Geophysical Research Abstracts
Vol. 17, EGU2015-6505, 2015
EGU General Assembly 2015
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Scaling of frequency-magnitude distributions of fluid-induced seismicity

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We compare b value and seismogenic index Σ estimates using two different approaches: a standard Gutenberg-Richter power-law fitting and a frequency-magnitude lower bound probability fitting. The latter takes into account the finite size of the perturbed rock volume. Our results reveal that the smaller is the perturbed rock volume the larger are the deviations between the two sets of derived parameters. It means that the magnitude statistics of the induced events is most affected for low injection volumes and/or short injection times. In sufficiently large stimulated volumes both fitting approaches provide comparable b value and seismogenic index estimates. In particular, the b value is then in the range universally obtained for tectonic earthquakes (b 0.8 - 1.2). We introduce the specific magnitude M_Σ as a seismotectonic characteristic of a reservoir location. Defined as the ratio between seismogenic index Σ and b value, this magnitude scaling parameter is unaffected by the size of perturbed rock volumes. Using both seismogenic index model and specific magnitude model we predict frequency-magnitude distributions for two different scenarios and compare these to observed data. We conclude that the seismogenic index model provides reliable predictions which confirm its applicability as a forecast tool. On the other hand, the specific magnitude model can be applied to predict the asymptotical limit of probable frequency-magnitude distributions.