The Paleo-ocean challenge: data meet models

PMIP-MARUM-PAGES Workshop on Comparing Ocean Models with Paleo-Archives 2012 (COMPARE 2012) – Bremen, Germany, 18-21 March 2012

Michal Kucera, A. Paul and S. Mulitza
MARUM - Center for Marine Environmental Sciences, University of Bremen, Germany; mkucera@marum.de

Comparisons of model simulations with data on the state of the ocean in the past are frequently used to study climate processes under different boundary conditions and to understand climate and ocean change in Earth history. Such approaches can be used to benchmark climate models and model ensembles (Hargreaves et al. 2011). They hold considerable promise in demonstrating the ability of climate models to simulate the response to changes in forcing factors (Braconnot et al. 2012) and to help constrain critical parameters, such as climate sensitivity (Schmittner et al. 2011).

The Phase 3 of the Paleoclimate Modelling Intercomparision Project (http://pmip3.lsce.ipsl.fr), which is the paleo-component of the fifth phase of the Coupled Model Intercomparison Project (http://cmip-pcmdi.llnl.gov/cmip5), is currently being completed with a number of new model run results. For the first time, the paleoclimate simulations use the same model setups as those used for projecting future climate. One of the goals of PMIP3 is to examine climate predictability and to determine why similarly forced climate models produce a range of climate responses. To this end, the PMIP3 model runs have to be confronted with paleodata for the time intervals that have been modeled. Among these are the last glacial maximum (LGM), but also the last interglacial, the early Holocene, and the last deglaciation. For this comparison, marine sedimentary data will play a crucial role, because of their precise and consistent dating, and the fact that they record regionally representative patterns in key modeled variables, which can be reconstructed quantitatively (e.g. Lynch-Stieglitz et al. 2007; MARGO 2009).

Considering the wealth of existing proxy data on the state of the past oceans and the imminent release of the new PMIP3 paleoclimate simulations, the scientific community became convinced that the upcoming data-model comparisons would benefit from the joint expertise of modelers and paleoceanographers. Joint initiatives potentially include working towards innovative statistical methods, quantifying uncertainty, and making the most of proxies for parameters besides sea surface temperature. With this in mind, the COMPARE 2012 meeting was conceived as a joint initiative of PMIP3, PAGES and MARUM. Over 40 scientists from nine countries assembled in Bremen to work towards establishing the union between paleo-ocean data and model simulations. The first half of the workshop was dedicated to presenting the latest model results of the status of paleo-ocean data and emerging new approaches for combining the two, including inverse methods (Fig. 1) and forward modeling of proxies.

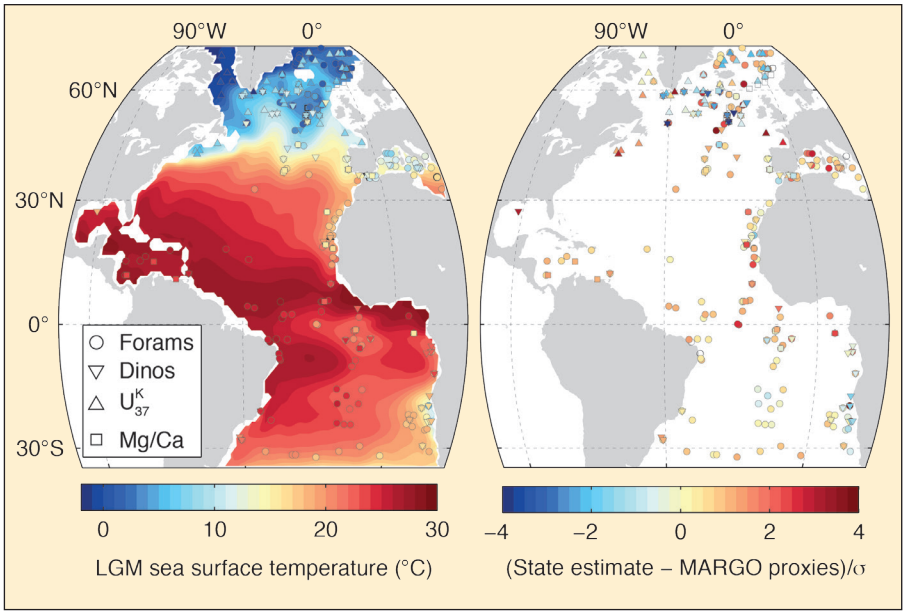

*Figure 1: An example of the application of an inverse approach to LGM ocean data (MARGO 2009). The **left panel** shows annual mean sea surface temperature (SST) in an LGM Atlantic ocean state estimate (contours) with MARGO LGM SST proxy records overlaid (symbols; Forams and Dinos refers to SST estimates from transfer functions based on assemblages of planktonic foraminifera and dinoflagellate cysts). The state estimate is created by application of the "adjoint method" to identify an ocean state that is consistent with both oceanic physics and with the proxy records, given their uncertainties. The **right panel** shows normalized misfits, computed as [(state estimate – MARGO proxies)/σ] where σ is the uncertainty in the data. Symbol colors show where the state estimate is consistent with the data, given their uncertainties. Values near zero indicate consistency. In this map, a satisfactory fit is obtained for most low latitude data. In the high latitudes, large values indicate that a satisfactory fit to all of the MARGO data simultaneously is not possible. Analysis and graphics: unpublished data courtesy of Holly Dail, Massachusetts Institute of Technology, USA.*

The workshop culminated in splinter meetings of three task groups that brainstormed the main issues that arose from the initial discussions: how to best deal with data uncertainty, how to quantify model data misfit and model error, and what the potential benefits and challenges are to working with non-traditional variables, time slices and transients. A number of individual projects, including an ocean data synthesis for the 6 ka time slice, were set up. Besides this, the workshop delivered important take-home messages: A thorough consideration of uncertainty is essential for a meaningful data-model comparison; a dialogue between data and modeling communities is important in finding most useful ways of evaluating model results; multi-proxy information adds complexity to data but helps reveal uncertainties that would otherwise have gone unnoticed; and future data-model comparisons need to be quantitative and "intelligent" (diagnostic, process-oriented). The complexity of handling multiple sources of uncertainty in proxy data (proxy attribution, age model) calls for the development of a data portal or interface allowing an interactive access to large datasets, their on-line handling and visualization.

References

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