



HAL
open science

Contribution of Artificial Intelligence models for the management of rockfall risks

Marie-Aurélié Chanut, Clara Lévy, Lucas Meignan, Muriel Gasc, Abdourrahmane Atto, Nickolas Stelzenmuller, Guilherme Cunha de Barros-Santos, Hermann Courteille, Emmanuel Trouvé, Sylvie Galichet, et al.

► **To cite this version:**

Marie-Aurélié Chanut, Clara Lévy, Lucas Meignan, Muriel Gasc, Abdourrahmane Atto, et al.. Contribution of Artificial Intelligence models for the management of rockfall risks. 5th RSS Rock Slope Stability Symposium, Nov 2021, Chambéry, France. hal-03729346

HAL Id: hal-03729346

<https://hal.archives-ouvertes.fr/hal-03729346>

Submitted on 20 Jul 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Contribution of Artificial Intelligence models for the management of rockfall risks

Marie-Aurélié Chanut (corresponding author)¹, Clara Lévy², Lucas Meignan³, Muriel Gasc¹, Abdourrahmane Atto⁴, Nickolas Stelzenmuller³, Guilherme Cunha de Barros-Santos^{1,2,3}, Hermann Courteille⁴, Emmanuel Trouvé⁴, Sylvie Galichet⁴, Nicolas Meger⁴

Keywords: rockfall, climatic factors, risk management, Artificial Intelligence (AI) models

ABSTRACT IN ENGLISH:

This paper proposes a methodology to evaluate the suitability of AI models to describe rockfalls triggered by several factors, such as meteorological and geological conditions. So, we aim to train neural networks with all relevant and available data that could effectively predict rockfalls. To achieve this goal, we have already selected appropriate sites, collected data at high temporal and spatial resolution, and we propose some relevant models for this task. Ultimately, this type of model could assist in the operational management of infrastructure, especially during major climatic events.

ABSTRACT IN FRENCH:

Cette communication présente une méthodologie pour évaluer la pertinence des modèles type IA à décrire des chutes de blocs déclenchées par des facteurs multiples, tels que les conditions météorologiques et géologiques. Ainsi, nous voulons entraîner des modèles IA à prédire la probabilité de chute de pierres en partant des données pertinentes et disponibles. Pour atteindre ce but, nous présentons ici les sites d'études sélectionnés, les caractéristiques des données recueillies à haute résolution temporelle et spatiale, et enfin des typologies de réseaux de neurones appropriés. A terme, ce type de modèle représenterait un outil supplémentaire pour le management des infrastructures, particulièrement lors d'événements climatiques majeurs.

The role of climatic factors (precipitation, temperature variations and freeze/thaw cycles) in the triggering of rockfalls was evidenced in numerous publications (e.g. Hemstetter and Garambois, 2009; Delonca et al, 2014; D'amato et al, 2016). The quantification of this triggering role remains a difficult task for specific sites, challenging the operational management of infrastructures during major climatic events (road closures in connection with weather forecasts, deployment of monitoring, etc.). Classical multi-scale and multi-physical models integrate thermal, hydric and mechanical couplings to provide a coherent understanding and reliable prediction of phenomena and their impacts. In addition to these physical models, the approach proposed in this paper aims at learning from the data themselves to build predictive models of rockfalls using AI methods. The prediction of landslide behavior using such methods have been recently developed (Ma et al., 2018) while the use of AI for the prediction of rockfalls is still limited due to the scarcity of documented events.

1 SITES AND DATA

Two sites with documented rockfall events together with measurements of meteorological factors (precipitation, temperature or snowmelt) were selected in France: the RN1 road in La Réunion (974) and the Saint-Eynard cliff near Grenoble (38). In La Réunion (Figure 1), we study the rockfalls that reached the road using the database fed by RN1 management services where date, mass and location of the events are referenced. At the Saint-Eynard cliff site, we focus on the failure of the rocks from the cliff using seismic monitoring of rockfall collapses and high-frequency monitoring of topographic changes (at least every day) thanks to laser scans or photogrammetric acquisitions. In this latter case, we need data pre-processing to accurately date and describe rockfall events. At first level, rockfall events are daily recorded with locations, masses and meteorological data such as rains. Hereafter, other data will be integrated in the analysis such as geology, topography, and the presence of protective structures.

We perform initial tests of our methodology using event-rich databases from specific sites, in order to facilitate training and validation of the AI models and sites where the correlation between rockfalls and climatic factors has already been shown statistically. The generalization of other sites could be carried out in a second step.

