Brest, 26th May 2011

Response to Michael Rogerson

Major comments

→ "Inadequate quantitative analysis: The analysis of differences between SST estimates is handled verbally, rather than fully quantitatively. I really feel this part of the manuscript would benefit from being altered to form a quantitative assessment about how important these differences are. I am very surprised to see no form of binary plot or correlation analysis between these different lines of evidence, and also no quantitative comparison of the correlation between various SST estimates and 18Opf (suitably detrended for sea level). Wiggles are nice, but they are not the only way to represent this data!"

→Each proxy has been analysed independently and not specifically in the same interval. Doing binary plots on the few existing common points excludes many of the time intervals here investigated : for example only 17 samples (maximum of 160) are common to $\delta^{18}O$, foraminifera derived SST and dinocyst derived SST for core MD99-2239, 25 samples (maximum of 76) on core MD04-2805 CQ and 0 sample (maximum of 68) for core SU-8118.

→It is not actually so frequent to observe such a convergent variability between proxies in paleoclimatic studies (obtaining converging multi-SST records on a same core, i.e Marshall et al., QSR 2002; Eynaud et al., JQS 2004). However, in order to quantify the differences between proxy reconstructions, we have interpolated foraminiferal data (with generally higher

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resolution than dinocyst ones) according to the dinocyst levels. It enables us to obtain a correlation coefficient, mean differences (and standard deviations) between SST reconstructions. This information will be added on Figure 5. Of course, we could repeat this operation in order to compare dinocyst and foraminiferal SST with $\delta^{18}O$ values. It will require interpolating data once more and coefficient correlation will not reach 0.9 so far for any of the proxies. This calculation, provided that it is realistic (?), will not help us more to discriminate the best reconstruction of temperature. Hence the need for overlapping reconstructions...

→ "I would also strongly recommend comparison of their averaged LGM output with recently published compilations from MARGO and PMIP / PMIP2. This would place their findings better into the regional context, and also help them contribute to ongoing efforts in model-data comparison. Several papers showing MARGO time-slice data could be used to source the information (e.g. (Waelbroeck et al. 2009) and although the Gulf of Cadiz is on the edge of their regions of interest, (Kageyama et al. 2006) and (Otto-Bliesner et al. 2009) provide appropriate model data for comparison. The various means and variances for the LGM temperature anomaly from the authors data could be compared to the model output in a similar method to that used in figure 6 from (Kageyama et al. 2006)."

→ Masa Kageyama will be included in the authors of the revised manuscript and will help us to enlarge the discussion with a new focus on the comparison between data and model outputs. She has prepared a figure analogous to the figure cited by the reviewer updated with the new data presented here.

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→ “Is the MARGO "MAT" actually the ANN? It is worth double checking this point, as most MARGO foraminiferal SST maps are built on the newer ANN method!”

→ The modern analog technique (MAT), developed by Guiot (1990) - also known as the best analogue technique (see Guiot and de Vernal, 2007 for a review) - and used here to generate foraminifera derived reconstructions is very different from the Artificial Neural Networks (ANN) method, but very close to the SIMMAX one (Pflaumann et al., 1996). The MARGO foraminifera-derived reconstructions tested different approaches (including ANN, SIMMAX/MAT; see Kucera et al., 2005) to conclude that “all methods produced fairly robust glacial Atlantic SST”.

→ Maps, generated for the “Nature geosciences 2009” paper, combine multiproxy results (including dinocyst + foraminifera) but are not only based on ANN. The same can be applied to the maps in the paper of Kucera et al. (2005): only one figure (Figure 13) used the ANN results.

→ Referring to the comparison with MARGO results means, for us, the comparison to a multi-proxy compilation (the originality of the MARGO approach) and not only to a foraminifera derived one (i.e. as CLIMAP, 1981). The new figure on model-data comparison will include both the individual MARGO data sets (for each proxy) and the MARGO gridded multiproxy-based reconstructions from Waelbroeck et al. (Nature Geoscience 2009).

