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GIGJ: a crustal gravity model of the Guangdong Province for predicting the geoneutrino signal at the JUNO experiment

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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 modelled by gravimetric methods. In particular, recent satellite missions have provided the scientific community with highly accurate and homogeneously distributed gravimetric data, offering an extraordinary opportunity to probe the regional structure of the crustal layers surrounding a geoneutrino detector.
GIGJ (GOCE Inversion for Geoneutrinos at JUNO) is a 3-D numerical model constituted by about 46×10^3 voxels of $50 \times 50 \times 0.1$ km, built by inverting GOCE (Gravity field and steady-state Ocean Circulation Explorer) gravimetric data over the $6° \times 4°$ area centered at the JUNO (Jiangmen Underground Neutrino Observatory) experiment, currently under construction in the Guangdong Province (China). GIGJ results from a finely tuned Bayesian inversion that combines the GOCE gravimetric information with deep seismic sounding profiles, receiver functions, teleseismic P-wave velocity models and Moho depth maps, each of them weighted according to their own accuracy and spatial resolution. Some mathematical regularization is also introduced in order to obtain smooth discontinuity surfaces between crustal layers, as well as smooth lateral and vertical density variations. GIGJ is retrieved by maximizing the posterior probability distribution through Monte Carlo Markov Chains methods and by testing different values of the input regularization parameters. Its estimated uncertainty comprises an estimation error associated to the solution of the inverse gravimetric problem and a systematic error related to the adoption of a fixed sedimentary layer.
GIGJ fits the GOCE gravimetric gravity data with a standard deviation of the residuals of about 1 mGal, compatible with the observation accuracy and thus confirming the good performance of the inversion algorithm. Whereas global crustal models (e.g., CRUST 1.0) report for the upper, middle, and lower crust an equal thickness corresponding to 33% of the total crustal thickness, GIGJ provides a site-specific subdivision of the crustal masses. The consequence of this local rearrangement of the crustal layer thicknesses is a reduction of about 21% and an increase of about 24% of the geoneutrino signal produced by unitary uranium and thorium abundances in the middle and lower crust, respectively. The contribution of the upper crust is basically unchanged. These results are supported by a significant reduction of their estimation uncertainty. Compared to global models, the uncertainty of the estimated geoneutrino signal at JUNO is in fact reduced by 77%, 55%, and 78% for the upper, middle, and lower crust, respectively. The numerical model is available at the website http://www.fe.infn.it/radioactivity/GIGJ.

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