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Cell-based Dynamic Modelling of Lahar Initiation in Pyroclastic Flows Deposits

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The eruption of Mt. Pinatubo, Philippines in June 15-16, 1991 grossly altered eight major watersheds surrounding the volcano by depositing roughly 6.5 cubic kilometers of pyroclastic flows. During the rainy seasons, these deposits generated several major lahars for several years. Several rain-gauges and flow sensors were installed in different watersheds in order to study the rainfall-lahar thresholds and at the same time they were used for lahar warnings. With several lahar occurrences and field observations, it is important to make a watershed-scaled cell based lahar model in order to predict the duration and magnitude of lahar events given a certain rainfall. This study concentrates on the cell-based dynamic modeling of lahars in a GIS environment based on actual rainfall events on the Sacobia-Pasig watershed located on the east side of the volcano where population and infrastructures are densely concentrated.

The dynamic lahar model in this study is a physically based model that takes into account several site-specific conditions. It incorporates the extraction of hydrologic parameters from field experimental data as well as field observation of lahar discharges. The model considered several parameters including terrain, infiltration capacity, channel width, channel density and initial volumetric concentration of flows. The simulation program model is run entirely on PCRASTER environmental modelling software. The model is robust to operate in an environment where rapid erosion of very loose sediment occurs, capable of producing lahars. The objective of the model is to predict a mudflow hydrograph taking into account the velocity, mud heights along the channel, mud concentrations and other flow properties.

The different parameters that were mentioned in the model have to be tested for sensitivity in order to understand which parameters have more influence on the result. In the model, the most sensitive parameter is volumetric concentration, followed by channel density and infiltration, while channel width is the least sensitive.

It has been demonstrated that simulations of the period between 1992 and 1998 produced significant lahar magnitudes in the Sacobia and Pasig channels. The volumetric concentration of lahars largely decreased due to the depletion of source materials and the widening of channels, which made bank erosion and collapse less effective. Lahar hydrographs calculated by the model were compared with actual lahar hydrographs that were measured in the field. The conclusion was that the model gives reasonable estimates that can be used for lahar warning and also gives an acceptable approximation of the total sediments transported. Calculated flow velocities and the concentration of lahar flows throughout the simulation can be adopted for mitigation purposes.

The lahar model can be applied to other volcanoes with similar eruption characteristics. However, due to the uniqueness of the conditions in the Mt. Pinatubo's are, the relationships between parameters in the model have to be studied carefully before the model can be applied elsewhere. This research is among the first attempts to model rainfall runoff utilizing a cell-based distributed model in a dynamic GIS environment, which takes into account several catchment parameters, to predict lahar runoff.