DTU Space

Danish Ministry of the Environment
National Survey and Cadastre

EUREF Densification on the Faroe Islands 2011

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Content

1. Introduction

The National Survey and Cadastre in Denmark (Kort & Matrikelstyrelsen; KMS) is responsible for the definition of the national reference system on the Faroe Islands. In 2008 KMS and the Environmental Agency on the Faroe Island (Umhvørvisstovan; US) decided to define a new national reference system on the Faroe Islands. This new reference system consists of a GPS based reference frame and a height reference frame based on levelling. The system will also include a new fitted geoid model and a new map projection. Furthermore, transformation parameters between the old and the new reference systems will be defined. The definition of the new reference system is performed by the National Space Institute at the Technical University of Denmark (DTU Space) and KMS.

The new reference frame on the Faroe Islands is based on ETRS89, which is realized through GPS observations in 4 fix points. KMS and US wish these 4 fix points and the corresponding ETRS89 coordinates to be accepted as an official EUREF densification.

This purpose of this document is to describe the EUREF densification project on the Faroe Islands, i.e. the document describes the collected GPS data, the data processing strategy and the results from the processing and the transformation to ETRS89.

The processing of GPS data and the evaluation of results are performed by Shfaqat Abbas Khan (DTU Space), and the transformation to ETRS89 is performed by Karsten Enggaard Engsager (DTU Space).

2. Acknowledgments

The GPS campaign and this report would not have been possible without the effort and assistance of other colleagues and facilities.

- Casper Jepsen, National Survey and Cadastre, Denmark
- Stein Fossá, Environmental Agency, Faroe Islands
- Per Knudsen, DTU Space
- Carine Bruyninx, Günter Stangl and Helmut Hornik from the EUREF TWG

3. Campaign configuration

The realization of ETRS89 on the Faroe Islands (FO) is based on GPS data collected during the NKG campaign in September/October 2008. The points used for the EUREF densification project is the 4 manually observed fix points in Torshavn (TORH), Klaksvik (KLAK), Sørvagur (SORV) and Tvøroyri (TVOR). The stations are observed by KMS for 7 full days from September 29 to October 4, 2008 (DOY 272 to 278). The stations are shown in Figure 1.

Besides data from the 4 FO stations data is also collected from 5 IGS/EPN stations shown in Figure 2. These stations are used as fiducial stations. Data is available for all 4 fiducial stations from DOY 272 to 278, and the stations fulfil the criteria in section 3.2 in the “Guidelines for EUREF Densifications” [Bruyninx et al., 2010].

All stations including the domes numbers, the location of stations etc. are listed in Table 1. The GNSS equipment and the monument description for each station are listed in Table 2.

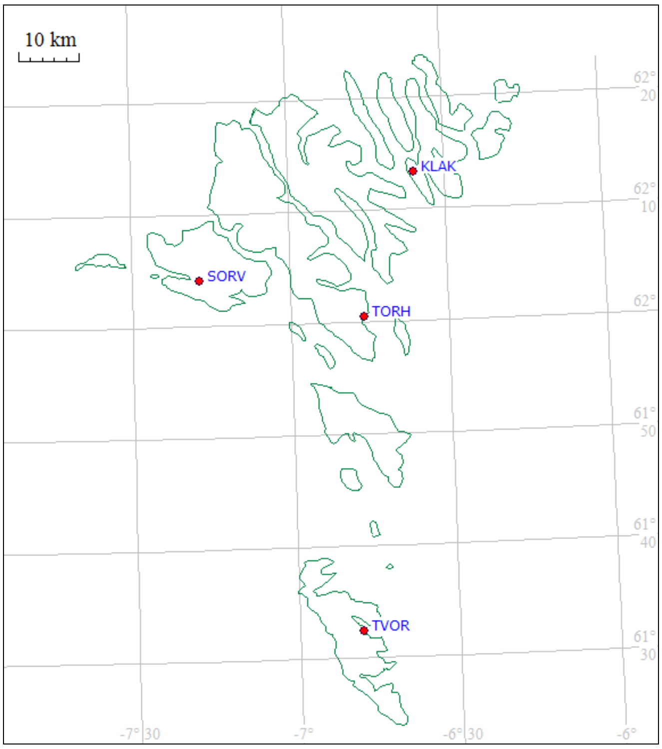

Figure 1. Densification stations on the Faroe Islands (FO)

