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Update of EUREF GNSS Analysis to Bernese SW V5.2: New Features and Impact on Results

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Bernese GNSS Software Version 5.2

- **Bernese GNSS Software Version 5.2** (BSW V5.2) was announced on 18 December 2012 in BSW Mail No. 310 (please be referred to www.bernese.unibe.ch >Support >BSW Mail Index and in particular to >Features)
- BSW V5.2 downloaded/installed via CVS access from the AIUB computer cluster. Other BSW versions (e.g. current development V5.3) would be accessible to us (PNAC), too.
- Changed data formats: satellite information, (multi-GNSS) PCV (phase center variations), CRD/VEL, station (STA) information; STD+, OBS+, NQ0+ (NEQ), TRO+, BLQ+.
- Special note: A number of BSW V5.2 changes originates from further developments, or ideas made at PNAC: improved baseline forming (SNGDIF), improved phase data preprocessing for short baselines (MAUPRP), GLONASS ambiguity resolution, “ISTPs” (GPSEST/ADDNEQ2), etc.

General Overview of Bernese SW Components and Update (Levels)

Bernese SW Components	BSW50BSW52
Datapool (RINEX, orbits/ERPs/ION, GEN)	Linked/copied/new
General (Perl) scripts ($X/AUTO)	Copied&adjusted
BPE Processing Control Files ($U/PCF)	Copied&extended
BPE Perl scripts ($U/SCRIPT)	Copied&adjusted
INP panels ($U/OPT)	Copied&updated&adjusted
BSW source code and *executables* ($FG)	New (few minor changes)
REF(erence) files (CRD/VEL, STA, PCV, BLQ)	Converted (…)
Other scripts and tools	

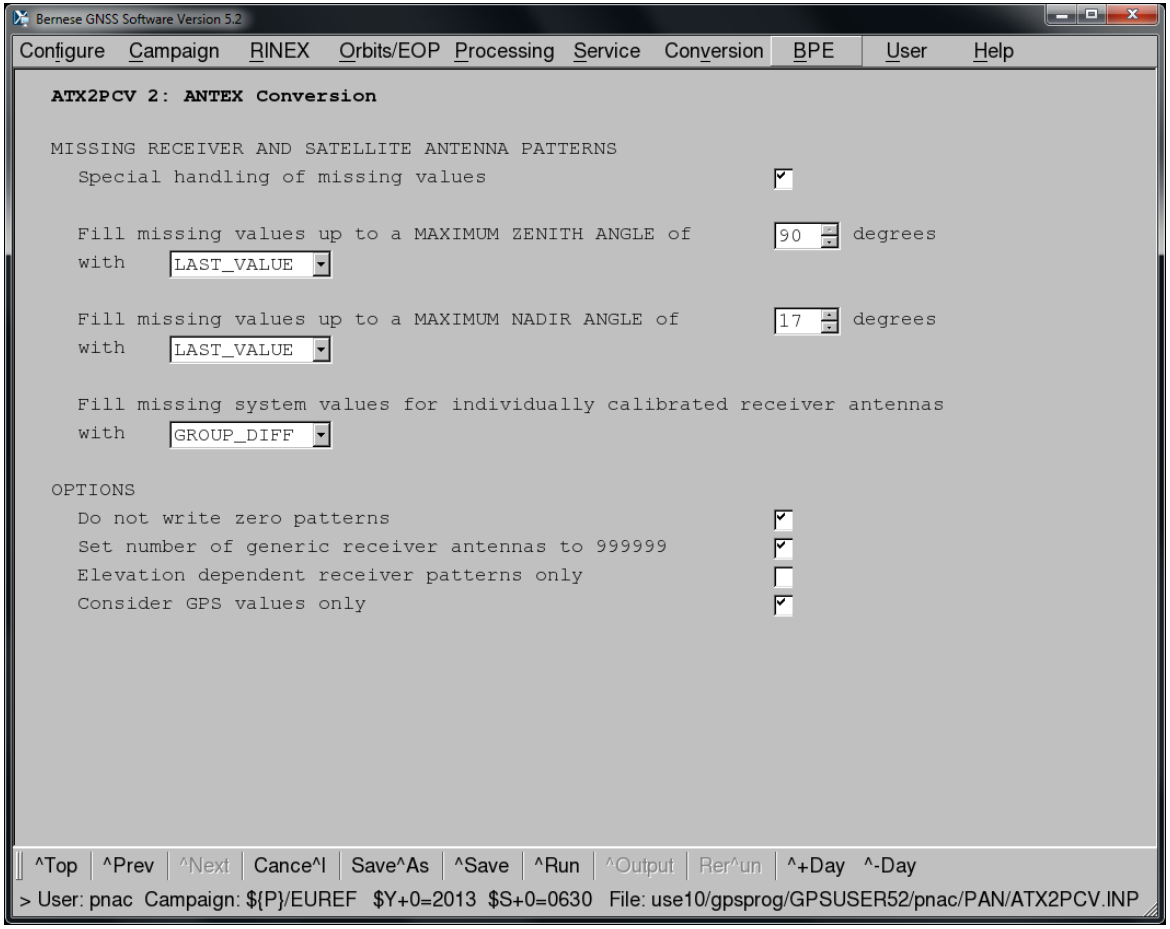
- Updated FES2004.BLQ (ocean loading correction tables).
- Hatanaka RINEX decompression/compression software to be updated from V4.0.3 (2007-06-21) to V4.0.5 (2012-07-18) (see: http://terras.gsi.go.jp/ja/crx2rnx.html)

