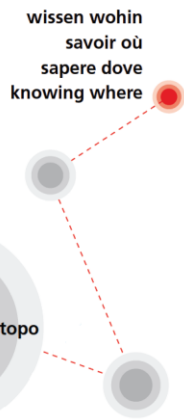Schweizerische Eidgenossenschaft
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Update of EUREF GNSS Analysis to Bernese SW V5.2: New Features and Impact on Results

S. Schaer, D. Ineichen, E. Brockmann

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.

- 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, "inter-system translation parameters" (GPSEST/ADDNEQ2), etc.

BSW V5.0(+) to BSW V5.2: Approach

Two step approach:

Step 1: BSW V5.0(+) to BSW V5.2 with options as close as possible to "old" processing with BSW V5.0

Step 2: Activation of new options, among others:

- Troposphere: GMF/GPT, Chen-Herring for gradients
- Receiver antenna calibration (PCV) values for GLONASS
- IERS2010 conventions
- Higher-order ionosphere
- Moderate handling of potential GPS quarter-cycle phase biases
- (GPS-GLONASS inter-system translation and troposphere bias parameters set up, but "deleted" for final solution)

Alternative approach:

- Consideration of RNX2SNX BPE V5.2 → <u>EUREF reprocessing</u>

Characteristics of Various EUREF GNSS Analysis Solutions Computed at LPT (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	IERS2000[0]
New (1)	BSW V5.2	NMF/TILTING	No	No/ZERO	IERS2000[1]
A (2A)	BSW V5.2	NMF/TILTING	No	No	IERS2010[2]
B (2B)	BSW V5.2	GMF/GPT/CHENHER	No	No	IERS2010[2]
C (2C)	BSW V5.2	GMF/GPT/CHENHER	Yes	No	IERS2010[2]
D (2D)	BSW V5.2	GMF/GPT/CHENHER	Yes	No/ZERO	IERS2010[2]
Last (2)	BSW V5.2	GMF/GPT/CHENHER	Yes	Yes/ONE	IERS2010[2]
VMF	BSW V5.2	VMF/ECMWF/CHENHER	Yes	Yes	IERS2010[2]
COE	BSW V5.3	VMF/ECMWF/CHENHER	Yes	Yes/ONE	IERS2010[3]

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

EUREF Subnetwork as Considered at swisstopo (LPT)

@ epncb
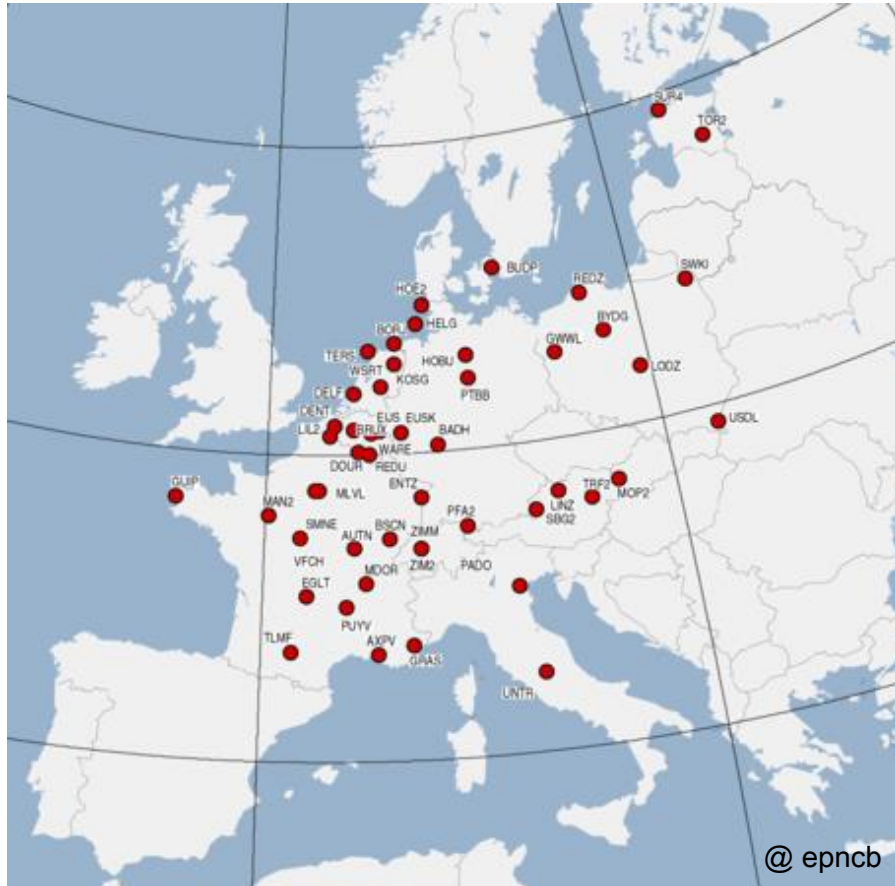
- 52 stations (from France to Estonia)

