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Uncovering deformation processes from surface displacements

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The aim of this talk is to provide an overview about the most recent outcomes in Earth Sciences, describe the role of satellite remote sensing, together with GPS, ground measurement and further data, for geophysical parameter retrieval in well known case studies where the combined approach dealing with the use of two or more techniques/datasets have demonstrated their effectiveness.
The Earth Sciences have today a wide availability of instruments and sensors able to provide scientists with an unprecedented capability to study the physical processes driving earthquakes, volcanic eruptions, landslides, and other dynamic Earth systems. Indeed measurements from satellites allow systematic observation of the Earth surface covering large areas, over a long time period and characterized by growing sample intervals.
Interferometric Synthetic Aperture Radar (InSAR) technique has demonstrated its effectiveness to investigate processes responsible for crustal faulting stemming from the detection of surface deformation patterns. Indeed using satellite data along ascending and descending orbits, as well as different incident angles, it is possible in principle to retrieve the full 3D character of the ground motion. To such aim the use of GPS stations providing 3D displacement components is a reliable complementary instrument. Finally, offset tracking techniques and Multiple Aperture Interferometry (MAI) may provide a contribution to the analysis of horizontal and NS deformation vectors. The estimation of geophysical parameters using InSAR has been widely discussed in seismology and volcanology, and also applied to deformation associated with groundwater and other subsurface fluids. These applications often involve the solution of an inverse problem, which means the retrieval of optimal source parameters at depth for volcanoes and earthquakes, from the knowledge of surface deformation from InSAR. In recent years, InSAR measurements combined with traditional seismological and geophysical data, such as teleseismic waveforms, strong motion records and GPS, have also been used by geophysicists for improved rupture models. Many models use equations for a uniform elastic half space stemming from the Okada formulation, but improved data constraints and the use of increasingly sophisticated modeling and inverse methods allowed for the exploration of models with variation of elastic properties in layers or more complex representation of fault and lithosphere structure and rheology.
In volcanic studies the role of GPS and InSAR lies in the measurement of pre-eruptive inflation, co-eruptive deflation and the post-eruptive response. The spatio-temporal evolution of volcanic processes, the “breathing” of a volcano, can be monitored with temporal series of InSAR interferograms using multitemporal InSAR techniques. The measured deformation can be used as constraints for the formulation of the inverse problem, to retrieve information concerning the depth, size, shape of the magma chamber (and pressure change) and magma supply dynamics. Deformation modeling commonly relies on simple point sources, dikes and sills; or more complex volume-change sources to produce the different surface deformation patterns caused by magma intrusion.