We would like to thank Dr. Shaun Harrigan for the constructive and thoughtful comments. We will address all the comments in the revised version. Our responses to the main comments raised by Dr. Shaun Harrigan (*underlined and in italic*) are provided below.

Glad to see Hirschboeck (1988) being cited as shows the field of hydrolclimatology has some history, although it is only relatively recently that the benefit of the hydroclimatic perspective is being fully appreciated – this paper is therefore a welcome addition to the growing literature on hydroclimatology. As general point of interest (not required to include), the first definition of hydroclimatology I found was by Langbein (1967).

We agree and we thank the reviewer for pointing us to by Langbein (1967).

You mention in the abstract (Pg1; L6-9) that a Eulerian-Lagrangian model of ocean-atmosphere circulation would ideally be needed…", "However, some progress may be possible through empirical data analysis.". I agree with you here but this point needs to be raised in the introduction and expanded. What is the benefit of the empirical analysis, what progress can be made, what is the justification of this approach over others/is it complementary to other approaches?

We agree and we will extend the discussion. Also, we would like to highlight that we have provided more information about the value and benefits of our approach in lines 1-8 and 18-34 of page 1.

Along the lines of the above point, you base a lot of the results on the Self-Organizing Maps (SOM) analysis. I have no issue with the use of SOMs, and commend the authors for a rigorous application of the method, however there is little justification of why this method was chosen over others? What particular advantages does SOMs provide in comparison to other more widely used classical methods of classification and clustering (e.g. PCA, K-means clustering, etc.)?

Note that $\mathbf{X}$ (line 25, p. 5 and lines 25-28, p. 7) is a very large matrix (size 5138 x 7068) and, in this case, classical methods of clustering (e.g. K-means, spectral clustering) tend to fail. We have adopted SOMs which has found several applications in climate science (lines 31-34, p. 5) for similar purposes.

Pg4; L21: To avoid confusion for the international audience I would recommend referring to the flood season as the 'wet season' too rather than just 'warm season' throughout the manuscript. Also, is there an approximate % of total floods that occur in Nov-March (i.e., > 60% or > 95%) rather than just stating "most"?

We will be happy to make these changes in the revised version of the manuscript and indicate the % of floods that occur in the wet season.

Pg4; L22-27: Peak-Over-Threshold (or partial duration series) – The extraction of a POT series from daily flow can be challenging, especially for more groundwater influenced catchments with longer memory, hence the need for your independence/declustering criteria. Some literature to support your decision of 15 days could be Mallakpour and Villarini (2015b) or Svensson et al. (2005). On average you have extracted about a POT3 series (i.e. on average ~3 events per year [98 peaks over 34 year record] or POT2.88 to be more precise). However, can you give a range across the 33 basins if there are large deviations from the 98 event average (i.e. I would expect fewer independent peaks to be extracted from more groundwater catchments, and more from flashier headwater catchments) using a fixed threshold as used here.

We thank the reviewer for pointing us to these references and raising this interesting point. The number of events ranges from 76 to 131, with an average of 98. The reviewer is right: headwater basins have more events than downstream basins. In Figure 1 below we show how the number of floods events increases for headwater basins, which are located in the eastern region of the Upper Paraná basin (please see also Fig. 1 of the manuscript) and have smaller drainage areas.

