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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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Dear Dr. Morellon,

We genuinely appreciate your comments on "Tracking climate variability in the western Mediterranean during the Late Holocene: a multiproxy approach" (Clim. Past Discuss., 7, 635-675, 2011) and the detailed and constructive recommendations made to complement this interactive discussion and improve this study. As you indicate, we fully agree that a multidisciplinary approach coupled with statistical analyses for the interpretation of geochemical data can offer new insights and contribute to the research on natural climate variability in the Western Mediterranean realm. Furthermore, while

lake sediments usually display higher resolution for this time period, high-resolution marine records of the Late-Holocene are still scarce in this region, they are little influenced by external interactions, and they hold a large portion of the record of past global climate. We also agree it would be a good opportunity to compare these results with Late Holocene continental records of the Iberian Peninsula published during the last years. Indeed, we recently contributed a study published in "Climate of the Past" (Martín-Puertas et al., 2010), which presents a terrestrial-marine correlation for the Late Holocene, demonstrating the reliability and interest of western Mediterranean marine records for such reconstruction. In addition to published data, here we provide two new records, with a robust and improved age model that integrates a wide suite of proxies, allowing for a comprehensive reconstruction of climate responses during this time period. We are currently working on a compilation of marine and terrestrial records from the Iberian Peninsula that further evidences an integrated approach to cover the last 2000 years, and it includes some of these data and a comparison with continental records published during the last years (Moreno et al., submitted). In the following section, we would like to respond to your general remarks and particular comments in detail.

Concerning general remarks,

1.- The traditionally used term 'Medieval Warm Period' has been progressively replaced by the more adequate 'Medieval Climate Anomaly'. Thus, I suggest using the latter throughout the manuscript.

We absolutely agree with this replacement, so according to your suggestion we will use the latter throughout the revised version of the manuscript.

2.- The author compares her results with other global records, mainly W Mediterranean marine sequences and besides particular references to S Spain sequences, only with reviews of Mid-European lake level oscillations carried out by Magny (2004). The author states that NAO is the main forcing mechanism for climate variability during the last millennia in the Western Mediterranean area. According to this, opposite paleoclimatic trends could be expected when comparing N and S Europe. The location of most of the lakes reviewed by Magny, above N and about 1300 km NE from the study site, makes them less suitable for comparison than other sequences from S Europe. In fact, significant contributions to the study of paleoclimatic variability of the Iberian Peninsula during the Late Holocene have been provided by continental records from Spain and Morocco and marine sequences in the Iberian Margin. The general agreement of Alboran data with these results might reinforce some of the hypotheses stated by the author, thus improving the quality of the manuscript. In fact, recent investigations demonstrate a clear correspondence between all these records during the last two millennia (Moreno et al., in prep.).

As you say, one conclusion of our manuscript is the fact that the NAO is evidenced as one of the main forcing mechanisms driving natural climate variability over decadal to centennial time-scales in the westernmost Mediterranean realm. A persistent positive (negative) NAO state has been described in Europe during the MCA (LIA) (Trouet et al., 2009). So as to reinforce this hypothesis, we compare our results with northern and southern European records, thus evidencing wetter (drier) conditions over northern (southern) Europe during the MCA (LIA). We accept that, in order to evidence this contrast, mid-European lacustrine records from Magny (2004), due to their location, are probably not as suitable as records from farther north (Scandinavia, Scotland and Iceland) and south (South Iberia and Morocco). We will certainly revise and change this reference, providing others to evidence this contrast, such as stalagmites from NW Scotland (Proctor et al., 2002; Baker et al., 2011), tree ring records from Germany (Büntgen et al., 2010), and precipitacion data and tree ring records from NW Africa (Knippertz et al., 2003; Esper et al., 2007). Nevertheless, we consider that the scope of this manuscript is to characterize the main climate oscillations and local changes taking place in this region, using marine records at high resolution for the first time, as well as main factors driving these fluctuations to further advance our understanding of natural climate variability during the Late Holocene, rather than a comparison and/or

combination of lacustrine and marine records in the Iberian Peninsula. Indeed, the recent investigation carried out by Moreno et al (now submitted) includes some proxies from these two cores, although it was in early preparation when the present manuscript was submitted to this journal.

With relation to particular comments:

1.- p. 640, 2nd paragraph: citing a reference to support comment about the influence of NAO in the IP would be good here.

This section will be reworked and abbreviated according to Referee 2's suggestions, and we will include some references to further support this influence, such as Trigo et al. (2002, 2004) and Wanner et al. (2001).

2.- p. 647, I suggest including the full name of the climatic stages first mentioned here (e.g., DA, MWP, LIA,. . .) and their respective chronologies.

