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A Spatial Energy Balance Index to Analyze Geodetic and Seismic Time Series: The Eastern Flank of Mt. Etna Case Study

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In line with the aim of analyzing multivariate datasets, in this paper we propose a new methodology to merge different types of instrumental data, such as deformation data and seismic data, in order to extract and compare the common information about earthquake cycles. In particular, the development of large Continuously-operating Global Positioning System (CGPS) networks in recent years, has allowed measuring detailed surface deformations, generally used to obtain information on the strain accumulation along fault systems. The challenge is to combine the geodetic information coming from the CGPS networks with the seismic data from the earthquake databases. Here, we propose a Spatial Energy Balance Index (SEBI) which takes into account the accumulated geodetic strain and the seismically-released strain to quantify a balance of the energies, according to the elastic rebound theory. Indeed, a fault, being subjected to force and shift, accumulates energy and slowly deforms until its internal strength is exceeded, then releasing the accumulated energy. The proposed index synthesizes the energy state of an area, revealing possible dynamics of earthquake occurrences.
Furthermore, the paper sets out a novel technique for GPS displacement interpolation. The interpolation takes into account the GPS network topology and the topography effects to estimate the continuous displacement field at the surface. The technique is a combination of techniques coming from soft-computing algorithms; in particular, it is based on Cellular Automata and Artificial Neural Networks.
The whole process of data interpolation and index setting is mainly data-driven and consists of two steps: the first of model identification and a second step of testing.
The proposed approach was applied to the Eastern flank of Mt. Etna (Italy) for the period 2008-2012. Results quantify the energy state of different faults of the Mt. Etna's Eastern flank.