Updated Options and New Products of EPN Analysis

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Statement

- EPN Analysis is a ***continuous effort***...

  ...of Local Analysis Centres (LACs) in European countries

  ...to realize an European Reference Frame in the most accurate manner

  ...and thus requires ***to question the applied methods and strategies all the time***.

Outline

- Status of Local Analysis Centres
- Status of sub-network combination
- Updated options in the EPN analysis
- New rapid combination products
- New near real-time products
- ITRF 2005 Densification

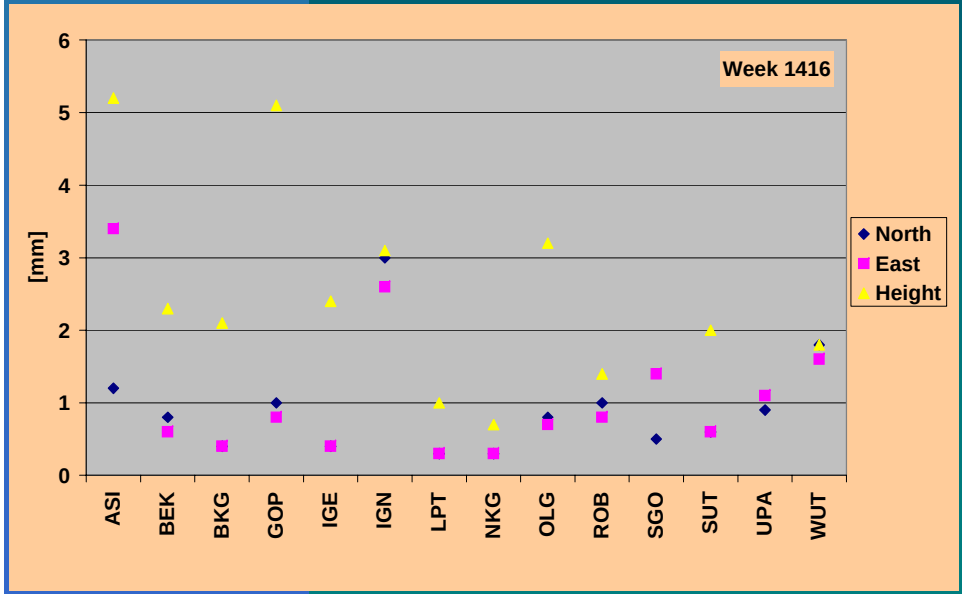
Status of Local Analysis Centres

ASI	MicroCosm 2005.0	Rapid
BEK	Bernese 5.0	Rapid
BKG	Bernese 5.0	Rapid
COE	Bernese 5.1	GLONASS
DEO	GIPSY v2.5/cov2snx	
GOP	Bernese 5.0	
IGE	Bernese 5.0	Rapid
IGN	Bernese 5.0	
LPT	Bernese 5.0	GLONASS, Rapid
NKG	Bernese 5.0	Rapid
OLG	Bernese 5.0	
ROB	Bernese 5.0	Rapid
SGO	Bernese 5.0	
SUT	Bernese 5.0	Rapid
UPA	Bernese 5.0	Rapid
WUT	Bernese 5.0	Rapid

