Estimate of Strain Rate Field in Japan from GNSS Data: Comparison between Shen's Method and Basis Function Expansion

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The method of Shen et al. (1996) (Shen's method) has been widely used to estimate strain rate fields from GNSS velocity data in various regions; for example, Sagiya et al. (2000) found a high strain-rate region named the Niigata-Kobe tectonic zone in central Japan. However, we point out three theoretical disadvantages of the method: inconsistency between estimated velocity and strain rate fields, inability to objectively determine the optimal value of the hyperparameter that controls the degree of smoothing, and inaccurate estimation of uncertainty. As an alternative, we propose a method of basis function expansion (Fukahata et al. 1996) with Akaike's Bayesian information criterion (ABIC) to estimate a velocity field; the above mentioned difficulties are overcome in the ABIC method, because the strain rate field is obtained by analytically differentiating the velocity field and the optimal values of hyperparameters are objectively determined with ABIC.

We applied both methods to GNSS data in Japan. The results of Shen's method significantly depend on a value of the hyperparameter, and show instability and inconsistency in peripheral regions of the observation network. On the other hand, the ABIC method does not suffer from these problems. The advantage of the ABIC method is also clear in terms of the trade-off between resolution and robustness. The strain rate field in Japan estimated form the ABIC method exhibits local deformation at active volcanos as well as regional deformation related to plate motions. The ABIC method is thus effective for analyzing crustal deformation using GNSS velocity data.

