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Establishment of the North Atlantic subpolar circulation in an eddy-resolving ocean model

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The subpolar North Atlantic is a key region for the global climate, linking the Arctic Ocean and the Nordic Seas to the rest of the Atlantic Ocean and being one of the main sites of deep-water formation. Processes taking place in this area are crucial for the modulation of the temperate climate of northwestern Europe and the dynamics of the North Atlantic Subpolar Gyre determine the rate of deep-water formation; these water masses constitute the cold lower limb of the Atlantic Meridional Overturning Circulation. Therefore, variations induced by climate change are most likely to arise in this area. Here we have used an eddy-resolving version of the NEMO (Nucleus for European Modelling of the Ocean) ocean general circulation model to investigate the establishment of the North Atlantic subpolar circulation. The model is run in a global configuration, with 75 vertical levels, DFS4.1 (DRAKKAR atmospheric Forcing Set) surface forcing, and a resolution of 1/12°, where the resolved length scales range from about 5 km at high latitudes to 9 km at the equator. We analysed the first 11 years of the run after its start-up (from 1978 to 1988) and validated the model against observations in the subpolar North Atlantic. This simulation shows a closure of the volume transport budget in this area, and also exhibits substantial improvements from the eddy-permitting version of the model (1/4°) in the representation of boundary currents, the mixed layer in the Labrador and Irminger Sea, and of the overflows from the Nordic Seas, where the mean simulated volume transport values are close to observed ones. The simulation of these processes has always been challenging for global ocean models. Our analysis shows that further improvements are still necessary to correctly reproduce the hydrographic structure of the Subpolar Gyre, which exhibits excessively deep convection in the Labrador Sea, boundary currents that are still too shallow, and a bias towards higher values of temperature and salinity for bottom waters in the Labrador Sea and overflow regions. Nevertheless, NEMO 1/12° is able to simulate the subpolar circulation with remarkable realism and will provide great support in understanding high latitude dynamics, testing hypotheses and designing monitoring systems.