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A method to compute topography and geoid from viscous convection overlaid by an elastic lithosphere

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Thermal convection that occurs in terrestrial planetary bodies induces density anomalies but also dynamic topographies of the main interfaces. Both contribute to the shape of the geoid. While a classical approach now is to combine gravity and altimetry measurements to infer the internal structure of a planet [1], our complementary approach consists in computing synthetic dynamic topography and geoid from thermal convection calculations in order to understand their relationship. Such an approach has been proposed recently to study the CMB topography of the Earth,[2], for example. Here, we couple the deformation of an elastic shell (mimicking a planetary lithosphere) with the viscous convective flow below it.
The viscous flow is computed using a 3D numerical tool for a spherical shell (OEDIPUS [3]) using a finite difference method that allows large lateral viscosity variations. The deformation of the elastic layer (located either on top of the viscous shell or included within it) is computed using a semi-spectral method. This hybrid model is tested against a very precise fully semi-spectral method through the computation of topography and geoid response functions . We then compare how locating the elastic shell whithin the viscous layer or above it affects the response functions.
Our results are the following : First, the elastic filtering is presented as a function of the elastic shell thickness. Second, we show that introducing the total traction force (instead of a simplified coupling involving only the radial component of the traction force as often assumed in earlier studies) results in a larger filtering effect caused by the elastic lithosphere (especially for thin elastic layers). This effect is maximum for loads located at middle depths and low spherical harmonic degrees. .
In a last step, we will apply our hybrid tool on simple thermal convection calculations designed to mimic Venus internal dynamics and compute the associated topography and geoid maps. Spectral characteristics of these synthetic signals (power spectrum, correlation) are presented and discussed.

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