Dear reviewers

We appreciate the detailed analysis of our manuscript. All the comments were reviewed and corrected. We consider that this review improved the quality of our scientific contribution. The research team behind the manuscript appreciate your invaluable contribution to increasing the development of landslide mitigations tools in the Southern Andes. We are sure that this contribution will support to move to operative RILEWS in the south of Chile.

Sincerely,

Ivo Fustos and co-authors

R1

The paper is suitable for NHESS. Unfortunately is not acceptable in present form. There are the following main deficiencies:

- In the abstract authors should resume what they did instead of writing a sequence of sentences in which the reader gets lost. If the writer is right, they should write that starting from a forecasting (WRF) corrected using data of 12 meteorological stations 4 distributions combining…………were used.

A: Our apologies. Now, we modified the abstract putting in relevance the main findings of our contribution.

Original Abstract:

Abstract. Rainfall-Induced Landslide Early Warning Systems (RILEWS) are critical tools for reducing and mitigating economic and social damages related to landslides. Despite this critical need, the Southern Andes does not yet possess an operational-scale system to support decision-makers. We propose RILEWS using a logistic regression system in the Southern Andes. The models were forced by corrected simulations of precipitation and geomorphological features. We evaluated the precipitation using the Weather and Research Forecast (WRF) model on an hourly scale. The precipitation was corrected using bias correction approaches with daily data from 12 meteorological stations. Four logistic and probabilistic models were then calibrated using Logit and Probit distributions. The predictor variables used were combinations of the slope, corrected daily precipitation and data preceding the events (7 and 30 days previous) for 57 Rainfall-Induced Landslides (RIL); validation was by ROC analysis. Our results showed that WRF does not represent the spatial variability of the precipitation. This situation was resolved by bias correcting. Specifically, the PP_M4a method with Bernoulli distribution for the occurrence and Gamma for the intensity produced lower MAE and RMSE values and higher correlation values. Finally, our RILEWS had a high predicting capacity with an AUC of 0.80 using daily precipitation data and slope. We conclude that our methodology is suitable at an operational level in the Southern

Andes. Our contribution could become a useful tool in the mitigation of impacts related to climate change.

Modified abstract

Abstract. Rainfall-Induced Landslide Early Warning Systems (RILEWS) are critical tools for reducing and mitigating economic and social damages related to landslides. Despite this utility, the Southern Andes do not have an operational-scale RILEWS yet. In this contribution, we present a pre-operational RILEWS using the Weather and Research Forecast (WRF) model and geomorphological features coupled to logistic models in the Southern Andes. The models have been forced using simulations of precipitation. We correct the precipitation derived from WRF using 12 weather stations through a bias correction approach. The models were trained using 57 well-characterized Rainfall-Induced Landslides (RIL) and validated by ROC analysis. We show that WRF does not represent the spatial variability of the precipitation. Therefore, accurate precipitation needs a bias correction in the study zone. Accurate precipitation simulations allow RILEWS with high predicting capacity (area under the curve, AUC of 0.80) using daily precipitation data and slope. We conclude that our proposal is suitable at an operational level. The proposed RILEWS will become a support in the mitigation of RIL events related to climate change.

- The abstract and the introduction seems two separate topics. In the abstract a forecasting model and 4 four logistic models were used combining precipitation and slope, while in the introduction a mesoscale logistic model is used. At lines 86-92 it is written that a mesoscale model provides precipitation data that are corrected with the data of the stations and combined in a logistic model with geomorphological features.

A: Our apologies. Now, correct line 53 from "the implementation of a mesoscale logistic model" to "the implementation of a logistic model". Moreover, we rewrite the introduction to be a more comprehensive introduction.

