Geophysical Research Abstracts, Vol. 8, 04483, 2006
SRef-ID: 1607-7962/gra/EGU06-A-04483

Gravity field variations from Superconducting Gravimeter recordings

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The modelling of both, the static and the time-variable global Earth gravity field has been considerably improved by using the observations from the CHAMP and GRACE gravity missions. This improvement is to a considerable part based on the excellent work of Peter Schwintzer. For the solutions based on GRACE observations the gravity resolution is about 1 μgal for a half-wavelength spatial resolution of 1330km (l_{max} = 15) and the temporal resolution is 1 month. The improved knowledge of the gravity field variations constrains both, hydrological and geophysical models, e.g. of mantle convection, which is the driving force for plate tectonics, volcanism and earthquakes. It is also significant for global change theories, when analyzing long-term mass redistributions associated with post-glacial rebound and sea level variations due to changes in the polar ice mass balance, etc.

On the Earth's surface high-precision gravity measurements are carried out with Superconducting Gravimeters forming the SG network of the Global Geodynamic Project (GGP). These measurements have a gravity resolution of about 0.1 μgal in time domain, about 1 ngal in frequency domain and a drift of a few μgal per year which is linear and therefore can be corrected. Because of their high gravity resolution and long-term stability SG measurements contribute to modelling of gravity field variations and geophysical signal interpretation like solid Earth and ocean tides, free oscillation of the Earth, core modes, Nearly Diurnal Free Wobble, polar motion, etc.

The SG is an integrating sensor measuring gravity variations associated with mass redistributions in its near and far surroundings. Therefore, the recordings include temporal gravity variations of different sources. The separation of the different gravity effects is based on appropriate physical models. The efficiency of the models for surface gravity effects (solid Earth and ocean tides, pole tide, atmosphere and hydrosphere) is estimated. The atmospheric pressure reduction of the SG data is carried out with a new 3D model.

GRACE derived temporal gravity variations are compared with ground measurements at selected SG stations. As a prerequisite, both data sets are reduced for the same known gravity effects (solid Earth and ocean tides, pole tide and atmosphere) by using the same models. The loading Love numbers h' and k' are used to adapt satellite and ground gravity variation measurements and allow for a comparison. Because of limited spatial resolution of GRACE all known local gravity effects are removed from the SG measurements. GRACE and SG gravity variations show a quite good agreement within their estimated error bars. The remaining gravity variations of both data sets are mainly caused by hydrological effects.

Additionally, a comparison is performed with gravity variations derived from global hydrological models. The degree of agreement with the gravity variations derived from GRACE and SG is shown. The problems of comparison are discussed.