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Relating mantle convection, epeirogeny and gravity anomalies

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Spatial variations of crustal thickness and density are the primary cause for most of Earth's topography. Indeed, short- to mid-wavelength topography and gravity anomalies can be explained with a relatively simple model that combines isostatic compensation and elastic support by the lithosphere.

As the wavelength increases, however, sub-lithospheric mass anomalies play an increasingly important role, both directly and through the convective stresses that they excite: these convective stresses deform the surface, generating what is called dynamic topography, and complicate the relationship between internal mass anomalies, surface topography and the resulting gravity anomalies. Here we show that this complexity can only be captured by global, self-gravitating, viscously stratified Earth models.

Moreover, sub-lithospheric mass anomalies are advected by global mantle convection — unlike near-surface mass anomalies, which stay frozen in the crust and lithosphere. Dynamic topography thus changes in time, causing epeirogenic movements. For this reason, the pattern, timing and amplitudes of past epeirogenic movements are primary geologic observables that can help constrain global mantle convection models.