



# EPN Analysis – Products and Report

---

Heinz Habrich

*EPN Analysis Coordinator*

Federal Agency for Cartography and  
Geodesy, Frankfurt, Germany

# Outline

---

- Status of Local Analysis Centres
- Status of sub-network combination
- (ITRF 2005 Densification)
- Short latency / high resolution products
- EPN Local Analysis Center Workshop 2008

# Status of Local Analysis Centres

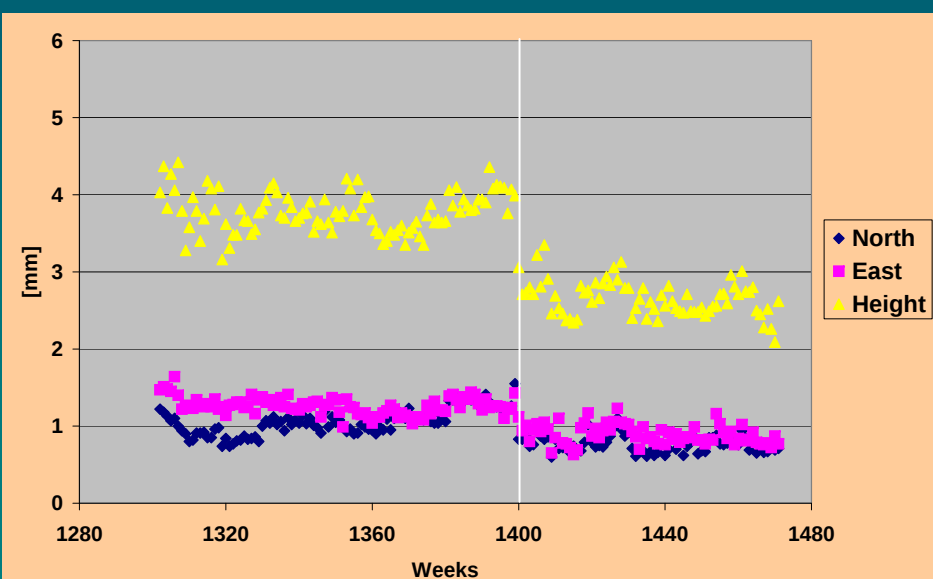
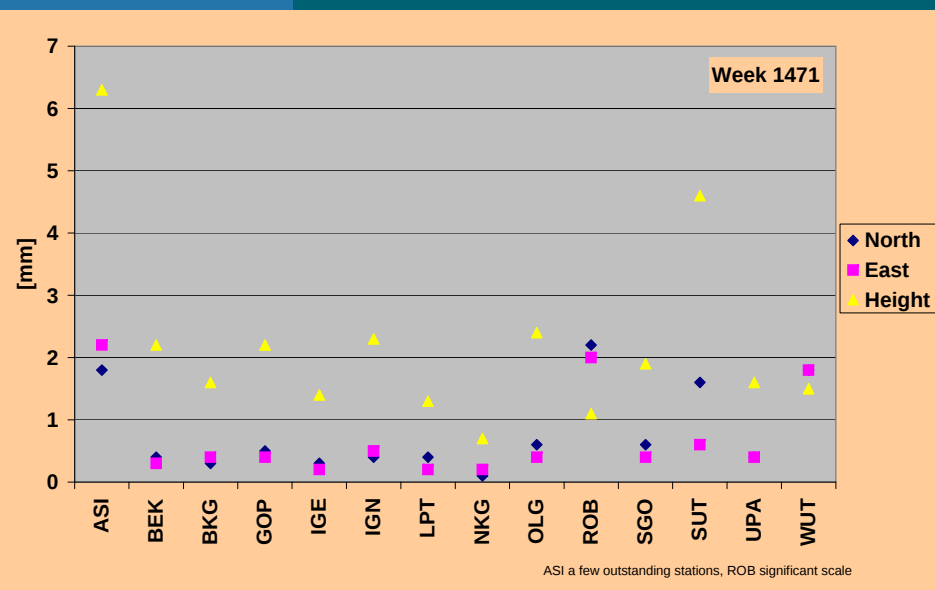
|     |                    |              |              |               |         |                |
|-----|--------------------|--------------|--------------|---------------|---------|----------------|
| ASI | MicroCosm 2005.0   | Final Weekly | Final Daily  | Rapid Daily,  | Hourly  | <u>GLONASS</u> |
| BEK | Bernese 5.0        |              | Final Daily, | Rapid Daily,  | Hourly  |                |
| BKG | Bernese 5.0        |              | (.)          |               |         |                |
| COE | Bernese 5.1        |              |              |               |         |                |
| DEO | GIPSY v2.5/cov2snx |              | Final Daily, | Rapid Daily   |         |                |
| GOP | Bernese 5.0        |              |              |               |         |                |
| IGE | Bernese 5.0        |              |              |               |         |                |
| IGN | Bernese 5.0        |              |              |               |         |                |
| LPT | Bernese 5.0        |              | Final Daily  | Rapid Daily,  | Hourly, |                |
| NKG | Bernese 5.0        |              |              |               |         |                |
| OLG | Bernese 5.0        |              |              |               |         |                |
| ROB | Bernese 5.0        |              |              | Rapid Daily   |         |                |
| SGO | Bernese 5.0        |              |              | Rapid Daily   |         |                |
| SUT | Bernese 5.0        |              | Final Daily  |               |         |                |
| UPA | Bernese 5.0        |              | Final Daily, | (Rapid Daily) |         |                |
| WUT | Bernese 5.0        |              | Final Daily  |               |         |                |

# Status of Sub-Network Combination

## Indication of Precision

### Precision between LACs

### Day to Day Repeatability



# EUREF Regional Densification of ITRF2005 - Scope

---

- Cumulative solution of EPN weekly results to realise a European densification of ITRF2005
- Providing a “reference coordinate list”
  - Coordinates and velocities unchanged after adoption unlike the operational (weekly) update of a cumulative solution
- Processing now finished and product files *online* available
- Draft report document distributed among TWG members

- ALL\_ITRF2005\_060920.snrx (*IGS offsets*)
- outliers.snrx (*IGS outliers*)
- EPN\_offsets.snrx (*EPN SP offsets*)
- EPN\_outliers.snrx (*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

