Autor's response to Graciela Gil-Romera - "Holocene aridification trend interrupted by millennial- and centennial-scale climate fluctuations from a new sedimentary record from Padul (Sierra Nevada, southern Iberian Peninsula)"

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Firstly, we would like to thank Graciela Gil-Romera for her comments and constructive suggestions, which will improve the manuscript, and for recommending this study for publication in Climate of the Past. Please find enclosed point by point responses to the general suggestions first and minor comments below.

The referee suggestions and comments are displayed in italics, and our answers in normal font. We marked the lines over the MS that we are going to modify and we show the modifications (in inverted commas), in the case that we do not follow the reviewer suggestions we discuss the reasons.

General

I find that the manuscript led by Ramos-Roman is a useful contribution to understanding the recent palaeoenvironments of an otherwise, poorly studied region of Southern Europe. The study presents a multiproxy analysis of Late Holocene change from the well known record of Padul. The main objective of the paper is to distinguish climate from human action driving landscape dynamics. The age model is coherent and well built, and the subsequent time series analyses performed on geochemistry and pollen is sound and within the accuracy of the age-depth model. I attach an edited version of the pdf with some, minor, comments and then I have a couple of wider suggestions:

General suggestions for the review

1. *Despite the main question posed in this work is essential to the paleosciences (human vs climate driven changes) quite often it's impossible to tell which is the main driving factor as they superimpose. This is also kind of patent in the study led Ramos-Roman and cols. where despite all proxies is difficult to detangle these effects. I would probably include the "human" factor in the title as it includes a large part of the discussion.*

2. *Despite authors present several proxies and connect with other terrestrial and marine records they lack charcoal as a proxy of fire occurrence. Considering the sampling has been done continuously, adding charcoal as a proxy may illustrate postfire responses of vegetation that are now been attributed to climate or human activities indirectly. Likewise it may help understanding the human-climate dialectic. Please do have a look to my comments in the attached documents (minor corrections and comments). Let me know if the document can't be accessed for any reason. I'd be pleased in seeing this study published in Climate of the Past.*

Author's response to general suggestions:

1. We agree with your comment about the importance human impact on the environments during the Late Holocene. In this record human impact doesn't seem to be very strong until the last 1.5 cal ka BP and that is the reason why we mostly focused on understanding the climate influence on the environments during the Late Holocene in the southern Iberian Peninsula. Anyhow, we agree in that human impact is also important and should appear in the title so we changed it for "Holocene aridification trend and human impact interrupted by millennial- and centennial-scale climate fluctuations from a new sedimentary record from Padul (Sierra Nevada, southern Iberian Peninsula)".
2. The suggestion of including the charcoal analysis from this sediment record to this manuscript is a great idea but this is the Masters thesis study that Cole Webster is carrying out at present under supervision of R. Scott Anderson at NAU, Arizona, USA. So even if we understand how important is to have a fire-proxy record to compare with the vegetation and sedimentation dynamics we do not have these data yet.

Minor comments insert in the pdf

1. line 63: Gil-Romera et al., 2014 is not highlighting any aridity trend at that time.

Ok, we deleted that one and inserted a correct reference

Modification in line 63:

"(Gil-Romera et al., 2010)"

2. line 80: quote which ones.

Thanks. We moved the references to the correct place.

Modifications in line 80:

"(Florschütz et al., 1971; Ortiz et al., 2004; Pons and Reille, 1988)".

3. line 98: it'd help to have a vegetation profile here sumarising the communities that you explain below,

so you don't have to go in such detail with taxa that you can't actually find later on in your pollen spectra.

Ok, this is a good idea. We summarized the vegetation to the principal species present in this vegetation belts, related with our pollen results.