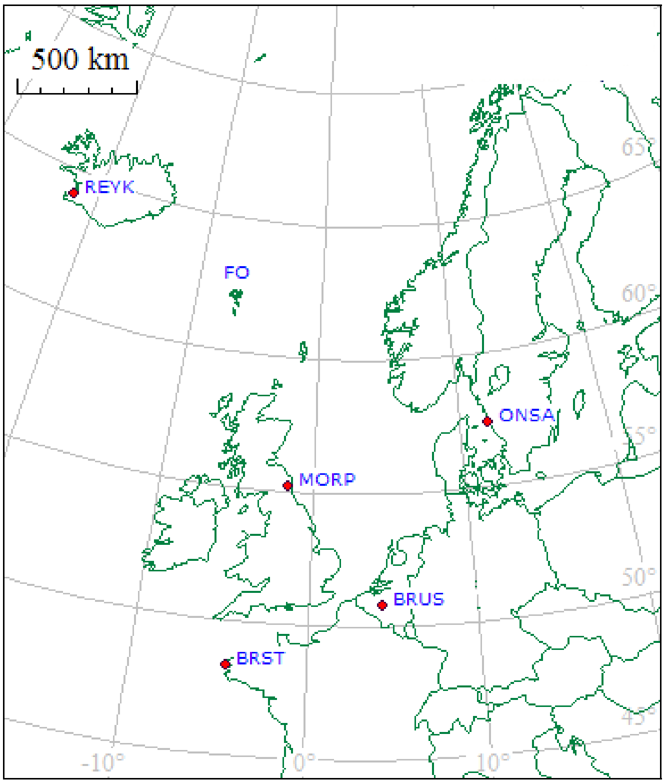

Figure 2. IGS/EPN fiducial stations

Station ID	Domes no.	Location	Type of station and remarks
EUREF Densification at the Faroe Islands			
TORH	-	Torshavn	National fix point
KLAK	-	Klaksvik	National fix point
SORV	-	Sørvagur	National fix point
TVOR	-	Tvøroyri	National fix point
IGS/EPN fiducial stations			
BRST	10004M004	Brest, France	IGS/EPN permanent station
BRUS	13101M004	Brussels, Belgium	IGS/EPN permanent station
MORP	13299S001	Morpeth, GB	IGS/EPN permanent station
ONSA	10402M004	Onsala, Sweden	IGS/EPN permanent station
REYK	10202M001	Reykjavik, Iceland	IGS/EPN permanent station

Table 1: List of densification stations and fiducial stations

Station ID	Receiver	Antenna and radome	Monument description
EUREF Densification at the Faroe Islands			
TORH	TPS EGGDT	LEIAT504GG NONE	Bolt in bedrock
KLAK	TPS EGGDT	LEIAT504GG NONE	Bolt in bedrock
SORV	TPS EGGDT	LEIAT504GG NONE	Bolt in bedrock
TVOR	TPS EGGDT	LEIAT504GG NONE	Brass bolt with plate in bedrock
IGS/EPN fiducial stations			
BRST	LEICA GRX1200GGPRO	LEIAT504GG NONE	Inox plate on top of a metallic pillar
BRUS	ASHTECH Z-XII3T	ASH701945B_M NONE	Steel mast
MORP	TRIMBLE NETRS	AOAD/M_T NONE	Pillar
ONSA	JPS E_GGD	AOAD/M_B OSOD	Pillar
REYK	TPS E_GGD	TPSCR.G3	Concrete balustrade wall

Table 2. GNSS equipment and monument description

4. Data processing

Processing software was the Bernese GPS Software Version 5.0 (BSW). The baseline processing strategy was broadly similar to the one recommended for double difference processing in the BSW manual [Dach et al., 2007]. Only GPS data were used in the processing.

Most of the text in this section is also given in the EUREF IE/UK 2009 Final report [Greaves, 2010].

4.1. External data

All external data files used in the processing are listed in Table 3 below.