Original introduction manuscript:

Rainfall-Induced Landslides (RIL) are one of the most frequent and dangerous natural hazards. They can affect critical infrastructure and highways in populated areas (Chikalamo et al., 2020; Fustos et al., 2020a; Peruccacci et al., 2017). In recent decades, the occurrence of RIL events has increased with devastating effects, including loss of human life and destruction of the natural and urban environment (Marjanović et al., 2018). In South America, RIL has caused high social and economic impacts; they require better evaluation in future (Sepulveda & Petley, 2015). Nowadays, Rainfall Induced Landslide Early Warning Systems (RILEWS) become a powerful alternative for mitigating human losses and reduced infrastructure damages (Guzzetti et al., 2020; Chikalamo et al., 2020; Hermle et al., 2021). The present work evaluates the design of a RILEWS using a mesoscale atmospheric model coupled to a logistic discriminator in the Southern Andes.
Due new rainfall scenarios related to climate change, RILEWS have become increasingly used in recent years, reducing the vulnerability of populations using different approaches (Peres & Cancelliere, 2014; Segoni et al., 2018; Fan et al., 2019; Tiranti et al., 2019; Thirugnanam et al., 2020; Lee et al., 2021). RILEWS based on

intensity/duration curves that do not consider the effect of soil moisture, leading to bias in their predictive capacity (Marra et al., 2017; Zhao et al., 2019; Chikalamo et al., 2020). Some RILEWS use historical precipitation data with long-term observations, climate reanalysis models and atmospheric mesoscale models (Lazzari & Piccarreta, 2018; Tichavský et al., 2019). Moreover, atmospheric mesoscale models have shown a high uncertainty in areas with scarce meteorological stations and complex topography. Recently, the integration of mesoscale atmospheric models with local weather stations allowed areas susceptible to RIL to be defined by determinist numerical models (Fustos et al., 2020a). Therefore, a correct implementation of mesoscale models could allow the implementation of this source of information in RILEWS.

In recent years, mesoscale models showed incapable of representing precipitation fields suitable for RILEWS in areas with complex topography like the Southern Andes (Yáñez-Morroni et al., 2018). Currently, mesoscale models are restricted to the quality of their atmospheric forcings, needing to generate ensembles to obtain approximate solutions (Wayand et al., 2013). Moreover, the mesoscale models demand intensive computing efforts increasing the difficultness coupling to RILEWS (Yáñez-Morroni et al., 2018; Schumacher et al., 2020; Yang et al., 2021). Nowadays, bias correction approaches contribute to reducing the time computing of mesoscale models, improving the estimation of precipitation using in-situ stations (Srivastava et al., 2015; Bannister et al., 2019; Heredia et al., 2018; Jeong & Lee, 2018; Osman et al., 2019; Worku et al., 2020). Nonetheless, the application of corrected mesoscale models in RILEWS in complex topography has not been evaluated.

The object of the present work was to evaluate the implementation of a mesoscale logistic model forced by geomorphological and precipitation constraints. We corrected mesoscale models using weather stations, generating RIL-prone probability zones for the first time in the Southern Andes. The paper is structured as follows: after the introduction, the second section describes the study site and its pertinence to implement RILEWS. In the third section, we describe the data and methods, including the calibration and validation procedures. In the fourth section, we outline the main results of the proposed RILEWS, focusing on the quality of predictors and model outputs. The fifth and final section comprises the discussion and conclusions, presenting the implications of this proposal and their general applicability to the southern Andes.

Modified manuscript:

Rainfall Induced Landslide Early Warning Systems (RILEWS) become a powerful alternative for mitigating human losses and reducing infrastructure damages (Guzzetti et al., 2020; Chikalamo et al., 2020; Hermle et al., 2021). The increase of Rainfall-Induced Landslides (RIL) events showed devastating effects, including loss of human life and destruction of the natural and urban environment (Marjanovi? et al., 2018). Recent RIL affected critical infrastructure and highways in populated areas (Chikalamo et al., 2020; Fustos et al., 2020a; Peruccacci et al., 2017; Fustos et al., 2021). In South America, RIL has caused high social and economic impacts; they require better evaluation in future (Sepulveda & Petley, 2015). The present work evaluates the design of a RILEWS using a mesoscale atmospheric model coupled to a logistic model to mitigate the effect of RIL in the Southern Andes.

