Processing of the NKG 2003 GPS Campaign

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1. Abstract

The NKG 2003 GPS campaign was carried out from September 28th to October 4th, 2003 as a co-operation between members of NKG and the Baltic Countries. The aim of the campaign is, according to resolution No 3 of the 14th General Meeting of NKG, the development of a unified ETRS 89 reference frame on the cm level for the Nordic area and of formulas for transformation from such a reference frame to the national realizations of ETRS 89, as well as the transformation from ITRF to the unified ETRS 89 reference frame."

The campaign was processed by four analysis centres, using three different softwares:

- NMA, Torbjørn Nørbech, GIPSY/OASIS II
- OSO, Martin Lidberg, GAMIT/GLOBK
- LMV, Lotti Jivall, Bernese version 5.0
- KMS, Mette Weber /Henrik Rønnest, Bernese version 4.2

This paper presents the campaign and the processing of it. The four individual solutions and the comparison and combination of them are presented. Problems in the data analysis and differences between the solutions are discussed. The final coordinates from the campaign are in ITRF 2000 epoch 2003.75.

2. Introduction

The Nordic countries have implemented national realizations of ETRS 89. Depending on when the realizations were made and on which ITRF the realizations are based, there are differences between the realizations up to a few cm [Jivall, Lidberg 2000]. The national realizations have already been introduced to the users and will not be replaced. There are however situations were a common reference frame could be useful, e.g. for the Nordic Position Service which is under development. A common reference frame could also act as a link for transformations between the different national realizations and between the realizations and ITRF.

The full documentation of the processing part is found in [Jivall et al 2005].

3. The campaign

GPS observations for the NKG 2003 GPS campaign were carried out from September 28th to October 4th, 2003 (day 271 to 277, GPS-week 1238). The observation campaign was co-ordinated by Finn Bo Madsen at KMS, Denmark.

Stations from Denmark, Estonia, Finland, Greenland, Iceland, Latvia, Lithuania, Norway and Sweden – finally 133 stations – participated in the campaign – see figure 1 and 2.

Table 1 contains names, sorted by country, for all the observing locations. All stations are permanent except some defining ETRS 89 stations in Denmark, Latvia and Lithuania. Non-permanent stations have been written under a line.

The Lithuanian observers noticed problems with one of their stations (L311). To be sure to have this station included in the resulting coordinate set from the campaign, this station was observed for 5 extra days (292-296), ten days after the campaign together with the Lithuanian stations VLNS and KLPD.

Data were transferred to an ftp-server at KMS, Denmark, where they were checked and corrected in the preprocessing carried out by Henrik Rønnest, KMS.

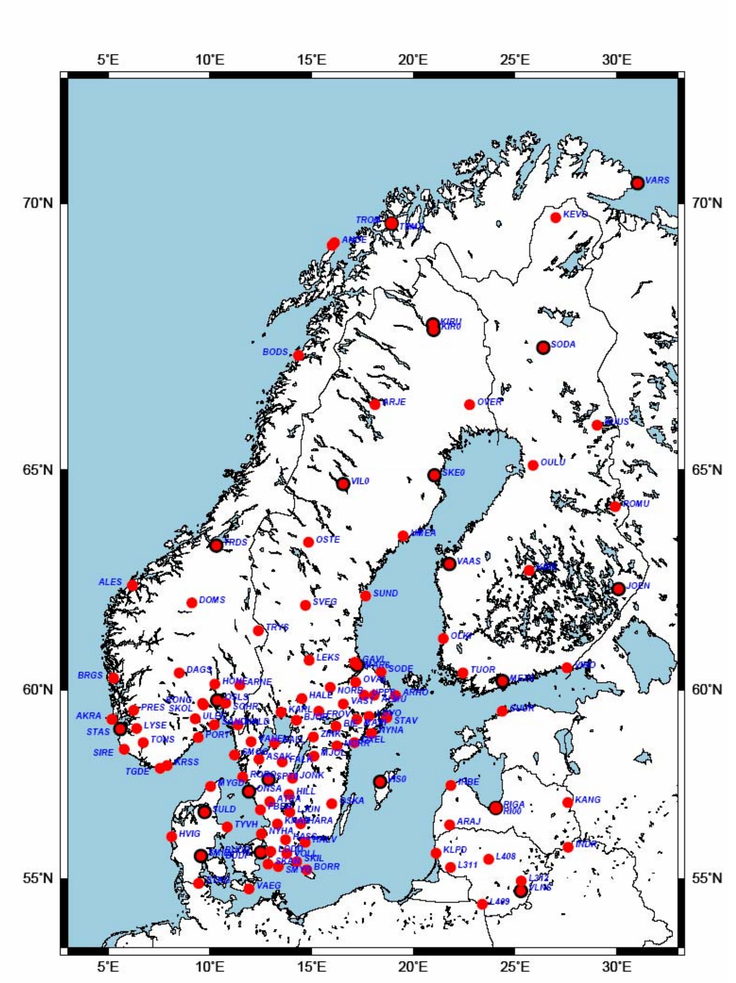


Figure 1: Stations in the Nordic-Baltic part of the NKG 2003 campaign.

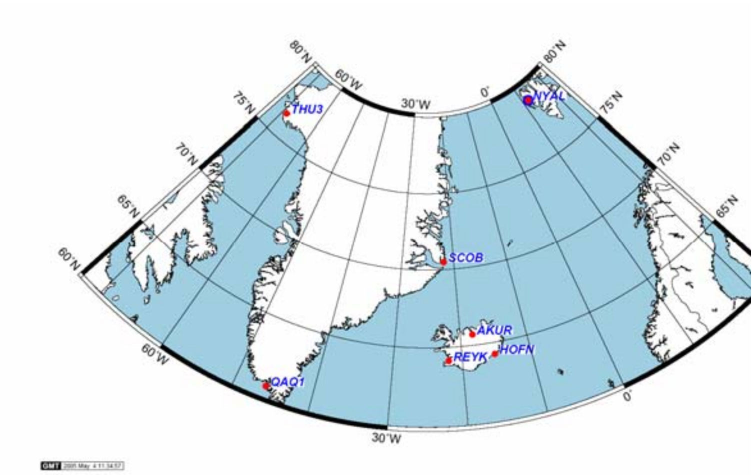


Figure 2: Stations in the Atlantic part of the NKG 2003 campaign.

Table 1: Stations included in the NKG 2003 GPS Campaign.

Denmark	TUOR	-------	PRES	FROV	OSTE
BUDP	VIRO	L311	SAND	GAVL	OVAL
SMID	VAAS	L312	SIRE	HALE	OVER
SULD		L408	SKOL	HALV	OXEL
-------	**Greenland**	L409	SOHR	HARA	RORO
BORR	QAQ1		STAS	HASS	SKAN
BUDD	SCOB	**Norway**	TGDE	HILL	SKE0
HVIG	THU3	AKRA	TONS	JONK	SKIL
MYGD		ALES	TRDS	KALL	SMOG
STAG	**Iceland**	ANDE	TRMS	KARL	SMYG
TYVH	AKUR	ANDO	TRO1	KIR0	SODE
VAEG	HOFN	ARNE	TROM	KIRU	SPT0
	REYK	BODS	TRYS	KNAR	STAV
Estonia		BRGS	ULEF	LEKS	SUND
SUUR	**Latvia**	DAGS	VARS	LJUN	SVEG
	IRBE	DOMS		LODD	UMEA
Finland	RIGA	HALD	**Sweden**	LOVO	UPPS
JOEN	--------	HONE	ALMU	MAR6	VANE
KEVO	ARAJ	KONG	ARHO	MARI	VAST
KIVE	INDR	KRSS	ARJE	MJOL	VIL0
KUUS	KANG	LYSE	ASAK	NORB	VIS0
METS	RI00	NALS	ATRA	NORR	VOLL
OLKI		NYA1	BIE_	NYHA	ZINK
OULU	**Lithuania**	NYAL	BJOR	NYNA	
ROMU	KLPD	OSLS	FALK	ONSA	
SODA	VLNS	PORT	FBER	OSKA	

4. Strategy for Processing

We decided to process the GPS campaign using the different software packages available within the group. These are:

- the Bernese GPS processing software
- GIPSY/OASIS II
- GAMIT/GLOBK

As a general philosophy for computing a GPS campaign using different software packages, we have concluded that each software package should be used together with the recommended settings for the respective software. Using this approach we will be able to check for possible differences in the result not only depending on the programs used, but also due to differences in processing strategy.

No attempt is therefore done to fully harmonise the processing strategy. We have rather tried to document how the programs are commonly used and if possible explain and compare differences.

Just for a few (but important) parameters, common recommendations were set:

- elevation cut-off = 10°

- elevation dependent weighting of the observations
- ocean tide loading corrections using the FES 99 model (values from Onsala provided for the stations in the campaign)
- no atmospheric loading correction.

