Abstract

Geoid signatures from glacial isostatic adjustment models with
low-viscosity crustal zones in the realm of the GOCE satellite mission

by L.L.A. Vermeersen (1), G. di Donato (2) and R. Sabadini (2)

(1) DEOS - Faculty of Aerospace Engineering, Delft University of Technology, Kluyverweg 1, NL-2629 HS Delft, The Netherlands; email: b.vermeersen@lr.tudelft.nl, tel. +31 15 27-88272, fax -85322.

(2) Dipartimento di Scienze della Terra, Sezione Geofisica, Universita di Milano, Via L. Cicognara 7, I-20129 Milano, Italy.

Glacial Isostatic Adjustment (GIA) due to ice melt of the last Great Ice Age that ended some 10,000 years ago, has a world-wide non-negligible contribution to present-day secular sea-level variations and has left a clear imprint in the present-day geoid. Both melt of the great continental Pleistocene ice domes (negative loading) and their consequential rise of sea level of more than 100 meters (positive loading) are responsible for this, so that GIA and its resulting geoid signatures are global phenomena, not constrained to the formerly glaciated areas and their surroundings.

The solid earth models that are used in simulating GIA due to Pleistocene deglaciation and its concomitant meltwater distribution commonly take the upper layer (the crust/lithosphere) elastic. While this is a good assumption for oceanic lithosphere, it is over-simplified for most continental crustal areas, of which many are submerged beneath oceans and seas at continental margins. Some of these continental areas have a lower crust that has low viscosities. Such a low-viscosity layer is sandwiched between an approximately elastic upper crust and lithosphere. Low-viscosity zones might also occur at the top of the shallow mantle (the asthenosphere).

GIA modeling results show that, due to their shallowness and their laterally non-homogeneous occurrence, these low-viscosity solid-earth layers are expected to leave discernible signatures in the high-harmonic steady-state components of the geoid. These high harmonic geoid anomalies are the main observational aim of the GOCE satellite mission, that is expected to be launched in 2006 or 2007. Depending on depth, width and viscosity of the low-viscosity zone, patchlike features emerge with typical wavelengths of less than 100 km and up to about 1,000 km, and magnitudes of down to a few cm and up to a few m. GOCE is expected to deliver a global map of geoid anomalies with resolution down to 100 km or less, and magnitudes of down to 1 cm. The GOCE mission might therefore contribute in constraining both stratification and rheological properties of the shallow solid Earth, and thereby also contribute to establish the contribution of on-going GIA to present-day

secular sea-level changes.

Complications in correlating GIA modeling results with observed geoid anomalies might arise from uncertainties in isostatic corrections (topography, non-uniform composition of crust and lithosphere) and from other non-GIA contributions to the observed anomalies. Although the forward GIA simulations do show clear signatures arising from shallow solid-earth low-viscosity zones, it therefore remains to be seen whether inversions can uniquely link the observed geoid anomalies to the sought-for earth structure and properties. Additional observations, like seismic ones, and explicit modeling of tectonic components might assist in such data interpretation. As GIA leaves distinct, characteristic patterns in the geoid, it is expected that geographical pattern comparison will be a helpful tool in retrieving the GIA contributions.