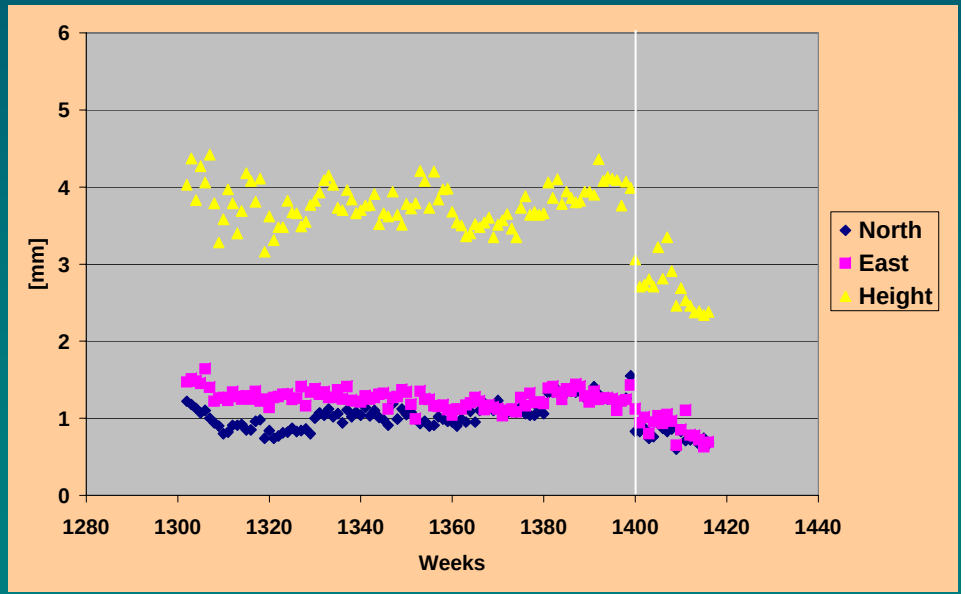
Status of Sub-Network Combination

Indication of Precision

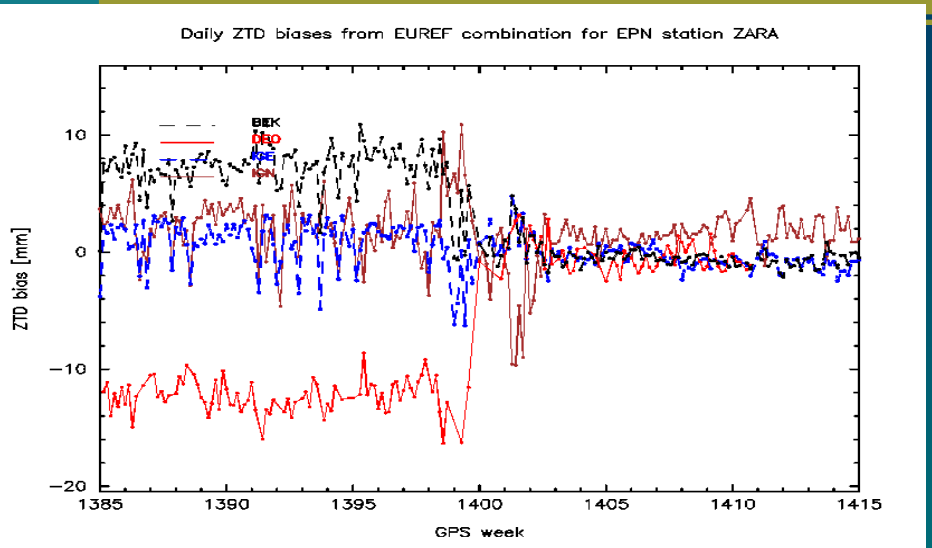
Precision between LACs

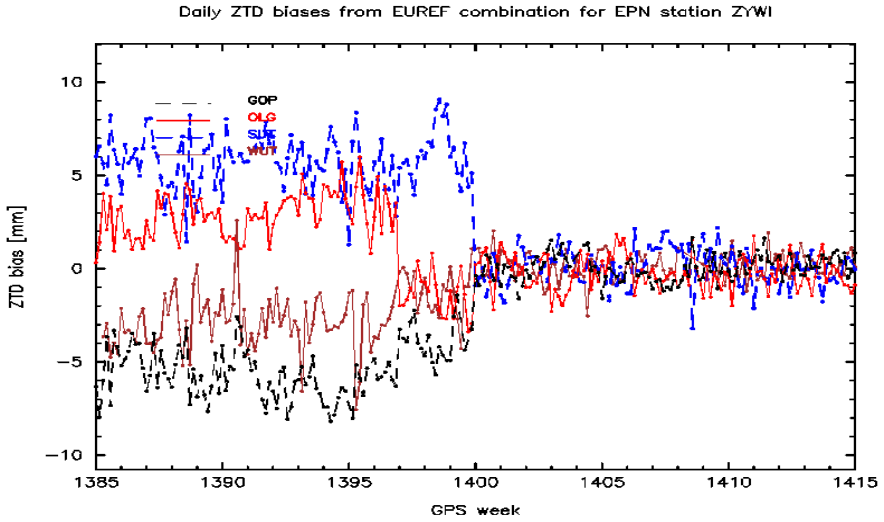


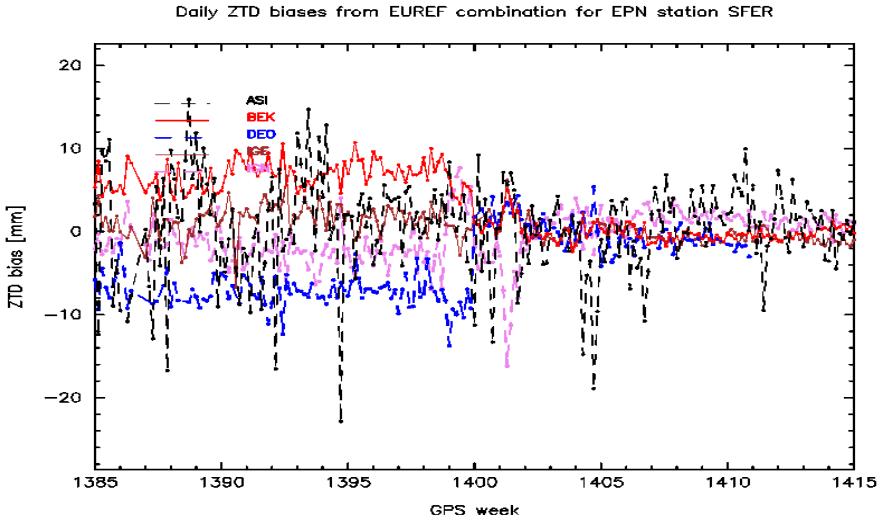
Day to Day Repeatability



Status Troposphere Combination



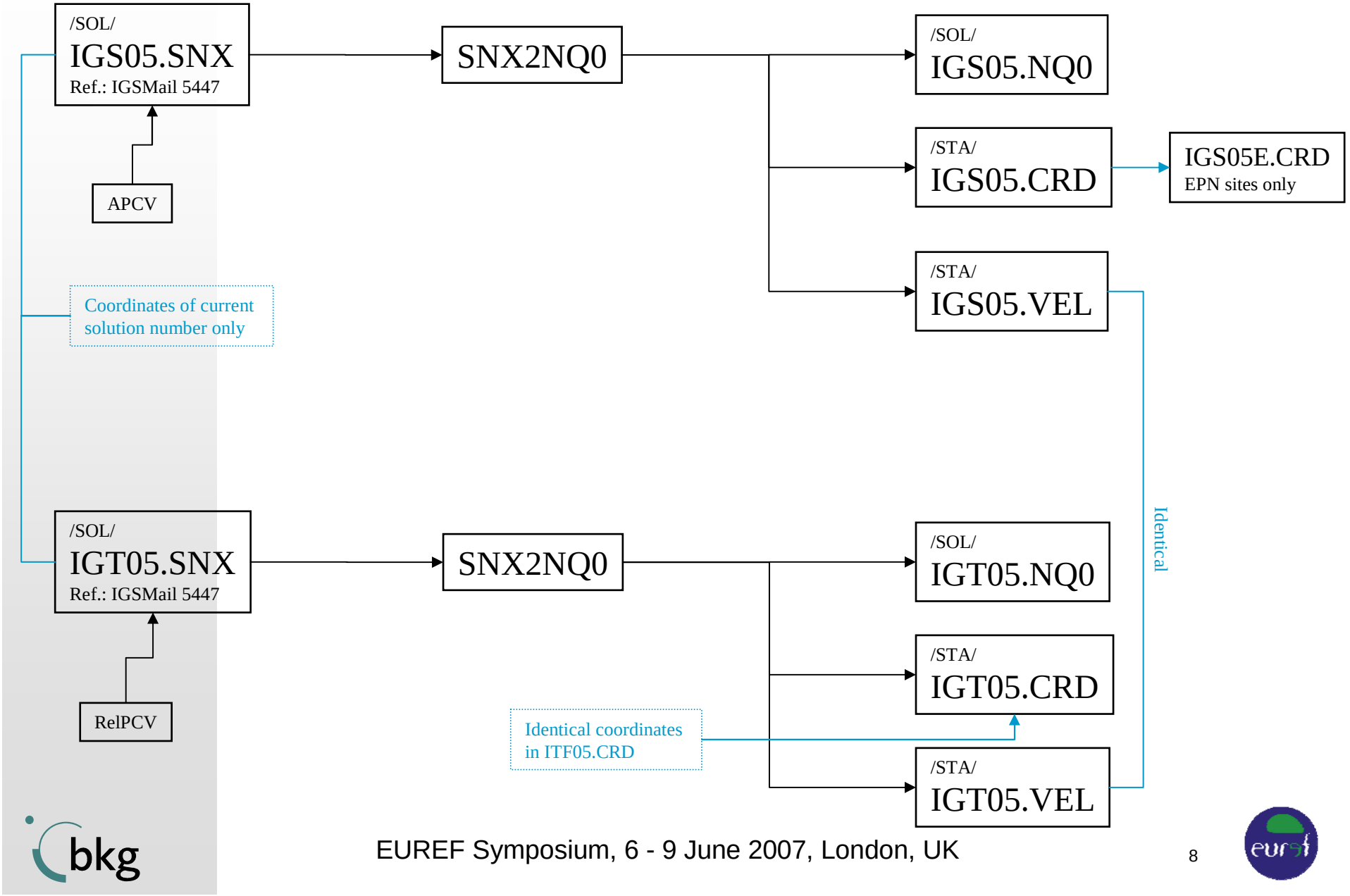




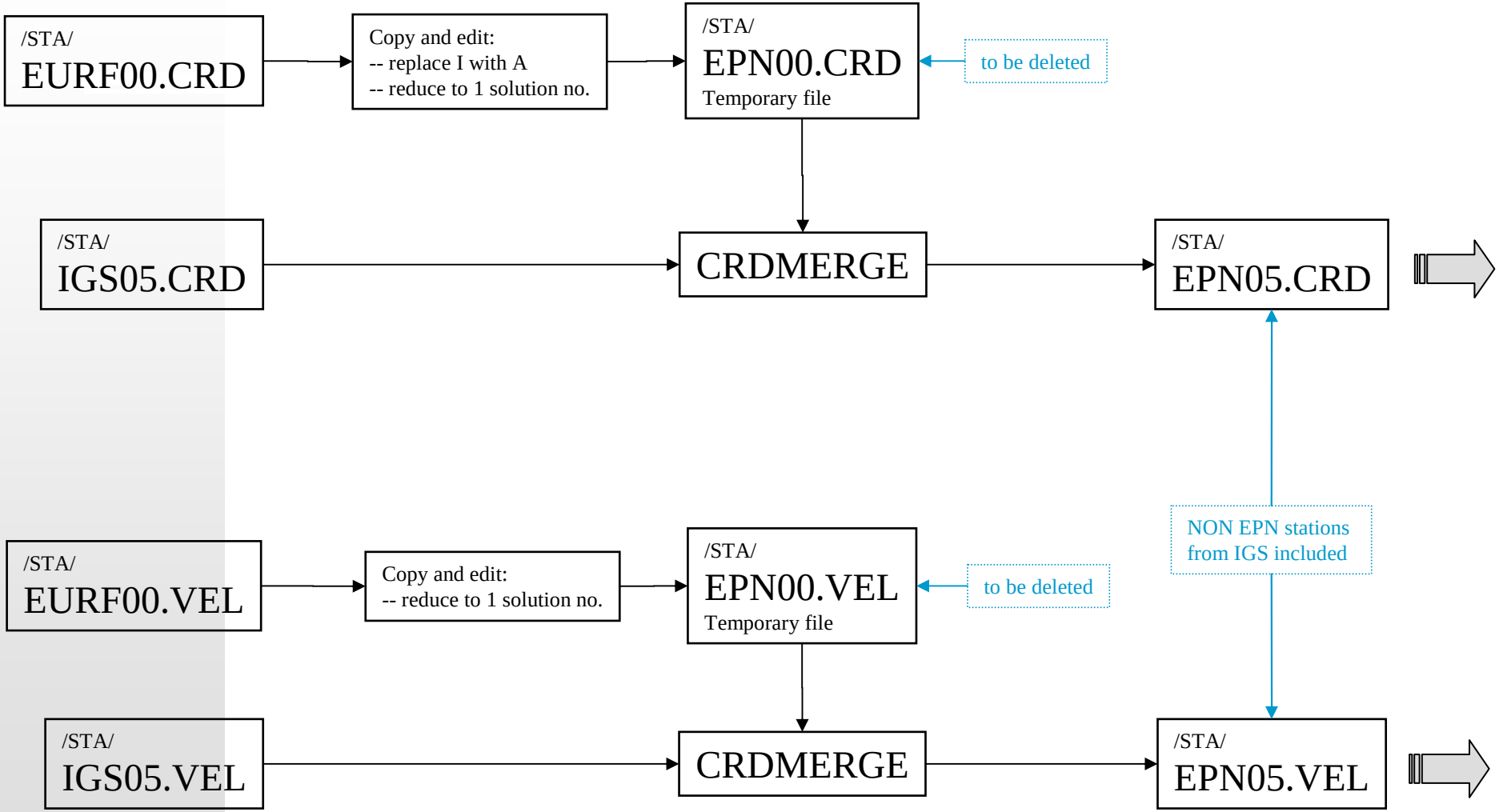
Updated Options at Week 1400

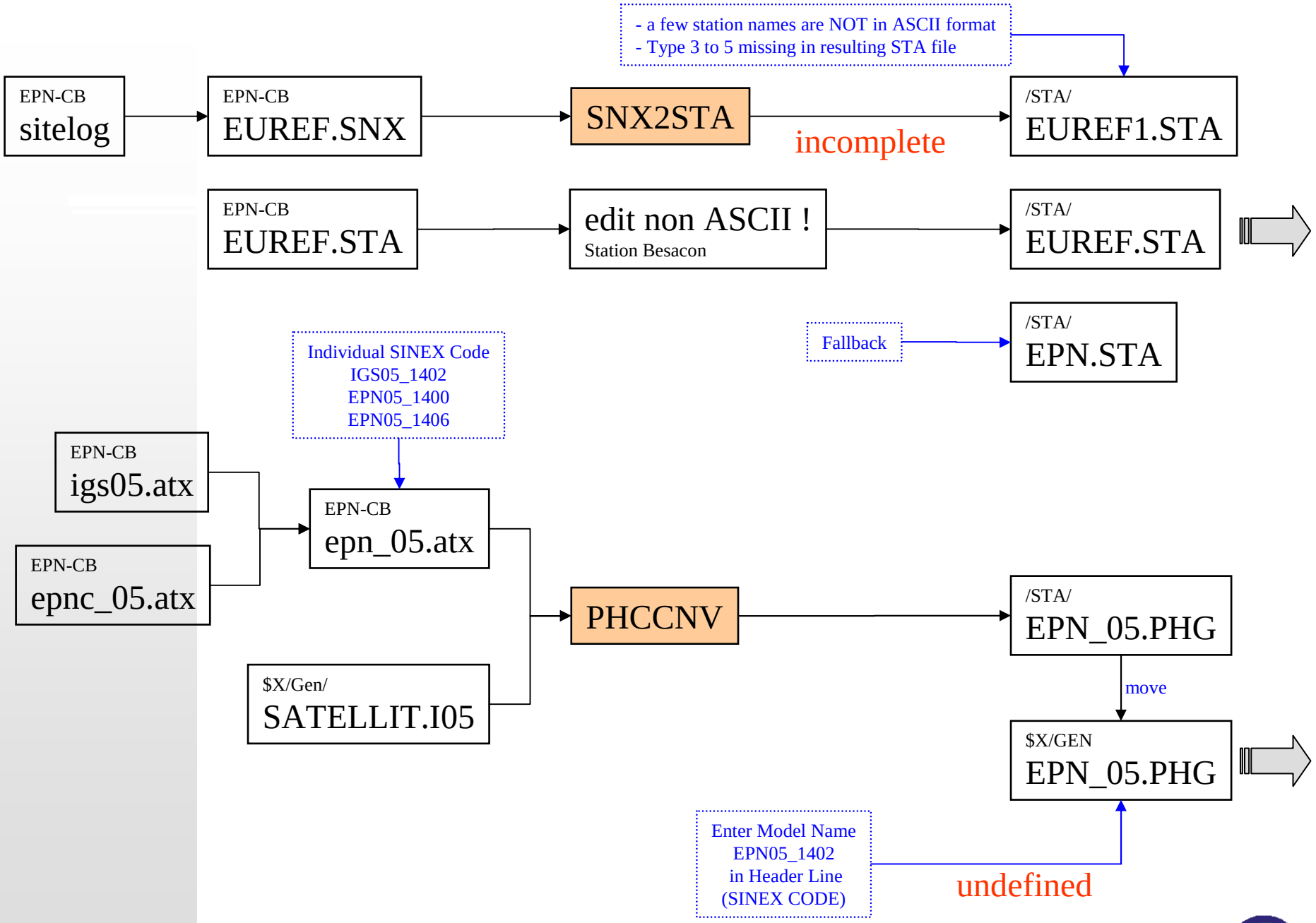
- Antennae absolute phase center variation (APCV)
- ITRF2005 reference frame
- Ocean tidal loading model update to FES2004
- Estimation of horizontal troposphere gradient parameters
- Use of low-elevation data (down to 3 degrees) permitted
- Inclusion of GLONASS observations permitted

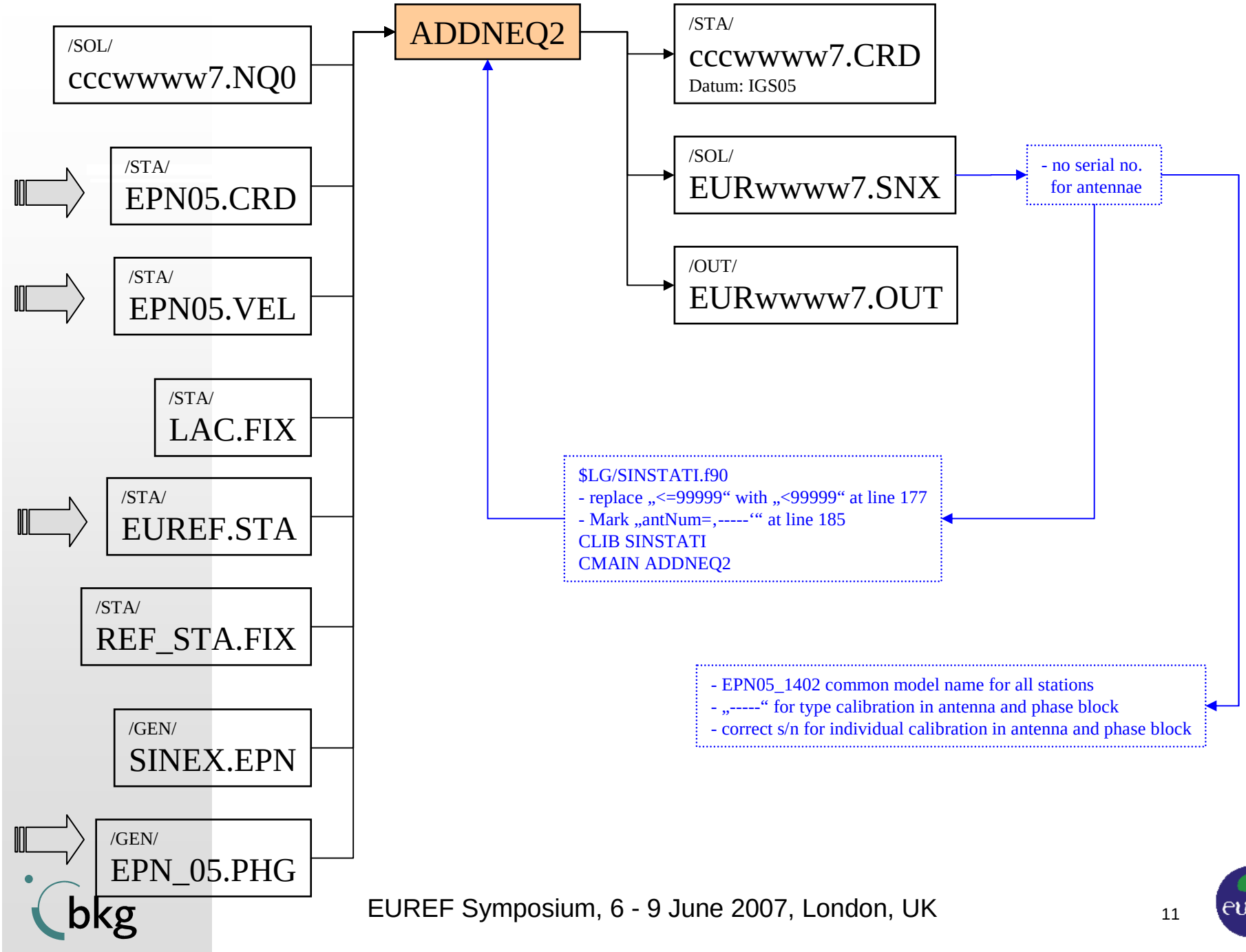
IGS05 Coordinate and Velocity Files



Extension of IGS Sites by EPN Sites




- a few station names are NOT in ASCII format
- Type 3 to 5 missing in resulting STA file
EPN-CB
sitelog
EPN-CB
EUREF.SNX
SNX2STA
incomplete
/STA/
EUREF1.STA
EPN-CB
EUREF.STA
edit non ASCII !
Station Besacon
/STA/
EUREF.STA
Fallback
/STA/
EPN.STA
Individual SINEX Code
IGS05_1402
EPN05_1400
EPN05_1406
EPN-CB
igs05.atx
EPN-CB
epnc_05.atx
EPN-CB
epn_05.atx
PHCCNV
$X/Gen/
SATELLIT.I05
/STA/
EPN_05.PHG
move
$X/GEN
EPN_05.PHG
Enter Model Name
EPN05_1402
in Header Line
(SINEX CODE)
undefined

