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Ground deformation modelling of the flank dynamics preparing the 2002 eruption on Mt. Etna

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The Pernicana fault system is very well known in recent literature on Mt. Etna [1-6]. It is described as one of the most active structures in the geodynamic framework of the volcano, and models proposing flank collapse [1,2] agree in identifying it as the northern margin of the volcano's sliding flank. On September 22nd 2002 a M = 3.7 earthquake, located at the westernmost part of the Pernicana fault, struck the north-eastern part of the volcano. In order to measure the ground deformations associated with this event, existing GPS and EDM networks were re-surveyed on the north-eastern part of the volcano. Also the leveling route on the north-eastern flank of the volcano was surveyed. For the period from July to September 2002, we also considered signals recorded at PDN long base tiltmeter that showed a clear and continuous downing of the radial component. In addition, the 31st July 2002 and 9th October 2002 ascending ERS2 passes were used to generate an interferogram. This pair has a perpendicular baseline (i.e. the distance between the orbits) of only 2 m, producing a so called "height ambiguity" of 4400 m; this means that the interferogram is insensitive to topographic errors (i.e. for a 10m DEM error, the phase error is less than 0.1mm). The short temporal (3 months) and spatial baselines allowed a good coherence to be obtained even on vegetated areas, such as the North-eastern flank of the volcano. GPS, EDM, DInSAR and leveling measurements carried out after the September 22nd earthquake show a ground deformation pattern, affecting the North-eastern flank of the volcano, too wide and strong for a M=3.7 event; the measured displacements were probably cumulated during the three-month period encompassing the event, as suggested by tilt data. The 3D station motions, provided by GPS data,

define an eastward displacement of this sector of Mt. Etna, driven by the Pernicana fault. The high spatial detail of the ground deformation pattern provided by DInSAR interferogram also highlights a local maximum LOS displacement of about 8 cm in a narrow area between Piano Provenzana and Piano Pernicana. This feature is in very good agreement with leveling measurements, which evidence a subsidence of about 6.5 cm; the slightly greater displacement measured by InSAR is probably due to the horizontal component of motion, that represents 15-20% of the total LOS displacement (i.e. about 1.5 cm). Furthermore, both techniques detect a rapid decay of the ground deformation within 2 km. Both techniques in fact, thanks to the higher spatial detail with respect to the GPS one, were able to detect the effect of a local landslide affecting that area. To model this complex ground deformation pattern, we used the results of the inversion of the 3D GPS displacement vectors as a starting point; the other data sets allow us to infer the local effect of a general strain field. The structural framework resulting from data inversions is built on five planar structures whose displacements define a general eastward motion of the northeastern sector of Mt. Etna. The moving sector is bounded westward by the Provenzana fault - NE Rift system, which behaves mainly as a normal fault, and by the left-lateral transcurrent Pernicana Fault, on the northern one; furthermore, it is bounded southwestward by a tensile structure that could indicate a shallow intrusion of a dyke beneath the summit craters. This structural framework identifies the same principal structures that were active during the first days of the 2002-2003 eruption: the NNW-SSE trending tensile plane that seems to facilitate the upraise of the dyke triggering the eruption, the Provenzana - NE Rift system that was intruded in a few hours on 28-29 October and the Pernicana fault that moved about 0.6 m from October 27th to 28th. In that context, the dynamic of the Mt. Etna in summer 2002 prepared the optimal conditions for the onset of the 2002-2003 eruption.