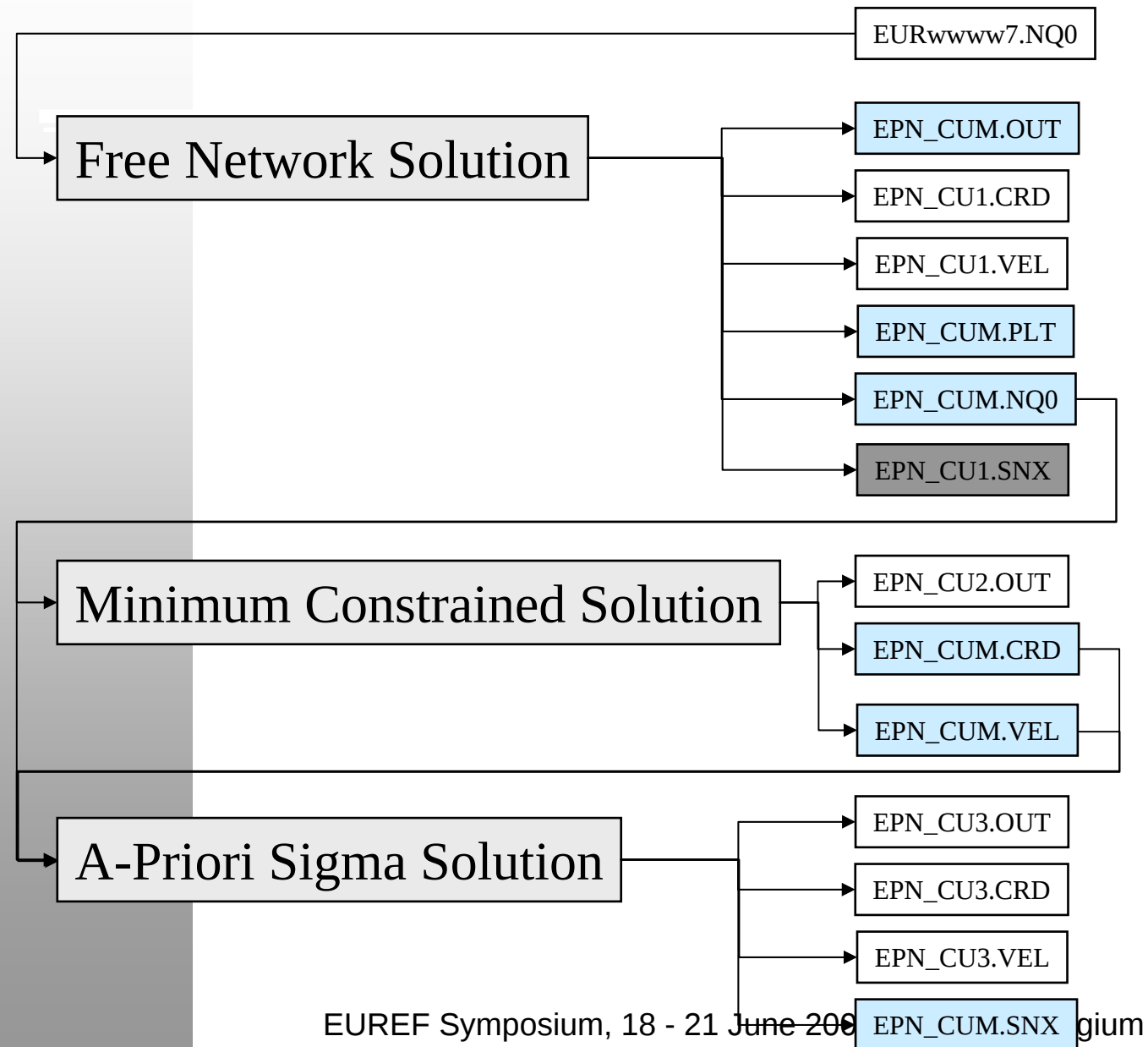
Priority Coordinates/Vel.:

1. ITRF2005 (Flag I)
2. EPN Weekly (Flag E)

Many, many ...  
manual editing

EPNC.STA  
EURF05.CRD  
EURF05.VEL

# EPN Multiyear Solution Strategy



# Contributing NEQ-Files

---

- Weekly SINEX files converted to NEQs (mandatory to start with 1 solution per week)
- Weeks 860 to 1355 result to 496 contributing files
- Covered time span in conformance with ITRF2005  
→ basic component of concept

# Rejection Criteria

## ADDNEQ2 4: Comparison of Individual Solutions

### NOTIFICATION OF POSSIBLE OUTLIERS

|                                              |       |                                 |                                                                                       |
|----------------------------------------------|-------|---------------------------------|---------------------------------------------------------------------------------------|
| Maximum tolerated residual                   | North | <input type="text" value="10"/> | millimeters                                                                           |
|                                              | East  | <input type="text" value="10"/> | millimeters                                                                           |
|                                              | Up    | <input type="text" value="20"/> | millimeters                                                                           |
| Maximum tolerated root-mean-square error     | North | <input type="text" value="10"/> | millimeters                                                                           |
|                                              | East  | <input type="text" value="10"/> | millimeters                                                                           |
|                                              | Up    | <input type="text" value="20"/> | millimeters                                                                           |
| Minimum number of solutions for each station |       | <input type="text" value="2"/>  |  |

# Reference Station Selection

---

- Initially all ITRF2005 sites of EPN have been considered as references site
- Exclusion of stations from reference list after residual screening
- Finally 44 stations with 57 solution numbers selected for definition of minimum constraint conditions