The campaign was processed by four analysis centres, using three different softwares:

- NMA, Torbjørn Nørbech, GIPSY/OASIS II
- OSO, Martin Lidberg, GAMIT/GLOBK
- LMV, Lotti Jivall, Bernese version 5.0
- KMS, Mette Weber /Henrik Rønnest, Bernese version 4.2

The processing was co-ordinated by Lotti Jivall at LMV.

The four ananlysis centres processed preliminary solutions during 2004 and by the end of the year the solutions were compared and some problems were identified. Final solutions were processed in the beginning of 2005, which during the spring were combined to a final solution of the campaign.

5. NMA, GIPSY/OASIS II

Truong-An Phong processed a preliminary solution of Norway and Sweden under supervision of Torbjørn Nørbech in the beginning of 2004.

Torbjørn Nørbech carried out a new preliminary solution of all 133 stations during November 2004.

A final solution was carried out February 2005.

5.1 Characteristics of the processing

- Fiducial free Precise Point Positioning solution for all 133 stations, 5 min. epoch interval.
- JPL satellite clock corrections (yyyy-mm-dd_nf.tdp and yyyy-mm-dd_nf.tdpc), orbits (yyyy-mm-dd_nf.eci) and earth orientation parameters (yyyy-mm-ddtpeo_nf.nml).
- Local tie information is taken from RINEX file header
- Antenna type information is taken from RINEX file header
- Antenna characteristics information from the antenna file ant_info.003, including both IGS and NGS models. Mainly IGS-models but NGS-models for ASH700228D, ASH700936A_M (=B_M, D_M, E), ASH701008.01B, ASH701073.1, ASH701933B_M, ASH701945B_M (=C_M), ASH701945E_M, TRM22020.00+GP and TRM29659.00).
- Ocean loading coefficients from http://www.oso.chalmers.se/~loading/
- Float,L3 solution (no ambiguity resolution)
- 10 deg elevation cut-off
- The fiducial free solutions are then transformed with so called JPL products X-files (yymmmdd.itrf00.x) to ITRF2000. The X-files contain 7 parameters parameters for a Helmert transformation. The parameters are determined daily by JPL from a global fit on 65-70 IGS stations. So this is a global connection to ITRF2000.
- Finally the daily transformed solutions are combined to a weekly solution/solution for the campaign. This combination is performed as a least square adjustment of the daily transformed PPP solutions weighted by their corresponding co-variance information.
- The additional observations in Lithuania (L311, VLNS and KLPD, day 292-296) have also been included in the processing.

5.2 Results

The internal estimated standard deviations (from the covariance matrix of the least square adjustment) on the combined solution of seven days are:

Sx: max 1.7 mm, min 0.5 mm, average of 0.6 mm

Sy: max 1.8 mm, min 0.4 mm, average of 0.5 mm

Sz: max 2.9 mm, min 0.7 mm, average of 1.0 mm

5.3 Problems

Some modifications of the RINEX files where necessary because GIPSY is not quite RINEX compatible.

The variations of the local tie vectors at the stations L311, L312, L408,and L409 are compensated for.

The radome codes NONE, OSOD DUTD and SCIS are neglected.

Problems with processing of the Swedish stations

GAVL/273, NYHA/271, OSKA/271, OVAL/271, SKIL/271, SODE/271, UMEA/271, VAST/271, ZINK/274.

According to SWEPOS operational centre all doy 271 RINEX files have been manually edited, due to some problems. No explanation found for the stations GAVL/273 and ZINK/274 except that the ZINK/274 had ”large position change” in the s-file.

The problem was however overcome by using the program ”clockprep” in the GIPSY software package to identify problems and then do manual deleting of some data. We discovered no regular pattern, but did some data deleting until GIPSY was running properly.

We have to emphasize that this manual editing is only done on one of seven days for the actual stations. The total amount of data was not dramatically reduces, except for the station ZINK/274 which was reduced by 60%.

6. OSO, GAMIT/GLOBK

Martin Lidberg processed the campaign during the summer 2004. Some antenna model errors were found, which were corrected in a new preliminary solution delivered in November 2004. The final solution was processed and delivered in February 2005, where incorrect handled horizontal GPS antenna eccentricities have been corrected.

6.1 Characteristics of the processing

- GPS observations (RINEX data) are processed using GAMIT (version 10.1) up to so called “quasi-observations” including relative station position, satellite orbits and their co-variances.
- Network solution divided into 7 sub-networks with many common stations. Additional EPN and IGS stations added to the network.
- Double differences
- Ambiguity resolution
- 10° elevation cut off
- Saastamoinen a priori troposphere model
- troposphere zenith delay parameters estimated every 2nd hour (piece-wise-linear)
- daily gradient parameters estimated
- the Niell 1996 mapping function
- a priori orbits from SOPAC
- Solving for orbit corrections
- “Quasi observations” from the 7 sub networks of the stations in the current campaign processed using GAMIT are combined with “quasi observations” of global/regional networks of IGS stations (from SCRIPPS) are combined using GLOBK.
- The connection to ITRF2000 is done in the combination (stabilization) with the global quasi observations. 39 “good” IGS stations globally distributed are constrained to IERS ITRF2000 when solving for daily Helmert parameters (3 translations, 3 rotations and a scale). This is a global connection to ITRF.
- IGS antenna models except for the antenna types ASH701008.01B, ASH701073.1, ASH701945C_M, and ASH 701945E_M, where NGS models have been used. For the site L312 the IGS antenna model ASH700228 NOTCH has been used.

6.2 Results, problems e.t.c.

Position standard errors are computed from the daily differences as $s = \sqrt{(1/n)\cdot\left\{\sum v^2/(n-1)\right\}}$.

The standard errors are usually below 1 mm in north and east components, and below 2 mm in the vertical component. Exceptions are DOMS (e 1.5 mm), IRBE (u 4 mm), KONG (n & e 1.5 mm), L311, L312, L409 (u 4 mm) and QAQ1 (u 3mm).

The success rate of the resolved ambiguities are not presented in the result reports from GAMIT10.1, so it is not known if the fixed solutions really are fixed solutions, some baselines might be mainly (closer to) float solutions.

In the results of the GAMIT processing, the stations BRGS, HALD, KONG and SAND get phase observation residuals exceeding 10 mm which are above the usually considered acceptable level.

For the station BRGS, the daily repeatability is satisfactory in this solution. However, the east component may get bad repeatability depending on GPS processing strategy and choice of stations included in the GAMIT computation. Therefore, there are indications of possible problems in the GPS data collection at the station BRGS.

7. LMV, Bernese ver 5.0

A preliminary processing was carried out during November 2004 using version 5.0 of the Bernese Software by Lotti Jivall. Some improvements concerning exclusion of stations and replacement of the BRGS fixed solution with a float solution was carried out in February 2005.

7.1 Characteristics of the processing

- Final solution just containing GPS week 1238 (day 271-277).
- Network solution, full network 133 stations
- Double differences, baselines formed with OBSMAX strategy (maximizing the number of observations)
- ambiguity fixing (QIF)
- Orbits, EOPs and Satellite clocks from IGS
- P1-P2 and P1-C1 code biases from CODE
- Global ionosphere model from CODE

- Ocean tide loading FES 99 from Onsala
- Relative antenna models from IGS + NGS model for antenna ASH701008.01B.
- Saastamoinen apriori troposphere model (hydrostatic part) with dry Niell 1996 mapping function
- Estimating ZTD using wet Niell 1996 mapping function (2 h interval)
- Horizontal gradient parameters: tilting (24 h interval)
- 10 deg cut off , elevation dependent weighting
- Data files shorter than 12 hours were rejected
- ITRF coordinates from IGS cumulative solution (up to week 1294) used for connection to ITRF, which was done through minimum constrained adjustment with no translation condition. This is a regional constraint to ITRF.
- (Alternative connection to the EPN based ITRF was also performed)

7.2 Results, problems e.t.c.

7.2.1 Quality of daily solutions

The daily solutions of the full network were of good quality, rms = 1-1.1 mm, average rate of resolved ambiguities per day vary between 86% and 89%. The worst individual ambiguity resolution was the baseline HOFN-SCOB with 65% resolved ambiguities day 277.

The following observations were rejected because of less than 12 hours with good observations per day: MYGD day 271, IRBE, SKOL and VLNS day 272 and finally SKOL day 273. UMEA had problems with the single point positioning (determination of receiver clock correction) day 271 and was also rejected. (The same problem as was found with GIPSY/OASIS II. It should be noted that UMEA did not show any problems that day in the ordinary SWEPOS processing, which is performed with the Bernese version 4.2.)

