Contribution ID: **19** Type: **not specified**

Crust modeling with quantitative and objective uncertainty estimation

Monday 21 October 2019 15:00 (20 minutes)

Geoneutrino observations, first achieved by KamLAND in 2005 and followed by Borexino in 2010, have accumulated statistics and improved sensitivity for more than ten years. The uncertainty of the geoneutrino flux at the surface is now reduced to a level small enough to set useful constraints on U and Th abundances in the bulk silicate earth (BSE). However, in order to make inferences on earth's compositional model, the contributions from the local crust need to be understood within a similar uncertainty. Here we develop a new method to construct a stochastic crustal composition model utilizing Bayesian inference. While the methodology has general applicability, it incorporates all the local uniqueness in its probabilistic framework.

In our method, we consistently use explicit PDFs for all relevant quantities. We utilize Bayesian inference techniques to model the 3-D lithology map by combining seismological data as "observation"with a prior model constructed from local exposure. By using seismological tomography, we avoid the difficulty of dealing with the upper / middle / lower crust classification and boundary definition. For rock composition, we adopt a gamma distribution model, which does not bias the mean value estimation (unlike the log-normal model) and fits consistently well to both highly-skewed and close-to-normal distributions (for which neither log-normal nor normal distributions apply). Convolving the obtained PDFs of lithology distribution map and rock composition, we construct 3-D PDFs of U and Th concentrations.

At the time of the presentation, after showing the flow chart of our modeling method, we will discuss the key features of our lithology map inference. Our lithology model represents a probabilistic distribution map and allows quantitative studies with error estimations, making it fundamentally different from previous models. Note that the probabilistic representation allows us to construct probability density functions and thus errors of various physical quantities (such as abundance of radioactive elements, total mass of the crust, and geoneutrino flux) evaluated from the lithology distribution model, while the deterministic statements only allow estimation of central values. We also discuss the plausibility of our prior and the obtained posterior together with future topics for further improvements.

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