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Potential for deep convection in the Arctic Basin under a warming climate and contribution to the AMOC

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Model studies have previously suggested a link between variations in the rate of deep water formation in the northern North Atlantic and variations in the strength of the Atlantic Meridional Overturning Circulation (AMOC), but the dynamical link between the two is not fully understood. The goal of this study is to investigate the potential for deep Mixed Layer Depths (MLDs) to appear close to the sea ice edge in the Arctic Basin under a warming climate, and to quantify the potential contribution of deep convection in the Arctic Basin to the AMOC.

This study uses results from "present day" simulations of two climate models, CNRM and HiGEM, and also from simulations with a four times increase in atmospheric CO_2 levels, representing a future, warmer climate. Under a warming climate, we expect (i) a reduction of the AMOC, (ii) a shoaling of the MLD in the North Atlantic and (iii) a northward retreat of the sea ice edge.

First, we document the changes affecting the MLD in the Arctic and the North Atlantic under a warming climate. There is a strong shoaling of the MLD in the present-day areas of deep convection in the North Atlantic, but also a deepening in the Eurasian Basin of the Arctic Ocean, where the MLD can episodically reach up to $\sim$600m. A detailed examination of the temporal and spatial structures of the changes affecting the ocean surface properties reveals that the Eurasian Basin undergoes a strong surface warming (linked with the retreat of the sea ice edge) and a strong salinization (possibly due the intensification of the surface gyres in the Arctic driven by stronger surface stress as the sea ice pack is thinning and shrinking). Together, these changes decrease the stratification, which triggers convective events in the basin.

Second, a quantitative Lagrangian diagnostic is applied to climate model output in order to determine where the mixed layer subduction contributes to the Atlantic Meridional Overturning Circulation at 26°N. We find that, for "present-day" conditions, the main contributions to the AMOC are mixed layer subduction in the Labrador, Irminger and Greenland Seas. In contrast, in the $4xCO_2$ simulations, the AMOC is greatly reduced and mixed layer subduction in the Arctic Basin and the subtropical gyre contribute significantly to the AMOC, the latter being likely related to a change of the stratification in this region.