Products	Source
ITRF2005 coordinates	ftp://ftp.epncb.oma.be/pub/station/coord/EPN/
Satellite orbit and clocks	ftp://cddis.gsfc.nasa.gov/gps/products/repro1/
Ocean tide loading parameters	http://www.oso.chalmers.se/~loading/, model FES2004, no correction for the motion of the centre of mass of the solid Earth.
Antenna phase centre offsets	ftp://ftp.epncb.oma.be/pub/station/general/epn_05.atx
Differential clock biases	ftp://ftp.unibe.ch/aiub/CODE/yyyy/, P1C1yymm.DCB & P1P2yymm.DCB files.
Ionosphere maps	ftp://ftp.unibe.ch/aiub/CODE/yyyy/, CODwwwwd.ION files
Final, precise GPS orbits	ftp://cddis.gsfc.nasa.gov/gps/product/wwww/, igswwwwd.sp3 files

Satellite clocks	ftp://cddis.gsfc.nasa.gov/gps/product/wwww/, igswwwwd.clk_30s files
Earth rotation parameters	ftp://cddis.gsfc.nasa.gov/gps/product/wwww/, igswwwwd.erp files

Table 3: External data products used in the processing

4.2. Reference frame coordinates

The ITRF2005 epoch 2005.0 coordinates of the fiducial stations and their corresponding velocities were extracted from the file EPN_A_ITRF2005_C1600.SSC. The coordinates and velocities are shown in Table 4. The velocities are used to compute the coordinates at the mid epoch of the campaign period. The computed coordinates are listed in Table 5.

Station ID	X (m)	Vx (m/yr)	Y (m)	Vy (m/yr)	Z (m)	Vz (m/yr)
BRST	4231162.5840	(-0.0116)	-332746.6800	(0.0171)	4745130.9270	(0.0111)
BRUS	4027893.7510	(-0.0128)	307045.8250	(0.0163)	4919475.1220	(0.0112)
MORP	3645667.8410	(-0.0112)	-107277.2370	(0.0159)	5215053.5300	(0.0111)
ONSA	3370658.5450	(-0.0128)	711877.1390	(0.0144)	5349786.9540	(0.0120)
REYK	2587384.3150	(-0.0212)	-1043033.5220	(-0.0032)	5716564.0560	(0.0067)

Table 4: ITRF2005 epoch 2005.0 coordinates and velocities of fiducial stations

Station ID	X (m)	Y (m)	Z (m)
BRST	4231162.5405	-332746.6159	4745130.9686
BRUS	4027893.7030	307045.8861	4919475.1640
MORP	3645667.7990	-107277.1774	5215053.5716
ONSA	3370658.4970	711877.1930	5349786.9990
REYK	2587384.2355	-1043033.5340	5716564.0811

Table 5. ITRF2005 epoch 2008.753 (DOY 275) coordinates of fiducial stations

4.3. Antenna calibrations and ocean tide loading

Absolute antenna calibrations were used throughout the processing. The epn_05.atx file was used as a template to create a custom antenna calibration file for the campaign.

Ocean tide loading parameters used throughout the processing were obtained from http://www.oso.chalmers.se/~loading/, using model FES2004 with no correction for the motion of the centre of mass of the solid Earth. Station coordinates used for the ocean tide loading parameter computation came from an initial precise point positioning (PPP) run through one whole day of data for all stations.

4.4. Daily processing strategy

The scripts used for the daily processing are listed in Table 6. Further details on key aspects of the processing are given in the following sections. An elevation cut off angle of 3 degrees and cos*z* elevation dependent weighting was used through out the processing.

1	GET_IGS	This script copies the needed files into the respective campaign directory. Control that a certain set of files are present.
2	POLUPD	Create BSW ERP format file from precise IGS ERP file
3	PRETAB	Create tabular orbit file using files from steps 1 and 2 as input. Also save satellite clocks.
4	ORBGEN	The program integrates the equation of motion using the positions given in the tabular orbit file to produce Bernese standard orbit file used in all processing

