Bundesamt für
Kartographie und Geodäsie

New Developments in EPN Analysis

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Overview

- Bernese 5.0 for sub-network combination
- Bernese 5.0 for LACs
- Combination of daily sub-network solutions
- Benefit of GLONASS observations in the EPN analysis
- ITRF2004 and ITRF2004 regional densification
- Re-processing of the EPN on the NEQ-level

Bernese 5.0 for Sub-Network Combination

- Since the beginning of 2005 the ADDNEQ2 program of the Bernese GPS Software Version 5.0 has been used for the sub-network combination.
  - Station coordinates are introduced as observations and the original number of phase observations are no longer used.
  - „Minimum constraint conditions“ are applied to reference stations. The datum in general remains unchanged.
  - A-priori constraint matrix will be regularized before writing SINEX format.
- No significant changes of the station coordinates, beside the reference stations.

Sub-Network Combination

Response to ADDNEQ2 Combination

Sub-Network Combination

- Zinovy Malkin, Institute of Applied Astronomy RAS, St. Petersburg
  - Variance factor of combined solutions increased from 0.002 to about 60.
  - Temporary solution: 8 mm instead of 1 mm a-priori sigma
- Carine Bruyninx
  - Combination of new SINEX files failed with CATREF software
- Alessandro Caporali, UPA
  - Wrong solution epoch in some blocks of new SINEX
  - ➡ Will not affect the new solution (Stefan Schaer)
- Stefan Schaer, AIUB, Berne
  - Combination of new SINEX files with Bernese Software version 5.0 failed.
- Marek Lehmann and Leszek Jaworski, Astrogeodynamical Observatory Borowiec
  - A change in the coordinates of BOR1 was noticed.
  - This is an expected result, because BOR1 is a reference station.

➡The introduction of coordinates as observations requires modifications of the ADDNEQ2 program that is not yet implemented.

Comparison Version 4.2 versus 5.0 (week 1302)

Sub-Network Combination

- Helmert transformation of station coordinates in ITRF2000:
  (Reference stations marked)

```
NUMBER OF PARAMETERS  :      7
NUMBER OF COORDINATES :    405
RMS OF TRANSFORMATION :      0.5 MM
PARAMETERS:
TRANSLATION IN  X     :            0.3     +-   0.3    MM
TRANSLATION IN  Y     :            5.7     +-   0.3    MM
TRANSLATION IN  Z     :            0.7     +-   0.2    MM
ROTATION AROUND X-AXIS:  -  0   0  0.00008 +-   0.00001 "
ROTATION AROUND Y-AXIS:  -  0   0  0.00004 +-   0.00001 "
ROTATION AROUND Z-AXIS:     0   0  0.00006 +-   0.00001 "
SCALE FACTOR          :            0.0001  +-   0.0000 MM/KM
```

```
  3
405
  0.6 MM

1.7      +-   0.1    MM
2.6      +-   0.1    MM
0.3      +-   0.1    MM
```

- Comparison of station coordinates in ITRF2000:

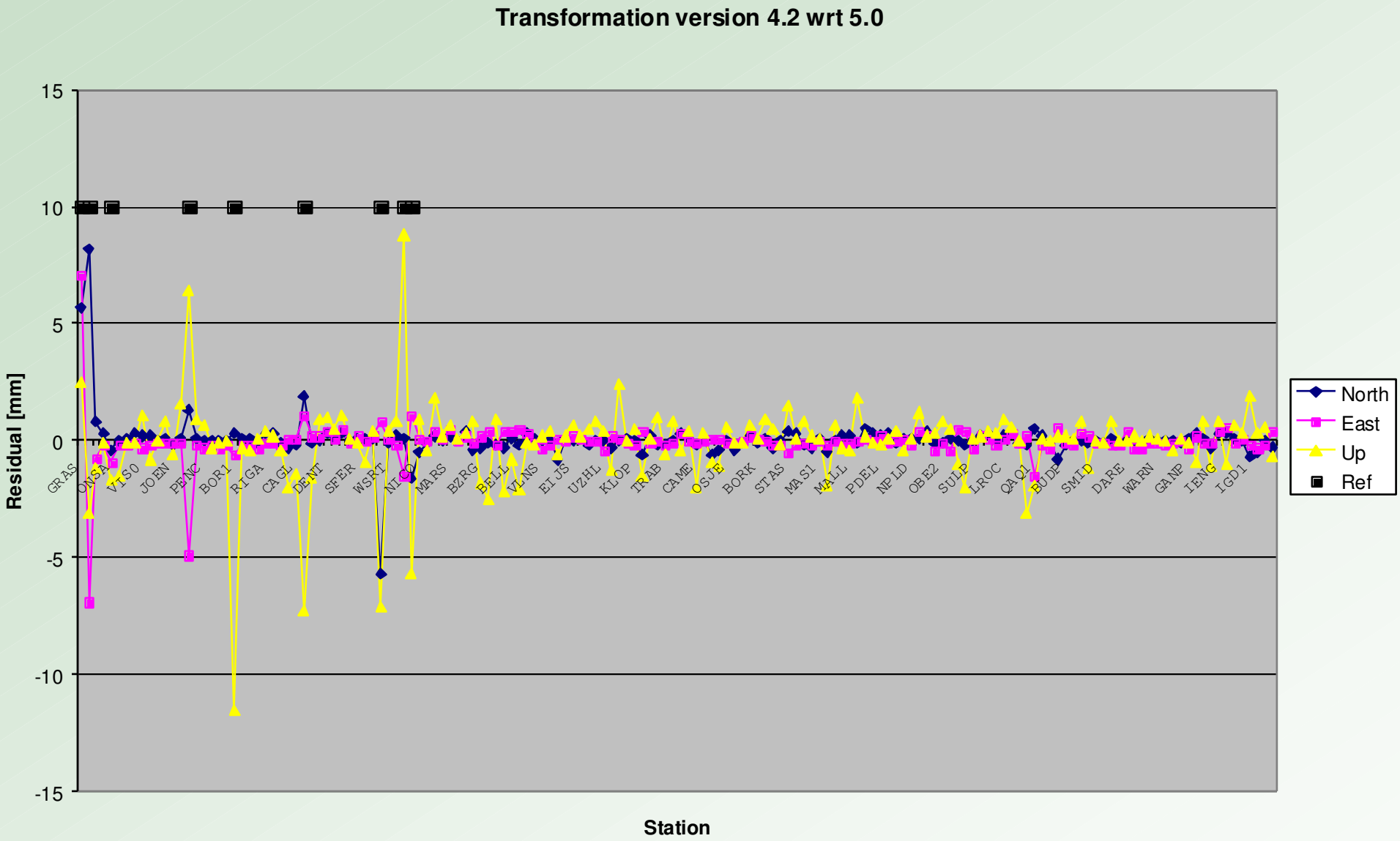
```
RMS OF UNIT WEIGHT FOR COORDINATE COMPARISON :  0.0026 m
```

  Systematic difference for station height, stations from version 5.0 are „higher“.

- Comparison to CATREF software:
  - „Minimum constraint condition“ of Bernese software and CATREF result in station height differences of about 5 mm.
    - ➡ under investigation

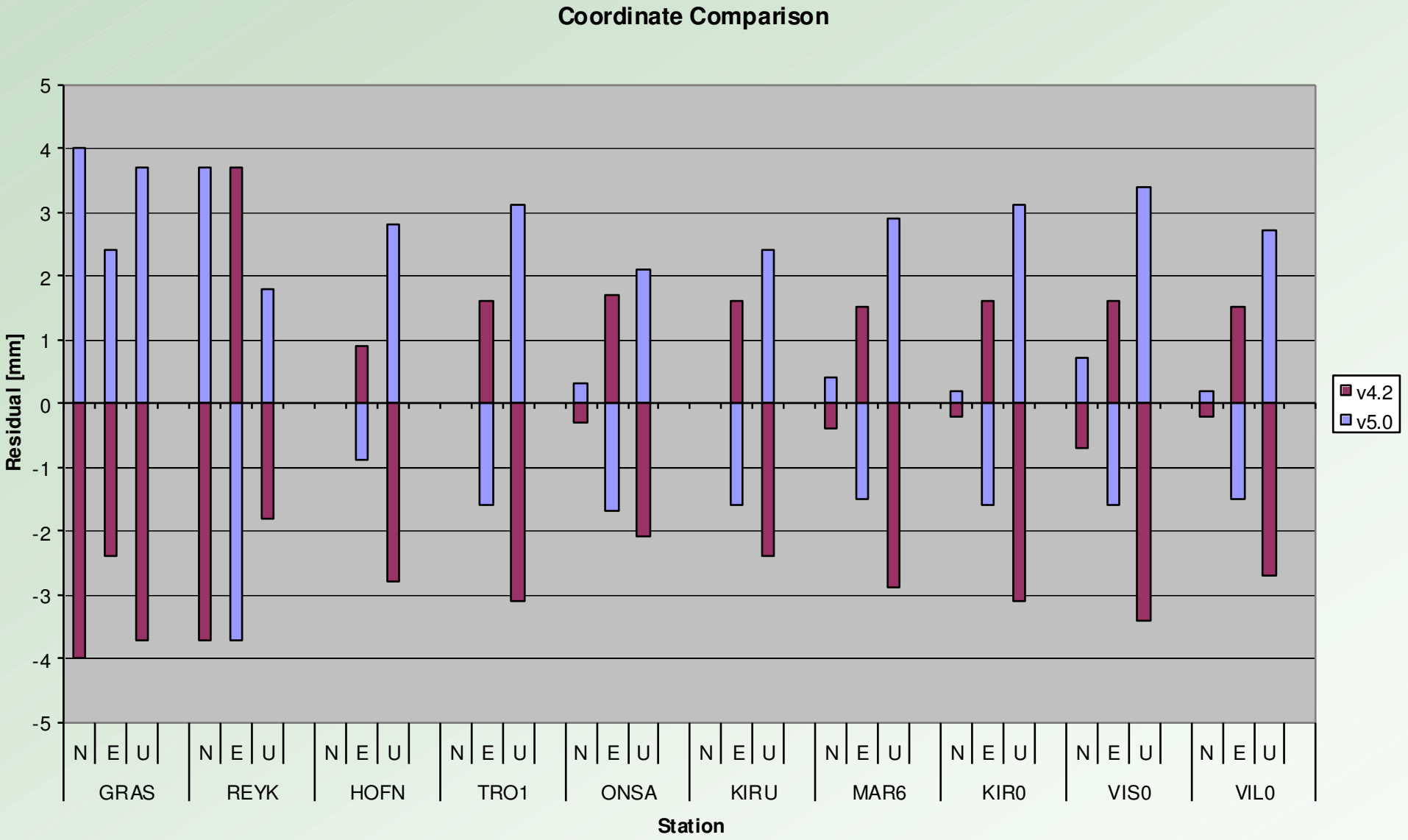
Helmert Transformation, Week 1302

Sub-Network Combination



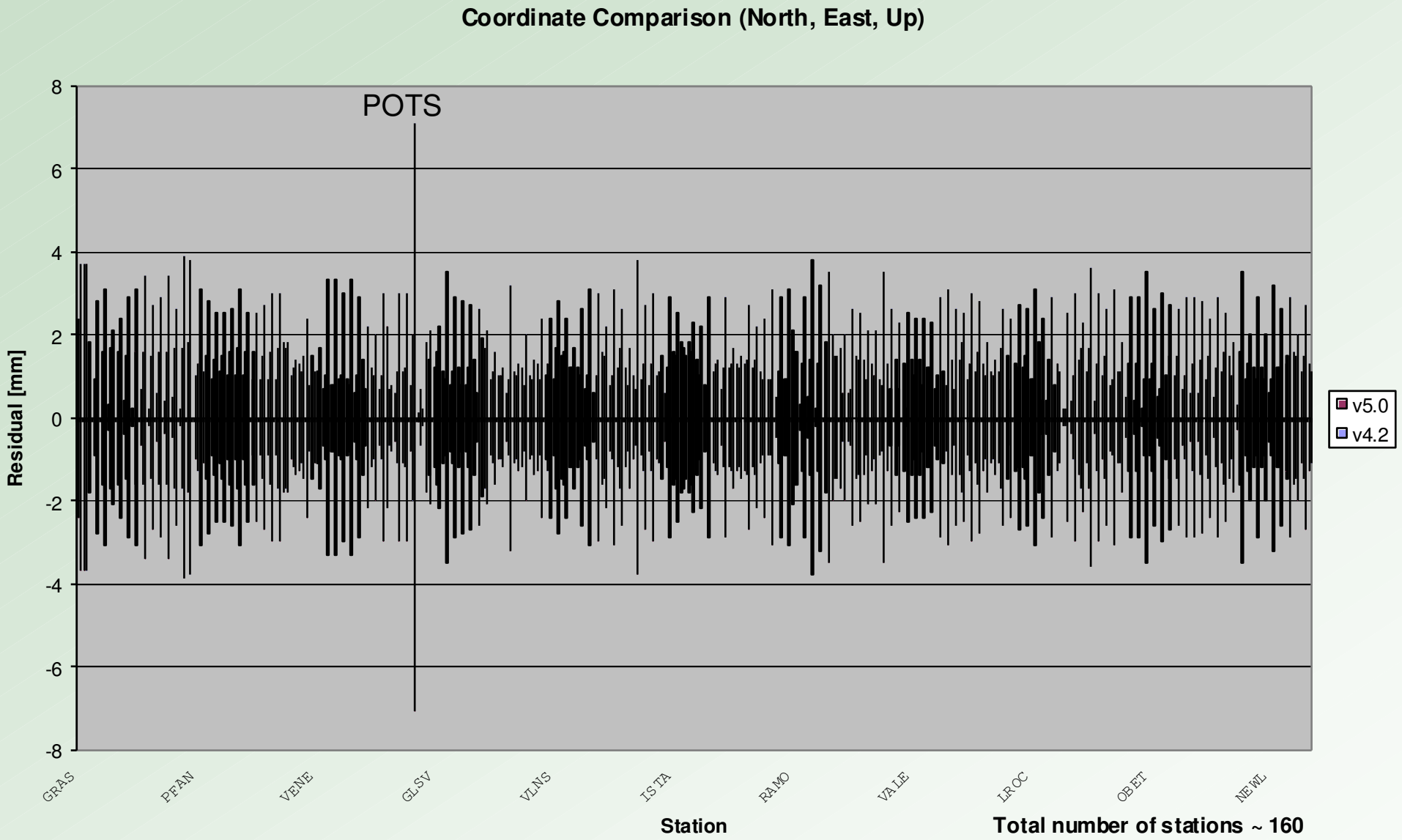
Residuals to Mean Coordinates, Week 1302

