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GEODETIC ACTIVITIES AT FINNISH ANTARCTIC RESEARCH STATION ABOA

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Abstract. *We summarise geodetic activities at the Finnish Antarctic research station Aboa since 1989. In 1989–1992 a regional gravity network was established. Absolute gravity measurements were performed in 1994 and 2001. In 2003 a permanent GPS station was installed. In the future we plan to maintain the GPS time series, and to perform absolute-gravity measurements at other sites in Queen Maud Land, too.*

Geodetic Activities at Aboa 1989–2001

The Finnish Antarctic Research Station Aboa (73°02' S, 13°25'W) in Western Queen Maud Land (*Fig. 1*) on the nunatak Basen was built in 1988–1989. It is a summer station and has not been occupied every year. The Finnish Geodetic Institute (FGI) has taken part in five of the ten Finnish scientific Antarctic expeditions (FINNARP) organized so far. Here we summarise shortly the activities of the first four of them. For more information see Ollikainen and Rouhiainen (1990), Jokela et al. (1993), Virtanen et al. (1994), Mäkinen (1994, 2001).

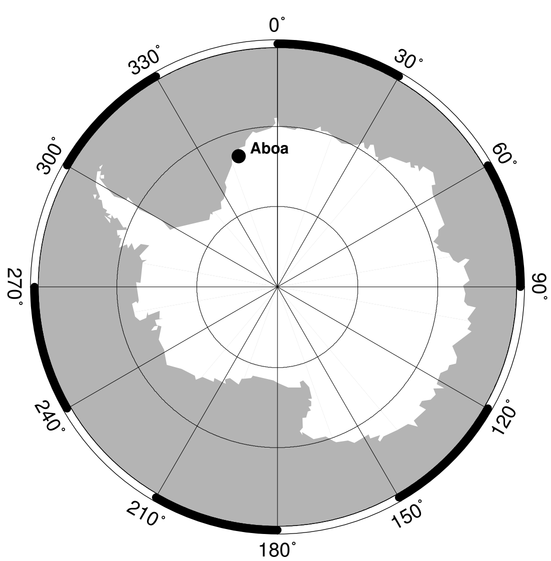

Figure 1. *Finnish Antarctic Research station Aboa is located at 73°02' S, 13°25'W in Western Queen Maud Land.*

<u>*Finnarp89 (1989/1990) and Finnarp91 (1991/1992).*</u> A regional gravity survey covering 10000 km^2 was measured using Worden Master and LaCoste&Romberg gravimeters, with 493 points at the spacing of 5 km. Snowmobile and helicopter transport, and GPS positioning were used. The Aboa reference station was tied to the International Gravity Standardization Network 1971 through station no. 43846J in Montevideo. A set of benchmarks was built around Aboa and measured with static GPS to create a local coordinate system. Snow accumulation and ice motion were studied on stake lines. A concrete pier was constructed on solid basaltic rock for future absolute gravity measurements.

<u>*Finnarp93 (1993/1994) and Finnarp2000 (2000/2001).*</u> Absolute gravity was measured by the second author with the JILAg-5 of the FGI in January 1994 and in January 2001. The results (Fig. 2*)* show an apparent gravity change of +9±7 µgal (one-sigma) over 7 years. The change is thus not statistically significant. In 2001, the 5.5 km stake line of Sinisalo et al. (2003) was re-surveyed by GPS for snow surface elevations, and density of the top 0.5 m layer sampled. A similar local survey within 100 m of the absolute site was performed with tachymeter. The GPS station at the neighbouring Swedish base Wasa was occupied during the SCAR epoch 2001 and 2002 GPS campaigns.

