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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Intra-annual variability of the Western Mediterranean Oscillation (WeMO) and occurrence of extreme torrential rainfall in Catalonia (NE Iberia)" *by* Joan Albert Lopez-Bustins et al.

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Anonymous Referee #2 "Author's response"

General Overview:

The authors analyzed the intra-annual variability of the Western Mediterranean Oscillation and occurrence of extreme torrential rainfall in Catalonia (NE Iberia). Despite the target region and topic is of interest to be study due the possible socio-economic impacts of the torrential rainfall, the manuscript in the present form do not add much

to the present knowledge. In addition, it has some very important methodological and organizational issues which are listed below:

"We wish to thank the reviewer for his/her comments and for reviewing our manuscript. The manuscript has been revised in consonance with the referee's comments and suggestions, which are addressed below. Our answers appear within quotation marks".

1) My main concern is that the manuscript fails to add new knowledge to the literature. In the present form, the manuscript is rather descriptive specially in section 4.2 and 4.3 where there is a statistical description between WeMO and the torrential rain which was previously known. From my point of view, there is the lack of understanding what is the physical mechanism which are behind the extreme torrential rainfall in Catalonia, for example, the atmospheric forcing, the role of SST, or even the soil moisture availability.

"We agree with the reviewer regarding the lack of physical mechanisms; consequently, we have included new analyses, considering the temporal evolution of sea temperature from one specific high-quality series on the coast which encompasses several decades (1973-2017) (please see tables 2 and 3, and figures 10, 11 and 12). The results show a statistical relationship between changes in the WeMOi and SST trends. Furthermore, we have added a text explaining the atmospheric mechanisms related to mesoscale convective systems in the Western Mediterranean, which justifies the application of WeMO calendars (L88-114). Moreover, we have added new references to the introduction. We have also added three references from 2020. Furthermore, we have added NAOi values for figures 4 and 5 in order to demonstrate the better fit of the WeMOi in relation to that of the NAOi".

2) Figure 2a) is computed with data from where? The monthly series provided by the Meteorological Service of Catalonia?

"Figure 2a is extracted from the 70 precipitation monthly series computed by the SMC (Yearly Bulletin of Climate Indicators, 2017) which have been quality controlled and analysed for homogeneity. The caption of Figure 2 now includes a paragraph explaining

the origin of the data. The study period has been changed from 1950-2015 to 1951-2016. The caption now reads “Figure 2. (a) Annual mean precipitation (mm) and (b) seasonal precipitation regimes for 70 weather stations in Catalonia for the 1951-2016 study period. Data source: SMC (2017). Base map provided by the Cartographic and Geological Institute of Catalonia””.

3) The authors use a fix threshold to define the extreme torrential episodes which is >200mm in 24h. L168-173. I do not agree with this sentence. Based on my experience I can imagine that precipitation >100mm in a relative larger area will have more impacts than a precipitation >200mm only recorded in one single weather station. Therefore, I encourage the authors to think of a way to define the torrential episodes based not only on the amount of precipitation but also on its spatial extent.

“Thank you for your comment, which has brought us to further reflect upon the thresholds defining torrential rainfall in the Mediterranean. We partly agree with your comment, but episodes presenting precipitation $\geq$100 mm/day in a relatively larger area are not so common in Catalonia, and when they do occur, they do not cause major damage or destruction. For example, Gilabert and Llasat (2018), one of the new references we have included, found that catastrophic flood events (rivers overflowing with major damage or total destruction), associated with extreme torrential precipitation events, are generally of synoptic origin and are enhanced by certain mesoscale factors, a phenomenon that is clearly reflected by the negative phase of the WeMO. We have chosen the threshold of $\geq$200 mm in one single weather station as a maximum value in order to capture the most important torrential precipitation events, but within these, the area affected by precipitation values $\geq$100 mm is sizeable. This area usually encompasses a significant part of Catalonia (almost one third). Further information in this respect has been added to the new manuscript on L109-114, L193-201 and L659-661”.

