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Climate of the Past Discussions

Interactive comment on "Tracking climate variability in the western Mediterranean during the Late Holocene: a multiproxy approach" *by* V. Nieto-Moreno et al.

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Reply to review #2 on "Tracking climate variability in the western Mediterranean during the Late Holocene: a multiproxy approach" (Clim. Past Discuss., 7, 635-675, 2011):

We appreciate the suggestions and constructive comments made by Referee #2. We will incorporate them to improve the revised version of the manuscript. We also provide two figures as supplementary material. Responses to specific points are given below:

1.- The proposed correlation between the two records is not convincing and the authors should provide more information and details to demonstrate the achieved age model and correlation between the two cores. A synthetic figure with radiocarbon ages and

^{210}Pb profiles is needed to persuade the reader about that.

We agree that this is an important point which calls for improvement (see also Referee #1). Two new figures will be attached in the revised version of the manuscript drawing radiocarbon ages and total ^{210}Pb activity profiles with error bars (see new additional Figures I and II in response to Referee #1). A new table, including ^{210}Pb inventories for both cores, will be attached as well (see Table I in reply to Referee #1). Furthermore, we will specify in the text that these sedimentation rates (page 645, line 10) and ^{210}Pb inventories obtained for cores 305G and 306G (see Table I in Referee #1's reply) are similar to those reported in other deep Mediterranean areas by previous authors (1-13 cm.kyr^{-1}) (García-Orellana et al, 2009). Additionally, at the baseline of the rest of the multiproxy figures in the manuscript (Figs. 3-7), we will add marking points including ^{14}C dates and error bars.

2.- The discussion on climate/ocean dynamics of the Mediterranean during the studied interval is generally superficial and needs a significant improvement. The proposed dataset is important and the multi-proxy approach provides significant information to explore in more details and depth the evolution of the Mediterranean system during the studied interval. In its present form, the manuscript represents an important collection of data without an appropriate exploitation in terms of climate concepts.

We will carefully revise and rework sections 9 and 10 in order to refocus our discussion, to provide a deeper and more precise exploration of data, and to highlight the actual contributions of this work.

3.- Visual correlation between the two cores for the different proxy records should be discussed in more details mostly when proxy records show important differences. Actually, the geographic closeness of the two records contrasts with many different behaviour of element distributions in coeval intervals. This suggests an important dynamicity of the seafloor with associated problems of correlation between the two records. This should be considered and discussed in details by the authors.

Referee #2 rightfully underlines the dynamicity of the seafloor in this region. The semi-enclosed configuration of the westernmost Mediterranean sea in combination with the irregular sea-floor topography makes its sedimentary record particularly sensitive to the intensity and direction of deep currents, and the influx of the terrigenous component into the basin is mainly governed by submarine canyons (Krijgsman, 2002). It is also true that the geographic closeness of the two records (~25 km; Figure 1a) sometimes contrasts with the diverse behaviour of element distributions in coeval intervals, although this is due to the different location of these sites, the topography and bathymetry (Figure 1b). Discrepancies between the two records owing to this fact are considered and discussed throughout the manuscript: (Page 647, lines 2-8; Page 648, lines 5-8; Page 650, lines 3-20). Although some isolated discrepancies could arise between certain proxies from both cores because of this (different paleoceanographic conditions due to topography), we consider these cores to show a remarkably good correlation as evidenced by sedimentation rates (see Figures I and II in response to Referee #1), the climatic signal (detrital input, Fig. 3), and statistical analyses (Figures 2a, b, c, d) where both the mineralogical and geochemical proxies are grouped showing the same behaviour and correlation in both cores. Moreover, they show a common underlying climatic pattern in the westernmost Mediterranean, supported by the same climatic conditions described in this region during this time interval. In any case, as said before, discussion of the data will be reconsidered, and additional emphasis and care will be implemented where proxy records display important differences.

4.- Chapter 2 should be shortened and reduced to the essential concepts of Mediterranean circulation. Actually, many concepts are already reported in many papers the authors could simply refer in their manuscript. Also, chapter 3 could removed and basic concepts synthetized and reported in different part of the discussion.

We will rewrite both sections in the revised version of the manuscript, although in light of Referee #1's suggestions, section 3 will be reconsidered and some concepts will be expanded, synoptically.

5.- The authors should give more details about REEs analysis (which elements did they analyse?) and try to explore the behaviour of the different elements once normalised to chondrites, PAAS, etc. I am not definitively convinced that pumped together, REEs could offer a significant paleoceanographic proxy. A different response of the single elements to different environmental forcing (redox conditions, productivity, etc.) should be considered and explored in detail.

