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BOOK OF ABSTRACTS
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Assessing the seismic hazard of the Campotosto Lake dams by near-source ground motion simulations

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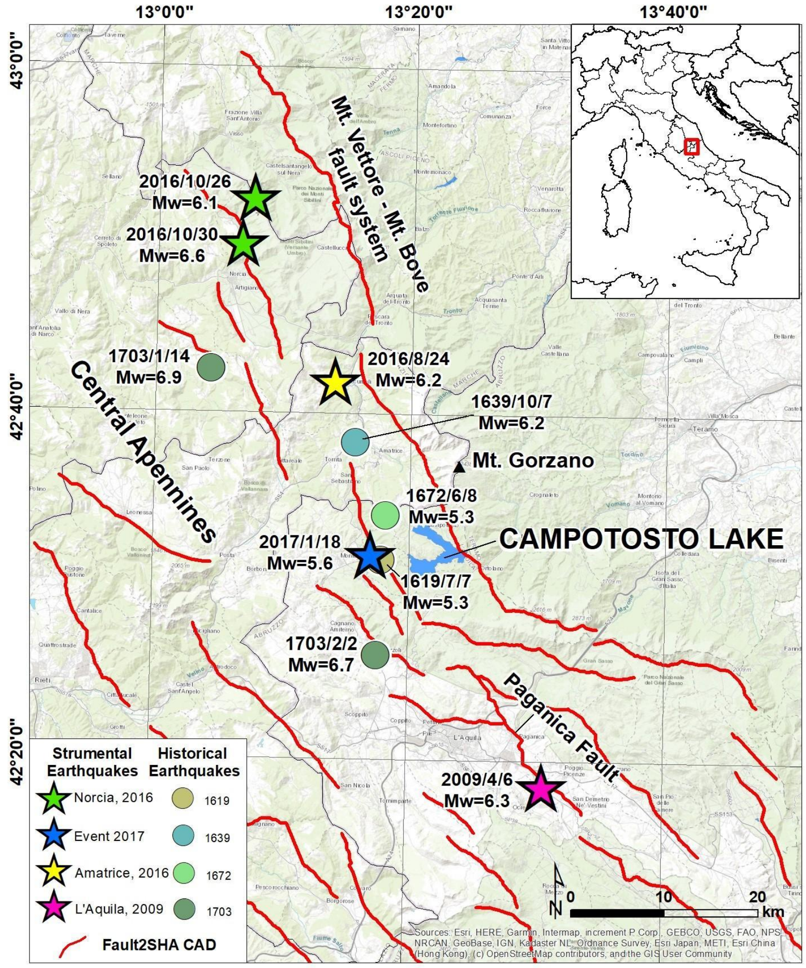
Reliable estimates of the ground motion in the near-source are crucial to evaluate the seismic hazard, mainly if some critical facilities operate there. Ground motion models (GMM) are weakly constrained in the near-source because of the lack of recorded waveforms. Numerical simulations can fill this gap and provide the input design for specific sites.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Fig. 1 Map of the study area with the capable active faults (red lines) taken from the Fault2SHA CAD (Faure Walker et al., 2020); the historical (circles) and major instrumental earthquakes (stars) are also plotted (reproduced from Moratto et al., 2023).

We apply the Probabilistic Seismic Hazard Analysis (PSHA) and compute Physics-Based Simulations (PBS) of ground motion for three dams in the Campotosto area (Central Italy). The dams, which confine an artificial water reservoir feeding hydroelectric power plants, are located in an active seismic zone between the 2009 L'Aquila and 2016-2017 Central Italy seismic sequences (Fig. 1). The PSHA is performed following the approach of seismotectonic probabilism by modelling fault sources (Chartier et al., 2019). The disaggregation of the probabilistic seismic hazard, calculated for the return period of 2475 years (Fig. 2), corresponding to the collapse limit state for critical facilities, provides the magnitude-distance pair of M_W=6.75±0.25 within the first 10 km of distance. This magnitude-distance pair represents the most influencing earthquake for the hazard estimate in the study area.

