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Constraining the continental crust heat production with a gravimetric Moho

Alberto Pastorutti and Carla Braitenberg
University of Trieste, Department of Mathematics and Geosciences, 34128 Trieste, Italy (alberto.pastorutti@phd.units.it)

Satellite-only global gravity models (GGMs) offer an unparalleled homogeneity in coverage and data quality. Solutions including the gradiometry data from the GOCE mission reach high resolutions (degree and order up to 200 and above), which have already proven adequate in resolving the geometry of crustal structures (e.g. the Moho morphology). We enquire to what extent an estimate of the crustal radiogenic heat production based on crustal thickness as sensed through gravity can provide predictive results.

These characteristics make GGMs a promising candidate in solving two issues affecting the available surface heat flow measurements: those affecting the spatial sampling, which is often inhomogeneous and biased (so care must be taken in interpolations) and those concerning the superposition of components, which cannot be uniquely isolated from heat flow alone. Stripping the crustal component from the measurements is of utmost importance both "downwards", in modelling the lithospheric thermo-mechanical structure and sublithospheric dynamics, and "upwards", when assessing the near-surface (i.e. above basement) thermal regime in energy applications.

Choosing a least-structure inversion strategy (i.e. gravity anomaly to Moho depth), to keep the dependence on other observables as limited as possible, we enquire with a set of synthetic experiments the sensitivity of estimates of the heat flow contribution of continental crust against factors deviating from a perfect, static Earth assumption (such as ongoing dynamics, crustal inhomogeneities not accounted for, thermal refraction). These tests are carried out both with thermal parameter uncertainties included, to assess their propagation, and without them, to test if our starting hypotheses are sound. The results show the promising predictive power of even such a single-observable approach and the extent of the detectability of regional scale thermal regimes using global gravity products.

Since these aims required a flexible and light modelling framework, we developed a forward thermal modelling tool to estimate the temperature field in the lithosphere (surface to thermal-LAB). It comprises a 3D finite-difference heat equation solver on non-constant step rectilinear grids, taking into account temperature and pressure dependent density and thermal conductivity (using a Picard iterative scheme) and relying on a direct solver based on the Cholesky decomposition (CHOLMOD). The 3D volumes of input parameters are easily filled in starting from a layer-based model definition. The adopted grid discretisation is coherent with the prism definition, enabling to evaluate the effect of the same model both in the temperature and gravity field.