

# ***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  $^{18}\text{O}$  based on Mg/Ca proxies and Mg/Ca and  $^{18}\text{O}$  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?

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  $^{18}\text{O}$  thermometry. Please explain this method (and add references). Is  $^{18}\text{O}$  thermometry based on eq 3? If yes, how were surface water  $^{18}\text{O}$  values determined and how do these values influence surface water  $^{18}\text{O}$  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 alpha3 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:  $^{18}\text{O}$  of foraminifera is modeled as a function of  $^{18}\text{O}$  of surface water, BWT and  $\text{BWT}^2$ . However, credible intervals of beta3 (parameter relating  $\text{BWT}^2$  and  $^{18}\text{O}$ ) include 0 for *Cibicoides* as well as *Uvigerina*. Including  $\text{BWT}^2$  in the model therefore needs additional justification. As the authors note in the discussion, posterior distributions of beta3 place even more weight on values close to 0 than the prior distribution.

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