		programs needing orbit information.
5	CCRNXC	This program converts clock RINEX files into a Bernese satellite clock file (extension CLK). The file resides in the campaign´s ORB directory.
6	RNXSMTAP	This script and the following form a unit. The purpose is to clean data on the RINEX level. This script prepares the parallelization, the actual processing is done in the next PID. The next PID is RNXSMT_P who clean and smooth RINEX files.
7	SMTBV3	Calls RXOBV3 who import smoothed RINEX files into BSW format. Export coordinates for use as a priori values.
8	CODSPP	Station by station single point positioning from code observations using precise SV clocks from step 5. Coordinate results used to update a priori coordinate values. Receiver clock estimates saved in observation files.
9	GPSEST	Station by station zero difference processing using precise IGS orbits (step 1), ERPs (step 2), clocks (step 5) and a priori coordinates from step 8. Save coordinates, residuals and normal equations.
10	RESRMS & SATMRK	Screen and mark high residuals from previous GPSEST run
11	GPSEST	Same as step 9 but use screened observation files from step 10 and a priori coordinates from step 9.
12	ADDNEQ2	Combine individual station normal equations and a priori coordinates from step 11. Output final PPP coordinates and daily PPP normal equations
13	CRDMERGE	Create new a priori coordinate file for double difference processing using final PPP coordinates from step 12.
14	SNGDIF	Create phase single difference observation files using the OBSMAX strategy.
15	MAUPRP_P	Observation pre processing. Filter out observations: • Lower than 3º elevation; • Unpaired (L1 but no L2 or vice versa); • In “small pieces” (<301 seconds, gap between continuous obs <61seconds). Identify data with no cycle slips and in remaining data find and if possible repair cycle slips.
16	GPSEST	Baseline by baseline ambiguity free solution. Troposphere parameters estimated. Residuals (normalised) and normal equations saved.
17	RESRMS & SATMRK	Screen and mark high residuals from previous GPSEST run.
18	GPSEST	Same as step 16 but use screened observation files from step 17.
19	ADDNEQ2	Combine individual baseline normal equations from step 18. Output coordinates and troposphere parameters.
20	GPSQIFAP	Prepare the parallel execution of the ambiguity resolution step. Program BASLST is used to select baselines up to a maximum length of 2000 km.
21	GPSQIF_P	One GPEST is started for each baseline to be processed. Baseline by baseline ambiguity resolution using the QIF algorithm.
22	GPSEST	Final free network processing of all baselines in a single run. Coordinates and normal equations saved.
23	ADDNEQ2	Based on the normal equations from the previous GPEST run, a final solution is computed.
24	HELMR1	Helmert transformation of coordinates from step 22 to coordinates of EPN A fiducial stations to check for problems at fiducial stations.

Table 6. List of scripts for the daily processing strategy

4.5. Troposphere and ionosphere strategy

A simple troposphere strategy was applied in programs CODSPP and MAUPRP. CODSPP used the Saastamoinen model and MAUPRP used Niell (combined wet and dry) zenith path delay model and mapping function.

In the ambiguity free and ambiguity resolution GPSEST runs the Dry Niell a priori model was used plus the estimation of zenith path delay Wet Niell parameters every hour with a 5 m a priori weight for the absolute and relative parameters.

For the final GPSEST runs for PPP and double difference processing a Dry Niell a priori model was used plus the estimation of zenith path delay Wet Niell parameters every hour. Horizontal gradient parameters with a tilting model were also computed every 24 hours. A 5 m a priori weight for the absolute and relative parameters was used.

The ionosphere free L3 combination was used throughout the processing to remove the effects of the ionosphere. The exception to this was at the QIF ambiguity resolution stage when the L1+L2 observable were used and an a priori ionosphere model introduced.

4.6. Ambiguity resolution

The a priori coordinates for the ambiguity resolution processing were introduced from the previous ambiguity free stage and the CODwwwwd.ION model was introduced so ionosphere parameters were not estimated.

With reference to the BSW example campaign options a test was performed to see the effect of raising the elevation cut off angle for ambiguity resolution to 10 degrees. The final coordinate differences between processing at 10 and 3 degrees were insignificant so a 3 degree cut off was used in the final solution. The ambiguity resolution results from the test are shown in Appendix A.

4.7. Daily free network solution processing

The final daily free network solutions were produced by processing all baselines in a single GPSEST run (step 22). A priori coordinates from the ambiguity free processing were introduced. The “CORRECT” correlation strategy was used to ensure the statistically correct modeling of correlations between all baselines. The sampling interval was 180 seconds. The troposphere and ionosphere strategy was as described in section 4.5 above. The previously resolved ambiguities were introduced as known integer values. Normal equations were saved for later use in the final combined solution.

