Seasonal variation of seismicity in San-in district, SW Japan

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It has been reported that earth surface's process such as tidal loading, ice and snow load, and heavy rainfall load, modulates seismicity in the crust (e.g. Heki, 2003). Moreover, temporal change of sensitivity of triggering is investigated. For example, Tanaka (2012) indicates that sensitivity of tidal triggering only increases prior to the 2011 Tohoku-Oki earthquake (Mw 9.1) and Iwata and Katao (2006) indicates that it only increases after the 1995 Kobe earthquake (Mw 6.9). Elucidation of the periodicity of seismicity provides us a new insight into earthquake physics.

We here investigate seasonal variation of crustal seismicity in San-in district, SW Japan, using the JMA catalog (constructed by Japan Meteorological Agency) from 1975 to 2017 (magnitude >= 3.0). We applied Epidemic Type Aftershock Sequence (ETAS) model (e.g. Ogata, 1988) to the catalog to calculate the possibility how likely each event is to be an aftershock. Then, we produced many stochastic copies of the declustered catalog, following a method proposed by Zhuang et al. (2002), to evaluate the significance of seasonal variation of background seismicity rate.

Using each stochastic-declustered catalog, we made a time-series of a background seismicity rate for the studied period. Then we evaluated temporal change of annual and semiannual components of each background seismicity rate using multiple 10-years windows shifted by one-year increment. We performed Fourier transform to each 10-years window, and calculated the amplitude of sinusoidal and cosine functions. As a result, half-year seasonal variation become statistically significant at periods both from 1988 to 1998, and from 2006 to 2016. These two periods roughly coincide with times before two large earthquakes in the studied area (the 2000 western Tottori earthquake (Mw6.7) and the 2016 central Tottori earthquake (Mw6.2)). This temporal increase in the sensitivity of seasonal variation is like a precursory-increase in sensitivity of tidal triggering prior to a few megathrust earthquakes (e.g. Tanaka, 2012). Interestingly, past large earthquakes in the studied region (from 1850 to 2017, magnitude >= 6.2) have similar seasonal variation to smaller earthquakes.

The half-year seasonal variation revealed in the present study would likely be explained by a combination of following two factors; 1) a change in stress loading rate induced by the thaw in spring, 2) a fault-weakening by increase in pore fluid pressure associated with heavy rainfall in autumn.