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TOMO-ETNA Experiment –Etna volcano, Sicily, investigated with active and passive seismic methods

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The TOMO-ETNA experiment, as part of the European Union project “MEDiterranean SUpersite Volcanoes (MED-SUV)”, was devised to image the crustal structure beneath Etna by using state of the art passive and active seismic methods. Activities on-land and offshore are aiming to obtain new high-resolution seismic images to improve the knowledge of crustal structures existing beneath the Etna volcano and northeast Sicily up to the Aeolian Islands. In a first phase (June 15 - July 24, 2014) at Etna volcano and surrounding areas two removable seismic networks were installed composed by 80 Short Period and 20 Broadband stations, additionally to the existing network belonging to the “Istituto Nazionale di Geofisica e Vulcanologia” (INGV). So in total air-gun shots could be recorded by 168 stations onshore plus 27 ocean bottom instruments offshore in the Tyrrhenian and Ionian Seas. Offshore activities were performed by Spanish and Italian research vessels. In a second phase the broadband seismic network remained operative until October 28, 2014, as well as offshore surveys during November 19 -27, 2014. Active seismic sources were generated by an array of air-guns mounted in the Spanish Oceanographic vessel “Sarmiento de Gamboa” with a power capacity of up to 5.200 cubic inches. In total more than 26.000 shots were fired and more than 450 local and regional earthquakes could be recorded and will be analyzed.

For resolving a volcanic structure the investigation of attenuation and scattering of seismic waves is important. In contrast to existing studies that are almost exclusively based on S-wave signals emitted by local earthquakes, here air-gun signals were investigated by applying a new methodology based on the coda energy ratio defined as the ratio between the energy of the direct P-wave and the energy in a later coda window. It is based on the assumption that scattering caused by heterogeneities removes energy from direct P-waves that constitutes the earliest possible arrival to any part later in the seismic wave train. As an independent proxy of the scattering strength along the ray path, we measure the peak delay time of a direct P-wave, which is well correlated with the coda energy ratio. As a result the distribution of heterogeneities around Etna could be visualized as the projection of the observation in directions of incident rays at the stations. Increased seismic scattering could be detected in the volcano and east of it. The strong heterogeneous zone towards the east coast of Sicily supports earlier observations, and is interpreted as a potential signature of the eastward sliding volcano flank.

Beside the investigation of P-wave scattering the new seismic tomography software PARTOS (Passive Active Ray Tomography Software) has been developed based on a joint inversion of active and passive seismic sources. With PARTOS real data inversion has been carried out using three different subsets: i) active data; ii) passive data; and iii) joint dataset, permitting to obtain a new tomographic approach of that region.