The EPN A fiducial station coordinates from this solution were transformed to their “correct” coordinates from the ‘EPN_A_ITRF2005_C1600.SSC’ file. The residuals from this transformation were used to check the daily performance of the processed EPN A stations. The results are shown in section 5.2

4.8. Final combined network solution

An a priori coordinate file was produced that contained the “correct” coordinates of the fiducial EPN A stations from the ‘EPN_A_ITRF2005_C1600.SSC’ file – see section 4.2. A test was performed to study the impact of using only translation minimal constraint on the fiducial stations as opposed to using translation and scale. Using only translation constraints resulted in slightly better fiducial station coordinate recovery so this constraint was used for datum definition in the combined solution.

The daily solutions were combined using program ADDNEQ2 and the daily coordinate repeatabilities, compared to the combined solution, were analysed for outliers. Outliers for individual, daily repeatabilities were set at the BSW defaults of 10 mm for N and E and 20 mm for U. The repeatability results are presented in section 5.3 and Appendix B.

To produce the final campaign solution the daily network solutions were combined using program ADDNEQ2.

5. Processing results

The computed ITRF2005 epoch 2008.753 coordinates for the stations on the Faroe Islands are listed in Appendix C. The processing results and the results from the performed tests are shown below.

5.1. Ambiguity resolution

The overall mean ambiguity resolution was 79.0% and the daily mean percentages are shown below in Figure 3.

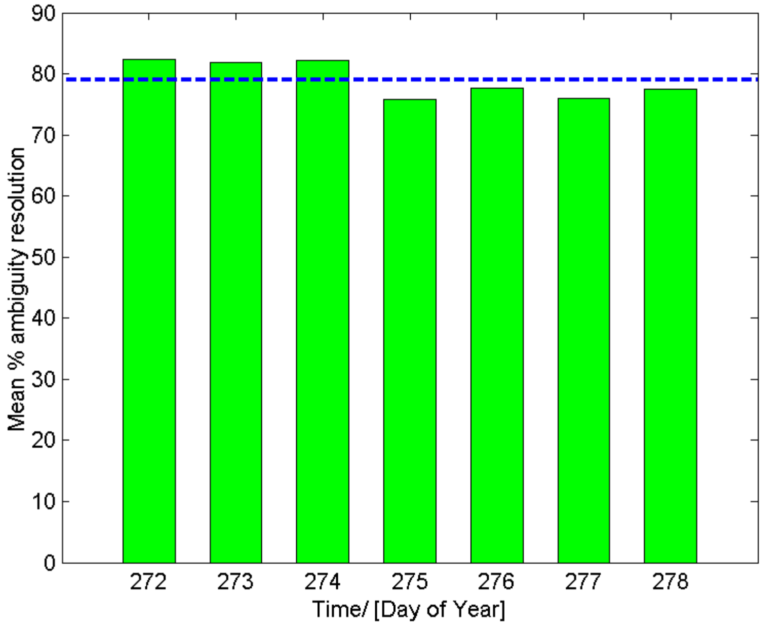

Figure 3. Daily mean ambiguity resolution.

5.2. Daily free network fiducial station tests

The results of the Helmert transformation tests on the fiducial station coordinates from the daily free network solutions are shown in Table 7 below. This test shows small residuals for all stations, days and N/E/U components indicating a good performance of the fiducial stations.

Station	N(mm)	E(mm)	U(mm)	N(mm)	E(mm)	U(mm)	N(mm)	E(mm)	U(mm)	N(mm)	E(mm)	U(mm)
	272			273			274			275		
BRST	0.6	0.7	-2.5	-0.3	-0.7	0.1	0.2	4.8	-3.3	0.7	4.0	4.3
BRUS	-0.3	2.6	8.0	1.7	2.3	-0.4	0.8	-1.9	11.0	-0.4	-3.0	8.3
MORP	-1.2	-2.2	-10.0	-0.3	-1.3	-0.4	1.1	1.1	-6.6	0.0	1.5	-6.0
ONSA	1.9	0.8	8.1	1.1	1.3	-0.1	-0.5	-4.7	2.7	-0.2	-3.4	-0.9
REYK	-1.1	-1.9	-3.7	-2.1	-1.6	0.6	-1.6	0.6	-3.8	-0.2	0.8	-5.6
RMS	**1.3**	**2.0**	**7.9**	**1.5**	**1.7**	**0.4**	**1.1**	**3.5**	**7.0**	**0.4**	**3.2**	**6.2**

