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Non-tidal oceanic mass shifts and their impact on terrestrial gravity observations

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In the last years the application of high-quality terrestrial gravity observations to studies of mass transport has become more and more a focus of interest. This goes hand in hand with efforts to enhance the signal-to-noise ratios in the time series by more comprehensive and sophisticated reductions for geodynamic studies. In addition a precondition for a consistent combination of terrestrial and satellite-derived gravity field variations comprehends not only to apply reductions to the data sets as good as possible, but also to ensure that reductions for the same influences either are applied or evidence is provided that the respective effect is negligible.

One of the effects which thus moved into focus encompasses non-tidal mass shifts in the oceans. A major benefit of including this effect in the reductions is the appropriate response of the oceans with respect to changes in atmospheric loading, when sea surface pressure anomalies are applied as additional forcing in the ocean simulations, redundantising assumptions with regard to inverted or non-inverted barometer response. For example from a study by Fratepietro et al. (2006) a significant influence of storm surge-related effects in the North Sea on gravity even for inland sites emerged.

Based on the OMCT and the ECCO model the gravity effect of non-tidal oceanic mass shifts is computed for various sites equipped with a superconducting gravimeter (SG) esp. with a view on seasonal variations. A five year-long period covering the years 2002 through 2006 is considered.

The results so far are ambiguous: The systematic seasonal change of about 10 nm/s^2 peak-to-peak in gravity found for mid-European stations is presently not found in the observed gravity variations. Generally, the order of magnitude of the total effect of 22 to 27 nm/s^2 peak-to-peak is quite large for stations at a distance of some 100 km from the coast. In some data sections an agreement between observed and modelled gravity variation can be found which then results in the removal of larger residuals. For the South-African station Sutherland a different result is obtained. Here the seasonal variation caused by the non-tidal oceanic mass shifts and gravity residuals correlate. In this instance the application of the additional reduction leads to an overall substantial improvement of the signal-to-noise ratio in the gravity observations.

One explanation for the different results might be found in the principle accuracy of the global continental hydrological models. Such a model is needed in order to remove the effect of large-scale variations in continental water storage in the gravity observations in order to obtain residuals which contain mainly variations related to the non-tidal oceanic mass shifts. This reduction plays a greater role for European stations than for the South African site. A possible critical impact of the land-sea-mask of the oceanic models resp. the negligence of the shelf areas could not be confirmed. The OMCT and the ECCO model have with 1.875° and 1° a different spatial resolution. The incorporation of a regional high resolution model (5' x 3', resp. 50" x 30") for the North and Baltic Sea from the BSH (Bundesamt für Seeschifffahrt und Hydrographie) does not change the principle order of magnitude of the seasonal effect. Thus, there are presently strong indications that the order of magnitude of the long-period contribution is real. This means the influence of non-tidal mass shifts in the oceans should not only be considered for studies in the short periods, but also in the long-period spectral range.