

Authors' Response to Reviewer 3

General Comments. This manuscript presents a systematic classification of Extratropical cyclones (ECs) over the Euro-Atlantic region based on two types of intensity metrics: dynamical and impact-based. The authors highlight using of 5 metrics to assess the intensity of ECs and present a classification of 4 clusters consistent with previous studies. I consider the present manuscript well-written, the analysis well-performed, and the topic of interest to the community of NHESS. Therefore, the manuscript may be published. Minor issues have been found that need to be addressed before the manuscript can be published. My detailed comments are found below.

Response: We would like to thank you for the feedback and the valuable comments which helped improve the quality of our manuscript. We have carefully addressed all the issues item by item as follows.

Specific comments:

Comment 1

I found it novel that this study considers both the dynamics and impacts of cyclones. However, weak cyclones are located in the Mediterranean area where we have seen several EC damages in recent years. You have mentioned that Medicane Apollo is one of the weak cyclones (line 553).

How would you suggest using your framework in operational forecasting to determine tropical cyclone impacts? (as suggested in lines 690-692) Is it necessary to look at all 5 metrics? If so, what role do the 4 clusters play?

Response:

As to why medicane Apollo is classified as “Weak”, we believe in the following explanation. The region of interest encompassed the eastern coast of North America and the open ocean, two areas with larger storm-associated precipitation than in Europe (Hawcroft et al., 2012). As a result, the average precipitation (as depicted in section 4.2) is relatively high for Europe. This also explains why most of the XWS storms fall in the center of PC2 (see Figure 11). This explanation has been added to the discussion. As the cluster analysis is also dependent on the wind-based intensity measures, the above-average precipitation is not enough to classify Apollo to one of the on average more intense clusters. This has also been discussed in Specific Comments 5, 6, and 7 of Reviewer 1. These issues have also been addressed in the discussion of the revised manuscript.

To answer the second part of the comment: We assume the reviewer is asking about extratropical cyclone impacts rather than tropical cyclone impacts given the topic of our study. As discussed also in the second part of General Comment 1 of Reviewer 2, we state that our framework could be used in operational forecasting to assess the uncertainty of possible storm impacts. Although we reduce the set of intensity measures to five measures, this is a lot of information to investigate when one uses an ensemble prediction system with possibly tens of ensemble members. We suggest that the information could be condensed to a manageable level by first determining the cluster of a storm in each ensemble member by using the trained GMM instance and then seeing how much disagreement there is in the ensemble. This would offer information on both the intensity and possible impacts of a storm as well as how uncertain this estimate is. This of course requires additional information such as predictions of storm locations and is dependent on the selection of points of interest. We propose that in this framework it is necessary to look at all five metrics. However, by using the trained GMM instance, these five metrics can be condensed into a single number, a cluster label. With enough statistical power, i.e. in this case ensemble members, it is possible to assess the reliability of this label.

Technical corrections:

Comment 1

I found the abbreviation for 850 hPa relative vorticity (“VO”) confusing. Why is not “RV850” used?

Response:

The abbreviation “VO” is used for relative vorticity in the data documentation of ERA5. Since vorticity is investigated only at a single level, the need for the specifying “850” was not considered necessary.

Comment 2

For the case study, it might help to have a map with the cyclone tracks.

Response:

A figure (Figure S7) which shows the tracks of the case study storms has been added to the supplement .

Comment 3

The caption of Figure 2 needs more details.

Response:

References to the section explaining the intensity measures and Table 1, which summarizes the measures, have been added to the figure caption.

Comment 4

Line 16: What do you mean by “sensible weather”?

Response:

By sensible weather we mean the weather that humans can sense, i.e., winds and rain. To avoid unnecessary confusion, the word “sensible” has been removed from the sentence.

Comment 5

Line 18: “Buildings” are also “infrastructure.”

Response:

The word “buildings” has been removed from the sentence.