	N(mm)	E(mm)	U(mm)	N(mm)	E(mm)	U(mm)	N(mm)	E(mm)	U(mm)
	276			277			278		
BRST	0.2	5.3	-0.4	2.7	2.6	-10.6	-1.0	0.1	-1.6
BRUS	3.9	9.9	0.6	-0.3	-0.3	6.5	0.1	-0.3	1.8
MORP	-2.7	-6.6	2.6	-1.8	-1.4	0.3	-0.4	-0.6	1.0
ONSA	-1.8	-7.1	-5.9	-0.8	-1.5	4.3	0.7	-0.7	3.1
REYK	0.5	-1.5	3.1	0.3	0.6	-0.5	0.6	1.4	-4.2
RMS	**2.5**	**7.5**	**3.6**	**1.7**	**1.7**	**6.6**	**0.7**	**0.9**	**2.9**

Table 7. Transformation residuals of daily free network fiducial station coordinates compared to accepted coordinates.

5.3. Daily coordinate repeatability test

As stated in section 4.8 N, E, U outlier limits were set as follows: 10 mm N and E and 20 mm U for daily repeatabilities. The RMS of coordinate repeatabilities from the combination of the daily solutions are shown in Table 8 below. The complete list of daily coordinate repeatabilities are listed in Appendix B. No stations are exceeding the given limits.

Station	N(mm)	E(mm)	U(mm)
	RMS	RMS	RMS
BRST	1.2	2.4	4.5
BRUS	1.6	4.3	4.4
MORP	1.3	2.7	4.8
ONSA	1.3	3.0	4.4
REYK	1.1	1.4	4.2
KLAK	2.1	3.6	4.5
SORV	1.5	2.5	4.2
TORH	1.3	2.3	4.1
TVOR	2.0	3.2	4.6

Table 8. RMS of coordinate repeatabilities from combination of daily solutions.

6. Transformation to ETRS89

The ITRF2005 epoch 2008.753 coordinates are transformed to ETRS89 using the guidelines given in "Memo: Specifications for reference frame fixing in the analysis of a EUREF GPS campaign" by Claude Boucher and Zuheir Altamimi, Version 7: 24-10-2008, chapter 3, case 2b. The ETRF2000 is used as conventional frame. The ETRF2000 coordinates are shown in Appendix D.

The parameters below are used in the transformation from ITRF2005 to ITRF2000. These parameters are also given at http://itrf.ensg.ign.fr/ITRF_solutions/2005/tp_05-00.php. The units for the translations are mm and mm/year and the units for the rotations are mas and mas/year. The scale is multiplied by 10^{-9}.

ITRF2000 → ITRF2005 (note the sign)

20000101	-0.1	0.8	5.8	-0.40	0.00	0.00	0.00
	0.2	-0.1	1.8	-0.08	0.00	0.00	0.00
Date	Tx	Ty	Tz	Dscale	Rx	Ry	Rz
	Tx/Y	Ty/Y	Tz/Y	Dscale/Y	Rx/Y	Ry/Y	Rz/Y

The parameters below are used in the transformation from ITRF2000 to ETRS89 (ETRF2000). The parameters are given by [Boucher, Altamimi, 2008] in Table 3 (line A) and Table 4. The units for the translations are cm and cm/year and the units for the rotations are mas and mas/year. The scale is multiplied by 10^{-9}.

ITRF2000 → ETRS89

19890101	5.4	5.1	-4.8	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.081	0.490	-0.792
Date	Tx	Ty	Tz	Dscale	Rx	Ry	Rz
	Tx/Y	Ty/Y	Tz/Y	Dscale/Y	Rx/Y	Ry/Y	Rz/Y

The transformations are furthermore checked using the transformation service given on the EUREF home page http://www.epncb.oma.be/_dataproducts/coord_trans/. The results from this service agree with the results from the transformations above.

7. Conclusions

Bernese Software 5.0 was used for the data processing of the ETRS89 densification campaign on the Faroe Islands. Five IGS sites were used as fiducial stations for the calculation of ITRF2005 epoch 2008.753 coordinates for four local sites.

The internal quality of the solution, as indicated by the daily coordinate repeatabilities, is around 2-3 mm in N and E and around 5-7 mm in U.

