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Imaging the structural changes and instability of the Merapi dome

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Actively growing volcano domes may gradually oversteepen, which can lead to catastrophic collapse and associated block and ash flows. Here we test how the structural architecture of such instability is initiated and gradual altered by volcanic activity. After the climactic 2010 eruption, the dome at Merapi volcano has been regrown and partially destroyed again during several eruptions that occurred between 2012 and 2014. At least 6 eruptions produced 1 to 2 km high ash columns and three major fractures formed that split the dome into several segments. Here we elaborate the geometric details of these structural continuing changes.

We combine three methodologies (LiDAR-, image-, and thermal-analysis) in order to investigate the dynamic structures on the Merapi dome with a so far unprecedented level of detail. Fixed cameras first identified an unstable block that appeared after the Nov 18, 2013 eruption. We then identified a gradual augmentation of the fracture dimensions, associated with eruptions on March 10, March 24 and April 10, 2014. LiDAR surveys executed before and after these eruptions show structural details of this instability, which we compare with high resolution thermal imagery. We observe that the fractures form at pre-defined anisotropies, and that they concentrate the thermal signal. These thermal concentrations may point to zones of ongoing hydro-thermal mineralization and alteration processes. We therefore hypothesize that two mechanisms of destabilization are presently at play, one associated with small sized eruptions developing structural instability, and the other with continued hydro-thermal alteration and potential weakening along these newly developed structures. Close observation is therefore required at Merapi volcano, as the formation of block and ash flows is structurally initiated long before parts of the dome finally collapse.