Geophysical Research Abstracts, Vol. 9, 03905, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-03905

Inversions by 3D finite element solutions: deformation of Mount Etna from 1993 to 1997

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Inversions of geodetic data are usually performed by using analytical forward models. Very few analytical solutions exist, and they are characterized by fixed source geometry (e.g. planar dislocation, sphere, dike) and simplified medium properties (e.g. homogeneous, flat and elastic halfspace). These assumptions can potentially bias the estimation of realistic source parameters. We develop a general tool to perform inversions of geodetic data taking into account lateral variations of mechanical properties of the medium and effects due to the topographic relief. The forward models are realized by Finite Element technique. The deformation source is a combination of simple point source mechanisms, i.e. dipoles and double couples. The FE forward technique is based on the equivalence, under specific conditions, of the element-source and the deformation of a 3D ellipsoid dilating under a constant pressure. This procedure is applied to study the inflation process on Mount Etna from 1993 to 1997, as evidenced by data recorded by GPS stations, EDM measurements and analysis of InSAR images. We build a matrix of displacement solutions at data points for each potential element-source. We consider forward models characterized by heterogeneous medium and topographic free surface. A direct search is performed in the parameters space using the neighbourhood algorithm followed by an appraisal of the sampled solutions. From the inversions we retrieve a source located below the NW sector of Etna, at 6-7 km b.s.l. Our results suggest that while the effect of topography can be negligible, elastic heterogeneities in the medium can significantly alter the position of the inferred source. Furthermore, since the data show a significant signal in the SE sector due to flank instability, we also include in our study some simple sliding mechanisms.