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Mt. Etna 2008-2009 eruption: a model from the integration of GPS and DInSAR data

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GPS and DInSAR data collected from June 2007 to June 2008 are analyzed in order to define the dynamics preceding and accompanying the onset of the Mt. Etna eruption starting on 13 May 2008. Some short and long-term comparisons have been performed by using both GPS and Envisat SAR data, covering similar time windows.
Five GPS surveys are considered in this work. The first GPS survey, which we use as reference in this work, was carried out in June 2007 on the entire Mt. Etna network. During the first months of 2008, before the eruption onset, three surveys on part of this network were carried out (on February, April and May) on limited areas on the eastern flank of the volcano, close to the Pernicana fault and the Timpe fault system. Immediately after the beginning of the eruption, on May 13 2008, further GPS measurements were carried out on the north-eastern part of the network to better image the ground deformation pattern related to the dyke intrusion and to monitor the possible northward dyke propagation. The last survey considered in this work was carried out in June 2008; like the 2007 one, it covered the entire GPS network
The Envisat interferograms used for the integration with the GPS data cover similar time windows spanning from July 2007 to June 2008; in particular, we considered a long-term ascending pair images referring to the entire year, and two short-term interferograms (one ascending and another descending) for imaging the May 2008 dike emplacement.
We apply the SISTEM (Simultaneous and Integrated Strain Tensor Estimation from geodetic and satellite deformation Measurements) method to integrate GPS and DInSAR data. The SISTEM method computes 3D displacement maps on each point of the studied area; being based on elastic theory, it provides the complete 3D strain and the rigid body rotation tensors.
Ground deformation patterns show a slight inflation visible on the upper western side of the volcano from June 2007 to May 2008. The emplacement of the eruptive dike has been imaged by three Envisat DInSAR pairs, and by comparing two GPS surveys carried out on the uppermost part of the volcano on May 6 and 13, i.e. a few hours after the eruption onset. The results of the SISTEM method highlighted strong displacements localized on the summit area, quickly decreasing towards the middle flanks of the volcano. It is noteworthy that no significant ground deformations affected the volcano below about 1500m a.s.l.
A preliminary analysis of DInSAR data, also covering a post-intrusion period, showed a clear anomaly in the fringe pattern, suggesting the presence of a depressurizing source localized beneath the upper south-western area. This pattern seems to be confirmed by the displacements measured from May to June by GPS stations on the uppermost part of the volcano.
In order to image the geometry of the feeding system of the volcano during the months preceding and accompanying the onset of the eruption, data inversions were also performed. A mainly tensile dislocation with a minor left-lateral kinematics has been found, outcropping exactly on the eruptive fracture field, with the same orientation. The dyke dips westwards and passes beneath the summit craters area.