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Toward community resources for paleoclimate data assimilation, reanalysis, and proxy system modeling

DAPS workshop participants*

2nd DAPS workshop, College Park, MD, USA, 29-31 May 2019

Friends and members of the Data Assimilation, Reanalysis and Proxy System Modeling (DAPS; pastglobalchanges.org/daps) working group came together for a brief meeting to discuss activities and progress since our first meeting in Louvaine-la-Neuve, Belgium, in May 2017.

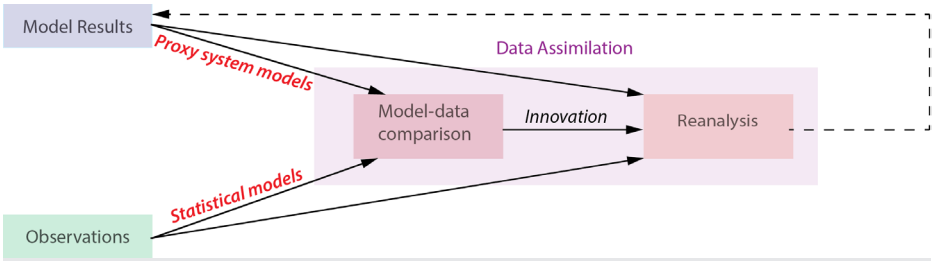

Figure 1: Schematic representation of the procedure leading to a reanalysis (i.e. a reconstruction of the state of a system) using data assimilation (modified from Goosse 2016). Reproduced from the PAGES/DAPS website (pastglobalchanges.org/daps).

Data assimilation for paleoenvironmental reconstruction: methods intercomparison

Operational systems for weather to seasonal forecasting are now modular and open platforms, allowing for automated quality control, rejection of nonconforming observations, assessment of stochastic parameterizations, uniform multivariate skill assessment, and assessment of novel approaches such as use of future forecasts (see schematic Fig. 1). By comparison with the methods used in the DAPS Data Assimilation Intercomparison Project (DAIP), we identified similarities and differences between operational online data assimilation (DA) for weather and seasonal forecasting, and offline assimilation, optimal interpolation and linear regression/transfer function approaches to paleoclimatic reconstruction (Hakim et al. 2016; Franke et al. 2017). A key question, even for offline or time-independent formulations, is whether and how to incorporate information at local versus remote scales in space. Can we trust the remote information, and at what level of filtering? Conversely, do we trust the local information? The answers likely depend on multiple approaches to skill estimation and validation of the results, at the process, data and parameter levels. Under some conditions, temporally aware data assimilation might improve results – processes for which timescales of variation are much longer than the timescales resolved by observations. For the present generation of paleo DA, this condition has not yet been met, but might be in the future, for analysis of variations associated with the intermediate and deep ocean, deep soil moisture, vegetation, and the cryosphere. These long timescales are at the heart of what might be gained from the exercise: identifying processes consistent with the observational evidence given uncertainties in all elements.

Proxy system modeling: spatial and structural considerations

We reviewed results from two Data Model Intercomparison projects (DMIP) across sensors, archives, and model complexity. Applying a bivariate linear model across marine carbonate archives identifies discrepancies between simulated and observed variance, which may be due to complex and variable growth responses. Limited validated information was retrieved from complex and nonlinear proxy system models producing tree-ring width simulations, and arose from modeling observations as bivariate indicators of both temperature and moisture variation, and under slowly changing mean climate states. However, conclusions might be sensitive to limitation by observational target and uncertainty, parameter estimation, timescale, and evaluation metrics. For more complex processes and targets, more complex models might outperform simpler ones, but require additional inputs and parameters to be specified. At present, bivariate linear regression-based PSMs may be a good point of reference and null hypothesis on PSM complexity sufficient for use in paleo reanalysis products (Zhu et al. 2019a). Advances in unified platforms for proxy system modeling and evaluation, and for exploiting digitized paleodata and metadata via the Linked Paleo Data (LiPD; lipd.net) format (Dee et al. 2015; Zhu et al. 2019b) will enable more comprehensive studies and advances in the use of PSMs in paleoclimatic data assimilation exercises.

Products and next steps

An overarching theme that emerged from our discussions, fueled by nearly intravenous espresso and homemade food, was that a common, open platform for development and assessment of approaches to paleoenvironmental data assimilation, reanalysis and proxy system modeling is sorely needed. As a result of a concentrated working session, such a community platform is being constructed (daps-pages.github.io) as a basis for ongoing work, and papers synthesizing DAIP, DMIP and challenges/outlook are developing. However, DAPS was founded as a three-year project, and will sunset in 2019 – unless new leadership proposes a second phase! If you are interested in picking up on the themes and initiatives described here, please contact the group leaders (pastglobalchanges.org/science/wg/daps/people) for more information and suggestions for doing so.

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