Lahar characteristics and erosion measurements using multiparameter recording stations and DEMs in the Gendol catchment after the 2010 Merapi eruption

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Lahars, including debris flows and hyperconcentrated streamflows, represent the most frequent natural hazard around the Merapi volcano because they can be triggered during and after, or even without eruptions. Each year lahars with a discharge range between 200 and 2000 m^3/s are triggered during the rainy season in several rivers which drain the west, SW and south flanks. We carry out an experimental method to measure hydraulic and physical characteristics of lahars in the Gendol River channel on the south flank of Merapi. This valley was heavily impacted by Pyroclastic Density Currents (pyroclastic flows and surges) during the October-November 2010 eruption and flooded by lahars, which have started to remobilize the PDC deposits a few months later. Six months after the 2010 large (VEI 4) eruption, small areas in Gendol down-valley 20 km from summit have been affected by subsequent over-bank and avulsed lahars. The over-bank process can be attributed to low-gradient (0.04 m/meter), meandering rivers (sinuosity index of 1.25) across the low-angle (<2°) ring plain and the limited capacity (200-300 m^2) of river channels.

The method encompasses: (1) hydraulic and geophysical in situ measurements of flows with sensors located at the valley bottom and on the edges, (2) high-resolution (decimetric) Digital Elevation Models (DEM) of the valley channel before and after a lahar, aiming at measuring the processes of aggradation and degradation in the catchment, (3) remote sensing analysis of erosion processes such as lahars and fluvial transport remobilizing the 2010 thick aprons of pyroclastic deposits ($\sim$30 million m^3). We use two experimental stations located on two check-dams $\sim$250 m apart for in situ measurements along the middle course of the Gendol River at about 700 m elevation. The stations include 2 seismometers, 2 geophones, 2 load cells, 2 pore pressure sensors, 1 radar gauge, 2 rain gauges, a barometer and cameras. We measure discharge, sediment concentration, arrival and surface velocities, and dynamics features at the flow surface. The sediment concentration is measured simultaneously using buckets in the lower station every five minutes during the flow. We then compute the volumes of transported sediment allowing us to understand the flow dynamics, the processes of entrainment, and the parameters for describing the rheology of the lahar material. We finally evaluate the processes of erosion and sedimentation of two channel segments using multi-temporal DEM (before and after lahars) derived from low altitude stereoscopic images acquired by UAV (Unmanned Autonomous Vehicle). The final goal is to track the time-related propagation of the flows down valley and calibrate the input parameters of two numerical models (Titan2D, VolcFlow), which will be used to outline lahar-prone areas in the heavily populated ring plain of Merapi.