8. References

Boucher, C., Altamimi, Z. (2008), Memo : Specifications for reference frame fixing in the analysis of a EUREF GPS campaign, Version 7 : 24-10-2008, http://etrs89.ensg.ign.fr/memo-V7.pdf.

Bruyninx, C., Altamimi, Z., Caporali, A., Kenyeres, A., Lidberg, M., Stangl, G., Torres, G. A. (2009), Guidelines for EUREF Densifications, Version 2: 04-05-2010, ftp://epncb.oma.be/pub/general/Guidelines_for_EUREF_Densifications.pdf.

Dach, R., Hugentobler, U., Fridez, P., Meindl, M. (eds) (2007), Bernese GPS Software Version 5.0, Astronomical Institute of the University of Bern, Switzerland.

Greaves, M. (2010), EUREF IE/UK 2009, Final report on the processing and analysis of the EUREF IE/UK 2009 campaign.

A. Comparison of different elevation cut off angles in QIF ambiguity resolution

With reference to the BSW example campaign and other EUREF densification campaigns highlighted the practice of raising the elevation cut off angle from 3 degrees to 10 degrees for the QIF ambiguity resolution stage of the processing.

In order to determine which approach to use the effect on the final coordinates of the different cut off angles was tested. The campaign processing was run twice, up to the combination of the daily solutions, using 3 degree cut off in one run and 10 in the other. Coordinates and QIF summary output information from the two runs was compared. The comparison showed insignificant differences between the coordinates.

Figure 4 below shows the percentage of ambiguities resolved at each cut off angle and, as as expected, the 10 degree cut off results in a higher percentage of ambiguities resolved.

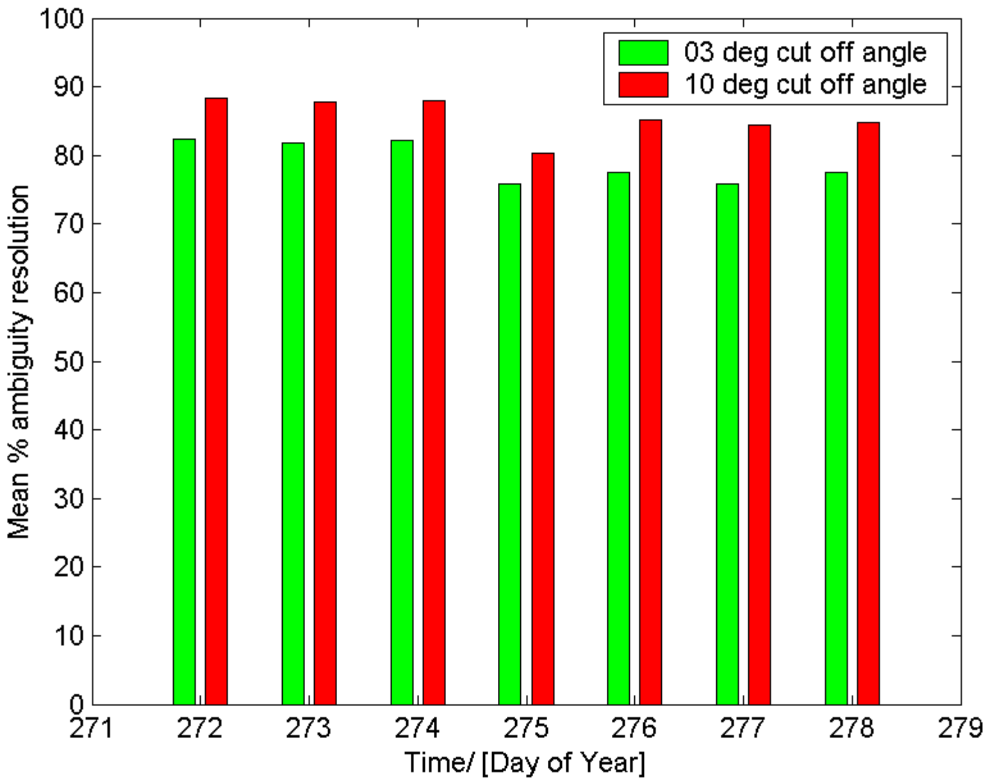

Figure 4. Ambiguity resolution for 3 and 10 degrees.