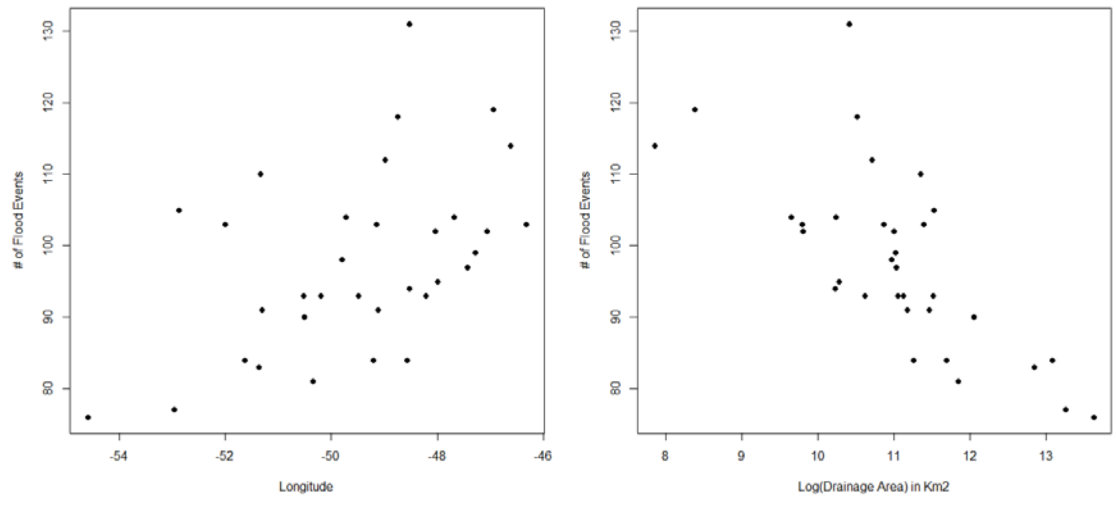

Figure 1 –Number of floods events versus longitude (left panel) and drainage area (right panel).

Pg4; last para: What is the grid resolution of the rainfall dataset?

The grid resolution is $0.25^{o} \times 0.25^{o}$.

Pg5; L9: Is it only climate/SST datasets that are interpolated to 2.5 deg grids, or is rainfall also interpolated? Why is such a coarse resolution used given ERA-Interim is at 0.75 deg resolution?

It is only the climate datasets that are interpolated to 2.5°. We acknowledge that ERA-Interim is also available at 0.75° resolution, but we think that, for the purposes of this work, the coarser resolution of 2.5° provides satisfactory results.

Pg8; L3-13: This is methods description and should be moved to previous methods section, rather in the results section.

We agree with the reviewer and will do this in the revised version of the manuscript.

Pg8; L3-4: I'm not an expert in SOMs so forgive my ignorance, however, your decision to decide on K = 4 clusters appears arbitrary and given it defines everything thereafter (e.g. text from the Abstract: "classify […] UPRB into four categories" and "classify floods into four types".). There needs to be some physical basis/justification to guide this decision.

In lines 3-4 of page 8 we provide a justification: we want a relatively large number of flood events in each cluster. Given the four clusters, we obtain, on average, $98/4 \cong 25$ events in each cluster, which we believe can provide some useful flood statistics. We have also noticed that, as we increase the number of clusters for more than 4, similar spatial patterns of rainfall (Figure 3) start to appear in different clusters.

Pg8; L30-31: By concluding cluster 4 reflects average rainfall conditions during the rainy season, you're essentially implying that the largest basin(s) in UPRB flood under average rainfall conditions (i.e. Figure 9 Neuron 4 panel). An alternative explanation could be that the larger basin reports a flood only when rainfall conditions are generally 'wet'/'moderately wet' for long periods of time (perhaps with wet antecedent conditions much longer than 5 days) and over the entire basin, rather than from more localised rainfall anomalies as is the case in clusters 1-3. This is also reflected in the fact the transition probability of Neuron 4 to Neuron 4 is highest (0.843 in Table 1).

We offer an explanation for this in page 14, lines 10-11 and 13-15. The Itaipu site is the largest basin in UPRB and we believe that floods there are essentially coming from routing flow from upstream sites. Note also that the rainfall pattern of neuron 4 shows rainfall conditions below the average (negative anomalies) across the entire basin.

Understanding rainfall/flood clusters: Are the 5138 days of rainfall data as used to identify the four rainfall clusters (i.e. from Pg7; L27-28) divided evenly (i.e. ~1285 days contributing to each cluster)?

No, in Figure 2 (left panel) we show the number of hits (i.e. days) in each neuron.

Following this, is the composite analysis (Pg9; L8-11) conducted only on the sub-selection of those rainfall days within each cluster that also had a reported flood event across the 33 river basins over the 1980-2013 period? If this is so, how many days within each cluster contribute to the composite analysis?

No, the composite analysis is conducted for the total number of days in each cluster.