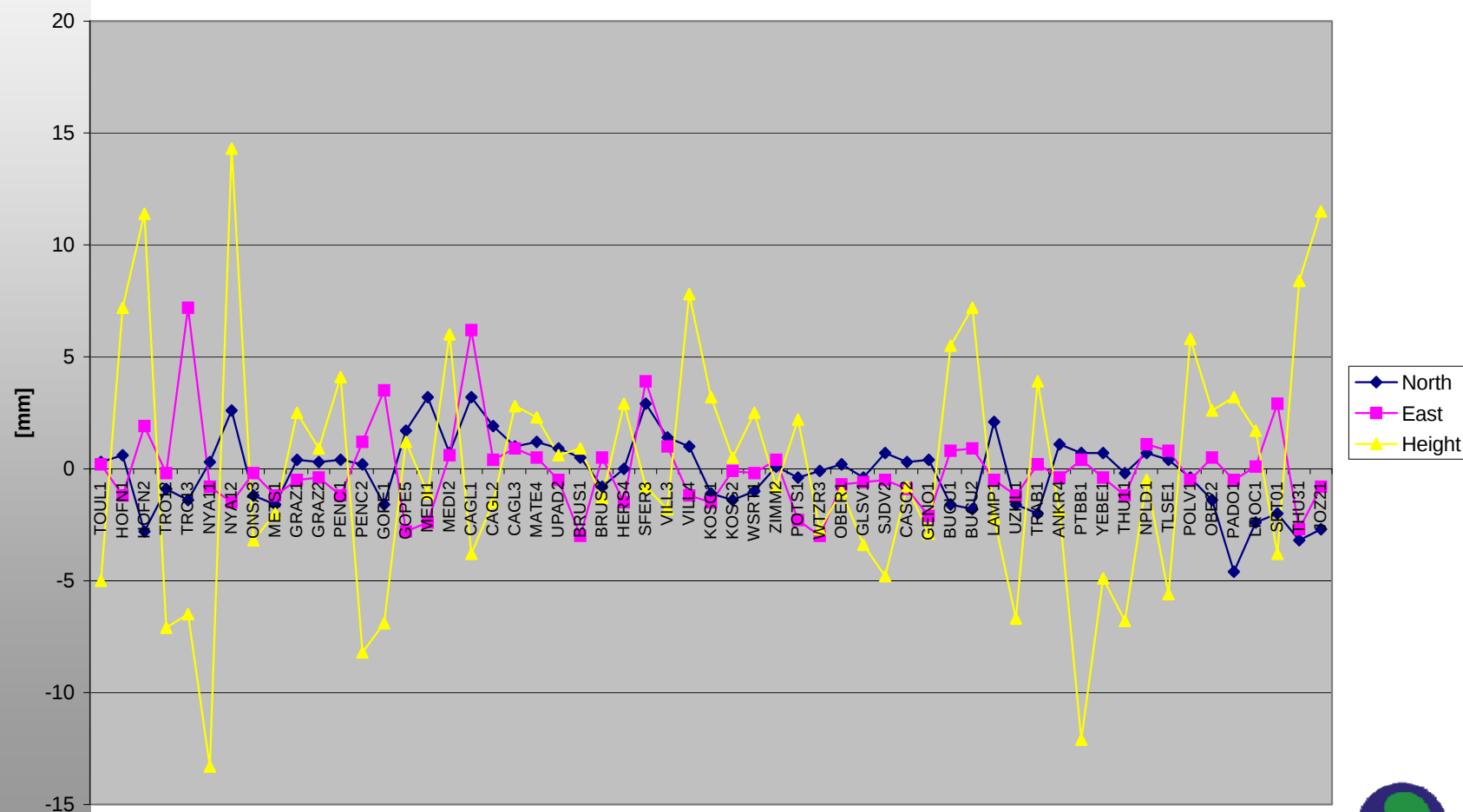
# Reference Sites



EUREF Symposium, 18 - 21 June 2008, Brussels, Belgium

# Residuals of Final Reference Stations

Free Network vs. ITRF2005



EUREF Symposium, 18 - 21 June 2008, Brussels, Belgium

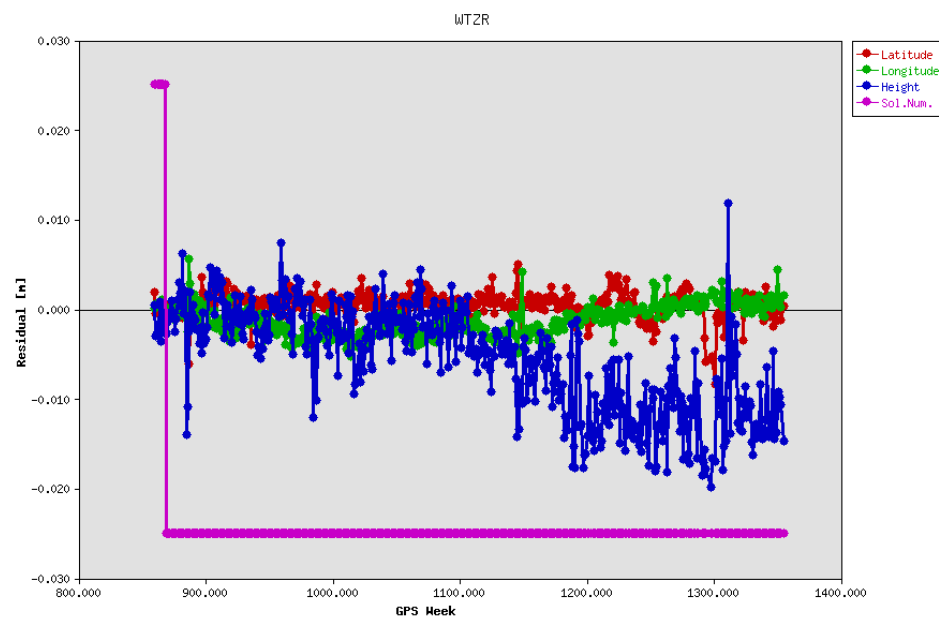
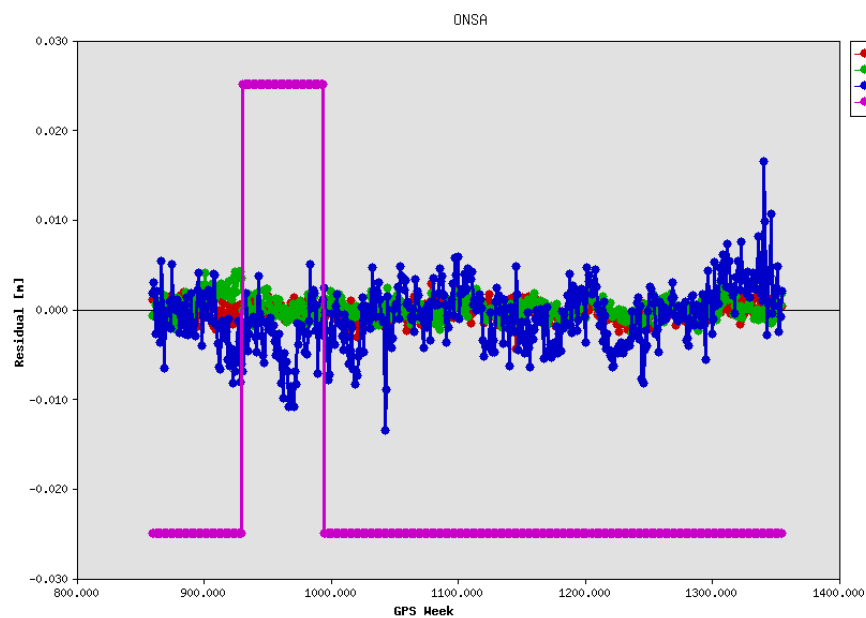
12



# Processing Runtime

|                                                       |             |
|-------------------------------------------------------|-------------|
| Total Time:                                           | 20:00 mm:ss |
| Free network solution<br>from weekly NEQs:            | 07:47 mm:ss |
| Minimum constrained<br>solution from combined<br>NEQ: | 01:53 mm:ss |
| Full Constrained solution<br>from combined NEQ:       | 09:36 mm:ss |

