Bayesian inference of model parameters controlling the thermal structure of subduction zones

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It is critical to estimate the thermal structure of subduction zones to better understand the mechanisms of magma genesis and the range of observed earthquake types including megathrust earthquakes, slow earthquakes, and intraslab earthquakes. Material circulation at geological timescales may also be strongly affected by the thermal structure, because subduction zones are the only regions where surface materials are subducted deep into the Earth' s interior. Geodynamic modeling has been widely used to compute the thermal structure and rock deformation. Surface heat flow observations have often been used to validate the predicted thermal structure. However, this type of approach has several limitations, including: (1) it is difficult to investigate the effects of a large number of model parameters in a systematic way, (2) uncertainties of model parameters are not obtained, (3) other sets of model parameters which better explain the observation might exist, and (4) information on the observation error cannot be considered. In this presentation, to overcome these difficulties in geodynamic modeling Bayesian inference is employed to simultaneously obtain five model parameters controlling the thermal structure of subduction zones based on surface heat flow observations.

The subduction zones at Tohoku in Japan and Cascadia are considered as the studied regions, because they are the representatives of cold and warm subduction zone, respectively. A 2D finite-element-based approach is used to solve the equations of mass conservation, momentum, and energy, to predict the surface heat flow. Metropolis algorithm, which is a Markov chain Monte Carlo method (MCMC), is used to sample the following model parameters: slab-mantle kinematically decoupling depth D_{dec}, the activation energy for shear viscosity E, the radiogenic heat production rate in the upper continental crust H_{UCC}, and the effective friction coefficient μ' controlling shear heating along the subducting plate interface. Preliminary results show that the obtained values of E are lower in both regions, and obtained values of H_{UCC} are lower in Cascadia, than the previously-reported values. This approach provides us a framework to validate and refine geodynamic models based on various types of observations.

Keywords: Bayesian inference, subduction zone, geodynamic modeling

