Geophysical Research Abstracts
Vol. 13, EGU2011-10180, 2011
EGU General Assembly 2011

SISTEM approach: geodetic integration of satellite and in situ ground deformation data

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In this paper the SISTEM (Simultaneous and Integrated Strain Tensor Estimation from geodetic and satellite deformation Measurements) method is presented. This new approach is aimed to combine geodetic and satellite data in order to derive the 3D displacement components and the complete strain tensor. Combining GPS and DInSAR data allows us to take advantage of their complementary nature. Indeed GPS measure is a point-wise three dimensional data characterized by high time resolution. On the other hand DInSAR data is a mono-dimensional spatial distributed data characterized by a low time resolution (namely 35 days for ERS and Envisat data). Adequately integrating these data it is possible to produce high resolution three dimensional ground deformation maps over the whole investigated area.

Previous approaches in literature to combine GPS and DInSAR data require two steps: a first step in which sparse GPS measurements are interpolated in order to fill in GPS displacements in the DInSAR grid, and a second step to estimate the three-dimensional surface displacement maps by using a suitable optimization technique.

The SISTEM approach does not require preliminary interpolation of the observed deformation pattern, because it is based on a linear matrix equation which accounts for both GPS and DInSAR data, thus the estimation problem can be suitably solved by using the Weighted Least Square approach, hence avoiding complicated search schemes such as simulated annealing optimization algorithm; furthermore the SISTEM method provides simultaneously the strain tensor, the displacement field and the rigid body rotation tensor within the entire investigated area.

Among the potentials of SISTEM we emphasize that, since it is based on the theory of the elasticity, we may include additional datasets (such as leveling data, EDM, Tilt, and DInSAR data taken from different geometry or by different SAR sensor, e.g. ENVISAT or ALOS), by using similar formulations, based on the same unknowns.

Three real cases study are reported: the 2003-2004 inflation of Mt. Etna imaged by GPS and ERS2 ascending InSAR data, the Abruzzo 2009 earthquake studied combining GPS, ALOS ascending data and ENVISAT ascending/descending geometry, and the 2010 earthquake occurred along the Pernicana Fault (Mt. Etna - ITALY) studied integrating GPS, levelling, ALOS ascending data and ENVISAT ascending/descending data.