“Moreover, in the first paragraph of subsection 3.1. ‘Selection of the torrential events’, we have further distinguished between ‘torrential events’ (threshold of $\geq$100 mm/24 h), widely used by Spanish authors, and ‘extreme torrential events’ ($\geq$200 mm/24 h),

already used in several previous studies, particularly in Lopez-Bustins et al (2016), cited in the References and also in Martin-Vide (2002), one of the new references we have included, as well as in others, with good results. It is true that the spatial domain of heavy precipitation conditions the fluvial response and the possibility of flooding, and the combination of precipitation amounts and area affected therefore enables a more complete hydrological analysis than when only precipitation amounts are used. In the future, the authors may intend to explore a hydrological definition of torrential precipitation for the western Mediterranean basin, taking into account both precipitation values and area affected”.

4) There is an inconsistent between the period of analyses. On line L126 is mentioned 1950-2015 and on L167 1950-2016.

“Many thanks for the observation. Indeed, there is an inconsistency that has been rectified both in the text (L162) and in Figure caption 2. The correct study period is 1951-2016”.

5) The authors need to include a better description of the weather stations. How many of them are at a daily scale vs semi-hourly data. Since which year do you have access to automatic weather stations?

“There were 749 weather stations at daily timescale (manual) and 305 at hourly or semi-hourly timescale (automatic) throughout Catalonia during the 1951-2016 period. The 1951-1987 period was covered by manual weather stations only. The 1988-2016 period was covered by both manual and automatic weather stations. We specified this information on L205-211”.

6) L220-222 The WeMo is computed using SLP from the weather stations mentioned in the text? They are quality controlled?

“Yes, it is (L243-247). Yes, they are (we have added new text to specify this L247-250)”.

7) In Figure 3 and Figure 8 the authors used the outdated NCEP/NCAR reanalysis.

Please use ERA5 instead.

“ERA5 is a better (higher resolution and a more complete global circulation model), updated reanalysis in comparison with the NCEP/NCAR reanalysis, but ERA5 currently only covers the time period from 1979. Therefore, we are unable to redesign figure 3 (a) and figures 8 (a) and 8 (b). Moreover, the definition of spatial resolution is not relevant with regard to shaping the WeMO phase occurring on these days. Nonetheless, we have improved the quality of all figures with NCEP/NCAR reanalysis”.

8) Figure 7 d , e ,f). These results are not mentioned in the text. I would exclude it from the manuscript.

“Following the suggestion of the other reviewer, we have checked why we used the 2nd-order polynomial fit. We did so after a simple visual inspection, but it makes little physical sense. There is no atmospheric reason for an increase in extreme torrential events presenting positive WeMOi values. We have therefore calculated the regression line for only the WeMOi negative values, having verified the statistically significant correlation between episodes and the WeMOi. In Figure 7 (d, e, and f) we replaced the quadratic fit with the linear fit, and accordingly, we did the same in the figure caption; the figures are now commented in the text on L497-504. The linear fit is especially significant at a 10-day resolution. There is an evident increase in the occurrence of events with a decrease in WeMOi values”.

9) L268 The mean and standard deviation is computed at an annual scale or at a day level?

“They are computed at a day level. We have included “daily” on L286”.

10) Figure 4. Why this division?

“Because we have already used it in previous studies and the results were sound (Martin-Vide and Lopez-Bustins, 2006; Azorin-Molina and Lopez-Bustins, 2008). These references are included in the bibliography and in the manuscript L301-302”.

11) Regarding section 3.3, why don’t the authors use a moving average instead of artificial 10-day or 15-days intervals?

“In the present paper we used moving averages to perform an inter-annual analysis of the frequency of extreme torrential events (Figure 6). The construction of a calendar involved an intra-annual analysis based on climatological means. In this case, in addition to the simple monthly frequency, we preferred to use the half-monthly and the 10-day frequencies. The relative scarcity and temporal randomness of extreme torrential events at daily resolution reveal many “saw teeth”, which are of no climatic or statistical significance”.

12) L468-470. I don’t think that 4 weather stations are representative of southern France. I would delete everything related with these 4 weather stations from the text, including Figure 9.

“We agree with the reviewer and we have discarded it from the study”.

13) L527-529 I agree with the authors and I think an analysis on this, among physical mechanisms (see comment 1), should be included in the new version of the manuscript.

“We have included new analyses considering the temporal evolution of SST from one specific high-quality station on the coast covering several decades (1973-2017) (please see Tables 2 and 3, and Figures 10, 11 and 12)”.

Therefore, I recommend the major revision of the manuscript

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