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DEVELOPING EARTHQUAKE GROUND MOTION MODELS FOR ICELAND USING BAYESIAN HIERARCHICAL MODELING

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Ground motion models (GMMs) are the key element of probabilistic seismic hazard assessment (PSHA). These models predict an earthquake ground motion intensity measure as a function of some independent variables that represent the earthquake source, path and site effects. The latter one can substantially influence the PSHA results since they are critical factors affecting the amplitude, frequency content, and duration of seismic waves. In regions with different geological characteristics, therefore, site effects should be appropriately accounted for in GMMs and thus PSHA. This is the case for southwest Iceland where due to its distinct geological characteristics (e.g., lava layers interbedded with sedimentary deposits), site-specific amplification varies significantly across different geological units, particularly at higher frequencies.

Therefore, in this study we develop a new set of GMMs with frequency-dependent site amplification factors for four site categories (i.e., hard rock, rock, lava, and stiff soil) in Iceland. For this purpose, we use advanced Bayesian hierarchical modeling (BHM). The BHM framework reduces uncertainty and enhances the reliability of predictions. The models also benefit from the inclusion of site-specific parameters, such as frequency-dependent amplification factors, which account for Iceland's unique geological conditions [1]. Moreover, due to the limited strong-motion data in Iceland, particularly for larger magnitudes, developing GMMs with all the essential terms such as magnitude saturation, magnitude-dependent distance scaling and inelastic attenuation terms, is challenging [2]. In this regard, the Bayesian statistical approach can be particularly useful as it allows taking prior information about the model parameters into account and adding it to the information in the likelihood that stems from the observed data. This study utilized 83 strong-motion records from six strike-slip earthquakes (M_w 5.1-6.5), recorded at 34 seismic stations across diverse geological settings.

In GMMs, uncertainty in the median prediction values is epistemic which depends on the GMM's functional form. To consider the epistemic uncertainty therefore, we take different functional forms as those used and proposed in Kowsari et al. [3]. It is worth noting that they proposed a new functional form specifically calibrated to Icelandic strong-motions that incorporates depth-dependent magnitude scaling and frequency-independent site effects to improve the applicability of GMMs in Iceland. Later, this epistemic uncertainty can be taken into account in PSHA using either a backbone or logic tree approach [4,5]. Figure 1 shows the Bayesian hierarchical ground motion models (BH-GMMs) developed in this study. This figure illustrates the attenuation of BH-GMMs for peak ground acceleration (PGA) at four site classes along with the observed Icelandic strong-motions (colored circles) that are color-coded by their corresponding magnitude. The models are evaluated at magnitudes M_w 5.2 (dotted line), M_w 6.4 (solid line), and M_w 7.2 (dashed line).

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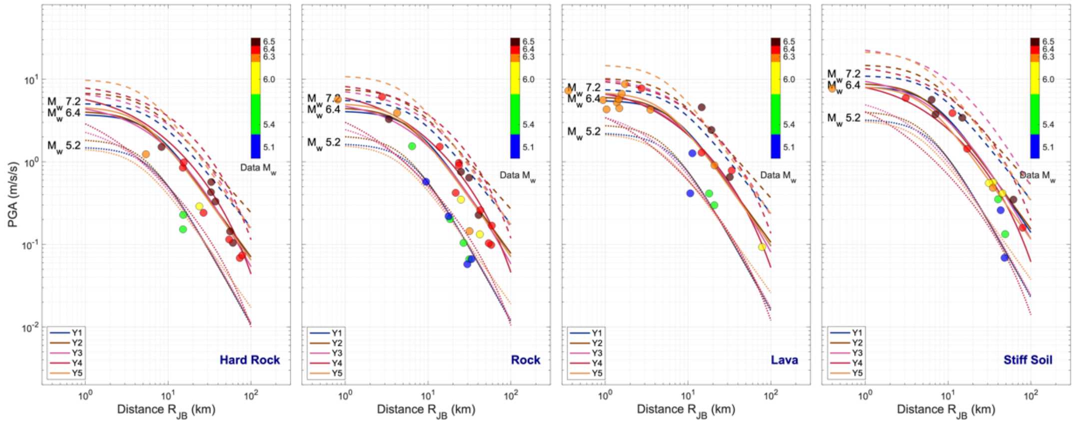

Figure 1. The attenuation of the Bayesian hierarchical ground motion models (BH-GMMs) for peak ground acceleration *PGA* at different site classes. The models are evaluated for magnitudes M_w 5.2 (dotted line), M_w 6.4 (solid line), and M_w 7.2 (dashed line). The circles are observed strong-motions that are color-coded by their corresponding magnitudes.

The results indicated the capability of BH-GMMs to effectively capture the attenuation of *PGA* with distance for varying magnitudes. Moreover, the attenuation trends of observed *PGA*s, align closely with the model predictions for each geological unit, underscoring the importance of incorporating site-specific amplification in PSHA. The distinction in amplification behaviors, particularly at higher frequencies, provides critical insights into the interaction between seismic waves and geological units. This study highlights the critical role of local geological conditions in shaping seismic responses and sets a benchmark for future research in seismic hazard assessment, particularly in regions with complex geological and seismic environments like Southwest Iceland.

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