Response Referee 1

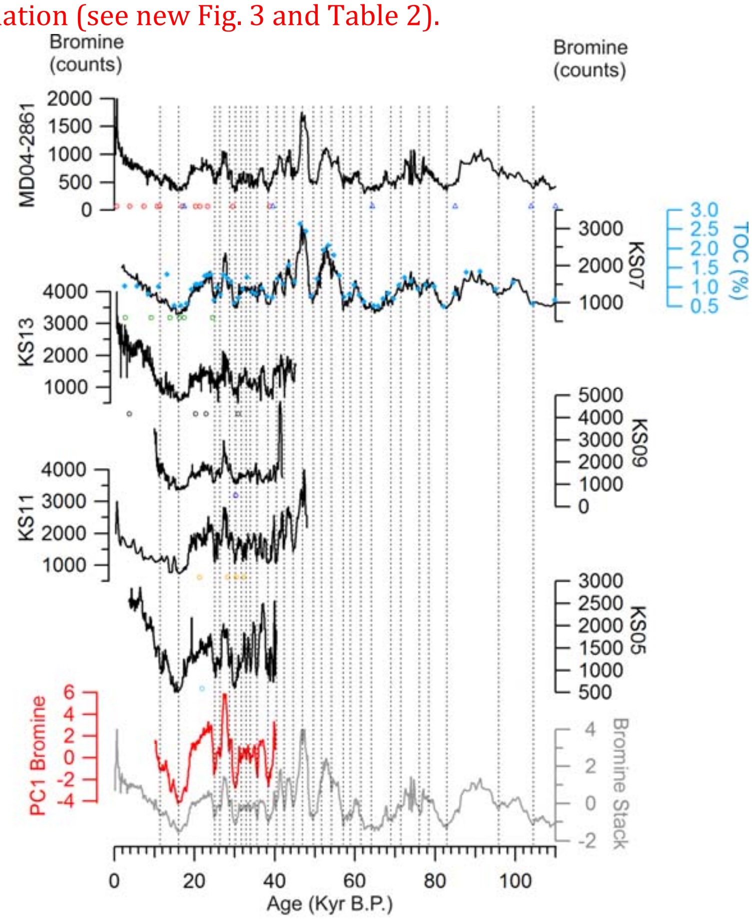
We thank the referee 1 for his careful review and comments. They will be helpful for the revision of our paper. Below, we provide point-by-point responses to the referee comments (red text).

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.

This is indeed very interesting to look at apparent systematic differences between records. This is done in the revised version. We only conserved Bromine records with the highest resolution (close to 120 years or less) to limit its potential influence on the statistical correlation (see new Fig. 3 and Table 2).



New Figure 3

Core	Lat	Lon	Depth	Last 40 kyr resolution (yrs)	R^2 -EDML (10-16 kyr)	P-value -EDML	R^2 -EDML (16-40 kyr)	P-value -EDML	R^2 NGRIP (10-16kyr)	P-Value NGRIP	R^2 NGRIP (16-40 kyr)	P-value NGRIP
KS05	19.4	60.8	2710	90	0.41	0.00	0.09	0.00	0.16	0.00	0.03	0,05*
KS07	18.0	58.0	2209	130	0.56	0.00	0.25	0.00	0.27	0.00	0.02	0.03
KS09	21.7	61.1	3185	80	0.64	0.00	0.25	0.00	0.36	0.00	0.02	0.01
KS11	20.2	61.3	4004	65	0.24	0.00	0.20	0.00	0.01	0,50*	0.01	0.01
KS13	22.3	60.3	2678	50	0.30	0.00	0.20	0.00	0.42	0.00	0.01	0.03
MD04-2861	24.1	63.9	2049	100	0.15	0.00	0.38	0.00	0.12	0.00	0.00	0,40*
NIOP 463 (Ziegler et al., 2010)	22.5	64.0	920	160	0.01	0,70*	0.12	0.00	0.16	0,10*	0.00	0,30*
SO90-111KL (Schulz et al., 1998)	23.1	66.5	775	90	0.00	0,90*	0.36	0.00	0.38	0.00	0.06	0.00
SO130-289KL (Deplazes et al., 2013)	23.1	66.5	571	annual	0.28	0.00	0.40	0.00	0.77	0.00	0.20	0.00
PC1 Bromine				120	**0.64**	0.00	**0.30**	0.00	**0.38**	0.00	**0.01**	0.00

