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Array analysis of volcanic tremor during the 2008 Etna eruption.

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The origin of low frequency seismicity at active volcano, such as volcanic tremor, VLP and LP events, is thought to be associated with subsurface fluid migration and/or resonating fluid-filled conduits and cavities. Therefore, the precise location of these sources is a crucial steps toward imaging magma pathways geometry and the understanding of volcanic processes and associated hazards.

In order to address this issues, a joint Italy-Ireland-France team conducted a large-scale, passive seismological experiment aimed at complementing the permanent Etna monitoring system in the near-field instrumental coverage. The ETNAVOL08 experiment lasted throughout the second half of June, 2008, tracking the evolution of the summit eruption which began on May 13, 2008. After the powerful explosion at South East Crater (SEC) which occurred on May 10, 2008, a new eruption started on May 13 from an eruptive fracture which developed from the base of the North East Crater (NEC), and extended into the western side-wall of the Valle del Bove. This eruption ended on July 7th, 2009. Between the 18th of June 2008 and the 3rd of July 2008, we deployed a total of 50 broad band stations. Moreover, three small-aperture antennas, were installed around the crater area of the volcano: (i) close to the Pizzi Deneri volcanological observatory (APDN); (ii) close to the Cratere del Piano (ACPN), south of the Central Craters; (iii) close to the Belvedere station (ABEL), south of the South East Crater (SEC).

This work focus on preliminary results from a detailed analysis of ACPN array recordings spanning the time-interval of the ETNAVOL08 experiment. During this period, the seismicity is dominated by a background seismicity constituted by volcanic tremor band LP events, to which are over-imposed several low-energy volcano-tectonic earthquakes, these latter probably associated with brittle failure at the eruptive fracture. For ACPN array data, we first conduct spectral and coherence analysis in order to identify the most significant frequency bands for the subsequent filtering procedures. These analyses indicate that significant wavefield coherence is maintained throughout three frequency bands: (i) LP band (0.3-0.8 Hz.); (ii) tremor band (0.8-1.5 Hz.); HF band (1.5-3.0 Hz.). For these particular frequency bands, propagation azimuths and apparent velocity of the incoming wavefronts are retrieved by inverting the inter-station delay times for the two cartesian components of the slowness vector, under a plane-wave approximation.

At all frequency bands, the most representative values of ray parameter are in the 0.7-1 s/km range, corresponding to apparent velocities between 1 and 1.4 km/s; these values are consistent with a wavefield composed by both surface and body-waves impinging at the array with shallow incidence angle.

For the three frequency bands, propagation azimuths point to three different source regions: (i) For the LP band, the source is located west of the Central Craters; (ii) For the tremor band, the source is located beneath the Central Craters; (iii) For the HF band, the source is located beneath the SEC and the eruptive fracture. Throughout the analysed time interval, the distribution of the propagation parameters does not change significantly, thus indicating a time-stationarity location of the different sources.

Thus, only the HF tremor source seems to be directly correlated with the ongoing eruptive activity. This latter finding is consistent with results from inversion of the spatial distribution of seismic amplitude applied to the same data set. Though preliminary, all these results highlight the complexity of the tremor wavefield at Etna Volcano, where distinct sources act concurrently over different, partially-overlapping frequency bands. Further studies are thus needed in order to improve our quantitative understanding of the tremor wavefield, and its significance in terms of eruption forecasting.