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Miscellanea

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Conferenza A. Rittmann

Nicolosi (Catania) 29 | 31 Ottobre 2014

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REGISTRAZIONE AL TRIBUNALE DI ROMA N.178 | 2014, 23 LUGLIO

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Sede legale: Via di Vigna Murata, 605 | Roma

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ISSN 2039-6651
Anno 2014_Numero 25

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Ornella Cocina e Eugenio Nicotra editors



25



**Istituto Nazionale di
Geofisica e Vulcanologia**

Sezione di Catania - Osservatorio Etneo



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Etna 2 luglio 1942
(Fondo fotografico Gaetano Ponte Archivio Fotografico Toscano Prato)

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Short-Term Impending Eruptive Activity at Mt Etna Revealed from a Multistation System based on Volcanic Tremor Analysis

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Over fifty eruptive episodes with Strombolian activity, lava fountains, and lava flows occurred at Mt Etna volcano between 2006 and 2013. Namely, there were seven paroxysmal lava fountains at the South-East Crater in 2007-2008 and 46 at the New South-East Crater between 2011 and 2013. Lava emissions lasting months affected the upper eastern flank of the volcano in 2006 and 2008-2009. Effective monitoring and forecast of such volcanic phenomena are particularly relevant for their potential socio-economic impact in densely populated regions like Catania and its surroundings. For example, explosive activity has often formed thick ash clouds with widespread tephra fall able to disrupt the air traffic, as well as to cause severe problems at infrastructures, such as highways and roads.