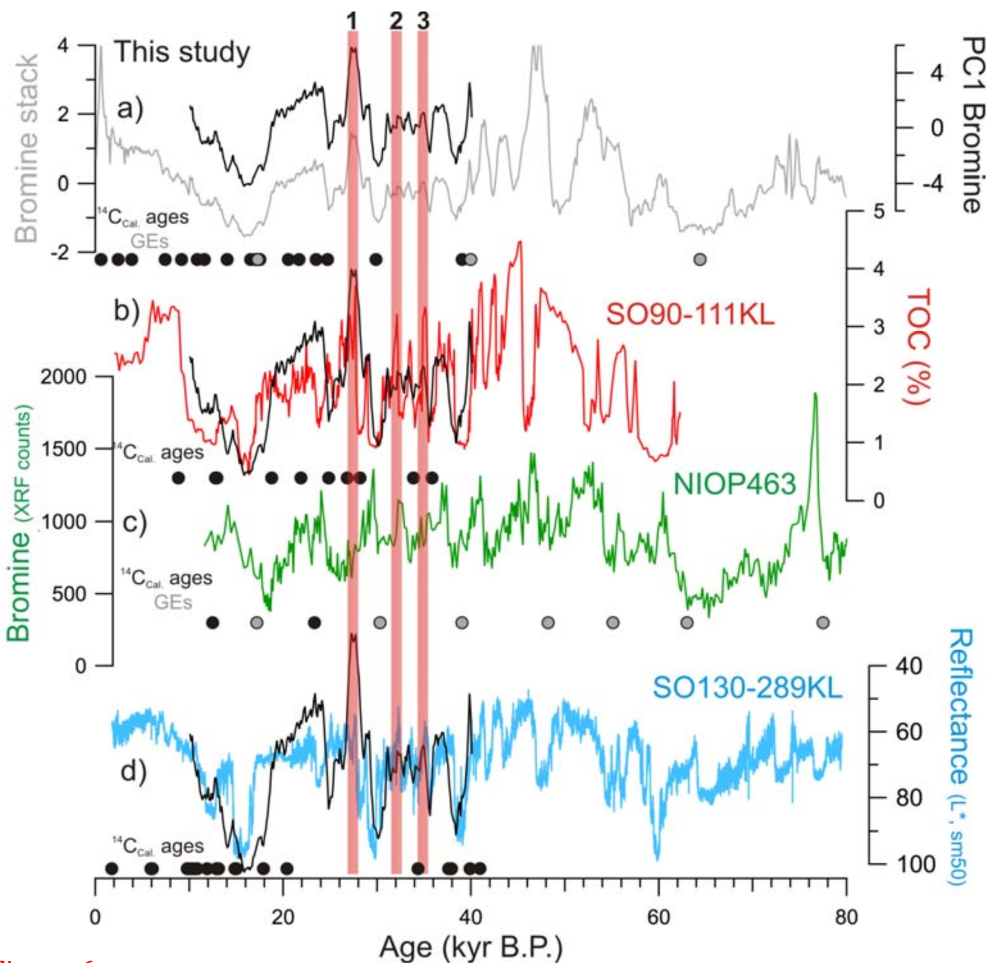
New Table 2

We added in the revised version in lines 205-214: *"Comparable events of higher bromine values can be observed at 20-24 kyr and centred at 27 kyr (Fig. 3). Between 30 and 38 kyr, five events with higher bromine values are documented in each record with the event centred at 37 kyr showing a more pronounced peak in core KS05. The more pronounced peak seems to be a local effect (exported production and diagenesis) as core KS13 is located in the same basin (Owen Basin) and at the same water depth than core KS05 but does not indicate a higher peak of Br (Fig. 1). Core KS09 shows much weak oscillation compared to the other cores that can also result from local effect (Fig. 3). Between 40 and 50 kyr, four comparable bromine peaks are visible in core MD04-2861, KS07 and KS11 with the more pronounced peak centred at 47 kyr (Fig. 3). Between 50 and 110kyr, similar bromine events are observed in core MD04-2861 and KS07 (Fig. 3)."*

In order to limit the smoothing effect during the stacking procedure, we used an alternative approach based on principal components analysis (PCA) with the "R" software (http://www.r project.org/) for the time period 10-40 kyr (Fig. 3). The first component (PC1-bromine) of the analysis explains 75% of the variance and confirms the common pattern between Br records as mention by reviewer 2 (Fig. 3).

