EGU21-11036
https://doi.org/10.5194/egusphere-egu21-11036
EGU General Assembly 2021

Markov modulated Poisson processes for stochastic modelling of background seismicity

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We investigate the statistical properties of declustered catalogs as obtained from the application of two different data-driven declustering algorithms, namely the nearest-neighbor method and the stochastic declustering method (Benali et al., Stoch. Environ Res Risk Assess, 2020). The nearest-neighbor method partitions earthquakes into background and clustered components, based on nearest-neighbor distances between earthquakes in the space-time-magnitude domain (Zaliapin and Ben-Zion, J Geophys Res, 2013); the stochastic declustering method classifies earthquakes into background and clustered components through a probabilistic procedure based on the estimation of the space-time ETAS model (Zhuang et al., J Geophys Res, 2004).

Two Italian case studies are considered: North-Eastern Italy (data from OGS Bulletins) and Central Italy (data from ISIDe catalog). For both case studies, the time series of background seismicity are obtained from the two declustering methods. Then we investigate the general assumption according to which the temporal sequence of background seismicity is suitably modelled by the stationary Poisson model. For this purpose, several features and statistical tests are considered to verify the main properties that characterize Poisson processes (e.g. events are independent, exponential inter-arrival times, etc.).

Whenever the Poissonian hypothesis is rejected, we get evidence of certain heterogeneity in the background sequence, which leads us to rule out the simple Poisson process for background seismicity modeling. As a simple and more suitable alternative, we consider here the Markov Modulated Poisson Process (MMPP model), which allows the Poisson seismicity rate to change over time according to a finite (unknown) number of states of the system. The MMPP model turns out suitable for identifying and quantifying heterogeneities in background seismicity, as well as for comparing them against the two considered declustering algorithms.