Improving short-term forecasting following a damaging earthquake in South Iceland Seismic Zone

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The Epidemic-Type Aftershock Sequence (ETAS) model is one of the top ranked seismicity models describing the occurrence of earthquakes in space and time. For this reason, the ETAS family models are widely used for short-term aftershock forecasting in operational earthquake forecasting systems throughout the world (e.g., United States, Japan, New Zealand, and Italy). However, ETAS model parameters estimation has always been challenging due to the complexity of the likelihood function. Therefore, most previous studies of the ETAS model have relied on point estimates of the model parameters. In this study, to take parameter estimation uncertainty into account, we use a fully simulation-based forecasting framework by leveraging the Bayesian inference technique to assess the uncertainties incorporated into the well-established spatio-temporal ETAS model parameters through the posterior joint probability distributions. Subsequently, we use Markov Chain Monte Carlo simulation to draw samples from the posteriors. Finally, we generate plausible earthquake sequences for the prescribed forecasting time interval across the defined aftershock zone.

We stress that, to our knowledge, the existing ETAS model for southwest-Iceland is not capable of providing efficient forecasting and thus has not found practical operational use so far. To explore the potential of the Bayesian spatio-temporal ETAS model, we used the adaptive prior estimation method employing the conventional ETAS model parameters proposed by Eberhard (2014) for south Iceland as initial values. In this regard, we conducted a retrospective forecasting experiment on the June 2000 earthquake sequence that followed the $M_{\mathrm{w}}6.4$ and $M_{\mathrm{w}}6.5$ mainshocks the aftershock sequence of which scattered over the South Iceland Seismic Zone (SISZ) and Reykjanes Peninsula Oblique Rift (RPOR) in Southwest Iceland. The results stress the importance of reliable and informative set of ETAS priors in order to attain reliable forecasts immediately after a strong earthquake. Then, by more data being available for the inference due to an ongoing sequence, well-determined posterior distributions for ETAS model parameters are quickly attained, and thus acceptable forecasted seismicity has been delivered. Moreover, the areas with increased seismicity forecasted across SISZ and RPOR regions were in great agreement with the geographical location of the actual aftershocks that occurred during the various forecasting intervals, thus indicating a strong spatial forecasting skill of the model. Robust seismicity forecasting framework used in this study has the potential of improving short-term forecasts in southwestern Iceland, even in early aftershock period and may potentially be implemented in a regional operational aftershock forecasting system.

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