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Polar-mid latitude responses to sea ice reduction from long term coupled simulations

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While summer sea ice reduced dramatically/significantly, and the atmospheric warming is amplified over the Arctic, changes in the ocean are less obvious due to its higher inertia. The understanding of the ongoing changes at polar latitudes and its linkages to mid-latitude climate has become a top subject among climate research community.

The ocean circulation response to an idealized decline in Arctic sea ice is investigated in a set of novel fully-coupled climate model (AWI-CM) experiments. The atmosphere and thermodynamics is resolved by ECHAM6.3 in a resolution of ca. 180Km, whereas FESOM resolves the ocean and dynamical aspects of the sea ice with resolution ranging from 25 to 150 km. A 250-year reference simulation (REF) is initialized with CORE II and WOA01 data and forced by 1990 greenhouse gases and aerosol concentrations. We conduct a comparative study in which three distinct thermodynamical perturbations are applied on the sea ice to induce a gradual sea ice reduction over 150-year period simulations.

Our sensitivity experiments consist of three different approaches to induce an Arctic sea ice reduction: I) the albedo is modified by the increase of snow aging factor; II) reducing the lead closing parameter which resembles a loss of sea ice thickness rather of sea ice area; III) 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 simply by initializing the experiments 30 years later. It is shown that ocean responses establish comparably in all sensitivity experiments. Dynamical adjustments of ocean fluxes and currents are not confined to the polar latitudes. The North Atlantic high-latitude indicates a southward shift of the North Atlantic Current pathway. Although the atmosphere seems to play a secondary role in responding and forcing dynamical changes in the Arctic Ocean, we believe that a negative annular-mode like trend explains the weakening of the westerly winds along the poleward flank of the jet stream, with in turn alters the upper ocean circulation.