Effect of lateral viscosity variations on mantle flow and the geoid

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We address the long-standing question of how lateral viscosity variations in the mantle such as due to presence of stiff slabs, affect the geoid. The long wavelength geoid is sensitive to the radial viscosity distribution within the Earth and an increase in viscosity, usually placed at the upper-lower mantle boundary at 660 km, is required to explain the long wavelength geoid. However, effects of lateral viscosity variations (LVVs) on the geoid are still not clearly understood. We are motivated by the findings of Zhong & Davies (1999) who found that introducing stiff slabs in the lower mantle degrades the fit to the Earth's long wavelength geoid compared to a model with only radial viscosity variations. This would indicate that slabs in the lower mantle are of the same strength as the ambient mantle, which is somewhat contrary to expectations. Moucha et al. (2007), however, recently argued that lateral viscosity variations inferred from seismic tomography have a minor effect on the geoid. We re-investigate the problem by computing the geoid in the presence of rheological complexity using the high resolution finite element mantle convection code, CitcomS. We use different models of slab and density anomalies in the mantle, and vary slab strength, temperature-dependent viscosity, and background layer viscosity profiles in a consistent way. We test different slab viscosities and compute the correlation with the observed geoid, striving to test which description of slab dynamics, and mantle rheology, is consistent with observations. As seen in previous studies, we find that presence of LVVs worsen the fit to the observed geoid for slab models, whereas the geoid from tomography models are robust to the changes in LVV. We attribute this effect to the differences in the two types of density models and the sensitivity of the geoid on those differences.

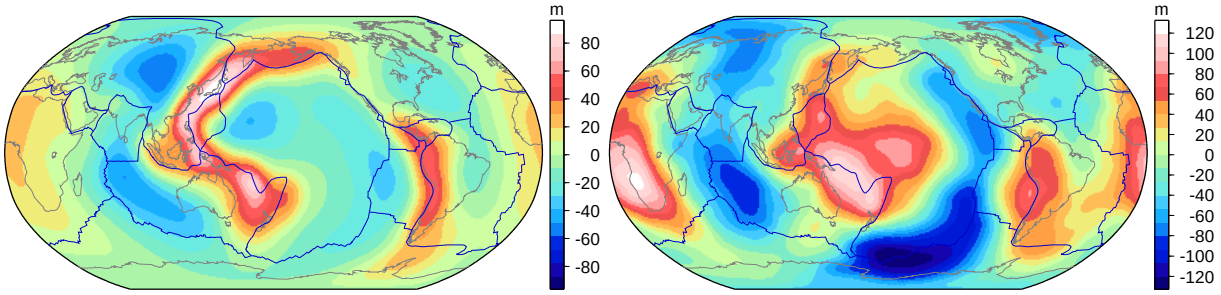

Figure 1. Predicted geoid from slab model (left) and tomography model (right) with strong LVVs.

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