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Global paleoclimate across the Phanerozoic: developing a new open-access database of geochemical, lithologic and paleontologic proxy records

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Quantitative paleoclimate reconstructions from geochemical and lithologic proxies provide insights into Earth's climate sensitivity and past climate transitions. However, many paleoclimate proxies are semi-quantitative, and all are spatially and temporally discontinuous. Additionally, many paleoclimate records are not digitized, or only available in older formats, limiting their availability. Thus, fully quantitative and gridded reconstructions of global and regional paleoclimate conditions using these proxies are hampered by the lack of a standardized, open-access paleoclimate proxy database and methods for integrating quantitative and semi-quantitative records to produce interpolated paleoclimate maps. Here, we report on the development of a new paleoclimate proxy database and associated geostatistical techniques designed to address these issues and facilitate the creation of gridded, proxy-based paleoclimate maps at a variety of spatial and temporal scales. A core focus of this repository and analysis methodology is the integration of geochemical climate proxies with sedimentological and paleontological climate indicators. To date, over 50,000 unique records—representing every continent and spanning over 250 million years of the late Phanerozoic— have been added to the prototype repository. We demonstrate the utility of this database through three case studies of different climatic regimes and timescales. First, we use the repository to produce proxy-based reconstructions of ice sheet extent during the Early Cenozoic and Cretaceous. These glacier reconstructions are compared to climate model simulations to constrain differences in proxy- and model-based estimates of Earth's cryosphere during greenhouse periods. Second, by comparing gridded mean annual temperature maps to a newly compiled plant fossil dataset, we test the hypothesis that circulation patterns in the Cretaceous and Paleocene Western Interior Seaway created a "climate barrier" in western North America and increased biogeographic provinciality. Third, we conduct a quantitative comparison of proxy and model global climate maps for the Paleocene-Eocene Thermal Maximum, to constrain spatial paleoclimate patterns across this interval. Through increased access to a growing body of proxy-based paleoclimate data, this repository provides a foundation for improving constraints on the evolution of Earth's climate. The development of a standardized, open-access paleoclimate proxy repository will advance interdisciplinary collaborations and enhance proxy-model comparison studies, fostering new insights into Earth's climate history.