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What climate variables are reconstructable over the past 2000 years? A data-assimilation perspective

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Data assimilation (DA)-based reconstructions provide a means of optimally combining proxy data with the statistical-dynamical constraints of a climate model. Through these reconstruction techniques one may explicitly reconstruct any climate variable of interest, from surface temperature to atmospheric or oceanic circulation. Standard DA approaches must be modified to meet the challenges of the available paleoclimatic data, including dating uncertainty, complex forward models, and multiple time scales. We present a DA-based reconstruction technique that addresses dating uncertainty and arbitrary proxy time scales. The performance of this technique is evaluated using pseudoproxy tests by: incorporating proxy dating uncertainty, varying proxy time scales, varying proxy network and noise characterizations, generating pseudoproxies through proxy system models, and varying climate models used in the reconstructions. Also, these tests are augmented by reconstructions using the updated PAGES2k proxy database. We find that annual-mean large-scale atmosphere-ocean variables are likely to be reconstructable over at least the past 1000 years, including shifts of the inter-tropical convergence zone, sea-surface temperature, tropospheric geopotential height, and jet-stream variability. Additionally, we find that hydroclimate variables associated with integrated measures of temperature, such as precipitation minus evaporation, are also likely to be reconstructable over this time period.