GNSS PCV Information and ATX2PCV: From PHAS_LPT.* (BSW50) to PCV_LPT.* (BSW52)

- 5 (actually 6) BSW50 (GPS) PCV files are maintained at PNAC:
  - I01: IGS01, relative, group calibrations (4 000 → 9000 lines)
  - C01: IGS01, relative, group plus all PNAC individual calibrations
  - I08: IGS08, absolute, group calibrations (30 000 → 45 000 lines)
  - C08: IGS08, absolute, group plus PNAC individual calibrations (52 000 → 89 000 lines)
  - E08: IGS08/EPNC, absolute, group plus EPN individual calibrations
  - B08: “GLONASS-specific C08”
- ANTEX data sources considered are:
  - I01 (GPS): IGS_01, relative group calibrations (1 300 lines)
  - I08 (GNSS): IGS08_1735, absolute group calibrations (40 000 lines)
  - E08 (GNSS): EPNC, absolute individual calibrations (19 000 lines)
  - Plus a number of (primarily AGNES-specific) ATX files
- ANTEX-to-PCV convertor: ATX2PCV V5.2 is the replacement for PHCCNV V5.0:
  - New **multi-GNSS-capable** PCV data format
  - Calibration method and calibration date is now considered (→ SINEX code)
  - Additional converter options are available, such as …

ATX2PCV

- GPS_VALUES/GROUP_VALUES/GROUP_DIFF
- “GPS-only”



Listing of Possible System/SINEX/Method-Combinations in PCV_LPT.E08:

SYS	SINEX	METHOD	DATE
*	**********	********************	**********
G	EPNC	CHAMBER	
G	EPNC	FIELD	
G	EPNC	ROBOT	
G	IGS08		
G	IGS08_1734	ADOPTED from NONE	
G	IGS08_1734	CONVERTED	
G	IGS08_1734	COPIED	
G	IGS08_1734	FIELD	
G	IGS08_1734	ROBOT	
G	IGS08	FIXED	
R	EPNC	ADOPTED from GPS	
R	EPNC	CHAMBER	
R	EPNC	ROBOT	
R	IGS08		
R	IGS08_1734	ADOPTED from GPS	
R	IGS08_1734	ADOPTED from group	
R	IGS08_1734	ADOPTED from NONE	
R	IGS08_1734	COPIED	
R	IGS08_1734	ROBOT	
R	IGS08	FIXED	

