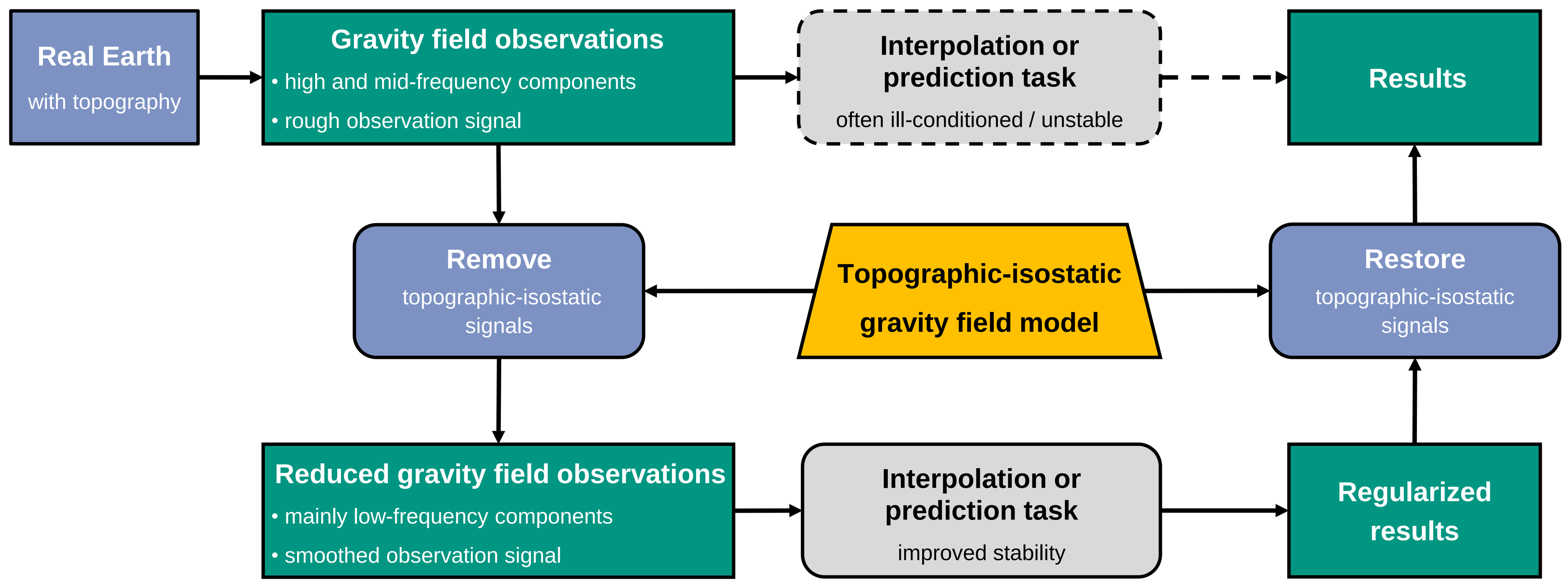
The Rock-Water-Ice topographic-isostatic gravity field model up to d/o 1800

Thomas Grombein, Kurt Seitz and Bernhard Heck

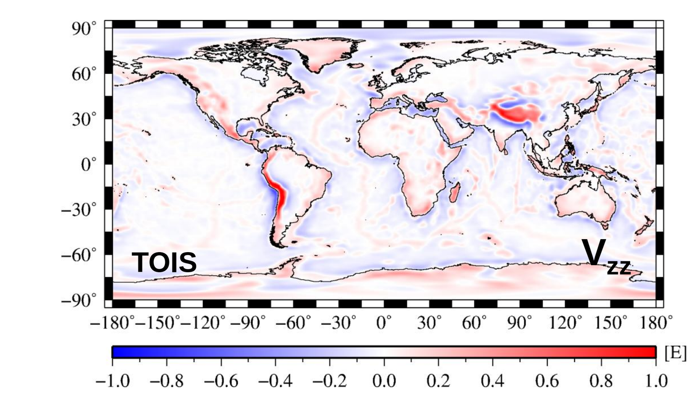
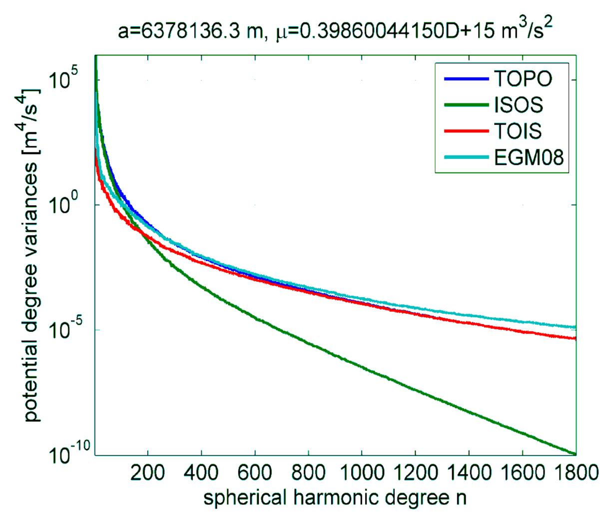
Introduction

