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When probabilistic seismic hazard climbs volcanoes: how 3D topography and scaling relationships influence hazard estimates. An example from Mt. Etna (Italy)

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We perform probabilistic seismic hazard assessment (PSHA) in the eastern flank of Mt. Etna, Sicily due to local volcano-tectonic earthquakes. Despite being low magnitude (ML<5.2), these earthquakes are capable of producing severe damage and even destruction because of their shallow hypocentres. Furthermore, local communities constantly suffer unease and economic loss due to the high occurrence rate of these earthquakes. This work has been conducted within the framework of the V3 Project, which was funded by the Italian Department of Civil Defence and represents the first efforts to perform PSHA specific to Mt Etna in terms of ground acceleration, while previous studies are either national-scale or in terms of macroseismic intensity.

The model preparation and calculations are performed using the OpenQuake-engine. We use a composite source model including fault, area, and 3D gridded seismicity sources. For the fault sources, earthquake occurrence is estimated using a historical approach (inter-time statistics of major earthquakes) and a seismotectonic approach (fault geometry and slip rate), and also considers time-independence and time-dependency. Earthquake occurrence rates are calculated using the open-source software code FiSH. A logic tree is then adopted to account for epistemic uncertainties. Final hazard maps focus on short to mid-term exposure times (5 and 30 years) and are intended to compliment the one calculated for the national territory (50 years), to define priorities of retrofitting at a local scale.

Working in this region presents unique problems including propagation of the seismic energy in a volcanic region, and taking into account the topographic surface of the volcano when computing the source-to-site distances. Therefore, we implemented into the software a ground-motion prediction equation and a scaling relationship specifically derived for Mt Etna, and have also made changes to include the 3D topographic surface of the volcano in the calculation by defining the location of sources and sites relative to the sea level. This impacts source-to-site distances because the elevation of the volcano increases sharply from sea level to 3 km, over a horizontal span of 20 km. The analyses and tests presented here highlight the influence of the above elements on the final hazard.