The daily repeatability expressed in rms values are up to 2-3 mm for the north component, up to 1 mm for the east component (except for station BRGS which had an rms of 3 mm) and up to 6 mm for the up component (except for L311, L312, L409 and QAQ1 which had rms of 11-13 mm in the up-component. L311 and L409 were excluded day 273 and QAQ1 day 271 reducing the rms values to 5-7 mm for these stations.

7.2.2 Comparison between fixed and float solution

The combined float and fixed solutions were compared to each other to see if there were any possible erroneous fixed solutions. The differences are normally below 5 mm in the horizontal components, but BRGS is an outlier with 23 mm difference in the east component. The float solution of BRGS has a better agreement with the GIPSY and GAMIT solutions as well as with the long time series (5 years) of GAMIT solutions processed by Martin Lidberg. The float solution for BRGS was considered to be more reliable. Float solutions are in general noisier than fixed solutions. For this network the average rms values of the 7 days were 1, 1, 3 mm (north, east and up) for the fixed solution and 2, 3, 12 mm for the float solution. This means that just use the combined float solution (for all stations) because of the problems with BRGS is not a very good idea. We decided just to replace the fixed solution of BRGS by the float solution at this station after a Helmert fit to the 5 closest stations (ALES, DOMS, DAGS, PRES and AKRA).

7.2.3 Elevation cut-off test

An elevation cut-off test was performed by comparing the final 10°-solution with a 25°-test solution. This test indicates that the station ANDO is less accurate in height, which might be caused by the used antenna model (AOAD/M_T) not perfectly modelling the antenna and its environment at this station. Also the stations ARNE, SPT0, ARAJ, KONG, DOMS, NYA1, KUUS and L312 and have somewhat larger differences between the two solutions than normal.

7.3 Connection to ITRF2000

The connection of the final solution of LMV was made using the IGS cumulative solution. The cumulative solution up to GPS week 1294 was used, i.e. the latest solution available when the processing was carried out. This was chosen to get the best velocities for the calculation of the coordinates at epoch of the campaign.

Eleven stations from the campaign are included in the cumulative IGS solution of week 1294. Two of them are twin stations, TROM/TRO1 and NYAL/NYA1 so just one for each site was chosen for the constraint (TROM and NYAL). REYK and QAQ1 were also excluded from the constraint as they did not fit so well.

The final LMV solution is a combined minimum constraint solution of the seven days with no translation condition to the seven remaining IGS stations (METS ONSA KIRU TROM THU3 NYAL HOFN).

The rms in the Helmert fittings were 3.1 and 1.5 mm for the 3-parameter fit and the 6-parameterfit respectively on the seven IGS-stations. The improvement with 6 parameters show that there are some tilt in the GPS-solution which probably depends on systematic effects in un-modelled errors.

As a test the GPS solution was also fitted an EPN based ITRF for the Nordic-Baltic part. This coordinate set was achieved by using five weekly EPN-solution centred on GPS-week 1238 (GPS-week 1236-1240) and constraining 9 IGS stations to their IERS ITRF2000 epoch 2003.75 coordinates. (Similar approach used for the Swedish ETRS 89 realization.) This fit resulted in an rms of 1.8 mm and 1.5 mm for the 3-parameter and 6-parameter fit respectively.

The two different ITRF connections (IGS cumulative solution and the "EPN based" ITRF, respectively) have a systematic difference of 0, 1 and 5 mm for the north, east and up-component respectively.

7.4 Additional Lithuanian data

As mentioned in section 3, extra measurements were performed at the Lithuanian station L311.

First, it could be noted that when processing the original campaign, the station L311 turned out to be of the same quality as the other Lithuanian stations (though some data were missing for the first days).

To further check the station L311, the extra observations were processed and compared to the campaign solution. In this processing the EPN stations RIGA and VIS0 were added. The differences to the combined solution of the campaign (the LMV solution) are found in table 2. Both a direct comparison between the additional data and the LMV solution and a comparison of the LMV solution with and without the additional data (i.e. the corrections to the LMV solution if the additional data were added to the solution) are presented.

The differences between the campaign solution and the combined solution of the campaign and extra data were below 1 mm in the horizontal and 2 mm in the vertical component at the station L311. This comparison shows that we could be confident with the coordinates for L311 of the original campaign.

Table 2: Differences at L311. The left column contains the differences between the additional data and the LMV solution. The right column contains the differences between the LMV solution with and without the additional data

	extra-gw1238	gw1238+extra-gw1238
N (mm)	0.6	0.3
E (mm)	0.7	0.4
U (mm)	5.9	1.5

8. KMS, Bernese ver 4.2

8.1 Preliminary processing and re-processing

A first preliminary processing was carried out by Henrik Rønnest during the spring 2004 using the Bernese version 4.2. The network was processed in two parts, one Nordic-Baltic part and one Atlantic part (Greenland, Iceland and Svalbard).

Henrik's solution for the Nordic-Baltic part was delivered in summer 2004. Lotti Jivall noticed problems with some antenna models and the coordinates used for the constraint. This was further investigated by Mette Weber. Seven antenna models were wrong affecting 33 stations and 47 baselines in the Nordic-Baltic part. Mette did a re-processing of the Nordic-Baltic part. As the time was short, the re-processing was just carried out for the affected baselines and just from the ambiguity resolution step.

In the Atlantic part of the network there were no problems with the antenna models and the solution estimated by Henrik during spring 2004 was combined with the re-processed solution for the Nordic-Baltic part forming a solution for the whole network. This solution was determined in January 2005.

8.2 Characteristics of the processing

- Network solution in six clusters; four clusters in the Nordic-Baltic part and two clusters in the Atlantic part (clusters connected with one baseline)
- Double differences, baselines formed to get the shortest distances. The same baseline definition for all days.
- Ambiguity fixing (QIF)
- Orbits, EOP's and Satellite clocks from IGS
- Calculated own regional ionosphere model (used for ambiguity resolution)
- Ocean tide loading FES 99 from Onsala
- Relative antenna models from IGS + NGS model antennas not present in the IGS-file.
- No a priori troposphere model
- Estimating ZTD using dry Niell 1996 mapping function
- 10 deg cut off, elevation dependent weighting
- ITRF coordinates from IGS cumulative solution (up to week 1294) used for connection to ITRF

8.3 Network solution in clusters

The network was divided into six clusters A to F due to the capacity of the machine. The Nordic-Baltic part consists of cluster A to D, and the Atlantic part consists of cluster E and F. In principle the entire network was formed in a first step and afterwards divided into clusters. Therefore there will only be one baseline connecting the clusters. The network configuration is the same for each day.

During the processing one station in each cluster was constrained: BUDP (A), OSLS (B), SKE0 (C), METS (D), HOFN (E) and NYAL (F). The normal equations for each day were formed by combining the normal equations from all clusters as shown in figure 3.

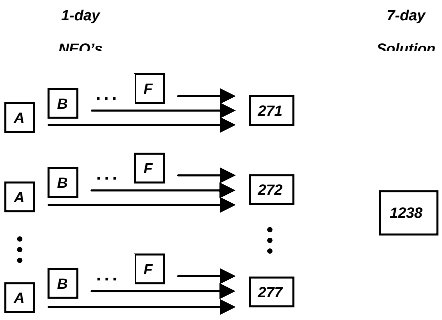


Figure 3: Combination of normal equations from each cluster, KMS solution.

In each 1-day NEQ these 6 stations were constrained. In the last step when forming the 7-day solution for the entire network selected IGS stations were constrained. This last step was not performed by KMS as explained in the next section.

8.4 Processing problems

Some stations had to be rejected for some sessions due to bad data quality or missing data. The following stations and sessions were rejected during the preliminary processing:

- RINEX-files from directory “ready” at the KMS ftp, INDR day 274 and 276 (Lotti had the same problem first but solved it by deleting a wrong “extra site info” and the observations before that)
- L312, L408, L409 day 273, missing observations
- GAVl day 276, problems with the triple difference solution
- SODE day 274, problems with the triple difference solution
- VLNS day 273, connecting baseline missing
- SKIL day 271, problems with the triple difference solution
- L311 day 271, missing observations
- QAQ1 day 271, excluded from 1-day NEQ due to high repeatability

During the re-processing the wrong antenna models were corrected. The corrections were in the order of 1-2 cm for the antenna phase centre offsets for L1 and L2. These corrections resulted in a change in the coordinates of 2-4 cm in X and Y and 8 cm in Z for the affected stations. Therefore the a priori coordinates were updated for these stations before the re-processing from the ambiguity resolution step.

The constrained coordinates in the preliminary solution were wrong. During re-processing the correct coordinates were introduced in the final step with ADDNEQ as fixed coordinates. In Bernese version 4.2 it is not possible to produce a constrained solution at a new set of coordinates with ADDNEQ. The correct coordinates have to be introduced at the beginning of the processing, which was not possible because the re-processing was only performed from the ambiguity resolution step and only for some baselines. In Bernese version 5.0 it is possible to introduce new constrained coordinates in the final step with ADDNEQ and therefore KMS provided Lotti with the 1-day NEQ-files from the KMS solution and she performed the last step of the KMS solution.