Furthermore, to assure that our conclusions were not affected by the stacking procedure or PCA we had also presented statistical analyses on individual records, having independent age model (**four of our records** if we exclude core KS05 and KS09 that have only one 14C control point, **Ziegler et al., 2010 and Schulz et al., 1998 records** and **Deplazes et al., 2013 record**) in the new Table 2 of our manuscript. The results support our conclusion based on the initial Bromine stack (Table 2).

We also added in the revised version a detailed comparison between the different productivity records of the Arabian Sea. This results in a new paragraph 3.3 and a revised Figure 6 (see below).



New Figure 6

We added in lines 252-307:" *At the moment, there is no clear consensus concerning the effect of oxygen on the preservation of organic matter (Cowie et al., 1999; 2005; Burdige, 2007).*

To investigate a potential impact of the absence of oxygen in the OMZ on the preservation of the productivity signal in the Arabian Sea, we compared different published productivity records (Schulz et al., 1998; Ziegler et al., 2010; Deplazes et al., 2013) with our results, covering various water depths (Fig. 1 and Fig. 6). We focus on the interval 10-40 kyr. PC1-bromine (mainly composed of records from below the modern OMZ) and TOC record of core SO90-111KL (Schulz et al., 1998) show a general good agreement (Fig. 6). Slight differences can be observed between 20 and 26 ka and can be related to age model uncertainties. Records can be reconciled by a time shift lower than 2kyr, in agreement with individual marine record uncertainties described previously. The only main *differences in term of peaks amplitude can be observed between 32 and 35 ka (Fig. 6) with higher TOC peaks in core SO90-111KL. To investigate the origin of these differences we further compared with Br results from core NIOP463 (Ziegler et al., 2010) and results from core SO130-289KL (Deplazes et al., 2013). Core NIOP463 has a low resolution compared to the other records (Table 2) and only two 14C dates, making difficult to identify and discussed the Br peaks. On the contrary, core SO130-289KL has an annual resolution and is well constrained by 14C dating (Deplazes et al., 2013) (Fig. 6). Results of core SO130-289KL do not indicate extreme productivity peaks at 32 kyr and 35 kyr and the structure of the signal is more comparable to the PC1-bromine signal rather than to the TOC signal in core SO90-111KL. Interestingly, a major peak in organic carbon can be observed at 27 kyr in the PC1-bromine record as well as in the TOC record of core SO90-111KL but not in core SO130-289KL (Fig. 6). These tree main differences (frames on Fig. 6) between Arabian Sea productivity records cannot be attributed to a problem of resolution between records. Concerning a potential effect of the OMZ on the preservation of the productivity signal, we note that some differences exist between records located within the modern OMZ (cores SO90-111KL, SO130-289KL and NIOP463) (Figs. 1 and 6). We also note that records located below the present OMZ fit with some records within the OMZ during such different events (peak at 27 kyr for example) (Fig. 6). In addition, a key argument for a minor role of the OMZ in driving the preservation of organic matter is the observation that records below and within the present OMZ co-varied with other surface productivity records (Reichart et al., 1998; Caley et al., 2011; see also Pichevin et al., 2007).*

Therefore, it can be suggested that (1) the dynamics of the OMZ in the past is not the main driver of the organic carbon preservation signals observed in marine records and (2) the potential effect of bioturbation under the OMZ is weak.

As the terrestrial organic matter is poor in Br compared to the marine (Mayer et al., 2007), a preferential input or degradation of terrestrial organic matter affecting the TOC record in cores located close to the Indus river (SO90-111KL and SO130-289KL) could explained some differences with Br records (Fig. 1 and 6). However, core SO90-111KL and SO130-289KL exhibit some differences in term of amplitude of events whereas they are at the same location, close to the Indus River (Fig. 1 and 6). In addition, the similarity between PC1-bromine event at 27 kyr with that of core SO90-111KL together with the similarity between PC1-bromine event at 32kyr and 35kyr and thus of core SO130-289KL (Fig. 6) argue against a preferential input or degradation of terrestrial organic matter.