# Coordinate Time Series Example

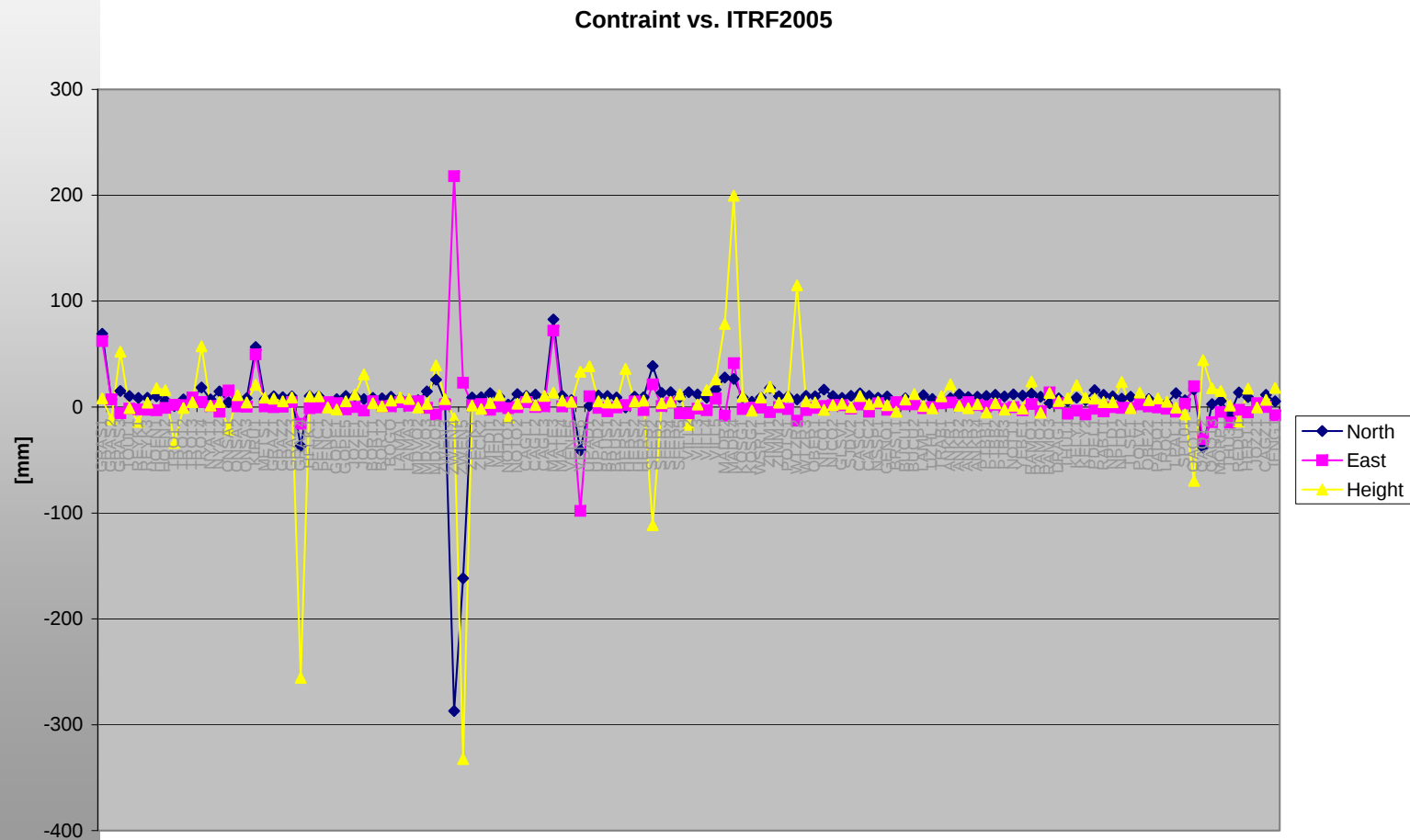


# Validation of Coordinates and Velocities

---

- Estimated station coordinates (epoch 2000.0) and velocities → coordinates for epoch 2007.0
- ITRF2005 station coordinates (epoch 2000.0) and velocities → coordinates for epoch 2007.0
- → Direct coordinates comparison for epoch 2007.0  
→ Validation of estimated coordinates and velocities

# No Velocity Constraints



# ZWEN

Converted from ITRF2005\_IGS-TRF.SNX (= ITF05.SNX)

ITF05.CRD

|     |      |            |              |              |              |   |
|-----|------|------------|--------------|--------------|--------------|---|
| 73  | ZWEN | 12330M001A | 2886325.4712 | 2155998.4337 | 5245816.1559 | I |
| 261 | ZWEN | 12330M001B | 2886325.4761 | 2155998.4393 | 5245816.1567 | I |
| 456 | ZWEN | 12330M001C | 2886325.4729 | 2155998.4515 | 5245816.1689 | I |
| 468 | ZWEN | 12330M001  | 2886325.4791 | 2155998.4420 | 5245816.1527 | I |

ITRF2005 GENERATED FROM ITRF2005\_GPS.SSC

08-OCT-06 15:00

EURF05.CRD

|     |                |              |              |              |   |
|-----|----------------|--------------|--------------|--------------|---|
| 135 | ZWEN112330M001 | 2886325.471  | 2155998.434  | 5245816.156  | I |
| 135 | ZWEN212330M001 | 2886325.4766 | 2155998.4356 | 5245816.1561 | E |
| 135 | ZWEN312330M001 | 2886325.476  | 2155998.439  | 5245816.157  | I |
| 135 | ZWEN412330M001 | 2886325.473  | 2155998.452  | 5245816.169  | I |
| 135 | ZWEN512330M001 | 2886325.479  | 2155998.442  | 5245816.153  | I |

CUMULATIVE SOLUTION OF EPN WEEKLY COMBINED SOLUTIONS - MCC

04-OCT-07 05:59

EPN\_CUM.CRD\_fin

|     |                |              |              |              |   |
|-----|----------------|--------------|--------------|--------------|---|
| 135 | ZWEN112330M001 | 2886325.4710 | 2155998.4340 | 5245816.1560 |   |
| 135 | ZWEN212330M001 | 2886325.4766 | 2155998.4356 | 5245816.1561 |   |
| 135 | ZWEN312330M001 | 2886325.4778 | 2155998.4372 | 5245816.1475 | A |
| 135 | ZWEN412330M001 | 2886325.4182 | 2155998.1389 | 5245816.3395 | A |
| 135 | ZWEN512330M001 | 2886325.5357 | 2155998.4558 | 5245816.5186 | A |

ITF05.VEL

|     |      |            |         |        |        |   |
|-----|------|------------|---------|--------|--------|---|
| 73  | ZWEN | 12330M001A | -0.0227 | 0.0109 | 0.0049 | I |
| 261 | ZWEN | 12330M001B | -0.0227 | 0.0109 | 0.0049 | I |
| 456 | ZWEN | 12330M001C | -0.0227 | 0.0109 | 0.0049 | I |
| 468 | ZWEN | 12330M001  | -0.0227 | 0.0109 | 0.0049 | I |

