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# Spatio-temporal renewal model for repeating earthquakes and analysis of slip rate on plate boundaries

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We propose a new spatio-temporal stochastic model based on a renewal process and analyze repeating earthquakes on the upper surface of the subducting Pacific Plate to estimate spatio-temporal transition of slip rate on the plate boundary.

A renewal process is a point process that assumes intervals of events are independently and identically distributed. It is applied to long-term forecast of large earthquakes in active faults or on plate boundaries.

But when we apply it to small repeating earthquakes, the assumption of stationarity in renewal processes often fails because their intervals are influenced largely by the change in slip rate near their hypocenters.

Thus, we consider a non-stationary renewal process that the repeating intervals are inversely proportional to their neighbourhood slip rate. We introduce the space-time structure into this model by smooth cubic B-spline functions allocated to partitioned grids. On estimating the coefficients of spline bases, we use a penalty function for unsmooth change into the model to avoid over-fitting for the dataset. Optimal hyper-parameters are selected by Akaike's Bayesian Infromation Criteria (ABIC). We use relations by Nadeau and Johnson (1998) to convert the magnitudes and intervals of repeating earthquakes into the absolute slip rate.

We apply proposal model to the dataset of repeating earthquakes on subduction zone of Pacific Plate and estimate slip rate history of plate boundary. We see the characteristic changes in slip rate before and after the major earthquakes such that Sanriku-Haruka-Oki (1994 M7.6), Tokachi-Oki (2003 M8.0), Kushiro-Oki (2004 M7.5), Fukushima-Oki (2008 M6.9), Ibaraki-Oki (2008 M7.0) and large foreshocks of Tohoku-Oki (2011 M9.0).

Proposal model can estimate slip rate at depth where GPS system can not measure directly. Although it is difficult to estimate coseismic slip of large earthquakes from repeating earthquakes, this model may be useful to monitor the transition of stress field or interplate coupling on plate boundaries.

There remains a problem that the afterslip of large earthquakes and slow slip events should be discriminated.

Keywords: repeating earthquake, Tohoku-oki earthquake, slip rate, spatio-temporal model