Interaction of meridional ocean heat transports and regional processes in the Arctic Ocean

D04

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1. Summary

Research questions:

Q1 How much do **feedbacks** associated with ocean heat and sea-ice transport, surface pressure, and wind affect Arctic warming? What is the influence of a cyclonic wind anomaly over the Barents Sea?

Q2 Is the warm water inflow at depth enhancing the heat flux from the ocean into the atmosphere? Under what conditions do **cold halocline breakdowns** occur and how important are they for Arctic surface warming?

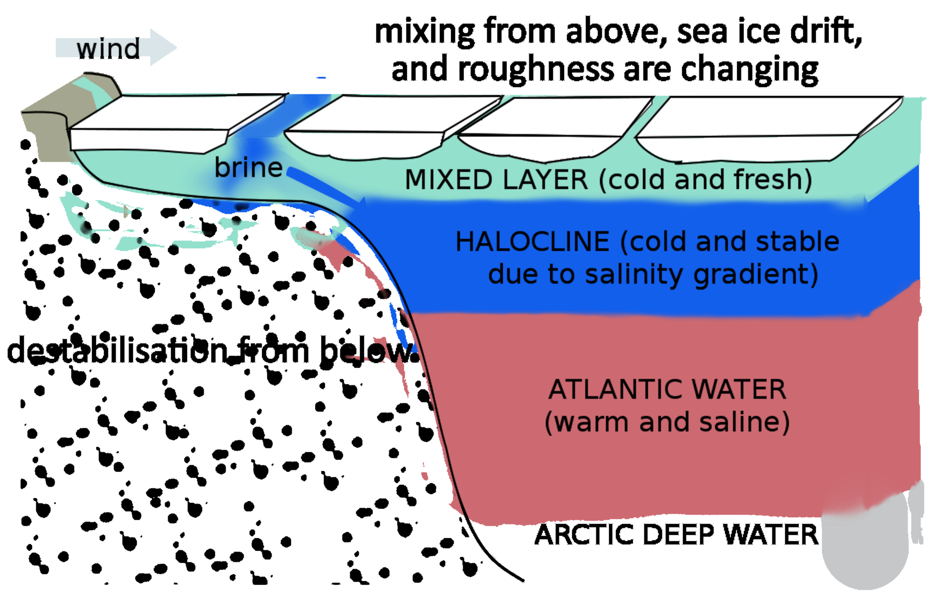
Hypothesis

The meridional ocean heat transport is self-sustained involving Arctic processes. Warming in the shelf seas inhibits the formation of the Arctic cold halocline.

2. Research rationale

State-of-the-art

- Many climate models suggest that meridional oceanic heat fluxes are the main driver of Arctic Ocean warming (Burgard and Notz, JGR Oceans, 2017)



- **Affected by dynamics** (Itkin et al., JGR Oceans, 2015)

Fig. 1: Schematic adapted from Itkin et al., 2015.

- A retreat of the cold halocline layer that separates the surface mixed layer from warmer Atlantic water was observed (Steele and Boyd, JGR Oceans, 1998, Polyakov et al., Science, 2017)
- Atlantic warm water inflow (Polyakov et al., 2017) and warming in the shelf regions (Timmermans et al., Sci. Adv., 2018) are expected to play a role for this retreat

Initial results

- Coupled Model Intercomparison Project Phase 5 (CMIP5) models show more frequent cold halocline breakdowns in high emission future climate scenario, especially in winter
- Surface energy flux from the ocean to the atmosphere increases, especially in **winter**, when the surface mixed layer is **exclusively** heated from below