Sub-Network Combination



Residuals to Mean Coordinates, Week 1302

Sub-Network Combination

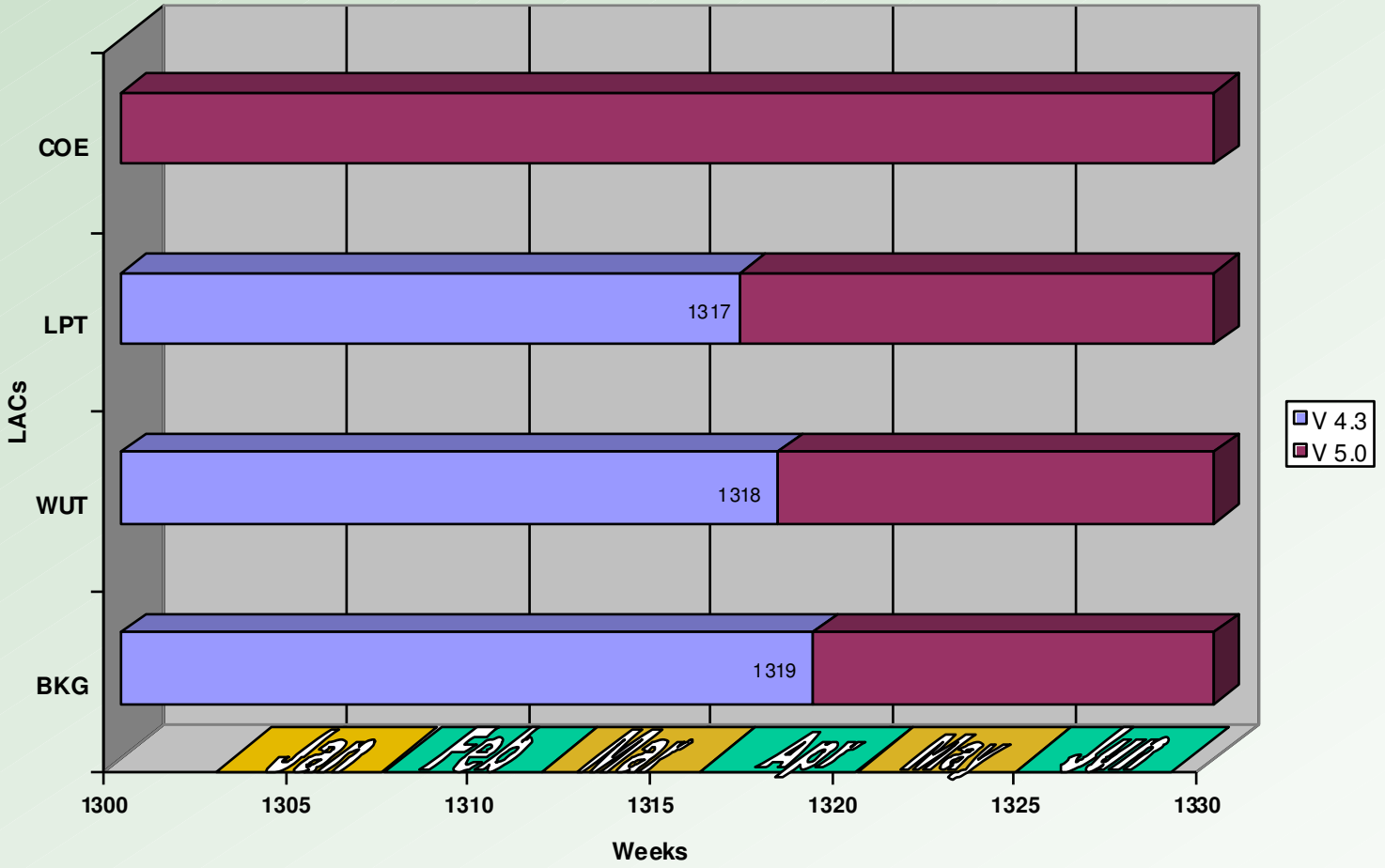


Bernese 5.0 for Sub-Network Analysis

- Procedure:
  - Step 1: Change from version 4.2 to 5.0
  - Step 2: Change of processing options, e.g., estimation of tropospheric gradients
- Recommendations distributed in EPN LAC-Mail No. 0486 in April 2005
  - Date of change is in responsibility of LACs
  - RNX2SNX PCF is used as „default“ with small changes
    - 10° elevation cut off for observations
    - No submission of tropospheric gradients
    - Unified ocean loading coefficients
  - RNX2SNX includes new options for station specific troposphere parameters:
    - Old: no a-priori model, estimation of dry Niell parameters
    - New: dry Niell a-priori model, estimation of wet Niell parameters

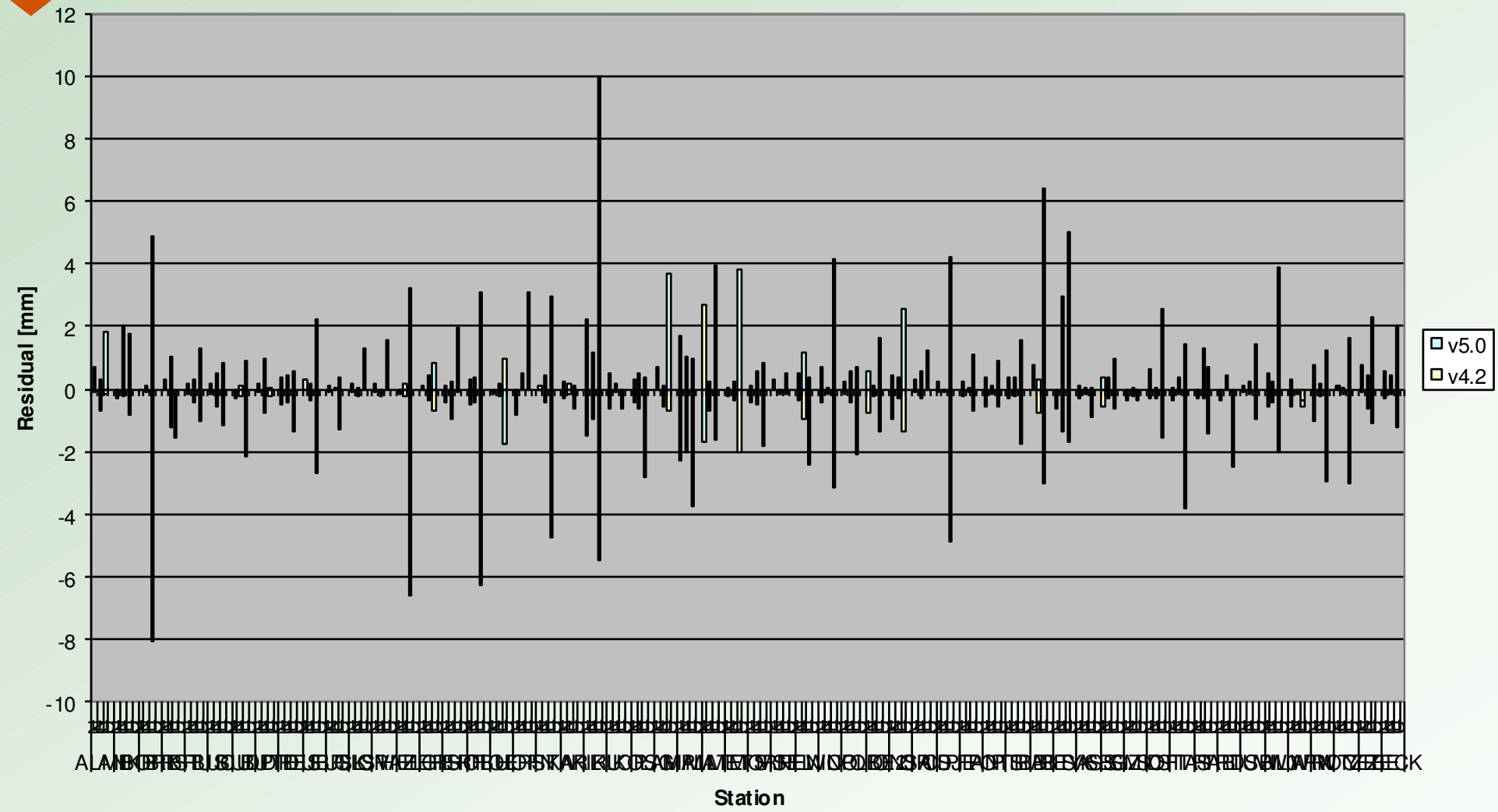
Bernese 5.0 Sub-Network Solutions

- Test Solutions submitted to EPN AC
  - UPA, ROB, WUT, BKG
- Regular Switch to 5.0



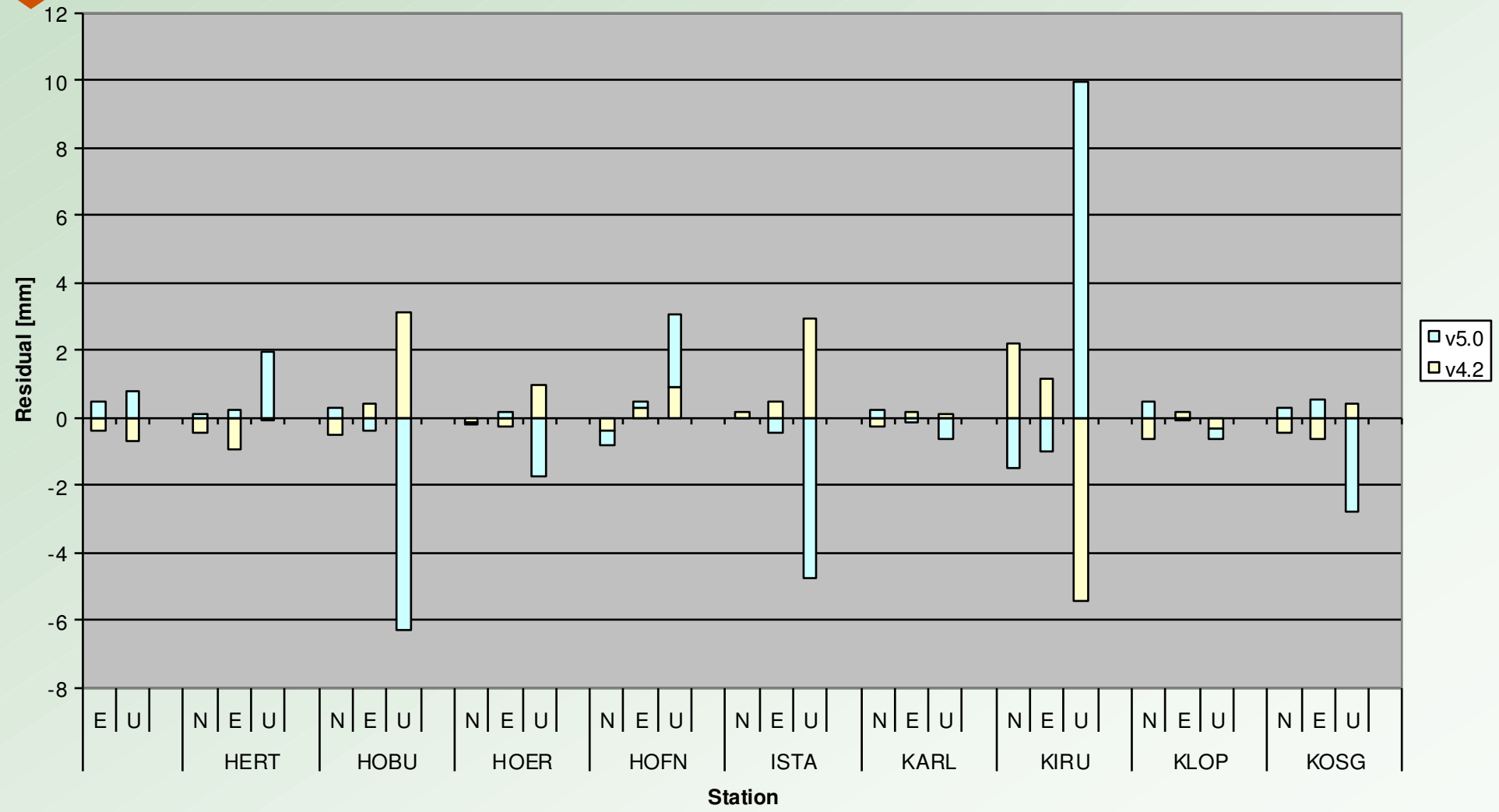
Residuals to Mean Coordinates, Week 1305

