Earthquake source models based on faults are increasingly being incorporated in seismic hazard assessment. We present 3 probabilistic seismic hazard assessment (PSHA) case studies in Italy that include fault models: the volcanic region of Mt Etna, the Collalto natural gas storage site, and Central Italy following the Amatrice earthquake.

Each of the studies aims to incorporate realistic geological complexities, which is facilitated by using the flexible seismic hazard modeling software, the OpenQuake-engine. For example, all of the studies use complex (i.e. non-rectangular) fault sources to model fault surfaces. We also incorporate the topographic surface in the hazard calculation at Mt Etna, and model aftershock hazard in Central Italy on the fault surface responsible for the Amatrice mainshock.

Sensitivity studies show how changing fault geometry can have large influences on hazard particularly for sites near the rupture surface, and how this depends on the choice of the GMPE. The results of this work are most relevant when working at the local and site-specific scales.

**Mt Etna: Volcanic features**

- Mt Etna region (Sicily) is modelled by small surficial "tectonic" faults that breathe with the volcanic activity (Azzaro et al., 2017; Perezza et al., 2017); they are characterized by high quality datasets and intersect a rough topographic surface; local site response cannot be treated by simple rules (e.g. V-S). Thus, we customized the seismic hazard software, e.g. the OpenQuake-engine, to account for some peculiarities in volcanic contexts, such as GMPE, magnitude scaling relations, to use of a digital elevation model (DEM) for the sites of the hazard calculation and for modeling non-Poissonian processes.
- Results show that the small magnitudes of surficial volcanic-tectonic events have a strong impact on 5-10 year shaking forecasts, thus driving retrofitting and impending strategies for risk reduction.

**Central Italy:** aftershock hazard is driven by the occurrences of minor-moderate earthquakes. Simple rules on the decay of aftershock, joined with a precise fault geometry definition and hypocentral parametrization of the main events, are able to reproduce the observations.

**Collalto: listric blind thrust**

- Collalto Stoccaggio is a natural gas storage facility, located within the thrust and fold system of South-Eastern Alps. The listric geometry of the faults is depicted thanks to the HG seismometric network installed for monitoring the potential seismocities induced by the storage (Pirolo et al., 2015 and http://rete-collalto.crs.inosg.it/en)
- The area has been affected by a Mw earthquake in the XIX century; the fault source is unknown; the seismic potential/coping behavior of Montalto thrust debated.
- No correlation between the storage activities and seismicity has been observed since 2012 (Romano et al., 2016); this means the hazard at the site is determined by natural seismicity.
- We performed sensitivity studies to reckon the influences of blind fault geometries on hazard for sites near the rupture, and their dependence on the GMPEs.

- We performed Aftershock PSHA just after the August 24th, 2016 Amatrice earthquake (Pezzuzza et al., 2016). The time-dependent model computes occurrence rates with a decrease following an Omori-Libbo decay curve.
- Different partitioning scheme is used, all based on very simple rules.
- After the occurrence of the October "main" events, the Omori curve is done by the summation of decay curves.
- Aftershock hazard is compared with observations at some accelerometric/velocometric stations.
- The agreement of modelled and observed hazard is very promising.

**Central Italy:** aftershock hazard is driven by the occurrences of minor-moderate earthquakes. Simple rules on the decay of aftershock, joined with a precise fault geometry definition and hypocentral parametrization of the main events, are able to reproduce the observations.

### Complex Source Modelling in Italy: Hints from some Case Studies

**Premise**

- All use the same fault source: geometry and magnitude frequency distribution.
- Comparison to hazard using different NGA-West2 GMPEs (Seismic Network, Abrahamson et al., 2016); seismicity rates are taken from the initial investigation period.
- Sensitivity to GMPE distance metric.
- Sensitivity to fault geometry.
- Sensitivity to topography.
- Sensitivity to GMPEs.
- Comparison of hazard using different NGA-West2 GMPEs (Azzaro et al., 2016).

**Results and comparison with observations**

**Central Italy:** aftershock hazard is driven by the occurrences of minor-moderate earthquakes. Simple rules on the decay of aftershock, joined with a precise fault geometry definition and hypocentral parametrization of the main events, are able to reproduce the observations.

**Take home message**

- Collalto: if you don't know the fault geometry with precision, avoid using sophisticated fault source models as they can drive the hazard in wrong places.
- Mt Etna: metrics of volcanic regions is different (e.g. for MSR, magnitude scaling relation; GMPE, ground motion prediction equation); minor-moderate earthquakes (M=4.5) and topography/local site response are key components.