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GIGJ: a crustal model of the Guangdong Province using GOCE gravity data for predicting geoneutrinos

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Recent geoneutrino measurements from the KamLAND (Japan) and Borexino (Italy) experiments have been opening the way to multiple-sites investigation of the radiogenic heat and composition of the terrestrial crust and mantle. Geoneutrino signal measured by a liquid scintillator detector placed on the continental crust is dominated by the natural radioactivity of the closest geological units, which can be properly studied by gravimetric methods.
The present study aims at investigating the crustal structure that lies within ∼300 km from the Jiangmen Underground Neutrino Observatory (JUNO), currently under construction in the Guangdong Province (China), by inverting satellite gravity data synthetized from the release 5 of the GOCE space-wise model up to degree and order 200. The inversion is performed by means of a Bayesian algorithm in which the region of interest is subdivided into voxels with a horizontal and vertical resolution equal to 50 km and 100 m, respectively. Each voxel is associated to a couple of random variables, namely the label describing the geological layer (i.e. upper crust, middle crust, lower crust, continental lithospheric mantle) and the voxel density. The prior probability is used to model the information carried by already existing geological studies, seismic observations and global crustal models, properly weighted according to their accuracy. Some mathematical regularization is also introduced into the prior probability in order to obtain smooth discontinuity surfaces, smooth lateral and vertical density variations and to guarantee a positive (for the crust) or negative (for the continental lithospheric mantle) vertical density gradient for increasing depth.
The solution is retrieved by invoking the Maximum A Posteriori (MAP) principle, leading to an optimization problem. The target function is minimized by Monte Carlo Markov Chains methods, i.e. a simulated annealing coupled with a Gibbs sampler at each iterative step. Since not all the weights balancing the different components of the prior probability have an explicit physical meaning, many solutions are computed trying different sets of weight values. This translates into the computation of 1000 solutions among which the best one is chosen. The choice is performed through some indexes that quantify the gravity fitting and the geometry and density regularity, leading to the GIGJ (GOCE Inversion for Geoneutrinos at JUNO) crustal model for the Guangdong Province.
Finally, the uncertainty of the estimated model is assessed by using again a Gibbs sampler to randomly draw solutions close to the GIGJ one, i.e. to investigate the shape of the posterior probability around the MAP. The GIGJ model fits the gravity data with a standard deviation of 1 mGal and shows an overall density and geometrical variability smaller than 1% of the estimated values, apart from the middle crust volume that can vary up to 2.5%. The validated numerical output is used to estimate the geoneutrino signal expected at JUNO and produced by unitary abundances of U and Th in the main crustal layers.