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Reviving absolute gravimetry in Hammerfest, Norway?

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Abstract
Absolute gravimetry was made in Hammerfest in 1976 (Cannizzo et al. 1978). The observing station was demolished in 1995. We describe the results of relative gravimetry in an attempt to transfer the value to a new site. The errors of these measurements invite new absolute gravimetry to be made in Hammerfest.

Introduction

Hammerfest entered international geodesy in 1845 when army surveyors F. L. Kloumann and C. A. B. Lundh selected Fuglenes as the northern terminal of the Struve arc. In 1847 Kloumann completed the geodetic arc measurements by including Fuglenes as the northernmost station measured with the Repsold theodolite. In 1850 Daniel Lindhagen of Pulkovo Observatory brought a transportable meridian circle, a universal instrument, a transit instrument and two chronometers to Fuglenes where they were mounted in a temporary observatory building of modest dimensions. Lindhagen determined an accurate latitude value and an azimuth angle for global orientation of the Norwegian section of the Struve arc. A memorial monument exists at the observing site.

Hammerfest was included into the *International Gravity Standardization Net 1971* (IGSN71) by LaCoste & Romberg instruments, and is the northern terminal of the absolute calibration line between Munich and Hammerfest (Torge 1984). It is also included in the Finnish First Order Gravity Net (FOGN, Kiviniemi 1980). The observation point was located in the basement of the fire station in Hammerfest. Morelli et al. (1974) lists the IGSN71-result as g = 982617620 μGal, while Kiviniemi (1980) lists the FOGN-result as g = 982617610 μGal.

In 1976 absolute gravimetry was made by Cannizzo et al. (1978) with a rise-and-fall gravimeter. Although these observations were not corrected for atmospheric pressure and polar motion, a reanalysis is possible (e.g. by using meteorological observations reduced to sea level). Gravity gradient measurements are also available (J. Mäkinen, 2005, private communication). If this exercise is attempted, historical polar motion data from IERS and a modern tidal model should be used.

Geometric observations in Hammerfest

A tide gauge time series is available for Hammerfest between 1957 and 2004 (Fig. 1). There are occasional gaps in the data which lead to lack of monthly values at various epochs throughout the time series. Long breaks of several months to one year exist in 1967-68, 1970, 1976, 1982, and 1990. A linear regression analysis of the monthly time series reveals a slope of 0.059 cm per year. The sea level at Hammerfest is thus rising by 0.6 mm per year. This suggests that Hammerfest is very close to the Fennoscandian zero uplift line.

There is no permanent GPS-station in Hammerfest, so the motion relative to the Earth's center of mass is not available at this time. We note that tide gauge data for Vardø shows the same slope as for Hammerfest, and may thus obtain some guidance from a GPS analysis at Vardø for data between 1996 and 2003 (Kristiansen, 2003), which yields a vertical motion of 1 mm per year.

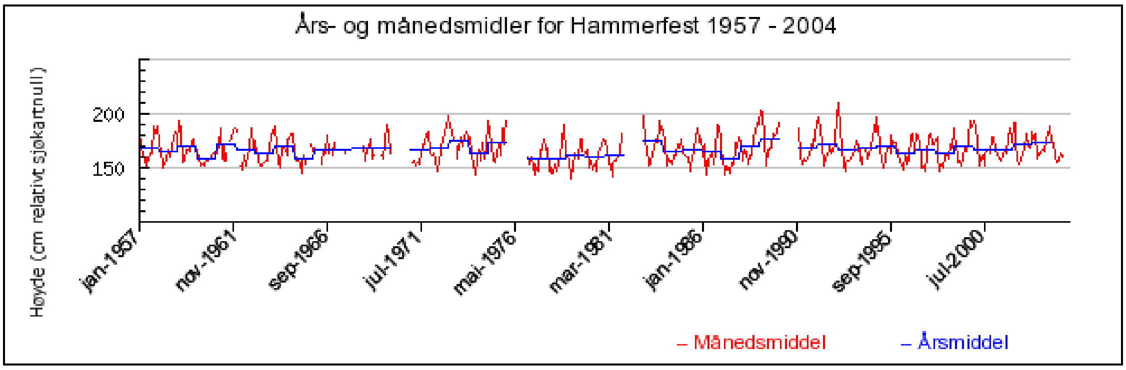

Figure 1. Time series of tide gauge measurements for Hammerfest, displaying monthly (red) and annual (blue) mean values. (Source: Hydrographic Office, Norway).

This corroborates a preliminary conclusion from geometric data that very small, if any, changes in the absolute gravity value are expected for Hammerfest. A long time span of accurate observations are expected in order to detect a gravity change.

Relative gravimetry

During a tenure of BRP at the Geodetic Institute of the Norwegian Mapping Authority, a call to transfer the old gravity point into a new location was received immediately prior to the demolition of the old fire station in Hammerfest. On very short notice a capable observer was dispatched to Hammerfest with the Lacoste and Romberg G-378 relative gravimeter to establish a new gravity point and perform the transfer from the old one in the basement of the fire station.

Before departure, on 22 February 1995 at 04:55 UT, a gravity measurement was made at the Norwegian Mapping Authority in Hønefoss. The gravimeter was transported by car to Fornebu Airport, Oslo where a measurement was made at 06:16 UT. The instrument accompanied the observer by airplane to Hammerfest, where the first measurement of the existing gravity point in the fire station was made at 11:10 UT. The instrument was carried by hand to the nearby church where a new gravity point was established and measured at 11:33 UT. The second observing cycle began at 11:52 UT with 10 minutes between sites, and was then repeated 6 times, until 13:21 UT, with two readings at each site. Eleven gravity differences may thus be produced. The result is $\Delta g=1227 \pm 4$ μGal, with the new site having a larger numerical value than the old site.

The following day one measurement was made at the old site (10:39 UT) before leaving Hammerfest by airplane. Upon arrival at Fornebu Airport, Oslo a measurement was made there at 15:56 UT. Car transport to Hønefoss closed the observing series at 17:12 UT.

New absolute station

The new gravity point in the church of Hammerfest was marked by a bolt in the concrete floor. The collar reads: *Statens kartverk 1995. Lovbeskyttet fastmerke.* The hand drawings made by the observer suggest that a FG5 absolute gravimeter may be mounted at the site only with great difficulty due to nearby walls. Thus an eccentric measurement may be required, or an A10 gravimeter may be used to transfer the gravity value to the new absolute gravity station in Honningsvåg. A future gravity time series would be continued there.

The previous observations in Hammerfest suggest that a reasonably accurate absolute gravity value may be estimated for epoch 1976 at the new station. Renewed absolute gravimetry in 2005 and 2006 would produce a time baseline of 30 years to investigate if gravity is changing in Hammerfest. If successful, this would be the longest time span available in Fennoscandia along with Sodankylä in Finland (Bilker et al. 2004).

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