- Development of GNSS (GPS&GLONASS):

  2008:   8 stations
  2013: 42 stations (80%)

- GNSS as well as GPS-only solutions computed (GNSS solution submitted to EUREF)

- Data sample used for comparison/validation purposes: GPS week 1730 (specifically day 063 of 2013, consisting of 51 station)

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
```
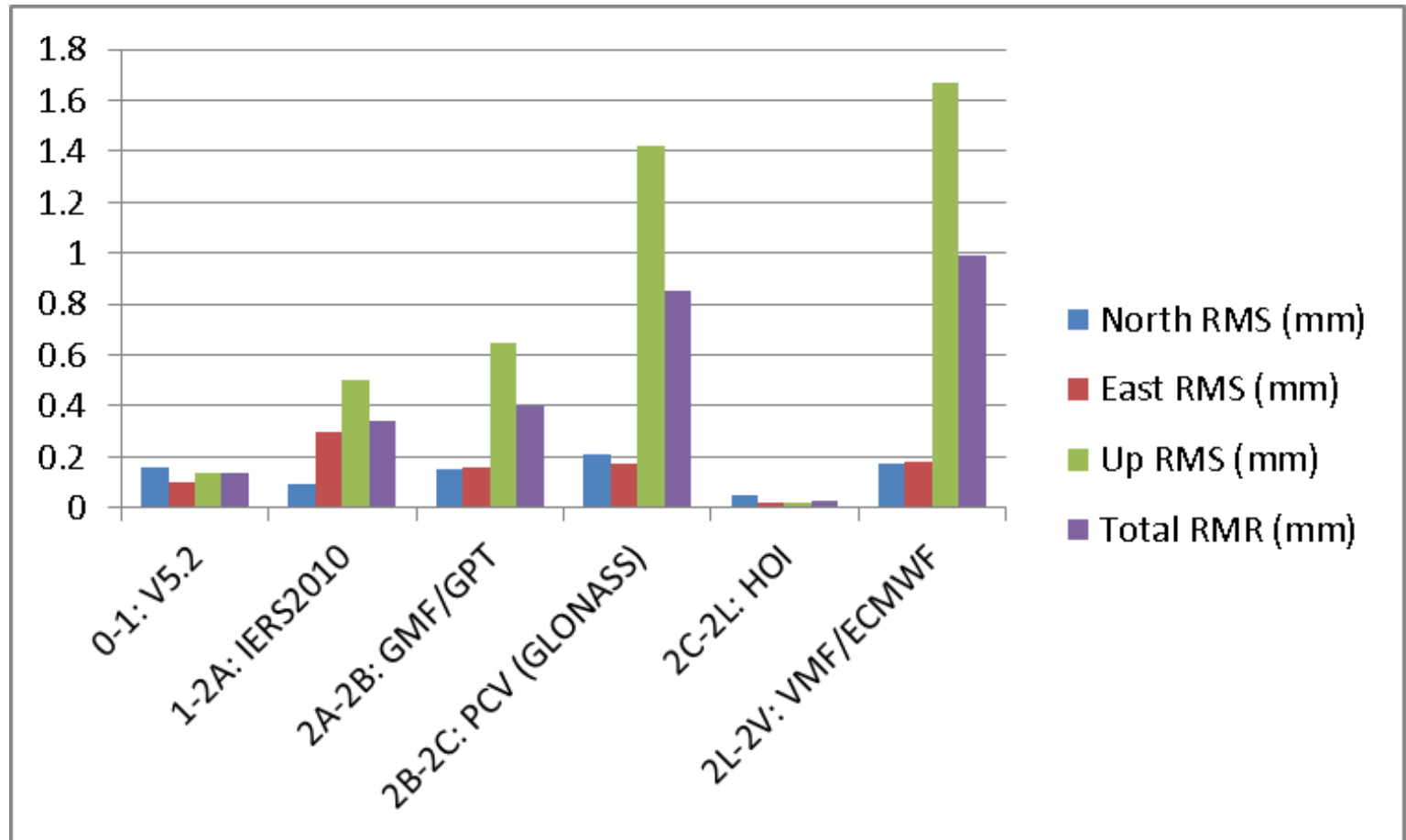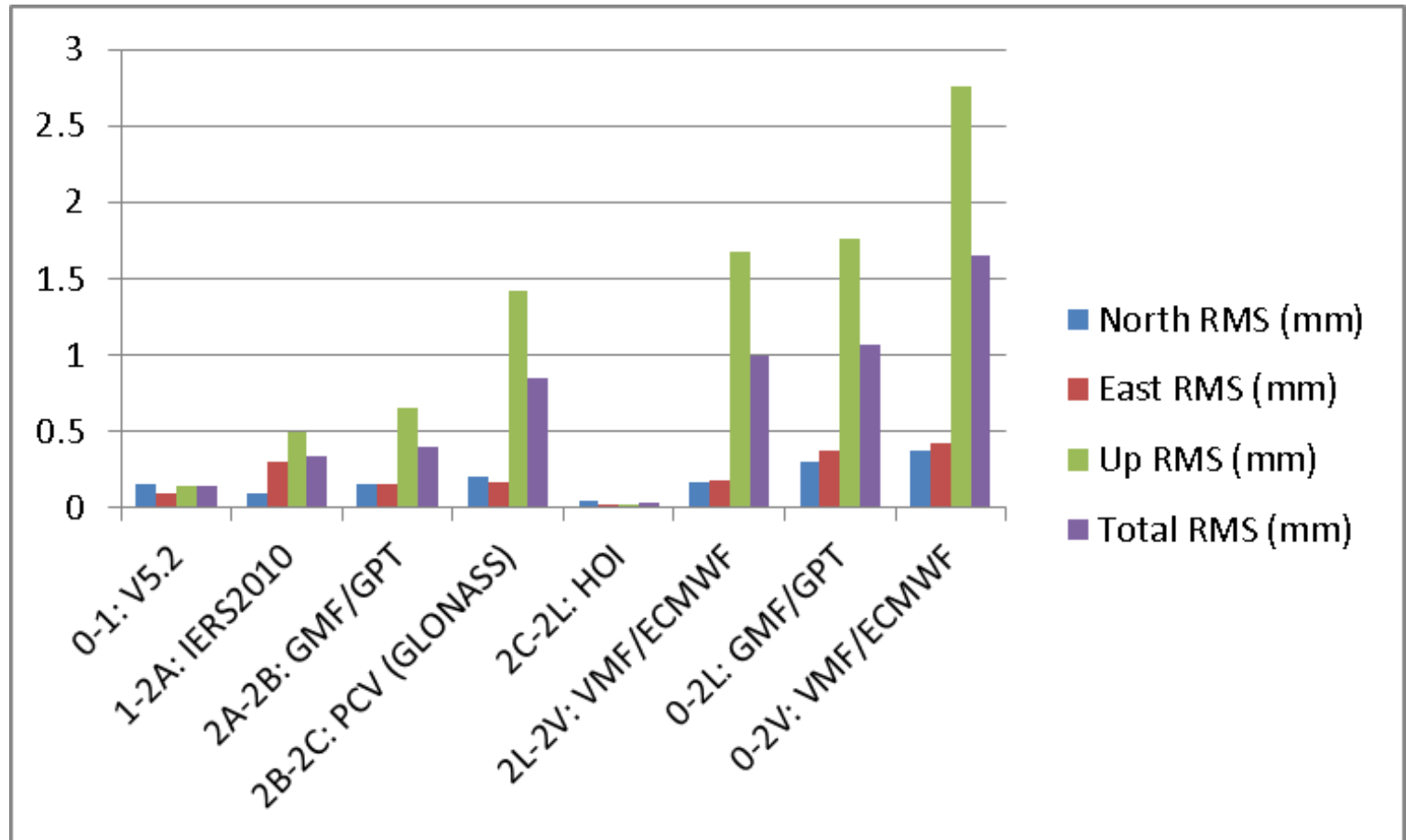
