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Climate of the Past Discussions

Interactive comment on "A global climatology of the ocean surface during the Last Glacial Maximum mapped on a regular grid (GLOMAP)" *by* André Paul et al.

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General comments:

Paul et al. present a spatial reconstruction of LGM SST anomalies and sea-ice extent using a new interpolation method, DIVA. Since the underlying data is mostly the MARGO data, the authors get generally the same results as MARGO (2009), with perhaps even smaller anomalies for glacial cooling. I have a couple of general comments here about the data and method used:

1) Underlying data. The sea-ice reconstruction appears to be based on both faunal

assemblages and biomarker evidence like IP25, but the SST reconstruction is based only on faunal data from the MARGO collection. Why is this? I'm not sure why the authors would not use the geochemical data in the MARGO collection (?) If there is a reason, then it should be made clear. There is arguably value in a single-proxy field reconstruction, but it should be justified. Also, I think some of the faunal data may have no-analog issues. Were these dealt with in any way?

A bigger problem with the choice of data is that MARGO is over a decade old now, and surely there have been more faunal datasets published since then (Certainly, there is far more geochemical data available now). Since the authors just use the MARGO data, they get results that nearly the same as MARGO. This doesn't seem like an advance in our understanding of the LGM. If the purpose of this paper is provide new insights into the LGM, I would suggest that the authors consider updating their dataset. If the purpose of this paper is to demonstrate a method (DIVA) then the cooling and ECS results should be downplayed.

2) DIVA method. This method is new to me, but seems appropriate for the problem at hand. However some more description of the method is needed here for non-specialists. I'm also wondering, given that DIVA was designed to work with more dense modern oceanographic data, how well it does with the sparse data of the LGM? Can the authors do some validation tests to assess this? E.g., withhold 10-25% of the data, fit the field using DIVA, then validate on the withheld data? This would provide some sense of performance.

3) Comparisons to other field reconstructions of the LGM. The authors discuss how their result is fairly similar to MARGO, which is not surprising since the underlying data are similar. What about other products? There are some data assimilation products to compare with (Annan and Hargreaves, 2013) - Paul is a co-author on one of them (Kurahaski-Nakamura et al., 2017 https://doi.org/10.1002/2016PA003001) and see also Amrhein et al., 2018 (https://doi.org/10.1175/JCLI-D-17-0769.1). We have a new data assimilation product available as well (in review, but a preprint is available

here: https://eartharxiv.org/me5uj/) based on an updated database of geochemical proxies.

4) Estimates of glacial cooling and climate sensitivity. In keeping with the MARGO results, these are arguably unrealistically low (global SST change of -1.7, ECS of 1.5). The MARGO-based results of ECS (Schmittner et al. 2011) have faced a lot of criticism. Multiple studies have suggested a global SST change closer to -3C (Ballantyne et al., 2005, Lea et al., 2000) and a corresponding global air temperature change closer to 5-6C (e.g. Snyder, 2016, Nature; Schneider von Deimling et al., 2006 GRL, Holden et al., 2010 Climate Dynamics, Bereiter et al., 2018, Nature, and our new estimate in our preprint noted above). There needs to be a critical discussion in light of these other results.

Also: how was ECS calculated? There must be a scaling assumption to translate to global mean surface temperature, and then there has to be estimation of the forcing as well (the denominator). Please describe this.

My overall take of this paper is: It's really interesting to see the application of DIVA to paleoclimate information, and this could use some more discussion and exploration (perhaps comparison to optimal interpolation). However in terms of providing new scientific insights into the LGM, the paper is limited here by use of the MARGO faunal dataset, which ultimately shapes the results. No matter what the method used, the MARGO data, particularly the assemblage data, provide an estimate of glacial cooling that is very small. This result has been challenged a lot over the years and there is a sense that perhaps no-analog problems still plague the faunal data.

I think the best solution here would be to update the underlying dataset with new studies - either new faunal data or new faunal data + geochemical data. Otherwise, the conclusions of the paper re: glacial cooling and climate sensitivity are just the same as MARGO.

Alternatively, the authors could treat this paper as a methods paper. If the goal is to

just demonstrate application of DIVA, then it's OK to stick with MARGO. But in that case comparisons should be made with other field estimation methods (OI, data assimilation) and the scientific results (LGM cooling and ECS) should be downplayed and presented critically since they are ultimately tied to the underlying data.

Specific comments:

Abstract: Clarify that GLOMAP is based on only faunal transfer function data (except for the use of IP25 for sea ice).

Section 2.1: Please clarify here what each reconstruction is based on (transfer functions, IP25, etc).

Section 2.2: Why did you only use the faunal data from the MARGO collection? Also MARGO is now 11 years old. I imagine that more data have been published since then. Certainly for the geochemical proxies this is true. I think it's worth updating the data with newly published results.

Section 2.3: This section could benefit from a little more explanation of how DIVA works since most readers will not be familiar with Troupin et al. (2012). In particular, it would be useful to describe how DIVA is distinct from pure interpolation (no information about spatial relationships) vs. optimal interpolation (covariance structure is set). Is DIVA essentially isotropic away from the coastlines?

Section 3.1: The use of past tense here is a little confusing. Use present tense for describing the results.

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