Machine learning classifiers for detecting and classifying major explosions and paroxysms at Stromboli volcano (Italy) using radar and optical satellite imagery

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The persistent explosive activity of Stromboli is characterized by several hundred of moderate-intensity events per day. These explosions eject pyroclastic fragments to the height of some tens of meters, which fall a short distance from the summit vents. Occasionally, major explosions eject pyroclastic material to more than a few hundred meters high, which can fall outside the crater terrace on the area visited by tourists. The frequency of these phenomena is variable, with an average of 2 events per year. Paroxysms, violent explosions that produce eruptive columns more than 3 km high and are often associated with pyroclastic flows, can also occur at Stromboli. Ballistic blocks associated with these explosions can reach up to 4 m in diameter and fall on the inhabited areas. Paroxysms are rare (5 events in the last 20 years) and their occurrence frequency varies over time. Nevertheless, major explosions and paroxysms represent the main danger to visitors and inhabitants of the Stromboli Island. Here, we propose a novel approach to detect and classify the type of explosive activity occurring on Stromboli volcano by combining radar and optical satellite imagery with machine learning algorithms. In particular, we considered the plume height, the summit area temperature, and the area affected by large ballistic projectiles as the discriminant factors to distinguish between ordinary activity, major explosions and paroxysms. These factors are retrieved from both radar (Sentinel-1-GRD) and multi-spectral (Landsat-MSI and TIR) satellite images and fed to a machine learning classifier. A retrospective analysis is conducted investigating the main explosive events that have occurred since 1983. This algorithm is based on the in the Google Earth Engine (GEE), which is a cloud computing platform for environmental data analysis from local to planetary scales, with fast access and processing of satellite data from different missions.