Answer to comments by reviewer #2

At first we would like to thank reviewer #2 for the instructive comments that were highly helpful to improve our manuscript. Below we answer to all points evoked by the reviewer. Italic parts are the reviewer's comments and our answers follow after.

All the modifications of the manuscript are indicated with yellow background considering the comments of both reviewers #1 and #2.

Some passages of the manuscript reveal that interpretations flaw sometimes of originality when compared to previous studies.

The originality of our study is the reconstruction of bottom water oxygenation at a critical water depth that was close to the upper limit of anoxic boundary (1800 m) during S1 deposition. This point has not been explicitly addressed by previous studies. We revised abstract and section "1. Introduction" to better demonstrate the state of art and unsolved issue, by referring a recent review by Rohling et al. (2015). Also we added in Figures 4 and 5 water depths of records compared with core MD04-2722 to clarify our focus of the study.

A more detailed analysis of the mechanisms leading to the second phase of sapropel (S1b just before S1 termination) would certainly have strengthened the quality of the manuscript.

We agree with reviewer #2 and added a short statement in the revised "6.3. Re-ventilation in the middle of the S1 period". Our results combined with previous studies indicate that S1 interruption affected water masses at water depths at least as deep as 1800 m in the Levantine Sea (see also our reply to the last comment of reviewer #2) leading to mixing between old dense (glacial) waters and overlaying lighter waters. Once cooling and/or reduced fresh water input finished, the stagnant ventilation mode came back, which suggests the density barrier was still too strong to shift to the present-day circulation mode. So the basic idea about the mechanism leading to the second phase of S1 deposition is removal of the forcing (cooling and/or fresh water inputs). For precise quantification of mechanisms, sensitivity tests with numerical modelling will be required.

Page 4659 line 17-20: We are aware that, due to diagenetic processes and postdespositional diffusion that can modify boundary positions, precise timing for ventilation changes is difficult to obtain from bulk geochemistry. This sentence is in contradiction with the objective of this study because precludes a precise interpretation of the geochemical dataset and a solid comparisons with other studies in the Eastern Mediterranean area. The authors should provide a more robust explanation on this point.

Since the distribution of element is affected by diagenetic processes and postdespositional diffusion that are specific to each element, our interpretation of geochemical indicators is not based on a single profile. We interpret and discuss the timing of ventilation changes when several proxy reconstructions are in good agreement. We added brief explanation in revised section "6.1. Geochemical meaning of elemental ratios" to clarify our strategy.

Conditions of bottom water circulation prior to S1 deposition. To restore δ^{18}Ow anomaly, the authors refer to SST reconstructions from core MD84- 632 by Essellami et al. (2007). I was wondering why the authors did not refer to the neighbor core MD84-641 (33°02' N; 32°28' E, 1375m water depth) that benefits of detailed oxygen isotope record, SST estimates, benthic foraminifera assemblages analyses as well as a robust age model based on a large dataset of AMS 14C dates (i.e. Fontugne et al. 1994 ; Melki et al. 2010), mineralogical and chemical analyses of bulk sediment and organic carbon and carbonate analyses (Fontugne & Calvert, 1992; Calvert et al. 2001).

We added *G. ruber* δ^{18}O in revised Figure 4 for comparison. Indeed, core MD84-641 location is close to the position of our study core, and *G. ruber* δ^{18}O records of both cores present very similar variability but temporal resolution for core MD84-641 is lower, reflecting a lower sedimentation rate (about a half of core MD04-2722). In fact, the studies using core MD84-641 focused on the sapropels S1 to S10 covering the last 390 ka records, and detailed variability during S1 period is difficult to see from figures. Since numerical SST data of core MD84-641 are not available, we used higher resolution SST records from close locations as shown in our original manuscript. Since SST effect on *G. ruber* δ^{18}O record of core MD04-2722 is of second order, there is no change in our discussion.