We suggest that the discrepancies between records reflect the effect of local particularities (mostly exported production, and secondly diagenesis) that can induce signal bias. If true, our strategy based on the extraction of the common variance between different records appears to be a good strategy and the obtained results more susceptible to be compared with other records. Indeed, our results based on PC1-bromine capture the peaks of core SO130-289KL at 32 and 35 kyr which are different in core SO90-111KL but also capture the major peak at 27 kyr which is visible in core SO90-111KL and in our six separated bromine records (Fig. 3) but not in core SO130-289KL.

To resume, SH ventilation changes and the dynamic of the OMZ can't be invoked as the main driver of the generation and preservation of productivity signals in the Arabian Sea. Indian summer monsoon dynamic induce variability in upwelling seems to be the good candidate to explain the productivity signals recorded."

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"

We apologize to have missed the study of Leuschner and Sirocko (2000, QSR). The authors indeed suggest a SH forcing for sub-Milankovitch variability but a D/O-scale component closely comparable to the Greenland based on visual inspection. I quote from Leuschner and Sirocko (2000, QSR) abstract: "mainly corroborating the result of Schulz et al. (1998) that the Indian monsoon showed D/O variability".
In addition, other and more recent studies call for a dominant control of northern hemisphere climate processes on monsoon intensity (Schulz et al., 1998; Wang et al., 2001; Altabet et al., 2002; Burns et al., 2003; Rohling et al., 2003; Yuan et al., 2004; Ivanochko et al., 2005; Cosford et al., 2008; Deplazes et al., 2013). Based on this and on the conclusion of Leuschner and Sirocko (2000, QSR) it appears that our understanding of the monsoon forcing during the last glacial in the Arabian Sea and its teleconnection to high latitudes is not fully understood.
Our study based on new dataset therefore help to advance on this debate, putting the Indian monsoon dynamic in a bi-hemispheric context rather than a unique NH context.
In the revised version, we cite Leuschner and Sirocko (2000, QSR) and we mention that our study corroborates their results for sub-Milankovitch variability. But, in addition, we proposed that the δ18O signal recorded in the Asian monsoon speleothem records could be exported by winds from the Indian summer monsoon region, as recently proposed in modelling exercise (Pausata et al., 2011), explaining the SH signature observed in Asian cave speleothems (Rohling et al., 2009). Our study newly provides an ultimate mechanism (the "link") between the SH forcing and the EA monsoon through the Indian monsoon system.
We added in the revised version in the abstract: *"Results demonstrate the existence of an imprint of suborbital southern hemisphere (SH) temperature changes (i.e., Antarctica) on the Indian summer monsoon during the last glacial period that is generally not recognized."* And in lines 102-104 *"However, such potential teleconnection for the Indian monsoon system is generally not recognized with an exception at the sub-Milankovitch variability (Leuschner and Sirocko, 2000)."* And in lines 346-348 *"These similarities indicate that SH changes might play an important role in Indian summer monsoon dynamics (Table 2) contrary to the traditional views of a strict NH control but corroborating the results for sub-Milankovitch variability of Leuschner and Sirocko (2000)."*

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.

We respond in details at these points below (see specific comments 1 and 4).

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.

We have rewritten in a more careful manner, using words as "suggest" and "argue".

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).

We are aware that the stack smooths the signal (this is mentioned on page 9320 in the manuscript) but it also reinforces the common down core pattern and limits influence of regional particularities that can induce signal bias.
Importantly, in order to limit the smoothing effect during the stacking procedure, we used in the revised version an alternative approach based on principal components analysis (PCA) with the "R" software (http://www.r project.org/) for the time period 10-40 kyr (Fig. 3). The first component (PC1-bromine) of the analysis explains 75% of the variance and confirms the common pattern between Br records as mention by reviewer 2 (Fig. 3).

