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New insights on the dynamics of the Sumatra and Mariana complexes inferred from the comparative analysis of gravity data and model predictions

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Subduction is responsible for surface displacements and deep mass redistribution. This rearrangement generates density anomalies in a wide spectrum of wavelengths which, in turn, causes important anomalies in the Earth's gravity field that are visible as lineaments parallel to the arc-trench systems. In these areas, when the traditional analysis of the deformation and stress fields is combined with the analysis of the perturbation of the gravity field and its slow time variation, new information on the background environment controlling the tectonic loading phase can be disclosed.

Here we present the results of a comparative analysis between the geodetically retrieved gravitational anomalies, based on the EIGEN-6C4 model, and those predicted by a 2D thermo-chemical mechanical modeling of the Sumatra and Mariana complexes.

The 2D model accounts for a wide range of parameters, such as the convergence velocity, the shallow dip angle, the different degrees of coupling between the facing plates. The marker in cell technique is used to compositionally differentiate the system. Phase changes in the crust and in the mantle and mantle hydration are also allowed. To be compliant with the geodetic EIGEN-6C4 gravity data, we define a model normal Earth considering the vertical density distribution at the margins of the model domain, where the masses are not perturbed by the subduction process.

Model predictions are in good agreement with data, both in terms of wavelengths and magnitude of the gravity anomalies measured in the surroundings of the Sumatra and Marina subductions. Furthermore, our modeling supports that the differences in the style of the gravity anomaly observed in the two areas are attributable to the different environments – ocean-ocean or ocean-continental subduction – that drives a significantly different dynamic in the wedge area.