EURF05.VEL

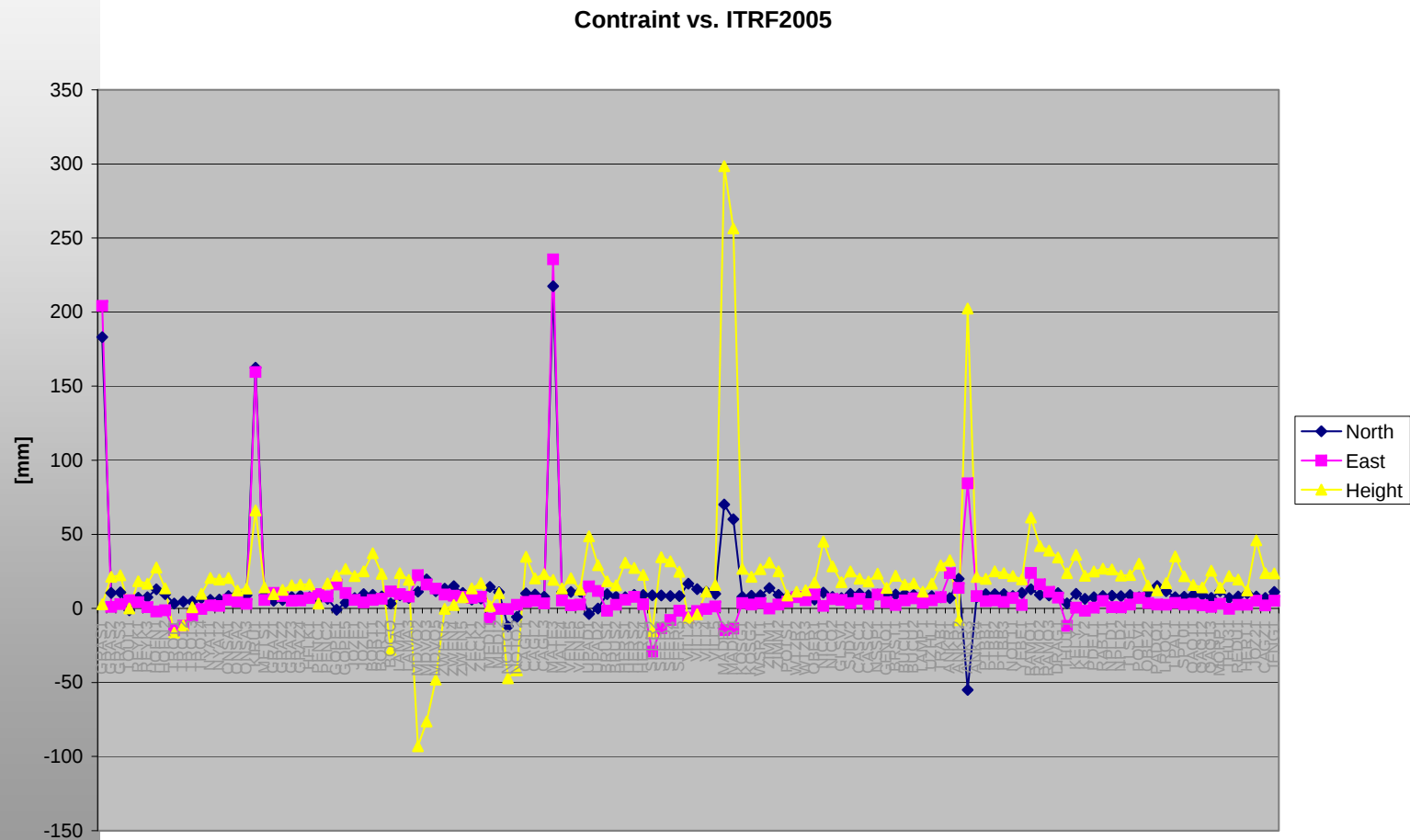
|     |                |         |        |        |  |      |
|-----|----------------|---------|--------|--------|--|------|
| 135 | ZWEN112330M001 | - .0227 | 0.0109 | 0.0049 |  | EURA |
| 135 | ZWEN212330M001 | - .0227 | 0.0109 | 0.0049 |  | EURA |
| 135 | ZWEN312330M001 | - .0227 | 0.0109 | 0.0049 |  | EURA |
| 135 | ZWEN412330M001 | - .0227 | 0.0109 | 0.0049 |  | EURA |
| 135 | ZWEN512330M001 | - .0227 | 0.0109 | 0.0049 |  | EURA |

EPN\_CUM.VEL\_fin

|     |                |         |        |         |   |      |
|-----|----------------|---------|--------|---------|---|------|
| 135 | ZWEN112330M001 | -0.0227 | 0.0109 | 0.0049  |   | EURA |
| 135 | ZWEN212330M001 | -0.0227 | 0.0109 | 0.0049  |   | EURA |
| 135 | ZWEN312330M001 | -0.0211 | 0.0111 | 0.0049  | A | EURA |
| 135 | ZWEN412330M001 | -0.0089 | 0.0790 | -0.0349 | A | EURA |
| 135 | ZWEN512330M001 | -0.0338 | 0.0072 | -0.0744 | A | EURA |

