

SCOR/IMAGES Workshop on Paleocean Circulation (Atlanta, 20-23 March 2005)

Report from Working Group “Inverse Methods”

Composition: Peter Huybers, Olivier Marchal, Gert Jan Weltje, Carl Wunsch

The WG recommends the construction of a paleoceanographic database, i.e., a compilation of data that are considered to be relevant to the general problem of the estimation of the paleocean circulations. Any information was thought to be useful, provided that an uncertainty estimate is attached to it. The database should include an estimate of the uncertainty of each paleodatum and an estimate of the uncertainty of the calendar ages as well. Indeed, uncertainty estimates are required for the rigorous interpretation of the paleoceanographic data whenever the interpretation is based on the use of inverse methods or on any other methods of statistical inference.

A concern was expressed about the possible distortion of the records owing, e.g., to undersampling in time and space (aliasing), and mis-interpretation of seasonal phenomena as representing annual averages. The use of existing water column data was discussed as a means to help estimate (i) the uncertainties in paleoceanographic data (variances) and (ii) the covariance between the uncertainties in the paleoceanographic data from different locations (at least the variances should be known for a proper interpretation of paleoceanographic data). The WG discussed the role that water column data sets may play in helping to determine spatial scales of variability associated with chemical/isotopic properties for which there are proxies in the sediment. Analysis of these data sets may allow one to assess the uncertainties associated with sampling the property fields at small spatial resolution, which is typically the case in paleoceanographic studies.

The WG also recommends the formulation of hypotheses that paleoceanographers anticipate can reasonably be refuted or confirmed from their data. Which elements of the paleocean circulation could reasonably be tested? It was believed that hypotheses related to the distribution of water masses in the paleocean may be less difficult to test than hypotheses related to water fluxes. For example, testing hypotheses related to the meridional overturning circulation (MOC) may require extensive measurements of non-conservative tracers or estimates of density gradients in the paleocean. These gradients remain largely unknown, even for relatively well-investigated periods such as the Last Glacial Maximum (LGM). Thus, a coordinated program aimed at estimating the paleocirculation may be more efficient if general hypotheses are tested first; more stringent hypotheses could then possibly be addressed, depending on the nature of the inference that one might have been able to make from the general hypotheses.

The WG also considered that the problem of the estimation of the large-scale paleocirculation should ultimately be viewed as a global problem. For example, any inference about the paleo-MOC in a given basin (e.g., Atlantic) must be consistent with data in the other basins (Southern Ocean and Pacific), even if these data are scarce and have large uncertainties.

Finally the WG discussed briefly the existing models and methods, which may be appropriate for the quantitative interpretation of the paleoceanographic database. It was thought that the problem of the estimation of the LGM circulation could be addressed with a steady-state model, at least in a first stage. More generally, a sensible approach for paleocirculation estimation would be to identify the simplest models that are consistent with the data. Should the combination of a given model with paleodata lead to large residuals, this would point to the need for changing the model, i.e., some knowledge would be acquired in the process of model-data combination. Although estimating the evolution of the MOC in the past is obviously a time-dependent problem, it was not clear to the WG that an unsteady model is

warranted given that unsteady terms in the governing equations may well be negligible at the time scales resolved by the paleoceanographic records (i.e., effects of finite accumulation rate and of bioturbation).

In summary the WG expressed the idea that a preliminary role of PACE could be the construction of a database (including uncertainty estimates) relevant to the general problem of the paleocirculation estimation. The WG believed that such a database might be very useful to the paleoceanographic community. The WG agreed that the models and methods used to help interpret the paleoceanographic data should be made publicly available as well.