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North Atlantic deep water formation and overturning strength during the Holocene: a model-data comparison

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Climate and ocean circulation in the North Atlantic region was mainly influenced over the course of the Holocene by two driving factors: disintegrating ice sheets, and the seasonally varying, orbitally-induced insolation trends. During the early Holocene, the Laurentide ice sheet released large melt water fluxes into the North Atlantic affecting ocean circulation and in combination with the cooling effect of the remnant ice sheet, cooling large parts of the Northern Hemisphere. This impact is accompanied in the Nordic Seas by a rather small, but significant, amount of Greenland ice sheet melting that accompanied these cooling effects even further. After about 7 ka BP most of these ice-sheet impacts vanished, marking the peak of the Holocene Thermal Maximum in many regions, before the climate continued to follow the orbitally-induced cooling trend until the pre-industrial era. There are numerous proxy-based reconstructions that cover the time since the beginning of the Holocene (11.5 ka BP) and record changes in for example convective activity or temperatures and can give information on key aspects of this past climate time periods. In this study, we have compared proxy-based reconstructions of North Atlantic meridional overturning circulation with the results of our transient simulations of the Holocene climate, performed with an fully coupled atmosphere-ocean-vegetation model of intermediate complexity. Our results show good agreement of Nordic Seas winter convection depth and Iceland-Scotland overflow speeds as reconstructed from sortable silt derived from deep ocean sediment cores. Both model and data suggest highest flow speeds at about 7 ka BP and a decline towards the present-day. The latter decline is likely to be driven by increasing Arctic sea-ice export into the Nordic Seas, therefore reducing ocean surface density, allowing shallower convection in the Nordic Seas in the late Holocene compared to the Holocene Thermal Maximum. However there are other records and other proxies, such as magnetic-based data and δ13C, that exhibit different long-term trends of components of the ocean circulation. We evaluate these different reconstructions and provide a more complete understanding of effects and responses compared to a single proxy-based comparison.