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Opportunities and Challenges in Paleo-CO_2 Reconstruction and Implications for Advancing our Understanding the Paleo-Earth System. Endowed Biogeochemistry Lecture

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Paleo-CO_2 reconstructions are integral to understanding the evolution of Earth system processes and their interactions given that atmospheric-CO_2 concentrations are intrinsically linked to planetary function. In this talk, we use several case studies, spanning the 3 Phanerozoic Eras, to illustrate the potential of paleo-CO_2 records to constrain the magnitude and state-dependency of equilibrium climate sensitivity, to advance our understanding of global biogeochemical cycles, to test the sensitivity of Earth System modeled atmospheric and oceanic circulation to PCO_2 over a range of climate states, and to interrogate ecosystem—CO_2—climate linkages and physiological responses to CO_2. Further advances in these areas, however, are dependent on how well we 'know' paleo-CO_2 estimates.

CO_2 estimates exist for much of the past half-billion years, but the degree to which the accuracy and precision of these estimates are constrained is quite variable, leading to substantial uncertainty and inconsistency in paleo-CO_2 estimates. Potential sources of this uncertainty and inconsistency include an incomplete understanding of how environmental and ecophysiological conditions and processes imprint the CO_2 proxy signals we measure, of the sensitivity of the CO_2 estimates to this uncertainty, and differences in approaches to assigning uncertainties to CO_2 estimates, among other factors. Application of newly established screening criteria, defined as part of an effort to improve our understanding of how atmospheric CO_2 has varied through the Cenozoic, illustrates how the majority of pre-Cenozoic estimates are unreliable in their current form.

To address these issues and to advance paleo-CO_2 reconstruction, we introduce CO_2PIP, a new community-scale project that takes a two-step approach to building the next generation Phanerozoic-CO_2 record. Collective efforts are modernizing existing terrestrial-based CO_2 estimates through additional analyses, measurements and proxy system modeling to constrain critical parameters used to estimate paleo-CO_2. A set of forward proxy system models being developed in collaboration with the CO_2 community, will provide a quantified representation of proxy sensitivities to environmental and ecophysiological conditions and processes that govern the CO_2 signals. Ultimately, statistical inversion analysis of the simulated and modernized proxy datasets will be used to revise individual CO_2 records and to build a new integrated model-data-constrained CO_2 record for the Phanerozoic.