3rd International Conference on Earth System Modelling
Vol. , 3ICESM-11, 2012
3rd International Conference on Earth System Modelling

MIS-11 and MIS-19, analogs of our Holocene interglacial

A. L. Berger, Q.Z. Yin, and N. Herold

Université Catholique de Louvain, TECLIM, ELI, Louvain-la-Neuve, Belgium (andre.berger@uclouvain.be, 0032-10-47 47 22)

To understand better our current interglacial and its future, we have investigated the response of the climate system to insolation and GHG at the peaks of the interglacials over the past 800,000 years using both LOVECLIM (Yin and Berger, 2010, 2012) and CCSM3 (Herold et al., submitted). If we identify these peaks with NH summer at perihelion, MIS-1, MIS-11 and MIS-19 show a pretty similar latitudinal and seasonal distribution of the incoming solar radiation. This is due to their similarities in obliquity and mainly in eccentricity (the 3 lowest values of the interglacials of the last 800 ka, due to their proximity to the minima of the 400-ka cycle of eccentricity). The phase between precession and obliquity is however different, with precession lagging behind obliquity during MIS-1 by about 3 ka, being in phase with obliquity at MIS-19, but with obliquity lagging behind precession by about 8 ka at MIS-11. Consequently, they are all under-insolated over the whole globe during boreal summer (as compared to the average of the last 9 interglacials), and are over-insolated during boreal winter with a maximum over the South Pole. For MIS-1, MIS-11 and MIS-19, the insolation distribution leads to a cooling over all the continents in boreal summer and to a warming over the whole Earth, except the Arctic, in boreal winter. A warming over the Southern Ocean in austral winter occurs during MIS-1 and MIS-19 due to the summer remnant effect of insolation. However, this does not happen in MIS11 because the large global cooling during this season is dominating the remnant effect of the austral summer. This leads to MIS-11 being a cool insolation-induced interglacials and thus not as good an analogue of MIS-1 as MIS-19, at least as far as insolation is concerned. The CO_2e of MIS-1 and MIS-19 is also practically the same (265 ppmv) but is larger for MIS-11 (286 ppmv). This pretty low value for MIS-1 and MIS-19 cools the Earth, reinforcing the insolation-induced cooling during boreal summer and moderating the warming during boreal winter. The reverse happens for MIS-11 for which its higher value allows it to be finally classified among the warm interglacials.

If we look now for analogues of the whole Holocene and its future, it must be stressed that the next minimum of eccentricity at the 400-ka time scale is approaching. With this and a CO_2 concentration at the interglacial level, and even larger under human influence, our interglacial was predicted to be exceptionally long (Berger and Loutre, 2002). The same happened during MIS-11, its long duration having been confirmed by the EPICA record (Jouzel et al., 2007). MIS-19, also associated with a very low eccentricity, is the next best astronomical analogue. According to the sensitivity experiments of Berger et al. (1999), moderate values of CO_2 sustained for sufficiently long might have led to an interglacial MIS-19 even much longer than MIS-11 and MIS-1.

The interglacials MIS-9 and MIS-5 are the warmest over the last 800 ka and, as such, are considered as analogues for our CO_2-induced future warm interglacial, although their astronomical forcings are largely different from MIS-1 and its future. MIS-9 is the warmest and MIS-5, which is generally assumed to be a good analogue for the future warmth of our interglacial, is slightly warmer than the simulated present-day climate. The warm climates of MIS-9 and MIS-5 are due to a warming contribution from both insolation and GHG, but MIS-11, as already said, is a warm interglacial only because of its high GHG concentrations, its insolation contributing to a cooling.

Being given the important role played by the insolation forcing at the seasonal time scale, we recommend that a particular attention be paid to MIS-11 and, in particular, to MIS-19 as possible analogs for the future of our Holocene interglacial.

Berger A., Li X.S., and M.F. Loutre, 1999. Modelling northern hemisphere ice volume over the last 3 Ma. Quaternary Science Reviews, 18, pp. 1-11

Berger A., Loutre M.F., 2002. An exceptionally long interglacial ahead? Science 297. 1287-1288

Jouzel J.et al.,2007. Orbital and Millennial Antarctic Climate Variability over the Past 800,000 Years. Science 317: 793-796

Yin Q.Z. and A. Berger, 2010. Insolation and CO_2 contribution to the interglacial climate before and after the Mid-Brunhes Event. Nature Geoscience, 3(4), pp. 243-246

Yin Q. and A. Berger, 2012. Individual contribution of insolation and CO_2 to the interglacial climates of the past 800,000 years. Clim Dyn, 38, pp.709-724 doi:10.1007/s00382-011-1013-5