Modifications in the MS - lines 105 to 125:

"According to the climatophilous series classification, Sierra Nevada is divided in four different vegetation belts (Fig. 1). The crioromediterranean vegetation belt, occurring above ~2800 m, is characterized by tundra vegetation principally composed by some species of Poaceae, Asteraceae, Brassicaceae, Gentianaceae, Scrophulariaceae and Plantaginaceae between other herbs and grasses featured by a big number of endemic plants (e.g. *Erigeron frigidus, Saxifraga nevadensis, Viola crassiuscula, Plantago nivalis*). The oromediterranean belt, between ~ 1900 to 2800 m, is principally made up of *Pinus sylvestris, P. nigra and Juniperus spp.* and other shrubs as some species of Fabaceae, Cistaceae and Brassicaceae. The supramediterranean belt, from ~ 1400 to 1900 m of elevation, bears principally *Quercus pyrenaica, Q. fagineae* and *Q. rotundifolia, Acer opalus* subsp. *granatense* between other trees as some species of Oleaceae and Rosaceae and shrubs as some Fabaceae, Thymelaeaceae, Cistaceae and *Artemisia* sp. as the most important. The mesomediterranean vegetation belt occurs between ~600 and 1400 m of elevation and is principally characterized by *Quercus rotundifolia*, some shrubs, herbs and plants as *Juniperus* sp., and some species of Fabaceae, Cistaceae and Liliaceae between others (Al Aallali et al., 1998; Valle, 2003). The human impact over this area, especially important during the last millennium, affected the natural vegetation distribution through fire, deforestation, cultivation. (i.e., *Olea*) and subsequent reforestation (mostly *Pinus*) (Anderson et al., 2011)"

4. line 216: can you please state how many samples did you analyze in the end? are these 115?

The total number of samples analysed was 103. This number does not correspond to the 115 cm-long sediment record studied because there was some compaction. Thanks for noticing, we also clarified this in the MS.

Modifications in the MS in line 216:

"Samples for pollen analysis (1-3 cm^3) were taken every 1 cm throughout the core, with a total of 103 samples analyzed"

5. *line 234: Please detail average sedimentation rate for core Padul 15-05*

Ok, we detailed the average sedimentation rate.

Modifications in the MS in lines 235 to 237:

"The age-model of the studied Padul-15-05 core (Fig. 2) shows that the top 115 cm, with an average sedimentation rate of 0.058 cm/yr, continuously cover approximately the last ca. 4700 cal yr BP being the

age constrained by seven AMS ^{14}C dates (Table 1)"

6. line 238: as far as I can see you have not done linear interpolation. Indeed you explain that you did smooth splines in Clam?? Please correct inconsistency

Yes, we used a smooth spline age model. However, the sedimentation rates were calculated by lineal interpolation between the radiocarbon dates. We agree in that they have to be consistent so we modified this SAR in Figure 2 and we now show the average SAR between radiocarbon dates using the modeled ages.

Modifications in the MS lines 237 to 239:

"Six distinct sediment accumulation rate (SAR) intervals can be differentiated between 0 and 122.96 cm between radiocarbon dates in the studied core"

7. line 409-415: I see the aridification argument as a more likely explanation than a real summer cooling due to reduced insolation. If anything, at these latitudes, that would help the forest reducing evapotranspiration. In other nothern mountain systems as the alps and the reduced summer insolation does not seem to affect the forest during the MId-late Holocene (Perez et al., 2013, Leunda et al., 2017) so I would see as more feasible the second aridification trend due to the westerlies moving northwards than the reduced growing season due to cooling.

Yes, we agree and also think that aridification was the main trigger of this vegetation change but we cannot underestimate the effect that summer insolation (perhaps very little) might have caused in the vegetation with a reduction of the growing season.

We try to clarify this point over the MS.

Modifications in the MS lines 410 to 418:

"The decline in forest can be mostly explained as a decrease in winter rainfall as consequence to a reorganization of the general atmospheric circulation with a northward shift of the westerlies - a long-term enhanced positive NAO trend - inducing drier conditions in this area since 6000 cal yr BP (Magny et al., 2012). Furthermore, the decrease in summer insolation would produce a progressive cooling, with a reduction in the length of the growing season as well as a decrease in the sea-surface temperature (Marchal et al., 2002), generating a decrease in the land-sea contrast that would be reflected in a reduction of the wind system and a reduced precipitation gradient from sea to shore during the fall-winter season"