Sub-Network Analysis

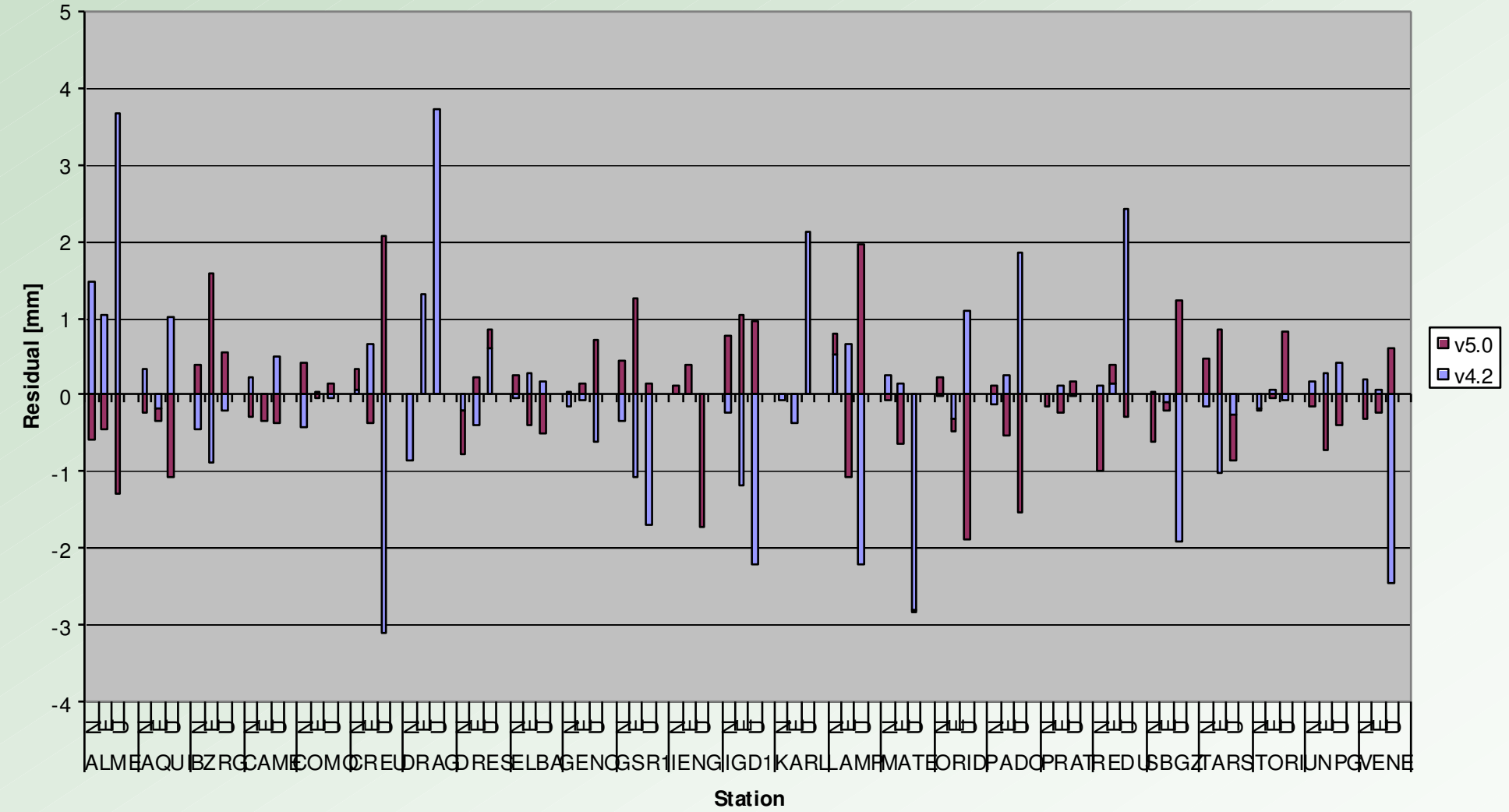


Residuals to Mean Coordinates, Week 1305

Sub-Network Analysis



Residuals to Mean Coordinates, Week 1305



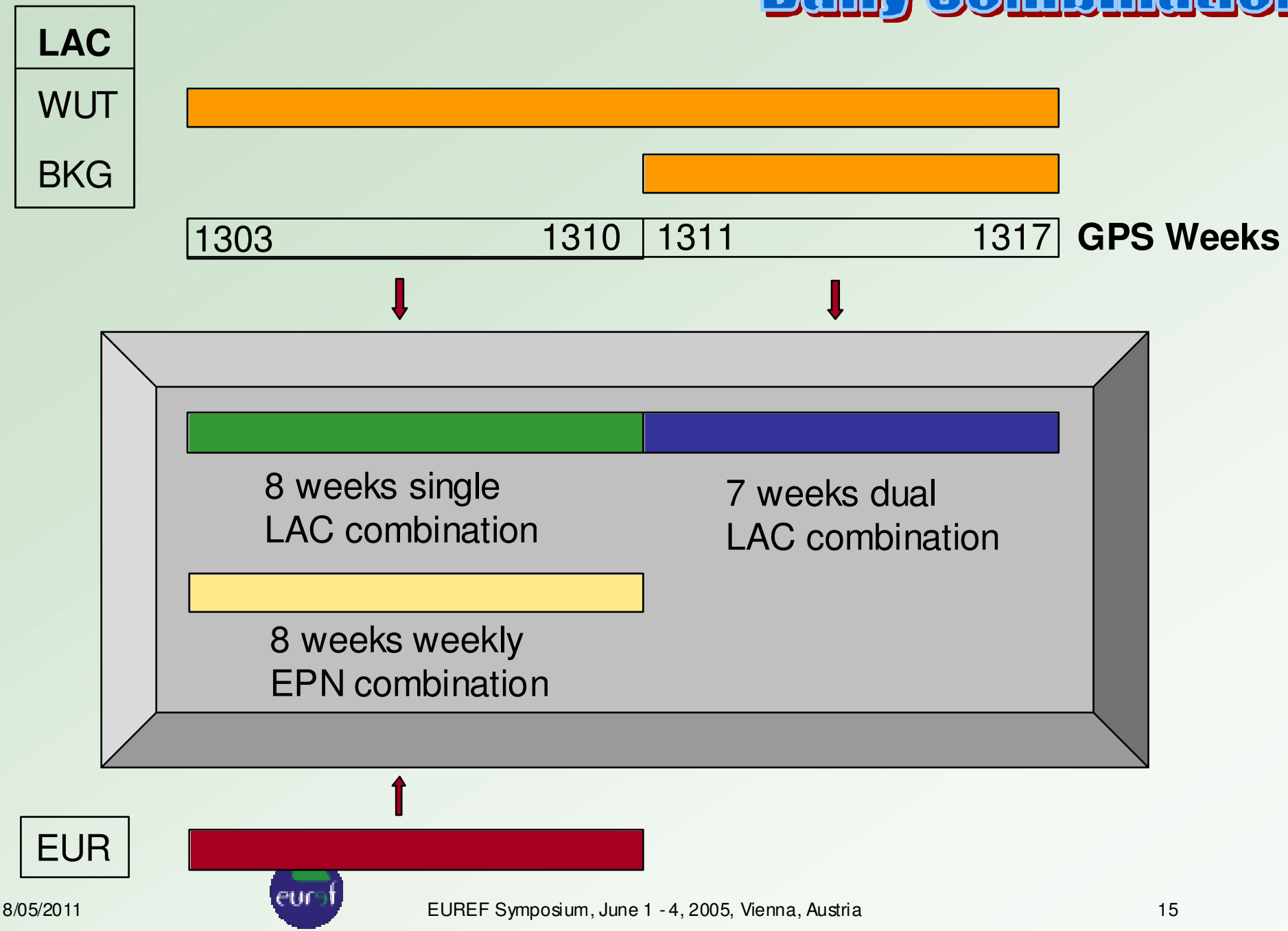
Combination of Daily Sub-network Solutions

Daily Combination

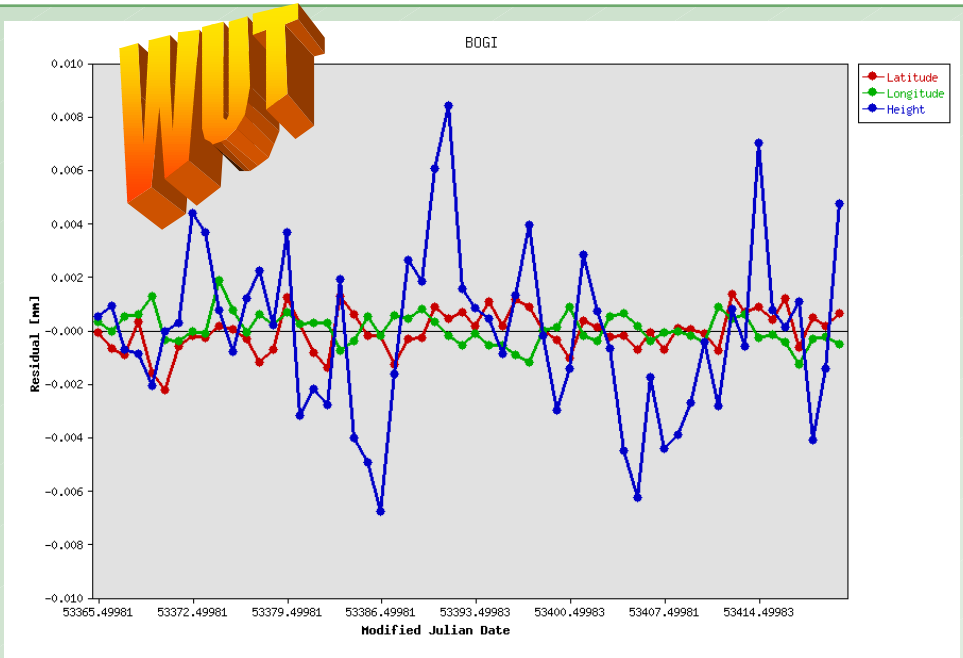
- Scope
  - Combination of daily EPN sub-networks as provided by LACs and generation of a daily combined network solution
- Objective
  - Better visibility of short-term effects on coordinate time series, e.g., atmospheric pressure
  - Support of external projects that apply daily solutions, e.g., European Sea Level Service (ESEAS)
- Questions
  - How do daily sub-network solutions from various LACs fit to each other?
    - Daily LAC1 w.r.t. daily LAC2
  - Are there significant differences between a combined (multi-LACs) daily solution and a single-LAC daily solution?
    - Daily combination w.r.t. daily single LAC
  - How performs the repeatability of combined daily solutions compared to combined weekly solutions?
    - Daily combination w.r.t. weekly combination

