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Forecasting Induced Seismicity In Deep Geothermal Energy Projects

Eszter Király (1), Valentin Gischig (2,1), Dimitrios Karvounis (1), Lukas Heiniger (1), and Stefan Wiemer (1)
(1) ETH Zürich, Institute of Geophysics, Schweizerischer Erdbebendienst (SED), Zürich, Switzerland, (2) Department of Earth , Ocean and Atmospheric Sciences, University of British Columbia, Vancouver

The decision to phase out nuclear power in Switzerland by 2034 accelerated research on deep geothermal energy, which has the ability to contribute to long-term energy resources. Induced seismicity occurring during early stimulation periods in deep geothermal projects of past years in Switzerland, however, clearly document our limited understanding of the processes at depth that lead to significant seismic hazard and that may influence public acceptance of future projects.
Controlling induced seismicity related to deep geothermal projects with adaptive warning systems require models that are forward looking, dynamically updated on the fly as new data arrive and probabilistic in the sense that the inherent uncertainties in our understanding of the processes and in the required model parameters.
We currently develop a fully coupled non-linear hydraulic-seismic 3D model joint with a hazard assessment procedure. The goal is to improve the forecasting skill owing to validated physical constraints. As a first step, we seek to answer the question: is it possible to forecast the seismic response of the geothermal site during and after stimulation based on observed seismicity and hydraulic data? Our goal is to find the most suitable model to date for forecasting induced micro-seismicity and unexpected large events in geothermal systems. In order to do so, available stochastic and hybrid models are tested and ranked such as Epidemic Type Aftershock Sequence models, models developed by Shapiro and his research group and two types of geomechanical seed models incorporating linear and non-linear fluid flow.
The aim is to balance model prediction performance and model complexity: which parameters are necessary to forecast seismicity well, and which are eventually those that increase model complexity but do not give better results. All tests are performed on the Basel 2006 dataset. Testing is carried out along the guidelines of the Collaboratory for the Study of Earthquake Predictability Center. Firstly, to validate model performance a number of tests are applied focusing on the overall consistency of forecast with the observation and comparing the number of forecast events, their magnitude and spatial distribution to the observed induced earthquakes. Secondly, models are ranked with respect to each other without giving absolute scores to them.
Long-term aim of this research is to develop an on-site decision-making tool for geothermal project to be able to avoid not yet occurred but foreseen induced seismic events.