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Developing an urban-scale 3D geophysical model for Basel, Switzerland

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Assessment of seismic risk at a local scale is fundamental to the adoption of efficient risk mitigation strategies for urban areas with spatially distributed building portfolios and infrastructure systems. An important component of such a study is to estimate the seismic ground motion amplification which is mainly controlled by parameters such as the local shear-wave velocity (Vs) structure. In this view, we attempted to characterize the shallow subsurface structure at an urban scale under the framework of developing an earthquake risk model for the canton of Basel-City in Switzerland. Different studies undertaken over last two decades in the area concluded that unconsolidated sediments were responsible for inducing fundamental resonance and large amplification of seismic waves over a range of frequencies pertinent to the engineering interest. They also highlighted the necessity of better characterizing complex geological domains (the Upper Rhine Graben and the Tabular Jura) and tectonic settings (the East Rhine Graben fault system) of the area. Therefore, we take a step forward by developing a three-dimensional (3D) geophysical model for Basel, which explicitly accounts for subsurface geological complexities.

We realize that the conventional optimization inversion techniques are limited in their ability to account for the inherent non-uniqueness of the inverse problem and related uncertainties in retrieving Vs profiles. Therefore, we apply a novel Bayesian inversion approach based on a Multizonal Transdimensional Inversion (MTI) and perform a joint inversion of multimodal Rayleigh- and Love-wave dispersion curves (DCs) along with Rayleigh-wave ellipticity. Such a joint inversion of Rayleigh- and Love-wave DCs could be performed only for a few sites in Basel in the past. We retrieve one-dimensional (1D) Vs profiles from 33 seismic ambient noise arrays located within about 130 sq. km area by using a single-zone transdimensional model space with homogeneous priors. We then divide the model space in different zones based on horizon depths extracted from the rigorous 3D geological model of Basel. We perform a mulitizonal inversion by drawing relevant constraints on the parameters within these zones. This process improves the final models as the major Vs contrasts and their depths are better resolved, especially in the complex sedimentary structure of the Rhine Graben area. The validation is performed by calculating the 1D site amplification and comparing it with that from seismic observations. Solution of the Bayesian inversion provides the posterior Probability Density Function (PDF) that results from prior

expectations and observed data supplemented by an expected distribution of data errors. Hence, the model uncertainties propagated from DCs to Vs profiles is better accounted for. We perform a combined analysis of all the inverted Vs profiles and their PDFs in order to characterize the horizons from the 3D geological model by means of geophysical parameters within their uncertainy bounds. The developed 3D geophysical model will be used to estimate ground motion amplifications and simulate risk scenarios for Basel.