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Systematic Investigation of Dynamic Earthquake Triggering in Japan

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Introduction. Previous studies (e.g., Harrington and Brodsky, 2006) documented a relative scarcity of remote triggering in Japan, compared to other seismic regions. For example, in California, dynamic triggering is reported to occur at levels of stress as small as 0.1 kPa, while in Japan it was reported that levels of 30 kPa or more are required to trigger detectable events (van der Elst and Brodsky, 2010). However, the threshold dynamic triggering level following the 2016 M7.3 Kumamoto earthquake was of just a few kPa (Enescu et al., 2016). Enescu et al. (2016) proposed that one of the possibilities to explain this observation is a change of stress triggering threshold that may have taken place after the 2011 M9.0 Tohoku-Oki earthquake.

Motivation. Given the above observations, this study investigates 1) the occurrence of dynamically triggered earthquakes in Japan after some large earthquakes from 2004, and 2) whether the threshold of dynamic triggering may have changed due to the 2011 Tohoku-Oki earthquake and why this threshold might have changed.

Analysis and Results. First, we investigated dynamic triggering throughout Japan, following some large earthquakes occurred after 2004. As a result, the threshold appears to decrease following the 2011 Tohoku-Oki earthquake, however the number of earthquakes we have investigated was relatively small, so we could not draw statistically significant conclusions. In the second part of the study, we have focused on a few specific areas within Japan to systematically investigate dynamic triggering, which reduced significantly the computational costs. Thus, we focused on some areas in Tohoku and Hida, where swarm earthquakes occurred after the 2011 Tohoku-Oki earthquake. As a result, the change of the triggering level in an area close to the Yamagata-Fukushima border is considered to be statically significant at a 5% significance level. In other regions, the significance at a 5% level could not be established, however a decrease of this threshold is apparent, except for one region. We speculate that changes in the stress triggering threshold levels might be related to pore pressure changes in the crust following the 2011 Tohoku-Oki earthquake.