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The relation between AMOC, gyre circulation, and meridional heat transports in the North Atlantic in model simulations of the last millennium

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While it is clear that the Atlantic Meridional Overturning Circulation (AMOC) is responsible for meridional heat transfer from the South Atlantic and the tropics to the North Atlantic, the majority of the heat transport in the northern North Atlantic and the Nordic seas is carried by the gyre system. However, the detailed mechanisms determining the interaction between and the temporal modulation of the components of the northward heat transport system are not clear. Long-term climate records and model simulations can help to identify important processes and to provide background for the changes that are presently observed.

Multi-centennial proxy records from the subpolar North Atlantic and the Nordic Seas indicate, for example, an out-of-phase behavior of sea surface temperature and gyre circulation between the two regions with consequences for regional climate. Paleoceanographic evidence from Fram Strait shows a pronounced modulation of heat transfer to the Arctic by the Atlantic Water layer during the last 2000 years and reconstructions from the Subpolar North Atlantic suggest a role of ocean circulation in the transition between the Medieval Climate Anomaly and the Little Ice Age.

Here we explore a small ensemble of last millennium simulations, carried out with the Max Planck Institute Earth System Model, and analyze mechanisms connecting the AMOC and gyre circulation and their relation to external forcing. Our results support the important role of the Subpolar Gyre strength and the related meridional mass and temperature fluxes. We find that the modulation of the northward heat transport into the Nordic Seas and the Arctic has pronounced impact on sea-ice distribution, ocean-atmosphere interaction, and the surface climate in Scandinavia and Western Europe.