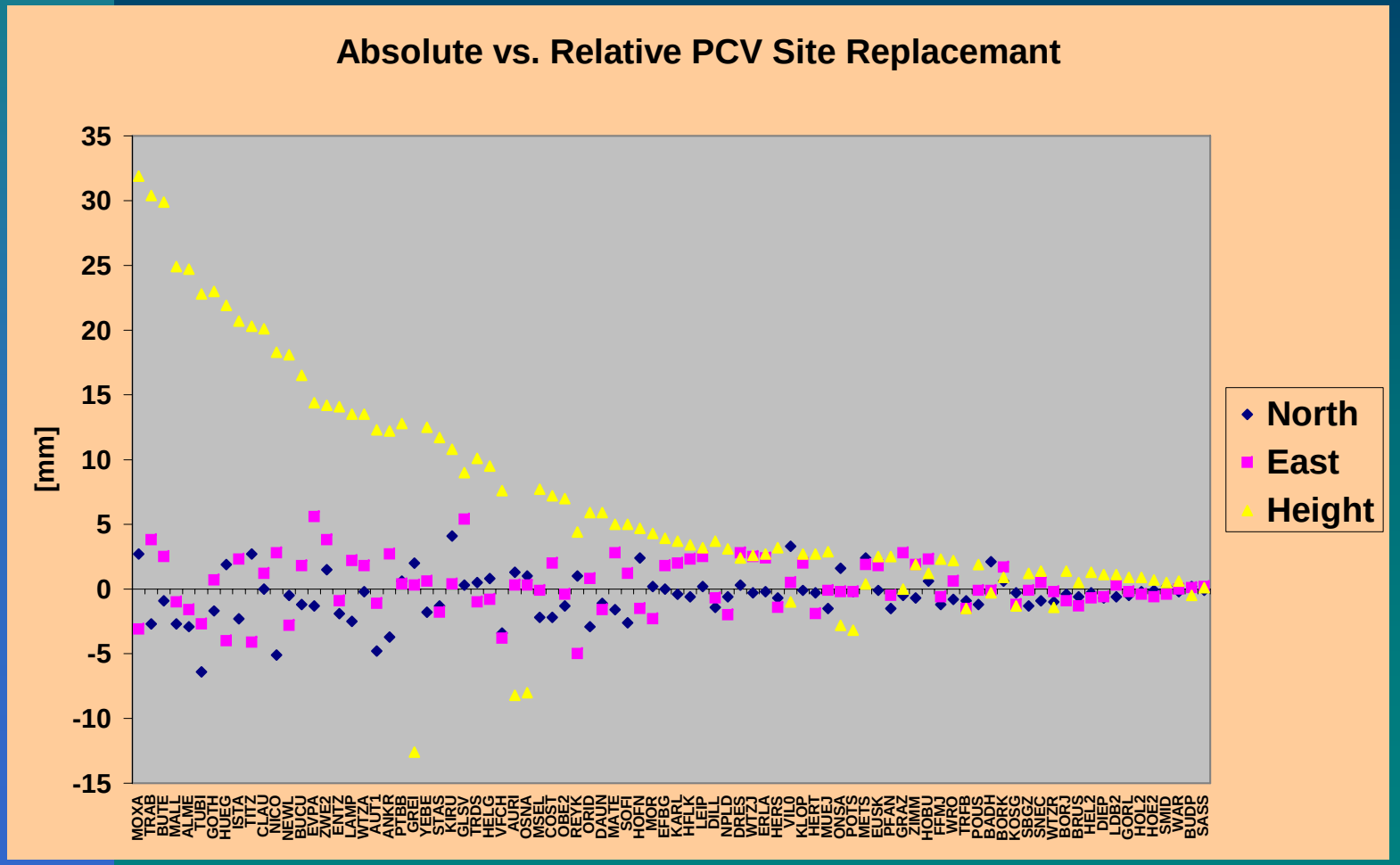

/SOL/
cccwwww7.NQ0
/STA/
EPN05.CRD
/STA/
EPN05.VEL
/STA/
LAC.FIX
/STA/
EUREF.STA
/STA/
REF_STA.FIX
/GEN/
SINEX.EPN
/GEN/
EPN_05.PHG
ADDNEQ2
/STA/
cccwwww7.CRD
Datum: IGS05
/SOL/
EURwwww7.SNX
/OUT/
EURwwww7.OUT
- no serial no.
for antennae
$LG/SINSTATI.f90
- replace „<=99999“ with „<99999“ at line 177
- Mark „antNum=,-----“ at line 185
CLIB SINSTATI
CMAIN ADDNEQ2
- EPN05_1402 common model name for all stations
- „-----“ for type calibration in antenna and phase block
- correct s/n for individual calibration in antenna and phase block

Receiver/Satellite Antennae

- Antenna type calibration of IGS extended by antennae individual numbers as far as available
  - IGS_05.ATX + EPNC_05.ATX = EPN_05.ATX
- Consideration of radome codes (different types of radome on one particular antenna type)
- Station-specific changes in height component up to 2 –3 cm expected!
  - Note: APCV impact will be mixed with more changes implemented at week 1400 !
    - (pre-study by BKG sub-network for week 1374)

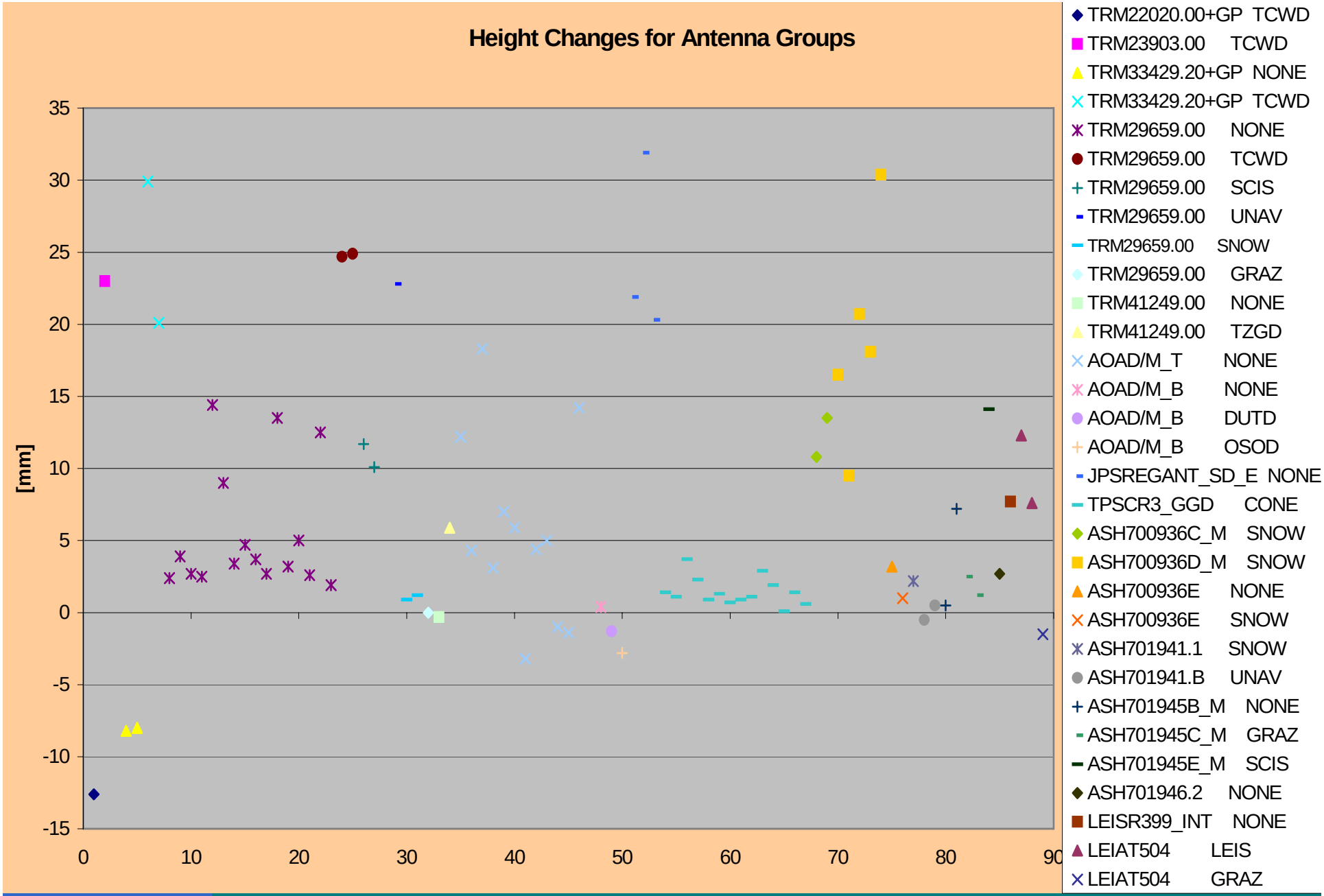
Relative vs. Absolute PCV
- BKG Sub-Network Week 1374 -

- Analysis by Peter Franke



Note

- The BKG sub-network was analysed with relative and absolute PCV numbers.
- Nearly 50 % of the stations experience height changes of larger than 5 mm
- It should be considered that minimum constraints have been applied to selected reference sites. This will restrict changes for the reference site coordinates.


Height Changes for Antenna Groups
[mm]
35
30
25
20
15
10
5
0
-5
-10
-15
0
10
20
30
40
50
60
70
80
90
TRM22020.00+GP TCWD
TRM23903.00 TCWD
TRM33429.20+GP NONE
TRM33429.20+GP TCWD
TRM29659.00 NONE
TRM29659.00 TCWD
TRM29659.00 SCIS
TRM29659.00 UNAV
TRM29659.00 SNOW
TRM29659.00 GRAZ
TRM41249.00 NONE
TRM41249.00 TZGD
AOAD/M_T NONE
AOAD/M_B NONE
AOAD/M_B DUTD
AOAD/M_B OSOD
JPSREGANT_SD_E NONE
TPSCR3_GGD CONE
ASH700936C_M SNOW
ASH700936D_M SNOW
ASH700936E NONE
ASH700936E SNOW
ASH701941.1 SNOW
ASH701941.B UNAV
ASH701945B_M NONE
ASH701945C_M GRAZ
ASH701945E_M SCIS
ASH701946.2 NONE
LEISR399_INT NONE
LEIAT504 LEIS
LEIAT504 GRAZ

Note

- The height changes evoked by the APCV have been ordered by antenna/dome types.
- For some types we observe common height changes, whereas other types shows several changes.
- The minimum constrained condition for the reference stations may affect this result.

ITRF2005 Reference Frame for EPN

- Updated reference coordinates and velocities
  - Reference coordinates are based on relative PCVs and could not by applied in GNSS analysis when using APCVs
  - Improved velocity vectors for many stations due to consideration of longer observation interval
  - Note differences between ITRF2000 and ITRF2005 (e.g., 1 cm shift in Z-direction and scale drift of $0.008*10^{-8}$)
- EPN analysis performed in IGS05
  - IGS05: Correction of station-specific height changes from parallel analysis with applying relativ resp. absolute PCVs and subsequent realignment to ITRF2005
- Updated transformation parameters to transform into ETRS89 realization

Transformation from IGS05 to ITRF2005 ?

- Is this transformation needed?
  - We need ITRF2005 to transform into ETRF2005 realization of ETRS89.
  - IGS05 has been aligned to ITRF2005 on the global level, but are there regional differences present?
  - Station-specific height differences could not be considered in a common set of Helmert transformation parameters. The transformation, as coordinate operation equally applied to all stations, becomes meaningless.

Coordinate Comparison: IGS05 vs. ITRF2005

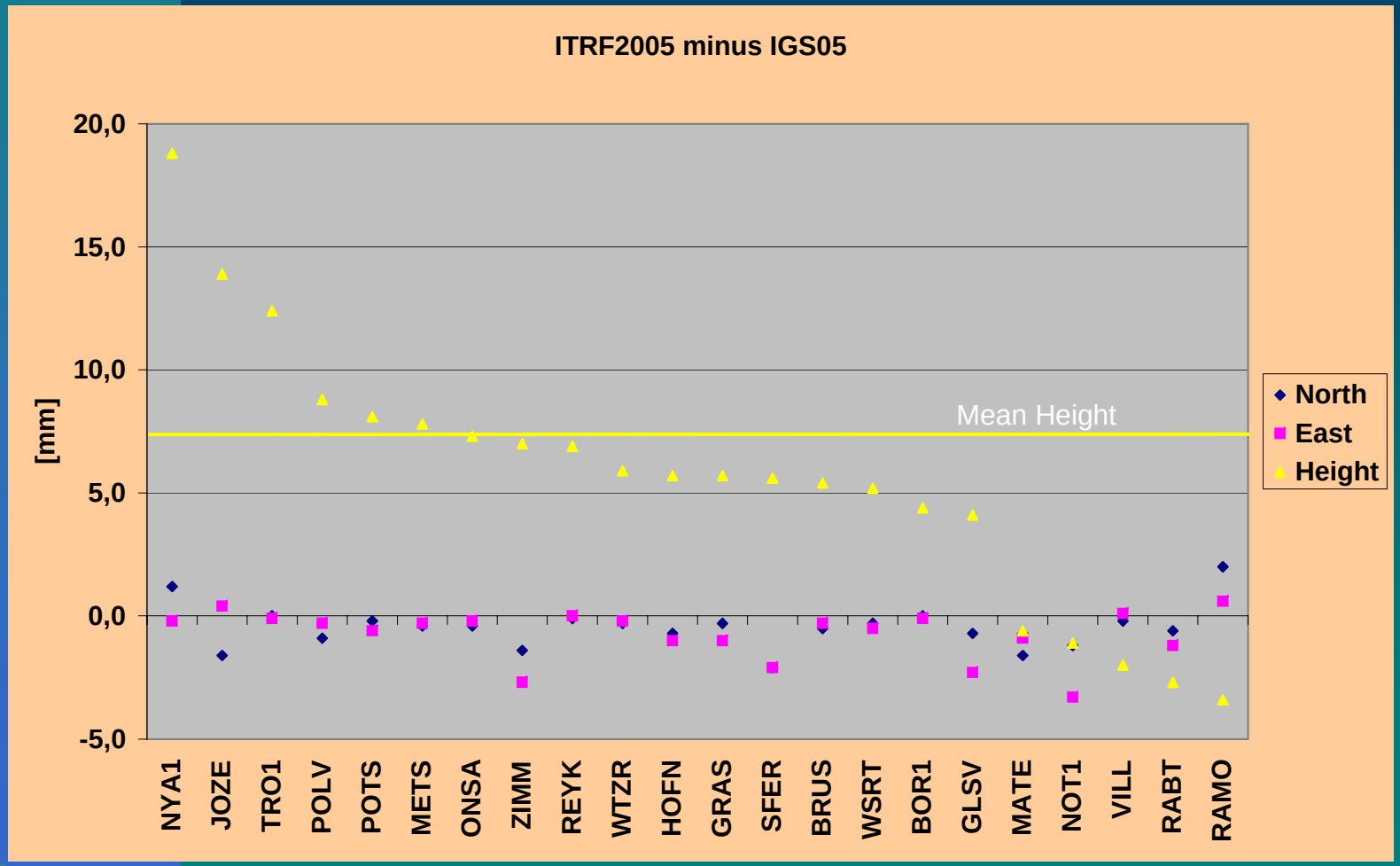
- Helmert transformation between IGS05 and IGT05 coordinates
  - IGT05 = IGS sites of ITRF2005
  - 3 Translation parameters: Regional 3D discrepancy of 5.7 mm for sub-network of EPN

File 1	File 2	TX [mm]	TY [mm]	TY [mm]	RMS N [mm]	RMS E [mm]	RMS U [mm]
IGS05 (global)	IGT05	0.0	0.0	0.0	1.5	1.3	7.4
IGS05 (EPN sites)	IGT05	-	-	-	1.0	1.3	7.9
		-3.3	0.1	-4.7	1.9	1.4	5.2

Note

- Global alignment of IGS05 to ITRF2005 confirmed by results of TX=TY=TZ=0
- Introduction of Translation improves RMS of Height component for 2.7 mm, but North component changes to the worse by 0.9 mm
- Regional discrepancy not significant
- Compare to station-specific height changes
- There may exist comparable discrepancy between GPS and other techniques (SLR, VLBI, DORIS,..)
- Additional transformation not recommended

Comparison IGS05 vs. ITRF2005
- EPN Sites of IGS05 -



Note

- Station-specific height changes clearly visible
- Correction of a mean height change, as would be applied by translation between IGS05 and ITRF2005, is not meaningful.
- Stations, where the difference exceeds the mean value, have been checked more detailed. But no systematics in terms of receiver/antenna type or geographical location could be detected.

