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Application of a Novel Paleoclimate Date Assimilation Method to Reconstruct Spatial Patterns of Temperature Variability During the Little Ice Age Using an Updated Multiproxy Network

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Abstract: Long records of past climate variability are needed to put recent changes into perspective and as validation data sets for predictive models because the modern instrumental record is too short to be useful for understanding multidecadal to century scale processes that are relevant to predicting the effects of anthropogenic climate change. Natural archives of climate information, known as paleoclimate proxies, can provide the necessary long records, but much work is needed to quantify the errors associated with these proxies and synthesize the many individual records into a coherent understanding of past climates. Particular attention has been paid to reconstructing the global-scale climate of the last two millennia because of the relative abundance of proxy data and because that time period is ideal for teasing apart natural vs. anthropogenic signals. Climate reconstructions covering recent centuries to millennia began with hemispheric and global means, but it is becoming increasingly clear that more detailed spatial and temporal patterns are needed to address the science questions. Additionally, we are realizing that in order to maximize the utility of the proxy data, it is important to interpret it in a way that leverages our understanding of climate physics and that quantifies proxy and reconstruction limitations.

We propose to demonstrate a new data assimilation method that is a paleo-data adaptation to modern three dimensional variational data assimilation schemes. The method uses a low-dimensional climate model derived from General Circulation Model (GCM) output through inverse modeling. This method simplifies the noisy climate system dynamics down to that which is predictable, and then uses that model as a constraint to interpret the paleoclimate data. Our initial demonstration of the method will include using it in the Paleoclimate Reconstruction Challenge funded by NOAA, testing the effects of different proxy data treatments on the results, and analyzing global surface temperature patterns over the last 550 years. We will first compile a new paleoclimate proxy data set, building upon previous examples, emphasizing the incorporation of new data from oceanic and tropical locations, regions that are important for the climate system but where the current data networks are lacking.

Products at the end of the proposed research will be: 1) an updated proxy data network extending back 2000 years with a user-friendly system for data extraction, making paleoclimate data more easily accessible for other climate scientists, 2) a demonstration and evaluation of a new, potentially better, way of doing quantitative paleoclimate reconstructions from climate proxy data, 3) an analysis of the radiatively forced spatial and temporal temperature variability during the Little Ice Age (LIA) using the updated proxy network, testing current hypotheses about the role of the tropical ocean during this time.