METH(od) Records as Extracted from epnc(_08).atx:

```
CHAMBER             AMK BONN                 1    01-Feb-11 METH / BY / # / DATE
CHAMBER             AMK BONN                 1    08-Mar-12 METH / BY / # / DATE
CHAMBER             AMK BONN                 1    14-Jul-10 METH / BY / # / DATE
CHAMBER             AMK BONN                 1    2010_10_07METH / BY / # / DATE

ROBOT               Geo++ GmbH               1    2000-05-28METH / BY / # / DATE
ROBOT               Geo++ GmbH               1    2000-10-30METH / BY / # / DATE
ROBOT               Geo++ GmbH               1    2002-03-11METH / BY / # / DATE
...
ROBOT               Geo++ GmbH               2    2008-04-15METH / BY / # / DATE
ROBOT               Geo++ GmbH               2    2008-04-16METH / BY / # / DATE
ROBOT               Geo++ GmbH               2    2008-04-17METH / BY / # / DATE

ROBOT               IfE                      1    2008-05-20METH / BY / # / DATE

FIELD               LWa                      1    06.02.2007METH / BY / # / DATE

ROBOT               SenStadt BERLIN          1    2007-05-18METH / BY / # / DATE
ROBOT               SenStadt BERLIN          1    2007-07-09METH / BY / # / DATE
ROBOT               SenStadt BERLIN          1    2007-09-14METH / BY / # / DATE
...
ROBOT               SenStadt BERLIN          1    2007-11-13METH / BY / # / DATE
ROBOT               SenStadt BERLIN          1    2008-02-19METH / BY / # / DATE
ROBOT               SenStadt_BERLIN         12    2010-02-17METH / BY / # / DATE

EPNC                                                    SINEX CODE
```

Characteristics of Various EUREF GNSS Analysis Solutions Computed at PNAC (for Comparison/Validation Purposes)

Solution ID (code)	SW version	Tropo/gradients	GLO PCV	HO Iono & 3 SPs	IERS conventions & other models
Old (0)	BSW V5.0+	NMF/TILTING	No	No	IERS20000
New (1)	BSW V5.2	NMF/TILTING	No	No/ZERO	IERS20001
A (2A)	BSW V5.2	NMF/TILTING	No	No	IERS20102
B (2B)	BSW V5.2	GMF/CHENHER	No	No	IERS20102
C (2C)	BSW V5.2	GMF/CHENHER	Yes	No	IERS20102
D (2D)	BSW V5.2	GMF/CHENHER	Yes	No/ZERO	IERS20102
Last (2)	BSW V5.2	GMF/CHENHER	Yes	Yes/ONE	IERS20102
VMF	BSW V5.2	VMF/CHENHER	Yes	Yes	IERS20102
COE	BSW V5.3	VMF/CHENHER	Yes	Yes/ONE	IERS20103

0DE200, JGM3, IERS2000.SUB, IAU2000.NUT, old BLQ, red. GLO AR SNGDIF bonus, MAUPRP auto
1DE405, JGM3, IERS2000.SUB, IAU2000.NUT, old BLQ, red. GLO AR HOI SPs, ISTPs
2DE405, EGM2008_SMALL, IERS2010XY.SUB, IAU2000R06.NUT, updated BLQ, GPS QCPB*, CMC/ATL, red. GLO AR, MAUPRP iono
3DE405, EGM2008_SMALL, IERS2010XY.SUB, IAU2000R06.NUT, updated BLQ, GPS QCPB, CMC/ATL, MW & full GLO AR, MAURPR iono

EUREF Subnetwork as Considered at swisstopo's PNAC

Data of 51 stations processed for day 063, 2013 (week 1730):

