Debris flows induced by Multiple Occurrence Regional Landslides Events in the Colombian Andes

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Second International Conference on Natural Hazards and Risks in a Changing World 2021

Abstract

Debris flows triggered by Multiple Occurrence Regional Landslide Events (MORLE) are common destructive phenomena in Colombia. In the Colombian Andes, characterized by tropical weather, deep weathering, and steep slopes, MORLE are often triggered by intense and convective rainstorms that are orographically anchored. When such rainstorms take place in steep and small basins, flash floods are triggered, which flow downstream mixing with the hillslope sediments supplied from landslides and erode the streambed sediments. The flow becomes a one-phase viscous surge with high solid concentrations traveling at high speed with great volume and destructive capacity. The final stage of such events is marked on fans or low-land areas that are often populated, turning into disasters.

Historical debris flow occurrence was analyzed from the disaster database provided by the Geohazards Research Group. The database includes 8248 reports from multiple natural hazards since 1880. 51% of the records correspond to landslides, and 5.7% to debris-flow processes, being rainfall the main trigger for both phenomena. Some of

the most deadly debris flow disasters in the record are: San Carlos, Antioquia in September of 1990 that caused 20 deaths, Salgar, Antioquia in May of 2015 that caused 104 deaths, and Mocoa, Puntumayo in March of 2017, that caused 400 deaths.

According to the records, there have been 4,238 landslides that caused 2,221 deceases, and 473 debris flow events that caused 440 deaths. These statistics show how debris flow phenomena are 77% deadlier than landslides, even though they are not so frequent. While not every debris flow in Colombia is related to the occurrence of a MORLE, those reports with a record of landslide clusters have caused a higher number of fatalities and losses. Furthermore, higher landslides count in MORLE are positively correlated with higher human losses and infrastructure damage.

Understanding the drivers of MORLE induced debris flows in Colombia and how these phenomena interact to create a multi-hazard settings is a crucial step towards reducing risks. Hazard and risk assessments are the basic tools for stakeholders to make better land use planning decisions. Such hazard studies are carried out using different modeling methods, which have been traditionally carried out from a single-hazard approach. For debris flows, these approaches include physically-based models to simulate the path of peak clear stream flows, which despise their contrasting rheology. Empirical models have also been used to define potential paths according to the geomorphological features of the terrain.

Nonetheless, new approaches are being developed, which account for the relationships between cluster of landslides and debris flow phenomena. Recent proposals focus on mass-routing mass and momentum conservation software, capable of routing multiphase flows considering the interactions between the flow and sediments. For the application of these methodologies in Colombia and its incorporation into land use planning, it is important to have a clear comprehension of the drivers and interactions of such events, given by the particular conditions of the study area.