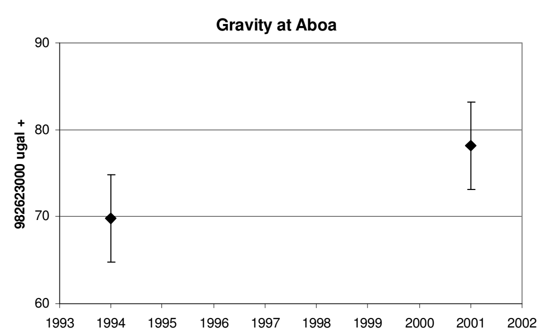

Figure 2. *The results of two absolute gravity measurements in 1994 and 2001 show a slight increase in gravity.*

Geodetic Activities at Aboa in 2002/2003

The first part of the season was mainly dedicated to the refurbishment of the Aboa station. Finnish Geodetic Institute sent the first author to Aboa for the latter part of the season. His main task was to install a permanent GPS station close to the absolute gravity hut.

Permanent GPS station. The Aboa permanent GPS station became operational on January 31, 2003 at 10:10 UT. The station (Fig 3) is unoccupied most of the year so the power consumption of the GPS receiver is an essential issue. We chose a Javad EURO80 GDA receiver, which has a power consumption of 1.8–2.4 W only. We collect both code and phase data with 30 s observing interval and store it on a 512MB Compact Flash memory card. Both the receiver and memory card are specified for temperatures down to –40°C. The electronics of the receiver are sealed into a box and it was estimated that the heat produced by the receiver keeps the temperature in the box 20 degrees higher than the outside temperature. This should be sufficient, as temperature measurements at Aboa do not have records below -50ºC. The memory card will be changed annually during austral summer expeditions by geodesists or any other research or logistics personnel available.

As an antenna platform we use a 1.5 m high steel grid mast that was anchored to basaltic rock with 1 m long screw bars (Fig. 4). The antenna is Ashtech choke ring (ASH701945C_M) with conical Ashtech snow radome. The receiver itself is located in the absolute gravity hut 15 m from the antenna mast.

The power is taken from a Ni-Cd battery pack (24V/1100Ah) located 100 m from the receiver at the main building of the base. During the field season the batteries are charged by diesel generators. When the station is not occupied the batteries are charged by four 50W solar panels, which are on test use. The batteries alone are able to keep the receiver running through the dark period of the austral winter. Finnarp logistics will install in the next season 26 solar panels of 100 W each, and 3 wind generators for shared use of all the research facilities at Aboa.

The permanent GPS station is mainly used for long coordinate time series to support deformation studies, but data are also available for any other geodetic purposes in the area.

RTK Service. When the Aboa station is occupied the GPS station offers also the RTK correction signal. It is sent using a Satelline-3As/d Epic radio modem (10W) with 430.15 MHz frequency. The RTK correction is available for any researcher working in the area, to obtain accurate coordinates within 20-30 km from the station.

SCAR 2003 Epoch GPS Campaign. We did GPS measurements on the Swedish point WASA that has participated in several SCAR epoch GPS campaigns (http://www.tu-dresden.de/ipg/FGHGIPG/Aktuell-Dienste/scargps/database.html). The 2003 campaign was performed between January 20 and February 10, in 2003. We did measurements from January 26 until the end of the campaign using Ashtech μZ receiver and choke ring antenna (ASH700936A_M). We have also data from the permanent GPS station starting from January 31. In the future the data from the permanent GPS station will be contributed to the SCAR epoch campaign database.

Local Geodetic Network. During the Finnarp91 expedition a local geodetic coordinate system was created around Aboa. We re-measured all points located on Basen including the new GPS station. Static GPS measurements were performed with two Ashtech Z-XII receivers and choke ring antennas (ASH700936A_M) using 30 s observing interval. The baselines varied between 15 and 460 m and sessions from a few hours to 24 hours. In the adjustment we fixed the WASA coordinates to those in ITRF96, epoch 1997.1 published by Dietrich et al. (2001). The results were processed with Pinnacle software and are shown in Table 1.

