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On the importance of reduced greenhouse gas concentrations during the early Last Interglacial

Petra M. Langebroek (1) and Kerim H. Nisancioglu (2)

(1) Uni Climate, Research AS & Bjerknes Centre for Climate Research, Bergen, Norway (petra.langebroek@uni.no), (2) Dept. of Earth Science and Bjerknes Centre for Climate Research, University of Bergen, Bergen, Norway (kerim@bjerknes.uib.no)

The last interglacial (LIG) is characterized by high latitude warmth and is often considered as a possible analogue for future warming. However, in contrast to predicted future greenhouse warming, LIG Northern Hemisphere peak warmth is the result of a maximum in summer insolation. Greenhouse gas (GHG) concentrations were relatively stable and similar to pre-industrial values, with the exception of the early LIG when, on average, GHGs were slightly lower.

We investigate 1) the different effects of GHG versus insolation forcing on climate during the LIG; and 2) whether reduced GHGs can explain the low surface temperatures reconstructed for the North Atlantic during the early LIG. Six time-slice simulations were performed with the low resolution version of the CMIP5 Norwegian Earth System Model (NorESM-L) covering the LIG. In four simulations only orbital forcing was changed. In two other simulations, representing the early LIG, additionally GHG forcing was reduced.

We show that insolation forcing results in seasonal and hemispheric differences in temperature. In contrast, a reduction in GHG concentrations causes a global and seasonal-independent cooling. Modelled North Atlantic summer sea surface temperatures capture the general trend of reconstructed summer temperatures, with low values in the early LIG, a peak around 125 ka, and a steady decrease towards the end of the LIG. Even tough there is a general fit, the proxy data indicate lower temperatures during the early LIG than simulated by the model. This misfit is reduced in simulations forced with reduced GHG concentrations. However, other climate feedbacks (e.g. changes in freshwater forcing, albedo or ice topography due to the melting of the Northern Hemisphere ice sheets) are needed to explain the remaining mismatch between simulated and reconstructed LIG surface temperatures in the North Atlantic.