Long period tides observed in gravity and VLBI observations at Ny-Ålesund, Spitzbergen

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Abstract

The aim of this research is to determine the precise magnitude of the body tide at the 13.66 day period, called harmonic Mf, with VLBI and tidal gravimetry. The Mf observations made in the past are mostly too inaccurate to put a tight constraint on modern theoretical body tide models. The availability of long VLBI records and recent technological advances in gravimetry has given us the hope that higher observation accuracy can be achieved. The VLBI and tidal gravimetry observations made at Ny-Ålesund, Spitzbergen, are especially promising because of the site's proximity to the North pole where the long period tides reach their maximum.

A VLBI data set of more than 200 observing days covering October 1994 to December 2000 was analysed and the topocentric coordinates of the Ny-Ålesund site were determined. Unfortunately, the sampling interval of the VLBI observations is on the average 14 days which is very close to the period of our signal of interest and thus leads to aliasing. Nevertheless, we detected a significant peak in the spectrum of the time series of the vertical station position at the Mf period when excluding this tide from the a-priori modelling of the body tide in the VLBI analysis software. This indicated that the VLBI data are sensitive to the Mf tide and encourages further investigation using a more direct analysis approach without involving time series of station positions (Bos and Haas, 2001).

The tidal gravimetry observations are made with a superconducting gravimeter which was installed in 1999 by Tadahiro Sato of the National Astronomy Observatory of Japan (Sato et al., 2001). This type of gravimeter has a low drift rate which makes it a very suitable instrument for this research. After analysing 2 years of data and applying the ocean tide loading correction, it was found that the gravimetric factor was higher than predicted by the model of Dehant et al. (1999). A review of other observed gravimetric factors showed that most of them are larger than the theoretical value. These data points were taken from Crossley and Xu (1998), Schwahn et al. (2000), Harnisch et al. (2000), Melchior et al. (1996), Sato et al. (1997) and Rydelek and Knopoff (1982), again corrected for ocean tide loading and are plotted in Figure 1. The solid line is the theoretical gravimetric value for an elastic Earth. The dotted line represents the gravimetric factor for an inelastic Earth.

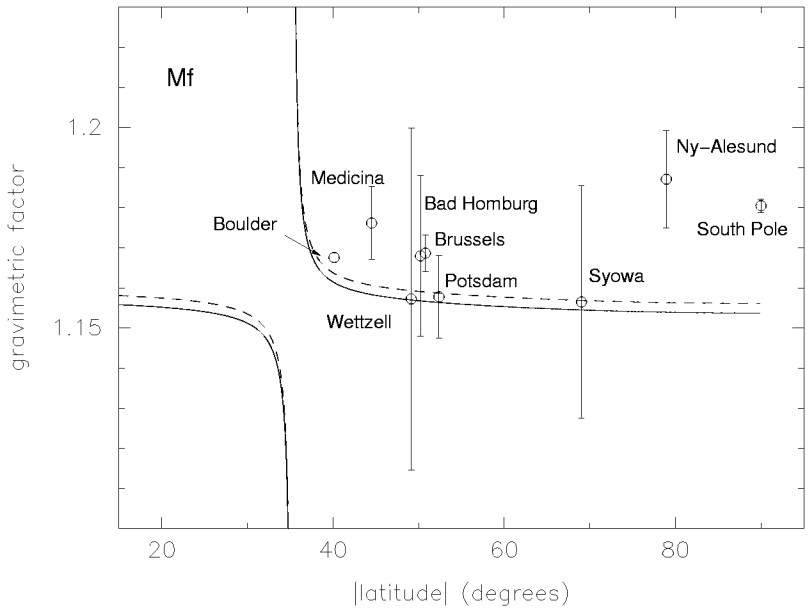

Figure 1: The gravimetric factors for the Mf harmonic as found in literature. All values have been corrected for ocean tide loading.

The high gravimetric factors at Ny-Ålesund and the South Pole could indicate some error in the theory, but could also be due to calibration problems and uncertainty in the ocean tide loading. Bos et al. (2000)[1] note that at the South Pole the 2 km thick ice sheet on which the gravimeter is located could in principle cause an even smaller theoretical gravimetric value. When the body tide is upwards, the Earth surface is stretched. The Antarctic ice sheet that is attached to the surface will become thinner and will move the gravimeter that is located on top of it downwards. As a result, the observed amplitude of the body tide is diminished.

Florsch et al. (1995) showed that in the tidal analysis the amplitude estimation of a spectral peak is biased and should be corrected when the signal-to-noise ratio is small. This bias is positive and because the noise at the Mf harmonic is relative large, it could explain why all listed observed gravimetric values are above the theoretical value. The noise in the gravity data at Ny-Ålesund was modelled as a first-order linear autoregressive process and produced a bias in the estimation of the gravimetric factor of +0.1%. This value is quite small but perhaps it will increase when a more realistic model for the noise is used and will be investigated further.

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