8.5 Connection to ITRF2000

The connection to ITRF2000 was done as a minimum constrained solution of the KMS NEQ-files in the same way as for the LMV solution, using Bernese version 5.0.

8.6 Results

The results were evaluated in terms of the ambiguity resolution and the rms of repeatability. The average ambiguity resolution for all baselines and all days is 66%.

The ambiguity resolution for most of the baselines is rather low; 31 baselines (i.e. 23%) have a resolution less than 60% and only 12 baselines (i.e. 9%) have a resolution of 80% or more. Generally the long baselines in the Atlantic part have the lowest ambiguity resolution of less than 50%.

Compared to the Bernese ver. 5.0 solution from LMV, KMS has a lower ambiguity resolution. Lotti and Mette made a few comparisons of some parameter settings in MAUPRP and the differences in these settings can maybe explain some of the differences in ambiguity resolution (generally more ambiguities are set up in the KMS solution, but more ambiguities are not resolved). Nevertheless, the LMV and the KMS solution seem to agree well.

The daily repeatability expressed in rms values are up to 2-3 mm for both the north and east components and up to 9 mm for the up component.

9. Comparison of the solutions from the four different analysis centres

9.1 Direct comparison of the solutions

The ITRF2000 coordinates from the different analysis centres were compared to each other. As mentioned before we have problems (related to ambiguity fixing) with the east component of the station BRGS. In the LMV solution BRGS was replaced by a float solution, since the difference between fixed and float solution was too big (23 mm in the east component) and the float solution was considered to be more reliable. In the comparison of fixed and float solutions in the KMS solution, the problems with BRGS were not so clear so the station was kept in a first comparison. It turned out that the KMS solution of BRGS differed c:a 20 mm in the east component, so BRGS was excluded from the KMS solution in the further comparisons and combinations.

The solutions agree for most stations within ±3 mm in the horizontal components and within ±10 mm for the vertical. RMS values computed on all the differences in north, east and up are 1.4, 1.5 and 4.7 mm respectively. There are however shifts between the solutions, e.g. OSO is c:a 2-3 mm south-east of the other solutions and LMV and KMS are c:a 5-10 mm below OSO and NMA. The reason for the shifts is that the connection to ITRF has been done in different ways. The OSO and NMA solutions are both global connections to ITRF while the LMV and KMS solutions are regional. Another difference is that the OSO and NMA solutions are aligned to ITRF2000 by solving for 7 parameters and the LMV and KMS solutions are aligned just with a translation.

9.2 Harmonizing the solutions

In order to better detect outliers and get an impression of the internal consistency between the solutions, we decided to harmonize/align the solutions to each other or a common coordinate set.

First all four solutions where fitted to two IGS realizations of ITRF 2000 with different number of parameters. The IGS-realizations of ITRF2000 where the weekly IGS-solution (GPS-week 1238) and the cumulative IGS-solution containing solutions up to GPS-week 1294. (Both solutions are connected to IERS ITRF2000 and not IGS 2000.)

It could be noted that the RMS for the fits with 7 parameters are on the same level for all four solutions (sigma 1.5 – 2.8 mm). The fits of the KMS and LMV solutions are improved quite a lot when a scale and rotations are solved for. The KMS and LMV scales are c:a 2 ppb. The improvement is not so large for the NMA and OSO solutions, since they already estimated these parameters, though on a daily basis.

The four solutions of the Nordic campaign were also fitted to each other with 7-parameter transformations. The two Bernese solutions (KMS and LMV) do of course agree best with each other (sigma 1.8 mm), but the agreement between KMS/LMV and OSO is not much worse (sigma 2.1 mm). The RMS for the fits between KMS/LMV and NMA is a little bit higher (sigma 3.5-3.7 mm, but still nothing to worry about). NMA has its best agreement with OSO (sigma 2.6 mm).

Regarding the translations between the solutions, LMV and NMA differ c:a 1 cm in height . KMS and OSO are in the middle. The OSO solution differs c:a 2 mm in the north component and a little bit less for the east component in comparison to the other solutions.

We decided to let the two global solutions (OSO and NMA) decide the connection to ITRF2000, as there are so many open questions concerning the regional connection of the two Bernese solutions (LMV and KMS).

An average of the OSO and NMA coordinates was calculated for each station (and component). All four solutions were then transformed to this averaged coordinate set with a 7-parameter transformation see figure 4.

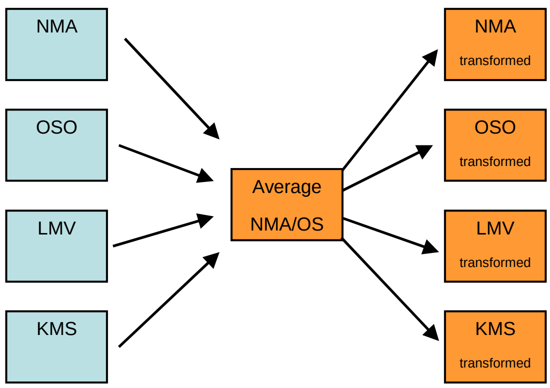


Figure 4: Harmonization of the solutions.

9.3 Comparison after harmonization

The four solutions transformed to the averaged NMA/OSO solution were compared to each other. Residuals from mean are presented in appendix A.

The differences are after this harmonization generally very small and the systematic effects seen before have (almost) disappeared. (Some small systematic effects in height are left.) The RMS values of all differences in each component are 0.9, 1.2 and 2.5 mm (north, east and up), which should be compared to the corresponding values before harmonization (1.4, 1.5 and 4.7 mm). Especially in height there is a large improvement. Just 7%, 17% and 11 % of the stations have residuals larger than 2 mm in the north , 2 mm in east and 5 mm in up, respectively.

In table 3 residuals larger than 3 mm in north and east and 6 mm in up are presented. The limits are just chosen to get a reasonable number of residuals to present. Even the largest residuals are not really much to bother about. We think that we have been able to correct/handle the real outliers, which were found when the preliminary solutions from November 2004 were compared.

The NMA solution has the largest noise and thus most of the "large" residuals. The Lithuanian stations L311 and L312 have the largest residuals in height. These stations have a quite bad repeatability in the individual solutions and e.g. in the Bernese solutions one day was excluded for L311, which might explain why we get discrepancies between the different solutions. Other differences are that different antenna models have been used for the ASH700228D antenna at L312 and that the NMA solution contains also the additional data for L311 (but according to section 7.4 the impact of these extra data is negligible).

Table 3: The largest residuals between the harmonized solutions.

Sol/comp	Station	Residual (mm)
NMA-N	L312	5,3
NMA-N	AKUR	-3,7
NMA-E	DOMS	5,2
LMV-E	KONG	4
KMS-E	KONG	3,9
NMA-E	SUUR	3,2
NMA-E	OVER	3,1
OSO-E	KRSS	-3,1
NMA-U	L312	-15,5
LMV-U	L312	11,4
NMA-U	L311	-10,1
NMA-U	ARAJ	-9,4
NMA-U	VIRO	9,3
NMA-U	QAQ1	9,1
NMA-U	RI00	-8,7
KMS-U	NALS	8,4
NMA-U	JOEN	8,1
KMS-U	KONG	-8
KMS-U	NYAL	7,9
NMA-U	KUUS	7,6
KMS-U	L312	7,5
NMA-U	KONG	6,9
NMA-U	ROMU	6,7
LMV-U	VIRO	-6,4
KMS-U	ARAJ	6,4
LMV-U	KUUS	-6,1
KMS-U	NYA1	6,1

10. Combined solution

The final combined solution of the NKG 2003 campaign is the average of the four harmonized solutions.

Using the harmonized solutions, instead of the original solutions, for an average is motivated by the fact that the agreement between the solutions is improved after harmonization. The Hemert-fits do also show that there are significant scales and rotations between the different solutions.

The choice of letting the NMA and OSO solutions define the connection to ITRF means further that we have a pure global connection to ITRF. If we should have used the Bernese solutions with regional connections as well, we would have got a mixture of global and a regional connection.

Final combined coordinates in ITRF2000 epoch 2003.75 are given both expressed as geocentric Cartesian coordinates and geodetic coordinates in appendix B.

The accuracy depends on the following components:

- Accuracy of the ITRF connection
- Systematic effects depending on un-modelled errors or wrong models
- Random errors, noise in the solutions

The accuracy of the ITRF connection could be estimated to a few mm in the horizontal components and 1 cm in height based on the direct comparison between the different solutions.

Neglected systematic effects, e.g. air pressure, might contribute to the relative uncertainty of maybe a few mm in the horizontal and half to one cm in the height component (left after the ITRF connection). Shortcomings in the used antenna models could add errors of up to a few cm. This type of error could mainly be expected for non choke ring antennas. In the performed elevation cut-off tests a few stations with possible antenna model problems were identified – see section 7.2.