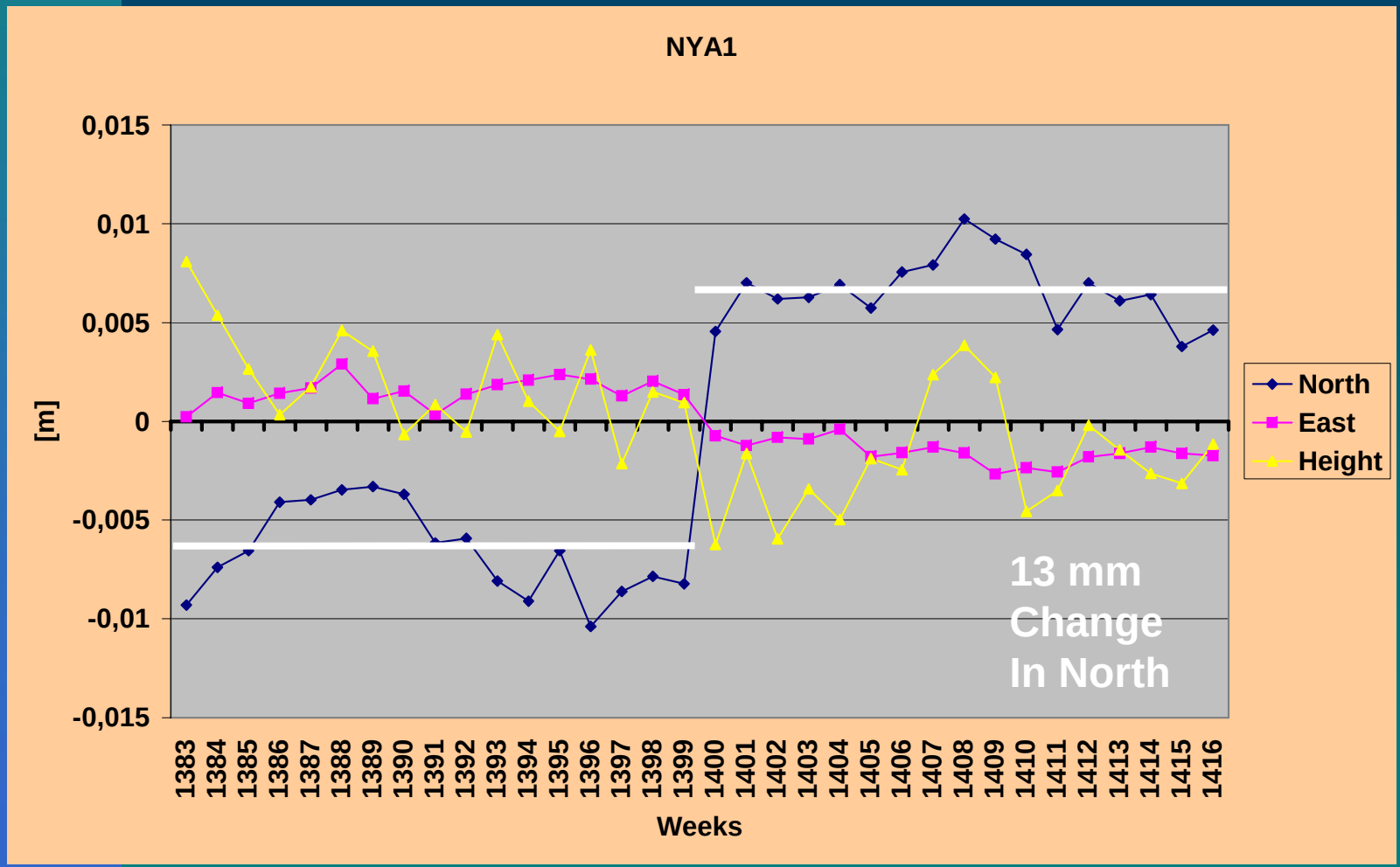
Station-Specific Height Changes

- IGS:
  - Appr. 1 year parallel processing of relative and absolute PCV
  - Estimation of station specific height changes
  - Subsequent alignment to ITRF2005
- EPN:
  - Parallel processing not performed, but optional
  - No set of „EPN05“ coordinates needed, after datum definition by IGS05

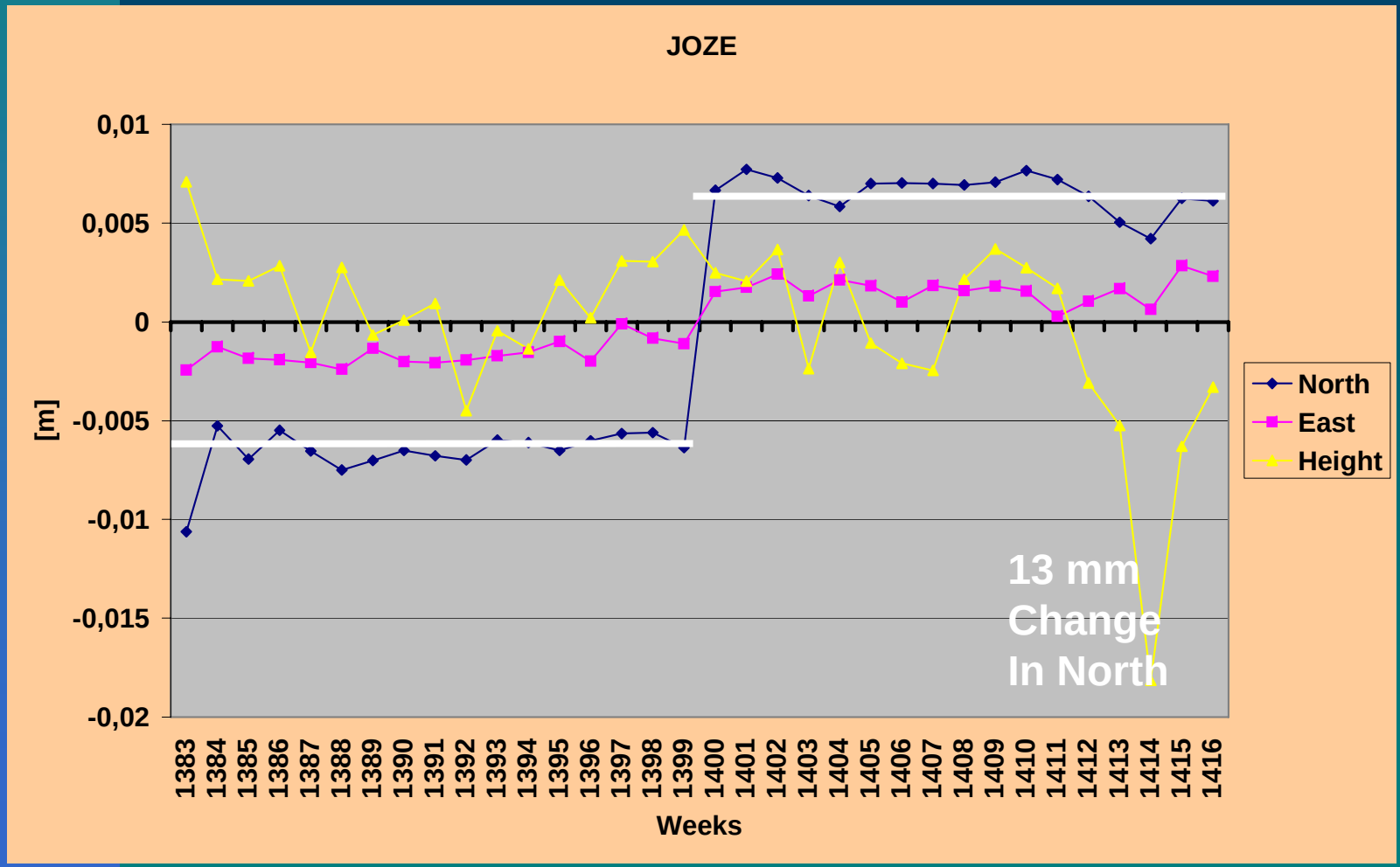
ITRF and ETRF Series
- Procedure -

- 17 weeks 1383 – 1399
  - Relative PCVs and ITRF2000
- 17 weeks 1400 – 1416
  - Absolute PCVs and IGS05
- ITRF: All coordinates shifted to week 1400 and compared
- Determination of changes
  - Mean over 2nd period minus mean over 1st period

ITRF Series cont.



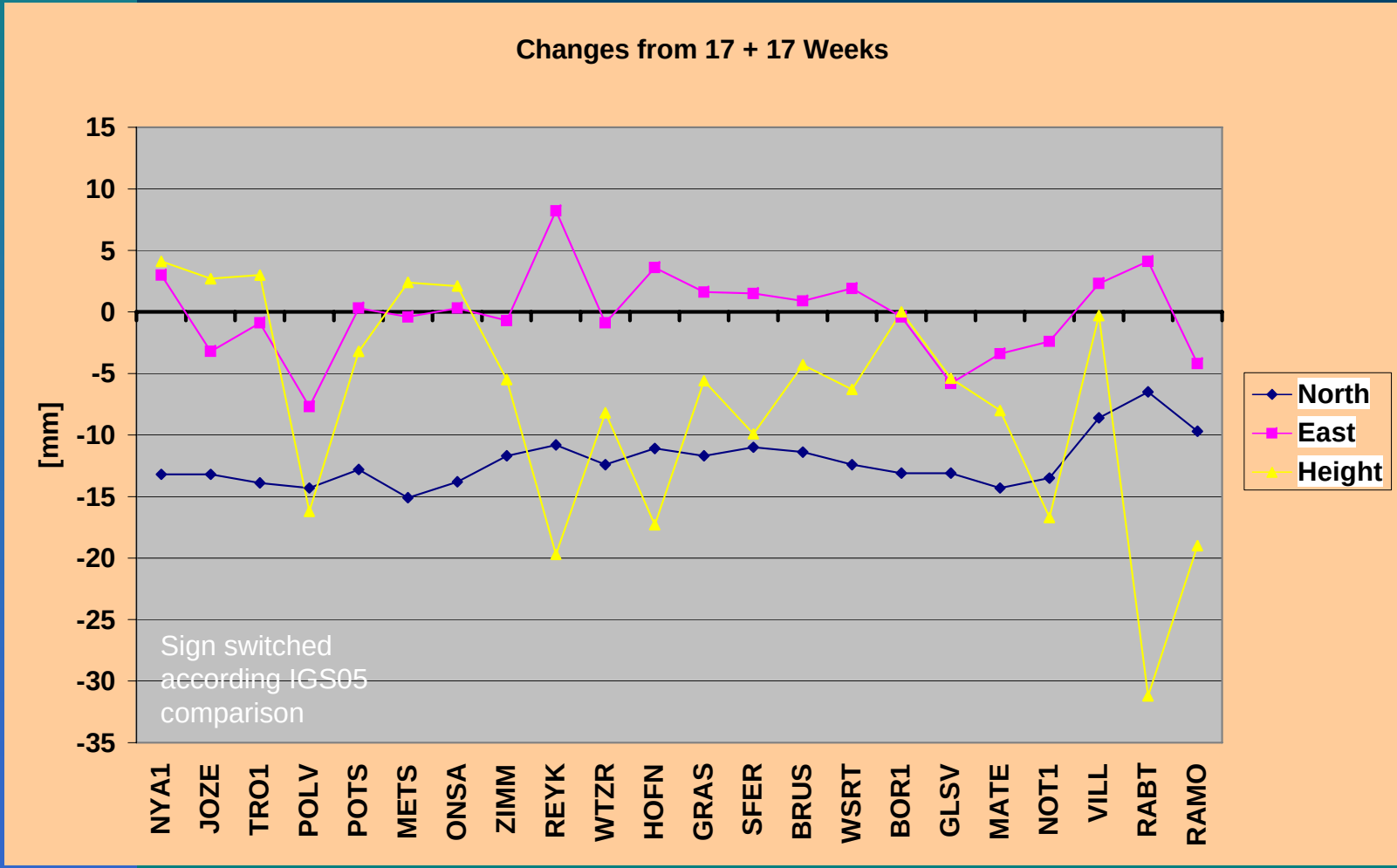
ITRF Series cont.



Note

- Weekly residuals as derived form the coordinate comparison have been shown for 2 stations as an example. We expect to observe significant height changes for these two stations from study of APCVs.
- The strategy to determine the coordinate changes has been shown.
- The following plots show such mean coordinate changes, in order to summarize the comparison.

