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Flank instability of Mount Etna

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Mount Etna geodetic and satellite monitoring systems have been recording surface deformation characterized by an instability of the E flank of the volcano for about 20 years. The seaward sliding of the E flank is observed either during summit and flank eruptions but also during quiescent recharging phases. Many investigations have not yet been able to give answers to the following questions:
i) is the sliding affecting a thin or thick layer of the volcanic/sedimentary cover?
ii) is this movement occurring along a sliding plane or is it accommodated by anelastic deformation?
iii) if a sliding plane exists, where is it located?
iv) if an anelastic material is responsible for the deformation, is it represented by pleistocenic clays or by the incoherent part of the flysh layers?
v) which rheology best represents this behavior?
vi) what is the role played by gravity?
Unfortunately, indirect investigations such as tomographic, stratigraphic, geoelectric or seismic reflection studies have not been able to provide a unique interpretation of volcanic edifice structure. Our purpose here is to select the most reliable features evidenced by recent studies and build a finite element model able to reproduce the basic patterns of the observed surface deformation. The geometry of the model includes both topography and the top of the sedimentary basement, together with a synthetic reconstruction of the internal layering constrained by geology and seismic tomography. Rheological parameters of the Etnean lithotypes are constrained by laboratory experiments conducted in the framework of FLANK INGV-DPC project. First we study a series of 2D models trying to understand the role of gravity, internal layering, rheology and sliding plane. Then we move to a more realistic and more complex 3D model including also the tectonic structures that may play a relevant role accommodating the observed eastward movements of the E flank. We study the effects of magma accumulation in a isotropic spherical cavity (0.5 km radius) located at almost 5 km b.s.l. northwest of the summit craters, according to the results of numerous recently published papers.
Among the results obtained, we want to remark that a significant contribution to increase the deformation in the E sector of Mount Etna may be due to the asymmetrical distribution of elastic parameters related to the presence of a high velocity body underneath summit craters imaged by seismic tomography. Moreover, when yield stress dependent rheologies are taken into account we observe that the initialization of stress in the model is very important. According to different assumptions about the initial stress distribution we predict different results characterized by a total or partial relaxation of the differential stress due to the gravity load. In the first case, only small effects on the computations are observed while in the latter case the flank collapse continuously overestimating the observed deformation. These preliminary results suggest that model assumptions severely influence the assessment of the physical mechanisms that may lead to flank instability.