

## Color scheme

- Reviewer comments (RC): blue
- Answers to reviewer (i.e. author comments: AC): black

RC: “General comments”

The submitted paper presents an innovative approach to combine the effects of precipitation on shallow landslides at four temporal scales: triggering precipitation relevant at the short-term, preparatory precipitation acting at the medium-term, cyclic seasonal conditions and across-year variability (the latter being relevant to account for biases in reporting landslide data). The analysis is based on using the generalized additive mixed models (GAMMs) to account for the interactions among the precipitation variables and successfully separate between precipitation conditions leading to failures and those not inducing landslide movements. The produced outputs are landslide occurrence probabilities associated to the interplay between short-term triggering precipitation and antecedent preparatory precipitation in dependence on the seasonal period of the year. The seasonal effect is interpreted as being mostly due to temporal changes in vegetation and secondarily to temperature and snowmelt. The manuscript is well structured and written and illustrations and tables are all necessary. In my opinion, the paper is worth publishing with only some very minor/technical revisions.

AC: We thank Marta-Cristina Jurchescu very much for the thorough review of our manuscript. We are delighted that the work was judged to be “*worth publishing with only some very minor/technical revisions*”.

RC: “Specific comments”

A major strength and innovation of the study consists in the explicit consideration, the emphasis put on and the modeling of the seasonal imprints on the combined action of preparatory precipitation and short-term triggering precipitation in inducing slope failures at a daily scale. The research is based on a data-driven modeling, applied following a thorough design of the study approach, and rendered highly transparently. The robust development of the method, e.g. by eliminating the effects of year and locations, the careful and original design for sampling temporal landslide presence and absence observations at the mere landslide locations, and the data filtering criteria are well acknowledged.

The practical applicability of findings derives from the communication of predicted probability values also in terms of model performance metrics, such as True Positive Rates (TPR) or True Negative Rates (TNR), as well as from the welcome modes for visualizing (e.g. 2D and 3D plots, animations) the resulted thresholds varying throughout the year. The value of the research also consists in the spatial and temporal cross-validation of the results, which ensure a high robustness and adaptability of the model to other regions and temporal periods. The paper is also to be appreciated for the R-scripts and codes made available as well as the open data.

AC: Thank you! We appreciate the positive feedback on our manuscript and are delighted to learn that the content of the paper, including technical details, has been well received by you.

RC: "Technical suggestions"

- Section 3.1, page 6, line 160: if I understand correctly that the South Tyrolean data is part of the IFFI database, then I would suggest replacing "version" with "subset";

AC: Yes, this is correct. We will replace "version" with "subset".

RC: - Section 3.1, page 7, line 165: please delete the plural "s" from the word "landslides", since it should be the singular form;

AC: This will be corrected.

RC: - Section 3.1, page 7, lines 168-169: it is not clear what do you mean with "(incl. pre-2000 events)" in: " From January 2000 to the end of 2020, a total of 11420 points related to different movement types (incl. pre-2000 events) were registered for South Tyrol";

AC: Thank you for highlighting this issue. In the revised version, we will replace this sentence by "*For South Tyrol, the unfiltered IFFI data contains a total of 11420 points related to different movement types.*". The final sentence of this paragraph then points to the data filtering "*Prior to the analysis, both the IFFI and the IRPI landslide records were subjected to a comprehensive data filtering process as described in Section 4.1.*"

In Section 4.1 we will then highlight details related to the temporal data filtering: "*...were then filtered according to an additional temporal criterion: only entries with reliable information on the day of occurrence, and from January 2000 to the end of 2020 were selected, resulting in a sample of 676 landslide records.*"

RC: - Section 3.2, page 7, line 188: please replace "times" by "with": "multiplying the gridded daily anomalies with the gridded....";

AC: We will replace these terms as suggested.

RC: - Section 3.3, page 8, lines 206-207: please adjust for the repeating word "based" and insert commas e.g.: "For the cross-validation (CV), based on a leave-one-factor-out data partitioning (Section 4.5), was based on several spatial environmental variables were used (Fig. 2).";

AC: We will replace the sentence with "*Cross-validation (CV) based on a leave-one-factor-out data partitioning (Section 4.5) focused on several spatial environmental variables (Fig. 2).*"

RC: - Section 3.3, page 8, line 207: I would suggest replacing "this data" with "the data": "The data was obtained from the open Geodata platform of South Tyrol (Geokatalog, 2021).";

AC: We will replace "this data" with "the data" as suggested.

RC: - Section 3.3, page 9, caption of Fig. 2: I would propose not using abbreviations in general in figure captions, thus I would propose replacing “CV” with “cross-validation”;

AC: We will modify the figure caption accordingly.

