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Site-specific characterization, single station sigma, host-to-target adjustments and non-linear behavior: Combined effects on seismic hazard estimates.

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Several recent dramatic events drew the attention on the need to carefully reassess the very rare, high-impact, seismic hazard for large urban centers and critical facilities. Following this aim, the present trend all over the world is to more and more rely on probabilistic approaches to estimate seismic hazard, and determine annual exceedance probabilities for various ground-motion levels (down to very low probability levels). Most developments regarding the probabilistic seismic hazard assessment ("PSHA") methods have been concentrated on rock sites, although many cities and critical facilities are located on (soft or stiff) soil sites, which can significantly affect the shaking. In most PSHA studies, the amplification of the soil at the site is taken into account in a crude way, where hazard estimates can be both under-estimated (e.g. site specific resonance effects are ignored) or over-estimated (nonlinear effects are ignored or improperly assessed). Critical facilities designed neglecting local site effects within the framework of PSHA may thus have unknown safety margins, with the possibility of under-design. This work contributes to provide recommendations for the incorporation of site response in PSHA estimates, from the lessons learned from an example application. Site-specific PSHA should in principle combine the use of single-site sigma, site-specific characterization, host-to-target adjustments and non-linear behavior of a soil column; the first item of this list leads to a significant reduction of the hazard estimate for long return periods, while the complexity of the other items introduce additional epistemic uncertainties. This will be illustrated on the case of site-specific hazard assessment for a 5000 year return period at the middle of the EUROSEISTEST valley (30 km east of Thessaloniki, Greece), a site where site effects have been extensively studied both experimentally and numerically. We have successively performed single station sigma hazard calculations, host to target adjustments when required, and various ways to account for site amplification (site-specific residuals, instrumental site-to-reference spectral ratios, 3D linear and 1D non-linear simulations). Their respective impact on hazard estimates and the associated uncertainties will be presented and discussed, and some practical recommendations will be issued.

Keywords: Site Effects, Epistemic Uncertainty, PSHA, Single Station Sigma, Host to Target Adjustments, Nonlinear Effects.