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Climatic response to orbital, solar and greenhouse gas forcings during the mid-Holocene in transient simulations with the coupled GCM ECHO-G

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Two transient simulations with the coupled atmosphere-ocean general circulation model ECHO-G have been carried out for the mid-Holocene. The first simulation is driven by changes in orbital forcings. The second is additionally driven by reconstructions of solar activity and greenhouse gas concentrations. The simulations have been carried out for the period 7 ka BP – 4.5 ka BP and compared to a 300 year long pre-industrial quasi-equilibrium (control) simulation.

The simulation reproduces well the mean temperature differences between 6 ka BP and pre-industrial times found by earlier studies carried out as time-slice experiments. For example, changes of orbital forcing cause increased temperatures over the northern continents during summer and autumn. Also indirect consequences related to changes in atmospheric circulation are evident. Temperatures are reduced south and west of Greenland during winter, however they increase over eastern Europe and the Arctic ocean, despite a negative Northern Hemisphere (NH) insolation anomaly. Although this pattern is similar to the NAO pattern, a closer inspection reveals distinct

differences. Reasons explaining these differences are related to changes of sea ice in the east Greenland current and SSTs south of Greenland.

The transient temperature response indicates a decline in NH summer and autumn temperatures towards pre-industrial conditions. During northern winter NH temperatures are similar to pre-industrial levels and show no clear-cut trends despite an orbitally driven insolation increase. The fingerprint of solar activity can also be found in NH temperatures as decadal-scale variability, especially during summer. Additionally, correlations between solar forcing and seasonally and annually resolved grid-point temperatures underpin the sensitivity of tropical regions throughout the year, and NH continental regions in summer, to changes in solar activity. Our results therefore help to identify regions potentially suited for further empirical proxy data studies related to the influence of solar activity on climate during the course of the Holocene.