Though every climate stage is defined by its full name in the abstract and by its full name and chronology in every headline in section 9, we agree it would be a good idea to incorporate them previously (full name and chronology, in the introduction).

3.- p. 649, line 3, I would say ‘constant’ post depositional patterns rather than ‘flat’.

We will change “flat” to “constant” as you suggest.

4.- p. 651, Roman Humid Period. Martín-Puertas et al., (2009) provided an annually resolved record of this period in Lake Zoñar and considered it as the most humid period in the last 4 ka. Does Alboran Sea record agree with Zoñar? Is it possible to find here internal fluctuations within this period? I think the original reference Martín-Puertas et al. (2009) should be included here.

Yes, the Alboran Sea record agrees with Zoñar as we acknowledge on page 651, lines 27-29 and page 652, lines 1-2. Indeed, Martín-Puertas et al. (2010) describe this period as the most humid of the Late Holocene based on a compilation of fluvial

(Mg/Al ratio at ODP 976 site) and eolian marine proxies (Zr/Al ratio at core 300G) from the Alboran Sea basin and detrital input into the Zoñar lake (Rb/Al ratio) extracted from Martín-Puertas et al. (2009). Therefore, we consider this reference sufficient to support agreement with the Zoñar record.

5.- p. 653, last paragraph. Medieval Warm Period. As evidenced in Moreno et al., (in prep.), the Medieval Climate Anomaly (MCA) was characterized by generally drier conditions in the Iberian Peninsula. Particularly dry conditions have been recorded in Lake Zoñar (Martín-Puertas et al., 2008), Estanya (Morellón et al., in press; Morellón et al., 2009), Lake Montcortés (Rull et al., in press) and Lake La Cruz (Julià et al., 1998), among others. Consistently, a decrease in flood frequency was registered in the Tagus Watershed (Benito et al., 2003, 2004; Moreno et al., 2008). References to these sequences are more adequate here than the one provided by the author, derived from the French Jura, as stated above.

We agree that Magny (2004) is possibly not the most suitable reference to characterize the dry conditions which took place during this time interval in the western Mediterranean region. We will revise and change the references in question. The work by Moreno et al. (submitted) is not referenced since its preparation started when this manuscript was already submitted; however, it will be cited now as submitted.

6.- p. 654, last paragraph. Little Ice Age. The previous situation is reversed in this period, which has been recorded as a generally humid period in Lake Zoñar (Martín-Puertas et al., 2008), Lake Montcortés (Rull et al., in press) and Lake Estanya (Morellón et al., in press). Higher frequency of floods in the Tagus has consistently been recorded by Benito et al (2003 and 2004) and Moreno et al. (2008). The internal structure of the LIA and the influence of changes in solar activity have also been unraveled in some of these publications, particularly in the Tagus River ones. Taking into account the resolution of this record, is it possible to reconstruct internal variability within the LIA and its potential connection with sunspot variability or other forcing mechanisms? In fact, an initial arid phase within the LIA was also found in some of these sites (see

Morellón et al., (in press) and references therein). Again, references to some of these records would be adequate here.

As stated above, we will remove any comparison with mid-European records from Magny (2004), and we will revise this section, adding new references which fit well with the wetter conditions found in the western Mediterranean. Elsewise, the potential forcing mechanisms driving internal climate variability during this period are discussed in page 654, paragraph 10.

7.- Page 654, Forcing mechanisms. The decoupling between solar radiation and climate variability in this area during the MWP and LIA is a very interesting finding. According to the author, the NAO would be the main forcing mechanism for this period. Consistently, I recommend the incorporation of a NAO index reconstruction in figure 8, which fits well with this discussion. Trouet et al., (2009) provided the longest NAO-index reconstruction available to date, demonstrating anomalous positive values during the MCA, declining progressively during the more humid LIA. Parallell records instead of an overlapping of different curves would improve the quality of this figure and the incorporation of other(s) continental records cited through the manuscript would help the reader to follow the comparisons between records discussed in previous sections.

We agree that the addition of the NAO index by Trouet et al. (2009) could improve this figure and this will be done in the revised version of the manuscript. However, the two records are overlapped in every figure throughout the manuscript to facilitate their comparison without increasing the number of figures. Figure 8 draws the main processes managing deposition at both sites depicted as the first eigenvector, thus including the entire detrital input into the basin (eolian and fluvial). Although fluctuations of the first eigenvector are directly linked to climate oscillations, its comparison with other records in the region might not fit as well as eolian and fluvial proxies do separately. Alternatively, we believe that a more synoptic and precise discussion could make it more dynamic, making unnecessary the inclusion of additional figures which are already numerous and complex.

8.- P. 656, Conclusions. If any of the changes suggested before are considered, this section should be modified accordingly.

If required, conclusions will be revised and modified according to the modifications effectively made in the next version of the manuscript.

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