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A terrestrial Pliocene-Pleistocene temperature record from North-Western Europe

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The Mid-Pliocene Warm Period (MPWP) (ca 3.3 to 3.0 Ma) is the most recent geological interval that serves as an appropriate analogue to our current climate for two main reasons. Firstly, atmospheric CO_2 levels were similar (400 – 450 ppmv) to present day levels. Secondly, continental configurations during the Pliocene were largely similar to the present day. The MPWP is especially interesting regarding future climate predictions as global temperatures were roughly 2 – 3 °C warmer than present, indicating that current climate may not yet be in equilibrium.
Reconstructions of MPWP sea surface temperatures (SSTs) indicate SSTs were warmer than present, particularly at high latitudes (ΔSST = 2 – 6 °C). However, continental temperatures for this interval remain poorly constrained due to a lack of trustworthy proxies, and scarcity of terrestrial sedimentary archives.
Here we analysed branched GDGTs (brGDGTs) in a sediment core from the Netherlands to reconstruct continental mean air temperatures (MAT) in North-Western Europe during the Early Pliocene to mid-Pleistocene. BrGDGTs are membrane lipids of organisms living predominantly in soils whose relative distributions relate with the temperature and pH of the soil in which they are biosynthesized. BrGDGTs can be delivered to coastal marine sediments by fluvially transported soil material. Due to the coastal position of the sample site, land-sea climate correlations can be studied by analysing temperature-sensitive marine biomarkers, i.e. alkenones and long chain diols, in the same sediment, and subsequently applying the Uk37’, TEX86, and long chain diol index (LDI) paleothermometers.
The obtained MAT record can be divided into four main events: two small ‘glacial’ events, the MPWP, and the onset of Northern Hemisphere glaciation marking the onset of the Pleistocene, the latter being characterized by unstable and fluctuating temperatures. The glacial periods have been tentatively assigned according to the De Schepper et al. (2014) framework for Pliocene glaciations, the first being the 4 Ma glacial, and the second being the MIS M2 glacial, occurring roughly at $\sim$ 3.4 Ma.
Notably, reconstructed SSTs do not correspond to the terrestrial temperature record; TEX86-based SSTs show stable and unchanging conditions. Therefore, we propose that the SST may be affected by an influx of warm North Atlantic waters, caused by the initiation of the modern Nordic Seas circulation, which was in turn influenced by an input of cool Pacific waters through the Bering Strait at ca. 4.5 Ma. Evidence is reflected in the palynology of the core, which records an abundance of sub-tropical and thermophilic cysts (Lingulodinium machaeophorum, Melitasphaeridium choanophorum, Operculodinium? eirikianum and O. israelianum), matching those described by de Schepper et al. in the Nordic Seas (2014).

Reference: De Schepper, et al., 2014, A global synthesis of the marine and terrestrial evidence for glaciation during the Pliocene Epoch. Earth-Science Reviews 135, 83-102.