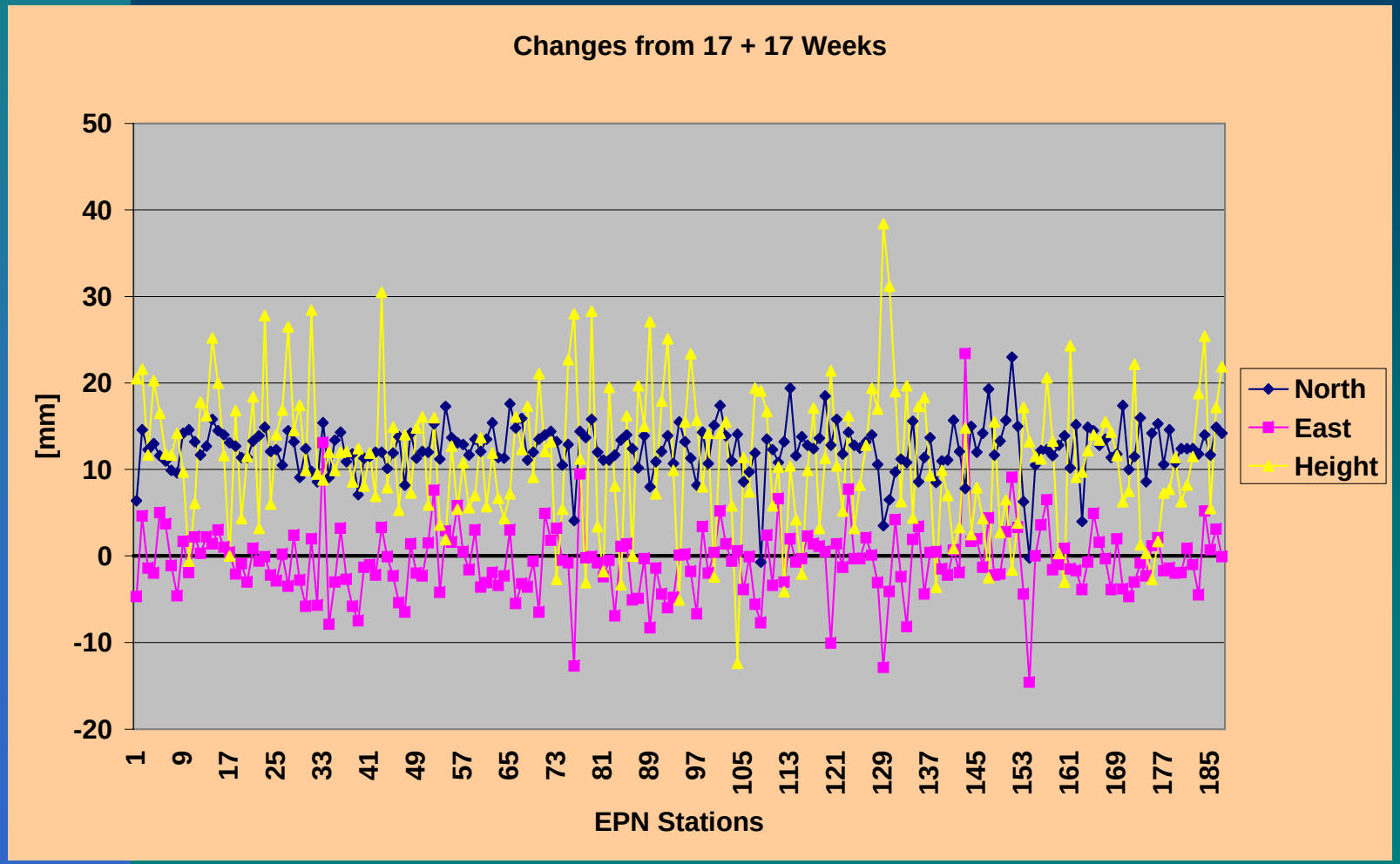
ITRF Series cont.
- *EPN Sites of IGS05* -



Note

- EPN of IGS05 is same order as used for IGS05 vs. ITRF2005 comparison,
  - The sign of residuals in this plot has been switch to be comparable to the IGS05 vs. ITRF2005 plot
- Station-specific height changes from IGS05 could not be confirmed
  - Expected height stations don‘t show up, e.g. we expect 19 mm for NYA1 and 14 mm for JOZE
  - All Height changes are shifted by approx. –15 mm
- Common shift in North direction
  - Mean of - 12.2 mm
- Caused by Z-shift of ITRF2005
- Remark: Station ISTA excluded in all HELMR Jobs!

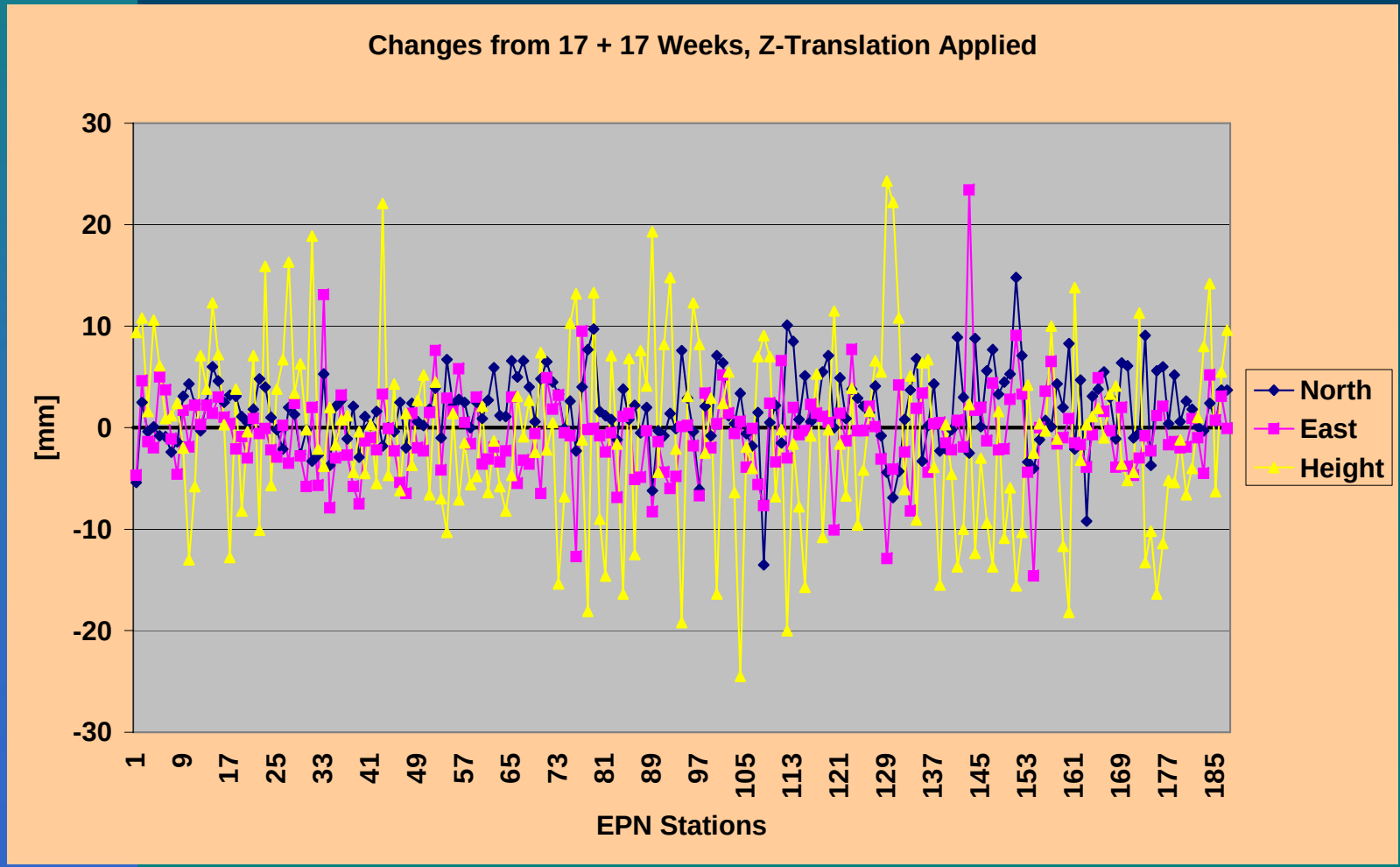
ITRF Series cont.
- All EPN Sites -



Note

- We observe a systematic change in North and Height component.
- The Heihgt components are superposed by station-specific changes.

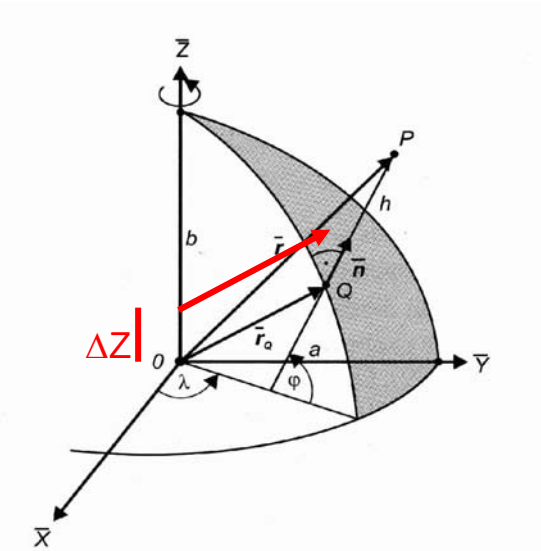
ITRF Series cont.
- Z-Shift of 16.2 +- 0.4 mm -



Note

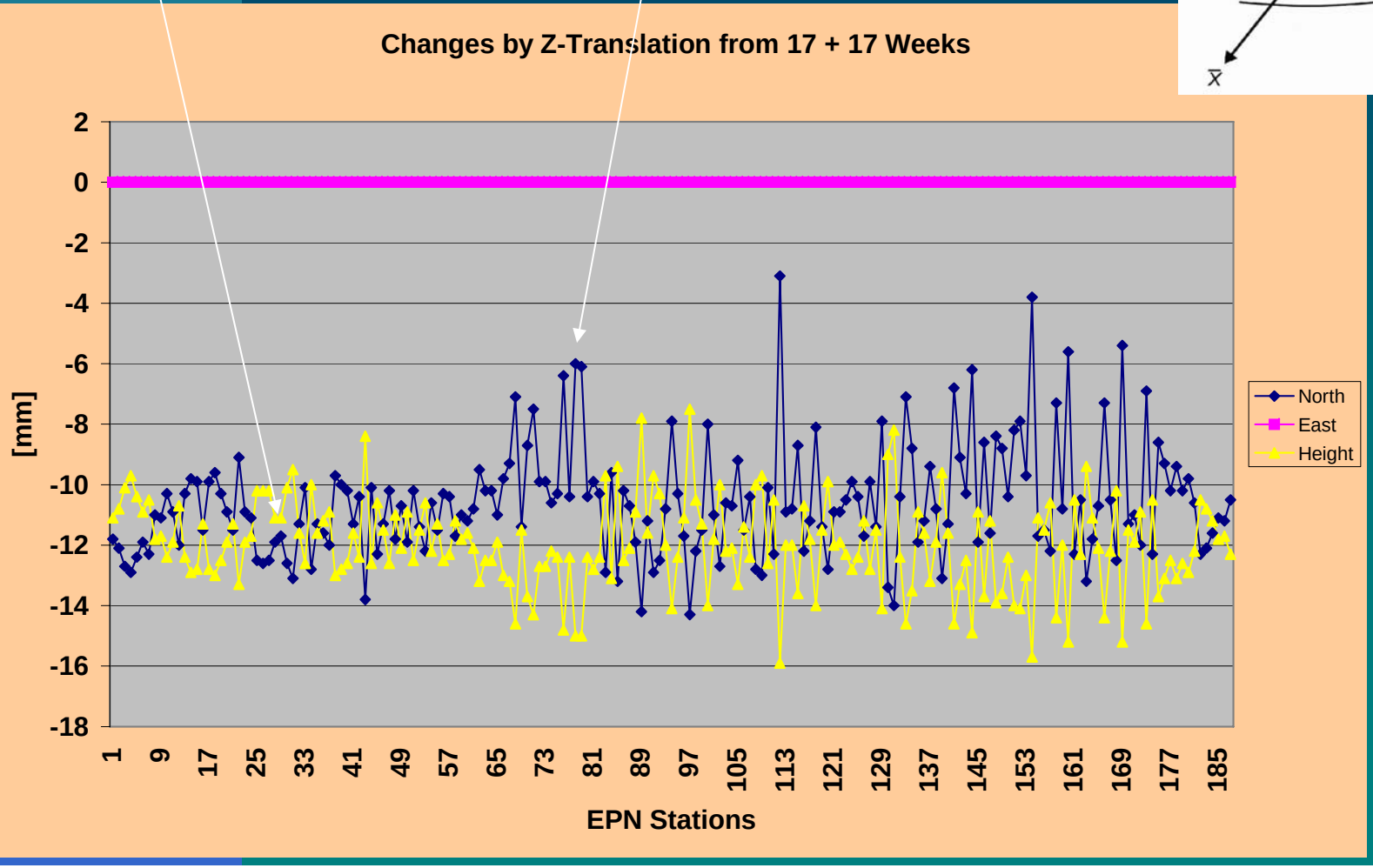
- A Helmert Transformation with 1 parameter for Z-Translation was estimated. Shown are the residuals.
- Systematic changes in North and Height component are removed by the Z-Translation
  - The 1 cm Z-Translation between ITRF2000 and ITRF2005 was „re-covered“ by this approach.
  - The discrepancy between the nominal value of 1 cm and the estimated 1.6 cm may be a regional effect.
- Station-specific Height changes remain visible

