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Polar amplification of the early Eocene indicated by δ^2H values of lignin methoxyl groups of mummified wood

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A number of well-preserved mummified wood samples have been excavated during diamond mining operations in early Eocene (55-50 Ma) kimberlite deposits located near the Arctic Circle (64° N, 110° W) in the Canadian Northwest Territories. The preserved wood, containing multi-decadal length tree-ring information, therefore allows the reconstruction of an unprecedented snapshot of terrestrial high-latitude climate during the early Eocene. Here we used wood-derived stable hydrogen isotopes (δ^2H) as proxy for paleoclimatic interpretations. While cellulose extractions are commonly used for the analysis of modern wood-derived δ^2H values, the mummified wood samples had been affected by selective degradation leading to a strong or even complete loss of cellulose while leaving a lignin-rich material behind. We have therefore analyzed δ^2H values of the lignin methoxyl groups that have previously been shown to reflect the δ^2H values of the local precipitation and can thus be used to infer paleoclimate information such as temperature changes. We applied this proxy to specimens found in three adjacent kimberlite pipes (30 km apart) which represent a range of early Eocene ages (Rb/Sr dating: 55.5 $\pm$ 0.7, 55.2 $\pm$ 0.3 and 53.3 $\pm$ 0.6 Ma [2σ standard deviation]). The δ^2H values were measured at annual resolution for the three mummified wood series (length of individual time series: 82, 62 and 40 years) and the mean δ^2H value of precipitation for the three decadal-scale time slices was reconstructed. Finally, we used existing relationships between early Eocene temperatures and stable isotopes in precipitation to quantify temperature changes. Warming phases such as the one covered here (culminating in the Early Eocene Climatic Optimum [52 to 50 Ma]) are commonly accompanied by a stronger increase in arctic/subarctic surface air temperatures in comparison to the global average (the ratio of these temperature differences is referred to as the polar amplification). Our estimation shows for the period between 55.5 and 53.3 Ma a mean subarctic temperature increase of 7.3 $\pm$ 3.7 °C. Globally, for the same period, a mean temperature increase of 1.5 °C has previously been derived from the δ^{18}O values of benthic foraminifera. This suggests a polar amplification with a magnitude of 5 ($\pm$3). Despite uncertainties regarding both the age determination and the temperature reconstructions, the magnitude of our estimation is broadly in line with polar amplifications estimated for other Cenozoic global warming intervals, which have shown magnitudes of 3 to 4. Even though occurring on a much shorter time scale, the current global warming shows a similar polar amplification pattern as post industrial revolution Arctic temperatures, which are projected to amplify significantly in the near future, have already increased up to 3 °C as compared to a lower latitude temperature increase of 1 °C.