I'm getting slightly confused here as you state that all 5138 rainfall days are used as input to SOM (Pg7; L27-28) then mention on Pg14; L20-21 that SOM was employed to find dynamics of "the rainfall field over the basin in the days that preceded the major flood events". Can you clarify this step for me please?

We use the entire 5138 days as input to SOM. We agree that the sentence on page 14, l. 20-21 is confusing and we will rephrase it in the revised version of the manuscript.

Pg10; L20: Need to be more specific when discussing 'El Niño region' (i.e. Niño 3, 3.4, or 4?) or make clear it's the broader area you are talking about – some people get very picky when it comes to ENSO definitions!

We will provide more details of the ENSO region in the revised version.

Pg11; L8: Should neuron 1 feature in sequence of neuron transitions?

Yes, it should be 3 → 1 → 2 → 4 → 3. We will correct in the revised version.

Pg11; L20-21: The point about large floods being generated under non-El Niño conditions is an important one that should be discussed more in the context of the wider international literature (You introduce such papers that do state El Niño-flood links in UPRB on Pg4; L11-13 but don't discuss your results again in this wider context). It is often assumed, wrongly, that majority/all flooding in South America is due to El Niño, this work suggests in UPRB things are more complex and uncertainties exist (also see Emerton et al., (2017)).

We thank the reviewer to point out this reference. In the revised version, we will extend the discussion and provide a broader perspective. In Section Conclusions (p. 14, lines 24-33 and page 15, lines 1-19) we mention the literature and provide more details about the atmospheric and oceans conditions during flood events.

Pg15; L5-6: Could you make a tentative conclusion that about 55% of floods (i.e. 35% in neuron 1 + 20% in neuron 3) are linked to El Niño-like SST patterns? I also acknowledge that El Niño *events have more strict definitions regarding strength and persistence of positive SST anomalies in a fixed region of the Pacific.*

We will gladly add this to the revised version.

16. Following the above point, the SST pattern in neuron 4 (Fig. 8) is similar to La Niña-like conditions with negative SST anomalies, so could the 11% of floods under neuron 4 be linked with this large-scale phenomenon, even tentatively? If further analysis suggests so, then it is interesting to conclude that floods in UPRB can occur under both El Niño and La Niña conditions.

We believe this is an interesting hypothesis that needs further investigation, but is beyond the scope of this paper.

17. Layout of paper: It is my opinion that the Impact of the paper would be greater if the layout was slightly modified – there is currently no distinct discussion section and some methods descriptions are mixed in with the results section (e.g. Pg8; L3-13). Renaming Section 4 to 'Results and Discussion' (or having a dedicated 'Discussion' section) and move some of the discussion from Section 5 (currently 'Summary and Conclusions') to Section 4, and rename Section 5 to 'Conclusions' would be my suggestion.

We thank the reviewer´s suggestion.

18. Comment on Figures: The foundation of this paper (and indeed the SOM method) is on visual display of results on maps. Figures 3-8 relay on the 'rainbow' colour scheme that makes distinguishing patterns difficult – a divergent colour scheme that had a neutral (or while) colour for zero values with diverging colours for positive and negative anomalies would be much more effective. I do note the authors include the zero contour line, but this is still misleading in places. The "end the rainbow" calls are well known and with good scientific basis (Light and Bartlein (2004) and this 2014 post by Ed Hawkins et al. https://www.climate-lab-book.ac.uk/2014/end-of-the-rainbow/). I can only make this a suggestion for improvement but it's ultimately up to the authors/journal as many papers/journals are still using this colour scheme.

We appreciate the reviewer´s suggestion.

19. Further refinement of figure axes and more descriptive captions would be beneficial: For example, what are the units (if any) in Figure 2; adding "t-5, t-4, … t" to the y-axis in Figure 3 would be more visually impactful.

There are no units in Figure 2. We will try to address this issue in the revised version.

20. Figure 15 could be combined within Figure 1.

We believe that it would be hard to convey the message if the figures are combined.

Mostly well written but would benefit from a final proof read to tidy-up grammar – (i.e. abstract and summary and conclusions, in particular, tense in Section 3 should be in past tense).

We will address it in the revised version.

We thank the reviewer for the other minor comments that we will fully address in the revised version of the manuscript.