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Operational Aftershock Forecasting for Mw7.3 Sarpol-e Zahab (2017) Earthquake in Western Iran

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Methodology:

The implementation of short-term forecasts for emergency response management in the immediate aftermath of a seismic event, and in the presence of an ongoing seismic sequence, requires two basic components: scientific advisories expressed in terms of risk assessment, and protocols that establish how the scientific results can be translated into decisions/actions for risk mitigation. The operational earthquake forecasting framework is geared towards providing scientific advisories in the form of time-dependent probabilities expressing seismicity, hazard and risk that can be practically translated into decisions. Considering the triggered sequence of aftershocks in the process of post-event decision-making and prioritization of emergency operations still seems to need and to deserve much more attention. To this end, the adopted novel and fully-probabilistic procedure succeeds in providing spatio-temporal predictions of aftershock occurrence in a prescribed forecasting time interval (in the order of hours or days). The procedure aims at exploiting the information provided by the ongoing seismic sequence in quasi-real time considering the time needed for registering and transmitting the data. The versatility of the Bayesian inference is exploited to adaptively update the forecasts based on the incoming information as it becomes available. The aftershock clustering in space and time is modelled based on an Epidemic Type Aftershock Sequence (ETAS). One of the main novelties of the proposed procedure is that it considers the uncertainties in the aftershock occurrence model and its model parameters. This is done by moving within a framework of robust reliability assessment which enables the treatment of uncertainties in an integrated manner. Pairing up the Bayesian robust reliability framework and the suitable simulation schemes (Markov Chain Monte Carlo Simulation) provides the possibility of performing the whole forecasting procedure with minimum (or no) need of human interference.

Application:

This procedure is demonstrated through a retrospective application to early forecasting of seismicity associated with the 2017 Sarpol-e Zahab seismic sequence activities. On Sunday

November 12, 2017, at 18:18:16 UTC, (21:48:16 local time), a strong earthquake with Mw7.3 occurred in western Iran in the border region between Iran and Iraq in vicinity of the Sarpol-e Zahab town. Unfortunately, this catastrophic seismic event caused 572 causalities, thousands of injured and vast amounts of damage to the buildings, houses and infrastructures in the epicentral area. The mainshock of this seismic sequence was felt in the entire western and central provinces of Iran and surrounding areas. The main event was preceded by a foreshock with magnitude 4.5 about 43 minutes before the mainshock that warned the local residence to leave their home and possibly reduced the number of human casualties. More than 2500 aftershocks with magnitude greater than 2.5 have been reported up to January 2019 with the largest registered aftershock of Mw6.4. The fully simulation-based procedure is examined for both Bayesian model updating of ETAS spatio-temporal model and robust operational forecasting of the number of events of interest expected to happen in various time intervals after main events within the sequence. The seismicity is predicted within a confidence interval from the mean estimate.