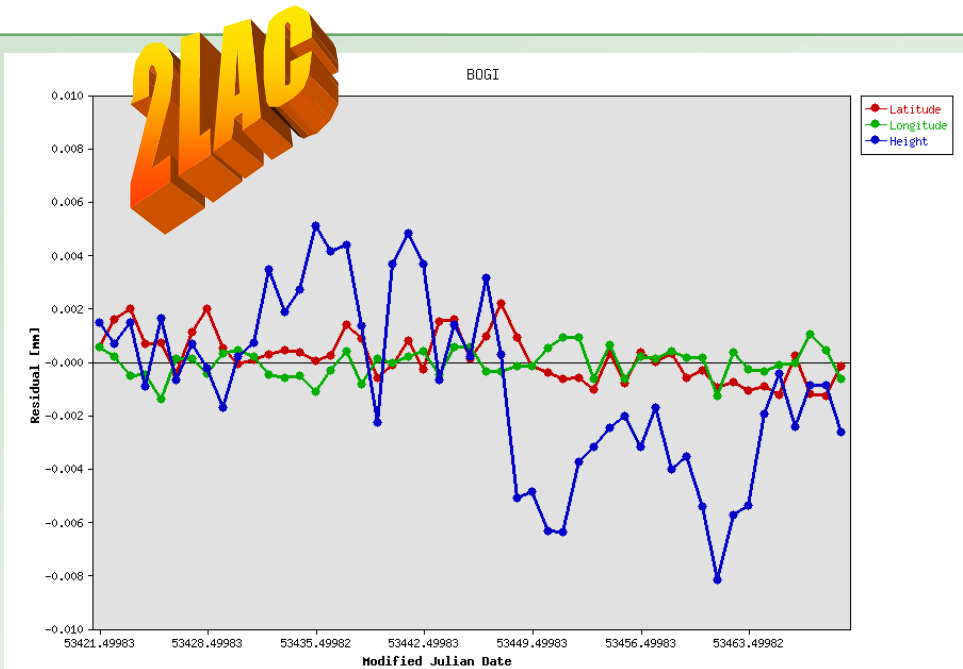
Solutions

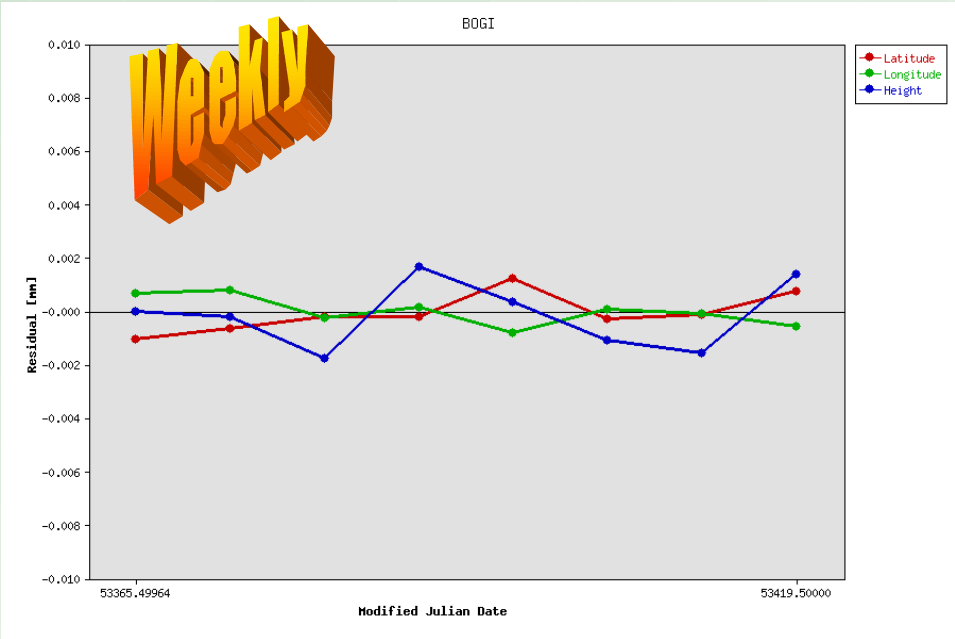
Daily Combination



BOGI



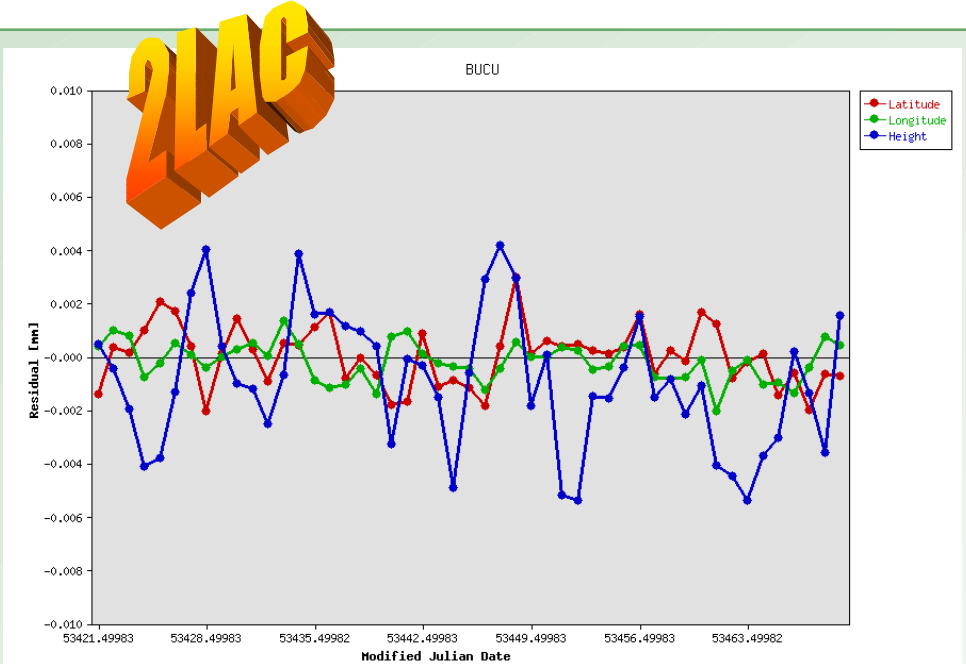


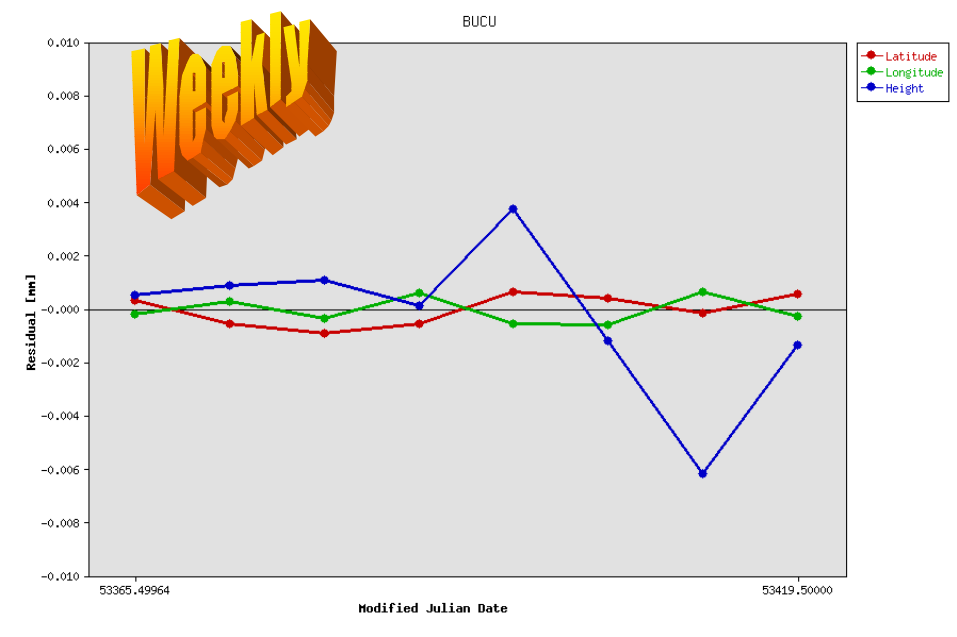


Borowa Gora, Poland

Daily Combination

BUCU

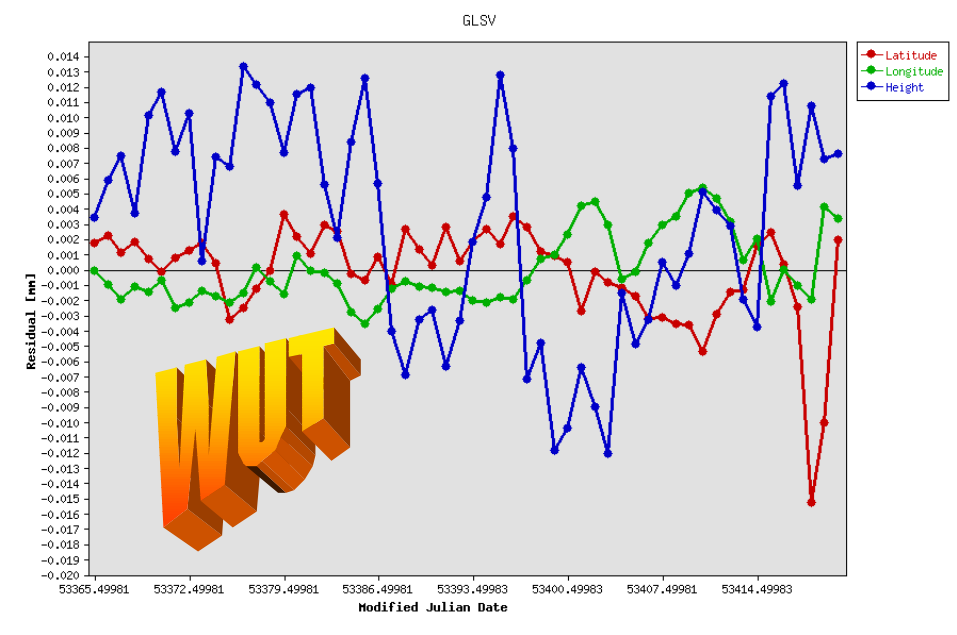


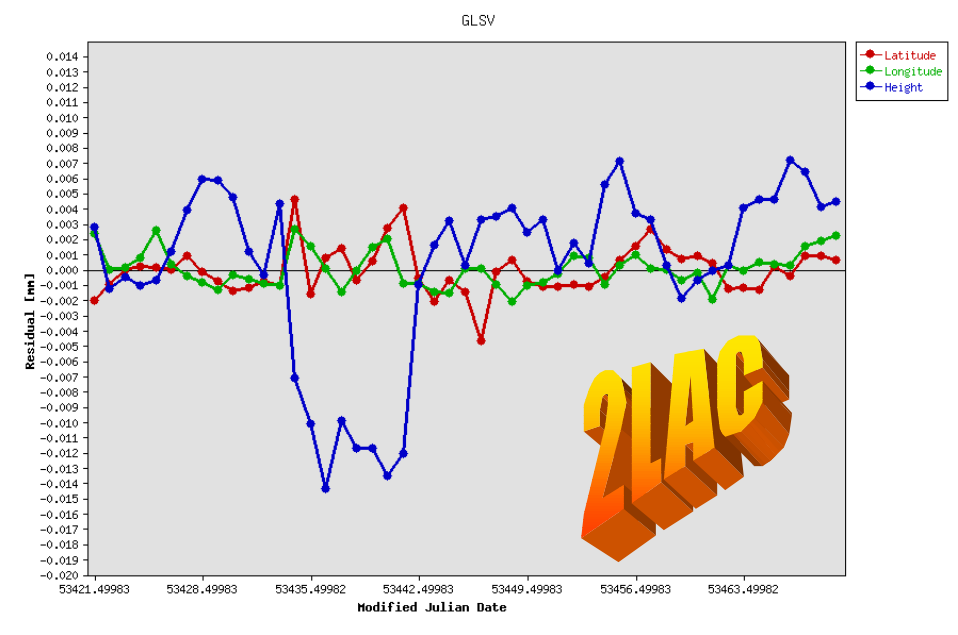


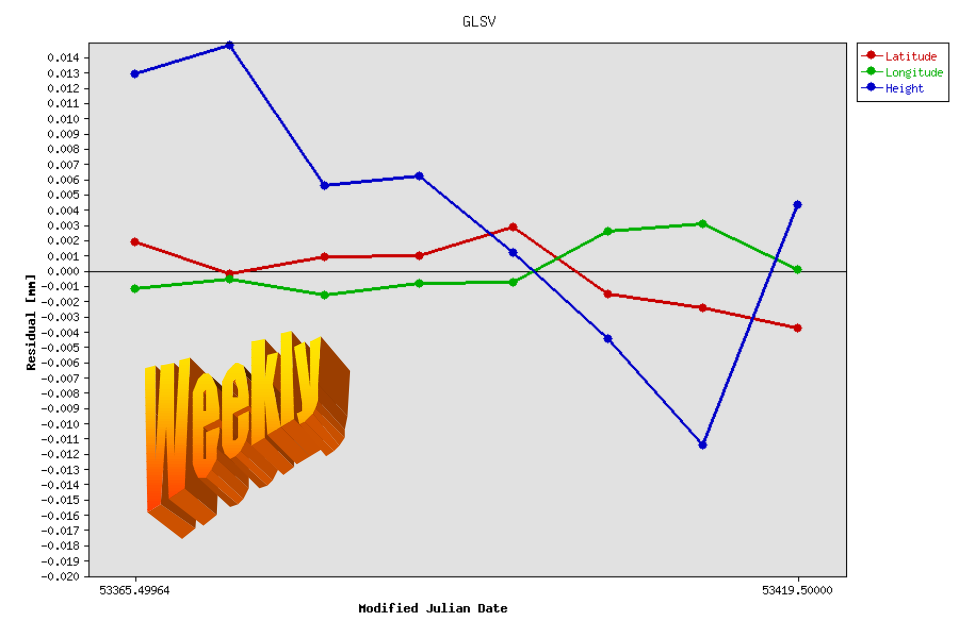
Bucuresti, Romania

Daily Combination

GLSV



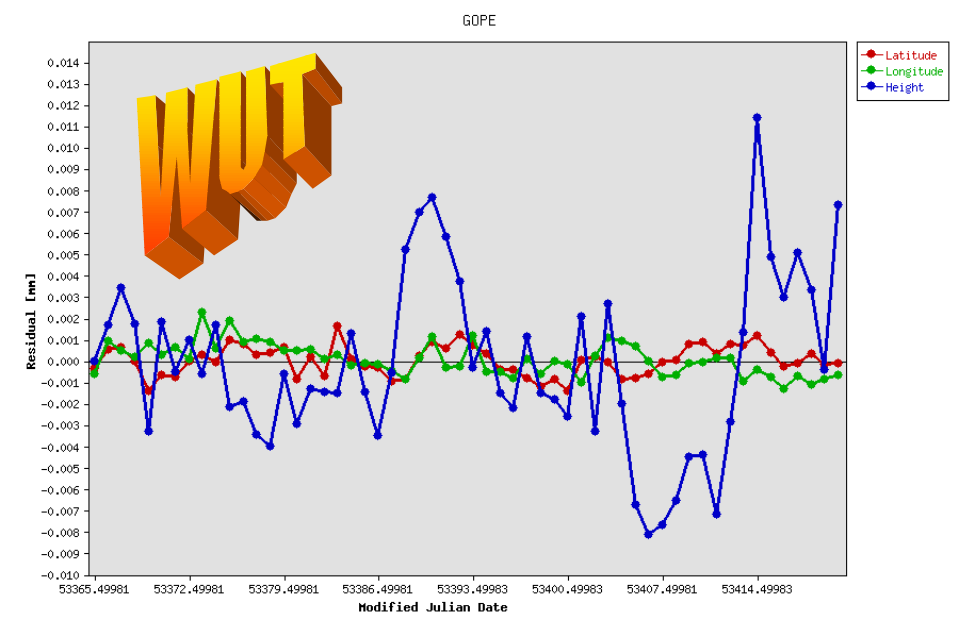


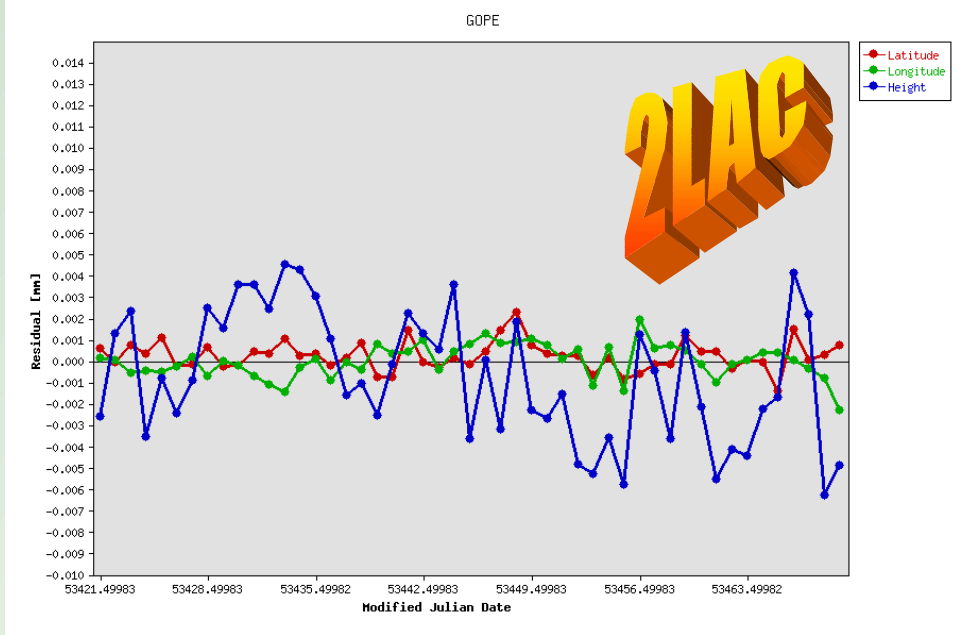


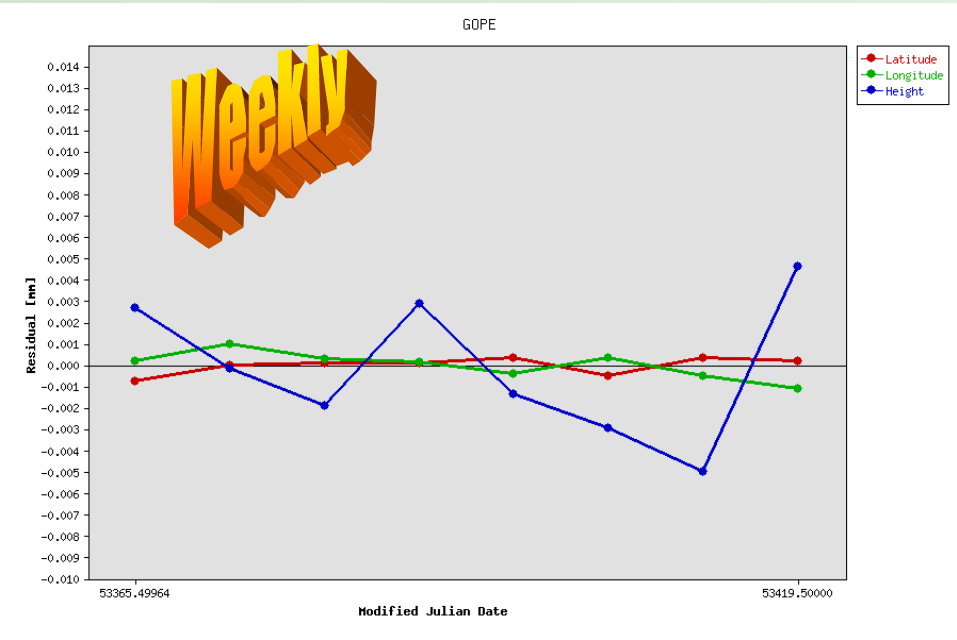
Kiev, Ukraine

Daily Combination

GOPE



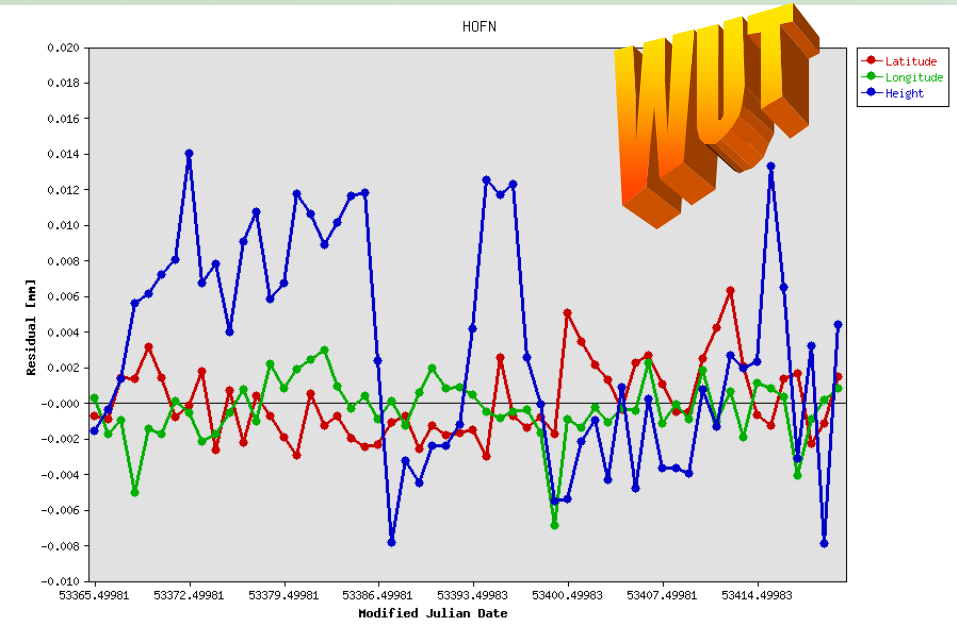


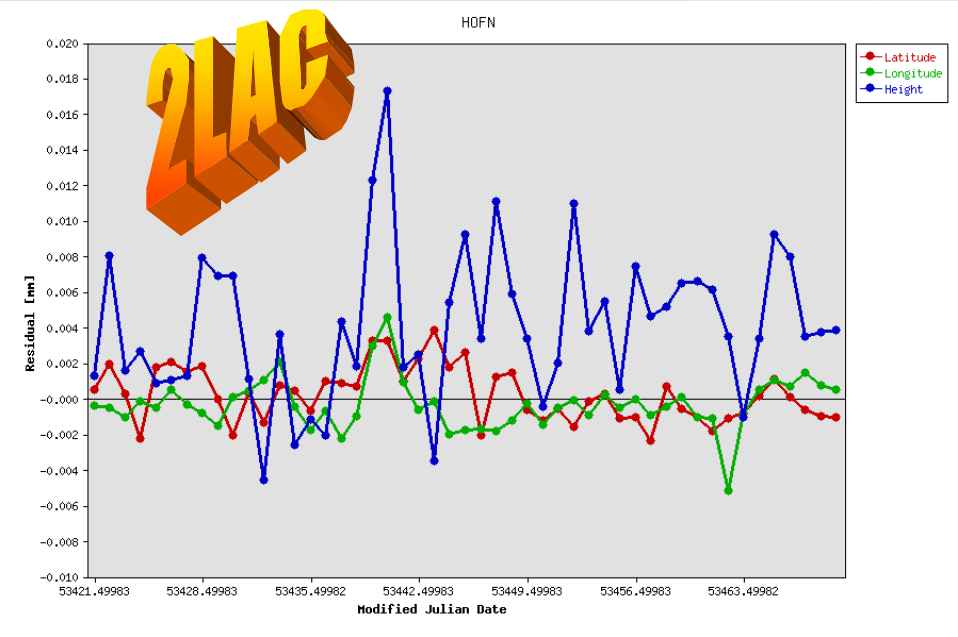


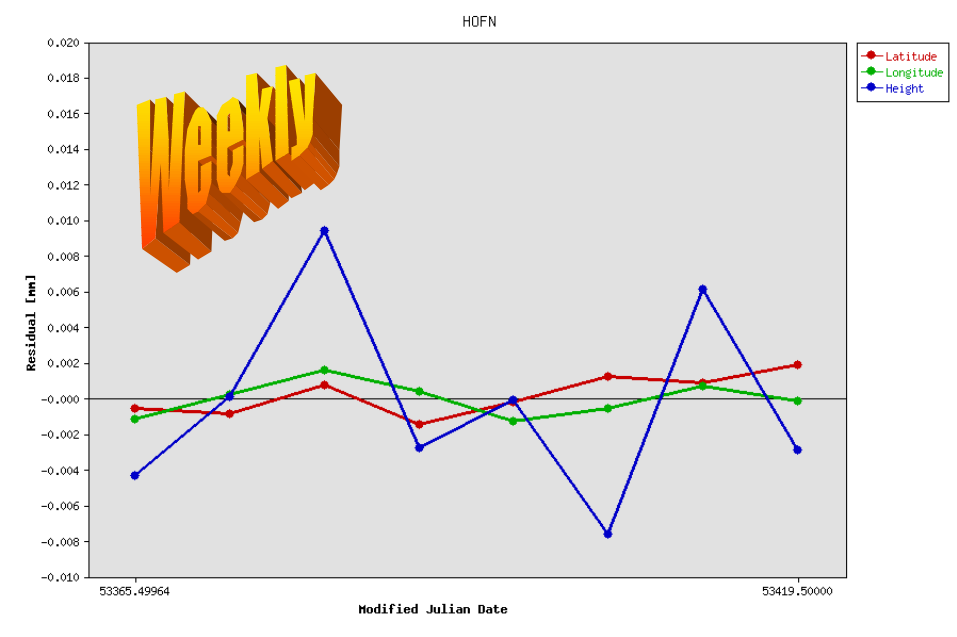
Ondrejov, Czech Republic

Daily Combination

HOFN



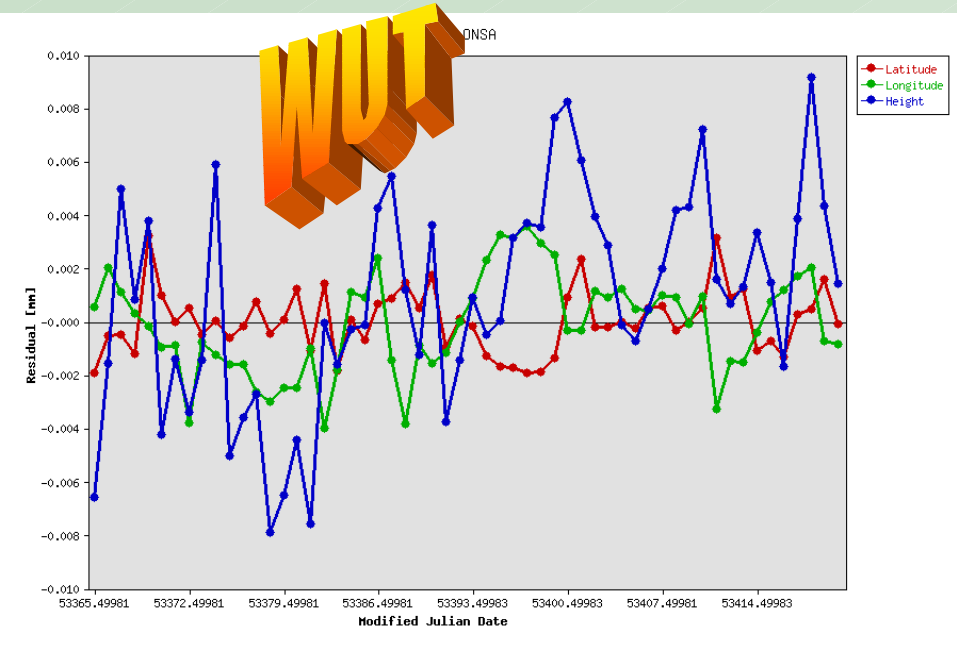


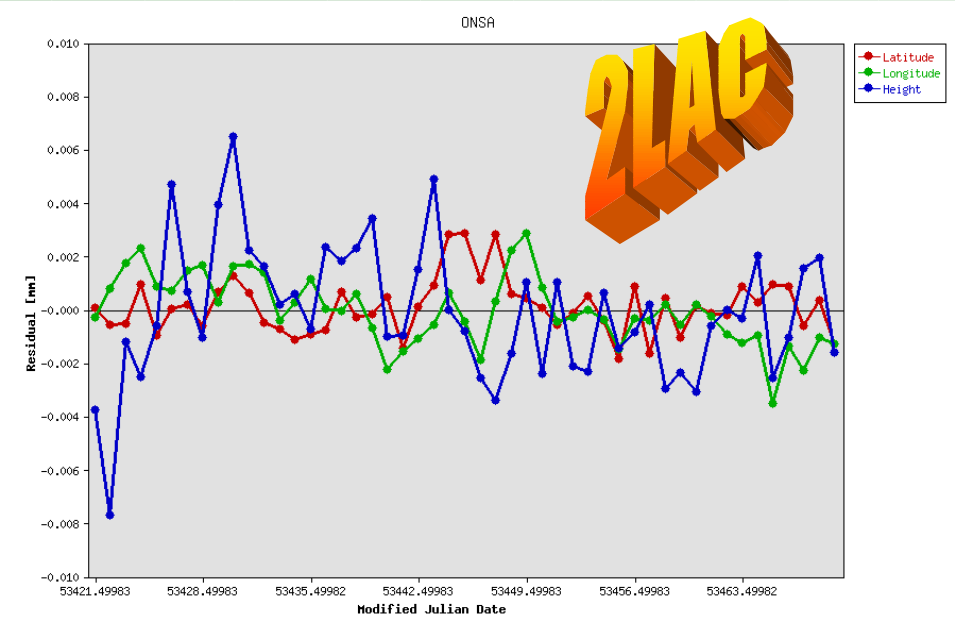


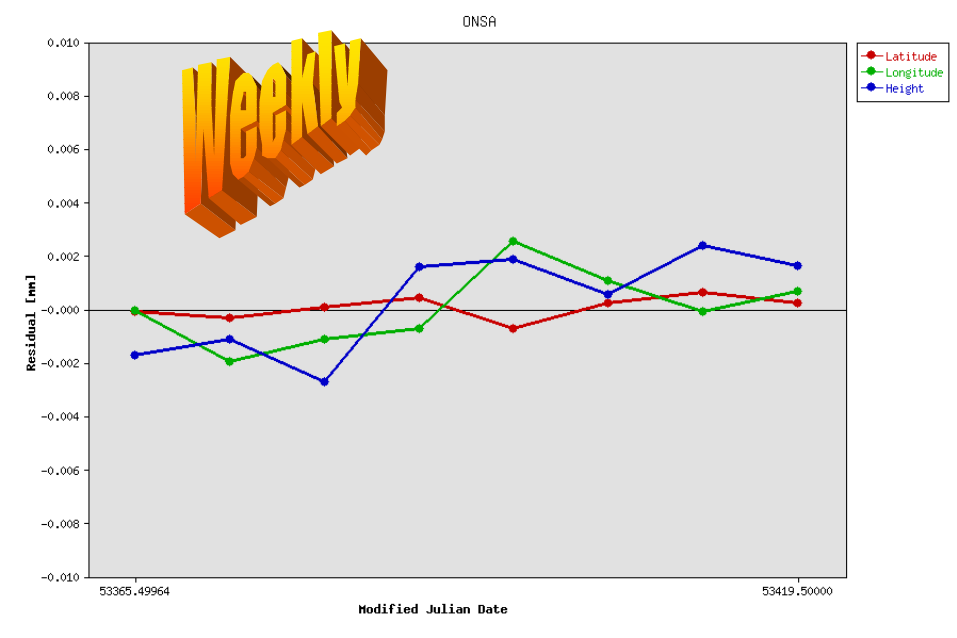
Hoefn, Iceland

Daily Combination

ONSA



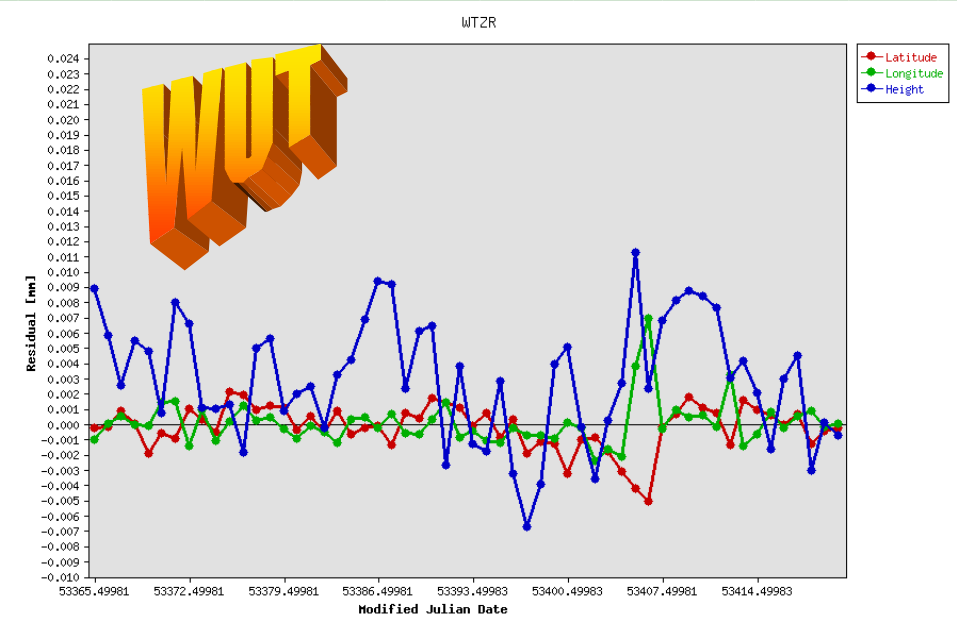


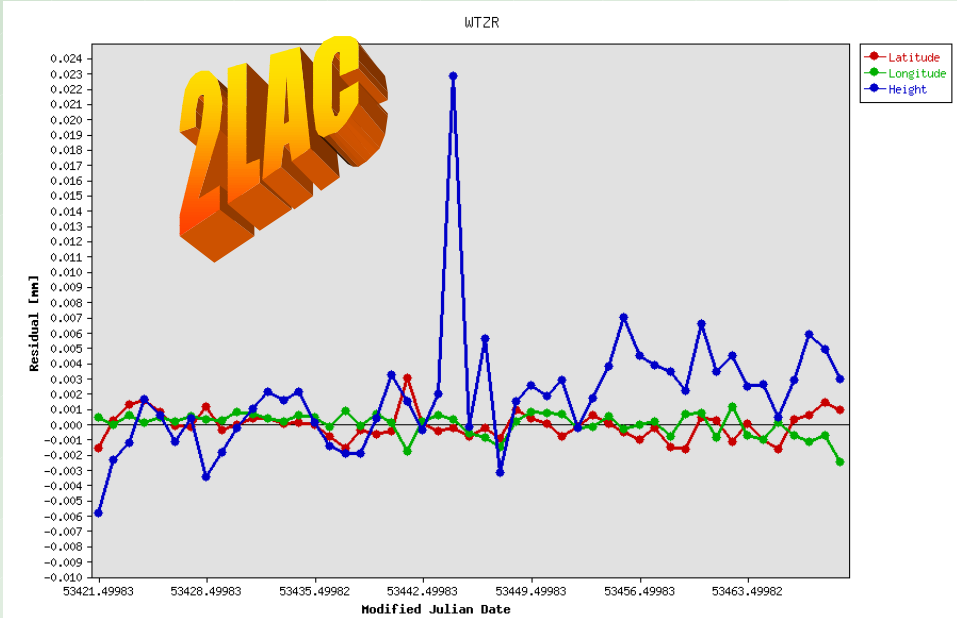


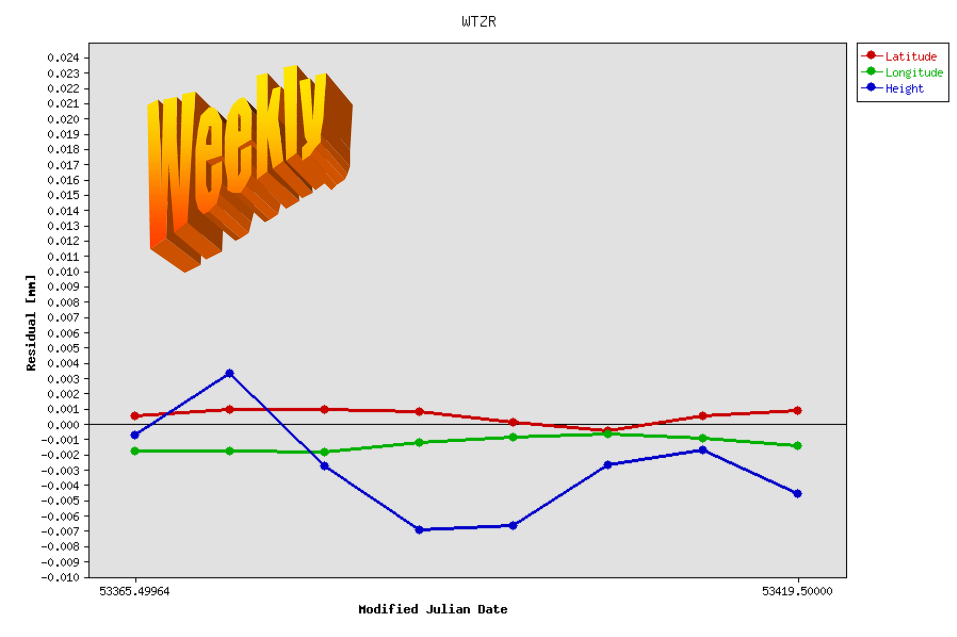
Onsala, Sweden

Daily Combination

WTZR







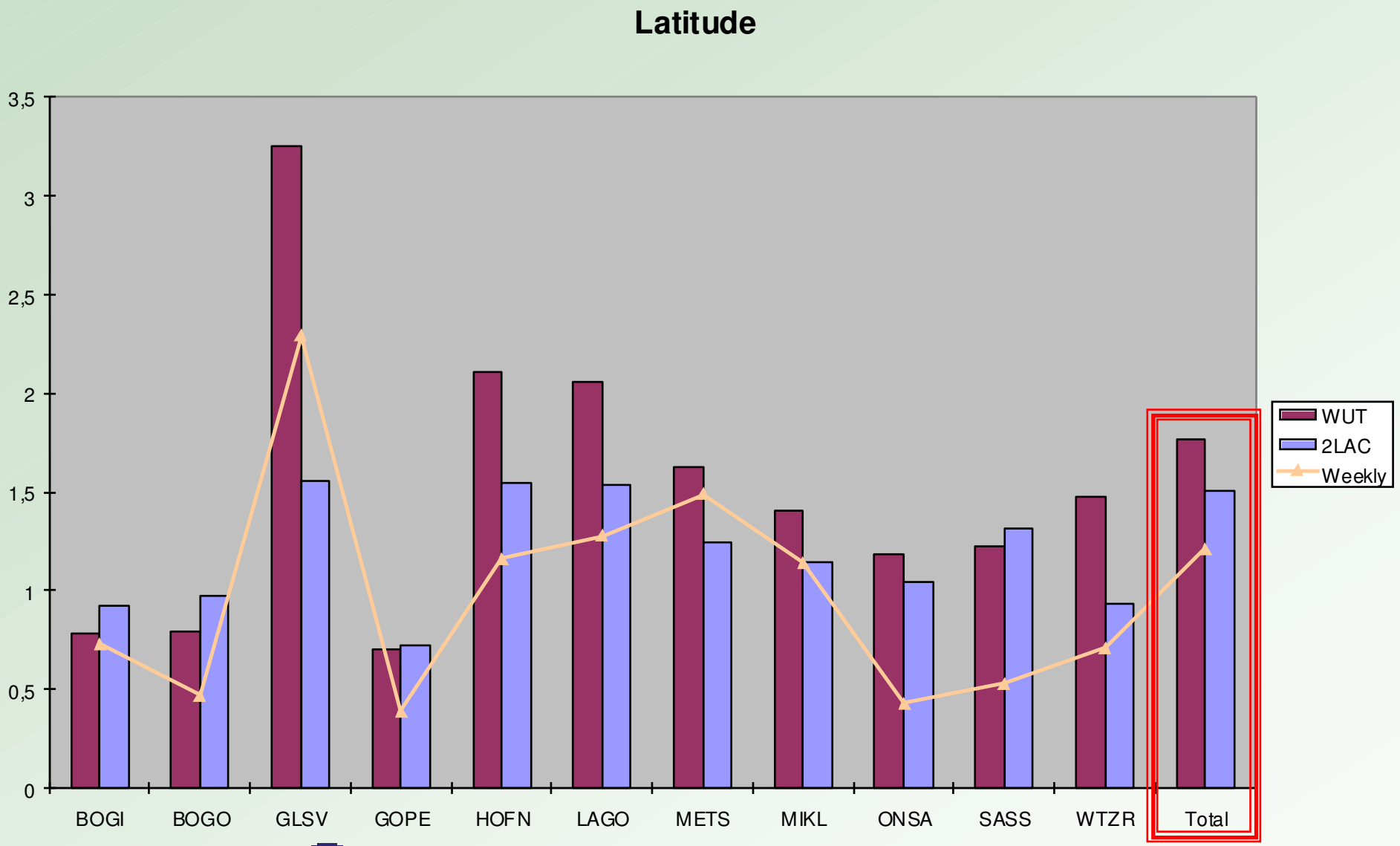
Wettzell, Germany

Daily Combination

Summarized Coordinate Repeatability

Daily Combination

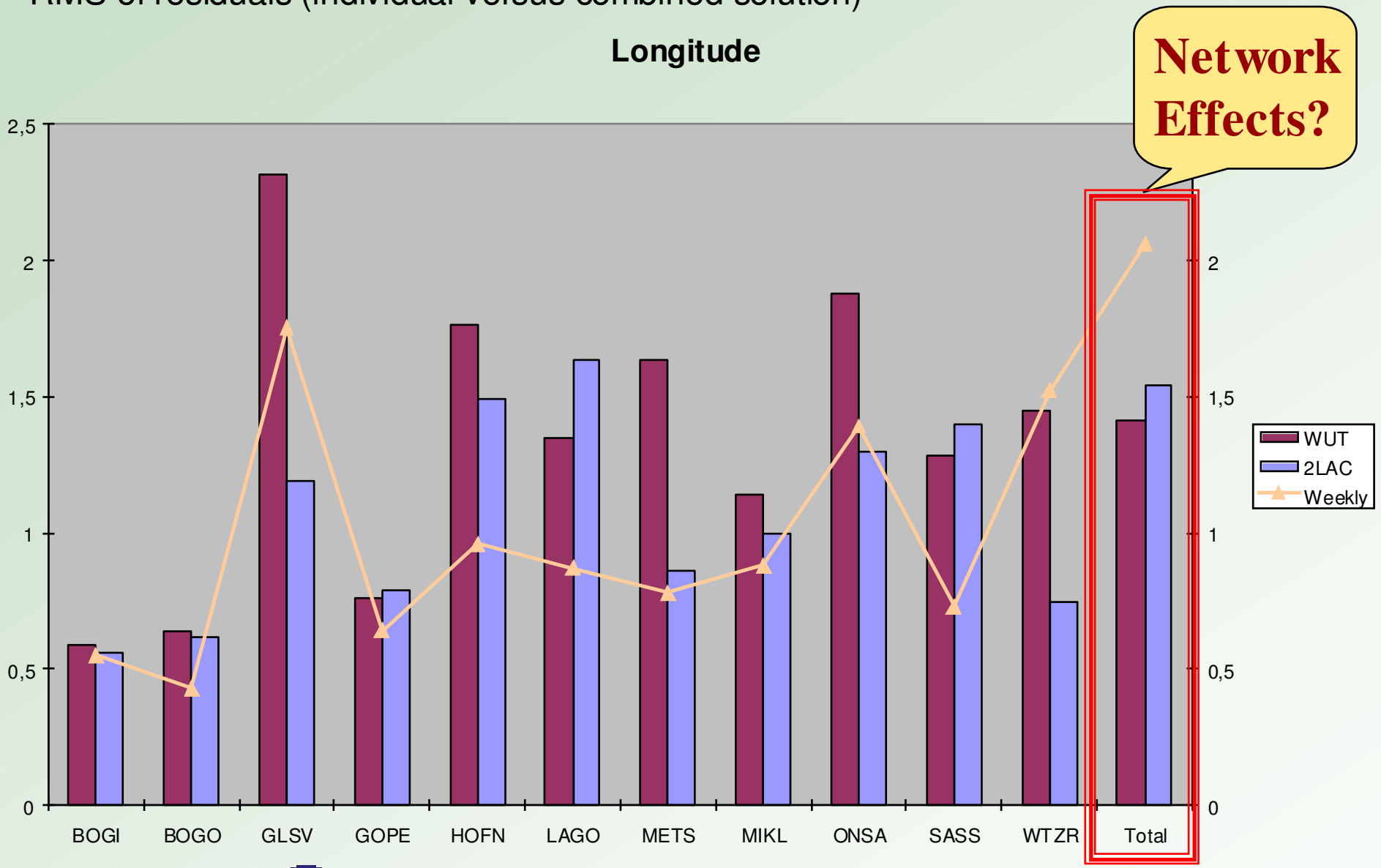
RMS of residuals (individual versus combined solution)