RC: - Section 4.3, page 12, line 313: please replace “This study used a GAMM to discriminate precipitation...” with “In this study, a GAMM was used to discriminate precipitation..”

AC: We will replace the sentence as suggested.

RC: - Section 4.3, page 13, lines 343-344: please replace “between” with “among” in: “In detail, this YEAR variable systematically captures data variability among the single years”;

AC: We will rephrase this sentence by using the expression “*inter-annual*” as follows: “*In detail, this YEAR variable systematically captures inter-annual data variability (...)*”.

RC: - Section 4.3, page 14, caption of Table 1: I would suggest adding in the caption information on the software used, e.g.: “Model setup and variables introduced into the binomial GAMM by means of/through the R software”; also, in the last row of the table, it would be clearer to specify “the following R command”;

AC: We will modify the caption as follows “*Model setup and variables introduced into the binomial GAMM through the R software (package mgcv).*”

The last row of the table will be rephrased as suggested: “*The model was fitted using the following R command*”

RC: - Section 5.1, page 16: lines 413-424 present the resulted number of records in the landslide samples as well as the impact of filtering out “dry” observations; however, for a better understanding and avoidance of repetitions, referring to the corresponding methodological sections, also depicting the numbers of records issued after the various filtering phases, would be of help;

AC: Within the revised paper, we will start Section 5.1 with a description of the respective numbers as follows: “*The initial 11420 IFFI points were reduced to 2714 entries by first filtering translational and rotational slide-types and by excluding deep-seated movements. Most of these entries (n = 2319) were selected according to the subsequent material type filter, i.e. only “earth” or “debris” slides were considered. Further data subsampling according to the assigned movement cause “precipitation-induced” led to a subsample consisting of 1822 landslides. Out of these 1822 entries, 676 landslides were associated with reliable day information while occurring between January 2000 and the end of 2020.*”

RC: - Section 5.1, page 18, caption of Fig. 5: since illustrations have to be self-explanatory, please explain the abbreviation “IQR” used in the figure legend; I would also recommend not using the abbreviation CV in the caption but rather the full word;

AC: We will replace “CV” with “cross-validation” and add “*Variability of AUROCs is shown by the interquartile range (IQR).*”

RC: - Section 5.4, page 24, caption of Fig. 10: similarly, I would recommend not using the abbreviation CV in the caption but rather the full word;

AC: We will replace “CV” with “cross-validation”.

RC: - Section 5.4, page 24, lines 555-556: please consider rephrasing as follows, using the plural: “..., meaning that, for the majority of the test locations, the predicted probability scores for the respective landslide observations were higher than the predicted probabilities for any pre-landslide absence observations.”

AC: Thank you for this suggestion. We will rephrase this sentence accordingly.

RC: - Section 5.4, page 24 line 558: please remove the word “a” from “suggests a slightly lower model performances” since you mean a plural term;

AC: We will correct this.

RC: - Section 5.4, page 24 line 559: please insert “the” in two locations as follows: “The influence of the test sample size on the variation in estimated...”

AC: We will correct this as suggested.

RC: - Section 5.4, page 25, caption of Fig. 11: same observation, but “CV” may be put into brackets after the first use of the entire word to explain the abbreviation used further in the caption as well as on the figures themselves;

AC: We will modify this according to the suggestions.

RC: - Section 5.4, page 25, caption of Fig. 11, line 565: please continue with lowercase letters after “In a”);

AC: We will correct this as suggested.

RC: - Section 5.4, page 26, caption of Fig. 12: similar observation as for the latter figure captions, regarding the use of the abbreviation “CV”;

AC: We will replace “CV” with “cross-validation”.

RC: - Section 5.4, page 27, caption of Fig. 12, line 588: I would suggest reversing the sentence into: “A map of the environmental units is shown in Fig. 3”, since this puts the emphasis on the map to ease understanding;

AC: We will adapt the caption as suggested.

RC: - Section 5.4, page 27, lines 596-597: please consider reversing the phrase as follows and adding “respectively” in the end: “The AUROC equalled 0.85 for the 7 shallow landslide locations and 0.9 for the 12 precipitation-induced flow-type landslides, respectively.”;

AC: Thank you. We will reverse the phrase accordingly.

RC: - Page 31, line 740: please change the number of this section title to “7 Conclusions”

AC: Thank you for highlighting this error. We will correct it accordingly.

RC: - I would suggest being consistent throughout the paper when writing the name of the model (“generalized additive mixed models”), i.e. with either upper- or lowercase letters.

AC: We will check the entire paper and use the lowercase letters throughout the manuscript.