Due to new extreme rainfall events related to climate change, RIL events are increasing in the Southern Andes and other parts of the world. To mitigate the impact of extreme precipitation RILEWS have gained interest to mitigate the impact of RIL using different approaches (Peres & Cancelliere, 2014; Tiranti et al., 2014; Sättele et al., 2015; Segoni et al., 2018; Cremonini and Tiranti, 2018; Fan et al., 2019; Tiranti et al., 2019; Thirugnanam et al., 2020; Bernard and Gregoretti, 2021; Lee et al., 2021). RILEWS based on precipitation thresholds shows good agreement but do not consider the effect of soil moisture, leading to bias in their predictive capacity (Marra et al., 2017; Zhao et al., 2019; Chikalamo et al., 2020). Some historical-based RILEWS with long-term observations, climate reanalysis models and atmospheric mesoscale models experiment issues related to the spatial and temporal resolution reducing the performance due to low precipitation accuracy (Lazzari & Piccarreta, 2018; Tichavský et al., 2019).

RILEWS requires accurate precipitation data delivered from local weather stations in dense weather networks, satellite estimations and atmospheric mesoscale models. However, atmospheric mesoscale models showed incapable of representing accurate precipitation fields in areas with complex topography like the Southern Andes (Yáñez-Morroni et al., 2018). Currently, mesoscale models are restricted to the quality of their atmospheric forcings, needing to generate ensembles to obtain approximate solutions (Wayand et al., 2013). Moreover, the mesoscale models demand intensive computational efforts that increase the difficulty of coupling to RILEWS (Yáñez-Morroni et al., 2018; Schumacher et al., 2020; Yang et al., 2021). Recently, mesoscale atmospheric models coupled to local weather stations allow delimitating susceptible to RIL areas means deterministic numerical models (Fustos et al., 2020a). Nowadays, bias correction approaches contribute to reducing the time computing of mesoscale models, improving the estimation of precipitation using in-situ stations (Srivastava et al., 2015; Bannister et al., 2019; Heredia et al., 2018; Jeong & Lee, 2018; Osman et al., 2019; Worku et al., 2020). Therefore, a correct implementation of mesoscale models could allow accurate precipitation in RILEWS. Nonetheless, the application of corrected mesoscale models in RILEWS in complex topography has not been evaluated yet.

The object of the present work was to evaluate the implementation of a RILEWS based on mesoscale atmospheric model coupled to logistic model. We corrected mesoscale models (models that allow represent atmospheric process to synoptic-scale) using weather stations, generating RIL-prone probability zones for the first time in the Southern Andes. The paper is structured as follows: after the introduction, the second section describes the study site and its pertinence to implement RILEWS. In the third section, we describe the data and methods, including the calibration and validation procedures. In the fourth section, we outline the main results of the proposed RILEWS, focusing on the quality of predictors and model outputs. The fifth and final section comprises the discussion and conclusions, presenting the implications of this proposal and their general applicability to the southern Andes.

- Authors should explain that rainfall data are obtained computing rainfall by means of a mesoscale model . The authors should also explain what is it a mesoscale model because the reader could not know it.

  A: We added additional information about the parametrization of the WRF model in section 3.1. We appreciate the comment allowing the reproducibility of our results.

Line 4. “The models were forced by corrected simulations of precipitation and geomorphological features.” Which models?

A: Now we added “logistic” to explain our approach. Thanks

Lines 21 “What is it AUC?

A: Thanks by your observation. Now, we replace

“AUC of 0.80”

To:

Area Under the Curve (AUC) of 0.80

Please considers also the references of Tiranti et al. (2014), Devoli and Tiranti, (2018), Cremonini et al. (2018), Piciullo et al. (2020). Moreover the use of models has also be tested in early warning systems against debris flows (Sattele et al., 2015, Bernard and Gregoretti, 2021).

A: We read the references suggested by the reviewer. Now, we include the references. Thanks for your suggestion.

Lines 90-91 “A database of previous RIL was studied (Gomez-Cardenas & Garrido-Urzua, 2018), divided into calibration subsets with subsequent validation of the method” Unclear sentence

A: We agree. The text were modified:

Original text:

A database of previous RIL was studied (Gomez-Cardenas & Garrido-Urzua, 2018), divided into calibration subsets with subsequent validation of the method.

Modified text:

We used a RIL database (Gomez-Cardenas & Garrido-Urzua, 2018) being separated into calibration sub-database and validation sub-database to evaluate the models' performance.

Line 102 “which allowed represent” poor English form

A: We agree. The text were modified:

Original text:

> We used a spatial resolution of 4 km, which allowed represent the complex topography of the Andes.