Furthermore, to assure that our conclusions were not affected by the stacking procedure or PCA we had also presented statistical analyses on individual records, having independent age model (**four of our records** if we exclude core KS05 and KS09 that have only one 14C control point, **Ziegler et al., 2010 and Schulz et al., 1998 records** and **Deplazes et al., 2013 record**) in the new Table 2 of our manuscript. The results support our conclusion based on the initial Bromine stack (Table 2).
We added in the revised version in lines 322-335: *"We performed regressions underlying the coefficient of determination (R2) and P-values between Arabian Sea marine records and NH NGRIP-SH EDML δ18O ice records over the intervals 16-40 kyr and 10-16 kyr (deglaciation period).*
Although the coefficients of determination and P-values between Br records, NGRIP and –EDML δ18O signals can vary (Table 2) as a consequence of the resolution and local effect for each record, statistical analyses for the interval 16-40 kyr reveal always better correlations between Br records (and PC1-bromine) and the –EDML atmospheric signal than between Br records (and PC1-bromine) and the NGRIP atmospheric signal (Table 2). The same observation is true for the Br record of Ziegler et al. (2010), the TOC record of Schulz et al. (1998) and the reflectance record of Deplazes et al. (2013) on their own age model (Table 2). Note that for the majority of these records, the resolution is high enough (lower or equal to 100 yrs) to allow comparison with the NGRIP record. This is particularly true for the record of Deplazes et al. (2013) that have an annual resolution, therefore even better than the resolution of the NGRIP record."
All these results indicate that resampling of the records and stacking don't bias the results of our statistical analysis and that the correlation with Greenland is less significant than with Antarctica for the time interval 16-40 kyr.
This doesn't exclude a role of the NH. We added in lines 356-357: *"Our results don't exclude a role of the NH as we observe, although weaker, significant correlations with NGRIP (Table 2)."*
In addition, during the interval 10-16ka (deglaciation period) the correlation between NGRIP and Bromine is more important suggesting a more important role of the Northern hemisphere (Table 2). These results are in good agreement with the results obtained by Rolhing et al. 2009 on asian speleothems, suggesting a teleconnection between the Indian monsoon and southern hemisphere (SH) climatic variations, a pattern only observed for the East Asian monsoon system until now. I quote from Rolhing et al. 2009 abstract: *"Previous studies have suggested a sound chronological correlation between the Hulu Cave record (East Asian monsoon) and Greenland ice-core records, which implies a dominant control of northern hemisphere climate processes on monsoon intensity. We present an objective, straightforward statistical evaluation that challenges this generally accepted paradigm for sub-orbital variability". And "Our analysis strongly suggests a dominant control on millennial-scale monsoon variability by southern hemisphere climate changes during glacial times when the monsoon is weak overall, and control by northern hemisphere climate changes during deglacial and interglacial times when the monsoon is strong."*
We can therefore proposed that the δ18O signal recorded in the Asian monsoon speleothem records could be exported by winds from the Indian summer monsoon region, as recently proposed in modelling exercise (Pausata et al., 2011), explaining the SH signature observed in Asian cave speleothems.

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).

The study of Van der Weijden et al. (1999, Deep Sea Research I) suggests that the OMZ is important in the enhanced preservation of organic matter for conditions similar to present day although the interpretation is more complex at the Oman and Indian Margin compare to the northeastern Arabian Sea. Indeed, at the moment, there is no clear consensus concerning the effect of oxygen on the preservation of organic matter (see the Review of Burdige, 2007 and Cowie et al., 1999; 2005).
At the paleoscale, the question is what controls the presence and extension of the OMZ? and so organic matter content preservation. Based on our study at millennial and orbital time scale, it seems that Intermediate water circulation is not the main driver. Therefore, the monsoon is most probably responsible of productivity variations and OMZ presence and extension, both affecting organic matter content and preservation. A key argument is the observation at the paleoscale that records below and within the present OMZ co-varied with other surface productivity records.
Reichart et al. (1997, 1998) showed that the MOC content of the Murray Ridge records (within the OMZ) co-varies with other upwelling productivity indicators (e.g. Globigerina bulloides abundances).
I quote from Reichart et al., 1998: *"Changes in organic carbon preservation could have been brought about by fluctuations in the intensity and thickness of the OMZ, but there are arguments against a mojor role of preservation in the general shaping of the Corg patterns. A first one comes from the covarying patterns of Corg and upwelling indicators species G. Bulloides. A second argument is provided by the covarying Corg pattern in cores from different water depth."* And *"We therefore conclude that fluctuation in Corg are primarily controlled by variations in surface water productivity that are driven by the summer monsoon".*
In another study below the OMZ (Caley et al., 2011 epsl), another upwelling productivity indicator (Foraminifera assemblage) co-varies with the Bromine record.
We added a new paragraph (3.3) in the revised version to discuss the 3.3 Oxygen minimum zone and organic matter preservation in lines 252-307: *"At the moment, there is no clear consensus concerning the effect of oxygen on the preservation of organic matter (Cowie et al., 1999; 2005; Burdige, 2007).*
To investigate a potential impact of the absence of oxygen in the OMZ on the preservation of the productivity signal in the Arabian Sea, we compared different published productivity records (Schulz et al., 1998; Ziegler et al., 2010; Deplazes et al., 2013) with our results, covering various water depths (Fig. 1 and Fig. 6). We focus on the interval 10-40 kyr. PC1-bromine (mainly composed of records from below the modern OMZ) and TOC record of core SO90-111KL (Schulz et al., 1998) show a general good agreement (Fig. 6). Slight differences can be observed between 20 and 26 ka and can be related to age model