Global high-resolution digital terrain models provide precise information on the Earth's topography which can be used to simulate the high and mid-frequency constituents of the gravity field (topographic-isostatic signals). By using a Remove-Compute-Restore concept (e.g. Forsberg and Tscherning, 1997) these signals can be incorporated into many methods of gravity field modelling. Due to the smoothing of observation signals such a procedure benefits from an improved numerical stability in the calculation process, particularly when interpolation and prediction tasks as well as field transformations are carried out. In this contribution the Rock-Water-Ice topographic-isostatic gravity field model (RWI model) is presented that we developed in order to generate topographic-isostatic signals which are suitable to smooth gravity-field-related quantities. In contrast to previous approaches this model is more sophisticated due to a three-layer decomposition of the topography and a modified Airy-Heiskanen isostatic concept. The development and the characteristics of the RWI model are described in detail. Taking ESA's gravity field mission GOCE as example, the RWI model is used to smooth the high and mid-frequency signal content in the observed gravity gradients.



Rock-Water-Ice methodology

Topographic-isostatic signals can be obtained by forward gravity modeling based on the numerical evaluation of Newton's integral (cf. Heiskanen and Moritz, 1967). Thereby, global information on the geometry and density is required which have to be defined by a topographic model and an isostatic concept. Being advantageous over previous approaches, we developed the so-called RWI model which is based on a vertical three-layer decomposition of the topography. Therefore, the rock, water, and ice masses are modeled individually using layer-specific density values. Geometry and density information is derived from the 5′x5′ topographic data base DTM2006.0 (Pavlis et al., 2007). Additionally, a modified Airy-Heiskanen isostatic concept is applied, which is improved by incorporating Crust2.0 Moho depths (Bassin et al., 2000) in combination with the derivation of local crust-mantle density contrasts. Topographic-isostatic effects are initially calculated in the space domain using tesseroidal mass bodies (e.g. Heck and Seitz, 2007; Grombein et al., 2012b) arranged on the GRS80 ellipsoid and then transformed into the frequency domain by applying harmonic analysis (e.g. Wittwer et al., 2008).

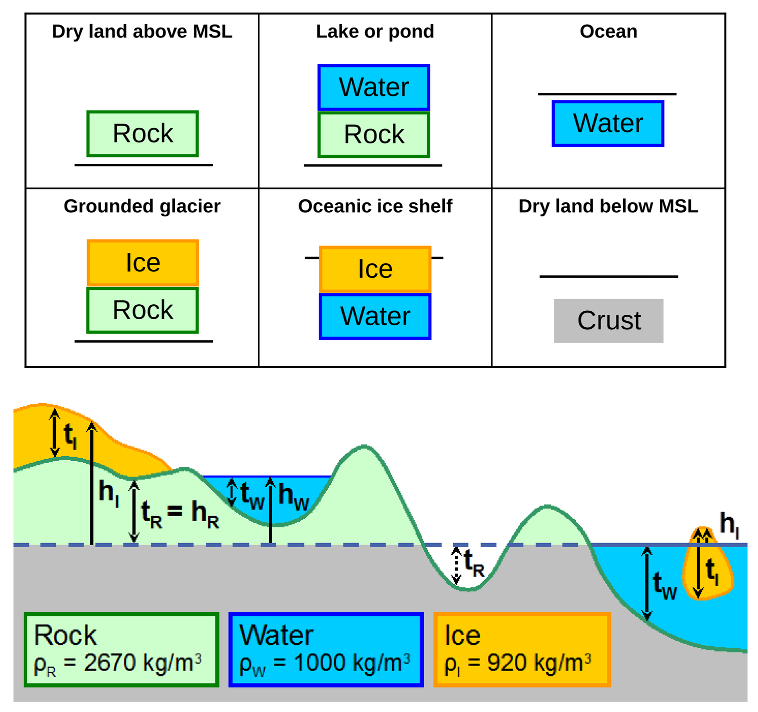
Space domain	Frequency domain
	

Topographic-isostatic signal of the RWI model at the GOCE satellite altitude (Vzz gravity gradient component)

