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Mercury's gravity field as constrained by the tectonic record

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Due to MESSENGER's elliptical orbit, Mercury's gravity field is unevenly known with resolution ranging from up to only about spherical harmonic degree 10 (□1,500 km wavelength) in the southern hemisphere to degree 90 and up to 160 in the north (□100–170 km; [1]). Such low-resolution gravity field represents a major obstacle to our understanding of the planet's interior structure and geodynamic history [2]. One objective of the BepiColombo mission is to improve Mercury's gravity field models using the Mercury Orbiter Radio Science Experiment (MORE) [3]. However, even after the extended mission, the gravity field is predicted to only reach about degree 40-50 globally. Some previous works have attempted to increase the resolution of the gravity field based on the expectation that, at sufficiently high harmonic degree, gravity should be correlated to topography [4]. Yet, at the measured wavelengths on Mercury, lithosphere deformations from geologic loads are expected to prominently affect the planet's gravity field, making gravity-from-topography models highly non-unique [2,4].

Before high-resolution gravity measurements were made available on the terrestrial planets, studies have commonly used elevation data and tectonic structures to investigate lithosphere deformations and the presence of subsurface loads [5]. Detailed characterization of subsurface loads and lithosphere deformations can in turn be used to break part of the non-uniqueness in the predicted, high-degree gravity, field. In this work, we combine topography data and tectonic deformations [6,7] together with a lithosphere loading model [8] to provide high-resolution gravity field and interior structure models of Mercury.

Using a global tectonic catalog together with analysis of elevation profiles across tectonic landforms, our previous works have estimated lateral variations in tectonic strain [6,7]. The estimated average shortening reflects Mercury's global contraction (with values of ranging from 6 to 8 km), while lateral variations have been attributed to local lithosphere deformations from geologic loads [7]. While lateral cooling efficiency due to crustal thickness or surface temperature variations can induce lateral variations in planetary contraction, these effects are expected to only moderately affect contraction [9] and would not fully explain the observed large variations. Here, we convert the estimated tectonic strain to membrane–flexural uplift and subsidence using a spectral transfer function similar to an admittance [7]. Lithosphere displacements are then used together with topography data to predict high-resolution gravity field models of Mercury. The models are patched to MESSENGER's observed gravity field based on the local degree-strength. A by-product of this inversion is the planet's interior structure, consisting here of a crust with laterally variable thickness and mantle with laterally variable density.

The estimated gravity field and interior structure maps will be presented at the conference.

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