Summarized Coordinate Repeatability

Daily Combination

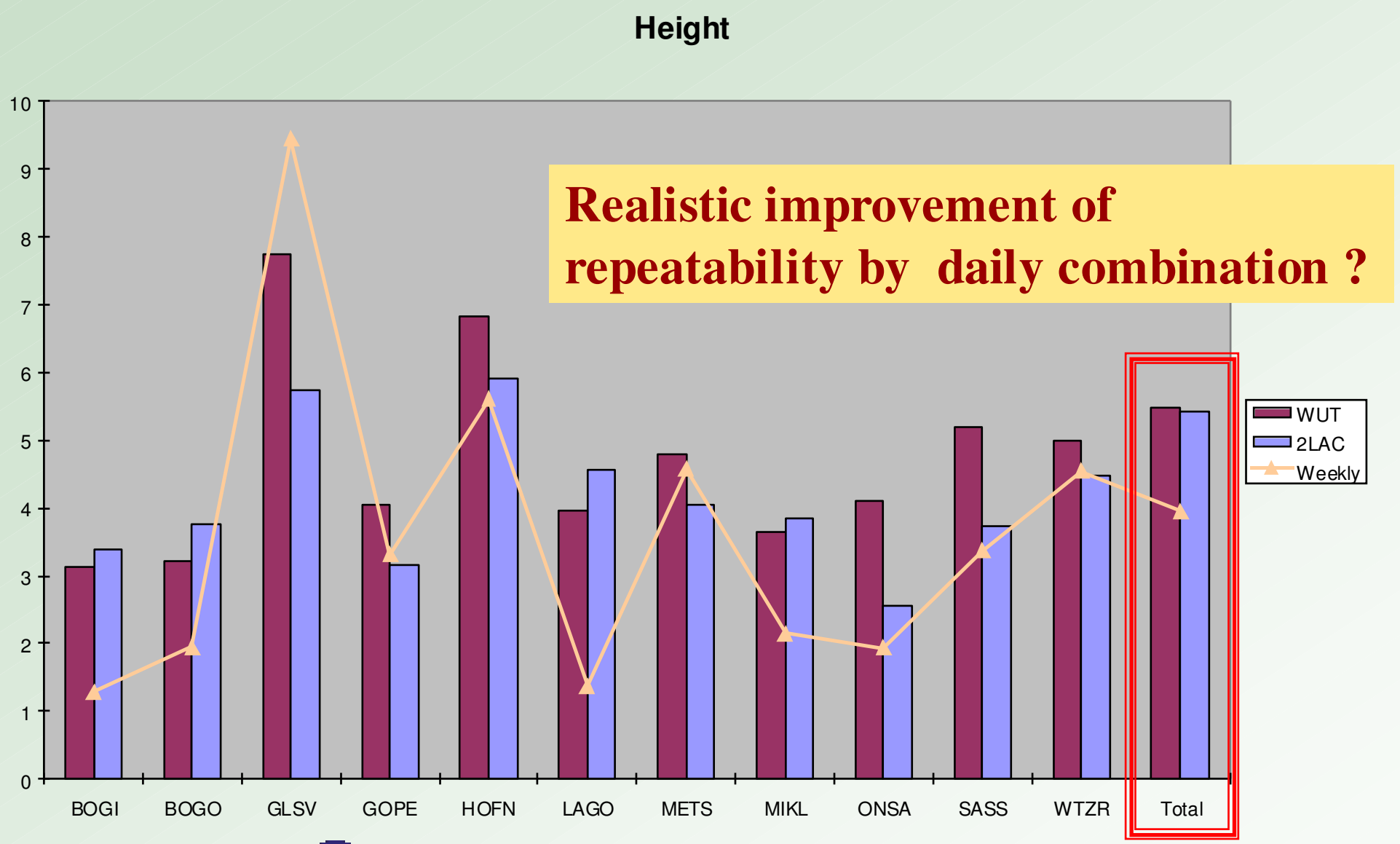
RMS of residuals (individual versus combined solution)



Summarized Coordinate Repeatability

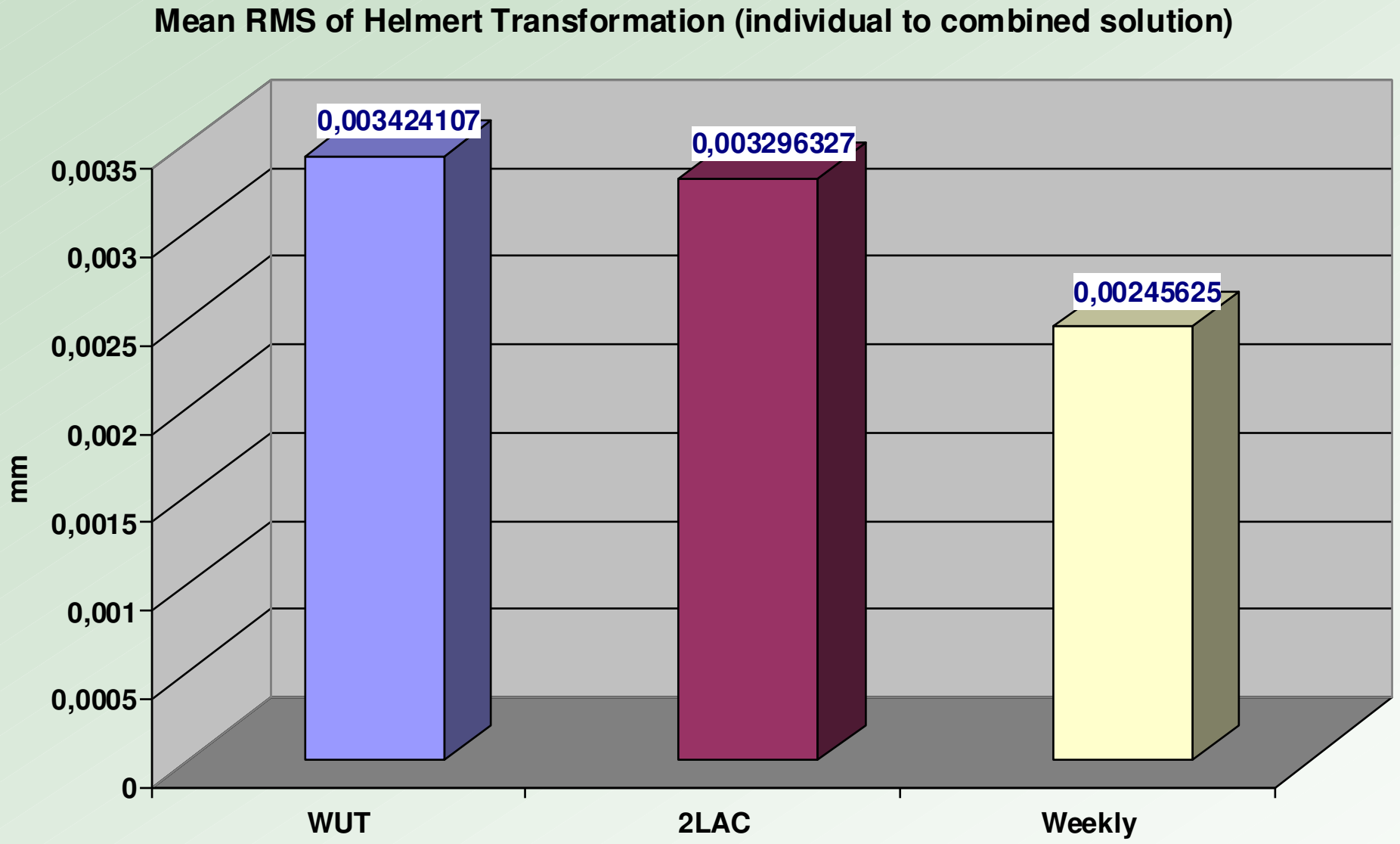
Daily Combination

RMS of residuals (individual versus combined solution)



Network Stability

Daily Combination



Combination improves daily network stability

Options of Daily Combination

Daily Combination

- Identify potential users of a daily EPN combination product
- Initiate an EPN daily combination experiment with 16 LACs
- Study network effects of contributing sub-networks
  - Question: How do differently designed sub-networks affect the combination of a single station?

Benefit of GLONASS for EPN

- Analysis: BKG sub-network plus German national network (GREF)
- GPS versus GPS/GLONASS

```
GPS (File EST05100.OUT)
=======================
 PARAMETER TYPE                                      #PARAMETERS
 STATION COORDINATES                                    234
 AMBIGUITIES                                            475
 SITE-SPECIFIC TROPOSPHERE PARAMETERS                  1950
 ------------------------------------------------------------------------
 TOTAL NUMBER OF PARAMETERS                            2659
 TYPE         FREQUENCY         FILE              #OBSERVATIONS