Topographic model

Basic idea: Three-layer model

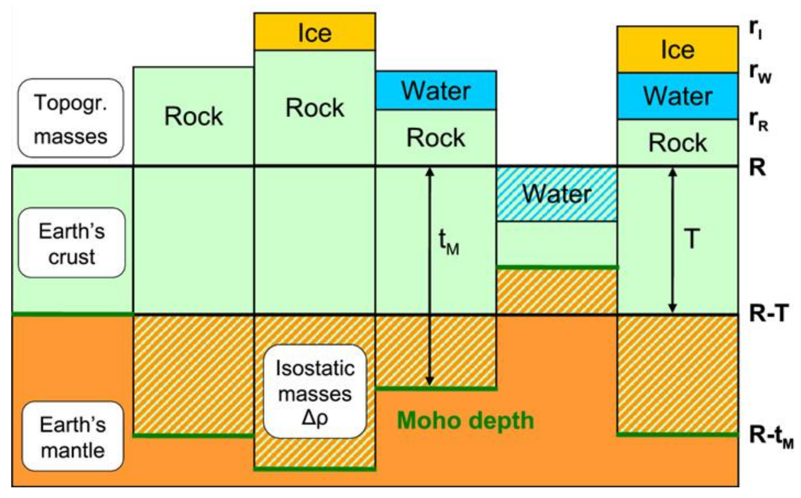
- Rock **(R)**, water **(W)**, and ice **(I)** masses are modelled individually.
- **5′ × 5′ DTM2006.0** information is used to construct a vertical three-layer terrain and density model.
- Each grid element consists of three components with different MSL-heights (h_R, h_W, h_I).
- **Layer-specific density values** (ρ_R, ρ_W, ρ_I) are derived from the specified DTM2006.0 terrain types.
- Topographic masses are represented by three vertically arranged **tesseroids** per grid element.



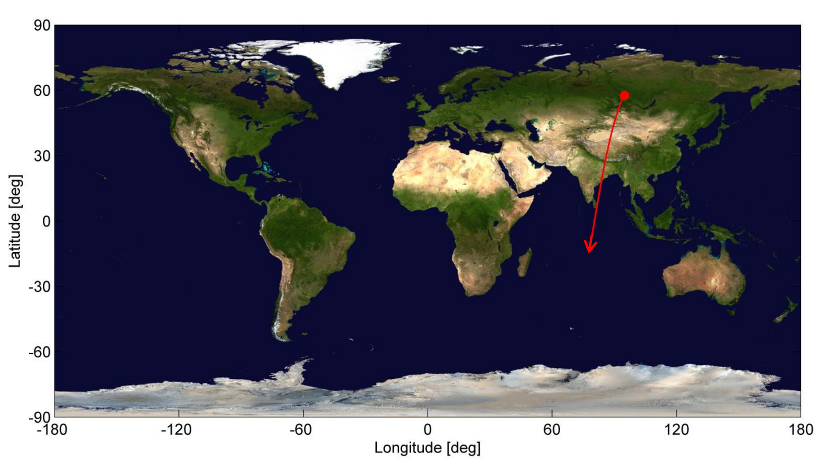
Isostatic concept

Basic idea: Mass equality condition

- Isostatic masses are derived from the **topographic load.**
- Classical concepts have been adopted to the RWI method.
- A **modified Airy-Heiskanen** concept is developed by introducing a Moho depth model derived from **CRUST2.0.**
- (Anti-)root depths are replaced by the Moho depths.
- The mantle-crust density contrast **Δρ is kept variable.**
- The normal compensation depth is set to **T = 31 km.**