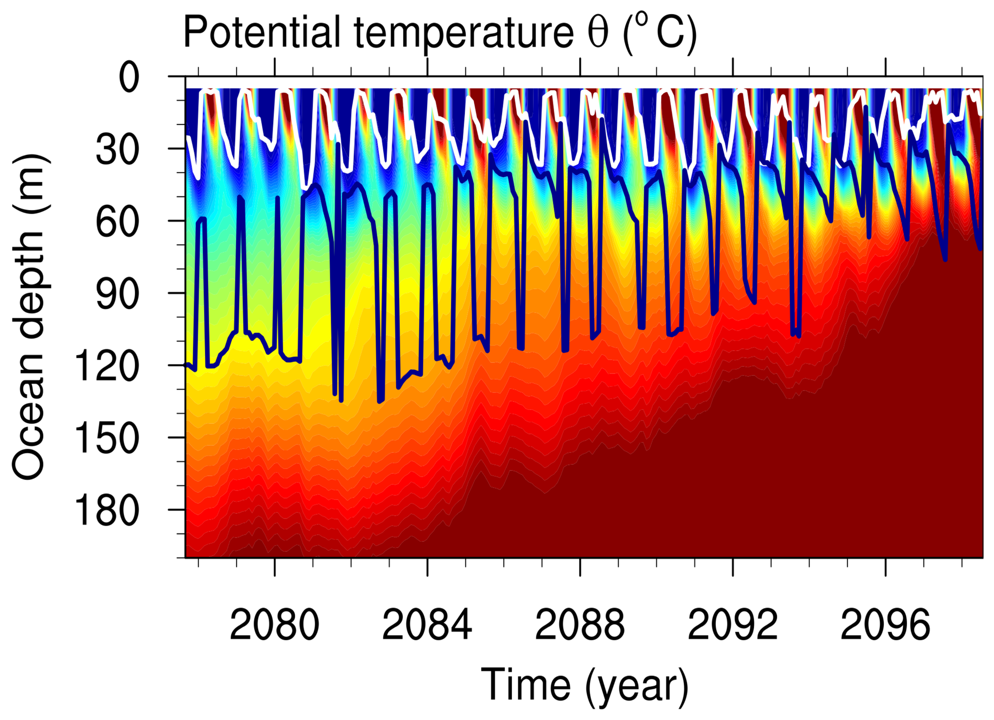
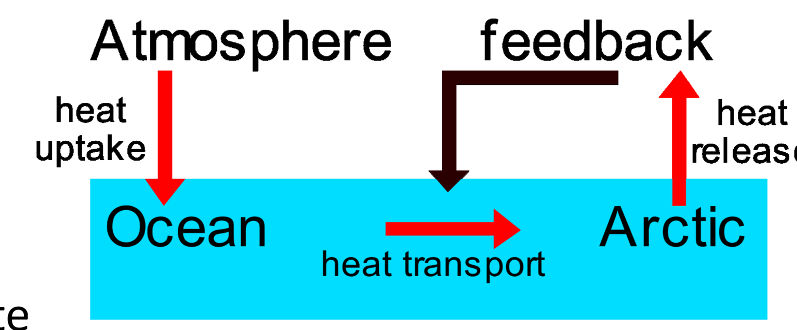


Fig. 2: Monthly mean upper ocean potential temperature for the RCP8.5 "high emission" scenario at grid point close to 125.7°E 81.1°N (in the Laptev sea) from the CanESM2 coupled climate model from 2077 to 2100. The white line indicates the bottom of the surface mixed layer. The blue line indicates the bottom of the cold halocline (Metzner et al., under revision, JGR Oceans).

3. Research plan phase II

Regional modelling



- Study feedbacks involving cold halocline & sea ice formation over shelves in regional ocean sea ice model NAOSIM
- Isolate individual feedbacks to investigate cause and effect relationships
- Prescribe cyclonic wind anomaly over Barents Sea in partially coupled model setup
- Investigate potential feedback in which the initial cyclonic anomaly strengthens
- Quantify relationship between wind stress, the near surface oceanic flow, and sea ice export on the one hand and inflow of warm and saline water from the Nordic Seas on the other hand

