Geophysical Research Abstracts
Vol. 14, EGU2012-9029, 2012
EGU General Assembly 2012

Building robust models to forecast the induced seismicity related to geothermal reservoir enhancement

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We test the Epistemic Type Aftershock Sequence, (ETAS) and the Reasenberg and Jones (R&J) models, which are the commonly used models for aftershock forecasting, for the induced seismicity sequence of the Enhanced Geothermal System (EGS) in Basel, in a pseudo-prospective manner. In addition to these two statistical models, we introduce the model of Shapiro et al. (2010) for forecasting induced seismicity due to EGS in a pseudo-prospective modeling approach. While the ETAS and the R&J models are statistical models, the model of Shapiro et al. (2010) is physics based method that takes into account the flow-rate and the seismogenic index that characterizes the level of seismic activity expected from injecting fluid into rock. We aim to define a weighted logic tree approach as input for induced seismicity probabilistic seismic hazard assessment. High performance forecast models defined in a weighted logic tree approach and then converted into time dependent probabilistic seismic hazard can feed probabilistic alarm systems for EGS experiments.

We forecast the seismicity rates of the next six hours based on these three model classes using different modeling and updating strategies. We quantitatively test the performances of the models and define a combined model constructed using Akaike weights. We show that such performance testing can be used as an indication for logic tree weighting. We also evaluate the performances of different models in forecasting a certain magnitude/magnitude range (for instance number of events with $M \geq 2$ that are of more concern). In addition, we perform a test on how well we can forecast during and post injection seismicity, with the very first coming data (first day or days). This initial testing with recordings of limited time can reveal the suitability of a site for full reservoir stimulation. Robust forecast models can lead us to an early operation of the traffic light system where a decision on continuing/slowing-down/stopping of fluid injection can be feasible before possible larger magnitude events occur.