ITRF Series cont.
- Z-Shift for EPN -



Mean latitude station

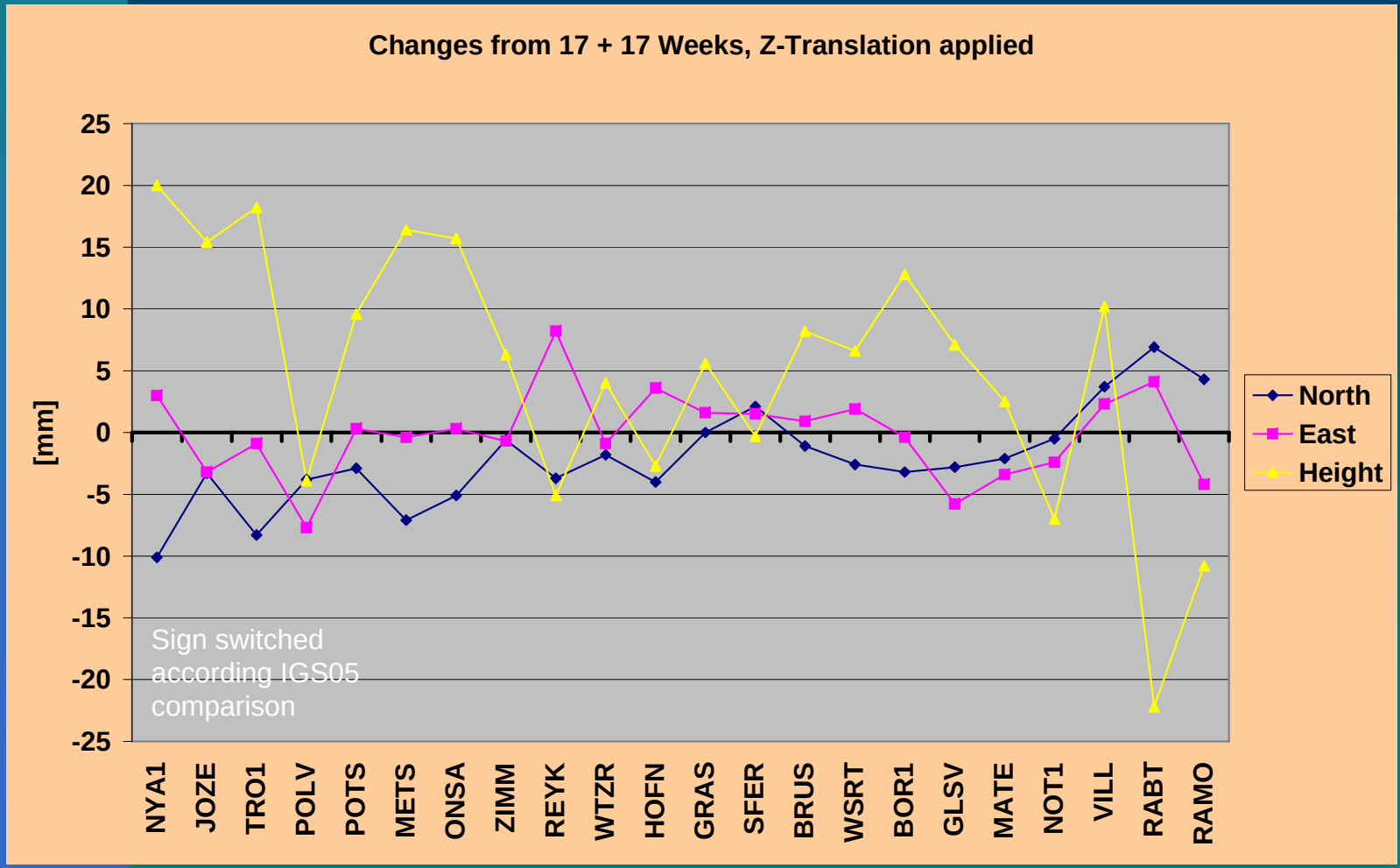
High latitude station



Note

- Differences between a comparison with and without a Z-Shift are shown
- The Z-Shift affects only the North and the Height component.
- In mean latitude Z-Shift results into nearly equally correction for North and Height, but for higher latitude the correction shows up more in the height component and less in the north component.

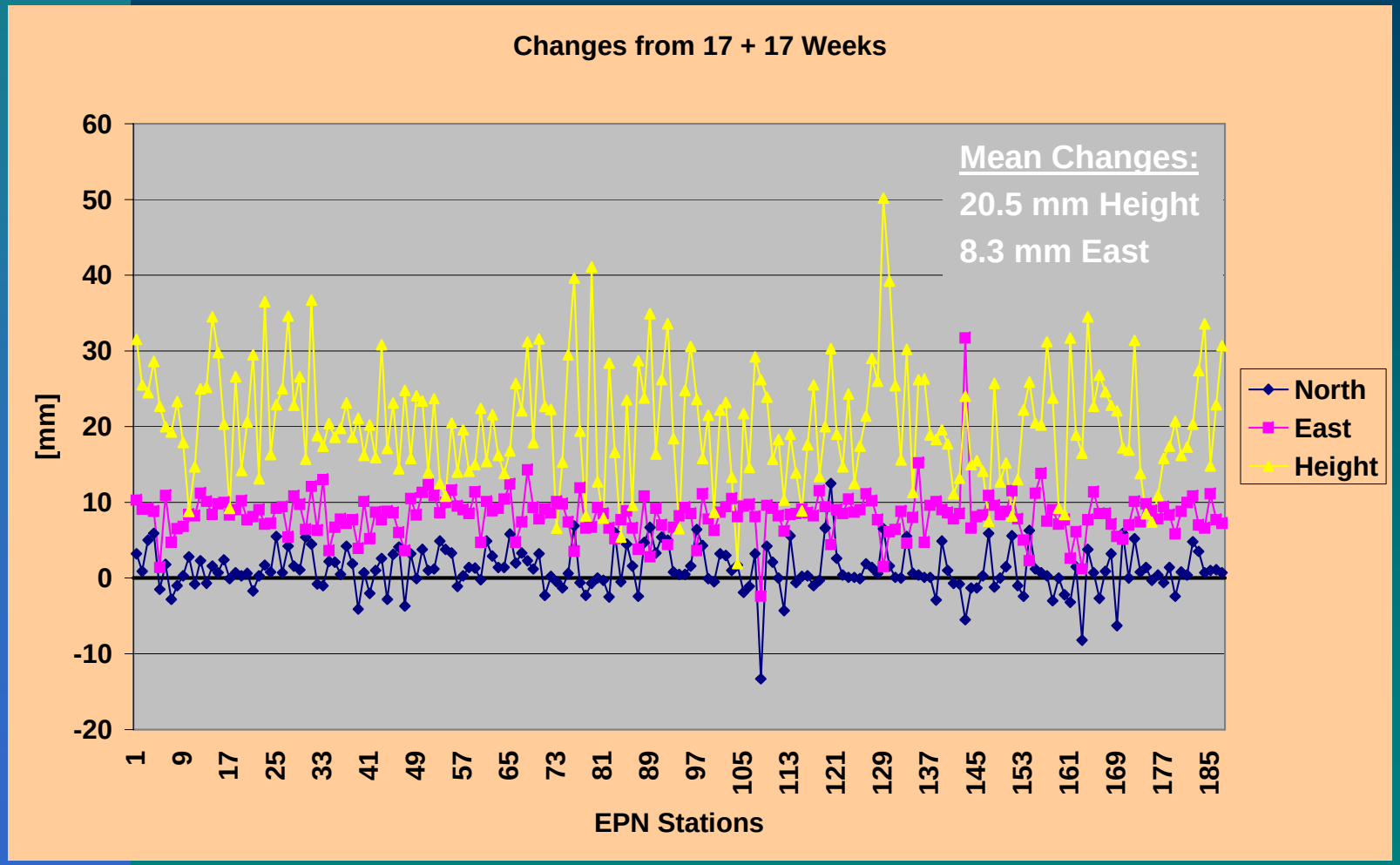
ITRF Series cont.
- EPN Sites of IGS05, Z-Shift -



Note

- Station-specific height changes are now in general agreement to the IGS05 vs. ITRF2005 comparison
- Differences in latitude for the EPN sites have not been taken into account for this study.

ETRF Series


Changes from 17 + 17 Weeks
Mean Changes:
20.5 mm Height
8.3 mm East
North
East
Height
[mm]
60
50
40
30
20
10
0
-10
-20
1
9
17
25
33
41
49
57
65
73
81
89
97
105
113
121
129
137
145
153
161
169
177
185
EPN Stations

Note

- Two mean coordinates in ETRF have been calculated for the weeks 1383-1399 and 1400-1416 respectively for each station. The difference is called „Change from 17 + 17 weeks“
- The systematic differences depend directly on the parameters to transform from ITRF2005 into ETRF2005.
- The systematic height difference is superposed with station-specific height changes, which are probably caused by the introduction of APCVs.
- Although the rotation of the European plate affects the horizontal position only, we have seen before that a Z-Shift of the ITRF will change North and Height for EPN stations.
- We habe to accept the systematic changes in Height and East.

Results from Coordinate Series
- Summary -

- Additional alignment of IGS05 to ITRF2005 is not recommended.
- Z-Shift of 1 cm between ITRF2000 and ITRF2005 leads to EPN coordinate changes in the north and height components.
- New parameters for ITRF2005 to ETRF2005 transformation lead to changes in east (8 mm) and height (20 mm) components in the ETRF series, where the height changes are superposed by the station-specific height changes.

EPN Rapid Solutions

- Scope:
  - Monitoring
  - High resolution coordinates
- Options:
  - Option 1, daily SINEX files from IGS final orbits
  - Option 2, daily SINEX files from IGS rapid orbits
  - Option 3, daily SINEX files from both, IGS final and rapid orbits
- Realization of Option 3
  - As result of questionnairre among LACs

Daily Combination from Rapid IGS Orbits

- Product generation at 22:50 UTC every day
- Product delay of < 1 day
- Product files:
  - `EURwwwwdR.CRD/SNX/SUM` , d=[0-6]
  - `EURwwwwMR.CRD/SNX/SUM` , combination of the 7 most recent days

Daily Combination from Final IGS Orbits

- Product generation at 04:20 UTC every day
- Product delay of currently 30 days
- Product files:
  - `EURwwwwd.CRD/SNX/SUM` , d=[0-6]
  - `EURwwwwM.CRD/SNX/SUM` , combination of the 7 most recent days

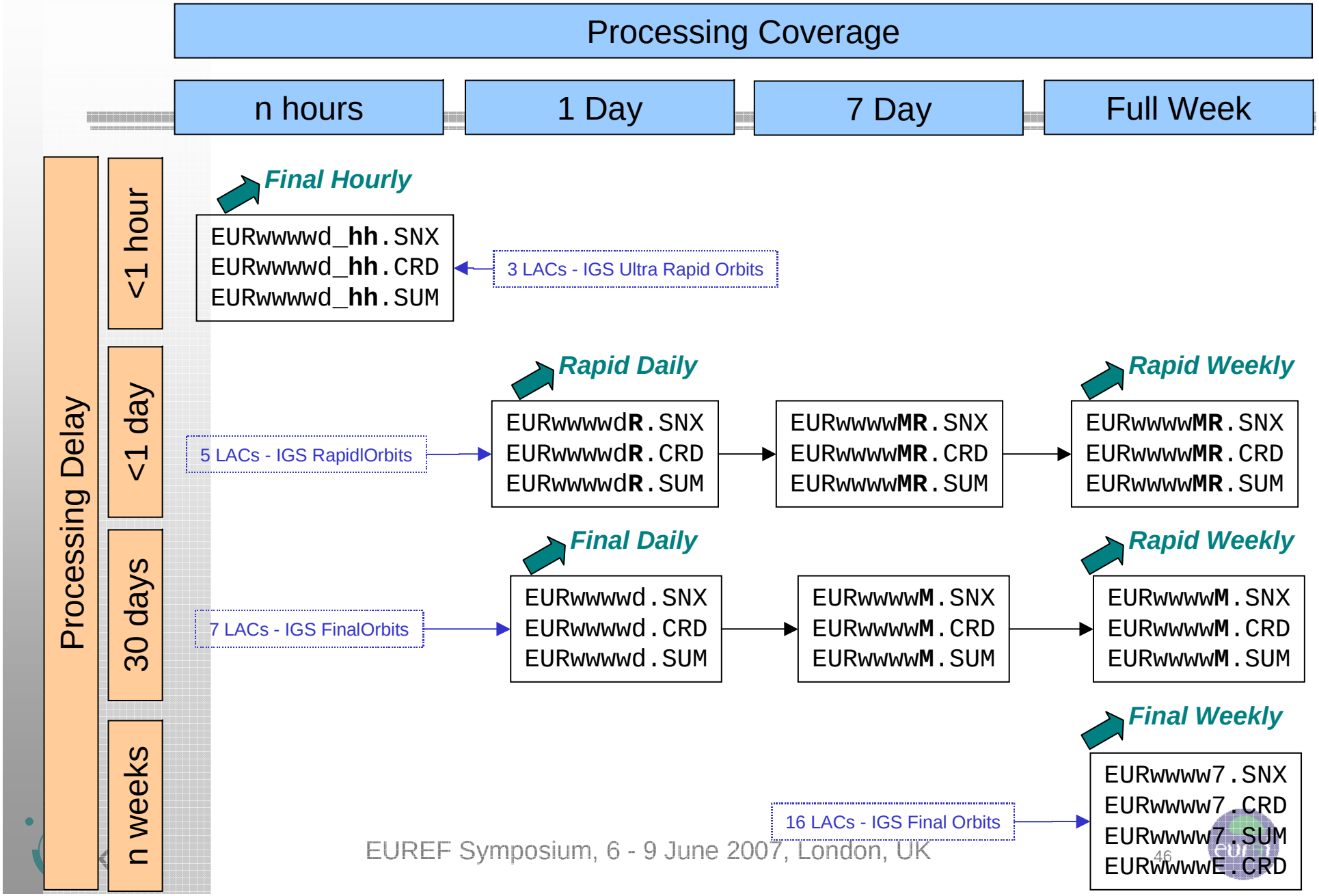
Daily Combination
- References -

- More details about the development of the daily products are available in
  - EPN LAC-Mail no. 0755, 0758, 0759 and 0778,
  - EUREF-Mail no. 3331

Near Real-Time Solutions
- Demonstration Phase -

- 3 LACs involved: BKG, LPT and NKG
- Hourly SINEX files:
  - `acnwwwwd_hh.snx`
  - `EURwwwwd_hh.snx/sum/crd` , where d = [0-6] day of the week and hh = 00 - 23 hour of the day
- Sub-directories BKG data centre:
  - EUREF/products/wwww/nrtd ,where d = [0-6] day of the week "nrt" is a fixed name and indicates the near real-time meaning of the sub-directories.
- Schedule
  - Each hour at minute 55. It results in a latency of < 1 hour

