Geophysical Research Abstracts
Vol. 21, EGU2019-17373, 2019
EGU General Assembly 2019

Quantitative analysis of spatial parameters leading to accelerated slope dynamics in West Papua, Indonesia

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The Southern margin of West Papua (Indonesia) is characterised by a very rough volcanic morphology, with steep slopes and abundant precipitation that concur to the development of a highly dynamic landscape. On top of this, dense rainforests dominate, with the eventual occurrence of scattered cultivated patches, tended by local villagers. Since the middle of the 20th century, one of the largest open pit mining facilities in the world was established at Grasberg, on top of the main Papuan ridge, which then expanded in time to become the most notable man-made landscape feature in the entire island. The mining grounds are served by a large array of factories and facilities, scattered from the top of the mountain down to the sea shore. They include large camps and mining villages hosting the working force and their families. The environment is challenging, due to the combination of highly active slope dynamics, climate and man-made presence so that the level of risk is notably high.

In this study, we present a numerical and statistical analysis of a large set of spatial data aimed at defining the main factors at play and the most important parameters driving the slope processes in the surrounding of the main elements at risk. Factors mainly pertaining to the morphometry, climate and vegetation of the area are quantified and cross-compared for their possible contribution in a multi-variate modelling of shallow landsliding and debris-flow occurrence according to the available inventories by using remote sensing, geo-morphometric techniques and machine learning methods. Results show that the combination of environmental variables possibly leading to accelerated sediment wasting processes in the area is complex and new with respect to other similar cases. In particular, specific morphometric closeness metrics and multi-temporal vegetation indexes seem to exert a strong control on landslide occurrence and on elements at risk exposure. The findings are then used to generate a probability map for expected occurrences and to apply numerical simulations for debris-flow type runout at the basin scale on high-res DEMs. Validation is carried out by comparing the predictions to the post-event damage maps of 2017 and 2018.