EURF

# Velocity Constraints



# Results ITRF2005 Densification

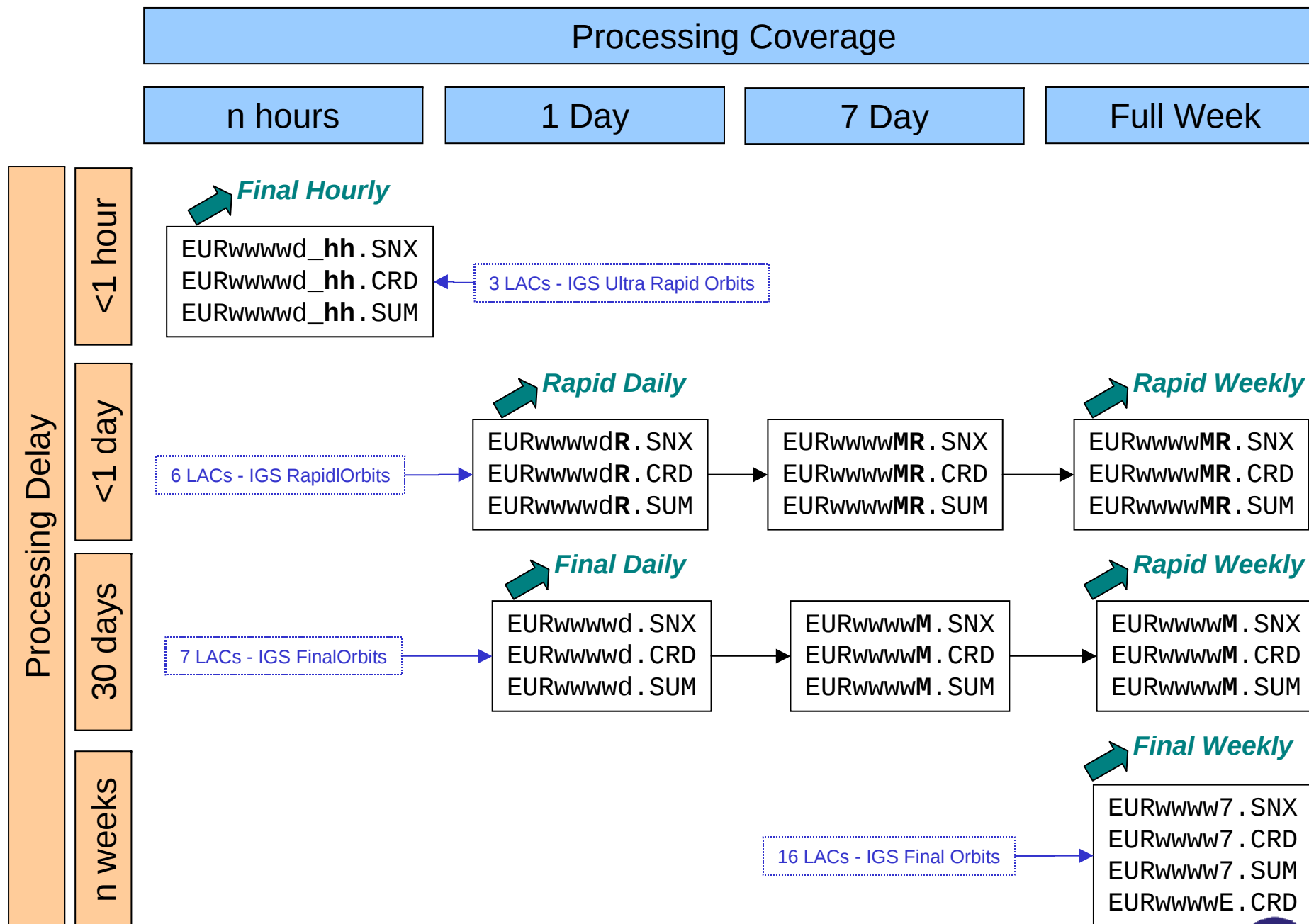
---

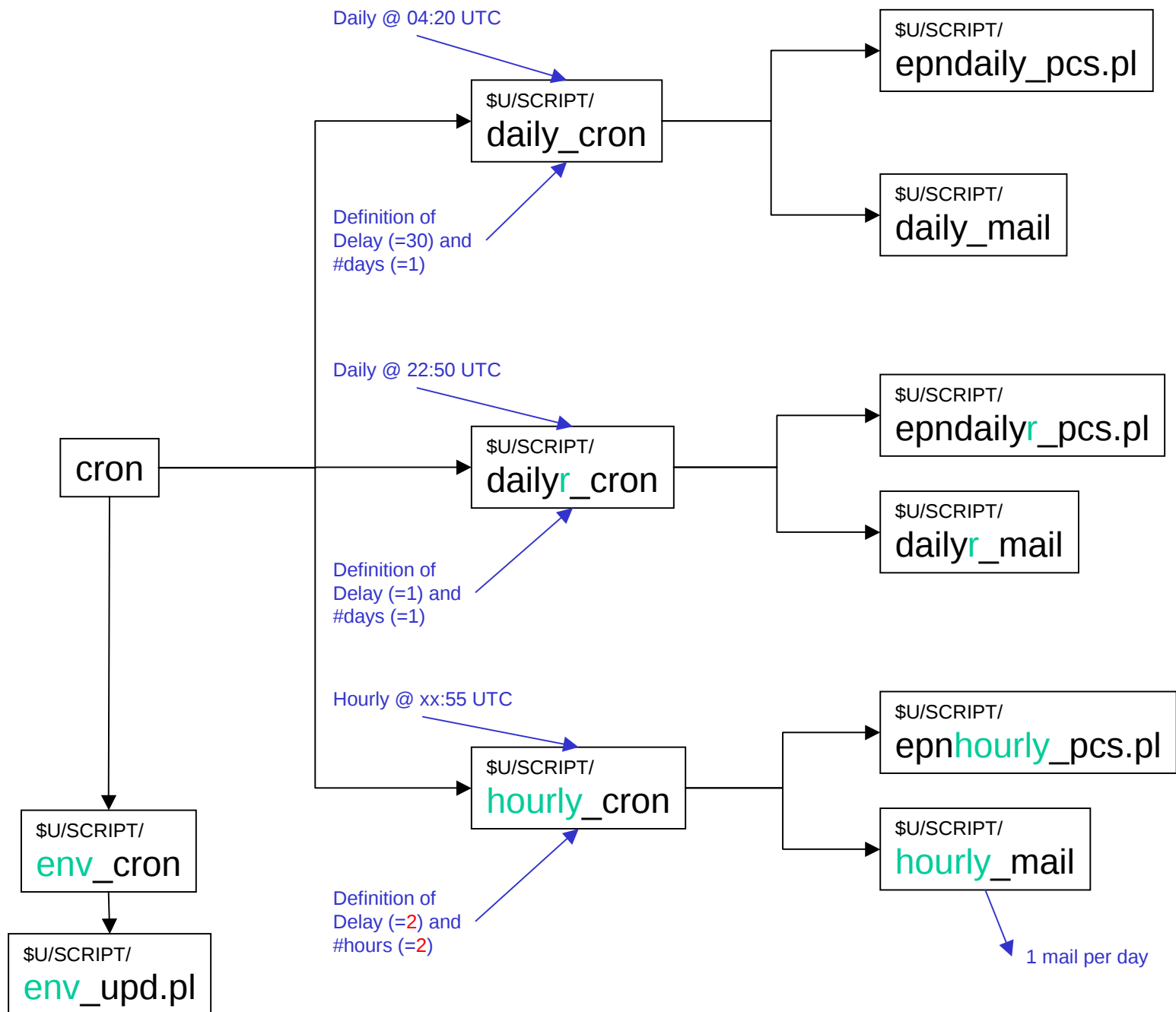
- Velocity constraints under consideration
  - Neither “no” nor “full” velocity constraints between solution numbers are in agreement with ITRF2005
  - Station specific solution?
  - Proof on concept ongoing
- Product files available at  
**<ftp://igs.bkg.bund.de/MISC/ITRF/ITRF2005/>**
- Comparisons to results from other organisations welcome
- Public announcement pending

# EPN Rapid Analysis Products - *Update*

---

- Scope:
  - Short latency of solutions
  - High resolution coordinates
  - Monitoring





# Hourly Combination – Daily report

\*\*\*\*\*

Hourly Summary for day 14721

\*\*\*\*\*

| Hour | #Sol. | #Sta. | Repeatability (mm) |       |       | Local Analysis Centres |         |                |        |            |
|------|-------|-------|--------------------|-------|-------|------------------------|---------|----------------|--------|------------|
|      |       |       | N                  | E     | U     | RMS                    | Helmert | Transformation | (mm)   |            |
| 00   | 3     | 120   | 3.92               | 4.33  | 15.03 | ASI(                   | 0.14)   | BKG(           | 6.66)  | LPT( 2.34) |
| 01   | 3     | 118   | 3.63               | 5.03  | 9.47  | ASI(                   | 0.18)   | BKG(           | 4.48)  | LPT( 2.35) |
| 02   | 3     | 120   | 4.30               | 7.09  | 9.65  | ASI(                   | 0.22)   | BKG(           | 5.04)  | LPT( 3.02) |
| 03   | 3     | 118   | 2.93               | 4.92  | 7.94  | ASI(                   | 0.15)   | BKG(           | 3.86)  | LPT( 1.53) |
| 04   | 3     | 121   | 5.86               | 6.91  | 14.63 | ASI(                   | 0.21)   | BKG(           | 6.90)  | LPT( 2.74) |
| 05   | 3     | 124   | 4.46               | 9.01  | 10.22 | ASI(                   | 0.91)   | BKG(           | 6.01)  | LPT( 2.53) |
| 06   | 3     | 122   | 11.23              | 31.07 | 14.74 | ASI(                   | 0.18)   | BKG(           | 15.04) | LPT( 2.91) |
| 07   | 3     | 121   | 3.64               | 8.85  | 7.62  | ASI(                   | 0.18)   | BKG(           | 4.85)  | LPT( 2.89) |
| 08   | 3     | 116   | 2.48               | 4.34  | 6.26  | ASI(                   | 0.15)   | BKG(           | 2.87)  | LPT( 2.68) |
| 09   | 3     | 121   | 15.54              | 31.43 | 12.71 | ASI(                   | 1.09)   | BKG(           | 15.89) | LPT( 2.60) |
| 10   | 3     | 109   | 1.89               | 3.93  | 5.68  | ASI(                   | 1.95)   | BKG(           | 2.56)  | LPT( 0.58) |
| 11   | 3     | 121   | 2.72               | 3.94  | 7.02  | ASI(                   | 1.14)   | BKG(           | 3.41)  | LPT( 2.16) |
| 12   | 3     | 120   | 2.67               | 4.76  | 6.51  | ASI(                   | 1.13)   | BKG(           | 3.46)  | LPT( 1.96) |
| 13   | 3     | 121   | 4.89               | 9.06  | 8.53  | ASI(                   | 1.30)   | BKG(           | 6.18)  | LPT( 1.92) |
| 14   | 3     | 118   | 6.22               | 11.64 | 9.97  | ASI(                   | 0.12)   | BKG(           | 6.76)  | LPT( 2.06) |
| 15   | 3     | 121   | 3.67               | 4.07  | 7.54  | ASI(                   | 0.87)   | BKG(           | 3.67)  | LPT( 2.10) |
| 16   | 3     | 120   | 3.27               | 3.84  | 7.87  | ASI(                   | 0.14)   | BKG(           | 3.74)  | LPT( 2.20) |
| 17   | 3     | 118   | 3.68               | 3.74  | 9.77  | ASI(                   | 1.09)   | BKG(           | 4.48)  | LPT( 2.04) |
| 18   | 3     | 122   | 4.59               | 4.53  | 9.33  | ASI(                   | 1.33)   | BKG(           | 4.68)  | LPT( 2.25) |
| 19   | 3     | 121   | 3.75               | 4.34  | 7.27  | ASI(                   | 0.11)   | BKG(           | 3.77)  | LPT( 2.26) |
| 20   | 3     | 119   | 10.55              | 10.74 | 6.96  | ASI(                   | 0.13)   | BKG(           | 6.95)  | LPT( 2.45) |
| 21   | 3     | 118   | 10.10              | 4.93  | 13.50 | ASI(                   | 0.12)   | BKG(           | 7.11)  | LPT( 2.27) |
| 22   | 3     | 119   | 6.29               | 5.80  | 14.11 | ASI(                   | 0.13)   | BKG(           | 6.89)  | LPT( 2.12) |
| 23   | 3     | 121   | 4.00               | 5.17  | 7.65  | ASI(                   | 0.13)   | BKG(           | 4.06)  | LPT( 2.23) |

