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The 2010 Pyroclastic Density Currents of Merapi Volcano, Central Java, Indonesia

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The 2010 pyroclastic density currents (PDC) at Merapi present a rare opportunity to collect a uniquely detailed dataset of the source, extent, lateral variations and impact of various PDC deposits on a densely populated area. Using traditional volcanological field-based methods and multi-temporal dataset of high-resolution satellite imagery, a total of 23 PDC events have been recognized, including 5 main channeled flows, 15 overbank flows derived from overspill and re-channelization of the main PDCs into adjacent tributaries and two main surge events. The 2010 PDC deposits covered an area of $\sim$22.3 km2, unequally distributed between valley-filling (6.9%), overbank (22.4%) and ash-cloud surge deposits (71.7%). Their total estimated volume is $\sim$36.3$\times$106 m3, with $\sim$50.2% of this volume accounting for valley-filling deposits, 39.3% for overbank deposits and 10.5% for ash-cloud surge deposits. The internal architecture and facies variations of the 2010 PDC deposit were investigated using data collected from 30 stratigraphic sections measured after one rainy season of erosion. The results show that complex, local-scale variations in flow dynamics and deposit architectures are apparent and that the main factors that control the propagation of the main flows and their potential hazards for overbanking were driven by: (1) the rapid emplacement of several voluminous PDCs, associated with the steady infilling of the receiving landscape after the two first phases of the eruption; (2) longitudinal changes in channel capacity following increased sinuosity in the valley and decreased containment space; and (3) the effects of varying generation mechanisms (gravitational dome collapse, vertical or lateral dome explosions and column-collapse) and source materials involved during individual PDC forming events.

Integration of these data into numerical simulations of the 3-5 November channeled and overbank PDCs using two well-established geophysical mass flow models, Titan2D and Volcflow, allow us to evaluate the ability of these models to reproduce the main features of the natural deposits and some of the flow overbanking processes observed in the field. Using such a multi-techniques approach, the dataset obtained in this study is considered not only instrumental for characterizing PDCs and related hazards at Merapi, but will allow comparisons with similar events at other volcanoes around the globe.