

## Reply to reviewer comments on Egusphere-2025-1009 (Samuele Segoni)

Dear Authors,

I was at EGU2025 and I had the opportunity of reading a poster based on this publication. I also got the chance to have an interesting discussion with the first author. Since I liked the work described in the poster very much, I was also very curious to check the submitted manuscript.

For what my opinion is worth (I'm not an official reviewer), I highly recommend the publication of this work, as I found it very interesting, based on a sound methodology, and original.

I just put forward a couple of comments that you are free to address or discard.

Thank you very much for your kind comments. It was a pleasure discussing our work with the reviewer at the EGU2025, and we are truly grateful for his encouraging feedback on the manuscript. We are especially grateful for his positive remarks regarding the originality and soundness of our methodology. We will carefully take his suggestions into account as we revise the manuscript. Below, we provide detailed responses to the comments he kindly shared.

**(CC1-00):** “I don't know how frequent similar events in Catalonia are, but one thing that maybe could be stated more clearly is that it is safe to assume that this disaster didn't come on top of another precedent disaster from which the study area hadn't fully recovered yet. This is to avoid complex compound effects among repeated shocks that stack each other in a non-linear way, complicating any mathematics beyond the analysis.”

**(Reply to CC1-00):** Thank you for the comment, we completely agree. In fact, there was a storm in December 2019, just a few weeks before Storm Gloria. While it was significant, it was not nearly as exceptional in terms of intensity, duration, or spatial extent compared to Gloria.

Regarding the potential for compounding effects, we fully acknowledge that the temporal proximity of the two events may have amplified the impacts. The reviewer correctly emphasizes that compound effects over time are one of the reasons why it is difficult to establish a linear relationship between hazard levels and resulting damages. In our study, these interactions were neglected. Nevertheless, during data collection and classification, we made a conscious effort to ensure that all reported damages and associated costs could be attributed solely and exclusively to Storm Gloria. However, we cannot be certain whether some of the damaged elements may have already been partially compromised or deteriorated prior to the storm.

Another important point is that, throughout the data compilation process, we found strong evidence that impact attribution tends to be assigned to individual hazards rather than to multi-hazard scenarios. Reporting on multi-hazard risk management is not a straightforward task, and at present, disaster risk management in Catalonia is not sufficiently detailed to assess the systemic effects of multi-hazard scenarios. We hope that this research will help drive change and promote greater attention to multi-hazard approaches in future disaster risk management strategies.

In response to the reviewer's comment, we will enrich the discussion in the revised manuscript by including the following sentences in the Section of “Discussion and conclusions”:

- “The temporal variation of exposure and vulnerability is another key factor that influences this correlation; however, it could not be considered in detail in this study.”
- “However, uncertainties and challenges arose in linking losses to return periods, particularly due to limitations in hazard assessment calculations and the temporal and spatial variability of exposure and vulnerability.”
- “Reporting on multi-hazard risk management is not a straightforward task.”
- “There is strong evidence indicating that impact attribution is more often assigned to single hazards rather than to multiple hazards.”
- “This work aims to support a shift toward more integrated disaster risk management by encouraging greater consideration of multi-hazard approaches in future strategies.”

**(CC1-01):** “While reading the paper I was very curious of finding some explanations or speculations about the spatial pattern of damages: why did some areas receive more direct damage than others? This issue is partially addressed in the manuscript, and I think you correctly pointed out that the impacts of some hazard are widespread, while others are clustered around the spots where the most severe phenomena occurred. Here I would suggest a rapid search for possible correlations with soil sealing (or soil consumption or imperviousness). Indeed, in recent research of my group (DOI 10.1088/1748-9326/ad5fa1), we discovered that such impacts do not occur at random places, are not driven only by the severity of the driving hazardous process (e.g. rainfall or discharge return time), but depend (a lot!) on how much each municipality built buildings and infrastructure, and, more importantly, where the urbanization occurred (specifically, to what extent high hazard and medium hazard areas were spared or aggressed by urbanization). I see that this is partially beyond the scopes of the work, but I think it is relevant for discussion and conclusion, as it could be useful information to better address future intervention by both the public and private sectors.”

**(Reply to CC1-00):** We thank the reviewer for this insightful comment. We fully agree that the severity of impacts is strongly influenced by the degree of urbanization of a municipality. As the reviewer rightly noted, soil sealing is a critical factor that can amplify the effects of extreme weather events. Although soil sealing analysis was beyond the main scope of this study, our findings indicate that more sealed areas often correspond to larger urban centers, which typically have greater administrative capacity to apply for public recovery funds. In contrast, smaller municipalities may lack skilled personnel to manage the complex and time-consuming application processes typically required for such funding. We agree that these aspects deserve further attention, and we will integrate this important perspective into the discussion and conclusions of the revised manuscript.

We will add the following sentence: “Geographically, damage appears concentrated in major cities, likely due not only to greater exposure and vulnerability (Gatto et al., 2024) but also to their stronger administrative capacity to apply for and manage public recovery funds.”

### **References:**

Gatto, A., Martellozzo, F., Ciulla, L., and Segoni, S.: The downward spiral entangling soil sealing and hydrogeological disasters, *Environ. Res. Lett.*, 19, 084023, <https://doi.org/10.1088/1748-9326/ad5fa1>, 2024.