Spectral Assessment of Isostatic Gravity Models Against CHAMP, GRACE, GOCE Satellite-Only and Combined Gravity Models

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Abstract

The availability of digital elevation databases representing the topographic and bathymetric relief with global homogeneous coverage and increasing resolution permits the computation of crust-related Earth gravity models, the so-called topographic/isostatic Earth gravity models (henceforth T/I models). Although expressing the spherical harmonic content of the topographic masses, the interpretation purpose of T/I models has not been given the attention it deserves, apart from the fact that they express some degree of compensation to the observed spectrum of the topographic heights, depending on the kind of the applied compensation mechanism. The present contribution attempts to improve the interpretation aspects of T/I Earth gravity models. To this end, a rigorous spectral assessment is performed to a standard Airy/Heiskanen T/I model against different CHAllenging Minisatellite Payload (CHAMP), Gravity Recovery and Climate Experiment (GRACE), Gravity field and steady-state Ocean Circulation Explorer (GOCE) satellite-only, and combined gravity models. Different correlation bandwidths emerge for these four groups of satellite-based gravity models. The band-limited forward computation of the models using these bandwidths reproduces nicely the main features of the applied T/I model.

Key words: topographic/isostatic gravity models, CHAMP-only models, GRACE-only models, GOCE-only models, combined gravity models.
1. INTRODUCTION

The implementation of the high-low and low-low Satellite-to Satellite Tracking (SST) and Satellite Gravity Gradiometry (SGG) configurations through the corresponding dedicated gravity satellite missions CHAMP (Reigber et al. 2002), GRACE (Tapley et al. 2004), and GOCE (Rummel et al. 2011) has enabled the production of some satellite-only and combined solutions for the Earth’s geopotential (Tapley et al. 2004, Flechtner et al. 2010, Pail et al. 2011). Using the perturbed satellite orbit observed by the on-board Global Positioning System (GPS) receiver and quantifying the non-gravitational components through the accelerometer readings, the release of different gravity field models over the last decade or so was made possible, depending on the mathematical model used for the adjustment and the range of the employed satellite data. Furthermore, the combination of these satellite observations with other satellite and terrestrial data led to the computation of so-called combined gravity models. The International Centre for Global Earth Gravity Field Models (ICGEM) Service at the GFZ Helmholtz Centre Potsdam administers almost all available satellite-only and combined gravity models in terms of their coefficients and their variances, when available. A separate category of gravity models concerns the so-called topographic/isostatic models. Their special feature lies in the fact that they are linked directly to the geometry of the upper crustal boundary surface, as this is expressed by the topography/bathymetry interface. Their numerical computation can be performed directly from the gridded height values of a global digital elevation model of continents and oceans (terrain and bathymetry), with their maximum degree and order of expansion being limited by the spatial resolution of the elevation database. In terms of their information content, the T/I models express the power spectrum of the topographical masses, thus they include the high and very high frequencies of the observed field. As the satellite-derived models capture mainly the medium-to-long part of the gravity spectrum it is the motivation of the present contribution to investigate the spectral characteristics of a standard T/I model when compared with a selection of the most representative CHAMP-only, GRACE-only, GOCE-only, and combined models. In this way we hope to increase our understanding on the spectral assets of T/I models and quantify their relation with the other available models.

2. TOPOGRAPHIC/ISOSTATIC GRAVITY MODELS

The theory of T/I gravity models is based on the definition of the gravitational potential which is generated by the mass balance between crust and mantle. Stimulated by the availability of global digital databases describing the shape and geometry of the Earth’s upper crust and the advance of com-