 ------------------------------------------------------------------------
 PHASE           L3              ALL                233053
------------------------------------------------------------------------
 A POSTERIORI SIGMA OF UNIT WEIGHT  :    0.0012 M  (SIGMA OF ONE-WAY L1 PHASE OBSERVABLE AT ZENITH)
 DEGREE OF FREEDOM (DOF)            :    230507
 CHI**2/DOF                         :      1.34

GPS/GLONASS (File EST05100.OUT)
===============================
 PARAMETER TYPE                                      #PARAMETERS
 STATION COORDINATES                                    234
 AMBIGUITIES                                           1122
 SITE-SPECIFIC TROPOSPHERE PARAMETERS                  1950
 ------------------------------------------------------------------------
 TOTAL NUMBER OF PARAMETERS                            3306
 TYPE         FREQUENCY         FILE              #OBSERVATIONS
 ------------------------------------------------------------------------
 PHASE           L3              ALL                211148
------------------------------------------------------------------------
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 DEGREE OF FREEDOM (DOF)            :    207960
 CHI**2/DOF                         :      1.35
```
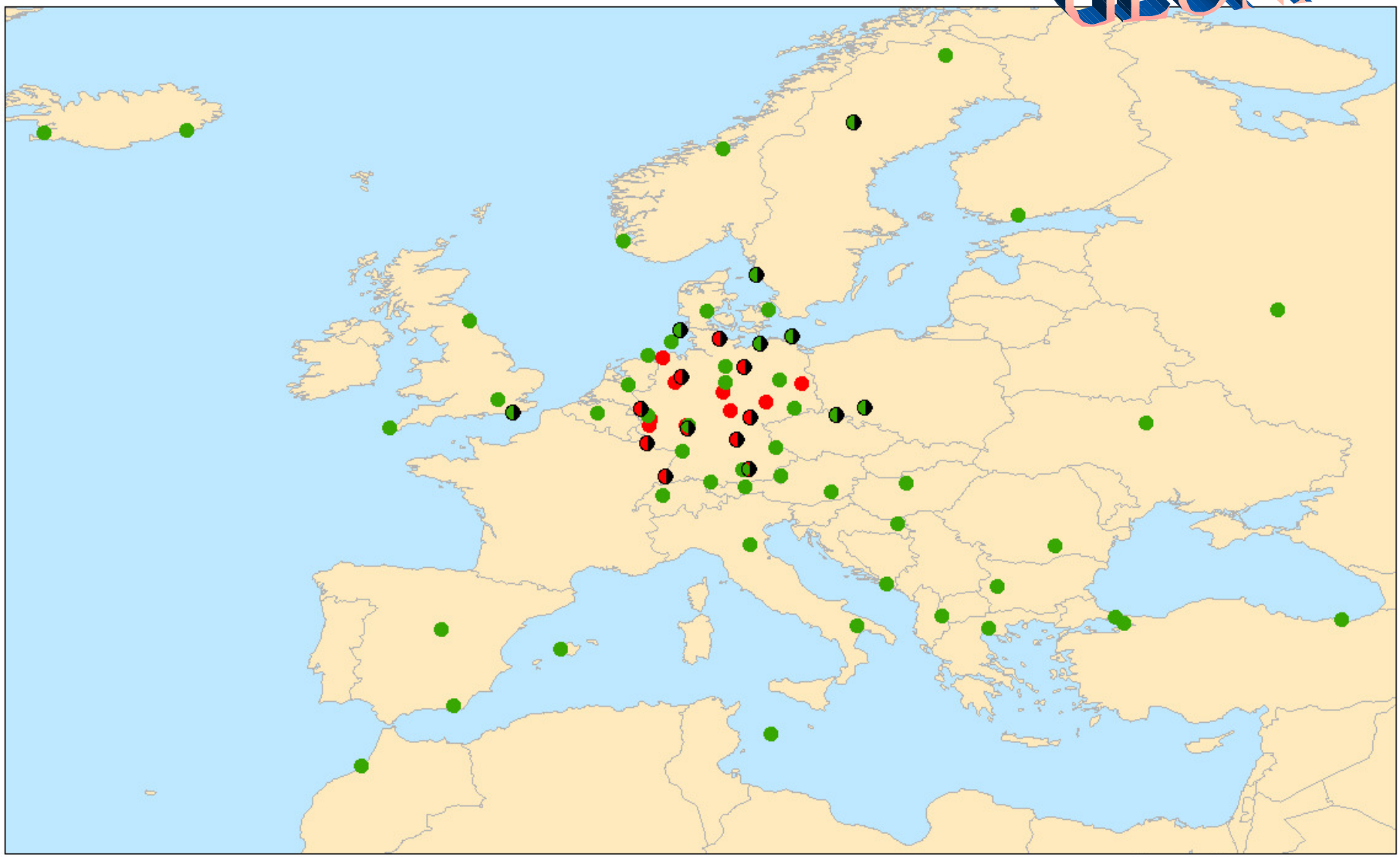

