**Reply to the Referee #2 comments**

The authors are thankful to referee for his/her critical and constructive comments which helped in improvising the manuscript. The necessary changes in view of the comments made by the referee have been incorporated in the manuscript and will be sent after the editor's decision. Here, we provide replies to the comments.

**Comment:** ***The comparison of the productivity record with the SST records is misleading. As the authors state, high productivity could be expected during periods of strong upwelling, i.e. low temperatures. The SST records, however, are dominated by the strong glacial-interglacial temperature increase. So during this phase it looks like SST and productivities are positively correlated. The authors discuss this (chapter 4.2.1.) and thus start the comparison with a phase when it does not work; so the Figure still does not help much with the data interpretation. A comparison of other productivity records, concentrating on the Somali and Oman upwelling areas could be more illustrative. The SST records of the Holocene (after the strong glacial-interglacial) may be plotted with reversed scale in order to better illustrate whether and when there is an anti-correlation. In addition: there is some discussion in Huguet et al. (2006) about the TEX86 temperatures; it may not represent annual average temperatures but has a SW monsoon bias. This needs to be addressed and could actually support the authors.***

***Reply:*** The high productivity is expected during the periods of strong upwelling and low SST, but only during southwest monsoon. Previous studies have shown that the southwest monsoon was weak/absent during LGM. Hence, modern relation of productivity and upwelling would not exist during LGM. The Mg/Ca based SST records are dominated by glacial-interglacial signal as it was measured in planktonic foraminifera G.*ruber*, which occurs throughout the year. But biogenic silica flux is dominated by southwest monsoon signal. The biogenic silica flux thus serves as a better proxy for upwelling rather than SST. This major observation is being underscored by comparing biogenic silica flux and SST and has been further elaborated in the revised manuscript. The other productivity records from Somali and Oman upwelling regions which record annual signal are either based on calcareous microfossils or organic matter. Therefore, comparison of biogenic silica flux with other productivity records would be improper. The TEX86 proxy related points of Huguet et al., (2006) have been included in the revised manuscript.

**Comment:** ***The comparison of the biogenic opal fluxes form the Somali upwelling and the delta18O (precipitation) records is a new idea (not published by Tiwari et al.) but is too vague to be the main part of the paper. The anti-correlation of Western Ghats precipitation with western Arabian Sea upwelling was modelled for the present Arabian Sea and the authors cite only one paper (Izuma, see above). As the authors also discuss, differences in evaporation and also surface water inflow from the Bay of Bengal have impacted the salinity off the west coast of India during the past so that much of the changes are related to several different processes (see Vijit et al., 2016; Mahesh and Banakar, 2014). Furthermore, even the present relationship between precipitation on the Indian Subcontinent and upwelling/productivity in the Arabian Sea is not very clear (see Levine and Turner, 2012) so this topic needs at least some further discussion.***

***Reply:*** Though the anti-correlation between western Arabian Sea upwelling/SST and rainfall in southwestern India is still open for investigation but few studies show evidence (Shukla, 1975; Arpe et al., 1998; Vecchi and Harrison, 2004; Izumo et al., 2008; Gimeno et al., 2010; Levine and Turner, 2012). Based on these modern observations, the comparison of upwelling and rainfall on longer time scales becomes an important aspect towards its understanding. As per reviewer's suggestion more studies on the modern climate are included in the revised manuscript.

**Comment:** ***In the paper by Tiwari et al. (2010), which the authors cite, more data on core SS4018 are available such as carbonate contents and stable isotopes of carbon and nitrogen. These data can be utilized to better understand the processes in the Somali upwelling and would help to better understand the Holocene productivity changes. Tiwari et al. come to similar conclusions, e.g. that productivity does not decline during the late Holocene despite the decreasing insolation, based on a multiproxy study. The authors have now additional evidence that this is the case and can prove what Tiwari et al. suggested: the decline of carbonate could be due to the replacement of carbonaceous by siliceous primary producers. The carbonate/opal ratio could show this and strengthen the authors' point. The published data need to be included and elaborated on.***

***Reply:*** Yes, there are more proxy data available in the same core. We also agree that Tiwari et al., 2010 have suggested siliceous productivity as an alternative for calcareous. The whole core is composed of carbonaceous sediments with some minor variations. The carbonate content variations in this case is a function of nutrient availability and upwelling due to southwest monsoon variability. Carbonaceous productivity requires nutrients and micro nutrients. Oceanic regions (like Southern Ocean) deficient in micro nutrients, equatorial regions and high upwelling regions are known to experience high siliceous productivity (Lizitzin, 1971). Somalia basin known for strong upwelling, receives excessive nutrients brought from the sub-surface waters, is one region which results in relatively high primary productivity as a function of upwelling (Burkill et al., 1993). Synchronous increase of B.Si/carbonate and biogenic silica flux (Figure r1) attests to increasing upwelling in the Somalia region. However detailed discussion on the findings of Tiwari et al., 2010 have been included in the revised manuscript, as per reviewer's suggestion. If the referee still suggests the inclusion of previously published data by Tiwari et al., 2010 is necessary, then we are ready to incorporate in the revised manuscript.

**<u>Minor Comments:</u>**

**Comment:** ***The authors use the term "glacial" and "deglaciation" without giving references for these phases. They should also give the correct time for the beginning of the Holocene. I think that the use of LGP is rather uncommon but LGM is more common and can be referenced (Clark et al, 2009).***

***Reply:*** The time for beginning of Holocene is modified from 11 ka to 11.7 ka BP in the revised manuscript text and figures. We agree with the referee that the use of LGM is more common, however, in this paper LGP has been used as it is a cumulative period comprising Heinrich event 1 and part of LGM, also explained in the beginning of chapter 4.2.1.

