Classifying compound coastal storm and heavy rainfall events in the north-western Spanish Mediterranean" by Marc Sanuy et al.

Anonymous Referee #1

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We thank the reviewer for the detailed review and constructive comments on the manuscript. We have performed a thorough revision to address all the comments, as detailed below.

The paper describes an interesting study on the probability of occurrence of extreme combined events (floods and sea storms). The study clearly shows which are the types of synoptic patterns that generate the different types of event and identifies the areas where it is most likely in the occurrence of compound events (multivariate). I think the paper can be published with a few minor revisions. In particular I find some basic assumptions for the study not sufficiently justified, although I guess the valid justification is there. Specifically,

1) I would suggest explaining why it was assumed, to define an event as "compound" the time window of three days.

[R1.1] The use of a three-days window to define compound events was selected for consistency with the definition of coastal storms in the study area. This is the time span used between consecutive storms to consider them statistically independent and generated by different meteorological conditions (e.g. Mendoza et al. 2011; Sanuy et al. 2020). When the time lag between consecutive storms is shorter than this value they are considered to be a multiple-peak event, which are not infrequent in the area and play an important role in controlling storm-induced coastal risk (see e.g. Sanuy and Jiménez 2021). Thus, heavy rainfall and wave storms occurring within this time window are considered to be part of the same event. Moreover, this time window is short enough to be useful for analysing spatially-compound events (SC), when civil protection services may be overwhelmed by responding to cumulative impacts at spatially distant locations in the territory within such a short time interval. This explanation will be included in the discussion section, with a mention on the possible use of a different time window in other areas when local (natural or managerial) conditions recommend it.

Mendoza, E.T., Jiménez, J.A., and Mateo, J.: A coastal storms intensity scale for the Catalan sea (NW Mediterranean), Nat. Hazards Earth Syst. Sci., 11, 2453-2462, doi: 10.5194/nhess-11-2453-2011, 2011.
Sanuy M, Jiménez JA, Ortego MI, Toimil A., 2020. Differences in assigning probabilities to coastal inundation hazard estimators: Event versus response approaches. J Flood Risk Management, e12557. https://doi.org/10.1111/jfr3.12557
Sanuy, M., Jiménez, JA. 2021. Probabilistic characterisation of coastal storm-induced risks using Bayesian Networks. Natural Hazards & Earth System Sciences, 21, 219–238, doi: 10.5194/nhess-21-219-2021

2) Another assumption that should be more fully justified is why MSLP and geopotential at 1000 hpa were chosen to characterize the weather patterns.

[R1.2] The most usual analysis used for synoptic classifications is Sea Level Pressure (see for instance the special issue of the International Journal of Climatology on circulation types, Einar and Huth, 2016). In some cases, the 500hPa level is added in order to represent the configuration in the middle-high troposphere. Classic synoptic classifications such as Jenkinson and Collison (1977) were made from surface pressure maps since these could be constructed manually. However, today it is usual to analyze the synoptic configuration closest to the surface from the level of 1000 hPa since it represents well the behavior of the atmosphere at low levels. Surface pressure maps are used essentially for the location of fronts.

Jenkinson AF, Collison FP. 1977. An initial climatology of gales over the North Sea. Technical Report, Synoptic climatology Branch Memorandum No. 62, Meteorological Office, Bracknell, UK
Einar, O., and R. Huth, 2016. Circulation-type classifications in Europe: results of the COST 733 Action. Int. J. Climatol. 36: 2671–2672 (2016). DOI: 10.1002/joc.4768 8 pp.

I also think that the final discussion can be extended, introducing hints on how the two types of events identified (spatially compound and multivariate) influence the overall damage and also any risk management problems. For example, there is some evidence that floods and sea storms interact with each other during a multivariate event, aggravating the hazard scenario of one of the two (e.g. contemporary sea storm in the same area does increase the intensity of the flood hazard scenario?)

[R1.3] This relates to [R2.1]. The Discussion section will undergo a thorough review. All text related to the description of specific episodes will be moved to a new subsection under Results. Additionally, the Discussion section will also address reviewers' comments and suggestions. With regards to the reviewer's specific comment, the two types of analysed compound events are compared in terms of their induced damages across the territory and how they can condition risk management operations. This will be done by comparing the observed consequences of the impact of selected events (as those reported in the paper -whose description will be moved to the Results section-). The reported Gloria January-2020 will be used to illustrate the aggravation of inundation in low-lying coastal areas surrounding river mouths due to co-occurring high precipitation and storm waves. Thus, for instance, previous analysis of the impact of (univariate) extreme coastal storms in the Tordera river mouth area predicted significant flooding and erosion driven damages. However, these damages are limited to a relative narrow fringe along the coastline. The co-occurring high river discharges during the event in combination of increased water levels and waves at the river mouth resulted in a significant riverine inundation of the floodplain, together a large coastal reshaping. As a result of this, the extension of the inundation in the floodplain was significantly larger than the associated with the "univariate" storms. Alternatively, the consequences of spatially-compounding events will be illustrated with the co-occurring demand of civil protection services to manage storm-induced risks in different (and remote) parts of the territory, e.g. high precipitation and river discharges (evacuation in flood-prone areas) and extreme waves (damages in coastal infrastructures).