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PARAMETRIZATION OF SYNTHETIC NEAR-FAULT SEISMIC WAVEFIELDS FOR THE SOUTHWEST ICELAND TRANSFORM ZONE

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Iceland is one of the northern European countries with the highest seismic activity. The strongest earthquakes take place on two large transform faults, one of which is the densely populated South Iceland Seismic Zone (SISZ), characterized by its unique North-South aligned bookshelf dextral strike-slip faults that are responsible for the long-term release of tectonic strain across the zone. The bookshelf fault system has been shown to be continuous towards West, all along the Reykjanes Peninsula Oblique Rift (RPOR) [1], bringing the Capital region of Reykjavík, in greater proximity to the bookshelf faults. It is well known both from the observations and the physics-based modeling of earthquake rupture and near-fault ground motion simulations, that the most damaging part of near-fault seismic motion is the large-amplitude, long-period velocity pulses found in the forward direction of fault rupture due to the directivity effect. With relatively large North-South striking faults now being mapped directly South of the evermore expanding Capital region, this becomes a cause for great concern. In particular since such effects have not been taken into account in any probabilistic seismic hazard assessment (PSHA) nor incorporated into any modern building standards such as Eurocode 8.

The recorded near-fault data in Iceland, however, is relatively sparse, making it difficult to accurately capture the physical characteristics of near-fault ground motions. Fortunately, the key elements of physics-based ground motion simulation have recently been developed in Southern Iceland, one of which is the 3D finite-fault system model of the bookshelf strike-slip faults in the SISZ-RPOR [2]. The model accounts for the systematic changes in how large the earthquakes can become along the zone by subdividing it into six distinct subzones, with the largest earthquakes (~$M_\mathrm{w}7$) taking place in the Eastern SISZ and the smallest (~$M_\mathrm{w}5.5$) in the Western RPOR, respectively. The fault system allows for both deterministic and random fault locations, and each fault is completely specified in terms of its maximum magnitude, its dimensions, and its long-term slip rate. The new model allows the derivation of the time-independent magnitude-frequency distribution (MFDs) for each subzone and explains the historical earthquake catalogue, thus validating the physics-based fault system model [3]. Kowsari et al [4] extended the 3D model and applied the MFDs in each subzone to generate different sets of physics-based finite-fault synthetic earthquake catalogues. One realization of such catalogue (500-yr long) has been incorporated into CyberShake [5], a high-performance computational platform developed by the Southern California Earthquake Center (SCEC) and the foundation of physics-based seismic hazard models [6]. Variations in the kinematic rupture properties of each fault result in the vast synthetic dataset of low-frequency two-component horizontal velocity time histories that sample the near-fault wavefield variations over a uniform spatial grid of hypothetical stations in Southwest Iceland.

In this study, we parametrize the synthetic waveforms and retrieve information about the source geometries and the kinematic rupture features into a single flat-file. The flat-file includes various intensity measures (e.g., the amplitude of pseudo spectral acceleration, *PSA* at different oscillatory periods) that are retrieved from the processing of velocity time histories in each station. The flat-file thus provides a uniformly processed and high-quality synthetic dataset, enabling the calibration of new scaling laws and predictive models, such as the empirical near-fault term to the ground motion models

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(GMMs). Figure 1 (a) illustrates the spatial distribution of the rotational invariant for two as-recorded horizontal components of the *PSA* at $T = 2$ s for two fault rupture variations, unilateral and bilateral of $M_w 7$. From the figure, it is evident that the unilateral ruptures exhibit positive directivity at the northern end of the fault, along with an increased amplitude of the PSA, similar to the bilateral scenarios at both ends of the strike-slip fault. In summary, this study significantly augments our comprehension of the near-fault seismic wavefield and its correlation with key independent variables of the seismic source model. This advancement facilitates the development of a near-fault GMM, crucial for implementing efficient and physics-based near-fault PSHA in the SISZ-RPOR.

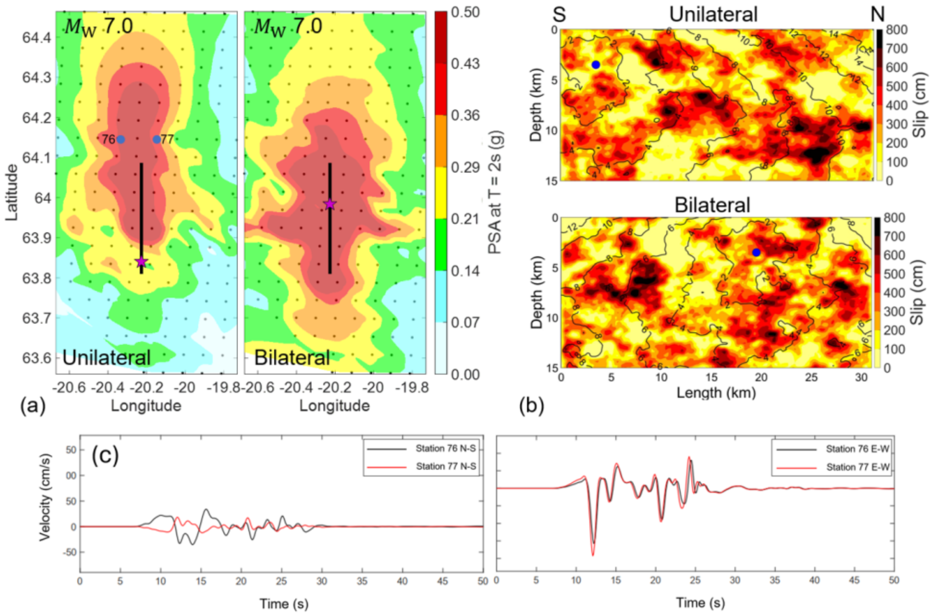

Figure 1. (a) Spatial distribution of rotational invariant *PSA* at $T = 2$ s for a $M_w 7$ earthquake with varying hypocentral locations (b) The slip distribution on the fault plane along with the contours of rupture time. (c) Comparison of two horizontal-component velocity time histories (cm/s) of two stations in blue circles.

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