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Interactive comment on "Southern Hemisphere imprint for Indo–Asian summer monsoons during the last glacial period as revealed by Arabian Sea productivity records" *by* T. Caley et al.

Anonymous Referee #1

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General comments

The manuscript by Caley et al. presents a stacked sedimentary Bromine record for the Arabian Sea over the past 80 kyrs. Bromine content of the sediment is linked to its organic matter content. Here, this record is interpreted as monsoon strength indicator, which is then compared with key ice core records from Greenland and Antarctica to test the presence of typical Northern and Southern Hemisphere millennial scale climate variability.

The manuscript presents new datasets from an extremely well studied region and time interval: The Arabian Sea during the last glacial cycle. The obvious advantage of

having so many similar datasets available in the literature, both core top and down core studies, is the potential to look at systematic differences between regions. I think it is unfortunate that the authors decide to average all their data and miss the opportunity to look at apparent systematic differences. My feeling is, that in its current form the manuscript mainly reiterates previously published ideas.

The main conclusion here was already presented in Leuschner and Sirocko (2000, QSR), who also studied Arabian Sea sediments. Surprisingly, this rather well-known study is not even mentioned here. I quote from Leuschner and Sirocko's abstract:

"...core 70KL from the Arabian Sea shows humid intervals which seem to correlate with temperature maxima in the Antarctic Vostok ice core. Apparently, the low-frequency, sub-Milankovitch variability of the monsoon is associated with the southern hemisphere. The D/O-scale component in the monsoonal climate, on the other hand, shows a succession of short humid intervals. The sequence is most closely comparable to the Greenland temperature record"

I will explain further down, that the approach of Caley et al. enhances this low-frequency sub-Milankovitch variability and suppresses the higher frequent D-O variability, biasing the interpretations and conclusion. There are other examples where the Literature is not appropriately referenced, see below.

In view of some of the uncertainties in the approach (see specific comments), I find the overall writing style in many places, too strong and sometimes unbalanced. The authors very often make use of words such as "demonstrate" and "show" in places where "suggest" and "argue" would be much more appropriate. In many of these cases the authors refer to interpretations of paleo-data and not hard facts.

I have a couple of other major comments that will hopefully help during revisions.

Specific comments:

1. Stacking leads to biased analysis:

The stacking procedure leads to a highly smoothed signal. This is related to 1. the resampling of each record, which reduces the resolution and 2. the stacking itself.

The consequence of this can be easily demonstrated in a little experiment: smooth (or artificially bioturbate) the Greenland ice core isotope record and then resample it at a 200 year resolution, what you get looks already quite similar to an Antarctic (gradual changes) signal and many D-O events completely disappear. If one would now stack several of such smoothed records this effect would be further enhanced.

The effect can be also seen in Figure 5 of the manuscript, when one compares the black record with the red one. The smoothed black record (the stack) has much more gradual transitions and many of the short events are totally removed, especially in the age range between 30-40, which is used for the statistical analysis.

The authors mention this effect briefly only on page 9320. However, I think for the reader it is not necessarily clear enough stated what the impact of this smoothing is on their statistical tests. These rapid events are not just local “noise” since they closely correspond to the D-O events in Greenland (although the might differ in shape, see discussion in Deplazes et al., Nature Geoscience). The stack combines records, which appear to have preserved this D-O variability in general only to some extent, see e.g. KS05 (Fig.3) and some that did not preserve DO-variability at all in this interval (KS04 or KS09). These effects will enhance the ‘low-frequency variability of the sub-Milankovitch variability’ (Leuschner and Sirocko).

2.Differences between Br/org C records from different water depths

The paper largely ignores quite significant and well know differences in org C content from sediment cores in different water depths in-between cores.

On page 9219, line 23: . . .the common Br pattern registered across time and across the whole Arabian Sea indicates that composite that comparable hydrological and sedimentological processes have driven the export. . ..

On page 9320, line 8 it says: As dowcore Br signals at each coring site show very similar structure and events a stack was produced.

e.g. Van der Weijden et al. (1999, Deep Sea Research I) studied organic matter content in the sediments of the northeastern Arabian Sea and concluded that the presence of the OMZ is the most important factor in determining organic matter concentration (not productivity). This would also explain why there are clear differences in Bromine downcore records from different water depths. The records that are very shallow prominently show the GE events/Heinrich events in the organic matter record, i.e. times when the OMZ was most likely completely broken down (cores shallower that 1000 meters in Fig.1).

In contrast deeper cores will react more sensitive to periods when the OMZ was expanded to much deeper waters. This seems to have occured during glacial periods in general and during MIS 3 in particular during DO 12 and 14. The Bromine record presented in Ziegler et al. (2010, Climate of the Past) that covers the last 800,000 years, shows highest values during glacials, wheres Ba content indicates highest productivity during interglacials.

In contrast the shallower record of NIOP463 (Ziegler et al., 2010 Paleoceanography), which is situated within the modern OMZ, shows highest Br values during the interglacials. It would be useful to show these two Br records as well, since the reader would get the glacial-interglacial perspective and could appreciate apparent differences at different water depths.