Modified text:

> We used a spatial resolution of 4 km that allows representing the complex topography of the Andes.

Line 107: what is it a mesoscale? Please explain.

A: We agree. The text were modified:

Original text:

> Final Operational Global Analysis product from the US–National Centers for Environmental Prediction NCEP, also known as FNL (NCEP, 2000), was used as the global forcing to obtain the solutions of precipitation at mesoscale.

Modified text:

> Final Operational Global Analysis product from the US–National Centers for Environmental Prediction NCEP, also known as FNL (NCEP, 2000), was used as the global forcing to obtain the solutions of precipitation at 4-km or mesoscale (resolution to an order of kilometres).

Line 119 “corrected simulations of precipitation” substitute it with “modeled and corrected precipitation data”

A: We partially agree. We state that a numerical simulation was carried out to represent the precipitation. We used coarse global atmospheric data. Therefore, we used numerical models instead of data. Our apologies for not being clear. We propose to modify the text:

Original text:

> The logistic regressions were trained based on the local geomorphological conditions (slope) and previously corrected simulations of precipitation.

Modified text:

> The logistic regressions were trained based on the local geomorphological conditions (slope) and previously modelled and corrected precipitation simulations.

Quantities, S, P and E of equations (3) and (4) must be explained in the text.

A: Thanks for your observation. The equations were defined not using the full name of the variables. We modified/clarified the text

Original text:

The sensitivity was defined as the ratio of true positive predictions of events (TP), over the total of positive events (including false-negative predictions – FN). The specificity was also calculated (Eq. 4) to evaluate the capacity of detection of non-RIL events or true negative (TN), to avoid false positives (FP) (Fawcett, 2006). Finally, this methodology made it possible to evaluate the capacity of each model to detect RIL events (Fustos et al., 2020b).

Modified text:

The sensitivity (S) was defined as the ratio of true positive predictions of events (TP), over the total of positive events (including false-negative predictions – FN). The specificity (E) was also calculated (Eq. 4) to evaluate the capacity of detection of non-RIL events or true negative (TN), to avoid false positives (FP) (Fawcett, 2006). Therefore, this methodology made it possible to evaluate the capacity of each model to detect RIL events (Fustos et al., 2020b).

$$S=TP/(TP+FN) \quad \textbf{(Eq. 3).}$$

$$E=TN/(TN+FP) \quad \textbf{(Eq. 4).}$$

Line 148 Perhaps “Therefore” would better than “Finally”

A: We agree, done.

Lines 156-158 “The stations were compared in the uncorrected simulation showing (~0.26-0.49) to medium (~0.32-0.67) correlation values by Pearson and Spearman coefficients.” Unclear sentence

A: Thanks for your observation. The equations were defined not using the full name of the variables. We modified/clarified the text

Original text:

The stations were compared in the uncorrected simulation showing (~0.26-0.49) to medium (~0.32-0.67) correlation values by Pearson and Spearman coefficients.

Modified text:

The uncorrected precipitation simulation showed (~0.26-0.49) to medium (~0.32-0.67) correlation values (Pearson and Spearman) in comparison to in-situ weather stations.

Line 245 “a low uncertainty precipitation representation” should be substituted “ “precipitation representation characterized by a low uncertainty“

> A: Thanks for your observation. We modified the sentence to : “Therefore, precipitation representation characterized by a low uncertainty in complex topography environments is a valuable contribution”

Line 260 It is “becomes”

> A: Modified

Line 262 “The bias-correction using meteolab improved the precipitation representation to compared with weather stations (Figure 4).” Unclear sentence

> A: Thanks for your observation. We modified/clarified the text
>
> Original text:
>
>> The bias-correction using meteolab improved the precipitation representation to compared with weather stations (Figure 4).
>
> Modified text:
>
>> From our results, the bias-correction improved the precipitation representation when we compared against the weather stations (Figure 4).

Line 273 “has a complex topography that triggers precipitation events” How topography can trigger a precipitation? Perhaps the complex topography influences…..