Impact of SW/Model Updates/Changes as Summarized for North, East, Up, Total RMS (mm), Scale (ppm) (Based on 7-Parameter Helmert Transformations):

```
BSW50-BSW52 (as close as possible):
P1_ O-N:   0.08  0.09  0.15  0.11  -0.00099   P1_ = Preliminary, ambiguity-float GNSS solution
F1_ O-N:   0.16  0.10  0.14  0.14  -0.00098   F1_ = Final, ambiguity-fixed GNSS solution
F1A O-N:   0.08  0.09  0.12  0.10  -0.00096   F1A = Final, ambiguity-fixed GPS-only solution

IERS2000-IERS2010 and other minor updates:
F1_ N-A:   0.09  0.30  0.50  0.34  -0.00035

Troposphere/gradients:
F1_ A-B:   0.15  0.16  0.65  0.40  -0.00098

GLONASS PCV:
F1_ B-C:   0.21  0.17  1.42  0.85  -0.00014
F1A B-C:   0.00  0.00  0.00  0.00   0.00000

Higher-order ionosphere (deactivated at NEQ level):
F1_ C-D:   0.00  0.00  0.00  0.00   0.00000

Higher-order ionosphere:
F1_ D-L:   0.05  0.02  0.02  0.03   0.00013

Overall impact of all BSW52 model updates:
P1_ N-L:   0.27  0.24  1.98  1.18  -0.00194
F1_ N-L:   0.24  0.37  1.75  1.06  -0.00134

BSW50-BSW52 (latest models):
P1_ O-L:   0.26  0.27  2.01  1.20  -0.00292
F1_ O-L:   0.30  0.37  1.76  1.07  -0.00233
```

Impact of SW/Model Updates/Changes as Summarized for North, East, Up, Total RMS (mm), Scale (ppm) (Based on 7-Parameter Helmert Transformations) (cont.):

```
BSW50(Old)-BSW52(VMF):
F1_ O-V:   0.37  0.42  2.76  1.65  -0.00265
F1A O-V:   0.32  0.36  2.20  1.32  -0.00252

BSW52(New)-BSW52(VMF):
F1_ N-V:   0.37  0.42  2.72  1.63  -0.00167
F1A N-V:   0.30  0.34  2.18  1.30  -0.00157

BSW52(Last)-BSW52(VMF): From GMF to VMF:
F1_ L-V:   0.17  0.18  1.67  0.99  -0.00032
F1A L-V:   0.16  0.17  1.60  0.95  -0.00033
```

“1ppb” Issue

BSW50-BSW52, with Shapiro, with Hardisp:
F1A O-N: 0.08 0.08 0.09 0.08 -0.00090

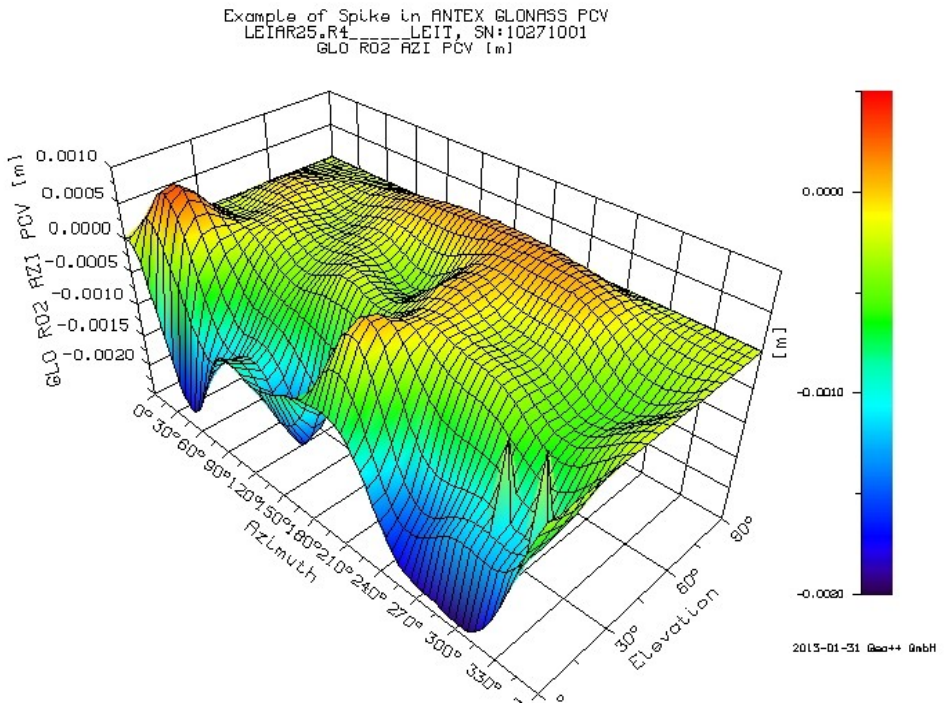
BSW50-BSW52, with Shapiro, without Hardisp:
F1A O-N: 0.08 0.08 0.09 0.08 -0.00089

BSW50-BSW52, without Shapiro, without Hardisp:
F1A O-N: 0.08 0.08 0.08 0.08 +0.00004

Many thanks to R. Dach (AIUB) for doing the corresponding test analyses (at swisstopo).