B. Complete list of coordinate repeatabilities

Station	N(mm)	E(mm)	U(mm)	N(mm)	E(mm)	U(mm)	N(mm)	E(mm)	U(mm)	N(mm)	E(mm)	U(mm)
	272			273			274			275		
BRST	0.6	0.7	-2.5	-0.4	-0.8	-0.3	0.2	4.8	-3.3	0.7	4.0	4.3
BRUS	-0.3	2.6	8.0	1.8	2.2	-0.9	0.8	-1.9	11.0	-0.4	-3.0	8.3
MORP	-1.2	-2.2	-10.0	-0.3	-1.2	-0.8	1.1	1.1	-6.6	0.0	1.5	-6.0
ONSA	1.9	0.8	8.1	1.3	1.4	1.3	-0.5	-4.7	2.7	-0.2	-3.4	-0.9
REYK	-1.5	-1.9	-3.7	-2.3	-1.6	0.7	-1.6	0.6	-3.8	-0.2	0.8	-5.6
KLAK	1.6	5.2	0.6	-1.4	-0.5	0.3	-2.2	-0.9	-2.5	-4.0	-1.5	-10.0
SORV	-0.9	-0.4	-9.6	-1.7	0.3	-2.0	-3.7	-0.8	-10.0	-2.4	-3.0	-9.5
TORH	-1.3	3.1	-8.1	-2.2	-0.3	0.6	-3.0	-0.2	-9.1	-1.0	0.1	-7.9
TVOR	2.8	8.2	5.0	-1.1	1.3	4.0	-2.5	-0.3	-3.7	-2.4	0.3	-3.8
RMS	**1.3**	**2.0**	**7.9**	**1.6**	**1.7**	**0.9**	**1.1**	**3.5**	**7.0**	**0.4**	**3.2**	**6.2**

Station	N(mm)	E(mm)	U(mm)	N(mm)	E(mm)	U(mm)	N(mm)	E(mm)	U(mm)
	276			277			278		
BRST	0.2	5.3	-0.4	2.7	2.6	-10.6	-1.0	0.1	-1.6
BRUS	3.9	9.9	0.6	-0.3	-0.3	6.5	0.1	-0.3	1.8
MORP	-2.7	-6.6	2.6	-1.8	-1.4	0.3	-0.4	-0.6	1.0
ONSA	-1.8	-7.1	-5.9	-0.8	-1.5	4.3	0.7	-0.7	3.1
REYK	0.5	-1.5	3.1	0.3	0.6	-0.5	0.6	1.4	-4.2
KLAK	-3.3	-6.1	2.6	0.8	-3.9	-0.6	-2.4	0.5	-6.7
SORV	-4.3	-6.7	-5.1	-0.0	-0.1	-8.2	-1.9	-0.5	-15.4
TORH	-0.1	-4.2	0.5	0.5	1.0	-2.8	0.3	2.1	-3.2
TVOR	-3.0	-1.4	-3.2	0.5	0.4	3.7	-0.7	0.0	-5.9
RMS	**2.5**	**7.5**	**3.6**	**1.7**	**1.7**	**6.6**	**0.7**	**0.9**	**2.9**

Table 9. Coordinate repeatabilities from combination of daily solutions.

C. ITRF2005 coordinates

Station	X	Y	Z
KLAK	2 960 777.7938 m	-342 299.5759 m	5 620 225.5647 m
SORV	2 971 444.8914 m	-379 959.1895 m	5 612 156.0046 m
TORH	2 980 573.3504 m	-353 744.2818 m	5 608 957.1081 m
TVOR	3 026 017.0824 m	-360 951.8291 m	5 584 332.3833 m

Table 10. ITRF2005 epoch 2008.753 coordinates for the stations on the Faroe Islands

D. ETRS89 coordinates

Station	X	Y	Z
KLAK	2 960 778.0871 m	-342 299.7933 m	5 620 225.3597 m
SORV	2 971 445.1814 m	-379 959.4076 m	5 612 155.7988 m
TORH	2 980 573.6424 m	-353 744.5006 m	5 608 956.9021 m
TVOR	3 026 017.3726 m	-360 952.0512 m	5 584 332.1752 m

Table 11. ETRF2000 epoch 1989.0 coordinates for the stations on the Faroe Islands