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Analysis of factors potentially triggering and/or constraining landslides occurring during the floods of February 20th, 2010 in Madeira Island

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Floods are the most important natural hazard affecting Madeira Island in terms of frequency and intensity of the events, affecting a territory of about 780 km2 with a human population of around 200 000 inhabitants located mainly close to the coastline. The floods that occurred in Madeira Island on February 20th, 2010, triggered landslides causing massive transport of solid materials (debris flow) with very relevant volumetry. The direct consequences were human casualties and huge material damages. The affected area included five main watersheds located at the south coast, namely: Ribeira Brava, Ribeira da Tabua, Ribeira de São João, Ribeira de Santa Luzia e Ribeira de João Gomes. The main streams of last three watersheds drain into the ocean within the city of Funchal, the largest and more populated urban area of the island.

The use of digital image processing techniques of remote sensing data allowed a quick and expeditiously mapping of landslide scars, as well as estimates of the volume of material being moved during the event. The tools of Geographic Information Systems were used for the spatial analysis of the landslide scars and its intersection with maps of potential triggering/constraining factors such as meteorological factors, geomorphology and land cover. A multivariate analysis was performed in order to better understand the relations between factors. In a first assessment, several precipitation variables were computed from 26 automatic udometric stations spatially distributed over Madeira Island: maximum precipitation accumulated in 10 minutes, 30 minutes, 1 hour, 3 hours and 6 hours during the event, and the number of hours with precipitation over 10 and 30 mm/hour. Results show that there is a good agreement between the spatial pattern of the landslide scars and the occurrence of more than two hours of precipitation over 30 mm/hour. The overlap of landslide scars with the COS 2007 land cover map suggests that the most affected areas were those with poor vegetation cover such as pastures, shrubs, temporary crops or agriculture with natural or semi-natural areas, where there was a very low cover of trees. The intersection of the landslide scars map with the slope map, computed from a 4x4m Digital Terrain Model, permitted to conclude that most landslides occurred in terrain with slope between 25º and 45º. Other variables were analysed, such as the type of soil and geology, but the scale of data was inadequate and the results were inconclusive.

This analysis was very important in understanding the phenomenon of land sliding caused by extreme precipitation events in Madeira Island, allowing a better characterization of risk and assist decision making on the implementation of measures to mitigate the risk.