Remark on “Spikes Removed From GLONASS PCV Calibrations”

- “Spikes” removed in IGS GNSS (GLONASS) PCV model with update from IGS08_1731 to IGS08_1734 (nominally to be considered as of 31 March 2013)
- See also: www.geopp.de >The company >News:



Remark on “Spikes Removed From GLONASS PCV Calibrations” (cont.)

IGSFINAL/STA/F1_13090.CRD: GNSS

		RMS / COMPONENT		**0.00**	**0.00**	**0.01**		
		MEAN		**0.00**	**0.00**	**0.00**		
		MIN		**-0.01**	**-0.01**	**-0.02**		
		MAX		**0.02**	**0.01**	**0.02**		

EPNFINAL/STA/F1_13069.CRD: GNSS

		RMS / COMPONENT		**0.00**	**0.00**	**0.00**		
		MEAN		**-0.00**	**-0.00**	**0.00**		
		MIN		**-0.01**	**-0.01**	**-0.01**		
		MAX		**0.01**	**0.01**	**0.01**		

EPNFINAL/STA/F1A13069.CRD: GPS-only

		RMS / COMPONENT		0.00	0.00	0.00		
		MEAN		0.00	0.00	0.00		
		MIN		0.00	0.00	0.00		
		MAX		0.00	0.00	0.00		

EPNFINAL/STA/F1B13069.CRD: GLONASS-only

		RMS / COMPONENT		**0.01**	**0.01**	**0.01**		
		MEAN		**-0.00**	**-0.00**	**0.00**		
		MIN		**-0.01**	**-0.03**	**-0.03**		
		MAX		**0.01**	**0.02**	**0.03**		

Given North/East/Up values are expressed in units of mm.

