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Constraining Uncertainties in Paleoclimate Proxies; Implications for Data Model Comparison

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Because past climate parameters, such as temperature, cannot be measured directly, the only means of assessing the boundaries of natural climate variability is through paleoclimate proxy data or sophisticated numerical climate models. When conducting paleoclimate model/proxy data comparisons, however, significant conflicts often exist. These conflicts often lead to the conclusion that the climate models are at fault. However, as is often the case in geoscience, much of our proxy data are interpretations, rather than empirical observations, and possess inherent uncertainties. Before meaningful conclusions can be made about the causes of conflicts between models and proxy data, an accurate assessment of the level of uncertainty in proxies is required.

A great variety of paleoclimate and paleoceanographic proxies now exist, providing insight into a wide range of climate parameters. However, the accuracy and uncertainty associated with these different proxies varies enormously. Although the most sophisticated geochemical proxies have an apparent high degree of accuracy, this often coincides with a high level of uncertainty that is often overlooked. For example, such uncertainties can relate to where in the water column the signal originates, the time of year it represents, how far geographically from the site of deposition it reflects, or even if the assumptions or equations used are relevant to the species/time interval being analyzed. Conversely, simpler ‘non-numeric’ proxies, such as certain lithotypes and fossil assemblages, have lower levels of accuracy, but often provide more certain constraints. Non-numeric proxies can provide insight into a wide range of parameters, including productivity, humidity/aridity, sea surface temperature, and seawater oxygen concentrations. Both sophisticated and non-numeric proxies also have associated spatial and temporal uncertainties that must be considered when comparing them with models.

Using an Early Eocene case study, the importance of capturing the true level of uncertainty in proxy data to properly assess data/model mismatches is demonstrated. To achieve this, uncertainties are split into three components: stratigraphic, geographic, and data, enabling the reliability of all types of proxy data to be assessed independently. This assessment method allows the relative merits of using sophisticated vs. simpler non-numeric proxies to be assessed, with some surprising and far-reaching-implications.