Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

MGI032-P03 Room:Convention Hall Time:May 23 13:45-16:15

Mixed linear-nonlinear inversion of crustal deformation data: Bayesian inference of model and hyperparameters

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We present a unified theoretical framework and solution method for probabilistic, Bayesian inversions of crustal deformation data. The inversions involve multiple data sets with unknown relative weights, model parameters that are related linearly or non-linearly through theoretic models to observations, prior information on model parameters, and regularization priors to stabilize underdetermined problems. To efficiently handle nonlinear inversions in which some of the model parameters are linearly related to the observations, this method combines both analytical least-squares solutions and a Markov chain Monte Carlo (MCMC) sampling technique. In this method, model parameters that are linearly and nonlinearly related to observations, relative weights of multiple data sets, and relative weights of prior information and regularization priors are determined in a unified Bayesian framework.

In this presentation, we define the mixed linear-nonlinear inverse problem, outline the theoretical basis for the method, provide a step-by-step algorithm for the inversion, validate the inversion method using synthetic data, and apply the method to real data sets. Our method can potentially be applied to high dimensional mixed linear-nonlinear inverse problems to which it is difficult to apply the MCMC methods to sample full posterior probability distributions due to high computational costs.

Keywords: inversion, Markov chain Monte Carlo, crustal deformation