The random errors in the solutions are reflected in the estimated standard errors/rms from repeatability of the four individual solutions see section 5-8 and in the comparison of the four harmonized solutions (see appendix A).

Considering the estimations in the error components above, an estimation of the real accuracy would be 0.5-1 cm in the horizontal components and 1-2 cm in the vertical on 95% level for the main part of the stations. ANDO, L311 and L312 might be less accurate in height.

11. Conclusion

Three completely different processing strategies and connections to ITRF were performed:

- Precise Point Positioning with JPL-products using GIPSY/OASISII
- Network solution with GAMIT combined with SCRIPPS global IGS-solutions for a global ITRF connection
- Network solution with the Bernese GPS software regionally connected to IGS cumulative solution (two solutions).

The resulting coordinates of the different strategies agree for most stations within a few mm horizontally and 1 cm vertically.

The internal differences are even smaller. After harmonization (transformation to the average of the GIPSY and GAMIT solution) rms of the differences are 0.9, 1.2 and 2.5 mm for north, east and up.

Also the two Bernese solutions differs in version of the program and strategy for e.g. baseline definitions and sub-division of the network, but the coordinates agree very well.

The processing in different softwares and at different analysis centres have given the final solution extra strength. Some errors were found in the comparison between the solutions and might not have been discovered if just one software at one centre had been used, e.g. bug affecting the computation of horizontal offsets, wrong antenna models and the problems with the fixed solution of the station BRGS. Comparison between fixed and float-solutions and elevation cut-off tests are useful to check the individual solutions.

The processing has indicated problems on some permanent stations, e.g. BRGS and ANDO, which need to be further investigated.

The result from the NKG 2003 campaign will be used in the development of transformations between the national realizations and to ITRF and in combination with the Nordic height solution for check of gravimetric geoids.

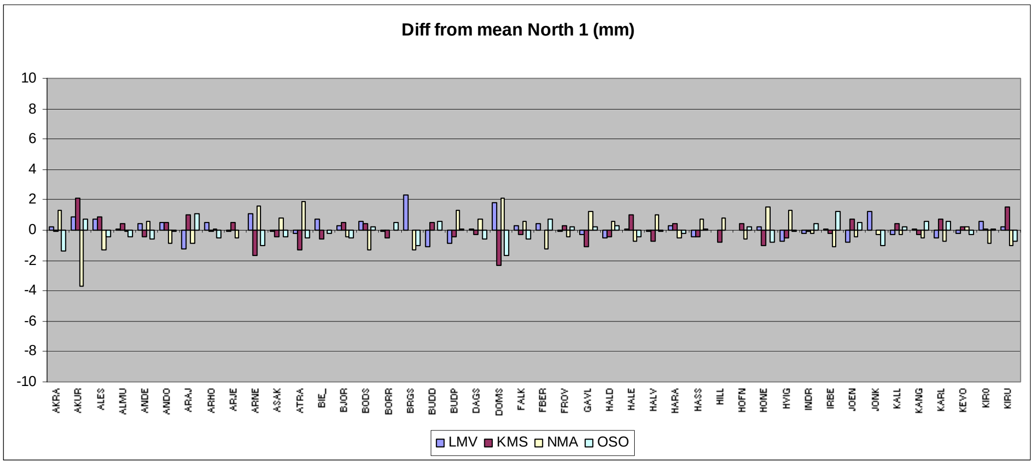
The coordinate set is a snap shot of the stations epoch 2003.75, in fact a very good one. Many of the stations are permanent and are regularly processed by different organizations (but not all stations by the same organization), so a possibility to get more general coordinates would be to combine these solutions. In such a work the snap shot of the NKG 2003 campaign could be very useful for check the consistency between the different solutions.

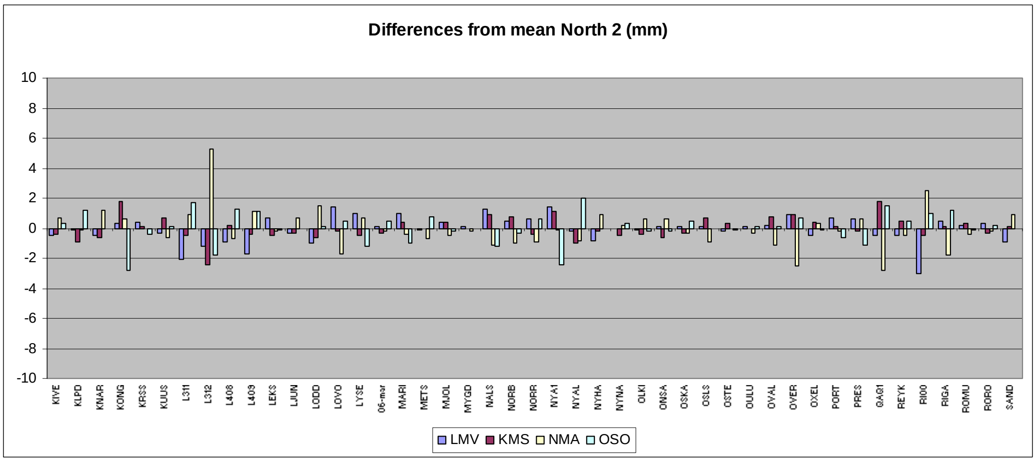
References

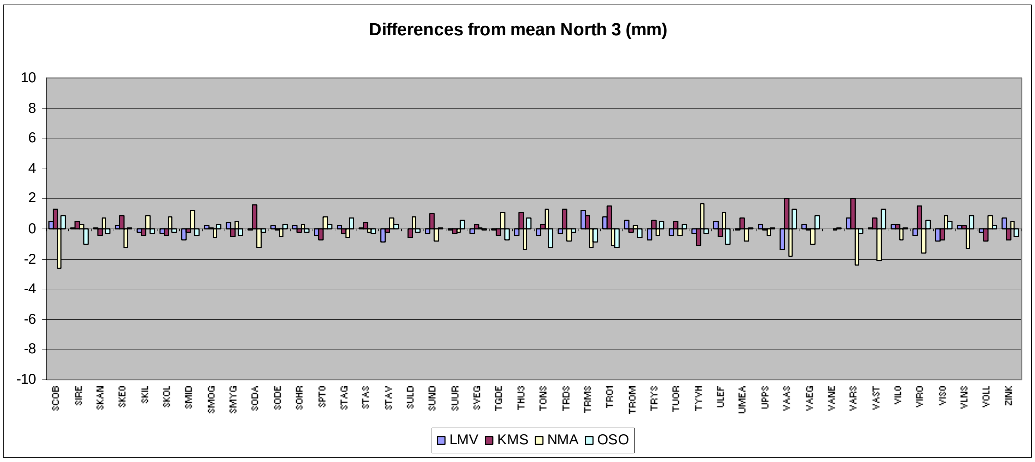
Jivall L & Lidberg M (2000): SWEREF 99 – an updated EUREF realization for Sweden. EUREF, Symposium of the IAG Sub commission for Europe (EUREF), June 22-24 2000, EUREF Publication No. 9, 167-175, Tromsö, Norway.

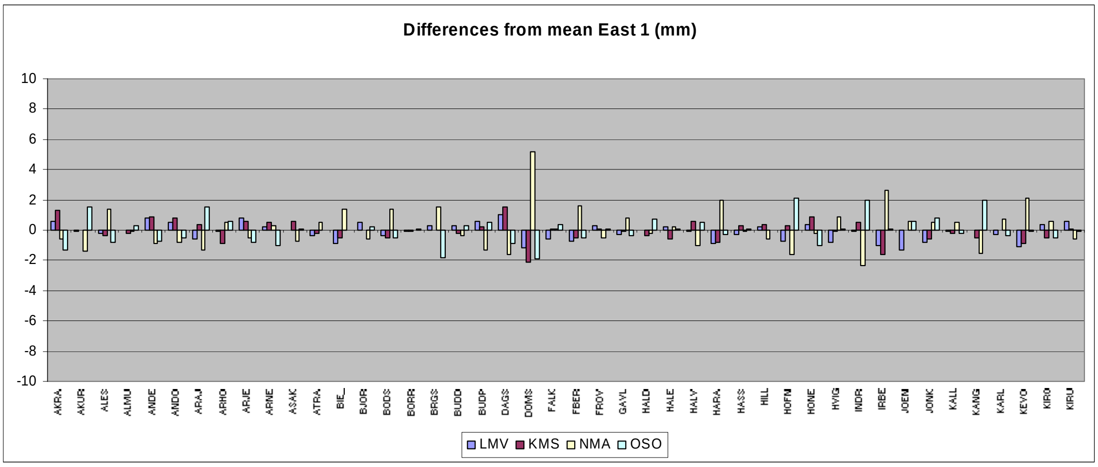
Jivall et al 2005: Processing of the NKG 2003 GPS campaign. LMV-report 2005:7. National Land Survey of Sweden. www.lantmateriet.se.

