The intensity of interglacials during the last 800 kyr

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An ultimate target of Quaternary climate studies is to predict the strength and timing of glacial cycles using only the Milankovic forcing as input. Here we consider just one aspect of this challenge, the intensity of interglacials. Previous work (PIGS Working Group, 2015) has identified 11 interglacials in the last 800 kyr. Are some of them globally strong or weak? Is there a step change at the mid-Brunhes (between MIS 13 and MIS 11)? And what controls the observed intensity?

We first discuss what we mean by intensity. Some datasets (such as mean global temperature or sea level) have a more global character and might be considered more robust indicators of interglacial strength, but are more difficult to estimate compared to simpler parameters such as CO₂ concentration and Antarctic temperature. Many records show “overshoots”, temporary maxima that are followed by longer plateaus of interglacial character. Despite these complications, some patterns do emerge. In global scale records, MIS 5e, 11, 9, 1 stand out as particularly warm, with 13 and 17 particularly cold. Some terrestrial records show a different pattern with MIS 13 unusually strong in many Asian records. There is a tendency to more intense interglacials after 450 ka, but MIS 7e and 7c would sit quite happily in the pre-mid-Brunhes pattern.

A first look at the astronomical/orbital context is not encouraging. We see the obvious MIS11 paradox, that weak precessional forcing leads to a strong interglacial (or the opposite, most clearly seen in MIS 15e and 7c). However two different approaches have been quite successful, and may point the way to a more satisfying conclusion. Yin and Berger (2010, 2012) predicted the strength of interglacials using Milankovic forcing plus CO₂ concentration as inputs. This approach suggests that the main cause of stronger interglacials after the mid-Brunhes is higher CO₂ and pushes the problem into understanding the controls on the intensity of CO₂ maxima. Mitsui et al (2022) used Milankovic forcing plus the strength of the previous glacial. In this model, the tendency to stronger interglacials after the mid-Brunhes arises essentially from a tendency to higher obliquity, as part of
a 1.2 Myr cycle. Neither approach views the change across the mid-Brunhes as an “event” and we propose it should rather be termed a mid-Brunhes “Shift” (MBS).

Here we discuss how we might approach a unified explanation that draws on both models, with periods of highest CO$_2$ perhaps being related to the pattern and timing of AMOC strength during the termination. This is influenced by the size of glacial ice sheets and by orbital intensity through their influence on the amount of freshwater available and the rate at which it is delivered into the ocean. Finally we consider whether the pattern of obliquity is enough to understand the MBS, i.e. is it part of a longer term oscillation.