uncertainties. Records can be reconciled by a time shift lower than 2kyr, in agreement with individual marine record uncertainties described previously. The only main differences in term of peaks amplitude can be observed between 32 and 35 ka (Fig. 6) with higher TOC peaks in core SO90-111KL. To investigate the origin of these differences we further compared with Br results from core NIOP463 (Ziegler et al., 2010) and results from core SO130-289KL (Deplazes et al., 2013). Core NIOP463 has a low resolution compared to the other records (Table 2) and only two 14C dates, making difficult to identify and discussed the Br peaks. On the contrary, core SO130-289KL has an annual resolution and is well constrained by 14C dating (Deplazes et al., 2013) (Fig. 6). Results of core SO130-289KL do not indicate extreme productivity peaks at 32 kyr and 35 kyr and the structure of the signal is more comparable to the PC1-bromine signal rather than to the TOC signal in core SO90-111KL. Interestingly, a major peak in organic carbon can be observed at 27 kyr in the PC1-bromine record as well as in the TOC record of core SO90-111KL but not in core SO130-289KL (Fig. 6). These tree main differences (frames on Fig. 6) between Arabian Sea productivity records cannot be attributed to a problem of resolution between records. Concerning a potential effect of the OMZ on the preservation of the productivity signal, we note that some differences exist between records located within the modern OMZ (cores SO90-111KL, SO130-289KL and NIOP463) (Figs. 1 and 6). We also note that records located below the present OMZ fit with some records within the OMZ during such different events (peak at 27 kyr for example) (Fig. 6). In addition, a key argument for a minor role of the OMZ in driving the preservation of organic matter is the observation that records below and within the present OMZ co-varied with other surface productivity records (Reichart et al., 1998; Caley et al., 2011; see also Pichevin et al., 2007).

Therefore, it can be suggested that (1) the dynamics of the OMZ in the past is not the main driver of the organic carbon preservation signals observed in marine records and (2) the potential effect of bioturbation under the OMZ is weak.

As the terrestrial organic matter is poor in Br compared to the marine (Mayer et al., 2007), a preferential input or degradation of terrestrial organic matter affecting the TOC record in cores located close to the Indus river (SO90-111KL and SO130-289KL) could explained some differences with Br records (Fig. 1 and 6). However, core SO90-111KL and SO130-289KL exhibit some differences in term of amplitude of events whereas they are at the same location, close to the Indus River (Fig. 1 and 6). In addition, the similarity between PC1-bromine event at 27 kyr with that of core SO90-111KL together with the similarity between PC1-bromine event at 32kyr and 35kyr and thus of core SO130-289KL (Fig. 6) argue against a preferential input or degradation of terrestrial organic matter.

We suggest that the discrepancies between records reflect the effect of local particularities (mostly exported production, and secondly diagenesis) that can induce signal bias. If true, our strategy based on the extraction of the common variance between different records appears to be a good strategy and the obtained results more susceptible to be compared with other records. Indeed, our results based on PC1-bromine capture the peaks of core SO130-289KL at 32 and 35 kyr which are different in core SO90-111KL but also capture the major peak at 27 kyr which is visible in core SO90-111KL and in our six separated bromine records (Fig. 3) but not in core SO130-289KL.