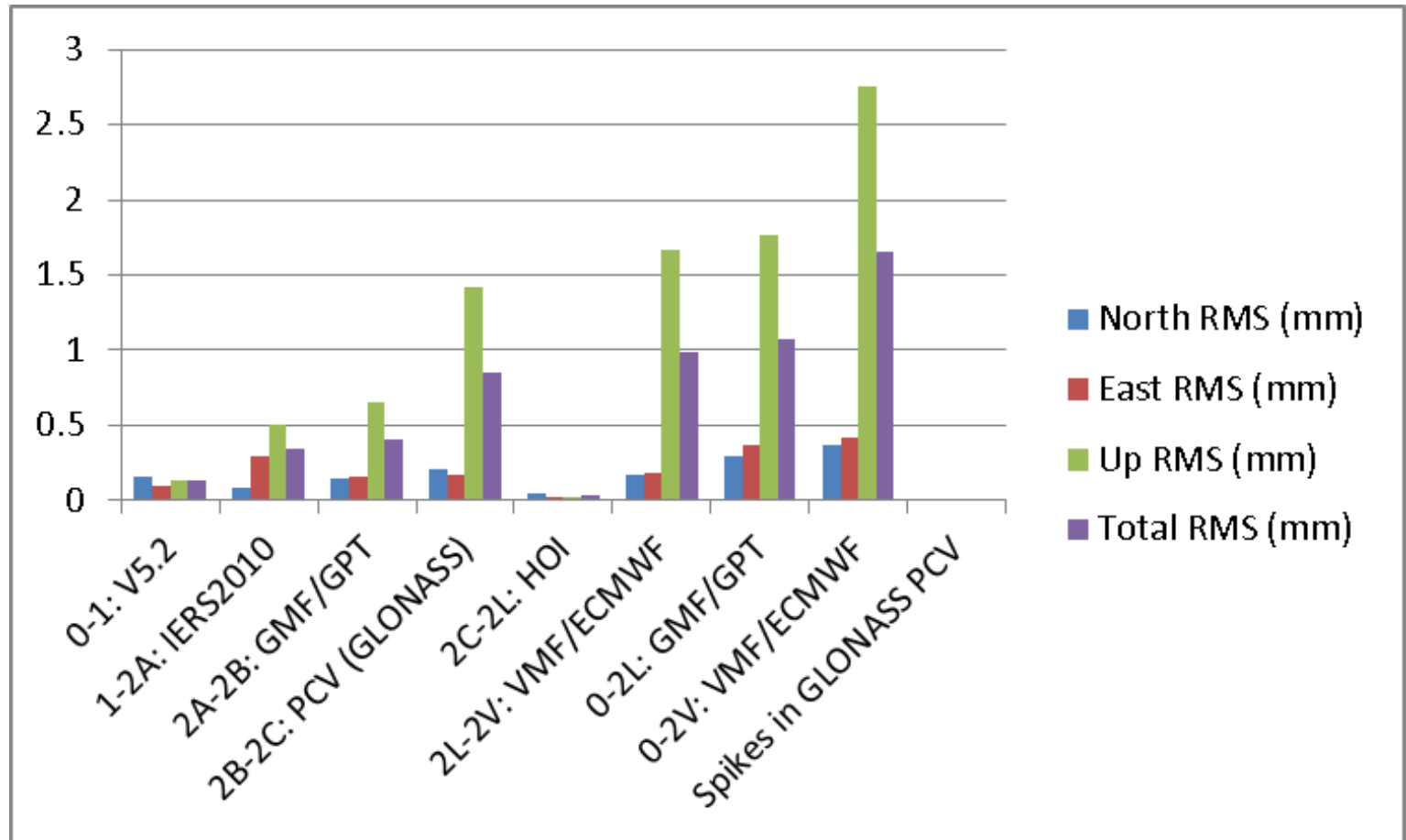# Station Coordinate RMS Differences for Various SW/Model Update Steps (1)

# Station Coordinate RMS Differences for Various SW/Model Update Steps (2)

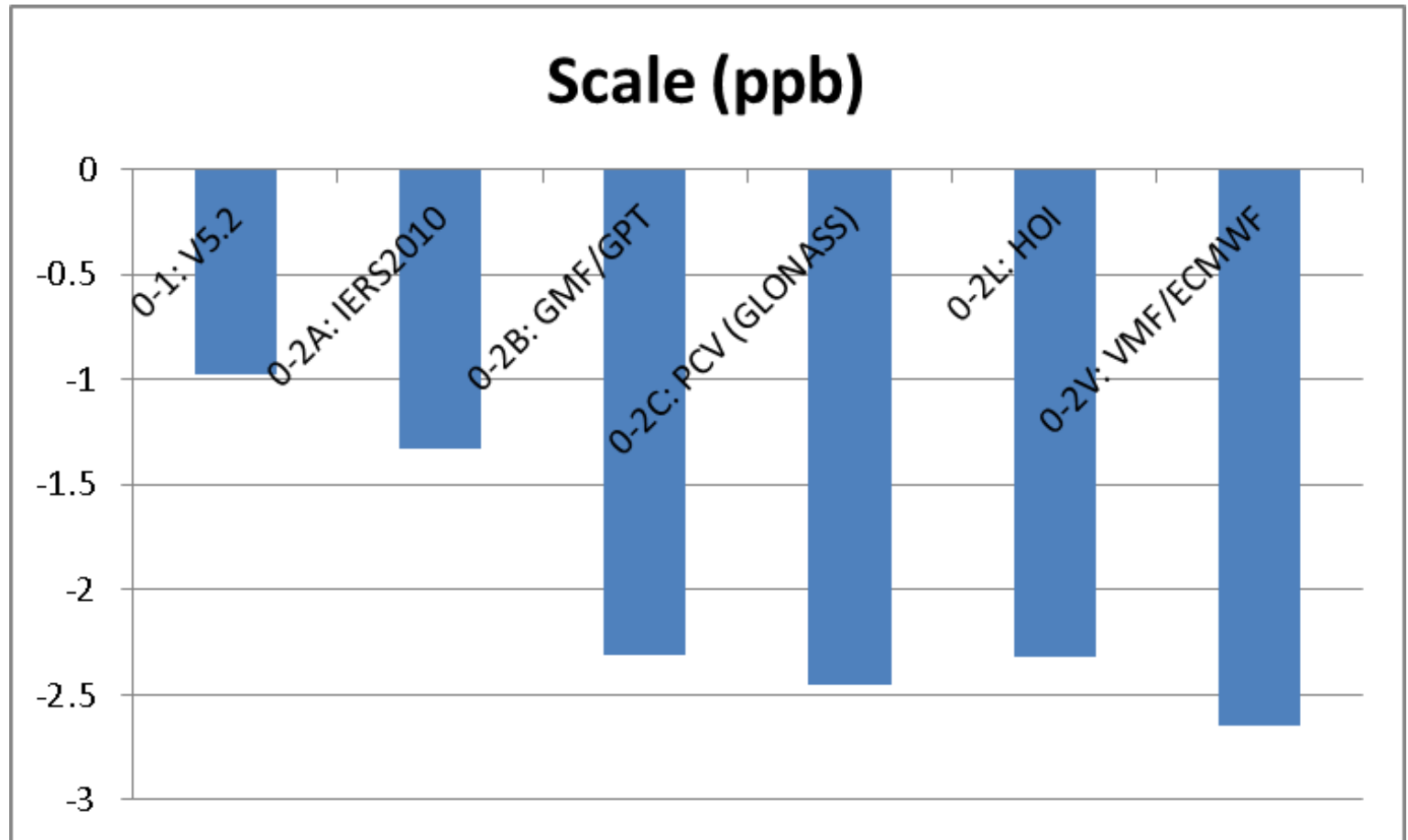# Station Coordinate RMS Differences for Various SW/Model Update Steps (3)

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:

Example of Spike in ANTEX GLONASS PCV
LEIAR25.R4_____LEIT, SN:10271001
GLO R02 AZI PCV [m]
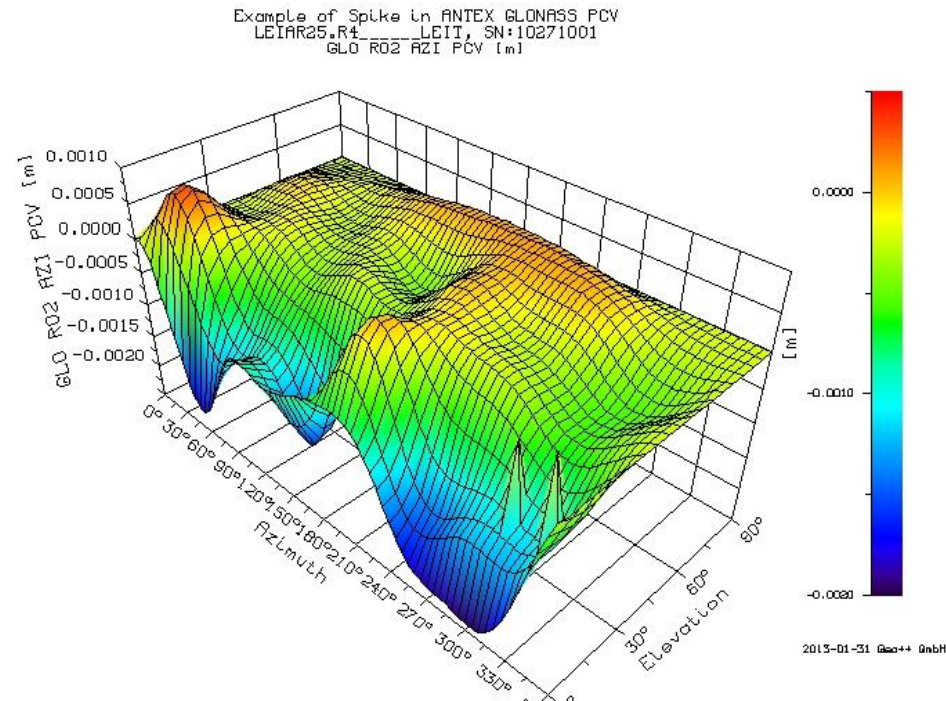
Impact on Network Scale for Various SW/Model Update Steps

