EGU21-14716, updated on 28 Jan 2022
https://doi.org/10.5194/egusphere-egu21-14716
EGU General Assembly 2021

Do Enhanced Seismicity Catalogs Improve Aftershock Forecasts? A Test on the 2016-2017 Central Italy Earthquake Cascade

Simone Mancini[1], Margarita Segou[1], and Maximilian J. Werner[2]
[1]British Geological Survey, Edinburgh, United Kingdom (simone@bgs.ac.uk)
[2]University of Bristol, Bristol, United Kingdom

Artificial intelligence methods are revolutionizing modern seismology by offering unprecedentedly rich seismic catalogs. Recent developments in short-term aftershock forecasting show that Coulomb rate-and-state (CRS) models hold the potential to achieve operational skills comparable to standard statistical Epidemic-Type Aftershock Sequence (ETAS) models, but only when the near real-time data quality allows to incorporate a more detailed representation of sources and receiver fault populations. In this framework, the high-resolution reconstructions of the seismicity patterns introduced by machine-learning-derived earthquake catalogs represent a unique opportunity to test whether they can be exploited to improve the predictive power of aftershock forecasts.

Here, we present a retrospective forecast experiment on the first year of the 2016-2017 Central Italy seismic cascade, where seven M5.4+ earthquakes occurred between a few hours and five months after the initial Mw 6.0 event, migrating over a 60-km long normal fault system. As target dataset, we employ the best available high-density machine learning catalog recently released for the sequence, which reports ~1 million events in total (~22,000 with M ≥ 2).

First, we develop a CRS model featuring (1) rate-and-state variables optimized on 30 years of pre-sequence regional seismicity, (2) finite fault slip models for the seven mainshocks of the sequence, (3) spatially heterogeneous receivers informed by pre-existing faults, and (4) updating receiver fault populations using focal planes gradually revealed by aftershocks. We then test the effect of considering stress perturbations from the M2+ events. Using the same high-precision catalog, we produce a standard ETAS model to benchmark the stress-based counterparts. All models are developed on a 3D spatial grid with 2 km spacing; they are updated daily and seek to forecast the space-time occurrence of M2+ seismicity for a total forecast horizon of one year. We formally rank the forecasts with the statistical scoring metrics introduced by the Collaboratory for the Study of Earthquake Predictability and compare their performance to a generation of CRS and ETAS models previously published for the same sequence by Mancini et al. (2019), who used solely real-time data and a minimum triggering magnitude of M=3.

We find that considering secondary triggering effects from events down to M=2 slightly improves model performance. While this result highlights the importance of better seismic catalogs to model local triggering mechanisms, it also suggests that to appreciate their full potential future

modelling efforts will likely have to incorporate also fine-scale rupture characterizations (e.g., smaller source fault geometries retrieved from enhanced focal mechanism catalogs) and introduce denser spatial model discretizations.