To resume, SH ventilation changes and the dynamic of the OMZ can't be invoked as the main driver of the generation and preservation of productivity signals in the Arabian Sea. Indian summer monsoon dynamic induce variability in upwelling seems to be the good candidate to explain the productivity signals recorded."

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 occurred 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, whereas 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.

It is out of the scope of our paper to discuss glacial-interglacial variability. We are interested by millennial events and the timing at the precession scale.
In addition, the Br and Ba data of Ziegler et al. are not presented in the same way: Br is not normalized, while Ba is normalized to Al. Moreover, the Ba is not the "standard" proxy to document productivity changes. As all proxies, it has its advantages and disadvantages (it is sensitive to sulphate-reduction for example).
Furthermore, the record of Ziegler et al., 2010 Paleoceanography is presented in figure 6. Core MD04-2881 presented in Ziegler et al. (2010, Climate of the Past) is in a very similar environment (22°12'5N; 63°05'5E, 2387m) that core MD04-2861 that we use in our study (24.1°;63.9°; 2049m). Therefore, records within the modern OMZ or below (our records) are presented, compared and discussed (Figure 1, Figure 6 and Table 2). We conducted our statistical test on each bromine record separately (below the modern OMZ) and on the Ziegler et al., 2010, Schulz et al., (1998) and Deplazes et al., 2013 records (within the modern OMZ) (Table 2 and Figure 1). Again, results of our statistical tests for the period 16-40 kyr are similar for records from different water depths (Table 2).

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

We mentioned more clearly this point in the revised version in line 258: "PC1-bromine (mainly composed of records from below the modern OMZ)".
Nonetheless, records within the modern OMZ (Ziegler et al., 2010, Schulz et al., 1998 and Deplazes et al., 2013) or below (our records) are presented, compared and discussed (Figure 1, Figure 6 and Table 2) and results of the statistical analyses highlight an imprint of the SH.

3. Northern vs. Southern forcing?
The abstract states: The effect can be also seen in Figure 5 when 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.

As mentioned previously we discuss and compare more clearly the records based on the new Figure 6 in the revised version.

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.

We agree with the referee 1. That's why we propose that the monsoon is an amplifier of inter-hemispheric transfer of energy (bipolar seesaw). We wrote in lines 378-385: *"This study argues that the Indo-Asian monsoon can be considered as an amplifier of inter-hemispheric energy transfer at sub-orbital scale during the last glacial period. During a glacial period, the monsoon is weak overall (An et al., 2011). The asynchronous relationship between Antarctic and Greenland millennial-scale temperature changes during the last glacial period has led to the theory that the bipolar seesaw acts to redistribute heat according to the state of the Atlantic Ocean meridional overturning circulation (Crowley, 1992; Broecker, 1998). We propose that atmospheric teleconnection can amplify this process and that the Indo-Asian monsoon plays an important role (Fig. 8)."*
Therefore, we propose that the monsoon can play an active role in the bipolar seesaw perspectives rather than a passive role.
We added in the abstract: *"This suggests that the Indian monsoon is better explained in a bipolar context."*

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 Greenland 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 18O 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 systemâ˘A˘ Tin particular sea-ice extentâ˘A˘Twhereas the intertropical convergence zone and Indian monsoon system respond primarily to variations in mean Northern Hemisphere temperature."

It was certainly not our intention to inappropriately cite the conclusions of deplazes et al., 2013. We just wanted to indicate that even if there is compelling agreement between their monsoon record and Greenland 18O, the observed differences could be associated to the SH imprint.
We recognize that the paragraph is misleading and it was rewritten in the revised version as follow: *"The study of Deplazes et al. (2013) concludes to a compelling correspondence between Arabian Sea monsoonal record and NGRIP δ18O but indicate that the characteristic sawtooth structure of NGRIP δ18O variability is not a good template for tropical hydroclimate change. Based on our comparison, we note a similar structure between the reflectance record and –EDML from about 22 to 16 kyr (Fig. 7). We hypothesis that the differences between NGRIP δ18O and the reflectance record (Deplazes et al., 2013) could be associated to the imprint of the SH, explaining the significant relationship with –EDML over the interval 16-40 kyr (Table 2)."*
We also added Deplazes et al., 2013 in the references in line 94 to avoid any misunderstanding: "It has been long suggested that the Northern Hemisphere (NH) climate controls the Indo-Asian summer monsoon dynamics at suborbital scale (Schulz et al., 1998; Wang et al., 2001; Altabet et al., 2002; Burns et al., 2003; Rohling et al., 2003; Yuan et al., 2004; Ivanochko et al., 2005; Cosford et al., 2008; Deplazes et al., 2013) based on the apparent similarity of these Indo-Asian record structures at millennial/suborbital-scale with that of Greenland δ18O ice-core records (NGRIP members, 2004)".