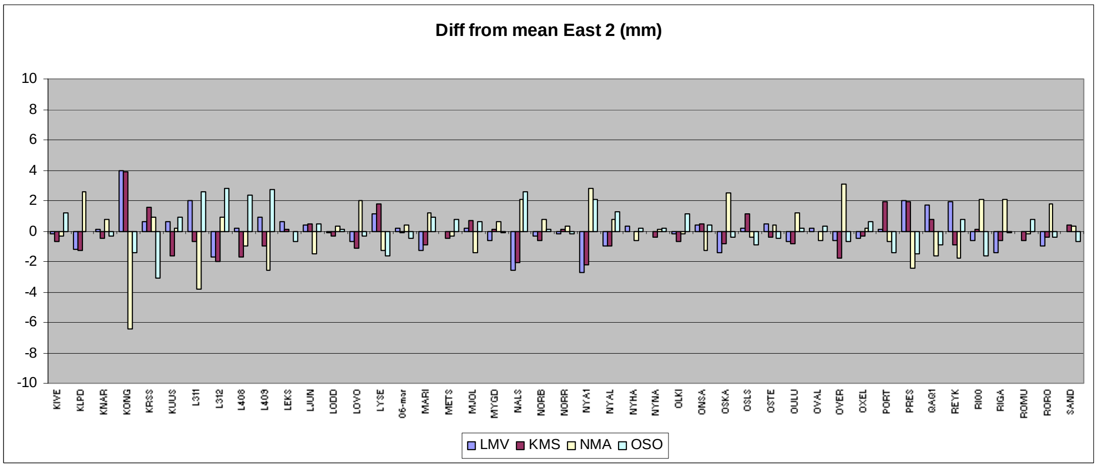
A. Comparison after harmonization








Differences from mean East 1 (mm)
10
8
6
4
2
0
-2
-4
-6
-8
-10
LMV KMS NMA OSO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8
6
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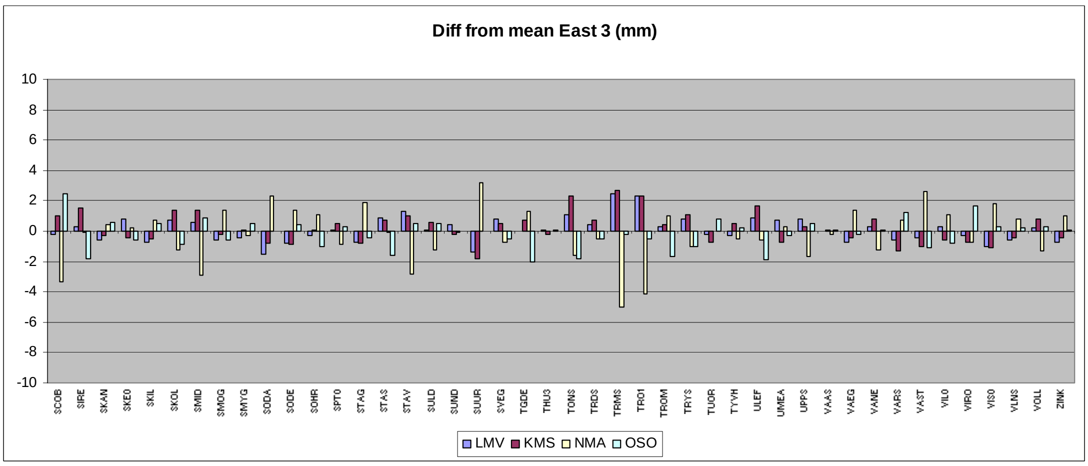
Diff from mean East 3 (mm)
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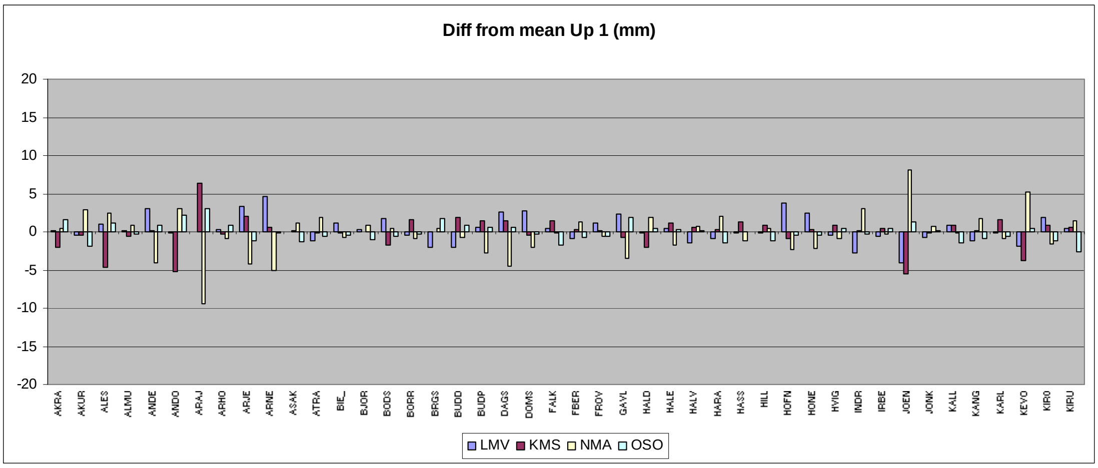
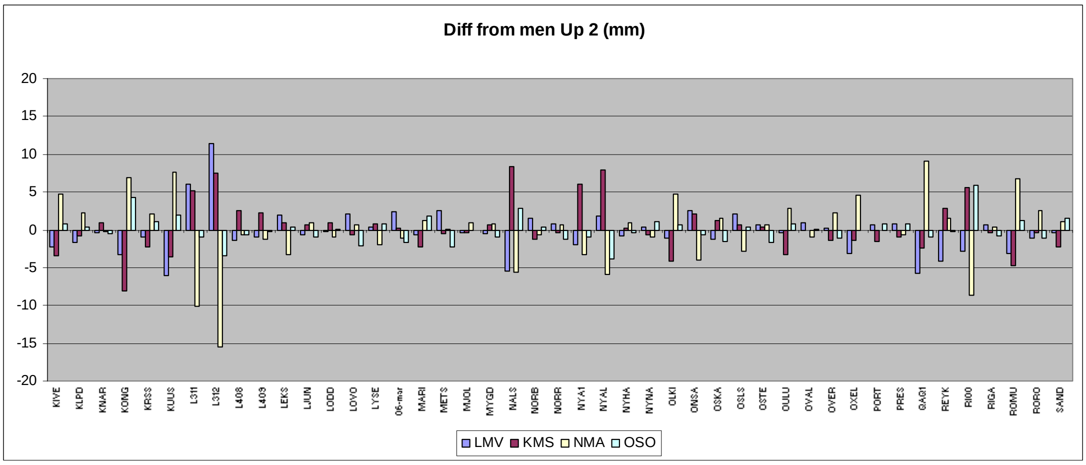
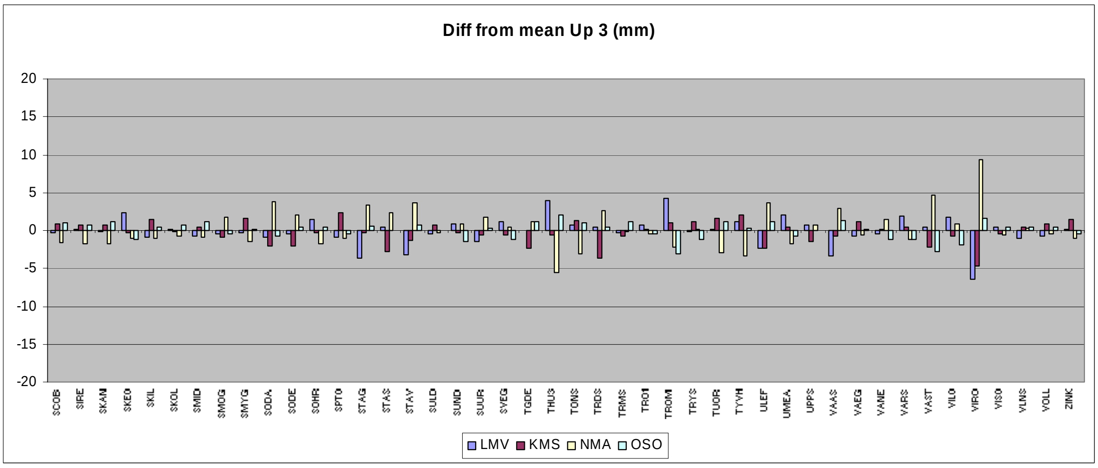
8
6
4
2
0
-2
-4
-6
-8
-10
LMV KMS NMA OSO


