POLAR-MID LATITUDE RESPONSES TO SEA ICE REDUCTION FROM LONG TERM COUPLED SIMULATIONS

Camila Campos*, Tido Semmler, Thomas Jung

Alfred Wegener Insitute, Helmholtz Center for Polar and Marine Research, Bremerhaven

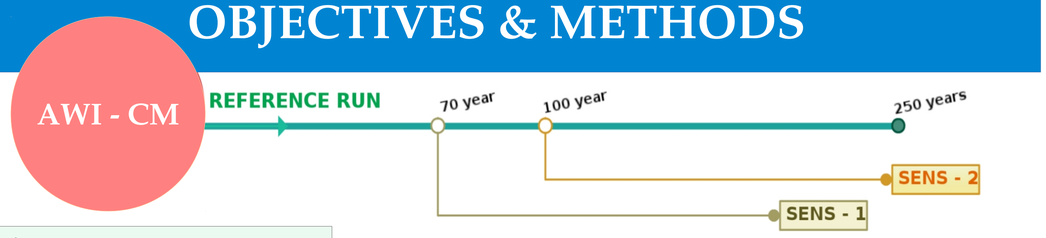
Contact:ccampos@awi.de

SUMMARY

The climate change in the Arctic has been at least twice as fast as the global average, and one of the most dramatic indicators of the Arctic warming has been the decline in the sea ice cover. Numerous relevant studies have been published on the effects of Arctic sea ice decline on weather and climate. Still, fundamental questions about the pathways and time scales on which the ocean drives and responds to changes in the coupled system remain, and urge clarification under the evidences of local and remote relevance of this component to the climate system.

Our results show that the ocean reacts comparably among the different set-ups. We argue that the lessening of the sea ice cover allows the spin up of the Beaufort Gyre through enhanced momentum transfer. This response propagates towards the North Atlantic as an increased outflow through the Fram Strait, which drives increased volume transport into the Barents Sea, thus fostering the Atlantification of the basin. The response is not confined to the interior of the Arctic and our results suggest that it may reach as far south as the North Atlantic Current as a combined response to the dynamical ocean adjustment triggered within the Arctic and, secondarily, to the atmospheric weakening of the westerly winds. Finally, the forced sea ice reduction in our experiments acts to magnify the changes in ocean due to the transient climate, and in contrast to recent similar studies, the Atlantic Meridional Overturning Circulation (AMOC) strength is insensitive to the imposed sea ice loss.

OBJECTIVES & METHODS



Reference run:
initialized from CORE II ocean-only spinup + WOA01;
forced with 1990 greenhouse gases and aerosols

Sensitivity simulations (SENS):
Thermodynamical perturbations
⇓
Reduced albedo [**ALB**]
Reduced lead closing parameter [**LEAD**]
Added longwave radiation [**LW**]

For this study, we used the **fully-coupled global climate model AWI-CM** to investigate:

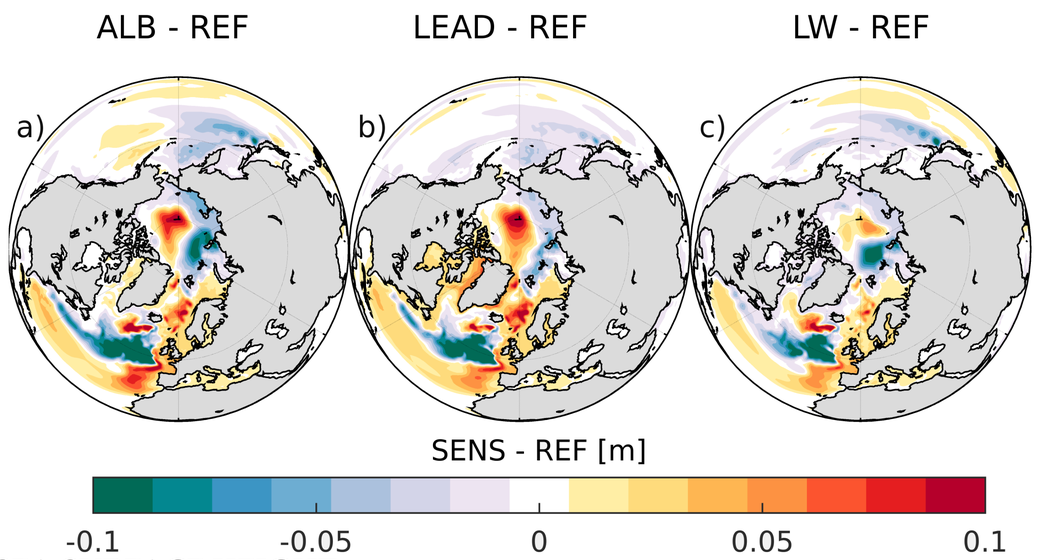
WHAT ARE THE LOCAL AND REMOTE RESPONSES OF THE OCEAN CIRCULATION TO ARCTIC SEA ICE DECLINE?

The sensitivity experiments span a period of 150-years and consist of three different set-ups: **ALB)** the albedo is modified by the increase of snow aging factor; **LEAD)** reducing the lead closing parameter which resembles a loss of sea ice thickness rather of sea ice area; **LW)** imposing an anomalous heat flux on the sea ice by adding 0.5 W/m² of long wave radiation. To check the robustness of our results we undertake a second realization of each sensitivity experiment (SENS-2) simply by initializing the experiments 30 years later. The responses of the six sensitivity studies are analyzed by the difference to the control run.

THE ARCTIC – ATLANTIC INTERPLAY

1 BEAUFORT GYRE SPEED UP

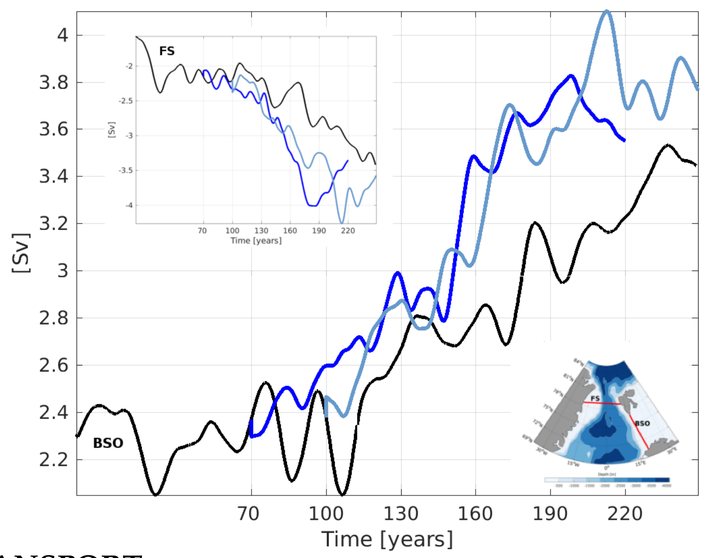
Reducing sea ice cover causes the **enhancement of the surface circulation in the Arctic Ocean**



SEA SURFACE HEIGHT:
Annual average SSH response (reference *minus* sensitivity) corresponding to last 60 years of simulation. Positive SSH suggest a spin up of the Beaufort Gyre. Negative SSH in the North Atlantic indicate southward shift of North Atlantic Current.