More unresolved ambiguities

Less observations

„Unchanged“ results

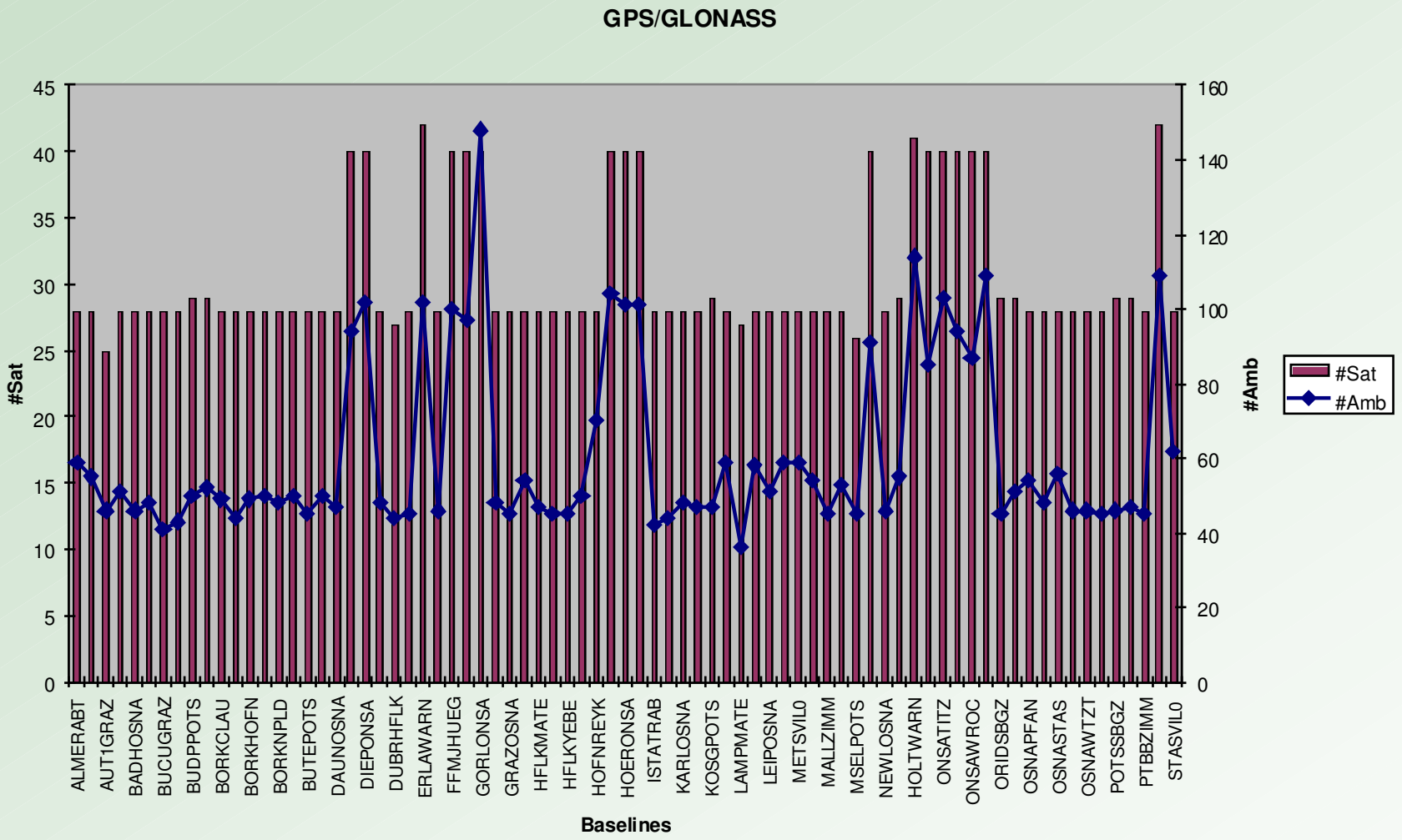
GPS/GLONASS Network



Baseline creation:
Pre-defined baselines instead of "max-obs" strategy?

GPS/GLONASS Parameter for 1 Day

- 17 Baselines with GLONASS (22 %)



Real “benefit” needs more GLONASS stations.

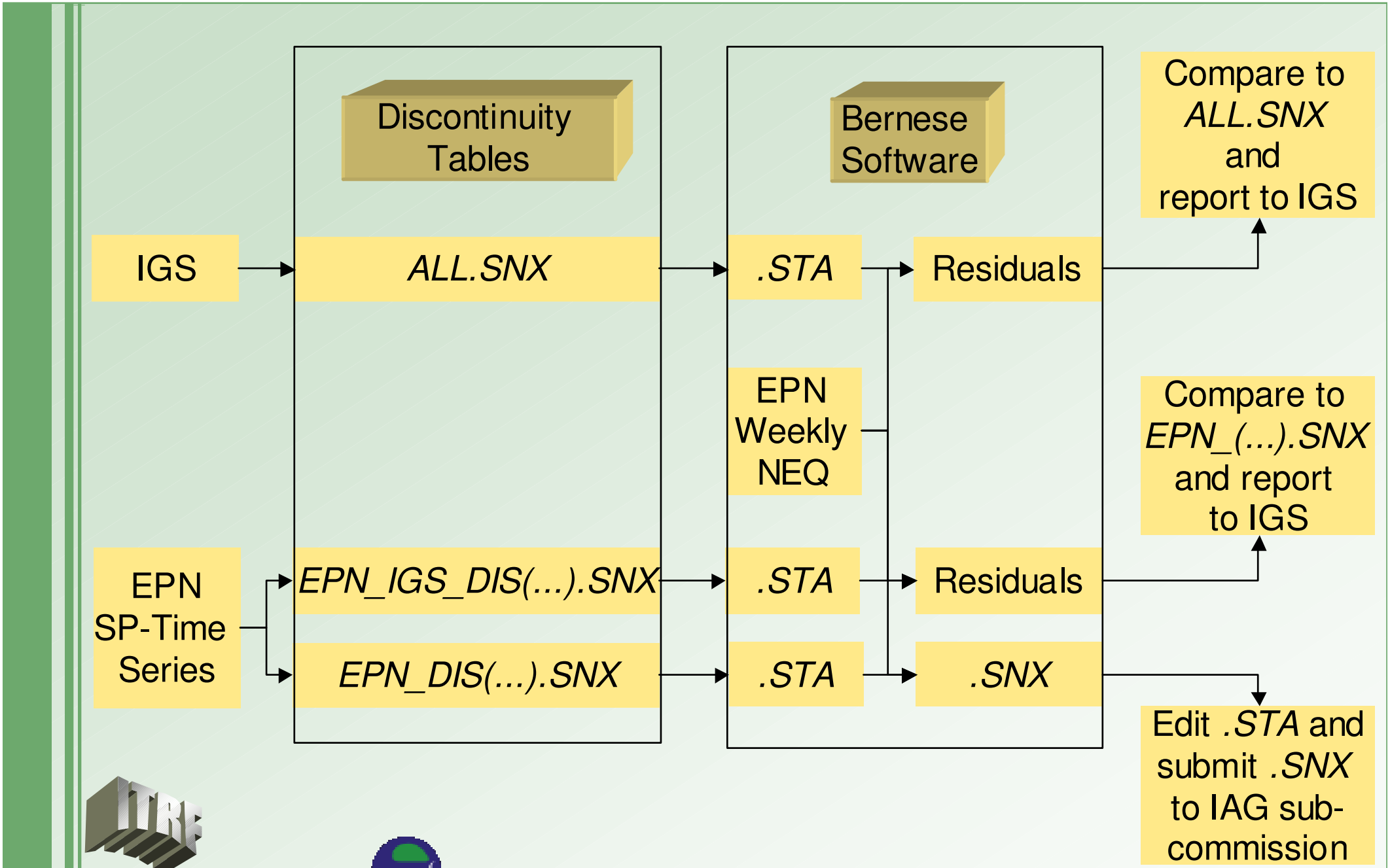
Contribution of EPN to ITRF2004

- December 16, 2004: Call for „weekly“ SINEX files for ITRF2004
- Combination of time series of station positions and EOPs from all techniques
- EPN contributes to GPS technique
  - with weekly SINEX files
  - IGS (NRCan) combines weekly solutions
  - only IGS station from EPN ?
- EUREF was asked to check the discontinuity table used by NRCan
  - Done by Ambrus Kenyeres, but still under investigation
  - Check will performed by Heinz Habrich (EPN AC) too

Densification of ITRF2004

- Initiative within IAG sub-commission 1.3 „Regional Reference Frames“ in responsibility of Zuheir Altamimi
- Time-integrated solutions (positions and velocities) of 6 regional sub-commissions have been inquired
- EPN contributes to regional European network
  - computation of corresponding a multi-year solution

Working Plan for ITRF2004 and Densification

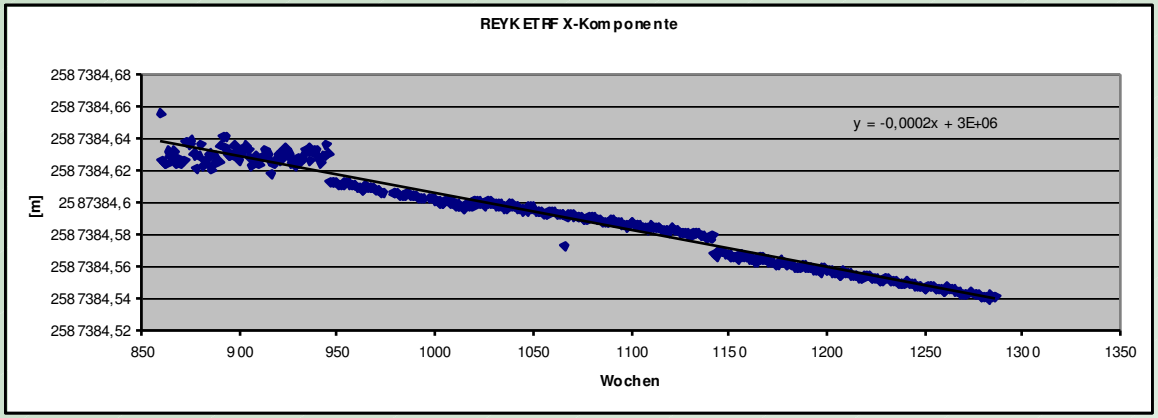


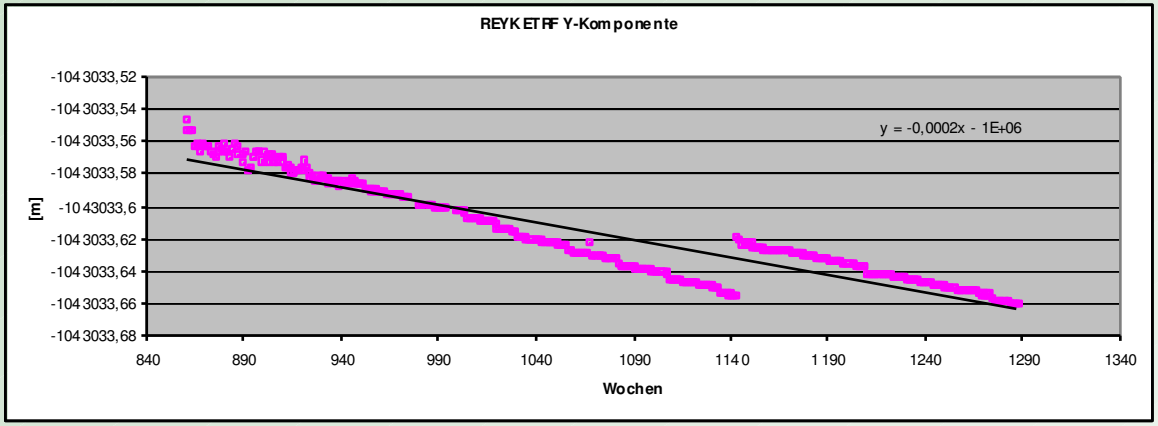
Re-Processing of EPN on NEQ Level

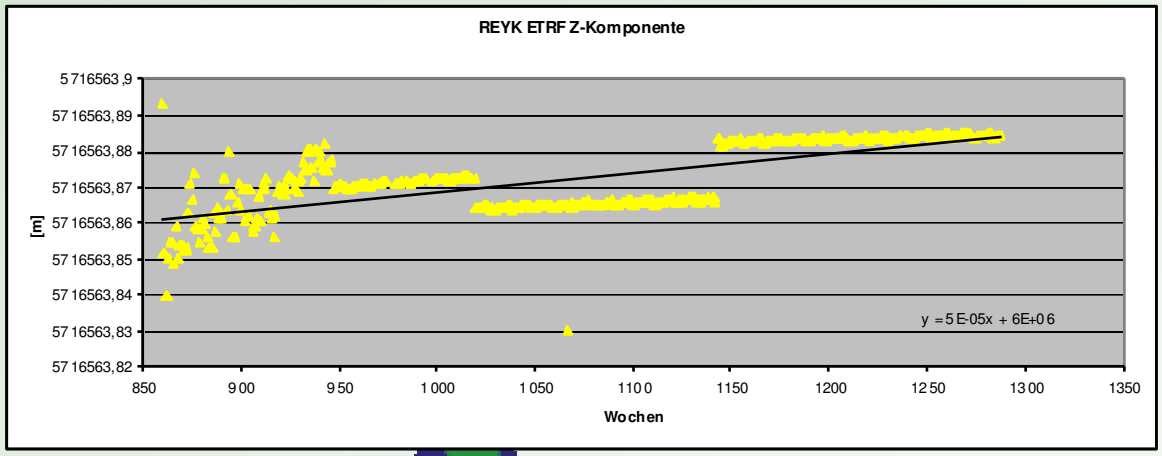
- Objective:
  - Improvement of ETRS89 Time Series
- Has been done by AC
- Will be re-done within ITRF2004 densification action

ETRF Velocities from weekly Coordinates

NEQ Re-Processing





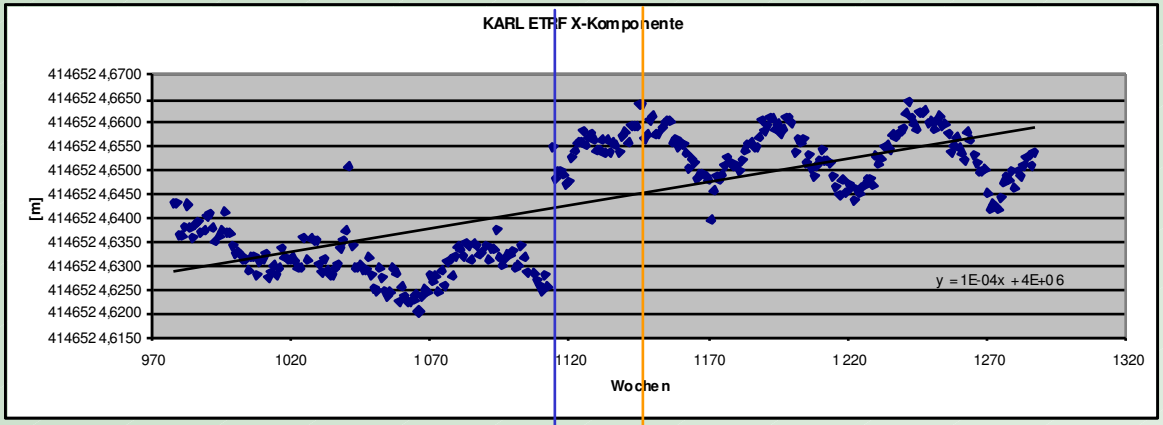


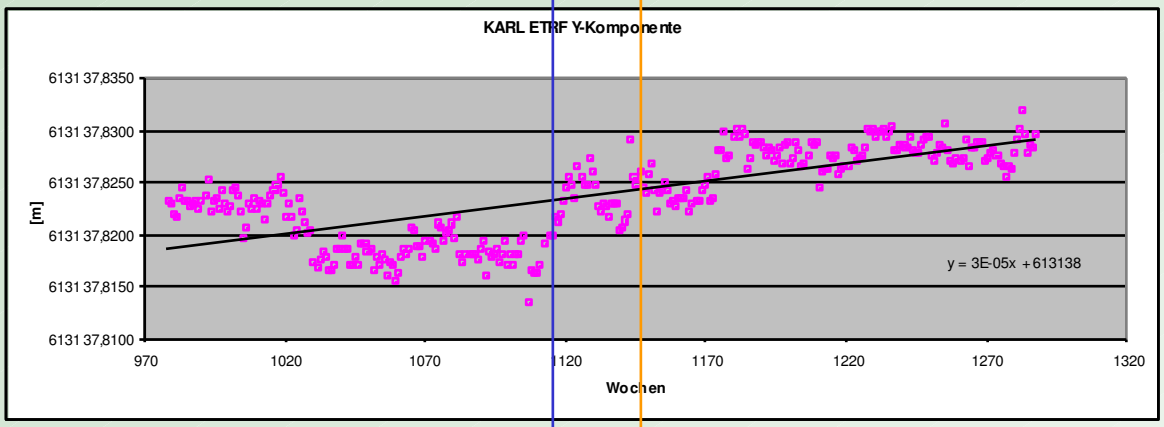
Velocity Vectors			
	Linear Trend [m/year]	Combined Solution [m/year]	Difference [m/year]
X	-0,0104	-0,0104	0,0000
Y	-0,0104	-0,0141	0,0037
Z	0,0026	0,0008	0,0018