# Rapid Combination Requirements

---

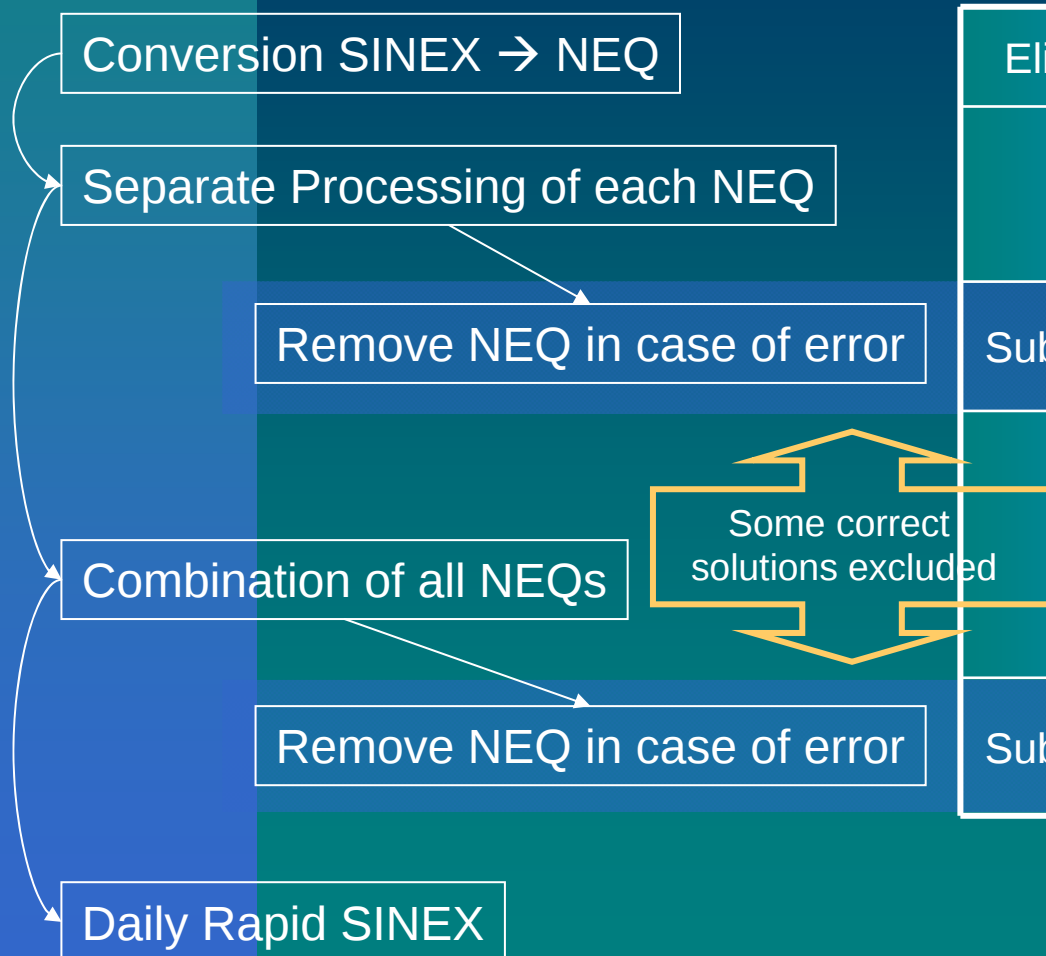
- Automated processing according to fixed schedule
- No manual interaction for day-to-day processing
- Automated event handling
  - Processing abort due to
    - ❖ Format error in SINEX file
    - ❖ Numerical problem in a single contribution
    - ❖ Numerical problem in the combination of all contributions
  - Clear objective needed to respond on processing abort
    - ❖ Generating a reference solution → eliminate outliers
    - ❖ Monitoring task → keep outliers included

# Product Objectives

|                    | Referencing | Monitoring |
|--------------------|-------------|------------|
| Final Hourly       |             | X          |
| Rapid Daily        | X           | X          |
| Rapid Weekly (IGR) | X           | X          |
| Final Daily        | X           |            |
| Rapid Weekly (IGS) | X           |            |
| Final Weekly       | X           |            |