> A: Thanks for your observation. We corrected/clarified the text
>
> Original text:
>
>> The Southern Andes has a complex topography that triggers precipitation events with different intensities in a few kilometres of separation
>
> Modified text:
>
>> The Southern Andes has a complex topography that influences precipitation events with different intensities in a few kilometres of separation

Line 283 “slope memory approach” what is it? Slope is it relative to the terrain morphology? Please explain

> A: Thanks. Now we explain in detail the aim of the sentence. We corrected/clarified the text
>
> Original text:

> The slope memory approach could be the best way to obtain a proxy of the soil moisture content, as there is no network of moisture sensors in the study area.

Modified text:

> In future, the soil moisture memory approach could be the best way to obtain a proxy of the soil moisture content and the slope response to landslides in zones without a network of moisture sensors.

Line 294 “The Andes in one of the most propensity zones to be affected by intense precipitation product of climate change.” Unclear sentence and Lines 294-295 “Moreover, the complex topography needs a high temporal resolution to reproduce the precipitation variability of the Southern Andes.” Meaningless sentence

A: Thanks for your accurate observation. We merge both comments to explain the scientific contribution of our manuscript and their impact on the zone. We modified the two comments:

Original text:

> The Andes in one of the most propensity zones to be affected by intense precipitation product of climate change. Moreover, the complex topography needs a high temporal resolution to reproduce the precipitation variability of the Southern Andes.

Modified text:

> The Andes in one of the most susceptible zones to be affected by intense precipitation changes product of climate change. To reproduce and understand intense precipitation changes and their impact on landslides, a high Spatio-temporal resolution is needed. The present contribution support reproducing accurate precipitation, contributing to robust RILEWS.

R2

Review of NHESS-2021-317 by Fustos et al.

Overview

The manuscript (MS) deals with the development of a mathematical tool useful for setting up a landslide early warning system (LEWS) in the Southern Andes, Chile. The methodology combines bias correction of precipitation products and a model for estimating the probability of landslide triggering. The topic is within NHESS and the Special Issue. Language and structure of the MS is acceptable but should be improved. I think the MS has potential for publication, but the current version needs major revisions, mainly because some important methodological aspects need to be explained more clearly and thus it is difficult to understand how scientifically sound are the results.

A: We appreciate your evaluation of our manuscript. We assessed all the comments to increase the quality of the MS. Following, we explain how the reviews were corrected/added.

Specific comments

Abstract needs to be improved: the various sentences are not adequately linked, so it is difficult to understand what is being done in the MS

A: We agree with the reviewer comment. We addressed this point in previous comment. Thanks you.

Methodology: it should be better explained how the results are supposed to be used within a LEWS. How is rainfall supposed to be used as input to the developed models to produce a warning? Which is the value of probability for which a warning should be issued?

A: Thanks you for this observation. Now, introduce additional information respect to the precipitation and geomorphological features.

Original text

Precipitation data and local geomorphological features were integrated into a logistic model to evaluate the occurrence of RIL.

Modified text:

Precipitation data and local geomorphological features were integrated into a logistic model as predictors to evaluate the occurrence of RIL.

Moreover, now improved the text including additional explanations about how the results will be used in LEWS. Original text:

None

Modified text:

We consider an approximation of the probability of occurrence of RIL through logistic distributions. The probability allows a spatialization of "prone-landslide" or "not prone-landslide" conditions under established precipitation and topographical conditions.

Regarding the probability for which a warning should be issued, now we introduce

Added text:

We propose that the threshold must be suitable to separate a prone-landslide event from a non-prone-landslide event. The threshold maximizes the sensibility in the four models with different degrees of performance of RILEWS.

Section 3.3: When computing ROC sensitivity and specificity how do you treat observed landslides? I mean, observed landslides are point features, while the output of your model is spatially distributed: how is the comparison between the two done? Is a buffer considered around observed landslide points, or you just take the value at the cell including the point?

A: Thanks you for this observation. Now, we clarify the comparison method

Original text

The quality of each regression was evaluated by ROC analysis (Fawcett, 2006) using the independent database BD2 (Figure 2).

Modified text:

The quality of each regression was evaluated by ROC analysis (Fawcett, 2006) using the independent database BD2 (Figure 2). The DB2 has georeferenced the initial failure zone. We compared the initial failure zone to the pixel of our models (pixel that includes the point).