Local snow and ice. RTK will be used by the FGI to support absolute gravity measurements. The snow and ice topography around the gravity point is surveyed using RTK. The density of snow and ice is determined by drilling. From repeated measurements we can estimate the variation in the attraction of the near field ice and snow masses. During this season the 5.5 km stake line was re-built, samples drilled and coordinates measured with RTK. The local tachymetric survey of 2001 was repeated with RTK. While there was no absolute gravity observation in 2003 this will help to estimate annual variability.

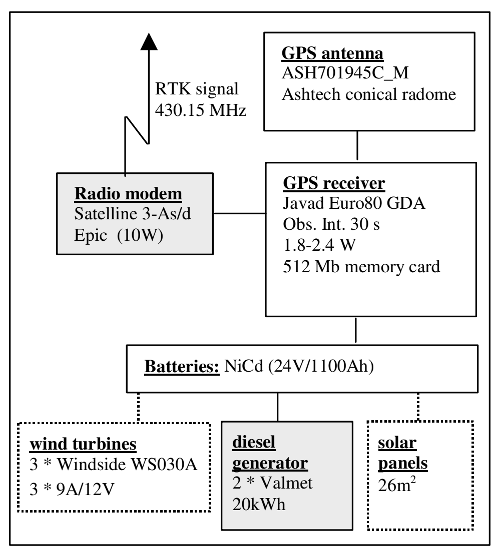

***Figure 3**. The components of the permanent GPS-station at Aboa. Grey boxes indicate components that are used the year around and keep the station operational in winter. White boxes indicate components used only when the station is occupied. Dotted lines indicate future components that are a part of a larger plan to support logistics and research facilities.*

Table 1. *The coordinates of the benchmarks on Basen. WASA was fixed to its ITRF96 epoch 1997.1 coordinates by Dietrich et al. (2001).*

Point	Coordinates			Sigmas (mm)		
Name	Latitude	Longitude	Height (m)	s(N)	s(E)	s(U)
900001	73°02'28.81537"S	13°24'05.69716"W	495.157	0.2	0.2	0.6
910023	73°02'29.94509"S	13°24'26.36215"W	482.557	0.2	0.1	0.6
910024	73°02'22.87693"S	13°24'32.74326"W	490.790	0.2	0.2	0.6
900032	73°02'37.59744"S	13°24'23.98902"W	467.352	0.8	0.4	1.9
ABOA	73°02'37.57989"S	13°24'25.68634"W	468.640	0.2	0.2	0.7
WASA	73°02'34.22900"S	13°24'50.52273"W	466.396	0.0	0.0	0.0

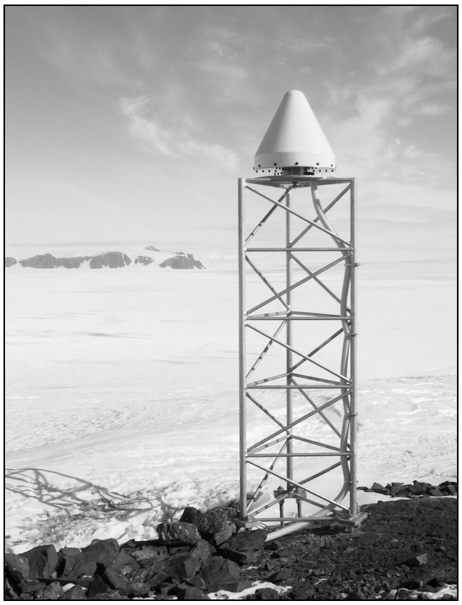

Figure 4. *The antenna mast of the Aboa GPS station*

Research rationale, future plans

With the repeated absolute gravity observations and with the permanent GPS station we strive to detect gravity change and contemporary crustal motion. They could be caused by past and present-day changes in the ice mass balance. Reconstructions of the last glacial cycle in the Antarctic are not well constrained by observational evidence, and differ appreciably both in ice volumes and in the timing of the deglaciation. Neither is the present-day mass balance well known. Thus there is considerable interest in collecting new observations related to past or present changes of the Antarctic ice mass. For predictions of gravity and vertical rates based on a number of scenarios of the ice mass balance see James and Ivins (1998).

