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Effects of orbital forcing and climate variability in a transient simulation of the Holocene with a comprehensive Earth System Model

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Changing orbital boundary conditions leads to spatio-temporal changes in insolation distribution especially in the higher latitudes and thus to changes in the seasonal cycle. We apply the orbital forcing from 6,000 years before present to today to a coupled atmosphere-biosphere-ocean model (ECHAM5-JSBACH-MPIOM) resulting in an unaccelerated transient 6,000 year long simulation of the Holocene.

The simulation shows cooling in the high northern and southern latitudes and warming in the equatorial and northern subtropical regions. These trends are enhanced by increased sea-ice cover in parts of the Arctic and a southward migration of the Intertropical Convergence Zone (ITCZ) leading to an additional warming signal over the Sahel region. An investigation of the North Atlantic Oscillation (NAO) index over the simulation length shows periods of prevailing positive and negative phases over up to 300 years with a trend from predominant positive phases in the beginning towards dominating negative phases at the end. The strength of the Atlantic Meridional Overturning Circulation (AMOC) increases by 2 Sv to 16 Sv at its maximum at 30°N. A spectral analysis of the AMOC time series reveals persistent significant variability on sub-decadal and multi-centennial time scales. We present the mechanisms responsible for the observed effects focusing on ocean-atmosphere interactions and their implications on patterns of climate variability.