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Editors: Ornella Cocina¹, Claudio Tranne², Alessandro Vona³, Marco Viccaro^{1,4}

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Cover In the foreground the crater "La Fossa di Vulcano". On the left, in the background, the snow-capped summit of Etna volcano. The photo (courtesy of Stefano Branca) was taken on 8 April 2022 during an overflight with the support of the Coast Guard of Catania | In copertina In primo piano il cratere La Fossa di Vulcano. A sinistra, sullo sfondo, la cima innevata dell'Etna. (Foto di Stefano Branca, ripresa l'8 aprile 2022 durante un sorvolo con il supporto del 2^o nucleo aereo Guardia Costiera di Catania).



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Fixing Criteria for Volcanic Unrest Warning

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In volcanic observatories worldwide, geophysical and geochemical data are usually collected remotely, providing continuous information about the state of volcanoes even in unfavorable conditions with respect to visibility and access to the area of eruptive centers. Early stages of unrest can be detected with high reliability; nonetheless, style and, in particular, intensity of eruptions are difficult to predict. Consequently, it turns out important to identify critical moments after which the development of a paroxysmal activity becomes highly probable.

In this perspective, we exploit a machine learning (ML) method for the analysis of seismic data continuously acquired by the permanent seismic network at Etna, Italy. Threshold criteria, which are based on parameters derived from the ML system and the number of stations where changes are detected, have been established with the scope of automatic alert flagging. As mild unrests may continue for weeks and even months, there is the need to adjust the trigger criteria with respect to style and intensity of the impending phenomenon. Our choice of the criteria was guided by so-called "Receive Operation Characteristics" (ROC) curves. These are based on the trade-off between the rate of False Positives and True Positives. With a more sensitive setting one can flag more paroxysms (True Positives); however, this may have the cost to flag an alert, but no paroxysm occurs. Carrying out various tests considering both the signal characteristics and the number of stations where the thresholds were met, we identified robust configurations allowing us to issue an alert of an impending paroxysm, widely avoiding the risk of false warnings. The system we propose here can provide timely and indicative information on possible eruptive scenarios to Civil Protection and other stakeholders. Also, it can be a guide for fixing onset and end-times of paroxysmal phenomena, which are especially helpful when image-based monitoring is hindered, for instance, by meteorological conditions. Finally, it offers the possibility to effectively re-analyze long time spans of data recorded in the past.