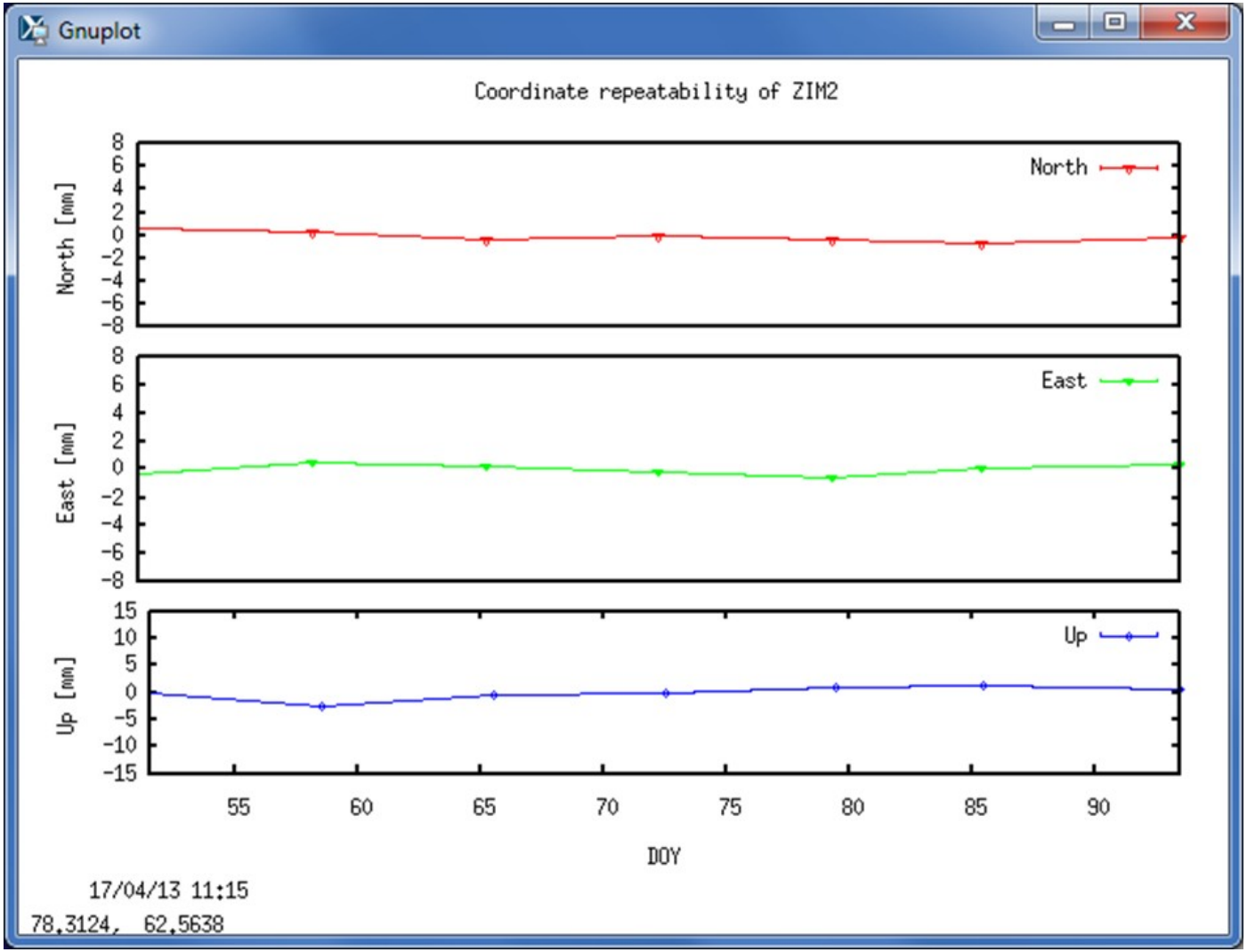
CPU Time Consumption

- GPSEST (just an issue with the Lahey compiler used at PNAC):
  - Considerably increased CPU time consumption for GPSEST
    - turned out to be in subroutines VECTRP, PRITRP, PRIEST
    - correction in subroutine TRPVEC:
      `REAL*8 XXX(*),ANOR(*)  REAL*8 XXX(:),ANOR(:)`
  - EUREF:
    - CPU time reduction from 8.5 to 4 min (approx. 2x)
  - AGNES:
    - CPU time reduction from 150 to 35 min (approx. 4-5x)
- ADDNEQ2:
  - MULTI_A (PNAC's multi-year solution using ADDNEQ2):
    - CPU time reduction from 4500 to 400 sec (9% or 11x)
    - specific option to be changed: HELMERT HLM_ALL
    - BSW52 results are *consistent* with BSW50 results
- Helpful BPE processing summary concerning CPU time consumption (see: BPE/EUREF.OUT,).

Summary and Conclusions

- The impact of various model updates could be demonstrated (gradually).
- The detailed study comparing the BSW V5.0/V5.2 results revealed a few problems (e.g. RXOBV3, ATX2PCV).
- First BSW V5.2 EUREF results (for GPS week 1731) could be submitted on 16 April 2013 by PNAC (addressed as “LPT”).
- Switching progress delayed due to two issues:
  - ATX2PCV
  - “1ppb”--finally attributed to the correction of the Shapiro effect
- Updated version of ATX2PCV may be expected soon (at least a first version covering commonly used advanced applications).

EUREF: 3 Weeks (BSW50) / 4 Weeks (BSW52)



Next Steps and Outlook

- Update accordingly: AMET, AGNES, AUTOCAMP, PPP.
- Further develop a refined, “repro”-capable RNX2SNX V5.2 BPE procedure for:
  - AGNES/EUREF reprocessing planned for 2013
  - eventual replacement of current BPE procedures
- Key words: Melbourne-Wübbena AR, full GLONASS AR, new GNSS observation selection (OBS.SEL) and proper handling of potential GPS quarter-cycle phase biases, VMF/APL, “SNX_LOOP”, “FIX_CHK”, improved RESRMS/RESCHK.

Scale With Respect to EUREF Combined Solution