

Numerical modeling of Mt Merapi 2020 instability crisis

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Abstract:

The western flank of Merapi volcano (Java, Indonesia) moved from July 2020 to January 2021. The cliff collapses at the summit, the size of the affected area (about 500 m in elevation and 118 km wide) and a flank displacement of about 14 m, never observed before, led to fears of a flank collapse. Field observations suggested a correlation between this flank movement and the opening of a NE–SW fracture crossing the entire summit, filled with magma. In the present study, we developed numerical models based on the discrete element method (DEM) to investigate the role of the NE–SW fracture pressurization on the deformation of Merapi. Even though simplified considering the complexity of the processes at stake, our approach enables us to reproduce the observed deformations both in terms of kinematics and kinetics. It shows that the deformation was inelastic and affected the western flank to a depth of about 500 m below the summit. Under the pressure of the magma within the fracture, the western flank tilted slightly, causing its sliding with displacement magnitudes increasing with elevation. As observed in the field, the sliding eventually stopped so that the flank reached a new stable state, demonstrating how topographic readjustments of a volcano, driven by magma pressure, can produce significant plastic deformation without leading to major instabilities.

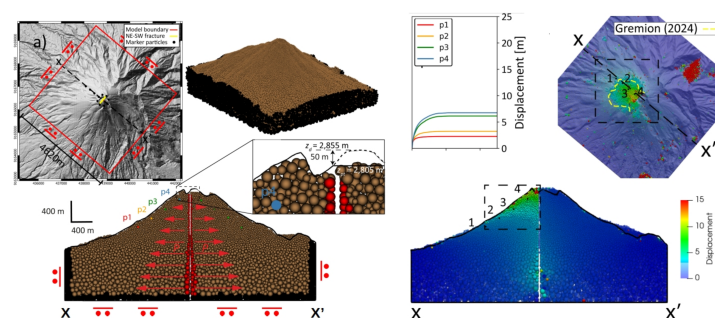


Figure 4: 3D DEM model of Mount Merapi: numerical setup (left), displacement field (right).

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