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Evaluating and understanding AMOC variability over the Holocene

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Climatic variations over the Holocene are not well understood yet. The Meridional Overturning Circulation (AMOC) has been proposed to play a key role in these variations, but its reconstruction is not coherent at different locations. To circumvent this issue, we propose a new AMOC statistical reconstruction based on multiple source of information, i.e. 22 SST proxies compiled in the North Atlantic and covering the Holocene. Our approach consists in isolating the main variability modes hidden in the Atlantic Ocean through principal component analysis (PCA) and then evaluate their link with the AMOC. To estimate the skill of our method, we use a pseudo-proxy approach applied to observational SST data covering the period 1870-2010, as well as simulation from a comprehensive climate model (IPSL-CM5A-LR), where the AMOC variations are known. In the model simulations and instrumental observations, the first mode of SST variations from the PCA analysis over the North Atlantic is usually associated with the external radiative forcing, while the second mode is reminiscent of the AMOC variability and of its signature on SST. Over the Holocene period, the first mode is indeed well correlated with the insolation changes, marked by a general cooling of the Northern Hemisphere from 9 kyrs BP. The second mode, that we consider here as an AMOC reconstruction, following the pseudo-proxy conclusion, is in line with a few independent reconstructions of the deep current in the North Atlantic. From this reconstruction, the Early Holocene is associated to an AMOC enhancement, possibly related with the decrease of the ice sheet melting followed by a weakening from around 6-7 kyrs BP. We find also that the late Holocene period is marked by two short fluctuations, with maxima at about 4.2 and 5 kyrs BP, in line with short-term variations identified in the proxy data using magnetic properties at the exit of Iceland.