Global modelling

- Investigate conditions for cold halocline breakdown events and consequences based on CMIP5 monthly output
- Analyse daily output from the new German ICON-Ocean (Korn, J. Comput. Phys., 2017) at horizontal resolutions between 5 to 160 km
- Investigate individual breakdown events in sensitivity studies with ICON-Ocean
- Compare with observations

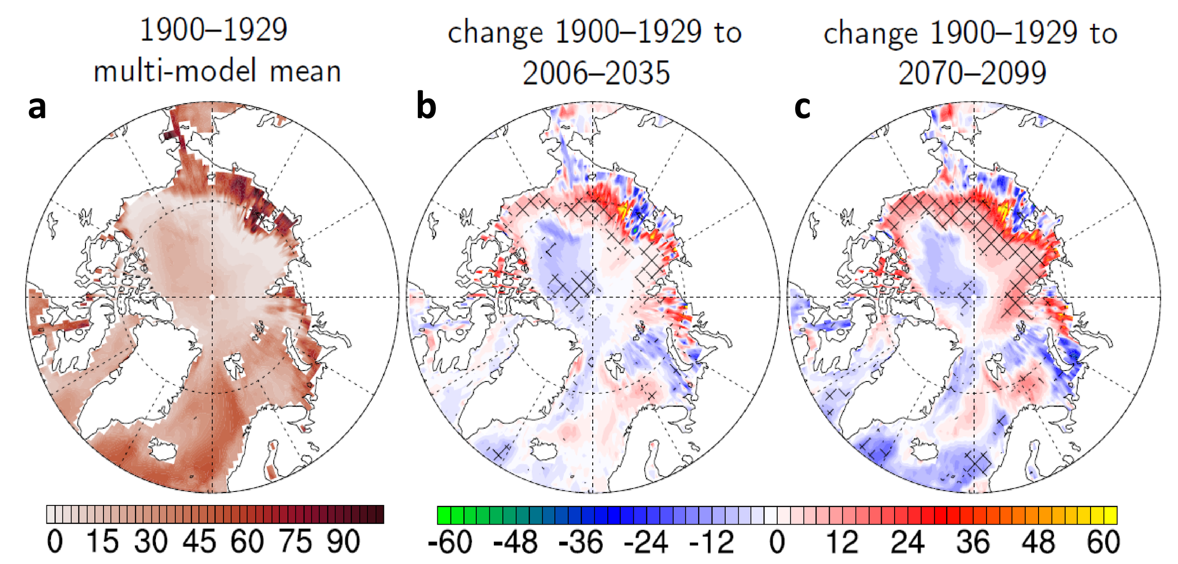


*Fig. 3: **a** CMIP5 multi-model mean breakdown event probability in percent based on monthly mean data for the months from 1900 to 1929. **b,c** Changes of breakdown event probability for the CMIP5 RCP8.5 "high emission" scenario (Metzner et al., under revision).*