In the eastern Mediterranean Sea, slow circulation seems to have begun from 15 to 12 cal ka BP and to have affected waters at 700 to 1780m in depth. However, between 15 to 11 ka $\delta^{13}C$ *values suggest ventilation state at 700 and 900 m similar to present-day. Similarly, benthic* $\delta^{13}C$ *record from the South Adriatic and the North Aegean Sea as well benthic assemblage oxygen index indicate that the EMDW still persist to feed the deep Levantine basin at the Early Holocene like today. A comment from the author turns out necessary for this point of the discussion taking into account recent model studies proposing initial glacial conditions for deep waters preconditioning the S1 formation (Adloff et al., 2011; Grimm, 2012).*

In order to clarify the point evoked by the reviewer, we complemented explanation in the revised section "6.2. Conditions of bottom water circulation prior to S1 deposition". As shown in Figure 4, epibenthic foraminiferal δ^{13}C values from South Aegean Sea and South-eastern Levantine Sea show a decreasing trend from 15 to 11 ka BP, with concomitant increase in U/Al and Mo/Al of core MD04-2722, which we considered as a sign of slower ventilation. It is worth noting that the decreasing trend of foraminiferal δ^{13}C values does not necessarily mean complete shutdown of ventilation. As mentioned by the reviewer, the absolute foraminiferal δ^{13}C values (Figure 4) were still comparable with the late Holocene values, and both benthic foraminiferal assemblage and trace elements (Figure 5) did not indicate strong anoxic conditions before S1 interval. We thus propose reduced intermediate/deepwater formation and consequent restricted extension of well-oxygenated water mass(es) for this period. The presence of glacial dense water in the bottom of the eastern Mediterranean Sea, as shown by modelling studies, further emphasized vertical density gradient, being consistent with our interpretation.

About Re-ventilation in the middle of the S1 period. The authors should provide the benthic oxygen index record from core MD04-2722 and compare it with those of figure 5 (LC-31, SL123 cores). One should be cautious on the interpretation of the LC31 BOI record (Abu-Zied et al., 2008) because the core contains a small slump confirmed by AMS 14C dates showing a significant dating reversal at 84 cm. Therefore, the interpretation of large spatial distribution of the S1 interruption stays questionable. The Authors should clarify this point by providing a coherent explanation of any mechanisms that would induce a stronger oxygenation of the Levantine deep water (LC31, 2300 m) with respect to the S. Aegean intermediate waters (SL123, 728 m). A more plausible explanation would be attributable to a misleading age model of the LC31 core.

We had decided not to show a benthic oxygen index record of core MD04-2722 because the number of tests and observed species were not enough to establish a reliable index record as initially defined by Schmiedl et al. (2003). Instead, detailed study on whole benthic foraminiferal assemblage as well as benthic foraminiferal stable isotope records of core MD04-2722 will be presented elsewhere (Cornuault et al., in prep.).

Taking into account the possible age model problem of LC-31 and the fact that S1 interruption is not systematically observed for geochemical records coming from cores collected at deep water depths, we propose two scenarios in revised section “6.3. Re-ventilation in the middle of the S1 period". In the first scenario, a re-ventilation is estimated to have occurred as deep as 2300 m as initially proposed. Absence of the S1 interruption in geochemical records can be explained by post-depositional oxidation of the second phase of S1 layer due to lower sedimentation rate of cores from deep water depths. The second scenario is that re-ventilation was limited to the water depths shallower than 1800 m, and the lack of double peaks of redox-sensitive elements is considered as initial signal.

We do not intend to quantitatively compare the degree of oxygenation using benthic oxygen index between Levantine deep water (LC31, 2300 m) and the South Aegean intermediate waters (SL123, 728 m) because the reconstructions based on the index provides "semi-quantitative", not quantitative estimates (Schmiedl et al., 2010). With currently available data, it is difficult to examine whether these sites were bathed in the same water mass. We thus compare relative variability of these records with the data of MD04-2722. Above-mentioned scenarios are consistent with the records.

References

Schmiedl, G., Mitschele, A., Beck, S., Emeis, K.-C., Hemleben, C., Schulz, H., Sperling, M., and Weldeab, S.: Benthic foraminiferal record of ecosystem variability in the eastern Mediterranean Sea during times of sapropel S5 and S6 deposition, Palaeogeography, Palaeoclimatology, Palaeoecology, 190, 139-164, 2003.

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