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The numerical reconstruction of three past eruptions at Gede volcano (Indonesia)

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Understanding past eruption dynamics at a volcano is crucial for forecasting the range of possible future eruptions and their associated hazards and risk. In this work we reconstructed pyroclastic density currents and tephra fall from three eruptions at Gede volcano, Indonesia with the aim of gaining further insight into past eruptions and identifying suitable eruption source parameters for future hazard and risk assessment. Gede has the largest number of people living within 100 km of any volcano worldwide, and has exhibited recent unrest activity, yet little is known about its eruption history. For pyroclastic density currents, we used Titan2D to reconstruct geological deposits dated at 1200 and c. 1000 years BP. An objective and quantitative multi-criteria method was developed to evaluate the fit of over 300 pyroclastic density current (PDC) model simulations to field observations. We found that the 1200 years BP geological deposits could be reproduced with either a dome collapse or column collapse as the generation mechanism although a relatively low basal friction of 6 degrees would suggest that the PDCs were markedly mobile. Lower basal frictions may reflect the occurrence of previous PDCs that smoothed the path, reducing frictional resistance and enabling greater runout for the reconstructed unit. For the 1,000 years BP PDC, a column collapse mechanism and higher basal friction was required to fit the geological deposits. In agreement with previous studies, we found that Titan2D simulations were most sensitive to the basal friction; however, we also found that the internal friction – often fixed and considered of low influence on outputs - can have a moderate effect on the simulated average deposit thickness. We used Tephra2 to reconstruct historic observations of tephra dispersed to Jakarta and other towns during the last known magmatic eruption of Gede in 1948. In the absence of observable field deposits, or detailed information from the published literature, we stochastically sampled eruption source parameters from wide ranges informed by analogous volcanic systems. Our modelling suggests that the deposition of tephra in Jakarta during the November 1948 eruption was a very low probability event, with approximately a 0.03 % chance of occurrence. Through this work, we exemplify the reconstruction of past eruptions when faced with epistemic uncertainty, and improve our understanding of past eruption dynamics at Gede volcano, providing a crucial step towards the reduction of risk to nearby populations through volcanic hazard assessment.