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Transports through the Arctic gateways linked to the ocean gyres in the Carbon Dioxide removal (CDR) CMIP6 simulations

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Currently freshwater anomaly is building up in the Beaufort gyre of the Arctic Ocean. There is a risk that this freshwater may discharge into the North Atlantic, disrupting the Atlantic Meridional Overturing Circulation (AMOC). Recent changes in Beaufort gyre size and circulation suggest this may occur soon or has already started: the North Atlantic has recently experienced its largest freshening for the last 120 years. In contrast, so far there is only limited evidence of Arctic fresh water impacting freshwater accumulation in the Labrador Sea. The North Atlantic is a region of high variability on interannual to decadal timescales, potentially affecting European and global climates.

The study focuses on changes in oceanic transports through the Arctic gateways under the Carbon Dioxide Removal (CDR) es-SSP5-3.4-ov CMIP6 emission–driven scenario 2015-2100 and analyses UKESM1 simulations. We examine historical and projected periods and compare the model results to the long-term observations in the key Arctic straits. The difference between the present-day and future model transports is in their partitioning between Fram Strait: in the future most of the Atlantic model inflow occurs via the Barents Sea (5.2 Sv northwards); model 2000-2020s and 2040-2090s Fram Strait transports are 2.4 Sv and 4.6 Sv southwards. It is worth noting that the observed Fram Strait volume transport estimates bear a large uncertainty, from 2.0±2.7 Sv southwards from moorings to 1.1±1.2 Sv from inverse modelling and 0.8 ±1.5 Sv from geostrophic analysis.

The model results show that during the increase of CO_2 in the 2040s–2060s, the Beaufort Gyre is getting stronger, whereas the North Atlantic Subpolar Gyre (SPG) weakens. At the carbon dioxide removal phase (2060s–2090s) the Beaufort Gyre is strengthened while SPG weakened further. However, the cyclonic gyres in the Nordic Seas (Greenland, Iceland and Norwegian) become stronger. This points to a potential future change in the oceanic pathways between the Arctic and the North Atlantic. The corresponding heat transports due to overturning and gyres present different trends in the North Atlantic and the Arctic Ocean and different reversibility at latitudes between 26°N and 80°N, suggesting loss of immediate oceanic connectivity between the Atlantic and the Arctic via Nordic Seas. The simulations show a hysteresis in the AMOC: AMOC does not recover to the same level as before the mitigation even if the atmospheric CO_2 concentration does.

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