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Stress-based statistical modeling of induced seismicity at various production types

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Seismicity occurring at different types of production sites (gas depletion or storage, geothermal reservoirs, hydraulic fracturing) shows some distinct characteristics that change from one site to another and that differ from natural seismicity. To investigate the underlying mechanisms the Geo:N project SECURE (Sustainable dEployment and Conservation of Underground Reservoirs and Environment) was started in 2017. As a part of this project, our goal is the forecast of the seismicity rate based on source models which predicts the stress changes at the production sites.
Our model framework takes into account the rate- and state-dependent friction observed in laboratory experiments, fault density, the distribution of receiver mechanisms, as well as parameter uncertainties. We constrain the model parameters by fitting the modeled seismicity rates to recorded seismicity. The comparison of the maximum likelihood values of the fits allows hypotheses testing of alternative source/stress models. The model is flexible to be adapted to different sites (production type, geomechanical environment).
The first application of the model is performed to the dataset of the Groningen gas field. The maximum likelihood estimation of the recorded earthquakes yields the optimal seismicity model parameter which are used to calculate the expected seismicity rate in space and time. We analyze the result of previously released source models related to the pore pressure field in the reservoir level and stresses determined by compaction data, respectively. We find that the long delay in onset of seismicity can be well fitted.