EGU22-12279, updated on 02 Oct 2022
https://doi.org/10.5194/egusphere-egu22-12279
EGU General Assembly 2022

Estimating states and parameters in earthquake sequence models in the presence of a parameter bias

Arundhuti Banerjee[1], Ylona van Dinther[2], and Femke Vossepoel[1]
[1]Department of Geoscience and Engineering, Delft University of Technology, the Netherlands
[2]Department of Earth Sciences, Utrecht University, the Netherlands

Forecasting earthquake occurrence is a challenging endeavor, which will ultimately require a combination of observations and physics-based models. Data assimilation may help to combine these and their uncertainties in a statistically solid manner. To understand the potential of ensemble data assimilation, we investigate whether the fault stress state can be estimated and forecasted in the presence of a bias in a friction parameter. In a perfect model test, we introduce different degrees of bias in rate-and-state parameter b. b describes the evolution of frictional strength with fault slip velocity and thus impacts earthquake slip and the subsequent recurrence interval. Our forward model is a simplified, zero-dimensional (0D) Burridge-Knopoff spring-block system with a rate- and state-dependent friction formulation using a 'slip law'. We assimilate synthetic observations of fault shear stress and slip rate variables and corresponding large uncertainties. We compare state estimation with joint state-parameter estimation using a sequential importance resampling particle filter by evaluating the quality of the estimated fault stress probability density functions (pdf's).

The results of the study indicate that state estimation works well for systems with low (3%) to intermediate (15%) bias. This performance for the case of intermediate bias can be improved through increasing model error combined with double resampling in the particle filter. For a large friction-parameter bias (42 %), we show that state-parameter estimation is the only way to correct the bias. This is an important result, because it shows that state-parameter estimation is able to identify trade-offs and separate error contributions coming from stress state and friction parameters. Furthermore, the results of this study can be applied to other data assimilation applications involving models that are particularly vulnerable to parameter biases.