4D velocity and attenuation tomography at Etna volcano (Italy) during 1994-2008

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A total of 4,000 well constrained earthquakes (40,000 P-wave arrivals and ca. 9,000 S-wave arrivals) recorded at Etna volcano during 1994-2008 interval time, have been inverted to compute a new 3D velocity and attenuation structure. The new velocity model has been calculated by using tomoDDPS code (Zhang et al., 2009) which simultaneously determines VP, VS, VP/VS models and event locations, according to a combination of absolute and differential arrival times. This method is able to produce more accurate event locations and velocity structures near the source region than standard tomography, which only uses absolute arrival times. The new attenuation structure has been computed following the approach outlined by Rietbrock, 2001. The inversion process of attenuation tomography can be divided into two main steps: the determination of t* in the frequency domain by the inversion of the P-wave spectrum, and the spatial inversion of the whole t* data set. t* is obtained modeling the far-field displacement of velocity spectrum. The medium is parameterized with the same 3D grid of nodes and velocity values obtained from 3D velocity model. The joint analysis of velocity and attenuation models (VP, VS, VP/VS, QP and QS) allows to better constrain the physical parameters of the area, in order to identify local lateral heterogeneities and/or fluid-filled cracked volumes. In particular, the attenuation of body waves is very sensitive to the thermal state of the crustal volume through which seismic waves travel and to the saturation of rocks with fluids and partial melts (Sato and Sacks, 1990 and references therein), giving the possibility to better understand the transient variations of the physical properties underneath the volcano during magma emplacement in the shallow crust.

After calculating the new velocity and attenuation structures using the whole initial data set and, on the basis of volcanological and geophysical observations indicating some cyclic recharging and discharging phases, we divided the initial data set into 9 different epochs. Then, we applied repeated three-dimensional tomography (4D tomography) thecniques to recognize possible changes in the velocity and attenuation anomalies during the different volcanic cycles observed in the study period (1999, 2001, 2002-2003, 2004, 2006-2007, 2008-2009). The results of this study suggest that time repeated tomography could provide a basis for more efficient volcano monitoring and short and midterm eruption forecasting.