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Geodynamics and seismic hazard in the Calabrian Arc: towards a Messina earthquake supersite

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The Messina region represents a key site of the Mediterranean, where active faulting, seismic shaking, volcanism, rapid uplift and landslides represent the surface manifestation of deep processes. Fast deformation results in one of the highest seismic hazard of the Mediterranean, as testified by historic destructive earthquakes occasionally accompanied by submarine mass flows and tsunami-events that added death and destruction to the already devastating effects of the earthquakes.

Several geophysical and geological studies carried out during the last decades help defining the kinematics and the dynamics of the system. The tectonic evolution of the Messina region is strictly linked with the Southern Tyrrhenian and Calabrian Arc system, the retreat of the Ionian slab and the back-arc basin opening. The present-day geometry of the Calabrian slab, as well imaged by tomographic analyses and shallow-to-deep seismicity, shows a narrow slab plunging down steeply into the mantle. At 100-150 km depth, the southern edge of the slab is positioned beneath Northeastern Sicily, approximately between Tindari and Messina.
Within this frame, several relevant questions are still unsolved. For example, it is not clear how the upper plate may deform as a response of a differential sinking of the subducting slabs, or how deep mantle flow at the slab edge may influence the pattern of surface deformation.
Structural and geodetic data show the first-order pattern of deformation in Northeastern Sicily, and define the Tindari-Messina area as the boundary between a region in compression to the west, dominated by the Africa convergence, and a region in extension to the east-northeast, dominated by slab rollback. In addition, geodetic studies also show an increase of crustal motion velocity from Sicily to Calabria with an overall clockwise rotation of the velocity vector. This pattern of surface deformation evidences a sharp extension process active in the Messina region. The elevation of marine terraces indicates that vertical uplift in this region is occurring at a very high rate, locally more than 1 mm/yr, and of the same order of magnitude estimated for horizontal deformation. This pattern is also indicative of non-isostatic deformation that may be related to deep mantle dynamics.
The Messina Straits region represents a very rare opportunity to investigate a wide variety of interrelated geological processes resulting in different types of high-impact geo-hazards affecting a single region. Notwithstanding the disastrous societal and economic impacts that these geo-hazards might cause in the study area, this opportunity, along with the ambition of revealing fundamental aspects of how mantle processes are coupled to shallow and surface ones, are among the main scientific motivations to propose the Messina Straits as a GEO earthquake supersite.