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The impact of centennial-scale solar forcing on the Holocene climate: simulations with a coupled climate model

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Centennial-scale climatic cooling events that occurred in the North Atlantic region during the Holocene (the last 11,500 years) have been linked to variations in solar irradiance. These cool phases have been registered in a variety of paleoclimatic archives, such as marine sediments, lake level data and glacier records. The timing of the coolings correlates with periods of reduced solar activity as reconstructed using cosmogenic isotopes. This solar-climate link, however, has been debated because the solar irradiance changes are assumed to be relatively small and probably cannot fully explain the temperature reductions (0.5 to 1˚C in Europe), suggesting that an amplifying mechanism is required to account for the magnitude of the observed climate changes.

We have used the coupled global atmosphere-ocean-vegetation model ECBilt-CLIO-VECODE to perform transient simulations of the last 9,000 years, forced by variations in orbital parameters, atmospheric greenhouse gas concentrations and total solar irradiance (TSI). The model has been run in ensemble mode to estimate the range of natural variability. Our objective is to study the impact of decadal-to-centennial scale TSI variations on Holocene climate variability. The simulations show that negative TSI anomalies increase the probability of temporary relocations of the site with deepwater formation in the Nordic Seas, causing an expansion of sea ice that produces additional cooling. The consequence is a characteristic climatic anomaly pattern with cooling over most of the North Atlantic region that is consistent with proxy evidence for Holocene cold phases, for instance the well-known cooling event centered at 2.7

kyr BP. Our results thus suggest that the ocean is able to play an important role in amplifying centennial-scale climate variability.