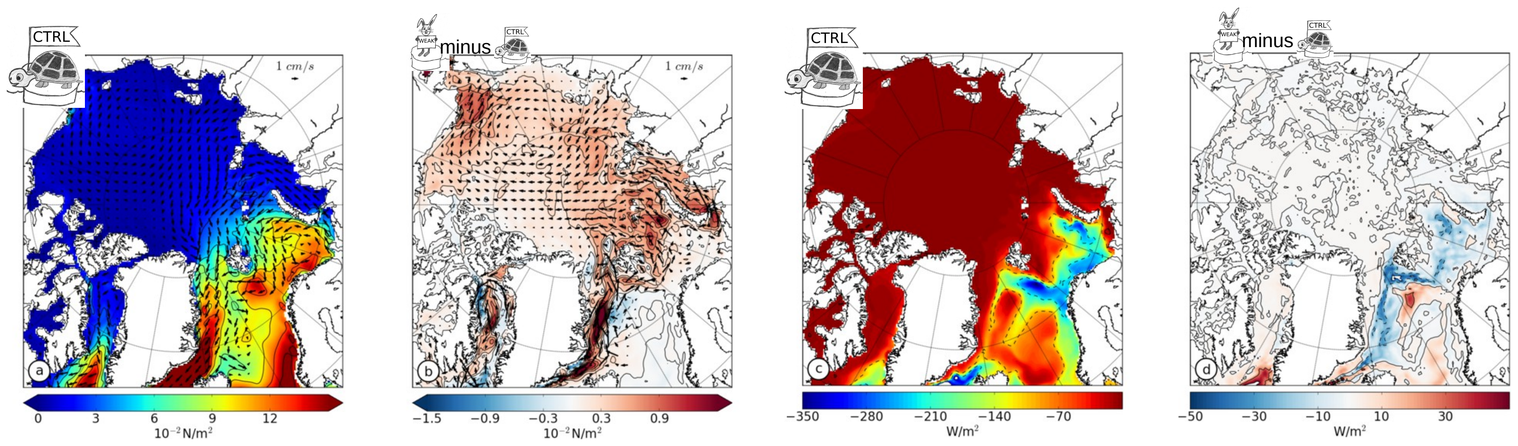



Figure 2: March (1968-2007) mean sea ice drift and ocean surface stress (a: CTRL, b: WEAK-CTRL) and surface heat fluxes (e: CTRL, f: CTRL-WEAK). In WEAK the sea ice is faster and the surface ocean is more exposed to the wind stress. The marginal ice zone (MIZ) is more ice free (not shown) and consequently the surface heat fluxes are lower.

## Summary

Lower sea ice cover in the Barents Sea contributes to high negative ocean surface heat fluxes and to formation of cooler and stronger Barents Sea branch water. The increased sea ice mobility in the central Arctic in WEAK results in faster and deeper ocean's anticyclonic Beaufort Gyre which hampers the cyclonic AW circulation beyond the Lomonosov Ridge and enhances the loop of the AW in the Eurasian Basin. As a results of both mechanisms, the AWL is cooler in WEAK by 0.2 K, the Fram Strait net outflow increases by 0.46 Sv whereas as a reaction the Davis Strait net outflow weakens by 0.29 Sv. This extends the importance of the Arctic sea ice mobility also on the water masses feeding the Atlantic Meridional Overturning in the North Atlantic.

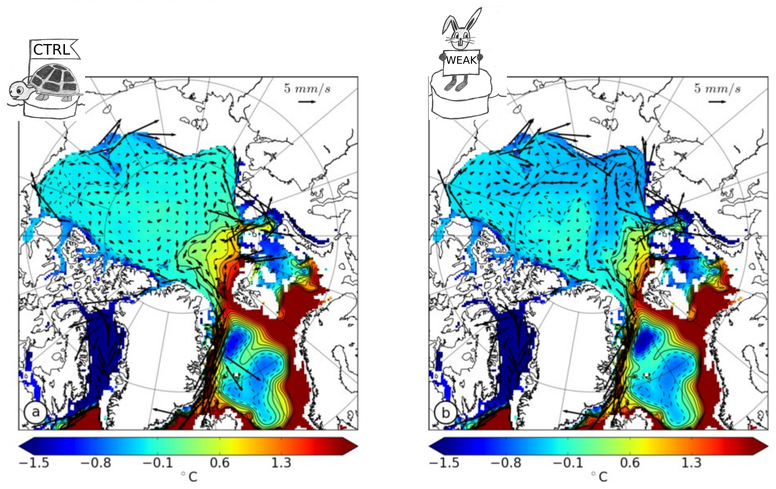



Figure 3: Atlantic water layer (AWL, 170-1200m) temperature, mean 1968-2007: a -CTRL, b – WEAK minus CTRL

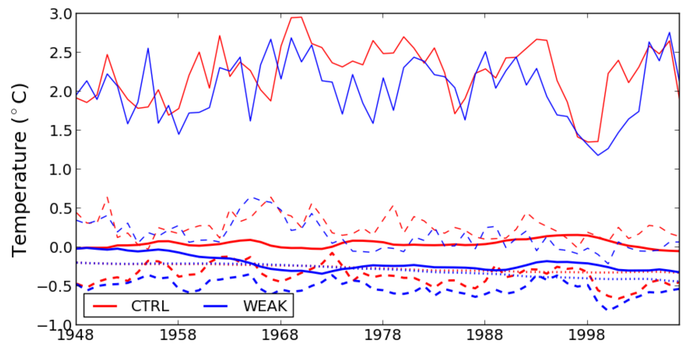



Figure 4: Time series of temperature in the Eurasian Basin (solid), Amerasian Basin (dot), Fram Strait inflow (thin solid), outflow(thin dash) and St. Anna inflow (dash).

References
(1) Spreen, G. et al., 2011. Trends in arctic sea ice drift and role of wind forcing. Geophysical Research Letters 38 (19), doi:10.1029/2011GL048970.
(2) Marshall, J., A. et al., 1997. A finite-volume, incompressible Navier Stokes model for studies of the ocean on parallel computers, J. Geophys. Res., 102(C3), 5753–5766, doi:10.1029/96JC02775.
(3) Losch, M., et al. 2010. On the formulation of sea-ice models. Part 1: Effects of different solver implementations and parameterizations, Ocean Modelling, 33(1-2), 129-144, doi:10.1016/j.ocemod.2009.12.008.
(4) Campin J.M., Marshall, J., Ferreira, D., 2008. Sea ice–ocean coupling using a rescaled vertical coordinate z∗, Ocean Modelling, 24 (1-2), 1-14, doi:10.1016/j.ocemod.2008.05.005.

MUNICIPALITY OF LJUBLJANA
JACOBS UNIVERSITY
POLMAR

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG
HELMHOLTZ GEMEINSCHAFT

BREMERHAVEN

Am Handelshafen 12
27570 Bremerhaven
Telefon 0471 4831-0
www.awi.de