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Gravitational stresses and interplay between topography and lithosphere structure: a quantitative analysis

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Gravitational potential stresses (i.e. GPSt) are known to play a first-order role in the state of stress of the Earth's lithosphere. Previous studies focussed mainly on topography and crust structure and little attention has been paid in modelling GPSt using realistic lithospheric structures. The aim of the present contribution is to quantify gravitational potential energies and stresses associated to stable lithospheric domains. In order to model realistic lithosphere structures, a wide variety of data (i.e. topography, crust thickness, surface heat flow and chemical depletion of mantle lithosphere) are considered. A numerical method was developed. The method involves classical steady-state heat equations to derive lithosphere thickness, geotherm and density distribution, but, in addition, the studied lithosphere is required to be isostatically compensated at its base. The impact of varying topography, surface and crust heat flow, Moho depth and crust density on the signs and magnitudes of predicted GPSt is systematically explored. In clear contrast with what is assumed in most previous studies, modelling results show that the density structure of mantle lithosphere has a significant impact on the value of predicted GPSt, in particular, in the case of thick lithospheres. Using independent information from the literature, the method was applied to get insights on the state of stress of continental domains with contrasting tectono-thermal ages. The modelling results suggest that in absence of tectonic stresses Phanerozoic and Proterozoic lithospheres are spontaneously submitted to compression whereas Archean lithospheres are in a neutral to slightly tensile stress state. These findings are in general in good agreement with global stress measurements and observed geoid undulations.