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The relationship between the global mean deep-sea and surface temperature during the Early Eocene

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Under continued high anthropogenic CO_2 emissions, the atmospheric CO_2 concentration around 2100 will be like that of the Early Eocene Climate Optimum (EECO, 56–48 Ma) hothouse period. Hence, reconstructions of the EECO climate give insight into the workings of the climate system under the possible future CO_2 conditions. Our current understanding of global mean surface temperature (GMST) during the Cenozoic era relies on paleo-proxy estimates of deep-sea temperature (DST) combined with assumed relationships between global mean DST (GMDST), global mean sea-surface temperature (GMSST), and GMST. The validity of these assumptions is essential in our understanding of past and future climate states under hothouse conditions.
We analyse the relationship between these global temperature indicators for the end-of-simulation global mean temperature values in 25 different millennia-long model simulations of the EECO climate under varying CO_2 levels, performed as part of the Deep-Time Model Intercomparison Project (DeepMIP). The model simulations show limited spatial variability in DST, indicating that local DST estimates can be regarded representative of GMDST. Linear regression analysis indicates that GMDST and GMST respond stronger to changes in atmospheric CO_2 than GMSST by factors 1.18 and 1.17, respectively. Consequently, the responses of GMDST and GMST to atmospheric CO_2 changes are similar in magnitude. This model-based analysis indicates that changes in GMDST can be used to estimate changes in GMST during the EECO, validating the assumed relationships. To test the robustness of these results, other Cenozoic climate states besides EECO should be analysed similarly.