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Time Series Analysis OF SAR Image Fractal Maps: The Somma-Vesuvio Volcanic Complex Case Study

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The fractal dimension is a significant geophysical parameter describing natural surfaces representing the distribution of the roughness over different spatial scale; in case of volcanic structures, it has been related to the specific nature of materials and to the effects of active geodynamic processes.
In this work, we present the analysis of the temporal behavior of the fractal dimension estimates generated from multi-pass SAR images relevant to the Somma-Vesuvio volcanic complex (South Italy). To this aim, we consider a Cosmo-SkyMed data-set of 42 stripmap images acquired from ascending orbits between October 2009 and December 2012. Starting from these images, we generate a three-dimensional stack composed by the corresponding fractal maps (ordered according to the acquisition dates), after a proper co-registration.
The time-series of the pixel-by-pixel estimated fractal dimension values show that, over invariant natural areas, the fractal dimension values do not reveal significant changes; on the contrary, over urban areas, it correctly assumes values outside the natural surfaces fractality range and show strong fluctuations. As a final result of our analysis, we generate a fractal map that includes only the areas where the fractal dimension is considered reliable and stable (i.e. whose standard deviation computed over the time series is reasonably small).
The so-obtained fractal dimension map is then used to identify areas that are homogeneous from a fractal viewpoint. Indeed, the analysis of this map reveals the presence of two distinctive landscape units corresponding to the Mt. Vesuvio and Gran Cono. The comparison with the (simplified) geological map clearly shows the presence in these two areas of volcanic products of different age.
The presented fractal dimension map analysis demonstrates the ability to get a figure about the evolution degree of the monitored volcanic edifice and can be profitably extended in the future to other volcanic systems with very distinctive characteristics, with the aim to perform land classification, such as the identification of areas characterized by similar soil use, slopes and exposures.