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Reappraisal of the 1887 Ligurian earthquake (western Mediterranean) from macroseismicity, active tectonics and tsunami modelling

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Early in the morning, of February 23, 1887 a major damaging earthquake hit the towns along the Italian and French Riviera. The earthquake was followed by a tsunami wave with a maximum runup of 2 m near Imperia. At least 600 hundred people died, mainly due to building collapses. The "Ligurian earthquake" occurred at the junction between the Southern French-Italian Alps and the Ligurian Basin in the western Mediterranean. For such historical event, the epicentre and the equivalent magnitude are difficult to characterize with a high degree of precision, and the tectonic fault responsible for the earthquake is still debated today. The recent MALISAR marine geophysical survey allowed identifying a set of N60-70°E recent scarps at the foot of the northern Ligurian margin, revealing a large system of active faults. The scarps correspond to cumulative reverse faulting, with a minor strike-slip component, consistent with the present-day kinematics of earthquakes. Since we have also identified submarine failures in the time-range of the Ligurian earthquake we addressed the question of the submarine slide-induced tsunami. Nevertheless, the maximum volume involved by these submarine slides was in the range of 0.005 km3. Such a volume appears too small to trigger a tsunami with the observed extent and run-up characteristics. Therefore, we propose that the rupture of fault segments belonging to the 80 km-long northern Ligurian Faults system is the source of the 1887 Ligurian earthquake. We investigate the macroseismic data from the historical databases SISFRANCE-08 and DBMI-04 using several models of intensity attenuation with distance and focal depth. Modelling results are consistent with the location offshore, indicating an epicentre around 43.70°-43.78°N and 7.81°-8.07°E with a magnitude Mw in the range of 6.3-7.5. A refinement of this range of magnitude is discussed in the light of the tsunami modelling. Numerous earthquake sources scenarios have been tested with hydrographic data (tsunami modelling and observations). The main material used here is the tide gauge record at Genoa harbour. As a result, we present several characteristic source earthquakes scenarios for a shallow strong earthquake occurring below the northern Ligurian margin. This effort indicates that the scenarios of a magnitude Mw of 6.8-6.9 along a reverse N55°E striking fault are the best candidates that could explain the known characteristics of the induced tsunami. The best-fit scenarios correspond equally to a 70°-dipping southward fault plane with Mw 6.8 and to a 16°-dipping northward fault plane with Mw 6.9. Taking into account the geometry of the active faults, the location of the macroseismic epicentre and the morphotectonic evolution of the continental slope, we propose that the 1887 Ligurian earthquake correspond to the reverse faulting of a N55°E striking fault plane dipping to the North with a co-seismic slip of 1.5 m.