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Gradient-based shear-wave velocity parameterization in Bayesian inversion of surface-wave dispersion for earthquake site response

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Knowledge of near-surface properties of the soil column, in particular, the shear-wave velocity (Vs) profile over the upper 10s of metres, are important for characterizing the expected ground response to earthquake shaking at a specific site. Non-invasive and passive methods based on recording ambient seismic noise are increasingly popular for estimating Vs structure with minimal cost and site disruption. This paper applies a fully nonlinear Bayesian inversion methodology to estimate Vs profiles and uncertainties using surface-wave dispersion data processed from passive seismic array recordings. In the inversion, the Vs profile is parameterized using a Bernstein polynomial basis, which efficiently characterizes general depth-dependent Vs gradients in the soil column. Bernstein polynomials provide a stable parameterization in that small perturbations to the model parameters (basis function coefficients) result in only small perturbations to the Vs profile. Shear-wave velocity profiles and uncertainties are obtained from the velocity-depth marginal posterior probability density. These probabilistic Vs profile results allow for probabilistic estimates of site response factors such as peak ground velocity/acceleration and VS30. This provides a quantitative assessment of the uncertainty in site response. This methodology is applied to synthetic scenarios as well as real passive seismic array recordings collected at sites in British Columbia, Canada.