Change in *b*-values following the three *M*6 or 7-class earthquakes in the 2016 Kumamoto earthquake sequence

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This study investigates whether or not *b*-values of the Gutenberg-Richter law change following the three events (*M*6.5 on 14 April, *M*6.4 on 15 April, and *M*7.3 on 16 April) in the 2016 Kumamoto earthquake sequence. To examine the statistical significance of the change, a Bayesian approach developed and used in Iwata [2008, 2013, GJI; 2016, Pageoph] was applied to the sequence. This approach introduces a statistical model of a magnitude-frequency distribution covering the entire magnitude range proposed by Ogata & Katsura [1993, GJI]. The proposed distribution contains a parameter representing the quality of detection capability of earthquakes. With the aforementioned Bayesian approach, we can estimate a *b*-value with the consideration of the temporal change in the quality of detectability; all observed events are used in the estimation while we discard events of which magnitude is less than a cut-off magnitude in an conventional method to find a *b*-value. This is the advantage of the Bayesian approach to examine the significance of the change in *b*-values.

Data analyzed in this study was taken from the JMA catalog (last accessed on 11 May 2016). A study area was chosen to cover the aftershock area just before the *M*7.3 event and the epicenter of the *M*7.3 event, and four periods were considered: from 1 August 2015 to the occurrence of the *M*6.5 event (Period 0), between the occurrences of the *M*6.5 and *M*6.4 events (Period 1), between the occurrences of the *M*6.4 and *M*7.3 events (Period 2), and after the M7.3 event (Period 3). For each of the four periods, the *b*-value and temporal change in detection capability (i.e, the parameter of the magnitude-frequency distribution proposed by Ogata & Katsura [1993]) were estimated simultaneously. Cases with the constraint of a common *b*-value over successive periods (e.g., *b*-values of Periods 1, 2, and 3 are the same while the one in Period 0 is different.) were also considered. In total, there were eight cases (models), depending on which periods have a common *b*-value, and the best model was selected from the eight with Akaike's Bayesian Information Criterion (ABIC).

The best model is the case where Periods 0, 1, and 2 have a common *b*-value of 0.736 and only Period 3 has a different value of 0.941; the *b*-value varies at the timing of the *M*7.3 event whereas it does not change with the *M*6.5 and *M*6.4 events. The difference of ABIC values between this model and the one where the *b*-values over the four periods are the same is 7.9, which suggests the statistical significance of the best model. Remarkable increase in the *b*-value following a major/megathrust earthquake has been found [e.g., Tormann et al., 2015, Nature Geoscience]. This increase will correspond to decrease of stress due to a large slip, because it has been suggested that the *b*-value is correlated inversely with stress [e.g., Scholz, 2015, GRL]. From this viewpoint, the result of this study suggests that the high stress in the focal area of the Kumamoto sequence was not decreased by the *M*6.5 and *M*6.4 events but the *M*7.3 event has released it.

Keywords: b-value, stress, detectability of earthquake, Bayesian estimation, aftershock sequence, Gutenberg-Richter law