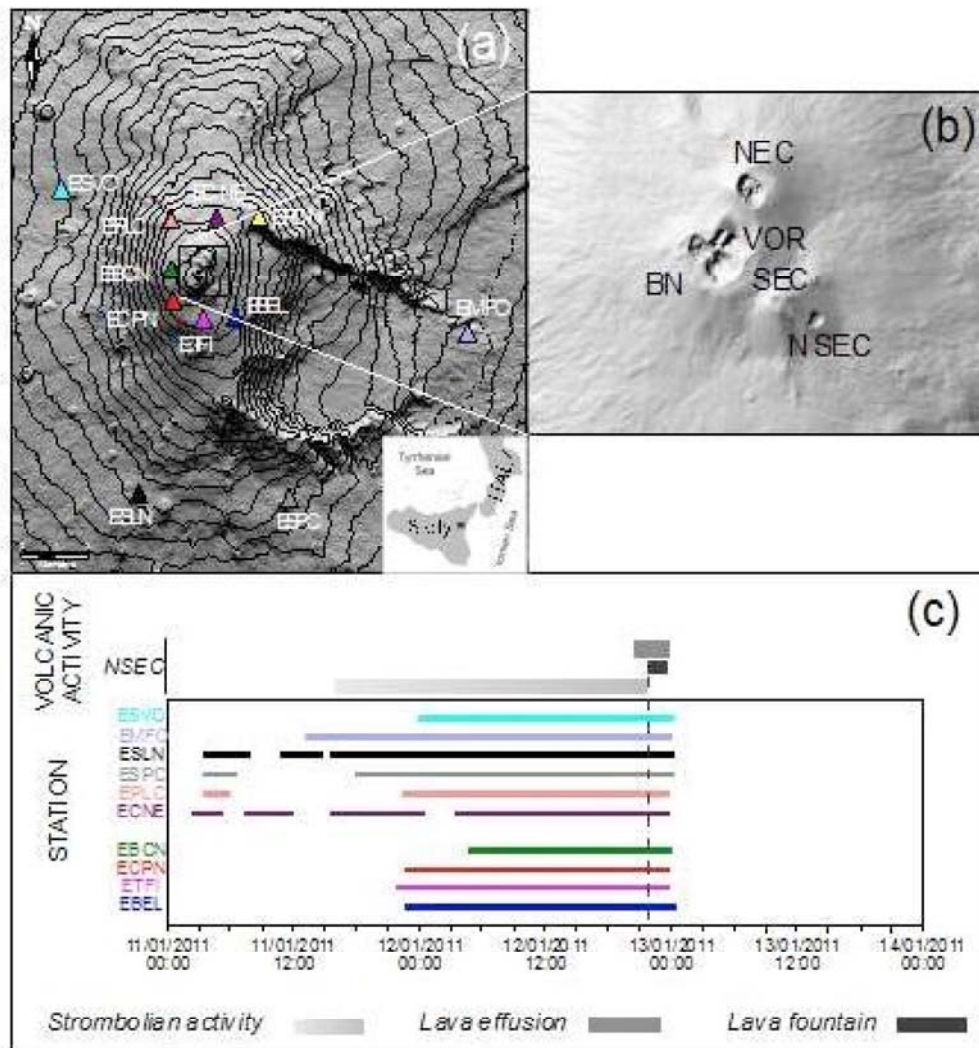


Figure 1. a) Seismic stations on Mt Etna. b) Craters: NEC, SEC, NSEC (North-East, South-East, New SE Crater); BN=Bocca Nuova; VOR=Voragine. c) Alarms flagged during an unrest. Bars on top mark different activity. Dashed line marks onset of the lava fountain.

Timely information about changes in the state of the volcano and possible onset of dangerous eruptive phenomena requires efficacious surveillance methods. The analysis of the continuous background seismic signal, the so-called volcanic tremor, turned out of paramount importance to follow the evolution of volcanic activity [e.g., Alparone et al., 2003; Falsaperla et al., 2005]. Changes in the state of the volcano as well as in its eruptive style are usually concurrent with variations of the spectral characteristics (amplitude and frequency) of tremor. The huge amount of digital data continuously acquired by INGV's broadband seismic stations every day makes a manual analysis difficult. In order to tackle this problem, techniques of automatic classification of the tremor signal are applied. In a comparative study, the robustness of different methods for the identification of regimes in volcanic activity were examined [Langer et al., 2009]. In particular, Langer et al. [2011] applied unsupervised classification techniques to the tremor data recorded at one station during seven paroxysmal episodes in 2007-2008. Their results revealed significant changes in the pattern classification well before the onset of the eruptive episodes. This evidence led to the development of specific software packages, such as the program KKAnalysis [Messina and Langer, 2011], a software that combines an unsupervised classification method (Kohonen Maps) with fuzzy cluster analysis. The operational characteristics of these tools - fail-safe, robustness with respect to noise and data outages, as well as computational efficiency - allowed on-line processing at the operative centre of the INGV-Osservatorio Etno in 2010 and the identification of criteria for automatic alarm flagging. The system is hitherto one of the main automatic alerting tools to identify impending eruptive events at Etna.

The software carries out the on-line processing of the new data stream coming from two seismic stations, merged with reference datasets of past eruptive episodes. In doing so, results obtained for new data are immediately compared to previous eruptive scenarios. Given the rich material collected in recent years, we are able to apply the alert system to eleven stations at different elevations (1200-3050 m) and distances (1-8 km) from the summit craters. Critical alert parameters were empirically defined to obtain an optimal tuning of the alert system for each station. To verify the robustness of this new, multistation alert system, a dataset encompassing about eight years of continuous seismic records (since 2006) was processed automatically using KKAnalysis and collateral software off-line. Then, we analyzed the performance of the classifier in terms of timing and spatial distribution of the stations. As an example, Figure 1a depicts the location of the seismic stations that were operative during an episode of eruptive activity evolving in paroxysm in 2011 [Behncke, 2011; INGV, 2011a, b]. Different colors allow us to follow the temporal order of triggers (Figure 1c). We also investigated the performance of the new alert system based on KKAnalysis in case of activation of whatever eruptive centre. Intriguing results were obtained in 2010 throughout periods characterized by the renewal of volcanic activity at Bocca Nuova-Voragine and North-East Crater, and in the absence of paroxysmal phenomena at South-East Crater and New South-East Crater. Despite the low-energy phenomena reported by volcanologists (i.e., degassing, low-to moderate explosions), the triggered alarms demonstrate the robustness of the classifier and its potential: i) to identify even subtle changes within the volcanic system using tremor, and ii) to highlight the activation of a single eruptive centre, even though different from the one for which the classifier was initially tested. It is worth noting that in case of activation of weak sources, the successful performance of the classifier depends upon the general level of signals originating from other sources in that specific time span.

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