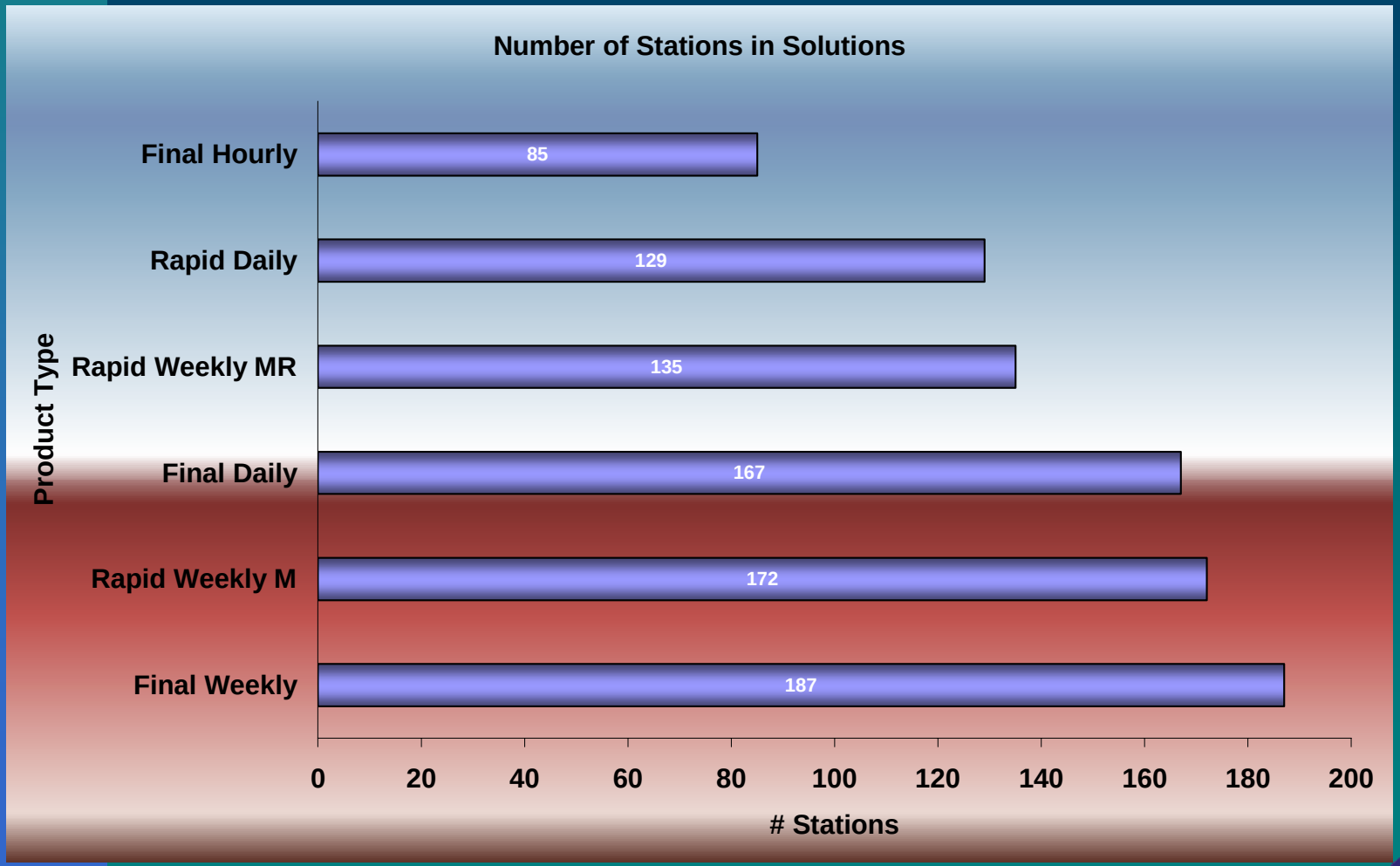
Full EPN Combination Product Series



Rapid Product Holdings

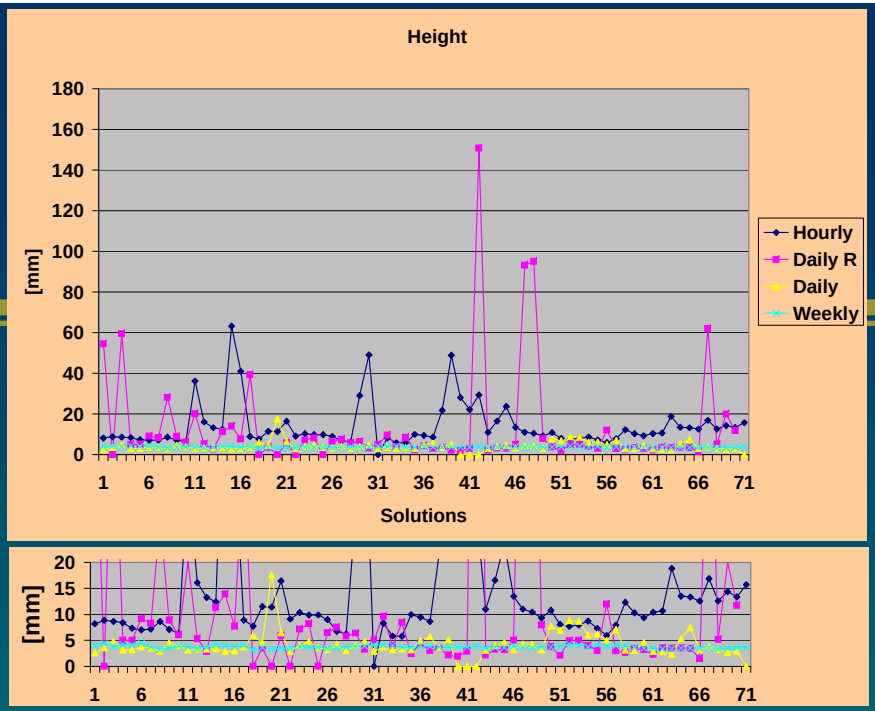
```
EPN Rapid Products Summary

Date: 2007-05-30 13:11
wwww=Week, d=Day, _D=Final Daily, RD=Rapid Daily, [00-23]=Hourly
-------------------------------------------------------------------------------------------
#Contributions
wwwwd _D RD 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23
-------------------------------------------------------------------------------------------
14293        2  2  2  2  2  2  2  2  2  2  2  2
14292        2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14291     4  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14290     4  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14286     4  2  2  2  2  2  2  1  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14285     4  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14284     4  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14283     4  2  2  2  2  2  2  1  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14282     4  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14281     4  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14280     4  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14276     2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14275     3  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14274     3  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14273     3  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14272     3  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14271     2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14270     2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14266     3  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14265     3  1     2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
14264     3        1  1  1  1  1  2  2  2  2  2  2  2  1  1  1  1  1  1  1  1  1  1
14263     3  1  1  1  1  1  1  1  1  1  1  1  1     1  1  1  1  1
14262     3  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
14261     4
14260     4
14256     4
14255     3
14254     4
14253     4
14252
14251  6  4
14250  6
14246  6
14245  6  5
14244  6  4
14243  6  3
14242  6  3
14241  6  3
14240  5  3
14236  6  4
```