The elevation change of the Antarctic from 1992 to 1996 was mapped by Wingham et al. (1998) using satellite radar altimetry. In the drainage basin around Aboa an average annual change of +4.4±1.1 cm is indicated. However, many 1ºby 1º squares lack data due to the terrain inclination limitations of the ERS altimetry. Currently, the change in the ice surface elevation is being mapped by ICESAT/GLAS, and in the future by the CRYOSAT mission. Contemporary change in total mass (ice + mantle flow due to postglacial rebound) is surveyed by GRACE.

Additional information is obtained by observing the deformation of the solid Earth. GPS provides information on vertical and horizontal motion, while gravity is sensitive to both vertical motion and changes in density distribution. GPS is indifferent to the underlying causes, but for a given amount of vertical motion, the gravity change depends on the mechanism: The response of the Earth to present deglaciation is elastic and for a typical regional load the ratio of gravity change to vertical motion is -0.27 µgal/mm (James and Ivins, 1998). The response to the past deglaciation ("postglacial rebound") is viscous mantle flow to restore the isostatic balance and the corresponding ratio is about -0.16 µgal/mm (Wahr et al., 1995). Combining GPS and repeated absolute gravity one thus could, in principle, not only determine total vertical motion, but also separate it into the postglacial rebound signal, and a signal showing present-day variation in ice mass.

In addition to the gravity change due to deformation of the solid Earth, the change in ice mass causes a change in gravity through the direct attraction. The Aboa absolute site is on bedrock, but model calculations show that a surface layer at a distance 15…1000 m from it has a (vertical) attraction of about 25% of the corresponding Bouguer sheet. This is of the same size than the deformation effect of the corresponding regional surface layer, and the near-field mass variation need not reflect the regional average. Thus the variation in the attraction by the local ice mass could overshadow the deformation effects we are looking for, and must be monitored separately.

We propose to continue both GPS and absolute gravity observations, and extend the latter to other sites in Queen Maud Land. The plan (Fig. 5) for the summer 2003/2004 includes absolute-gravity measurements at the bases Aboa (Finland), Sanae IV (Republic of South Africa) and Novolazarevskaya (Russia), using the recently acquired absolute gravimeter FG5 no. 221 of the FGI. At Aboa we will survey the snow topography with RTK, to control the attraction of the near-field ice/snow masses. At the same time the permanent GPS station at Aboa will provide a continuous time series of coordinates.

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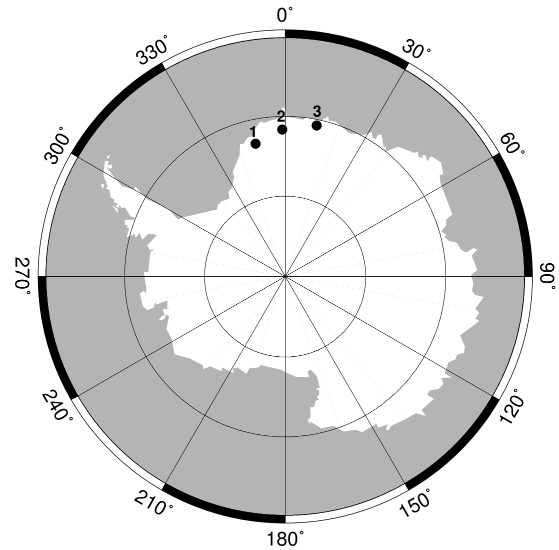

Figure 5. *Measurement plan for the absolute gravity for the next field season. 1 is Aboa (FIN), 2 is Sanae IV (RSA) and 3. is* Novolazarevskaya *(RU).*

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