ESC2016-319-1, 2016
35th General Assembly of the European Seismological Commission

High resolution 3D imaging of the Irpinia active fault zone part 1: Attenuation tomography

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Seismic tomography allows reconstructing images of the subsurface elastic/anelastic properties, which may provide insights on the physical conditions of the investigated medium (structural setting, fluid saturation, temperature etc.). These conditions are relevant to gain information about complex fault structures where large destructive earthquakes are expected to occur, as for the Irpinia fault zone in southern Italy. In a previous study, Amoroso et al. [2014] applied a delay time tomographic inversion technique to infer P- and S-wave velocity models, which indicate the presence of a high Vp/Vs volume including the hypocenter of the 23 November 1980, Irpinia earthquake and the recent microseismicity. The result was interpreted as a rock volume permeated by fluids. To better constrain and validate this interpretation, we performed a 3D attenuation tomography. We used the reduced travel time t*(i.e. the ratio of the slowness over the quality factor Q) data provided by Zollo et al. [2014] obtained from the inversion of the P- and S-wave displacement spectra of about 700 earthquakes occurred in the area recorded by the Irpinia Seismic Network (ISNet). To invert t* data, we modified the original tomographic code used for velocity by preserving the linearized iterative approach. Beside, we adopted a multi-scale inversion strategy. We started inverting for a coarse attenuation model (grid spacing 12x12x4 km3), which then used as starting model for a finer parametrization (6x6x2 and 3x3x1 km3). We show that this strategy allows improving both the stability and the resolution of the results.

The resulting 3D models exhibit significant spatial variations. As a general feature, the quality factor slowly increases with depth reaching values ranging between 50 and 250 at 6 km. In particular, Qp increases up to 1000 between 8 and 10 km depth while at larger depths this feature disappears. The volume involved in this significant increase is spatially correlated with the fault structure associated with the Irpinia earthquake. Qs shows different characteristics, being more sensitive to the structural setting, probably because of the different sensitivity of P- and S-waves to lithology, porosity and type of permeating fluids. In fact, even with the coarsest adopted parametrization, we observe important lateral variations along SW-NE direction (i.e. perpendicular to the strike of the Apennine chain) highlighted by a sharp lateral attenuation contrast with values reaching 1600 at SW, and very low values (up to 200) at NE.

References

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