**Comment:** ***Lines 55-59: it does not become clear why biogenic silica appears after carbonate, clarify in more detail.***

***Reply:*** Biogenic silica productivity as mentioned earlier are typical for regions like Southern Ocean, Equatorial Regions and high upwelling regions (like the present study site Somalia Basin). Silicate is low as compared to nitrate in surface and the intermediate ocean. Generally, in normal conditions in presence of nutrients and micro nutrients (Fe etc mostly supplied by terrestrial input or aeolian dust) or during the initial phase of upwelling (which brings high nitrate and low silicate water), it is mostly carbonaceous productivity which is dominated. But during high upwelling periods, due to excessive pumping of nutrients (silicate) to surface ocean by sub-surface waters (Haake et al., 1993), after initial carbonaceous productivity, depletion of micro nutrients to sustain excessive nutrient utilization and presence of more silicate results in siliceous productivity.

**Comment:** ***Line 68: Is the age model used here different from the one used by Tiwari et al. for the same core, if yes, why? Is the same rate of sedimentation used for the whole core, despite available C14 ages? Why?***

***Reply:*** Yes, we have used constant sedimentation rate to compute the flux. We considered that the variation in the sedimentation rate between 3-23 cm.ka-1 in our 4018 core as published by Tiwari et al., (2010), is a result of age control point selection. To minimize this effect, we computed an average sedimentation rate for the whole core.

**Comment:** ***Lines 130-134: difficult to understand, explain in more detail. Why should variations be three times greater?***

***Reply:*** If the observed variation in the biogenic silica flux is dominated by changes in burial efficiency (BE), low BE can be attributed to low flux and high BE to high flux i.e. result of low flux divided by low BF should be equal to high flux divided by high BE. High and low BE were assigned as per modern observation by Konning et al., 2001. In the present study, it was observed that the ratio of flux to BE was three times greater at the top as compared to the bottom, indicating the absence of preservation effect and the change in silica flux is exclusively a function of upwelling. Detailed explanation is presented in the revised manuscript.

**Comment:** ***Lines 145-148: very short and therefore difficult to understand, explain in more detail (see also general comment on the comparison of SST and productivity records above). When do you expect a correlation, when an anti-correlation, why? This cannot be explained in two sentences.***

***Reply:*** During southwest monsoon, with increase in upwelling anti-correlation exist between biogenic silica flux and SST. However, there is no relation between biogenic silica flux and SST in absence of southwest monsoon during LGP (18.5-15 ka BP). Detailed discussion on the comparison between biogenic silica flux and SST is now included in the revised manuscript.

**Comment:** ***Line 181: I find the use of the deglacial period (DP; 15-11 ka BP) rather problematic as it covers the Pleistocene/Holocene boundary.***

***Reply:*** We have used the deglacial period as the connecting phase between Holocene and LGP. The time range for deglacial period has been modified as 15-11.7 ka BP in the revised manuscript.

**Comment:** ***Line 185: what does "entrainment of the SW monsoon" mean?***

***Reply:*** We want to state that the northern limit of southwest monsoon was attained at the beginning of deglacial period onto the study site. The sentence has been modified as suggested.

**Comment:** ***Lines 197-204: these lines again show that the comparison of moisture and upwelling does not work (see above). So when does it work and is it at all useful to show it for the whole period?***

***Reply:*** The change in the relationship between upwelling and rainfall (moisture) at ~11 ka BP is the major finding of the present study. The upwelling-rainfall interaction was different during deglacial period than Holocene as well as modern. So the comparison for the whole period is necessary.

**Comment:** ***Lines 221: very short and not convincing. How does the record from the Qunf Cave come into the picture? How is rainfall related with the monsoon on the Arabian Peninsula? Is chronology such a big problem that the correlation does not work?***

***Reply:*** This part has been elaborated in the revised manuscript. Fleitmann et al., 2007 have used Qunf cave record as indicator of southwest monsoon rainfall. The location of the Qunf speleothem is very close to the study area. If southwest monsoon was the reason for rainfall in southern Oman then western Arabian Sea must be the moisture source and is the basis for comparing upwelling and Qunf cave record. This aspect is now included in the revised manuscript. Chronology limits the comparison of short time variations in upwelling and rainfall records, however, long-term trend comparison is possible.

**References suggested:**


1. Clark, P. U., Dyke, A. S., Shakun, J. D., Carlson, A. E., Clark, J., Wohlfarth, B., Mitrovica, J. X., Hostetler, S. W., and McCabe, A. M.: The Last Glacial Maximum, Science, 325, 710-714, 2009.
2. Levine, R. C. and Turner, A. G.: Dependence of Indian monsoon rainfall on moisture fluxes across the Arabian Sea and the impact of coupled model sea surface temperature biases, Climate Dynamics, 38, 2167-2190, 2012.
3. Mahesh, B. S. and Banakar, V. K.: Change in the intensity of low-salinity water inflow from the Bay of Bengal into the Eastern Arabian Sea from the Last Glacial Maximum to the Holocene: Implications for monsoon variations, Paleogeogr. Paleoclimatol. Paleoecol., 397, 31-37, 2014.
4. Vijith, V., Vinayachandran, P. N., Thushara, V., Amol, P., Shankar, D., and Anil, A. C.: Consequences of inhibition of mixed-layer deepening by the West India Coastal Current for winter phytoplankton bloom in the northeastern Arabian Sea, J. Geophys. Res.-Oceans, 121, 6583-6603, 2016.


***Reply:*** Suggested studies are included in the revised manuscript.