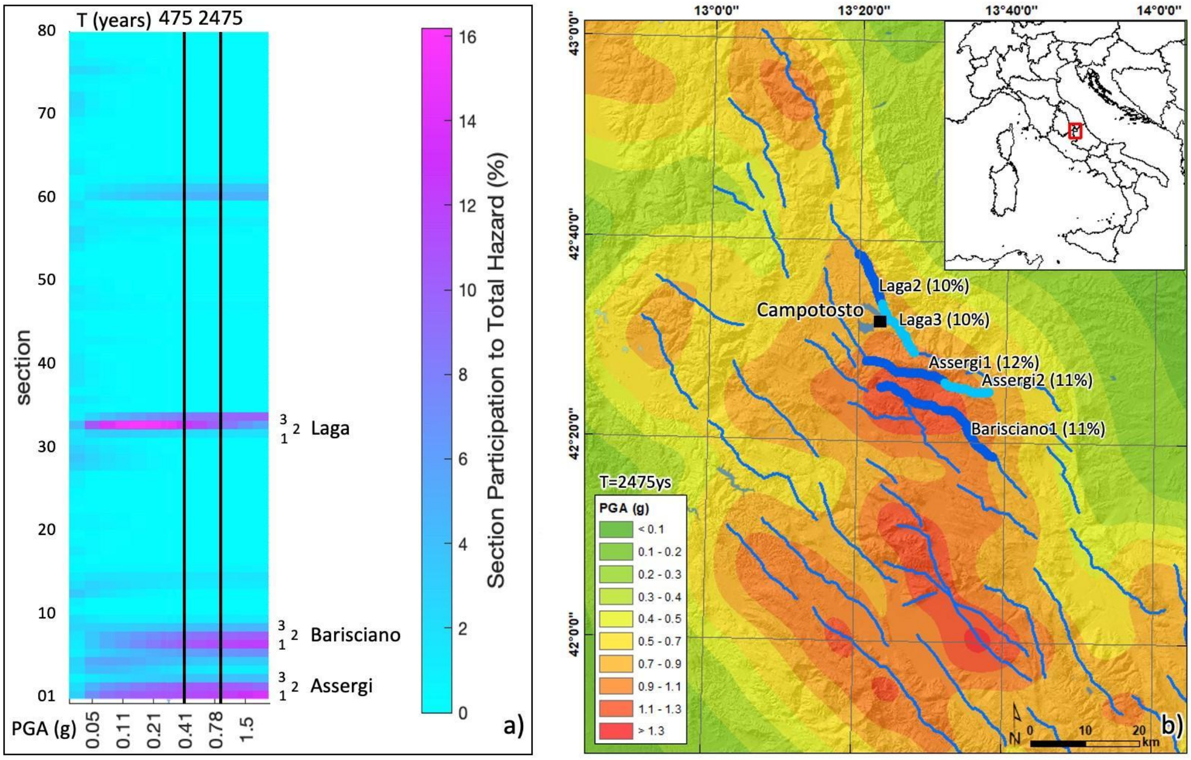


Fig. 2 a) The contribution of the sections utilized in PSHA, for each PGA level, to the probability of exceedance (POE) of that PGA level; the black lines correspond to the 475 and 2475 years return period. b) The PGA map for the 2475 years return period and the sections (thicker lines) of the faults that contribute most to the hazard of the Campotosto site (PGA 0.816 g) and surroundings for that return period; blue and light blue lines evidence different fault sources (reproduced from Moratto et al., 2023).

The PBS computation (Moratto et al., 2015) assumes as the Maximum Credible Earthquake case an Mw=6.7 earthquake and it is consistent with some field geology studies (e.g. Boncio et al., 2014). It provides the ground motion parameters for three receivers (PCB=Poggio Cancelli; RFC=Rio Fucino; SPD=Sella Pedicate) placed in near-source close the three dams that confine the Campotosto Lake. The ground motion variability is captured by a pseudo-dynamic source model (Mena et al., 2012), which encompass spatial and temporal variations in the slip, rise time, and rupture propagation, heavily affecting the near-source ground motion. Indeed, the ground motion above the rupture volume is mainly influenced by the epistemic uncertainties of rupture nucleation and slip distribution (e.g. Moratto et al., 2017).

