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Infrared remote sensing of volcanic activity using Sentinel-3 images

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Recent advances in satellite remote sensing techniques have greatly assisted the observations of volcanic eruptions improving our understanding of volcanic phenomena and our ability to identify renewed volcanic activity. Thermal observations at high refresh rates carried out by satellite-based sensors have been proved particularly suited for both following the manifestations of the eruption once it has started, as well as providing an estimation of the effusion rate that is basic to forecast the areas potentially threatened by lava in an effusive scenario. Several different satellite-based sensors have been developed and continuous technology advances led to the development of more and more precise and accurate measurement instruments. In particular, the Sea and Land Surface Temperature Radiometer (SLSTR) on board SENTINEL-3, has a global coverage at 1 km spatial resolution with a daily revisit time (with two satellites), appropriate for climate and meteorology. In particular, SLSTR has two additional dedicated channels (F1 3.74, F2 10.85) for fire and high temperature event monitoring capable of detecting thermal events at $\sim$650 K without saturation. Moreover, the SLSTR dual view (near-nadir and backward) is important to investigate the topographic influence of the possible terrain shades on volcano thermal anomalies.

Here, we propose a pattern recognition tool based on the artificial neural network (ANN) to detect clouds and thermal anomalies associated with volcanic activity on SENTINEL-3 SLSTR images. The ultimate goal is to improve the performance of thermal infrared remote sensing measurements of high-temperature volcanic features. The proposed method is based on artificial neural networks (ANNs), biologically inspired computational models mimicking complex pattern of neuron interconnections in the brain. These have demonstrated excellent performance in tasks such as pattern recognition in digital image analysis. In particular, noisy training data are considered in order to avoid over-fitting while improving the robustness of ANNs. In fact, it is known that noisy training data helps improving ANN generalization capability. This classifier has been trained and tested on SLSTR images acquired in 2017 and 2018 over the area of Etna volcano in Sicily (Italy). This approach has been proved to be robust and suitable for volcano monitoring application on SENTINEL-3 data showing good performance in detecting both clouds and hot spots. Although this approach has been tested on Etna volcano, it can be exported to any other volcanic area.