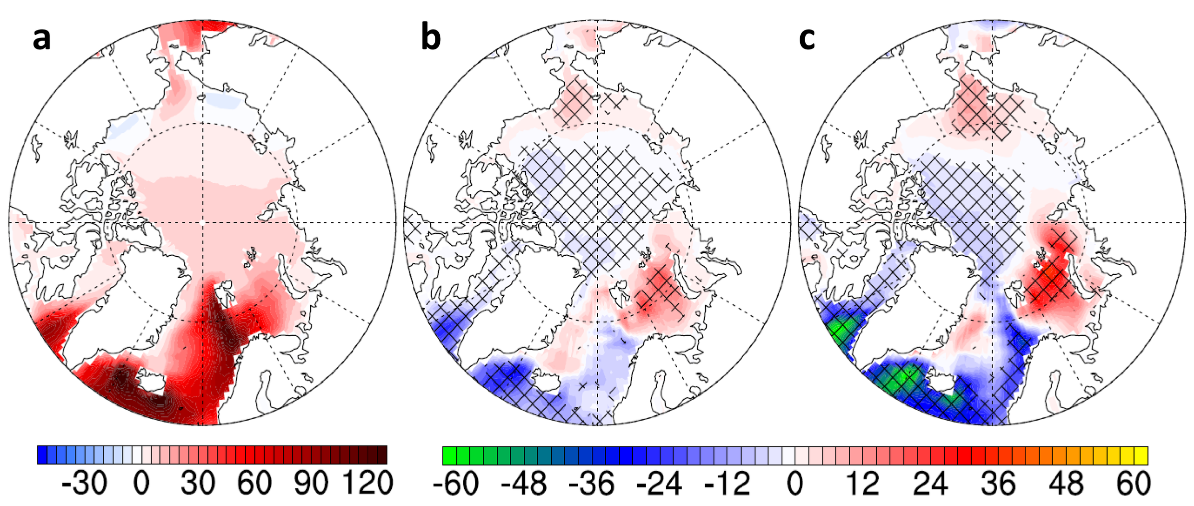


Fig. 4: As Fig. 3 but for upward surface heat flux (Wm^{-2}).

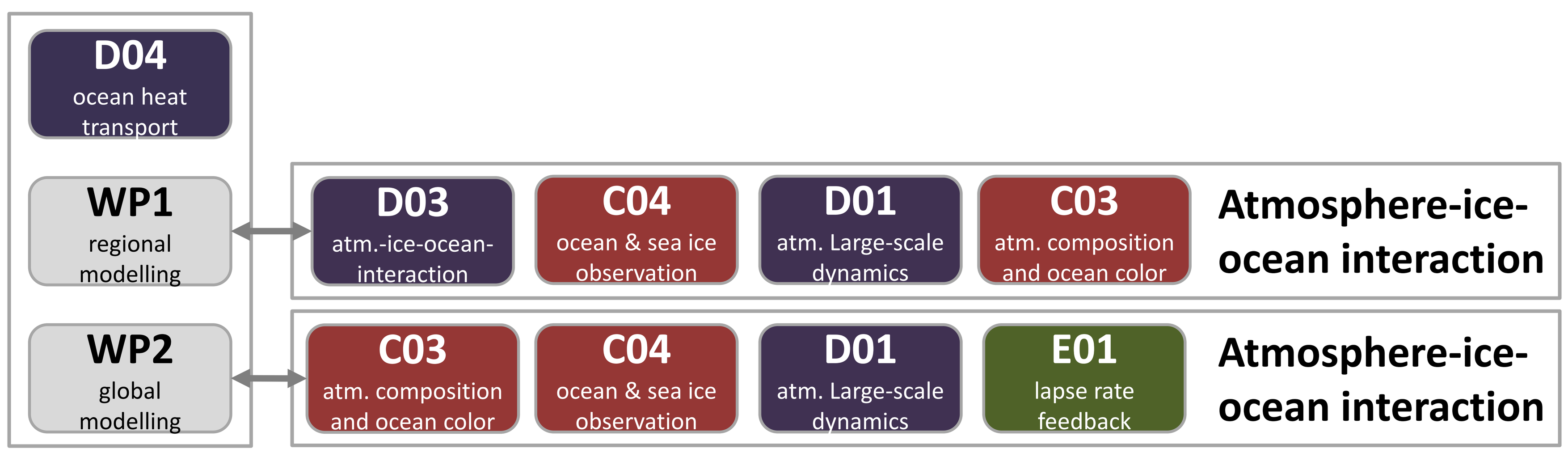
4. Role within (AC)³ & perspectives

Collaborations within (AC)³

- Triggering of mixing events through the cold halocline will be studied together with project D03
- Observations from project C04 will be used to evaluate model results
- The partitioning between oceanic and atmospheric heat transport will be studied in collaboration with project D01
- Together with project C03 we will explore links between upper ocean processes, aerosol emissions, and ocean colour
- The role of upper ocean changes for the lapse rate feedback will be investigated in collaboration with project E01

Perspectives

- Explore interactions and potential feedbacks between ocean circulation and cloud properties



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