Micromechanical model of fluid-induced seismicity to reproduce observed spatiotemporal changes in source parameters and on-fault fluid diffusion

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Fluid and seisimicity are considered to be related, as suggested from earthquake swams of natural earthquakes and man-made earhtquakes induced by fluid injection. Some data analysis with relocation techniques of earthquake sources showed that the earthquake activities propagete facially (e.g., Yukutake et al., 2010), and that some source parameters (such as stres drops, strength, b-value, seismicity rate) are functions of elapsed time from fluid injection (Bachmann et al., 2012) or sudden increase of (possibly fluid-induced) seisimicity rate not following mainshocks (Yoshida et al., 2017). In this research, by considering strength heterogeneity of faults expected from experimentally verified physics, we provide the micromechanical model of such seismicity induced by on-fault fluid diffusion, and explain the results of the above data-driven analysis.

Presentation contains following four contents. First, the micromechanical model is proposed. In the model, many patches are distributed randomly on a fault so that the patches are sufficiently small (or distant) to interact with each other; those patches rupture when the effective strength becomes smaller than applied shear stress due to the fluid diffusion. Second, the spatiotemporal changes of the source parameters are obtained as the solutions of the model. Consequently, multiple source parameters are parametrized by injected pressure, diffusion raidus of fluid, normal stress on the fault, and the fluctuation of the exess strength; after the parametrization, those source parameters are shown to follow the common master curve. Third, the observed data is fitted, and the consistency between the theory and the observation is suggested. Fourth, the thoretical prediction for the temporal transience in the moment release rate is checked by the data of Yoshida et al. (2017), and the result strongly supports the theory.

Keywords: earthquake swarms and induced-seismicity, micromechanical model, source paraemters

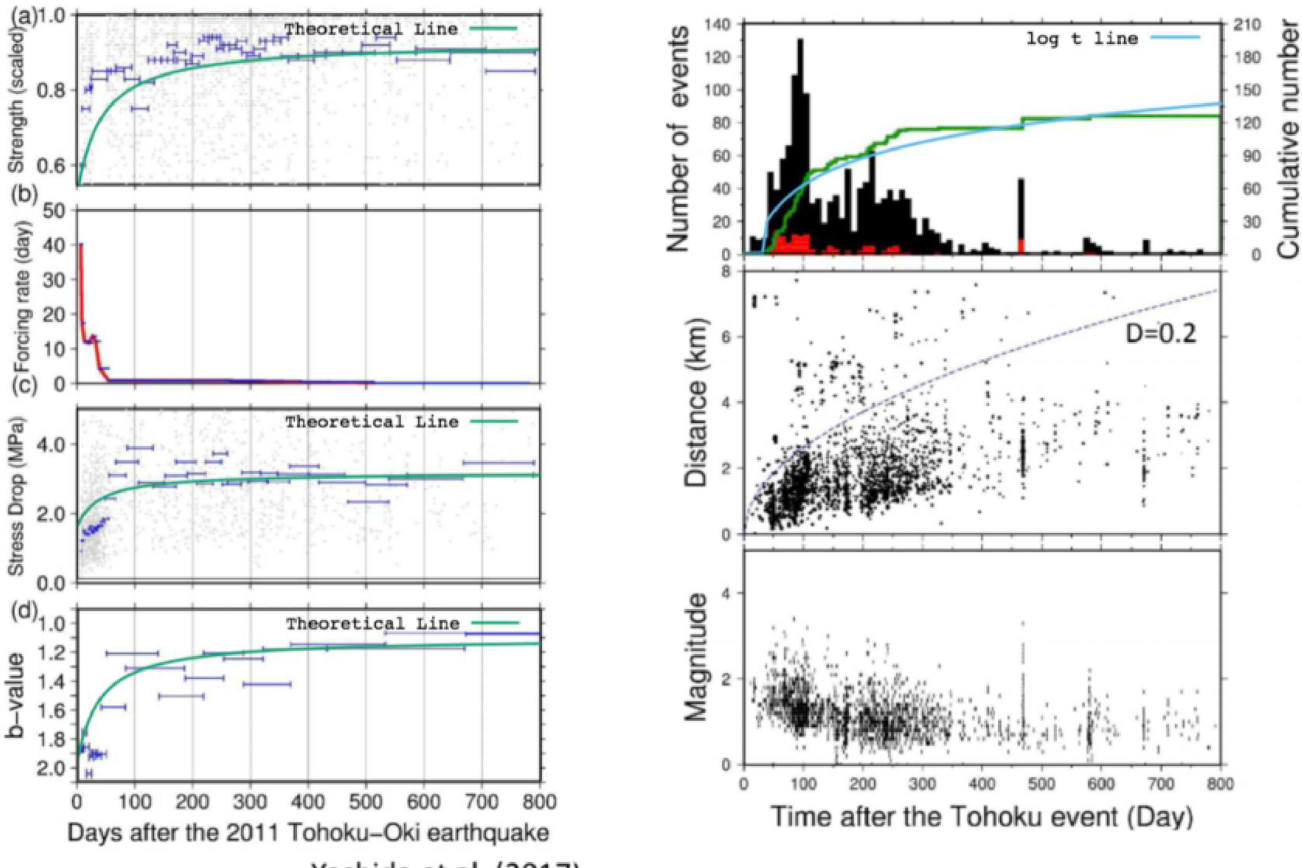

Fig. 1. A data example of Yoshida et al. (2017) fitted by our theoretical model (written as theoretical or log t line in the figure), after Yoshida et al (2017). (Left) Temporal evolution of the source paramters. (Right) Number of events and the spatial patterns of the seismicity.