RC1: 'Comment on egusphere-2025-4940', Nicola Nocentini, 01 Dec 2025 reply

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We thank the reviewer Nicola Nocentini (RC1) for the very positive assessment of our work. We are pleased that the manuscript is considered close to being publishable, and we appreciate the recognition of the modelling framework. The manuscript will undergo further revisions in response to comments raised by the second reviewer (RC2), which we believe will further strengthen the contribution.

Comment regarding the interpretation of the temperature-related predictors:

We agree that the reviewer raises an important point, and we acknowledge that interpreting modelled relationships, especially for variables that may act as proxies for multiple physical controls, requires particular care.

Indeed, also in our study area, temperature is correlated with elevation, and it is plausible that the temperature predictor may partly capture elevation-dependent spatial patterns. However, we note that in our case the modelling is performed at the basin scale, not at the pixel scale. Individual basins often span a large elevation range, from valley bottoms to crests, implying substantial internal variability. As a result, basin-aggregated temperature values (e.g., one mean temp. value per basin) may often not resolve contrasts between high-alpine areas and lower areas. We point out that lower-elevation areas are much better represented within our study, simply because our analysis explicitly focuses on damage-causing events. High-alpine mass movement processes are therefore not well represented in the impact database, nor captured by our variables. This supports the notion that the measured temperature effect is only partially attributable to elevation-dependent spatial effects. Furthermore, the underlying CERRA data is rather coarse in spatial resolution (5.5 km), which may further limit its ability to capture elevation-dependent temperature effects, as narrow alpine valleys may incorporate a wide range of elevations within one CERRA pixel.

A further and likely more important aspect is that the temperature predictor in our framework is spatio-temporal, meaning that it varies not only across space but also across time (i.e., each basin receives a value for each sampling day). Consequently, temporal variability in temperature may contribute substantially to the model response. Seasonal variations are already explicitly captured through the day-of-year (DOY) predictor, highlighting that temperature is intended to account for a different effect, as noted in **LINE 459:** ***"****Seasonal variation, modelled using a circular DOY effect, indicated that periods with reduced vegetation effects (i.e., winter, early spring) were associated with higher impact probabilities (Fig. 6g), noting that temperature and precipitation effects are accounted for by other variables in the model."*

In summary, this led us to interpret the "remaining" temperature effect as likely reflecting short-term meteorological influences. For example, on a summer day (DOY ~180) with heavy rainfall, convective activity is more likely than on a winter day with similar daily rainfall amount. This interpretation aligns with the literature indicating that high temperatures are associated with an increased potential for convective activity (see cited literature Giorgi et al., 2016). Given this, interpretation should still be provided with caution, acknowledging that confounding between predictors (e.g., temperature, elevation, and DOY) may influence modelled relationships. In the revised manuscript, we will therefore be more careful in our formulations to explicitly address this point and refine the interpretation. For instance:

LINE 588: *"In this context, daily precipitation and temperature variables represented …"* will be revised to: *"In this context, daily precipitation and temperature variables were assumed to represent …"*

In the Methods section, we will now include further information on our intention to use temperature by revising **LINE 317** from: *"Daily mean temperatures and two binary indicators were used to represent* *potential temperature effects."* to *"Daily mean temperatures and two binary indicators were used to mainly represent potential temporal temperature effects, while we emphasize that spatial temperature effects (i.e., differences between high elevations and valley bottoms) were likely to be only partially captured due to the basin-based landscape representation and the coarse resolution of the underlying CERRA data."*

Additional text in the Discussion section will now further clarify why data-driven model interpretation is challenging, highlighting potential confounding between predictors. We will add to **LINE 591**: *"However, it should be noted that the interpretation of individual predictor effects remains challenging, as confounding between variables (e.g., temperature, elevation, and DOY), along with specific biases in landslide inventories, can strongly influence the measured effects and limit a straightforward physical attribution, as discussed in Steger et al. (2021)."*

Steger, S., Mair, V., Kofler, C., Pittore, M., Zebisch, M., and Schneiderbauer, S.: Correlation does not imply geomorphic causation in data-driven landslide susceptibility modelling – Benefits of exploring landslide data collection effects, Science of The Total Environment, 776, 145935, https://doi.org/10.1016/j.scitotenv.2021.145935, 2021

Finally, we will now emphasize in the Discussion that incorporating specific weather types may reduce the models' reliance on temperature by adding the following to LINE 597:

"Incorporating information on specific precipitation and weather types to explicitly distinguish convective events from other weather dynamics could further improve the representation of rainfall-triggering conditions, making the models less reliant on proxies, such as dynamic temperature effects."