Diff from mean Up 1 (mm)
20
15
10
5
0
-5
-10
-15
-20
AKRA AKUR ALES ALMU ANDE ANDO ARAJ ARHO ARJE ARNE ASAK ATRA BIE_ BJOR BODS BORR BRGS BUDD BUDP DAGS DOMS FALK FBER FROY GAVL HALD HALE HALV HARA HASS HILL HOFN HONE HVIG INDR IRBE JOEN JONK KALL KANG KARL KEVO KIR0 KIRU
LMV KMS NMA OSO


Diff from men Up 2 (mm)
20
15
10
5
0
-5
-10
-15
-20
KIVE KLPD KNAR KONG KRSS KUUS L311 L312 L408 L409 LEKS LJUN LODD LOVO LYSE 06-mar MARI METS MJOL MYGD NALS NORB NORR NYA1 NYAL NYHA NYNA OLKI ONSA OSKA OSLS OSTE OULU OVAL OVER OXEL PORT PRES QAQ1 REYK RI00 RIGA ROMU RORO SAND
LMV KMS NMA OSO


Diff from mean Up 3 (mm)
20
15
10
5
0
-5
-10
-15
-20
SCOB SIRE SKAN SKE0 SKIL SKOL SMID SMOG SMYG SODA SODE SOHR SPT0 STAG STAS STAY SULD SUND SUUR SVEG TGDE THU3 TONS TRDS TRMS TRO1 TROM TRYS TUOR TYVH ULEF UMEA UPPS VAAS VAEG VANE VARS VAST VIL0 VIRO VIS0 VLNS VOLL ZINK
LMV KMS NMA OSO

B. Final combined coordinates in ITRF2000 epoch 2003.75

Station	X	Y	Z	Latitude			Longitude			h
AKRA	3254758.5874	295601.6128	5458918.8409	59	15	40.162546	5	11	21.997171	65.1172
AKUR	2502918.5717	-819166.9627	5789714.8936	65	41	7.527077	-18	7	20.928177	134.1588
ALES	2938027.3479	319096.3493	5633413.9555	62	28	34.980641	6	11	54.757201	189.8870
ALMU	3051686.9263	995723.6848	5493062.9845	59	51	58.665284	18	4	14.865394	56.6094
ANDE	2169480.9148	627616.8718	5944952.2349	69	19	33.806299	16	8	5.338510	44.2585
ANDO	2175764.8320	624247.8976	5943414.8317	69	16	42.143599	16	0	31.303832	410.6163
ARAJ	3277266.5876	1309685.8298	5295146.7568	56	29	36.592344	21	46	58.828475	208.5641
ARHO	3033319.5435	1051907.2736	5492748.4149	59	51	39.296362	19	7	32.655022	40.8546
ARJE	2441775.1562	799268.1815	5818729.3538	66	19	4.865846	18	7	29.513638	489.2236
ARNE	3121952.5970	633902.4445	5507296.4802	60	7	10.456920	11	28	39.675335	196.6044
ASAK	3286466.4641	723964.3668	5400051.7214	58	14	30.163506	12	25	23.080325	112.6673
ATRA	3382554.0630	777774.8477	5333332.8494	57	7	13.633050	12	56	57.640053	165.3756
BIE_	3154144.2738	917058.8568	5449043.1160	59	5	15.913277	16	12	41.923532	91.6453
BJOR	3169460.3481	805521.4644	5457845.8620	59	14	25.049725	14	15	35.523083	199.4249
BODS	2393811.6263	612747.7349	5860377.6599	67	16	30.158486	14	21	28.109270	50.8152
BORR	3523674.9150	928375.9673	5217378.7300	55	14	57.216280	14	45	36.663776	158.9460
BRGS	3155871.1642	290902.8634	5516573.5590	60	17	19.481129	5	15	59.563128	93.8190
BUDD	3513649.3528	778954.7377	5248201.9529	55	44	19.926687	12	29	59.856187	87.9557
BUDP	3513638.2818	778956.3810	5248216.4219	55	44	20.469399	12	30	0.085468	94.0294
DAGS	3122524.3628	466764.2060	5524286.5581	60	25	0.590496	8	30	6.449291	845.3651
DOMS	2957499.2597	474477.2292	5612998.1331	62	4	24.187291	9	6	51.853410	733.3466
FALK	3278189.6828	790418.5431	5395964.7976	58	10	11.776130	13	33	21.915732	259.9188
FBER	3408401.3181	755024.5572	5320097.1446	56	54	12.838713	12	29	25.399943	63.7055
FROV	3132396.4978	860615.4634	5470596.9011	59	27	59.749437	15	21	45.919430	83.0049
GAVL	2993586.6966	922761.7340	5537295.8504	60	40	0.409089	17	7	54.176227	55.3864
HALD	3216858.5498	647832.1092	5450991.3868	59	7	20.131135	11	23	10.683985	62.0599
HALE	3115217.6604	806835.8348	5488628.1283	59	47	3.675953	14	31	13.583395	234.5759
HALV	3456798.7196	906264.1963	5265352.9450	56	0	49.187975	14	41	25.945657	72.5524
HARA	3414100.0473	880514.9557	5297435.7386	56	31	50.548889	14	27	42.293419	211.8560
HASS	3464655.5746	845750.1366	5270271.6918	56	5	31.982963	13	43	5.076671	114.0576
HILL	3351528.4856	828634.3617	5345223.3891	57	19	1.178683	13	53	14.468955	212.4473
HOFN	2679689.9926	-727951.2438	5722789.2884	64	16	2.250331	-15	11	52.515360	82.6959
HONE	3132537.3405	566401.9816	5508615.1977	60	8	36.869260	10	14	56.617715	181.4228
HVIG	3523228.6414	502878.8676	5275213.1004	56	10	21.095560	8	7	23.151878	63.7218
INDR	3177703.5301	1662050.1151	5257080.3777	55	52	44.782764	27	36	40.107893	213.6405
IRBE	3183612.0641	1276706.6593	5359310.8632	57	33	15.905960	21	51	7.193165	40.6878
JOEN	2564139.1129	1486149.7560	5628951.4318	62	23	28.223771	30	5	46.169334	113.7375
JONK	3309991.5798	828932.2615	5370882.4564	57	44	43.705214	14	3	34.593751	260.4011
KALL	3237443.3561	758888.5786	5424620.9530	58	39	49.062907	13	11	33.010548	90.0978
KANG	3078174.9738	1608797.7677	5331767.6517	57	5	40.540959	27	35	37.200148	163.8297
KARL	3160763.0950	759160.3153	5469345.6926	59	26	38.476035	13	30	20.252058	114.3253
KEVO	1972158.1932	1005174.4726	5961798.7967	69	45	21.202191	27	0	25.711923	135.9368
KIR0	2248123.2150	865686.6698	5886425.7662	67	52	39.272419	21	3	36.863379	498.0413
KIRU	2251420.8155	862817.2074	5885476.6924	67	51	26.465067	20	58	6.408414	390.9694
KIVE	2632277.1946	1266957.4282	5651027.7075	62	49	11.544469	25	42	8.141467	216.3162
KLPD	3359228.1678	1297490.4662	5246690.3389	55	42	55.278148	21	7	7.983582	42.7483