We assessed REEs values as a reliably proxy of source provenance (detrital proxy) by normalization with respect to CI chondrite and comparison with the North American shale composite (NASC) and the Post-Archean Australian average shale (PAAS) (McLennan, 1989), as well as by statistical analyses. Nevertheless, results were not included in the final version of the manuscript. In heeding your suggestion, we will include some information from the following text and two figures in the revised version of the manuscript (see Figures IV and V below).

"Rare earth elements, REEs, (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu) are reliable indicators for tracing source provenance of marine sediments influencing chemical weathering of terrestrial material. In most sedimentary rocks, total REEs abundance patterns mirror the average upper continental crust, as REEs are transferred nearly quantitatively in the terrigenous component through erosion and sedimentation, the soluble fraction being negligible (McLennan, 1989).

REEs values were normalized with respect to CI chondrite with a resolution of five centimetres in both cores (McDonough and Sun, 1995) (Figures IV and V below). In both cases, REEs values display an uniform pattern parallel to the average upper continental crust composition, with a typical variation consisting of slight L-REE enrichment relative to H-REE depletion and a negative Eu-anomaly, as well as lower values than the North American shale composite (NASC) and the Post-Archean Australian average shale (PAAS) (McLennan, 1989). Thus, REEs are evidenced as a trustworthy proxy of source provenance to the basin. Furthermore, the statistical significance supported by the group of detrital proxies in both cores (Figures 2a, b), such as Al (305G: r^2=0.77, p<0.01; 306G: r^2=0.94, p<0.01), Th (305: r^2=0.89, p<0.01; 306G: r^2=0.96, p<0.01), Rb (305G: r^2=0.77, p<0.01; 306G: r^2=0.91, p<0.01), Ba (305G: r^2=0.79, p<0.01; 306G: r^2=0.96, p<0.01), Fe (305G: r^2=0.63, p<0.01; 306G: r^2=0.88, p<0.01), Si (305G: r^2=0.82, p<0.01; 306G: r^2=0.94, p<0.01), Ti (305G: r^2=0.80, p<0.01; 306G: r^2=0.94, p<0.01), Mg (305G: r^2=0.45, p<0.01; 306G: r^2=0.56, p<0.01) and K (305G: r^2=0.81, p<0.01; 306G: r^2=0.91, p<0.01) reveals clay minerals as the most important hosts for REEs."

Due to the lack of anomalies in the normalized REEs pattern, as in most sedimentary rocks, the REEs act as a detrital proxy, being quantitatively transferred to the basin together with the terrigenous fraction and hosted in clay minerals. Therefore, we did not consider the behaviour of single elements as to other different forcings, but only the sum of all REEs.

We hope we have adequately addressed your concerns and we will incorporate your suggestions in the revised version of the manuscript.

References:

Garcia-Orellana, J., Pates, J. M., Masqué, P., Bruach, J. M., and Sanchez-Cabeza, J. A.: Distribution of artificial radionuclides in deep sediments of the Mediterranean Sea, Sci. Total Environ., 407, 887-898, doi:10.1016/j.scitotenv.2008.09.018, 2009.

Krijgsman, W.: The Mediterranean: Mare Nostrum of earth sciences, Earth Planet. Sc. Lett., 205, 1-12, doi:10.1016/S0012-821X(02)01008-7, 2002.

McDonough, W. F., and Sun, S. S.: The composition of the Earth, Chem. Geol., 120, 223-253, doi:10.1016/0009-2541(94)00140-4, 1995.

McLennan, S. M.: Rare earth elements in sedimentary rocks; influence of provenance and sedimentary processes, Rev. Mineral. Geochem., 21, 169-200, 1989.

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- Figure IV. CI chondrite-normalized REEs patterns every five centimetres in core 305G compared with the standard REEs pattern of the North American shale composite (NASC) and the Post-Archean Australian average shale (PAAS) (McLennan, 1989).

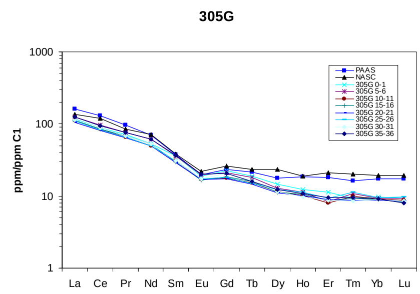

Fig. 1.

- Figure V. CI chondrite-normalized REEs patterns every five centimetres in core 306G compared with the standard REEs pattern of the North American shale composite (NASC) and the Post-Archean Australian average shale (PAAS) (McLennan, 1989).

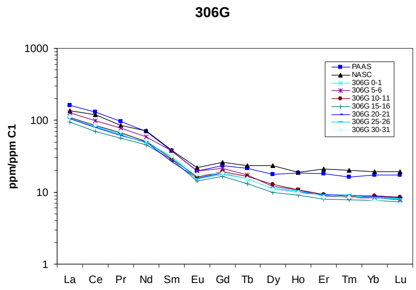

Fig. 2.