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Imprints of weak lithospheric plate boundaries in the observed geoid.

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The observed geoid is highly sensitive to both: density-viscosity variations within the Earth and lithosphere dynamics. While geoid undulations induced by the mantle dynamics is a subject of numerous studies, the effect of plate tectonics on the geoid and dynamic topography remains an open issue. In present study we investigate a joint effect of weak zones, dividing lithospheric plates, and lateral viscosity variations (LVV) in the whole mantle on the observed geoid. A new numerical technique is based on the substantially revised method introduced by Zhang and Christensen (1993) for solving the Navier-Stokes-Poisson equations in the spectral domain with strong LVV. Weak plate boundaries (WPB) are introduced based on the integrated global model of plate boundary deformations GSRM (Kreemer et al., 2003). We show that the effect of WPB on the geoid is significant and reaches -40 m to 70 m with RMS $\sim$20 m. Maximal WPB-related anomalies are observed over large subduction zones in South America and the Southwestern Pacific in agreement with previous studies. The positive geoid anomaly in South America could be explained largely by a dynamic effect of decoupling of the Nazca and South American plates. Mid-ocean ridges are mostly characterized by negative changes of the geoid compared to the model without WPB. The amplitude of the effect depends on the viscosity contrasts across WPB until its value reaches the limit of 2.5-3 orders of magnitude. This value might be considered as the level at which plates are completely decoupled. The effect of WPB alone, exceeds the effect of LVV in the whole mantle and generally does not correlate with it. However, inclusion of LVV reduces the geoid perturbations due to WPB by about 10 m. Therefore, it is important to consider all these factors together. The geoid changes mainly result from changes of the dynamic topography, which are about -300 to +500 m. The obtained results show that including WPB may significantly improve the reliability of instantaneous global dynamic models.

References

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