KNAR	3431762.5836	812400.2727	5296793.0496	56	31	17.664428	13	19	6.366517	113.9577
KONG	3183811.0452	541144.9938	5481926.0674	59	39	54.535417	9	38	46.484938	227.1250
KRSS	3348185.8605	465041.0271	5390738.2783	58	4	57.701015	7	54	26.705198	147.7625
KUUS	2282711.4838	1267071.8685	5800215.8486	65	54	36.895566	29	2	0.524665	379.0288
L311	3376643.0337	1352769.9641	5221718.8865	55	19	6.745000	21	49	56.307880	92.5089
L312	3320254.0314	1570665.2038	5197158.2262	54	55	51.397915	25	19	0.331053	229.5558
L408	3311606.6354	1453968.8188	5236111.2744	55	32	44.819957	23	42	14.368025	138.3882
L409	3425867.8966	1482315.7191	5154672.4781	54	16	19.523500	23	23	50.379655	228.4209
LEKS	3022572.9212	802945.8092	5540684.1541	60	43	19.722679	14	52	37.228130	478.1607
LJUN	3394252.5769	842398.5075	5316209.5268	56	50	16.314606	13	56	17.744586	196.3137
LODD	3504242.4443	808744.1673	5249934.9603	55	46	0.998333	12	59	44.690783	56.3532
LOVO	3104219.1798	998384.1615	5463290.7027	59	20	16.089503	17	49	44.098099	79.6678
LYSE	3269683.9398	366420.5995	5446037.5801	59	1	56.428671	6	23	39.240264	287.7511
MAR6	2998189.4392	931451.7616	5533398.6671	60	35	42.517043	17	15	30.693975	75.4408
MARI	3121535.1963	967771.3826	5458911.7085	59	15	41.193561	17	13	30.125719	37.8463
METS	2892570.8188	1311843.4328	5512634.1289	60	13	2.899021	24	23	43.151544	94.6198
MJOL	3241110.5949	876032.9902	5404956.8641	58	19	29.257692	15	7	29.815966	159.8037
MYGD	3379477.5810	598261.6074	5358170.5416	57	32	2.783052	10	2	20.186148	127.9848
NALS	1202433.8622	252632.2796	6237772.5829	78	55	46.396648	11	51	55.111702	84.2328
NORB	3068753.8376	875354.2331	5504108.8792	60	3	45.048255	15	55	14.391427	176.1418
NORR	3199093.0510	932231.4694	5420322.6793	58	35	24.833333	16	14	46.977951	40.9732
NYA1	1202433.8628	252632.2800	6237772.5863	78	55	46.396648	11	51	55.111747	84.2362
NYAL	1202430.5512	252626.6990	6237767.6112	78	55	46.504705	11	51	54.309162	78.5111
NYHA	3467557.7777	771271.7438	5279655.2769	56	14	39.356434	12	32	23.575306	63.1279
NYNA	3141747.3916	1017435.9871	5438418.3499	58	54	10.706008	17	56	39.242533	66.0969
OLKI	2863210.0008	1126271.5364	5568267.3953	61	14	22.757464	21	28	21.642601	30.6062
ONSA	3370658.5718	711877.1220	5349786.9410	57	23	43.075111	11	55	31.861171	45.5824
OSKA	3341339.9149	957912.4884	5330003.4077	57	3	56.300787	15	59	48.516623	149.7999
OSLS	3169981.9028	579956.7555	5485936.6695	59	44	11.712092	10	22	3.925258	221.5422
OSTE	2763885.2474	733247.4904	5682653.5420	63	26	34.057623	14	51	29.046746	490.0901
OULU	2423778.4672	1176553.8338	5761861.0191	65	5	11.506317	25	53	34.535813	88.8576
OVAL	3037697.4452	938862.3153	5510711.8425	60	10	58.642316	17	10	29.388550	81.8152
OVER	2368884.7404	994492.3224	5818478.3665	66	19	4.290500	22	46	24.145532	222.9736
OXEL	3177394.3820	977921.6621	5425008.4094	58	40	15.441066	17	6	25.352279	46.8192
PORT	3267084.8120	542580.9987	5432706.2499	58	48	13.928207	9	25	45.600089	63.6883
PRES	3227088.6670	353649.8215	5471909.9041	59	29	18.718022	6	15	14.282232	166.4434
QAQ1	2170942.1348	-2251829.9647	5539988.3259	60	42	54.947521	-46	2	51.944911	110.4130
REYK	2587384.3347	-1043033.5212	5716564.0159	64	8	19.622028	-21	57	19.747985	93.0254
RI00	3183914.0589	1421473.6508	5322796.8693	56	56	54.470984	24	3	30.965538	29.3703
RIGA	3183899.2311	1421478.4814	5322810.7950	56	56	55.030029	24	3	31.584060	34.7321
ROMU	2410839.1841	1388069.6051	5720515.3016	64	13	2.633043	29	55	54.128943	241.7122
RORO	3339312.1912	686422.8320	5372576.0238	57	46	37.037051	11	36	56.925641	51.3375
SAND	3228737.1194	582180.5439	5451381.2483	59	7	44.297174	10	13	16.667687	69.1965
SCOB	1982098.7615	-798842.3819	5989460.9759	70	29	6.843693	-21	57	3.030487	128.6601
SIRE	3323397.4067	336993.7003	5415278.0084	58	30	11.332457	5	47	24.081018	60.7412
SKAN	3537800.6052	807531.9492	5227707.7794	55	24	49.546891	12	51	28.598544	48.5894
SKE0	2534030.9116	975174.5562	5752078.5305	64	52	45.110128	21	2	53.843856	81.2760
SKIL	3511254.6709	893660.5319	5231575.3295	55	28	29.581761	14	16	45.689267	58.1286
SKOL	3187460.1361	543919.0213	5479516.0650	59	37	21.890422	9	41	1.931713	200.8681
SMID	3557911.2557	599176.6633	5242066.4356	55	38	26.322944	9	33	33.500665	122.8327
SMOG	3290543.5591	652615.2074	5406535.5696	58	21	12.471069	11	13	4.539838	45.2410
SMYG	3536512.2937	840549.8098	5223404.0052	55	20	44.521024	13	22	11.464728	50.1424

SODA	2200146.7036	1091638.3381	5866870.7880	67	25	15.093320	26	23	20.585324	299.8229
SODE	2993266.3958	996674.0302	5524712.0255	60	26	14.258303	18	24	58.739357	40.6700
SOHR	3172308.3354	603814.0171	5481968.1359	59	40	1.090794	10	46	36.166100	157.1570
SPT0	3328984.5532	761910.2482	5369033.6743	57	42	53.850377	12	53	28.855826	219.9590
STAG	3629048.0697	603765.6761	5192855.8322	54	51	55.046350	9	26	44.871500	107.8279
STAS	3275753.6501	321111.0210	5445042.0601	59	1	3.762503	5	35	55.045971	104.9091
STAV	3091410.6638	1045979.3692	5461608.2947	59	18	31.907169	18	41	35.729775	35.9610
SULD	3446394.2311	591713.1255	5316383.4430	56	50	30.333334	9	44	31.763396	120.7238
SUND	2838909.6615	903822.2116	5620660.4023	62	13	56.910531	17	39	35.596037	31.8545
SUUR	2959056.4001	1341058.5074	5470427.2905	59	27	48.885841	24	22	48.939380	84.3878
SVEG	2902494.8383	761455.9556	5609859.8784	62	1	2.688705	14	42	0.045826	491.2547
TGDE	3358080.9309	445364.8938	5386152.9195	58	0	22.955296	7	33	17.115036	45.8465
THU3	538093.5751	-1389088.0458	6180979.2342	76	32	13.370874	-68	49	30.128747	36.1128
TONS	3301576.3569	389093.1040	5425120.9079	58	40	18.850932	6	43	16.843288	114.2979
TRDS	2820170.8438	513486.0350	5678935.9228	63	22	16.980735	10	19	8.965119	317.7273
TRMS	2102928.4974	721619.4468	5958196.2416	69	39	45.784765	18	56	22.726281	138.0775
TRO1	2102928.5009	721619.4480	5958196.2509	69	39	45.784757	18	56	22.726281	138.0875
TROM	2102940.2233	721569.4457	5958192.1621	69	39	45.894457	18	56	17.985501	132.4668
TRYS	2987993.8613	655946.2118	5578690.2102	61	25	23.574380	12	22	53.696458	724.8430
TUOR	2917810.7826	1205222.7052	5523550.1084	60	24	57.056722	22	26	36.327098	60.6104
TYVH	3471138.4076	665488.5483	5291632.4792	56	26	16.774424	10	51	11.096034	88.7469
ULEF	3223773.3753	527002.8206	5459933.8030	59	16	41.076115	9	17	3.274375	125.3200
UMEA	2682407.6446	950396.0454	5688993.3082	63	34	41.300247	19	30	34.549591	54.5790
UPPS	3060037.7056	970123.0043	5492999.4098	59	51	54.540651	17	35	24.591261	57.1965
VAAS	2699864.3556	1078263.9918	5658064.8676	62	57	40.295035	21	46	14.289396	58.1255
VAEG	3612854.9835	763382.4428	5183133.8156	54	42	51.926954	11	55	51.201093	60.5552
VANE	3249408.0322	692758.0951	5426397.1326	58	41	35.258530	12	2	6.011876	169.7226
VARS	1844607.3153	1109719.1996	5983936.1431	70	20	10.942448	31	1	52.299045	174.8800
VAST	3097214.7217	921046.1324	5480693.5904	59	38	44.457217	16	33	40.910815	68.5528
VIL0	2620258.6177	779138.1343	5743799.4697	64	41	52.250636	16	33	35.750977	450.0173
VIRO	2788248.1976	1454873.4666	5530280.1810	60	32	19.682937	27	33	17.987572	36.9750
VIS0	3246470.2796	1077900.4966	5365278.0866	57	39	13.931083	18	22	2.340221	79.8217
VLNS	3343600.6532	1580417.7287	5179337.2871	54	39	11.313802	25	17	55.206790	240.8501
VOLL	3498678.0362	858203.7287	5245922.9922	55	42	6.565192	13	46	55.830832	141.3360
ZINK	3196313.2901	861751.7063	5433743.3811	58	49	9.704703	15	5	19.105467	231.2861