EGU21-8691, updated on 28 Jan 2022
https://doi.org/10.5194/egusphere-egu21-8691
EGU General Assembly 2021

The prognostic value of foreshocks - a statistical reevaluation

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The ability to forecast large earthquakes on short time scales is strongly limited by our understanding of the earthquake nucleation process. Foreshocks represent promising seismic signals that may improve earthquake forecasting as they precede many large earthquakes. However, foreshocks can currently only be identified as such after a large earthquake occurred. This inability is because it remains unclear whether foreshocks represent a different physical process than general seismicity (i.e., mainshocks and aftershocks). Several studies compared foreshock occurrence in real and synthetic catalogs, as simulated with a well-established earthquake triggering/forecasting model called Epidemic-Type Aftershock Sequence (ETAS) that does not discriminate between foreshocks, mainshocks, and aftershocks. Some of these studies show that the spatial distribution of foreshocks encodes information about the subsequent mainshock magnitude and that foreshock activity is significantly higher than predicted by the ETAS model. These findings attribute a unique underlying physical process to foreshocks, making them potentially useful for forecasting large earthquakes. We reinvestigate these scientific questions using high-quality earthquake catalogs and study carefully the influence of subjective parameter choices and catalog artifacts on the results. For instance, we use data from different regions, account for the short-term catalog incompleteness and its spatial variability, and explore different criteria for sequence selection and foreshock definition.