Geodynamic – seismological modelling of the Etna volcano structure and dynamics

(Proposer: Prof. Manuele Faccenda)

Monitoring areas with great volcanic hazard is crucial for decision-making processes and risk reduction, especially in densely populated areas. In fact, in active volcanic areas forecasting the onset of an eruption remains a significant challenge given that episodes of unrest are highly variable in character. Monitoring of active volcanic fields is mainly based on several geological and geophysical indicators that may facilitate eruption forecasting. These include tracking (i) accelerating rates of seismicity and deformation that may be detected before eruptions, (ii) the location of volcano-tectonic earthquakes in near real time, (iii) changes in gas emissions, (iv) changes in the geochemistry, temperature and level of crater lakes and groundwater. However, none of these indicators can provide detailed information about changes in the internal and deep structure of volcanic fields and, as a matter of fact, at present little is known about the time-evolution of the 3D subsurface structures that precedes a major volcanic eruption. Magma injection at depth and migration toward the surface can also cause large modifications of the medium elastic properties due to the replacement of solid rocks with fluid magma. These modifications can be tracked with seismic tomography, a widely used and non-invasive imaging method where seismic datasets are inverted to yield 3D seismic velocity models from which it is possible to infer the subsurface structure. However, the 3D velocity models are representative of the data acquisition time window, and for this reason provide an average, time-independent depiction of the subsurface structure.

The research activities intend to characterize the structure and dynamics of the Etna volcano (Figure 1) and its power systems through geodynamic modeling (Figure 2) and 3D and 4D anisotropic seismic tomographies. The latter allow us to reconstruct structures such as dykes, sills and the stress field to which the migration of magma and induced earthquakes are closely connected. Consequently, this multidisciplinary approach could have as potential developments the modeling of the conditions that lead to eruptive processes and the identification of the signals that precede eruptions.

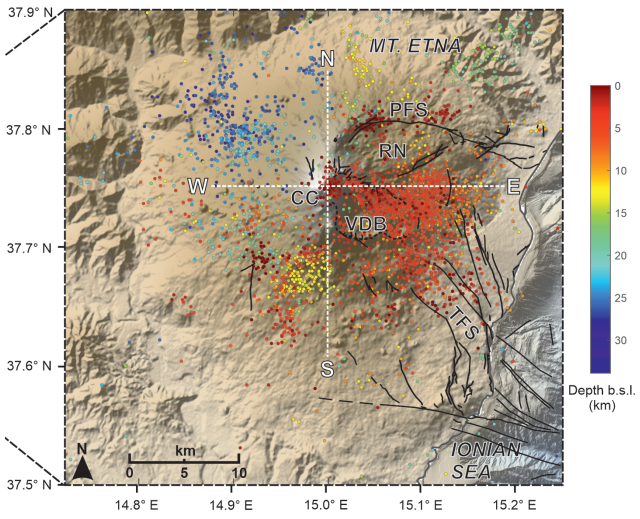

Figure 1 –Top view of the Etna volcano and local seismicity.

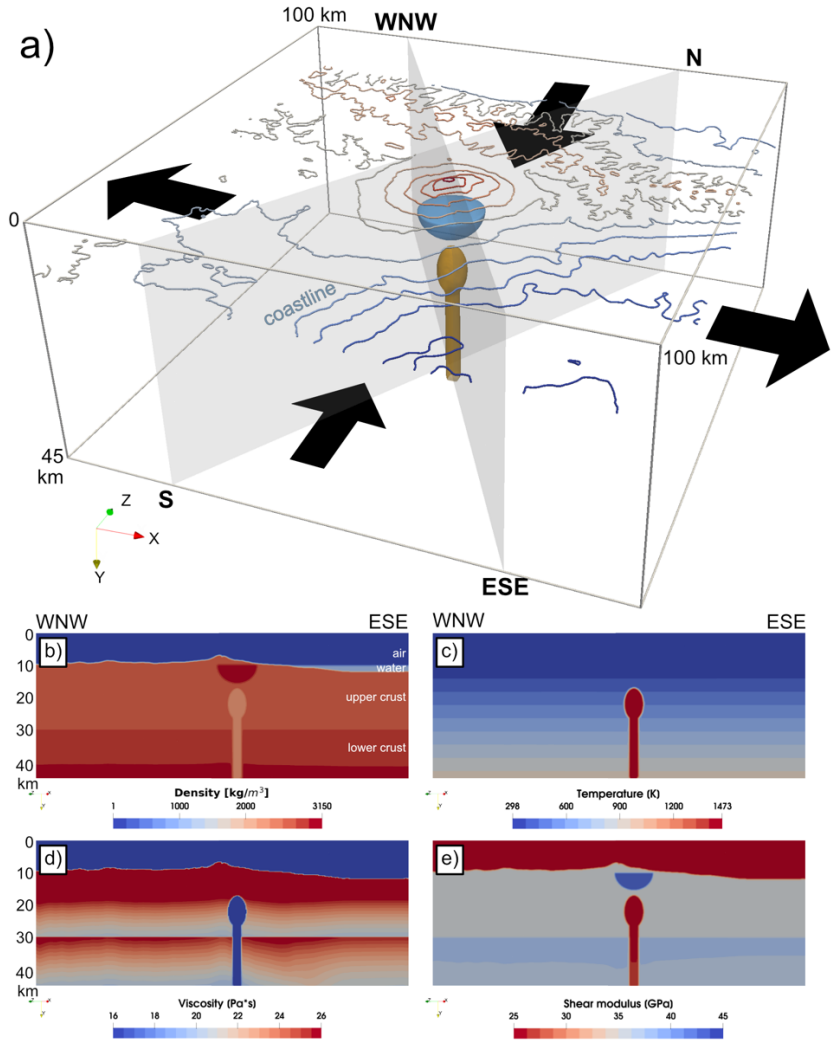

Figure 2 –a) 3D geodynamic model setup for studying the effects of tectonic stresses (black arrows), topographic load (contour lines), over pressurized magma chamber (orange) and a high-velocity body (blue). b-e) WNW-ESE cross sections of the density, temperature, viscosity and shear modulus fields.

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