All the records from the stack are mainly from below the modern OMZ. This needs to be mentioned and taken into account.

3. Northern vs. Southern forcing?

The abstract states: The effect can be also seen in Figure 5when the black record is compared with the red one. The smoothed black record has much more gradual

transitions and many of the short events are totally removed, especially in the age range between 30-40, which is used for the statistical analysis.

I would argue that Antarctic-type variability does not rule out a Northern Hemisphere forcing. Greenland and Antarctica millennial scale climate variability are two sides of the same medal: the bipolar seesaw. The tight relationship was for example demonstrated in a paper by Barker et al. (2011, Science), who use a simple mathematical transformation to turn the Antarctic record in something that looks like a Greenland record. In other words, even though the Antarctic record does not look like the Greenland record, it is (might be) still the North Atlantic that forces ultimately temperatures in Antarctica. I would therefore suggest to discuss the results more in a bipolar seesaw perspective and not so much in terms of North vs. South.

4. Referencing to previously published literature:

In addition to what I said above there are other cases where previously published literature is not appropriately referenced:

1) Deplazes et al. (2013, Nature Geoscience) presented a highly resolved sediment colour record from the Arabian Sea (color related to organic matter content). The resolution and quality allows a detail assessment of the millennial scale features. This record is very important in the context of the Caley et al manuscript. However Caley et al. do not reference appropriately to the conclusions of the paper. Instead they say:

On page 9322, line 20: “In addition a recent high-resolution study in the Arabian Sea, using a reflectance record as a proxy for Indian summer monsoon, indicates some differences with NGRIP (Deplazes et al., 2013). The authors mention that the characteristic sawtooth structure of NGRIP d18O variability is not a good template for tropical hydroclimate change.”

This is taking one point of the Deplazes et al. study out of its original context. Now it almost reads like Deplazes et al. actually argue that millennial scale features Green-

land and the Arabian Sea look fundamentally different. In contrast the Deplazes et al. paper actually says:

“Our results highlight a robust mechanism that associates tropical rainfall and its annual to centennial variability with variations in North Atlantic climate.”

And then also:

“Although the correspondence of our tropical records with Greenland δ18O is compelling, further insights can be gleaned from where they differ.”

It concludes the following:

“We therefore suggest that Greenland climate is especially sensitive to variations in the North Atlantic systemâĂŤin particular sea-ice extentâĂŤwhereas the intertropical convergence zone and Indian monsoon system respond primarily to variations in mean Northern Hemisphere temperature.”

2) Page 9325, line 16-29: The described approach was essential already followed in Ziegler et al, 2010 (Paleceanography), (speleothem based age constraints for Arabian Sea cores to test orbital tuning based age models) and it already lead in this study to the conclusion that age model uncertainties do not explain the long precession lag. While Caley et al. may want to mention that they added age control points, they should still point out that they reconfirm the earlier conclusion of the original study and reference it correctly.

Other comments:

âĂć The authors argue that the stacking enhances “common features”. However, the individual age models are not independent, instead the records are tuned to each others. Therefore, that stacking only enhances features that are defined as common features in the tuning process – circular argumentation. This is an important difference to an approach of e.g. Clemens and Prell, 2003, where the Arabian Monsoon Stack is build on different proxies in the same core. Implications should be discussed.

âĂć Abstract, line 18. Why do the results “strongly suggest” an active role in amplifying millennial scale variability? It is simply and idea that is being put forward, the data do not really allow to distinguish between an active or passive role.

âĂć Page 9321, line 20: It should say “suggested” instead of “demonstrated”, since the mid-depth benthic d13C gradient is affected by several factors and not straightforward to interpret

âĂć Page 9321, line 16: Zahn

âĂć Figure 5: add record by Deplazes et al.

References:

Barker, Stephen, et al. "800,000 years of abrupt climate variability." science 334.6054 (2011): 347-351.

Clemens, Steven C., and Warren L. Prell. "A 350,000 year summer-monsoon multi-proxy stack from the Owen Ridge, Northern Arabian Sea." Marine Geology 201.1 (2003): 35-51.

Deplazes, Gaudenz, et al. "Links between tropical rainfall and North Atlantic climate during the last glacial period." Nature Geoscience (2013).

Leuschner, Dirk C., and Frank Sirocko. "The low-latitude monsoon climate during Dansgaard–Oeschger cycles and Heinrich events." Quaternary Science Reviews 19.1 (2000): 243-254.

van der Weijden, Cornelis H., Gert Jan Reichart, and Hendrik Jan Visser. "Enhanced preservation of organic matter in sediments deposited within the oxygen minimum zone in the northeastern Arabian Sea." Deep Sea Research Part I: Oceanographic Research Papers 46.5 (1999): 807-830.

Ziegler, Martin, et al. "High Arabian Sea productivity conditions during MIS 13–odd monsoon event or intensified overturning circulation at the end of the Mid-Pleistocene

transition?." Climate of the Past 6.1 (2010): 63-76.

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