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The April 3, 2010 earthquake along the Pernicana fault (Mt. Etna - Italy): analysis of satellite and in situ ground deformation data integrated by the SISTEM approach

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Etna is worldwide known as one of the most studied and monitored active volcanoes. Flank instability along the eastern and southern portion of Mt. Etna has been observed and measured thanks to geodetic networks and InSAR data analysis. The spreading area is bordered to the north by the east-west Pernicana Fault System (PFS) which dynamic is often linked with the eruptive activity, as recently observed during the 2002-2003 eruption.
A seismic sequence occurred since April 2-3, 2010, along the PFS with two very shallow (a few hundred meters) mainshocks of magnitude 3.6 and 3.5. Explosions and ash emissions at the summit craters followed this swarm and culminated some days later (April 7-8).
Just after the earthquake, specific GPS surveys were carried out aimed at monitoring the eastern part of the Pernicana fault, and the leveling route on the northeastern flank of the volcano was also surveyed.
Trying to investigate the deformation occurred along the PFS during the events of April 3rd 2010, we performed a DInSAR (Differential Interferometric Synthetic Aperture Radar) analysis of ascending and descending Envisat, and of ascending ALOS-PALSAR images encompassing the date of the earthquake.
The Envisat interferograms show very intense but local deformation on the Envisat ascending data and a low signal for the descending geometry, close to the Pernicana fault trace. This is probably due to the oblique normal/left-lateral kinematics of the PFS (as deduced also by GPS and leveling data), indeed both vertical (lowering) and horizontal (eastwards) components of motion produce a strong stretching of the LOS (Line Of Sight) distance for ascending geometry, while the two components act in opposite ways for the descending geometry, resulting in lower LOS distance variations compared to the ascending data set.
We analyzed also the ALOS pair referring to 21/02/2010 – 08/04/2010 time and acquired along the ascending track number 638. The ALOS interferogram clearly show three fringes corresponding to roughly 35 cm of LOS displacement. The preliminary modeling of the interferograms agree with the seismic information (very shallow faulting, seismic moment) and show that the medium behave elastically.
In order to investigate the ground deformation pattern associated with this event, an application of the novel SISTEM (Simultaneous and Integrated Strain Tensor Estimation from geodetic and satellite deformation Measurements) approach is presented here. To achieve higher accuracy and get better constraint of the 3D components of the displacements, we improved the standard formulation of SISTEM approach, based on the GPS and a single DInSAR sensor, in order to take into account all the available dataset (GPS, leveling, ascending and descending ENVISAT C-Band interferograms and the ALOS L-Band data).
The 3D displacement maps obtained using the SISTEM approach well show the kinematics of the PFS, and are able to reconstruct also the ground deformation affecting the whole investigated area, defining the movements of the north-eastern flank of the volcano.
These results, which provide an accurate spatial characterization of ground deformation, are hence promising for future studies aimed at improving the knowledge about the kinematics of the active faults of Mt. Etna.