Figure 8 and 9, model 1 and model 4 have basically the same performance. This means that Seven-day precipitation does not add much information. Perhaps the authors should think and comment on this

A: Thanks for your accurate observation. We agree. Now we modified the text:

This is consistent when we compare M1 (AUC=0.80) and M4 (AUC=0.79); they present similar sensitivity values (~91% in both cases), suggesting that either model could be used.

Added text:

This is consistent when we compare M1 (AUC=0.80) and M4 (AUC=0.79); they present similar sensitivity values (~91% in both cases), suggesting that either model could be used. Model 1 and Model 4 showed similar performance due to one being contained in the second. Hence, we interpret that an overrepresentation could exist. Therefore, model 4 does not support additional information. At an operational level, the discard of model 4 reduces the computing loading, simplifying the alert processes.

Table 2 – Model 4 is the only one combining 3 explanatory variables. Why do not investigate also all the other possible combinations of 3 and 4 variables?

A: We agree that multiple combinations may contribute to accurate models. We noted that daily and 7-days accumulated precipitation are sufficient to create RILEWS. A RILEWS with many precipitation-derived variables will need additional computational time, increasing the load of the operational system. Therefore, we propose to use limited variables in the RILEWS proposed. We added additional information in section 3 (previous to figure 2).

Figure quality should be improved (all)

A: We agree with the reviewer. Now we upload vectorial format to the server, increasing the quality.

4.2 is mainly a list of the calibrated parameters for the logit and probit models. Perhaps revise but creating a table with the parameters' values, while the text comments the table

A: We appreciate your useful comment. Now, we added two tables to section 4.2 to improve the understood of our contribution. Thank you

Added tables:

TABLE XXX1: Values of the estimators for the Logit models

	Intercept	Daily precipitation	Seven-day accumulated precipitation	Thirty-day accumulated precipitation	Slope
Model 1	3.5235 ± 0.0069	- 0.8176 ± 0.0089	-	-	-0.1696 ± 0.0049
Model 2	3.3582±0.0067	-	0.6413 ± 0.0063	-	-0.1365 ± 0.0086
Model 3	3.1658±0.0091	-	-	-0.3518 ± 0.0033	-0.1289 ± 0.0072
Model 4	3.5206±0.0106	- 0.8124 ± 0.0066	0.0020 ± 0.0086	-	-0.1675 ± 0.0080

TABLE XXX2: Values of the estimators for the Probit models

	Intercept	Daily precipitation	Seven-day accumulated precipitation	Thirty-day accumulate d precipitatio n	Slope
Model 1	1.9113 ± 0.003	- 0.4166 ± 0.0046	-	-	- 0.0741 ± 0.0022
Model 2	1.8490±0.003 1	-	-0.3545 ±	-	-0.0675 ±

			0.0029		0.0038
Model 3	1.7482±0.0041	-	-	-0.1897 ± 0.0020	- 0.0596 ± 0.0033
Model 4	1.9110±0.0044	- 0.4016 ± 0.0027	- 0.0202 ± 0.0038	-	- 0.0732 ± 0.0040

Section 5.1 Precipitation accuracy, and about uncertainty in general: the paper may benefit from a more complete literature overview on this point: see, in addition to cited papers e.g.: https://doi.org/10.1016/j.geomorph.2015.04.028 , https://doi.org/10.1016/J.GEOMORPH.2014.06.015 https://doi.org/10.5194/hess-21-4525-2017 https://doi.org/10.1016/j.jhydrol.2015.10.010 https://doi.org/10.1016/j.geomorph.2016.11.019 https://doi.org/10.1016/j.geomorph.2017.02.001 https://doi.org/10.1007/s11069-018-3508-4 https://doi.org/10.1007/s11069-019-03830-x

A: We agree. Now we added additional information about the precipitation accuracy

In many areas of the world, the prediction of rainfall-induced landslides is usually carried out using empirical rainfall thresholds [Gariano et al., 2020]. Previous contributions showed that dense weather stations allow representing the complex precipitation distribution giving well threshold estimation [Nikolopoulos et al., 2014; Nikolopoulos et al., 2015]. However, the complex topography and the sparse weather stations availability underestimate rainfall thresholds for landslides in Southern Andes. Previous studies showed a systematic underestimation in debris flow early warning thresholds related to the use of sparse rain gauge networks [Marra et al., 2016; Destro et al., 2017; Marra et al., 2017]. Moreover, the topography has a strong influence on modifying the spatial distribution of precipitation that leads to debris flows [Marra et al., 2016; Fustos et al., 2021] and landslides [Fustos et al., 2017]. Hence, our contribution allows reducing the precipitation estimation uncertainty increasing the reliability of RILEWS in the Southern Andes.

