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Testing physics and statics based hybrid ETAS models

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Currently, the Epidemic Type Aftershock Sequence (ETAS) model is state-of-the-art for forecasting aftershocks. However, the under-performance of ETAS in forecasting the spatial distribution of aftershocks following a large earthquake make us adopt alternative approaches for the modelling of the spatial ETAS-kernel. Here we develop a hybrid physics and statics based forecasting model. The model uses stress changes, calculated from inverted slip models of large earthquakes, as the basis of the spatial kernel in the ETAS model in order to get more reliable estimates of spatiotemporal distribution of aftershocks. We evaluate six alternative approaches of stress-based ETAS-kernels and rank their performance against the base ETAS model. In all cases, an expectation maximization (EM) algorithm is used to estimate the ETAS parameters. The model approach has been tested on synthetic data to check if the known parameters can be inverted successfully. We apply the proposed method to forecast aftershocks of mainshocks available in SRCMOD database, which includes 192 mainshocks with magnitudes in the range between 4.1 and 9.2 occurred from 1906 to 2020. The probabilistic earthquake forecasts generated by the hybrid model have been tested using established CSEP test metrics and procedures. We show that the additional stress information, provided to estimate the spatial probability distribution, leads to more reliable spatiotemporal ETAS-forecasts of aftershocks as compared to the base ETAS model.