Geophysical models are combined with geochemical datasets to predict the geoneutrino signal at current and future geoneutrino detectors. We propagated uncertainties, both chemical and physical, through Monte Carlo methods. Estimated total signal uncertainties are on the order of $\sim$20%, proportionally with geophysical and geochemical inputs contributing $\sim$30% and $\sim$70%, respectively. Estimated signals, calculated using CRUST2.0, CRUST1.0, and LITHO1.0, are within physical uncertainty of each other, suggesting that the choice of underlying geophysical model will not change results significantly, but will shift the central value by up to $\sim$15%, depending on the crustal model and detector location. Similarly, we see no significant difference between calculated layer abundances and bulk-crustal heat production when using these geophysical models. The bulk crustal heat production is calculated as 7 ± 2 terrawatts, which includes an increase of 1~TW in uncertainty relative to previous studies.

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Heat flow from the core and the thermal evolution of the Earth

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The role of heat flow coming from the Earth's core has long been overlooked or underestimated in simple models of Earth's thermal evolution. Throughout most of Earth's history, the mantle must have been extracting from the core at least the amount of heat that is required to operate the geodynamo. In view of recent laboratory measurements and theoretical calculations indicating a higher thermal conductivity of iron than previously thought, the above constraint has important implications for the thermal history of the Earth's mantle. In this paper we construct a paramaterized mantle convection model that treats both the top and the core-mantle thermal boundary according to the boundary layer theory, and employs the model of Labrosse (2015) to compute the thermal evolution of the Earth's core. We show that the core is likely to provide all the missing heat that is necessary in order to avoid the so-called "thermal catastrophe" of the mantle. Moreover, we analyze the mutual feedback between the core and the mantle, providing the necessary ingredients for obtaining thermal histories that are consistent with the petrological record and have reasonable initial conditions.

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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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Geoneutrino Measurement at JUNO

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The Jiangmen Underground Neutrino Observatory (JUNO) is a multipurpose experiment currently under construction at an equal distance of 53 km from two nuclear power plant complexes in southern China, Yangjian and Taishan, with foreseen start of data taking in 2021. The experiment will primarily study reactor antineutrino oscillations with the goal of determining the neutrino mass hierarchy at the level of ~3σ and of measuring three oscillation parameters (θ_{12}, Δm^2_{31}, Δm^2_{31}) with <1% precision. Antineutrinos will be detected in the 20 kt liquid scintillator central detector, which will be the largest and most precise of its kind in history. In addition to reactor antineutrinos, the experiment will collect an unprecedentedly large sample of geoneutrinos. The measurement of the geoneutrino flux provides important constraints on the abundance of Earth's radiogenic elements and is of much interest to the geoscience community. The JUNO experiment aims to measure this flux with ~5% precision in 10 years. The precision depends heavily on the knowledge of the reactor antineutrino spectrum, the dominant background for geoneutrinos in JUNO. The ~1 t JUNO-TAO reference detector, placed at 30 m from one of Taishan's reactor cores, will be built to measure the shape of the reactor neutrino energy spectrum with very high statistics and an unprecedented resolution. The overview of the JUNO experiment and its current status will be discussed, with a focus on the challenges and opportunities of the geoneutrino measurement.

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