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\textbf{Arctic Oscillation during the mid-Holocene and last glacial maximum from PMIP2 coupled model simulations}

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Changes in the Arctic oscillation (AO) during the mid-Holocene and the last glacial maximum were compared to pre-industrial simulations using four coupled ocean-atmosphere models (i.e. CCSM, HadCM3M2, IPSL, and MIROC3.2) from the second phase of Paleoclimate Modeling Intercomparison Project. Results show that the amplitude of the simulated AO during the mid-Holocene is a little smaller than that of the pre-industrial simulation. While the AO pattern and vertical structures are similar to those in the pre-industrial simulation, the polar westerlies are slightly weakened and displaced downward to the lower stratosphere, accompanied by weakening of the polar vortex and warming of the cold polar cap region. During the last glacial maximum, when the Northern Hemisphere experiences severe cooling, the intensity of the AO decreases substantially compared to the mid-Holocene, with smaller standard deviation of the AO index in all models. Furthermore, the magnitude of positive and negative centers of the AO spatial pattern decreases, and the strength of the polar vortex and westerlies weakens further with the center of westerlies displaced into the mid-latitude upper troposphere. The polar cap region becomes slightly warm in the stratosphere, while it remains cold in the troposphere. The AO appears to be sensitive to background climate state.

Upward-propagating stationary Rossby waves are found to be stronger during the mid-Holocene and last glacial maximum than in the pre-industrial simulation. This increase in planetary wave activity might be responsible for the simulated weakening of the AO during the mid-Holocene and last glacial maximum. We propose that a large increase in fall snow depth during the last glacial maximum strengthens the upward-propagating stationary Rossby waves.