1 Cerema, Team GeoCoD, 25 avenue François Mitterrand, 69674 Bron, France; marie-aurelie.chanut@cerema.fr; muriel.gasc@cerema.fr; guilherme.cunha-de-barros-santos@cerema.fr

2 BRGM, 45100 Orleans, France; c.levy@brgm.fr

3 Géolithe, 181, rue des Bécasses, 38920 Crolles, France; lucas.meignan@geolithe.com; nickolas.stelzenmuller@geolithe.com

4 Université Savoie Mont-Blanc, LISTIC, BP 80439 -Annecy le Vieux - 74944 Annecy; emmanuel.trouve@univ-smb.fr; abdourrahmane.atto@univ-smb.fr; nicolas.meger@univ-smb.fr; hermann.courteille@univ-smb.fr; sylvie.galichet@univ-smb.fr

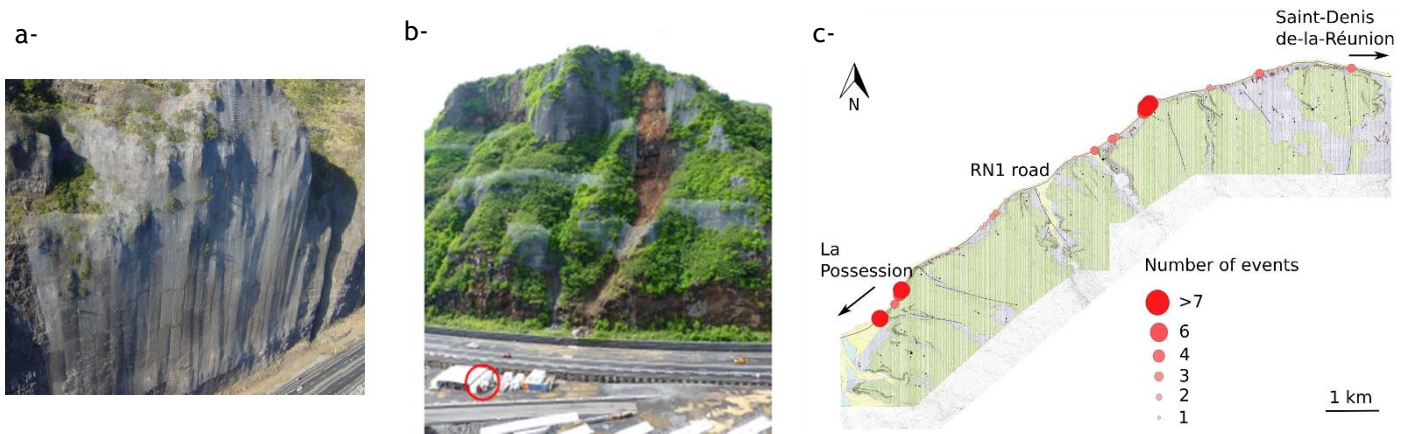


Figure 1: The RN1 Road in La Réunion : (a) an example of the cliff overhanging the road, (b) a rockfall event, (c) rockfalls distribution along the RN1

2 METHODOLOGY TO CALIBRATE AND EVALUATE AI MODELS

Machine learning and its deep learning branch seem to be promising ways to induce predictive models of risk from the data itself. As previously mentioned, rockfalls are discrete events that are highly correlated with weather events which exhibit seasonal patterns. Therefore, we want to model the intensity of the point process (rate of falls during a period Δt) with respect to exogenous variables such as rain, geological area ... A good challenger in such task could be Spiking Neural Networks (SNNs). Several calibrations of the neural networks are planned: first, a baseline with only dates and events, then others with external data and expertise (meteorological data, geology and topography) to improve performance. This approach will allow us to characterize more precisely the data and the minimum number of rockfall events needed to generate a relevant AI model. In addition, the validated results will be compared to the results of physical and statistical models.

CONCLUSION

With the use of AI models, we expect to be able to identify more precisely the cause and effect relationships within complex data (rockfalls, meteorological, geological, topographic data) and to predict the evolution of the risk of rockfall according to meteorological conditions with sufficient confidence for the operational management of infrastructure. In particular, an application integrating meteorological forecasts would allow infrastructure managers to anticipate monitoring, protection or closure measures for the infrastructure.

ACKNOWLEDGEMENTS

The authors would like to gratefully acknowledge the FEREC Fondation for funding this work. This work was carried out within the framework of the national C2ROP project and we thank the SNCF, CD 38 and CD 73 for their support and the CR La Réunion for sharing their data.

REFERENCES

- D'Amato, J., Hantz, D., Guerin, A., Jaboyedoff, M., Baillet, L., Mariscal, A., (2016) Influence of meteorological factors on rockfall occurrence in a middle mountain limestone cliff. *Natural Hazards and Earth System Sciences*, 16, 719–735
- Delonca, A., Gunzburger, Y., and Verdel, T (2014) Statistical correlation between meteorological and rockfall databases, *Nat. Hazards Earth Syst. Sci.*, 14, 1953–1964.
- Hemstetter, A., Garambois, S., (2010) Seismic monitoring of Séchilienne rockslide (French Alps): Analysis of seismic signals and their correlation with rainfalls, *Journal of Geophysical Research: Earth Surface*, 115 (F3)
- Ma, J., Tang, H., Wen, T., and Liu, X. (2018) A hybrid approach for prediction of changes in landslide rates based on clustering and a decision tree, *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*, XLII-3/W4, 335–341.