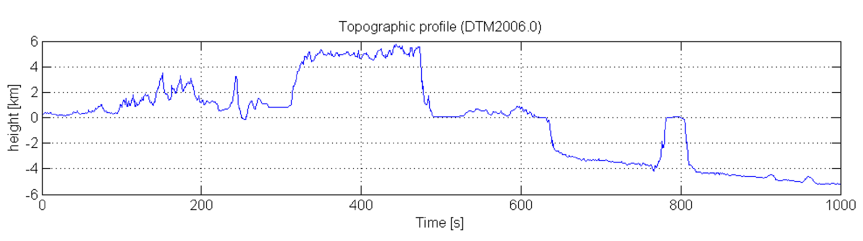


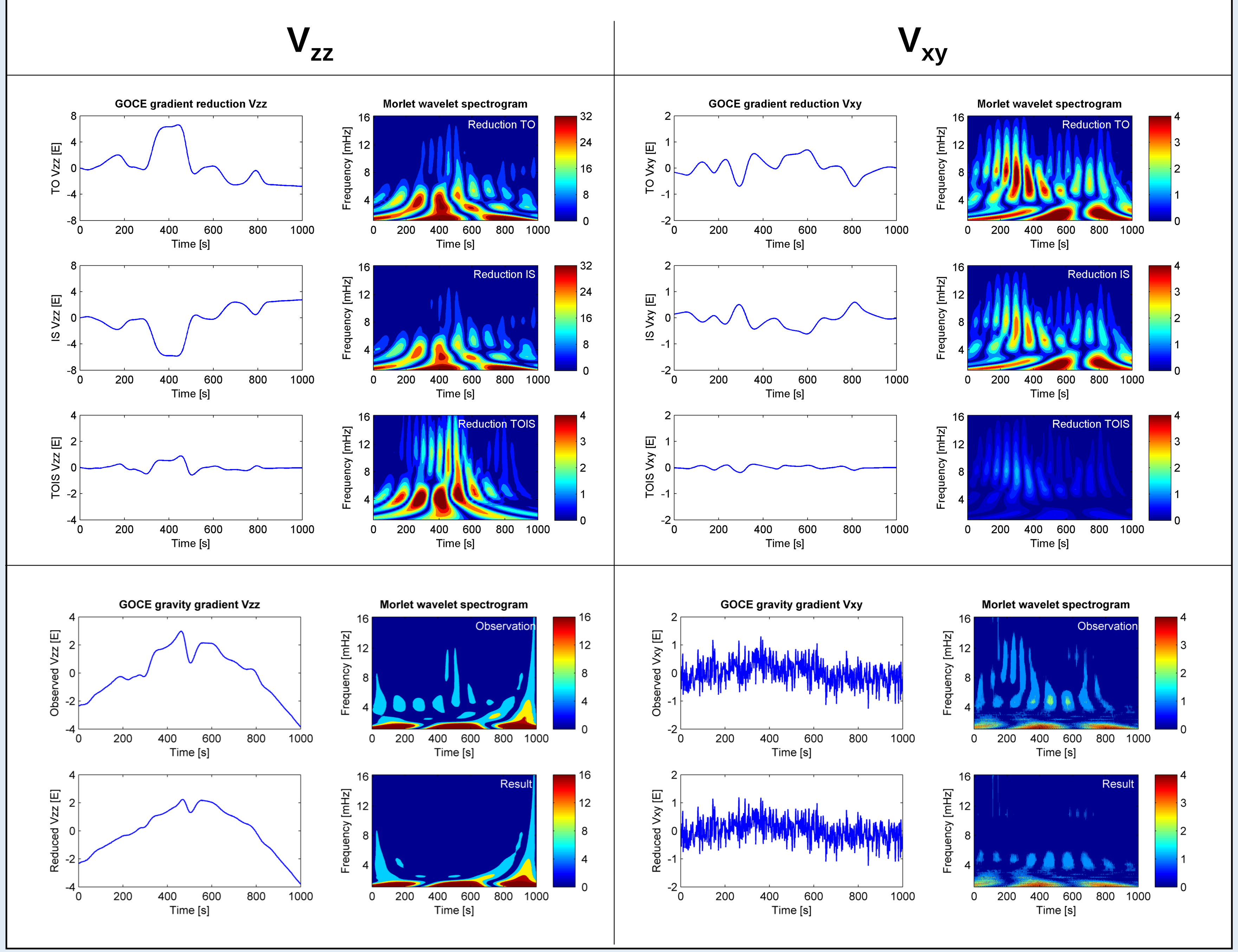
Smoothing GOCE gravity gradients by the RWI model *(cf. Grombein et al., 2012a)*



GOCE time series over the Himalaya Region

(04.11.2010, T = 1000 s, Δt = 1 s, Δs ~ 7.8 km)





Conclusions

- The Rock-Water-Ice topographic-isostatic gravity field model can be used to generate suitable topographic-isostatic signals which can be incorporated into a Remove-Compute-Restore concept.
- In contrast to previous approaches this model is based on a three-layer decomposition of the topography with layer-specific density values and a modified Airy-Heiskanen isostatic concept.
- Due to the representation of the potential values into spherical harmonics, topographic-isostatic signals of the RWI model can be computed for any gravity-field-related quantity.
- The performance of topographic-isostatic signals based on the RWI model has been validated by means of wavelet analysis.
- Taking a GOCE time series over the Himalaya as an example, the wavelet spectrograms confirm a significant smoothing effect on the high and mid-frequency constituents of the observations.

RWI topographic-isostatic gravity field models up to d/o 1800

→ Topographic-isostatic model: RWI_TOIS_2012_1.gfc
→ Topographic model: RWI_TOPO_2012_1.gfc
→ Isostatic model: RWI_ISOS_2012_1.gfc

can be downloaded at **http://www.gik.kit.edu/rwi_model.php**

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