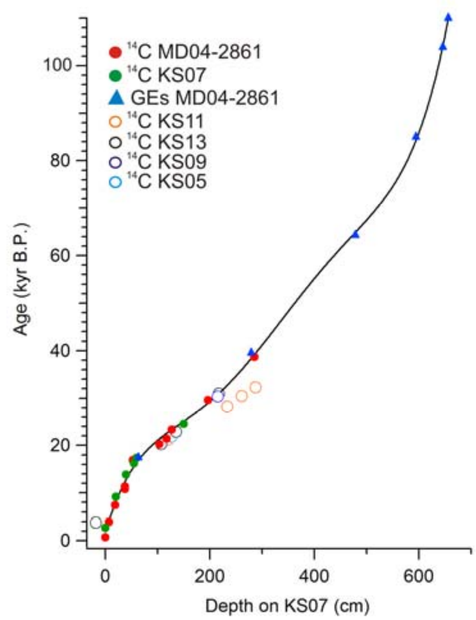
2) Page 9325, line 16-29: The described approach was essential already followed in Ziegler et al, 2010 (Paleceanography), (speleothem based age constraints for Arabian Sea cores to test orbital tuning based age models) and it already lead in this study to the conclusion that age model uncertainties do 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.

We don't use the same approach than Ziegler et al. 2010. These authors use a chronology based on a quantitative record of the planktonic foraminifera species Globorotalia truncatulinoides and Globorotalia crassaformis (GE events) assuming that Arabian Sea GE events, North Atlantic 980 IRD events, Iberian Margin total alkenone events and speleothem events are temporally correlative. This results in 7 controls points over the last 80 kyr (Figure 5).
We used the observed synchronicity between the Indian and Asian monsoon suborbital events to refine our age model by tuning the Arabian Sea bromine stack to the δ18O millennial events of speleothems (Supplementary). This method enables the high-

precision comparison of the Indian and Asian records over a common and orbital independent age scale with 21 control points. This is indeed higher than the previous study of Ziegler et al., 2010. We indicate in the revised version that we reconfirm the earlier conclusion of Ziegler et al., 2010.

Other comments:
â˘A ´c 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.

It is true that the records are tuned to each others in the initial version. Ages for other cores have not been provided because the sedimentation is not composed of constant hemipelagic material. Nonetheless, the addition of all available 14C dates on the new Figure 2 (added in the revised version) indicates no violation of our first age model.



New figure 2

The new Figure 3 show that at least four cores (MD04-2861 and KS07, KS13 and KS11), on their independent age model, show similar events over the last 30 kyrs. Furthermore, these events are quite similar to core 111KL (Schulz et al., 1998) and 289KL (Deplazes et al., 2013) which also have independent age model and the main differences are discussed in detailed based on the new Figure 6. Finally, we have six records, four below the modern OMZ and two within the modern OMZ, for which statistical results indicate a SH imprint (see Table 2) and for which we observe a distinct structure similar to –EDML as in our Bromine stack.

â˘A ´c 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.

The passive role is linked to the fact that the NH forcing exerts a direct and unique control on the monsoon. During warm interstadials of the North Atlantic, the atmosphere can hold more moisture as a result of higher air temperatures. In addition, the duration and intensity of winter snow cover over Asia exerts an important control on the intensity of the summer monsoon (Meehl, 1997). In a bipolar seesaw context, the monsoon system can serve as a process to transfer energy between low and high latitudes and amplified the millennial variability (see Figure 8). That's why we propose a more active role. We change in the revised version "could suggest".

â˘A ´c 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

Changed in the revised version

â˘A ´c Page 9321, line 16: Zahn

Changed in the revised version

â˘A ´c Figure 5: add record by Deplazes et al.

Added in the revised version