2 FRAM STRAIT & BARENTS SEA

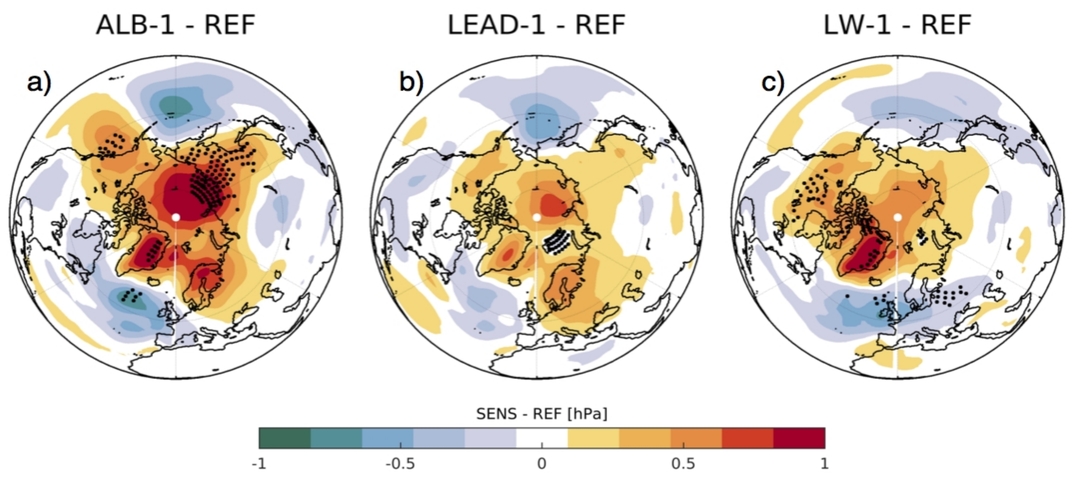
Dynamical responses are communicated to mid-latitudes through the **Arctic – Atlantic gateways** on time scales longer than 50 years.



VOLUME TRANSPORT:
Time series panel of the 20-year running mean of integrated net volume transport (1 Sv = 10^6 m^3s^{-1}) across sections: Barents Sea Opening (BSO) and Fram Strait (FS). Black line: reference simulation. Dark (light) blue first (second) realization of the added long wave sensitivity experiment.

3 WESTERLIES

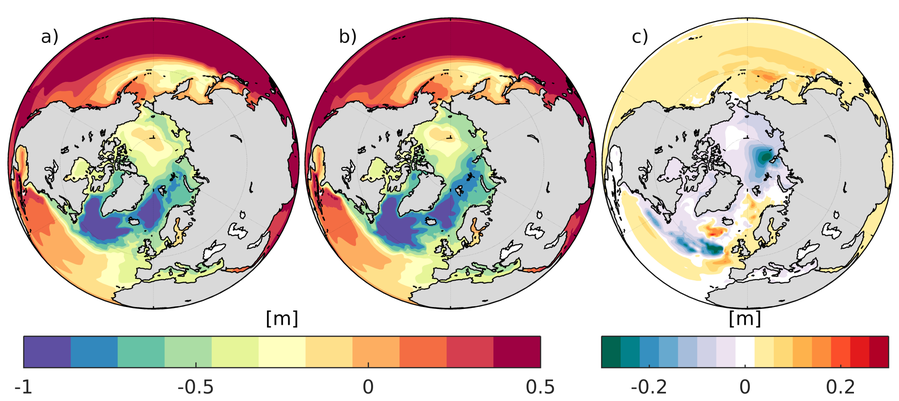
Anomalies show negative annular-mode like pattern which sustain the **weakening of the westerly winds**.



MEAN SEA LEVEL PRESSURE:
Annual average mean sea level pressure (MSLP) response over last 60 years of simulation. Dots indicate differences significant at 95% confidence interval.

4 SEPARATING EFFECTS: COMMITMENT WARMING

Atlantic Ocean circulation changes are amplified by sea ice decline, as we can also see similar response within the 1990- control simulation.



SEA SURFACE HICH IN REFERENCE SIMULATION:
Average SSH over a) high sea ice volume period (year 41 to 100), b) low sea ice vlume period in the reference simulation (year 191 to 250); c) SSH difference between period of low (b) and high (a).

FINAL REMARKS

- The ocean response is similar in all experiments
- "**Atlantification**" of the Barents Sea
- Pathway shift of **North Atlantic Current**
- No **AMOC** change across 45°N