L 134: you use only 20 – 30 % of the data for calibration. Why not an higher percentage?

A: We select this amount to has a "large" database form validation. The amount of RIL in the zone still poor in comparison to others studies. However, this correspond to the more dense database in the South of Chile that exists. Therefore, we want to develop a coarse logistic models using the worst data constrains.

It is unclear how you select 57 landslide events from the available 4,987 RIL. 57 events are a quite few, according to the literature (see, e.g. DOI: 1007/s10346-021-01704-7; https://nhess.copernicus.org/articles/21/2125/2021/)

A: Currently, the south of Chile has a well-identified landslide database without a date. The local database has 4987 RIL (with and without date). We select the RIL events inside the study zone that has precise dates. In to future, we expect to delimitate the landslide dates using the methodology of Morales et al. (2021). This constraint will allow us to develop better RILEWS and increase the spatial coverage of our system. Now, we correct the sentences:

Original text:

However, we had 2,035 of these, including the exact date. We used as database 57 RIL events, considering mudflow, debris flow and mass wasting.

Modified text:

However, 2.035 RIL exist in the zone, and only 57 RIL events have an exact date. The final database considers mudflow, debris flow and mass wasting. The actual database is not suitable to establish RILEWS using thresholds due to the scarce amount (Peres and Cancelliere, 2021). The current dataset is the most comprehensive landslide catalogue for the zone in comparison to well-validated global datasets such as Global Landslide Catalog (GLC) (Kirschbaum et al., 2010, 2015) and the Global Fatal Landslide Database (GFLD) (Froude and Petley, 2018) developed into other studies (Destro et al., 2017; Rossi et al., 2017; Wang et al., 2021).

References:

Froude, M. J. and Petley, D. N.: Global fatal landslide occurrence from 2004 to 2016, Nat. Hazards Earth Syst. Sci., 18, 2161–2181, https://doi.org/10.5194/nhess-18-2161-2018, 2018. a, b, c

Destro, E., Marra, F., Nikolopoulos, E. I., Zoccatelli, D., Creutin, J. D., and Borga, M.: Spatial estimation of debris flows-triggering rainfall and its dependence on rainfall return period, Geomorphology, 278, 269–279, https://doi.org/10.1016/j.geomorph.2016.11.019, 2017.

Kirschbaum, D. B., Adler, R., Hong, Y., Hill, S., and Lerner-Lam, A.: A global landslide catalog for hazard applications: method, results, and limitations, Nat. Hazards, 52, 561–575, 2010. a, b

Peres, D. J. and Cancelliere, A.: Comparing methods for determining landslide early warning thresholds: potential use of non-triggering rainfall for locations with scarce landslide data availability, Landslides, 18, 3135–3147, https://doi.org/10.1007/s10346-021-01704-7, 2021.

Rossi, M., Luciani, S., Valigi, D., Kirschbaum, D., Brunetti, M. T., Peruccacci, S., and Guzzetti, F.: Statistical approaches for the definition of landslide rainfall thresholds and their uncertainty using rain gauge and satellite data, Geomorphology, 285, 16–27, https://doi.org/10.1016/j.geomorph.2017.02.001, 2017.

Wang, X., Otto, M., and Scherer, D.: Atmospheric triggering conditions and climatic disposition of landslides in Kyrgyzstan and Tajikistan at the beginning of the 21st century, Nat. Hazards Earth Syst. Sci., 21, 2125–2144, https://doi.org/10.5194/nhess-21-2125-2021, 2021.

Technical corrections

I have annotated the manuscript with some technical corrections (See attachment).
Citation: https://doi.org/10.5194/nhess-2021-317-RC2

A: We reviewed the technical corrections. We rewrote the sentences/words that did not suffer changes due to the previous comments.