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Influence of density anomalies in the lower mantle on the geoid

Marcus Beuchert, Harro Schmeling, and Meysam Shahraki
Institut für Geowissenschaften, Goethe University Frankfurt am Main, Germany (beuchert@geophysik.uni-frankfurt.de)

The influence of the two near-equatorial, antipodal Large Low Shear Velocity Provinces (LLSVPs) in the lower mantle on global mantle dynamics is a topic of major interest in geodynamics. It was found in seismic studies that LLSVPs exhibit excess density with respect to the surrounding mantle which means that they are not thermal superplumes, as previously thought. This has important implications for the overall convection style of the Earth's interior. It also changes the interpretation of the correlation between LLSVPs and observed positive geoid anomalies. If the anomalies were hot superplumes, they would drive a rising flow in the mantle and thus cause positive geoid anomalies due to dynamic topography of the surface. Yet, since the anomalies were found to exhibit excess density, such flow is expected to be much less significant and the associated geoid anomalies would be smaller than for superplumes. The excess density, in turn, could then be the major cause of the positive geoid anomalies. Even though density anomalies in the lower mantle are in general expected to have a relatively small influence on the geoid due to their great distance from the surface, large volumes with wide lateral extent, as is the case for LLSVPs, could still produce a strong geoid signal and be responsible for the observed positive geoid anomalies. Since both density excess of the anomalies and dynamic effects (resulting in dynamic topography) have an influence on the geoid signal, we investigate both effects on the geoid in fully dynamic mantle convection models with cartesian and axisymmetric geometries. For models that produce both LLSVP shapes consistent with tomography and gravitational stability consistent with geological constraints, we quantitatively explore the influence of critical parameters and compare the obtained synthetic geoid anomalies with those observed on Earth.