We reproduce the variability due to the source rupture parameters that affect the simulated ground motion in the near-source (Fig. 3). This variability is related to the rupture propagation model heterogeneities and reliable finite fault parameters input in the modelling. The most significant ground motion values are obtained above the rupture area (PCB and SPD receivers), particularly at long periods. At the same time, high-frequency shaking characterizes the RFC receiver placed at the edge of the main fault. On average, the associated variability can reproduce the strong motion characteristics recorded in near-source for similar earthquakes. The Campotosto scenario shows that the vertical component might experience shaking values comparable with the horizontal. Therefore, their quantification can better constrain seismic hazard in the near-source area and support seismic design. The considered GMM (Schiappapietra et al., 2022) probably underestimates the vertical component's ground motion, especially at longer periods and above the rupture area (Fig. 3). In contrast, our PBS simulations generate vertical peak parameters and spectra comparable with the values recorded in near-source for the 2016 M_W 6.6 Norcia mainshock, also in the low frequency band (PGD and SO).

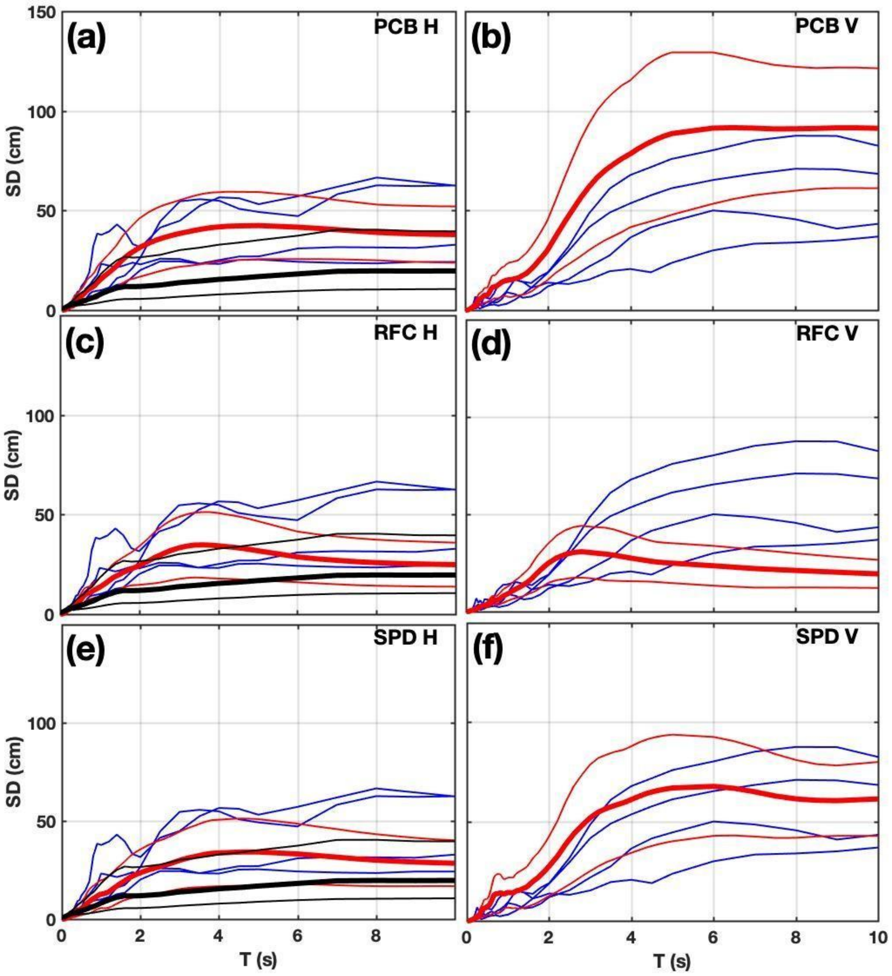


Fig. 3 Comparison between GMM (Schiappapietra et al., 2022; black lines), recorded SD spectra (Sgobba et al., 2021; blue lines), and PBS mean displacement spectra (red lines) at a) and b) PCB, c) and d) RFC; e) and f) SPD; on the left panels the horizontal component (geometrical mean), on the right boards the vertical component. Thin red and black lines show the related standard deviation (reproduced from Moratto et al., 2023).

The computed broadband seismograms constrain the upper bound of the simulated ground motion at specific sites; numerical simulations can exceed the limits of the GMM in the near source to fit observations and define reliable seismic input. However, ground motion simulations require a constrained definition for the seismic source, the propagation, and local site effects; adequate knowledge of these parameters' bounds is a primary key to defining reliable strong motion and uncertainties of the results.

This approach, extensively described by Moratto et al. (2023), can be applied in other areas with high seismic hazard to evaluate the seismic safety of existing critical facilities.

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