EXTRACTING PLIOCENE CONTINENTAL AIR TEMPERATURE EVOLUTION IN NW EUROPE FROM TETRAETHER LIPIDS

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Introduction

The Pliocene is often regarded as a suitable analogue for future climate, due to an overall warmer climate (2-3 °C) coupled with similar atmospheric CO_2 concentrations to the present (~ 400 ppmv). The drive to create environmental reconstructions of Pliocene climate has resulted in various Pliocene sea surface temperature (SST) records. Contrastingly, little is known about terrestrial climate, due to scarcity of appropriate sedimentary archives and a lack of suitable proxies.

In recent years, a terrestrial paleotemperature proxy has been developed, which uses the distributions of branched glycerol dialkyl glycerol tetraether (brGDGT) membrane lipids synthesized primarily in soils. BrGDGT-based proxy applications on coastal margin sediments have so far assumed a terrigenous origin of these compounds. However, identification of in situ brGDGT production in the marine environment[1] suggests that these proxy records actually reflect mixed signals. Hence, the creation of accurate terrestrial temperature records must disentangle the marine and terrestrial contributions to the sedimentary brGDGT record. A recent study on the Berau Delta (Indonesia) has shown that in situ brGDGT production occurs on the shelf, especially at 50-300 m water depths[2]. Furthermore, marine brGDGT production can be recognized by the degree of cyclisation of tetramethylated brGDGTs ($\#rings_{tetra}$), where values > 0.7 are indicative of a strong marine contribution to the brGDGT pool[2].

Results

Here, we generated a terrestrial mean air temperature (MAT) record for Pliocene Northwestern Europe by disentangling terrigenous and marine brGDGTs in coastal sediments from the North Sea Basin. The marine brGDGT contribution to the North Sea Basin sediments was assessed using $\#rings_{tetra}$, with marine ($\#rings_{tetra}$ = 0.93) and terrestrial ($\#rings_{tetra}$ = 0.2) end members based on the maximum value of $\#rings_{tetra}$ so far recorded in a marine environment (Svalbard)[1] and the minimum value of $\#rings_{tetra}$ recorded in the North Sea Basin sediments. Subsequently, the MAT record was corrected for marine contribution using a mixing model and a novel coastal marine transfer function. This function is currently based on all coastal marine sites from the literature for which in situ brGDGT production has been reported based on $\#rings_{tetra}$, i.e. the Berau Delta in the tropics and Svalbard in the Arctic[1,2].

In addition, the continental transfer function for the brGDGT paleothermometer was reassessed with Bayesian statistics cf. TEX_{86}[3] , and in doing so, now includes uncertainties in the observation of modern MATs and the MBT'5Me index. An extended set of surface soils with increasing global coverage (n = 299) was used[4]. The resulting 'Bayesian' MAT record contains similar trends as the original soil calibration[4] MAT and 'terrigenous' (MAT_{land}) records (Fig. 1). However, the amplitude of temperature changes in the MAT_{land} record is considerably larger (ΔT = 19 °C) than the other two MAT records.

The resulting 'corrected' MAT_{land} record indicates that temperatures were ~12 – 17 °C during the early Pliocene, and 11 – 15 °C during the Mid-Piacenzian Warm Period, confirming earlier Pliocene terrestrial temperature estimates from Northern and Central Europe. Notably, two cold (ΔT = 6 – 8 °C) periods in the MAT_{land} record indicate the occurrence of an early Pliocene glacial, before M2. These cold periods are furthermore characterized by an increased abundance of dinocysts thriving in (sub)polar conditions (e.g. *Habibacysta tectata*) and strong increases in the abundance of fern spores, providing first evidence for the influence of early Pliocene glacials on Northwestern European climate.

Conclusion

Applying the $\#rings_{tetra}$ index to North Sea sediments with a mixed source of brGDGTs has proven to be a promising method to disentangle marine and terrestrial sources. However, the newly developed coastal marine 'calibration' warrants further addition of a variety of globally distributed sites, in order to extend the calibration. The resulting MAT_{land} record herein gives more credence to the capability of brGDGTs as recorders of ancient climate changes.

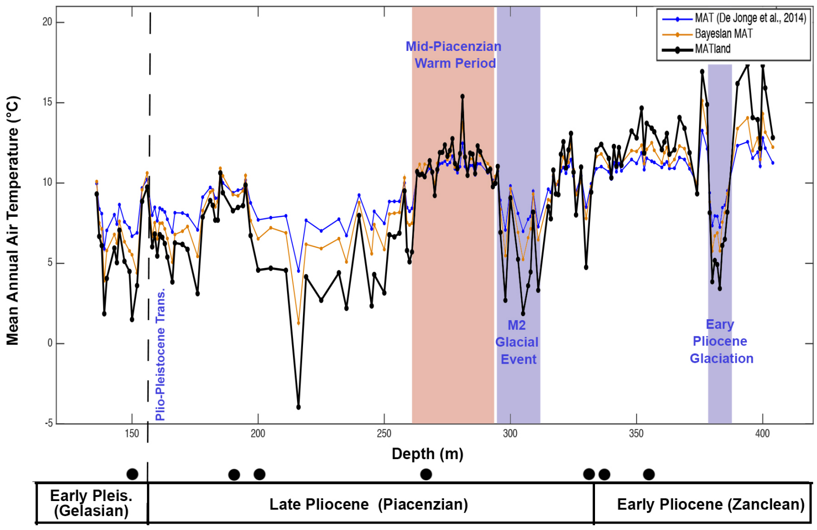

Figure 1 *The Pliocene-Early Pleistocene terrestrial temperature record of coastal sediments recovered from the North Sea. Black circles indicate biostratigraphic age-tying points.*

References

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