

Interactive comment on “Joint inversion of proxy system models to reconstruct paleoenvironmental time series from heterogeneous data” by Gabriel J. Bowen et al.

Anonymous Referee #2

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Bowen et al. combine several proxy system models in the frame of a Bayesian hierarchical model to reconstruct seawater Mg/Ca, bottom water temperatures and surface water 18O based on Mg/Ca proxies and Mg/Ca and 18O measurements on foraminifera. This is an excellent manuscript and I recommend publication in *Climate of the Past*.

Major comment:

Parts of the methods section were difficult to assess because of missing references.

Did the authors develop proxy system models described in equations 2 and 3 or are these described elsewhere?

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Page 4 line 30: How were these uncertainties determined?

Page 5 line 27: How is paleo-seawater Mg/Ca determined?

Page 4 line 30: How were bottom water temperature (BWT) uncertainties estimated?

Minor comments:

As far as I understood page 5 lines 25 – 32, proxy system model parameters are estimated based on observed (and inferred) BWT, surface water Mg/Ca and Mg/Ca of foraminifera. The posterior distributions of these parameters are then used as prior distributions when past surface water Mg/Ca and BWT are reconstructed.

The authors assume a paleo-seawater Mg/Ca of 1.5 when calibrating proxy system models. How do the authors get this value and how uncertain is it? How would including uncertainties affect parameter estimates?

Page 4: lines 28 and 29: some BWT values for calibration are based on 18O thermometry. Please explain this method (and add references). Is 18O thermometry based on eq 3? If yes, how were surface water 18O values determined and how do these values influence surface water 18O values reconstructed in this study?

Equation 2: Mg/Ca of foraminifera is modeled as a function of BWT and surface water Mg/Ca. However, credible intervals of α_3 clearly include 0 indicative of weak (or absent) influence of surface water Mg/Ca on Mg/Ca of foraminifera, which might explain the results described page 8 line 5 (proxy data doesn't seem to inform this parameter either Fig 5c). Why is surface water Mg/Ca included in this proxy model given that it doesn't have a clear influence on Mg/Ca of foraminifera?

Equation 3: 18O of foraminifera is modeled as a function of 18O of surface water, BWT and BWT^2 . However, credible intervals of β_3 (parameter relating BWT^2 and 18O) include 0 for *Cibicides* as well as *Uvigerina*. Including BWT^2 in the model therefore needs additional justification. As the authors note in the discussion, posterior distributions of β_3 place even more weight on values close to 0 than the prior distribution.

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