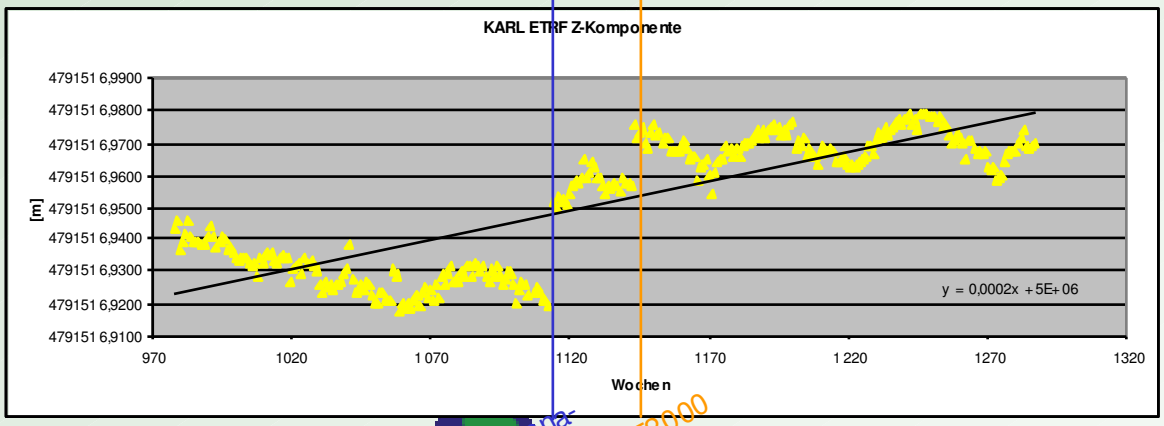
Reykjavik

ETRF Velocities from weekly Coordinates

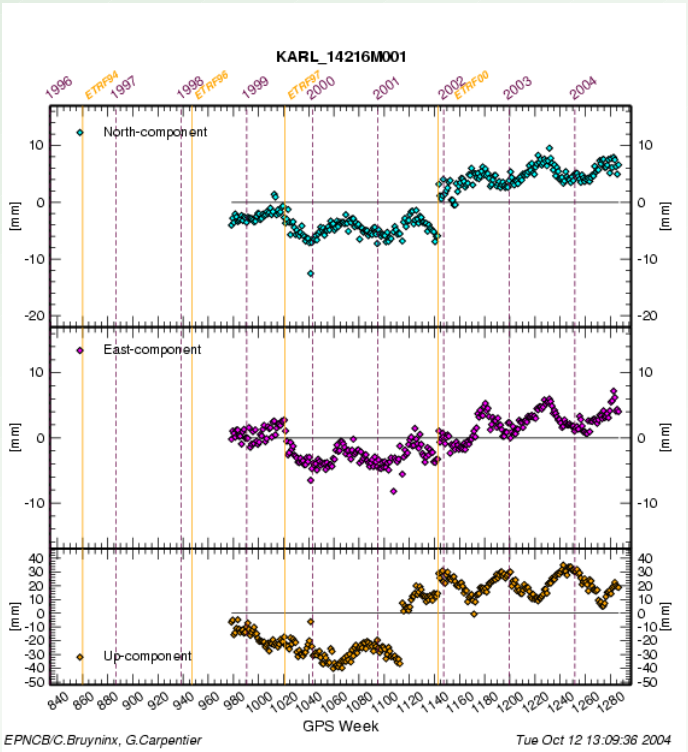
NEQ Re-Processing







Velocity Vectors			
	Linear Trend [m/year]	Combined Solution [m/year]	Difference [m/year]
X	0,0052	0,0019	0,0033
Y	0,0016	0,0006	0,0010
Z	0,0104	0,0007	0,0097

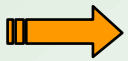


Karlsruhe

Improvement of ETRF Time Series

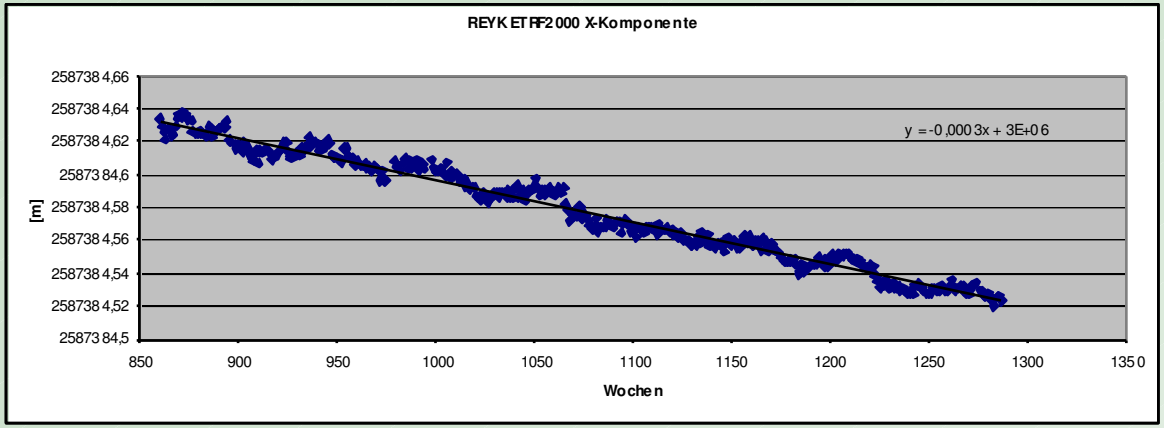
NEQ Re-Processing

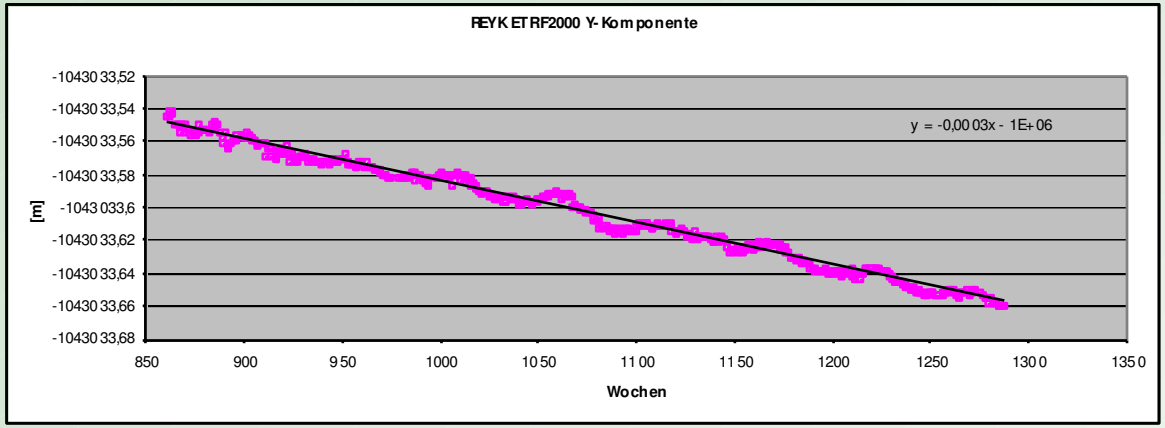
- Transform the weekly solutions into a homogeneous ETRF realisation
  - Step 1: Transform all weekly solutions from ITRFyy into ITRF2000.
  - Step 2: Transform all weekly solutions from ITRF2000 into ETRF2000.
- Re-processing of all weekly NEQs and definition of unique datum for the network
  - Step 1: ITRF2000 co-ordinates of the reference stations will define the datum of the network.
  - Step 2: Transform all weekly solutions from ITRF2000 into ETRF2000.
  - Results shown in the following

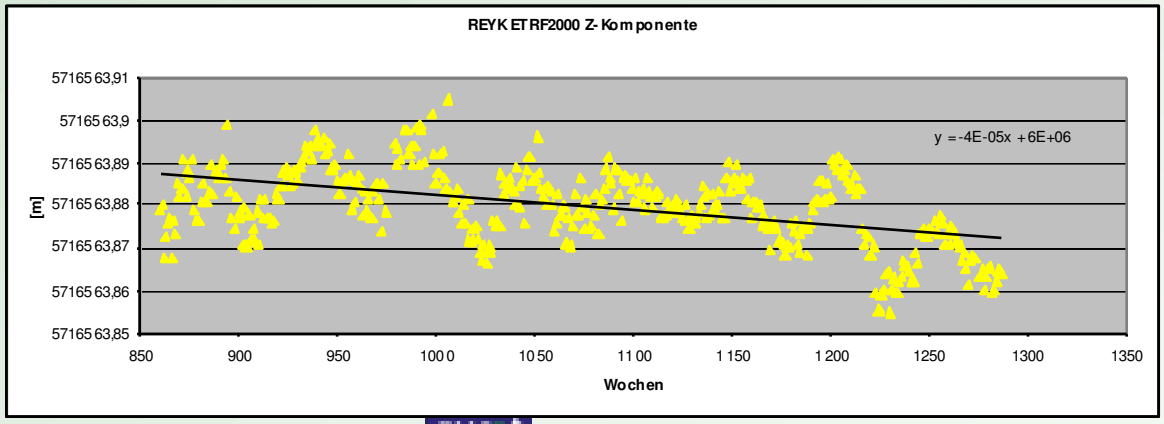


ETRF Velocities from weekly Coordinates

NEQ Re-Processing





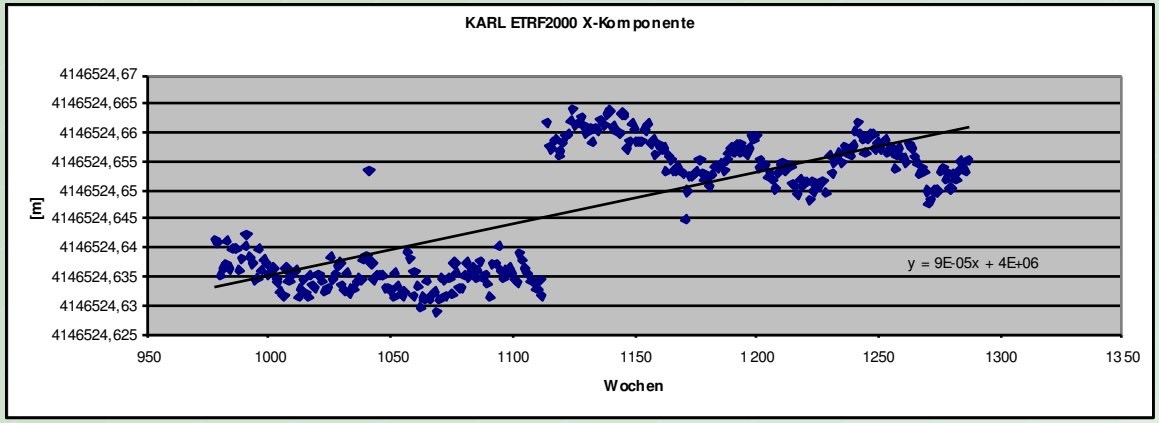


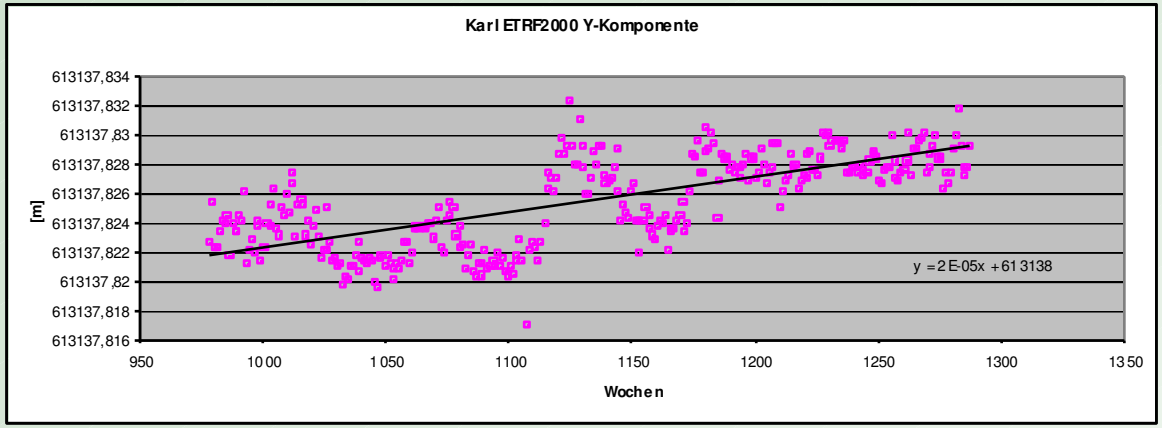
Velocity Vectors			
	Linear Trend [m/year]	Combined Solution [m/ year]	Difference [m/ year]
X	-0,0156	-0,0104	-0,0052
Y	-0,0156	-0,0141	-0,0015
Z	-0,0026	0,0008	-0,0034

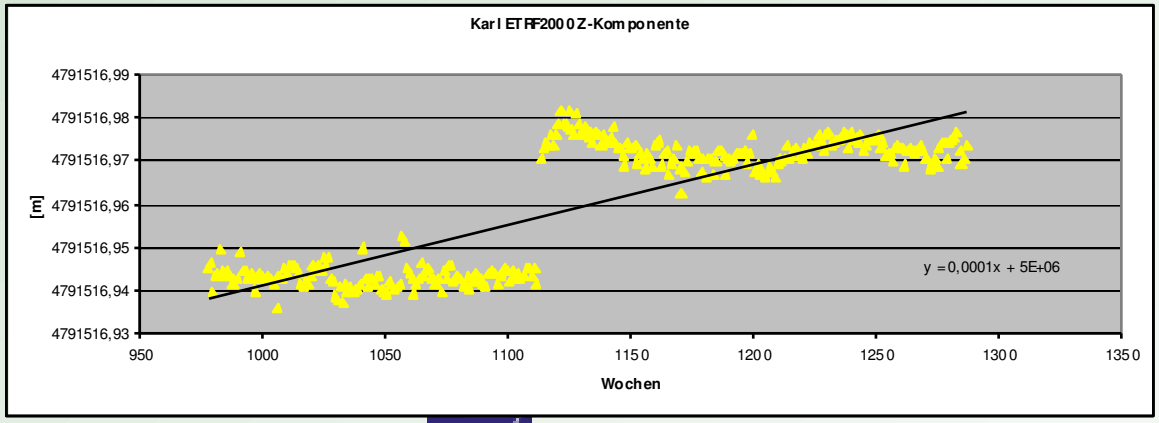
Reykjavik

ETRF Velocities from weekly Coordinates

NEQ Re-Processing







Velocity Vectors			
	Linear Trend [m/year]	Combined Solution [m/ year]	Difference [m/ year]
X	0,00468	0,0019	0,0027
Y	0,00104	0,0006	0,0004
Z	0,00520	0,0007	0,0045

Karlsruhe

Outlook

- Informal LAC Meeting today:

  18:00 – 18:30 , Festival Hall

- Next EPN LAC Workshop in 2005 ?
- Contact: heinz.habrich@bkg.bund.de

Thank you!