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Data-driven spatial modeling of frictional features at plate subduction zones

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Frictional properties at a plate boundary are considered to control the time evolution of fault slips, so that clarification of their spatial distribution is one of the major issues to predict the states in the Earth's crust.

Recently, various aspects of the whole earthquake generation such as intervals of occurrence times, interseismic tectonic loading, afterslips, and episodic slow slips, were qualitatively reproduced, empirically giving the frictional parameters in the rate and state friction law [e.g., Kato and Yoshida (2011), Hori and Miyazaki (2011)]. For a more realistic simulation, the frictional parameters should be quantitatively determined based on observational data and theoretical prior information. Data assimilation (DA) is a computational technique based on the Bayesian statistics to integrate numerical simulation models and observational data [Higuchi et al. (2011)], which is widely used in geoscience including the solid earth science [e.g., Nagao et al. (2013)]. DA has also been applied to clarify the frictional features at plate boundaries, which are considered to control postseismic phenomena, estimating the frictional parameters in afterslip regions [e.g., Fukuda et al. (2009), Mitsui et al. (2010), Kano et al. (2013), Kano (2014)]. These previous studies assumed that the frictional parameters were unrealistically uniform in the entire fault region or subjectively divided the afterslip region into several areas in each of which the frictional feature is uniform in order to avoid substantial computational cost due to too much high-resolution spatial grids never to be determined by the limited observations on the Earth's surface. Therefore, it is meaningful to develop a method to divide the region appropriately in an automatic and objective way. We propose a data-driven procedure consistng of the k-means-based clustering method to obtain candidate division patterns in the afterslip region and the Akaike's Information Criterion to determine the optimum model among the candidates. We have confirmed that the model obtained by an application to synthetic data is almost the true one. We will report results when the proposed mothod is applied to the case of the afterslip region of the 2003 Tokachi-oki earthquake. This method will help to extract the large-scale frictional features and make relevant simulations more effective, objective and realistic.