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Guiot, J., 1990. Methods and programs of statistics for paleoclimatology and paleoecology. In: Guiot, J., Labeyrie, L. (Eds.), Quantification des changements climatiques: méthode et

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Guiot, J., de Vernal, A., 2007. Transfer functions: methods for quantitative paleoceanography based on microfossils. In: Hillaire-Marcel, C., de Vernal, A. (Eds), Developments in Marine Geology, Volume 1, Proxies in late Cenozoic Paleoceanography. Elsevier, Amsterdam, The Netherlands, pp. 523-563.

Kucera, M., Weinelt, M., Kiefer, T., Pflaumann, U., Hayes, A., Weinelt, M., Chen, M.-T., Mix, A.C., Barrows, T.T., Cortijo, E., Duprat, J., Juggins, S., Waelbroeck, C., 2005. Reconstruction of sea-surface temperatures from assemblages of planktonic foraminifera: Multi-technique approach based on geographically constrained calibration data sets and its application to glacial Atlantic and Pacific Oceans. Quaternary Science Reviews 24 (7-9) SPEC. ISS., 951-998.

MARGO project members., 2009. Constraints on the magnitude and patterns of ocean cooling at the Last Glacial Maximum. Nature Geosciences, 2 (2), 127-132

Pflaumann, U., Duprat, J., Pujol, C., Labeyrie, L., 1996. SIMMAX: a modern analog technique to deduce Atlantic sea surface temperatures from planktonic foraminifera in deep-sea sediments. Paleoceanography 11, 15–35.

→ "Planktic foraminiferal MAT temperatures ≠ SST: The idea that the foraminifera may be generating colder temperatures than the dinocysts because they were dwelling deeper in the water column confused me. I could understand this if the data were a geochemical measurement that was set at the depth of calcification, but assemblage proxies are calibrated to SST not to in situ T. Surely, this mechanism is impossible for this data! Even if the

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assemblage at time X did comprise solely taxa dwelling below the surface layer, this would also be the case for the analog assemblage linked to it via the MAT analysis and the analog assemblage data would still be linked to the surface water characteristics via the calibration, which is common for all sites. I simply do not believe this explanation, and I suggest the authors try again to explain this anomaly! Maybe one / all of the methods are inherently biased (or not very good!)?"

→ It is true that SSTs reconstructed from foraminiferal assemblages are based on calibration on present-day SSTs and not in-situ temperatures, i.e. temperatures at deeper levels, where the foraminifera actually calcify. Implicitly, this calibration makes the assumption of a strong relationship between SSTs and the in-situ temperatures. When this calibration is used to reconstruct past SSTs, this same relationship is assumed. If the foraminifera move at larger depths, then the reconstruction will be biased. All reconstruction methods inherently make such assumptions; we just wanted to point out some possible reasons for the differences in reconstructions for the data we present in this manuscript.

→ Furthermore, migration of foraminifera deeply in the water column is furthermore well identify in their biological cycle now (i.e. for instance Schiebel et al., 2001 or results from an ecological model, i.e. Lombard et al., 2011, Biogeosciences Discuss., 8, 1–49, 2011).

REFERENCE:

Schiebel, R., Waniek, J., Bork, M., and Hemeleben, C., 2001. Planktic foraminiferal production simulated by 5 chlorophyll redistribution and entrainment of nutrients, Deep-Sea Res. Pt. I, 48, 721–740

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→ “The title: The most important parts of this study are 1) the assessment of the performance of the SST estimation methodologies, 2) the new insights into temperature changes observed in this key region during the last 30ka and 3) the claimed proof of the concept of a hydrological front in the Gulf of Cadiz during the LGM and other moderately cold periods. Given this, the title is a little vague! I would recommend altering it to something similar to "Assessment of Sea Surface Temperature changes in the Gulf of Cadiz during the last 30ka, and implications for glacial changes in regional hydrography".” → will be done.

Minor Comment

→ “I do apologise for the self-citation, but given the focus of much of this MS on the last 2 Heinrich Events, I think a contribution to this problem I published last year could be useful (Rogerson et al. 2010). I also identified the strong north-south temperature gradient during certain times, and not during other times.”

→ We have indeed added the reference in the revised manuscript and in the discussion of the two last HS within the manuscript. However, the E-W gradient across the strait of Gibraltar is much more discussed in the Rogerson et al., 2010 manuscript than the N-S gradient.

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