Classification of North Atlantic and European extratropical cyclones using multiple measures of intensity

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This paper aims to produce cyclones classes which capture various aspects of cyclone intensity better than metrics that use a single diagnostic. Overall, the paper describes the motivation and methods used well. There are however several parts of the paper that require clarification, particularly the clustering method, and more work is required to illustrate how future studies can implement the recommendations made. These points are described below in more detail and should be addressed before the paper is suitable for publication in NHESS.

General comment

1. My main concern is that the 4 clusters identified by the authors are not straightforward to implement by others in future studies. The authors recommend that 5 variables are considered, but how to combine these to identify different classes of cyclone in future studies is not clear. Will subsequent studies need to repeat the Gaussian mixture model with their own tracked cyclone data to identify the 4 clusters? Also, the clusters are identified from the sPCA figure, so that step would also need to be repeated I believe. I would like the authors to provide a more step-by-step guide to how the intensity measures should be combined to 'comprehensively and non-redundantly quantify the intensity of ETCs' (lines 645 and 659). If the cyclone clusters are to be used to see how different kinds of ETCs respond to climate change (line 688) simpler instructions are needed on how to create them. On a related point, on line 692 the authors state that their method 'allows a vast amount of information to be condensed to a level that is manageable for operational forecasters', how would the forecasters use the information? Is it envisaged that they would be provided with the 'intensity' of a cyclone based on a score from each of the clusters, or do the authors have something else in mind?

Specific comments

1. Line 11: What do the authors mean by 'impactful storms'?
2. Line 35: Vorticity is a noisy field typically including both mesoscale and synoptic scale features. Are the authors referring to a filtered vorticity field when they say that vorticity metrics describe the synoptic scale dynamics of ETCs?
3. Line 46 and 54: What is meant by 'concise' metrics? If the aim is to produce a concise metric, this should be defined.
4. Line88: What is T_1639?
5. Line 102: What is the consequence of ignoring the biases in ERA5 data? Are you results sensitive to these biases?
6. Line 125: What are the time steps referred to here?
7. Line 151: '… available as is in the reanalysis.' This sentence does not make sense to me.
8. Line 163 and 177: What is the consequence of a mismatch or even no match between the location of the vorticity maxima and mslp minima? Is the latter a consequence of the fact that vorticity can capture the early stages of cyclone development before a closed isobar is identified in mslp?
9. Line177, 330: Here and elsewhere the authors refer to ERA5 wind gusts. It would be useful to have a brief explanation of this diagnostic quantity and how it is derived? Why is it underestimated in some areas (line 206)?
10. Table 1: What is the difference between accumulated and time-integrated?
11. Line 252: Do the authors use the 'type' of correlation, i.e. linear or non-linear later in the analysis or interpretation of their results? I may have missed this. Does the fact that the MI correlations are higher for SSI than the Pearson correlation imply that they are non-linearly related to the windspeed for example?
12. Line 255: Why is it important to know that the method is 'heavily' used? This does not imply that it is the most appropriate method for this study.
13. Lines 281: What is the silhouette score?
14. Figure 2 caption: The caption should refer to table 1 for details of the intensity measures.

15. Line 365: Why do the SSI measures have no weight? What is the interpretation of this result?
16. Line 395: Here the 4 clusters and their names are introduced. Are the clusters identified from the sPCA figure (fig 5)? Or have I misunderstood the methodology here? Also, since these names are used frequently in the remainder of the paper, I would suggest using bullet points so that they stand out in the text.
17. Figure 5: The words Calm/Windy, Dry/Rainy and Small/Bigg should be referred to in the figure caption.
18. Line 526: It is a bit confusing to use intensity here, since one of the clusters is also called intense.
19. Line 534 and 539: How are the cyclones in the XWS storm catalogue identified. If they use SSI then it is not surprising that a large number of the SSI cluster are contained in the XWS storm catalogue. Similarly, the named storms are those that lead to impact, hence they are biased towards landfalling storms. Can these impact-based metrics be used independently to verify the usefulness of the storm clustering technique?
20. Lines 585-595: This is interesting information, but the authors make no link to the results in these studies to their study, so I'm not sure why this information is included?
21. Line 620-634: As above, it would be helpful if the authors could highlight the novelty of their results and how they build on the work in the previous studies described in this section. How is the cluster analysis a 'new perspective to the classification of ETC life cycles'? Could the authors be clear about what they are adding to the scientific literature?
22. Line 643: Given these limitations, could different criteria be used to identify Mediterranean cyclones?

Typographical errors
1. Line 166: Missing space before the bracket.
2. Line 167: Extra space after 2003.
3. Line 249: 'drawback' should be 'drawbacks'.