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Modelling the warm interglacials: analogues of MIS1

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Determining interglacial diversity, primarily as a function of duration, intensity and unique climate responses to Earth's orbital variations has become a focal point for researchers trying to better understand our current interglacial. Numerous interglacials have been espoused as Marine Isotopic Stage (MIS) 1 analogues or windows into the future of Holocene climate based on their astronomical characteristics, seasonal insolation patterns or their similarity with predicted anthropogenic warming. However, to date there has been little quantitative study of the climate of these interglacials within a physically robust framework. Here we examine the climate response to peak interglacial forcing during MIS1, 5, 9, 11 and 19 using the Community Climate System Model 3. We determine which interglacial provides the closest analogue to peak MIS1 conditions as well as the mechanisms which dominate the surface climate responses of these interglacials.

Considering the differences in astronomical parameters and greenhouse gases we discount MIS5 and 9 as analogues to peak MIS1 conditions due to their significant warmth and stronger precipitation and vegetation responses. Conversely, based on seasonal and hemispheric averages of surface temperature, precipitation and sea-ice cover, MIS11 and 19 are most similar to MIS1, with MIS11 actually exhibiting a higher affinity particularly during boreal summer. This is attributed to a greater similarity in the seasonal and latitudinal distribution of insolation over middle latitude Eurasia and North America, which are the regions most sensitive to insolation change given the absence of ice-sheet dynamics in our model. Global ocean overturning circulation during MIS11 is also closer to MIS1 than circulation during MIS19 is, due predominantly to differences in Weddell Sea bottom water formation. Thus, under the assumption of present-day ice-sheets MIS11 appears to be the better climatic analogue to peak MIS1 conditions.

In addition to the radiative effects of different greenhouse gas concentrations and insolation, wintertime surface wind variations associated with reduced sea-level pressure in the North Pacific and Southern Oceans contribute significantly to interglacial temperature variability. Significant sea-ice expansion in the Nordic Seas, induced by a cooler, fresher and weaker Norwegian current, also occurs during MIS1, 5 and 19, relative to MIS9 and 11. The manifestation of this cooling after 800 years of simulation emphasises the importance of long model integrations.

Given that our results may be to some extent model dependent we identify regions of greatest variability between the interglacials and where data collection will provide the best test of our model's - and possibly other models' - ability to simulate interglacial climates. Interestingly, annual mean temperature and precipitation over Europe shows little variation between the interglacials, despite the majority of proxy data originating there.

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