

Referee #1

We would like to thank Referee #1 for the helpful and constructive comments provided on our manuscript “Clim. Past Discuss., 6, C908–C912, 2010 Late Holocene climate variability in the southwestern Mediterranean region: an integrated marine and terrestrial geochemical approach” and we will reply to the suggestions raised.

- We have accepted all the specific comments.
- We have also included the justification for the use of Al normalization in the text. Nevertheless, as it has been a comment in common with the Referee #2, we would like to explain it more in detail.

Why are most elements plotted as ratios against Al?

Normalization of trace element contents in sediments to the content of an immobile element is a common practice in marine geochemical studies. It is a simple way of correcting for dilution by sedimentary phases barren of a particular trace element. Marine sediments are mainly composed of carbonates, alumino-silicates and other minerals related to three different sources: biological, detrital and diagenetic. In this sense, the information obtained from bulk chemical analyses of sediments is insufficient to distinguish the multiple origins and also to interpret the sedimentary record in terms of paleoredox processes or paleoclimate reconstruction, between others. The reason to choose Al is because it does not show fractionation and has very little ability to move during diagenesis (Calvert and Pedersen, 1992; Piper and Perkins, 2004). In this sense, normalizing to Al is a quick and easy way to obtain information about environmental and climate processes using geochemical data.

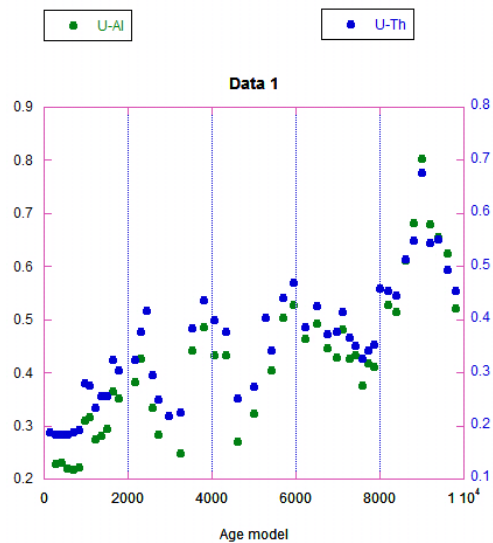
- Regarding the U/Th ratio, we have considered the referee’s advice and we have removed it. Nevertheless, we clarify some aspects below:

U/Th vs U/Al ratio:

The U/Th and the U/Al ratios are virtually identical ($r= 0.99$) (see figure).

- The reason: both Al and Th are detrital-derived trace elements. Both, U/Th or Th/U ratios are commonly used in the literature as redox proxies (e.g., Pattan and Pearce, 2009 Paleo3, Eusterhues et al., 2005 Chem. Geol., Rosing and Frei, 2004 EPSL).
- The difference: Th is a trace element measured using an inductively coupled plasma-mass spectrometry (ICP-MS) and Al is a major element, obtained by atomic

absorption spectrometry (AAS). The sample resolution was higher for the ICP-MS batch, and we decided to use the U/Th ratio.



U/Th as deepwater ventilation proxy

As it is said above, the U/Th ratio is a common redox indicator with a long tradition in the scientific literature (e.g., Adams and Weaver, 1958, Rogers and Adams, 1969, Wignall and Myers, 1988, Klinkhammer and Palmer, 1991; Pattan and Pearce, 2009). In short, U-content in marine bulk sediments can be related to the detrital input (detrital Uranium), incorporated from the sea water to the sediments (authigenic Uranium) and associated with the organic matter.

In anoxic sediments, the U (VI) dissolved in pore water is reduced to immobile U (IV) and it precipitates (Anderson, 1982, Anderson et al., 1989; Barnes and Cochran, 1990, 1993; Shaw et al., 1994). So, these environments work as sinks for the uranium dissolved in the sea water. Its incorporation in sediments generates U-enrichment so called "authigenic uranium". The average value of U/Th ratio in pelagic sediments is 0.25 (Mangini et al., 2001); in this study, U/Th ratio is higher than 0.40 indicating U-enrichment in sediments (authigenic Uranium). During the deposition of the last rich organic layer occurring in the early to mid-Holocene, U-content in the cores from the sediments of Alboran basin is well-correlated with the total organic matter content. This correlation finds an explanation during the process of organic matter oxidation. When organic matter is oxidized, authigenic Uranium is released to pore water and can return newly to the water column. Nevertheless organic matter content in Alboran is very low (< 0.35 wt.%) during the last 4000 years. It varies ± 0.1 (wt. %) and the correlation with U-content is also low. In addition, U/Th fluctuations

during the last 6000 year do not fit well with changes in bioproductivity nor detrital input.

So, we agree with the referee that the generation of deep water in the western Mediterranean Sea is a complex phenomenon. The simple interpretation of the U/Th ratio carried out in this study leaves unanswered questions such as the interaction between the different water masses and a clearer temperature-humidity relationship, which are not the aims of this article. Moreover the U/Th ratio information just could be reiterative, such as it was suggested by the referee. For these reasons we have preferred to follow the referee's recommendation and to remove the U/Th ratio.

- Finally, we thank the suggestion about enriching the Section 6 with the four main stages defined in the conclusions. We think that it is a very good idea and we have discussed the results following the schema of these intervals.