"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).

Computation of Multi-Year Solution Using ADDNEQ2 and CPU Time Consumption

- 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
- 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(:)
      ```
  - CPU time reduction:
    - EUREF: from 8.5 to 4 min (approx. 2x)
    - AGNES: from 150 to 35 min (approx. 4-5x)
- Helpful BPE processing summary concerning CPU time consumption (see: BPE/EUREF.OUT).

Summary and Conclusions

- The impact of various model updates could be demonstrated (step by step).

- The detailed study comparing the BSW V5.0/V5.2 results revealed a few problems (e.g. RXOBV3, ATX2PCV).

- High consistency between BSW V5.0 and V5.2 results.
    - "1ppb"--finally attributed to the correction of the Shapiro effect

- Scale difference of -2.3 ppb (Shapiro, IERS2010, GMF/GPT) and station coordinate differences (up to 2 mm horizontally and 5 mm vertically) when using new BSW V5.2 options.

- Mean troposphere difference of 1.9 mm when using new BSW V5.2 options (-0.1 mm in case of options close to BSW V5.0)

- LPT contributions to EUREF since GPS week 1731 are computed using BSW V5.2.

- Other network analysis (AGNES, NRT processing) has to be switched in next weeks.

- Updated version of ATX2PCV V5.2 (successor of PHCCNV V5.0) may be expected by the end of June 2013.

Scale With Respect to EUREF Combined Solution

Scale w.r.t Combined solution [ppb]