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Feasibility study to identify deep Earth signals in current and future gravity field missions

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Next generation gravity missions are expected to improve the accuracy of temporal Earth's gravity models significantly. Periodic signals and trends are related to mass redistributions in the Earth system and carry essential information on dynamic processes in the atmosphere, cryosphere, hydrosphere and the solid Earth. Gravity signals from the deep solid Earth are commonly thought to lie below the detection limit of satellite gravity missions, as one assumes them to have very small amplitudes and be restricted to the longest spatial and temporal scales. However, robust evidence from geologic records exists for episodes of very rapid uplift and subsidence events at regional scales, especially along passive continental margins. These uplift and subsidence events, which are inferred from regional seismic stratigraphy, landscape evolution studies, and the analysis of river profiles, result from flow in the underlying mantle and imply faster rates and smaller scales for the contribution of the solid Earth to the time-dependent gravity field.

Here we exploit high resolution global mantle convection models capable of resolving fine scale mantle flow in conjunction with an innovative adjoint method. The adjoint method allows us to derive time trajectories for global mantle flow, thus providing first order estimates for temporal variations of gravity signals related to solid Earth. This is then analyzed with numerical low–low SST closed-loop simulations including GRACE-like observation noise. We find out that a Bender-type double pair mission scenario would be able to resolve the gravitational signal from deep mantle convection.