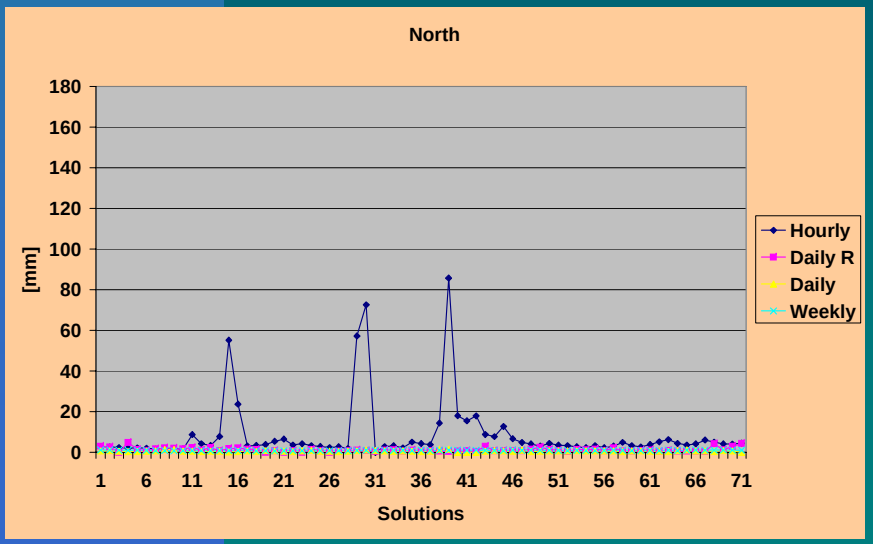
Rapid Product Stations

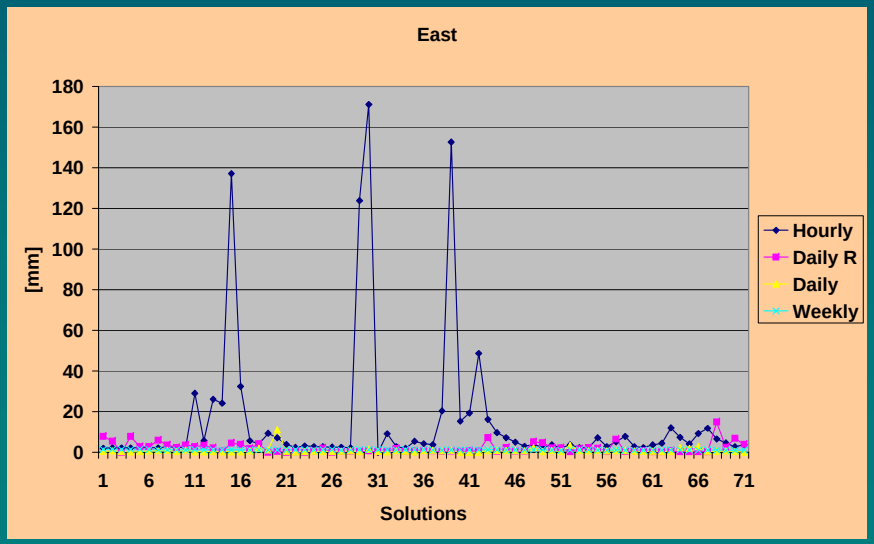


Rapid Product Series

Repeatability of 70 solutions





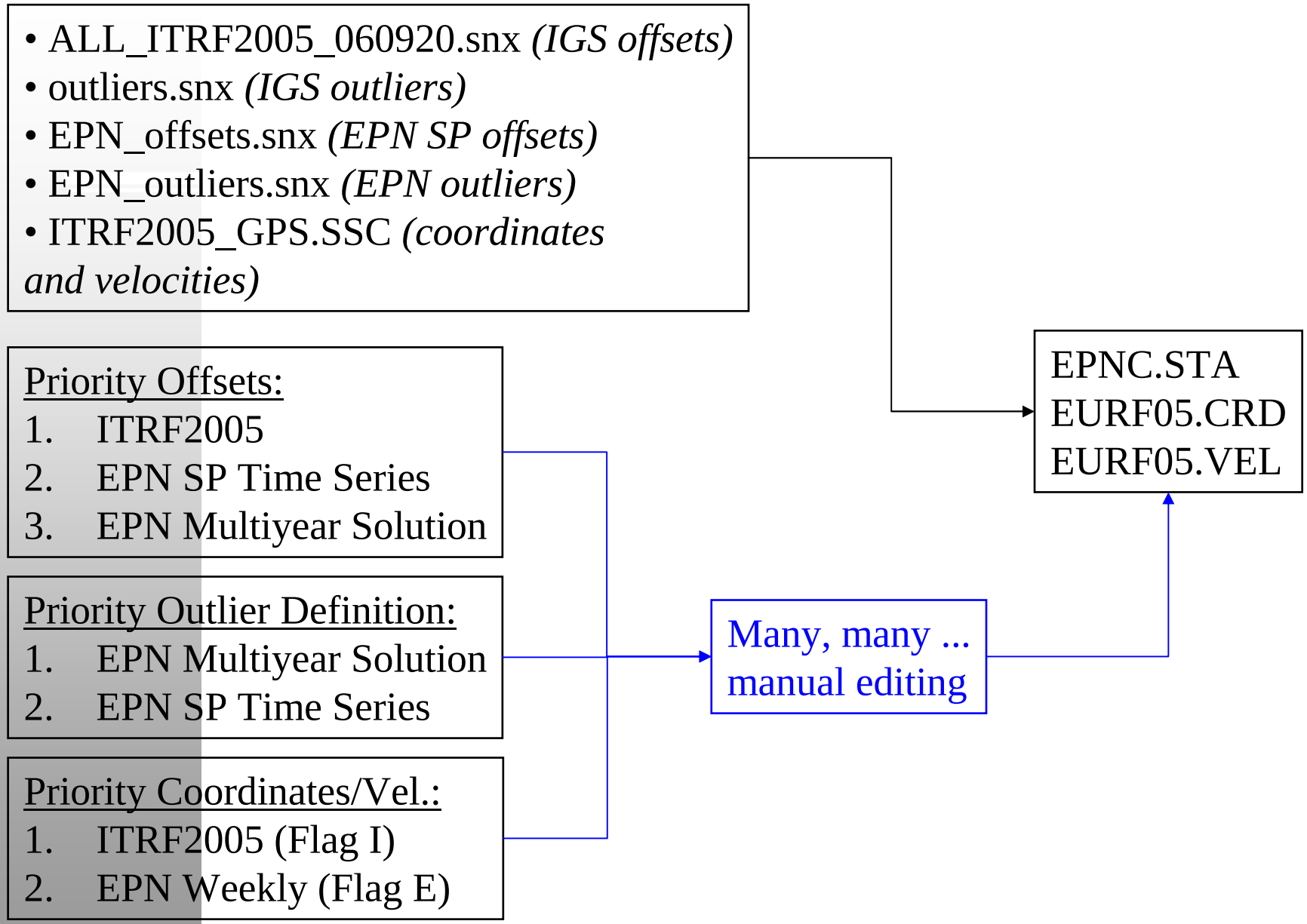


Note

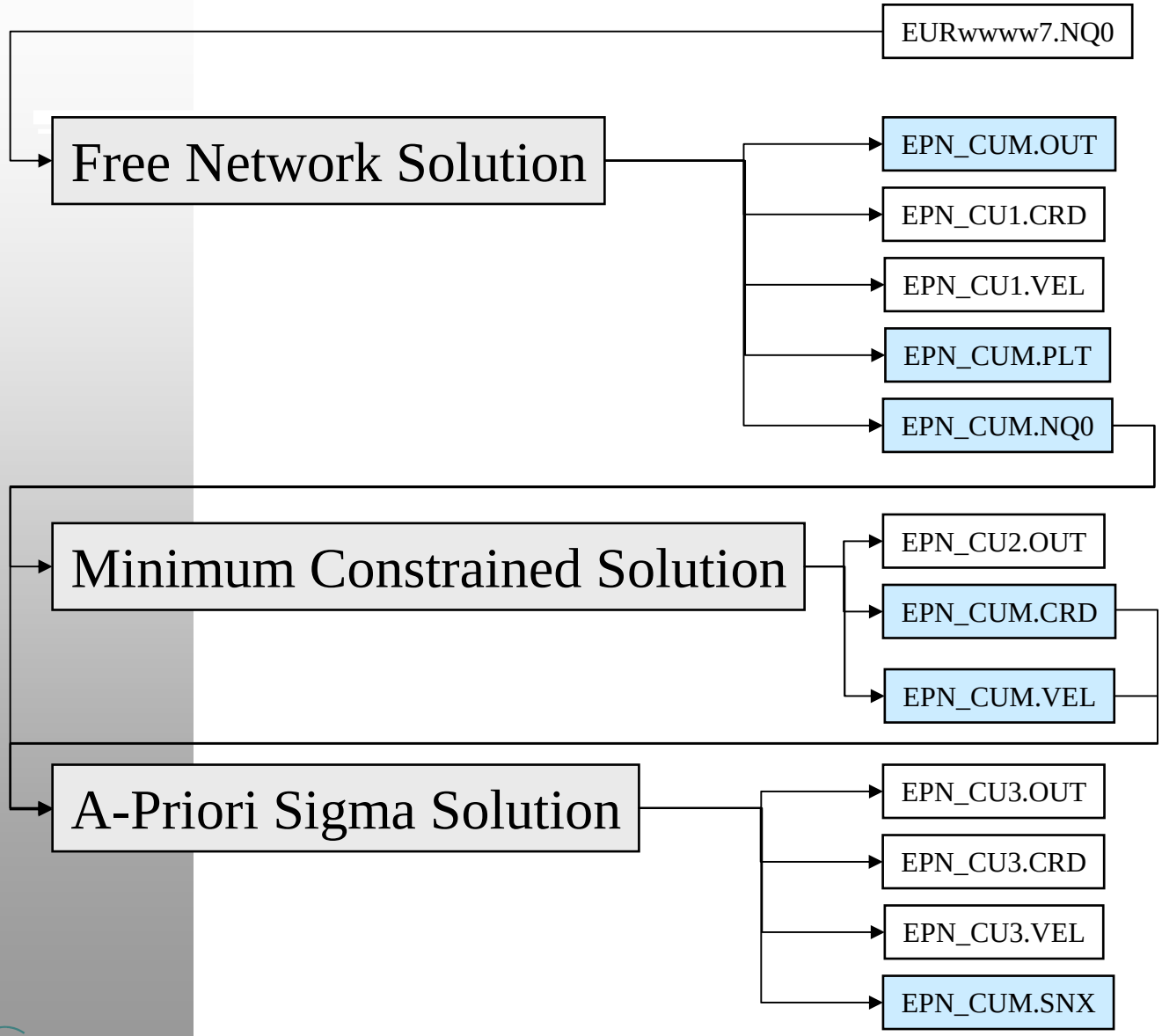
- Shown are 70 solutions of each series, which don‘t cover a common period of time.
- Repeatability of North and East component of the weekly solutions exceed the daily and rapid daily results. This may be explained by the fact that the weekly solutions cover mostly the time before week 1400 changes, but daily solutions refer to the time after that event.

ITRF2005 Densification

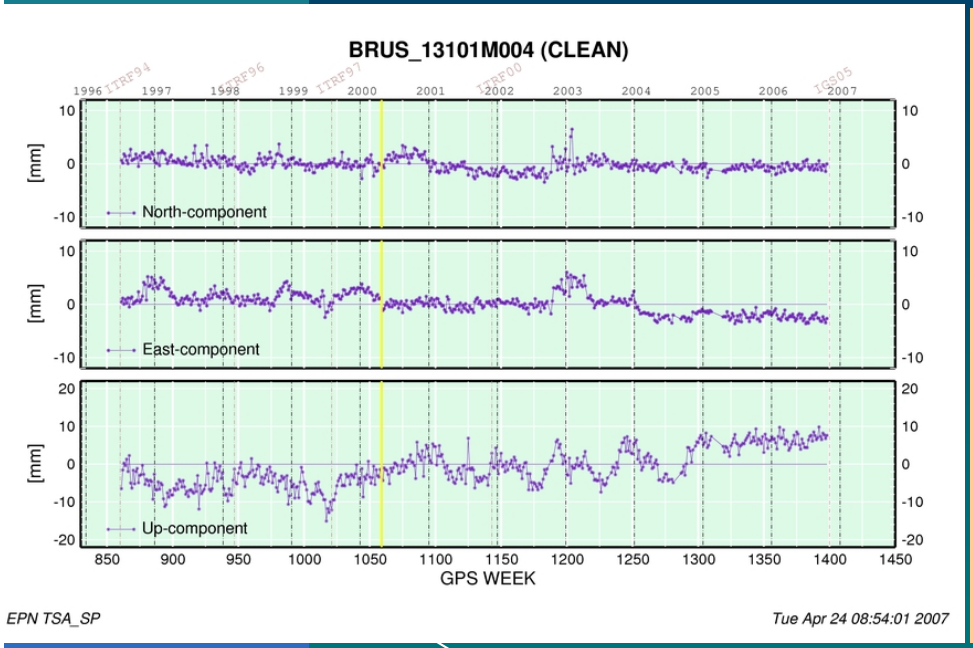
- Definition of discontinuities (solution numbers) and outliers primarily according to ITRF2005
- Realization of reference frame through ITRF2005
- Long computing time of MCC solution (> 3 h) avoided by intermediate combined free network solution
- All outstanding residual and singularities in multi-year solution removed
- Current problem:
  - During process of manual editing of discontinuities and outliers output of SINEX failed with error in “SINSTORE” !

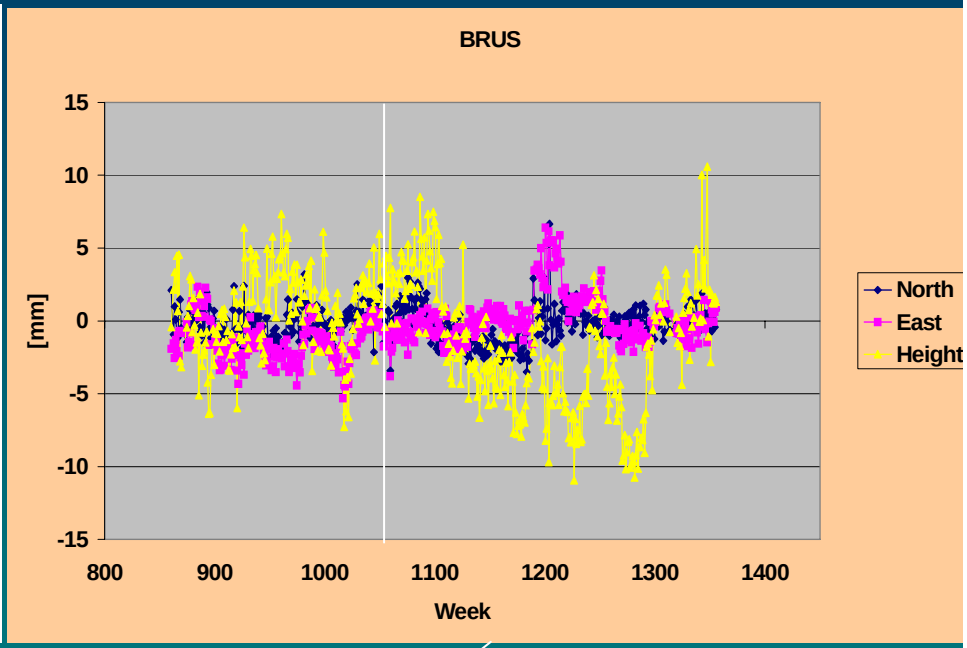

• ALL_ITRF2005_060920.snx (IGS offsets)
• outliers.snx (IGS outliers)
• EPN_offsets.snx (EPN SP offsets)
• EPN_outliers.snx (EPN outliers)
• ITRF2005_GPS.SSC (coordinates and velocities)
Priority Offsets:
1. ITRF2005
2. EPN SP Time Series
3. EPN Multiyear Solution
Priority Outlier Definition:
1. EPN Multiyear Solution
2. EPN SP Time Series
Priority Coordinates/Vel.:
1. ITRF2005 (Flag I)
2. EPN Weekly (Flag E)
Many, many ... manual editing
EPNC.STA
EURF05.CRD
EURF05.VEL

EPN Multiyear Solution Strategy



ITRF2005 Densification



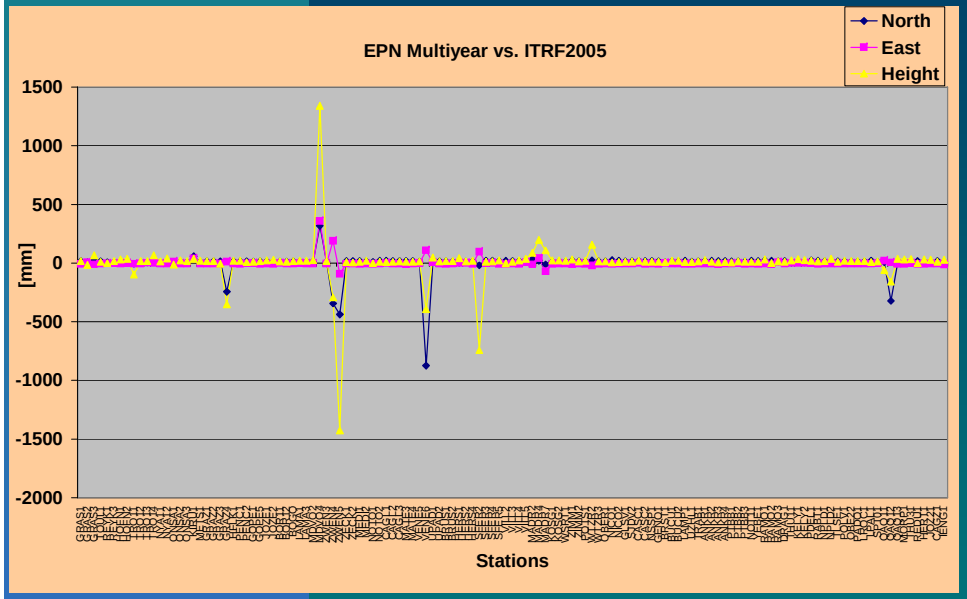


Estimated Velocity in mm

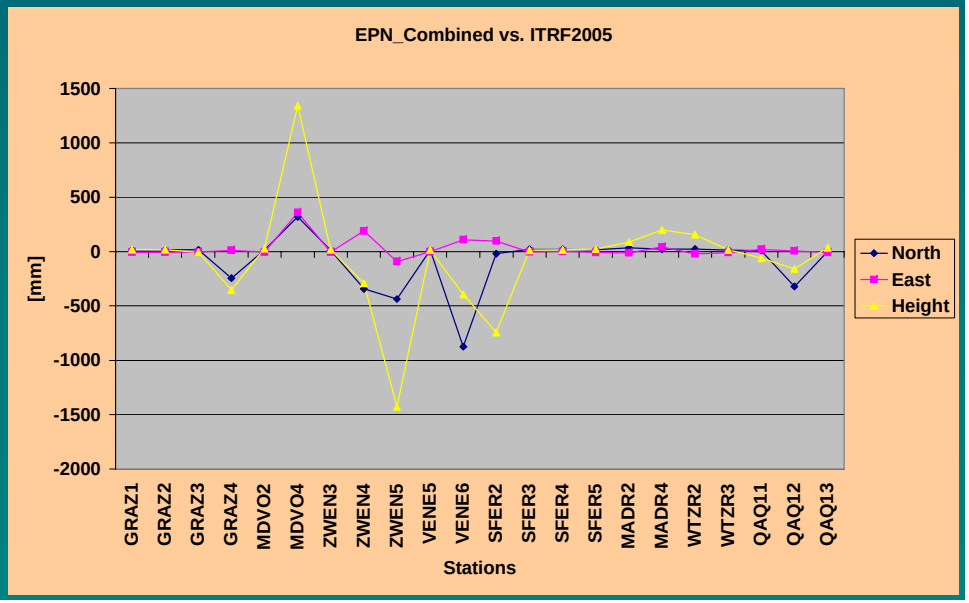
2 solutions caused by antenna change

Weeks	North	East	Height	North	East	Height
860 – 1059	15.7	17.1	1.5	16.3	15.0	2.2
1060 – 1355	15.7	17.0	1.5	16.7	15.5	0.7

ITRF2005 Densification



- Shown are the reference solutions
- Some solutions have to be removed from reference
- Data interval too small?
- To be improved...



- For any suggestions and questions related to EPN analysis please contact

heinz.habrich@bkg.bund.de

Thank you