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The Effect of Uncertainty in Predictor Variables on the Estimation of Ground-Motion Prediction Equations

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Ground-motion prediction equations (GMPEs) are typically estimated via regression of a ground-motion parameter of interest against source-, path-, and site-related parameters, such as magnitude, distance, or time-averaged shear-wave velocity in the upper 30 m (V_{S30}), with physical considerations taken into account. Typically, the predictor variables are treated as error free in the regression; however, there can be significant errors in these parameters because magnitudes are often converted from one scale to another (such as local magnitude to moment magnitude) and V_{S30} is often inferred from local geology instead of measured, leading to large uncertainties. We take these measurement uncertainties into account during the regression via a Bayesian measurement error model. The model treats the true, unknown value of the predictor variable as a parameter to be estimated, constrained by its observed value and (known) variance of the measurement error. The model is cast in a Bayesian fashion to allow the inclusion of relevant prior information, as well as a probabilistic interpretation of the results. We apply the model to California data of the Next Generation Attenuation-West2 data set and take into account measurement error in magnitudes and V_{S30}. Because the true magnitude and V_{S30} values are the same for all response spectral periods, the regression needs to be performed for all periods simultaneously. We find that the median ground-motion predictions are similar when compared with a standard regression but that the values of the between-event standard deviation τ and the within-event/within-station standard deviation ϕ_{S2S} are reduced by about 1%–13%, depending on the spectral period.