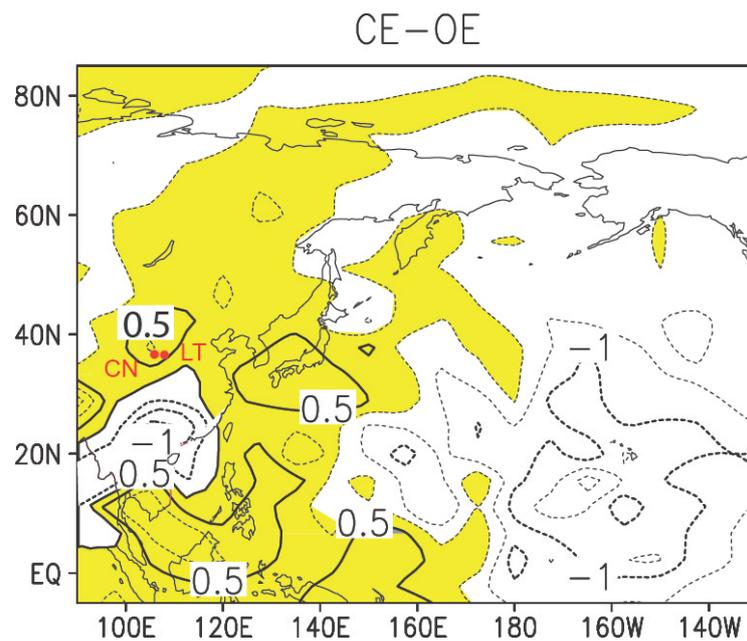


Supplementary materials for the manuscript " Pacific freshening drives Pliocene cooling and Asian monsoon intensification" by Junsheng Nie, Thomas Stevens, Yougui Song, John W. King, Rui Zhang, Shunchuan Ji, Lisa Gong, and Danielle Cares

Summary of palaeomagnetic climate proxies

The magnetic parameters have different correlation patterns when plotted against annual mean temperature (AMT) and annual mean precipitation (AMP). χ_{ARM} and $\chi_{\text{ARM}}/\text{SIRM}$ are more sensitive to high precipitation variations whereas $\chi_{\text{ARM}}/\chi_{\text{LF}}$ is more sensitive to low temperature variations. Both surface calibrations and the paleo-record consistently demonstrate these inferences. When the Chinese Loess Plateau shows a warming and wetting or cooling and drying trend, these three magnetic proxies will have covarying patterns. However, surface calibrations suggest that if the Chinese Loess Plateau has a cooling and wetting trend at the same time, χ_{ARM} and $\chi_{\text{ARM}}/\text{SIRM}$ will show a different pattern of variation than in the $\chi_{\text{ARM}}/\chi_{\text{LF}}$ record. This is how we can separate AMT and AMP, at least qualitatively. Furthermore, although χ_{ARM} is correlated with AMT, the R^2 value is less than the R^2 value of the correlation between AMT and AMP. This strongly suggests that any observed correlation between χ_{ARM} and AMT likely comes from the correlation between AMT and AMP, rather than direct causation or control of AMT on χ_{ARM} . As such, we used χ_{ARM} as a proxy for paleoprecipitation. However, for clarity and to avoid potential problems with large quantified uncertainties that result from correlations where variation in one parameter

is not explained fully by one climate parameter, we focus on the original magnetic records instead of the quantified records. We maintain that the salient features of the climatic trends discussed in the manuscript are valid based on these original magnetic parameter records, considering their correlation patterns with AMT and AMP.



Supplementary Fig. 1 Precipitation distribution differences during August associated with closure of the Panama Seaway. Closed Panama seaway minus open Panama seaway (CE-OE); Values are averaged over the last 100 years of a 5000 year integration. Contour interval is 0.5 mm day⁻¹. Positive values are shaded in yellow. The studied sections are shown by the red dots (CN: Chaona; LT: Lingtai). Figure is modified from ref. 41 in the main text.