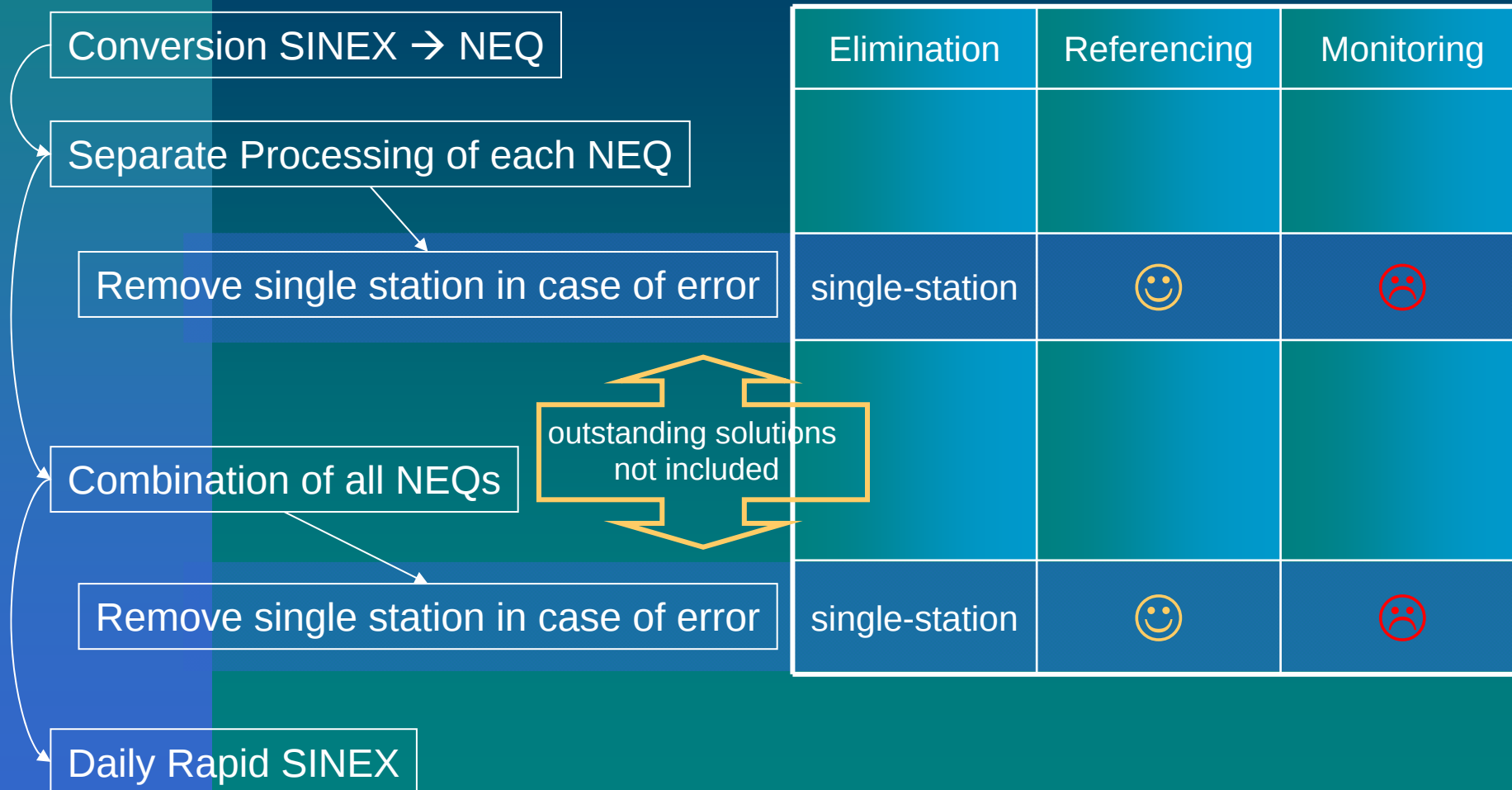
- Outlier Handling in „rapid daily“ and „rapid weekly (IGR)“ is a critical issue
- Majority of missing rapid combinations product are of type „rapid daily“

# Current Event Handling – Daily Rapid Combination



| Elimination | Referencing | Monitoring |
|-------------|-------------|------------|
|             |             |            |
| Sub-Network | ☹           | ☹          |
|             |             |            |
| Sub-Network | ☹           | ☹          |

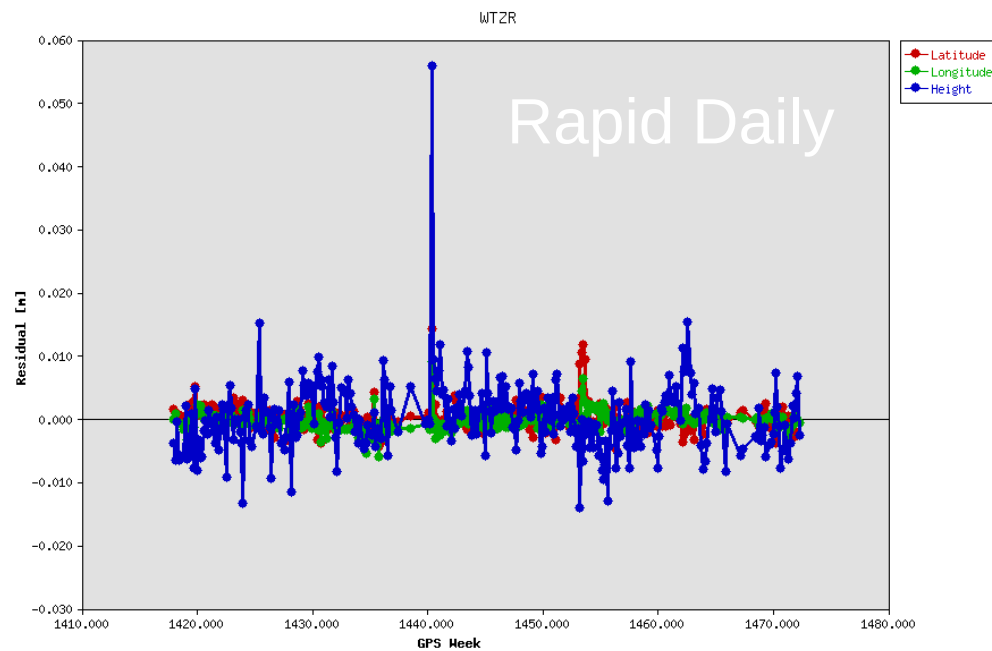
# Alternative Event Handling – Daily Rapid Combination



# More Product Objectives

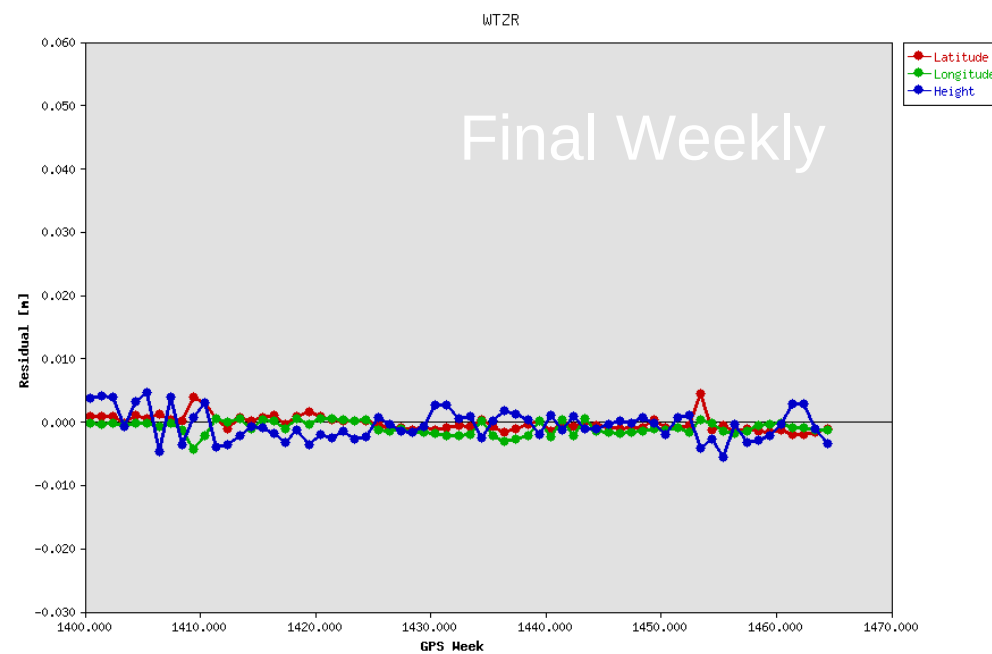
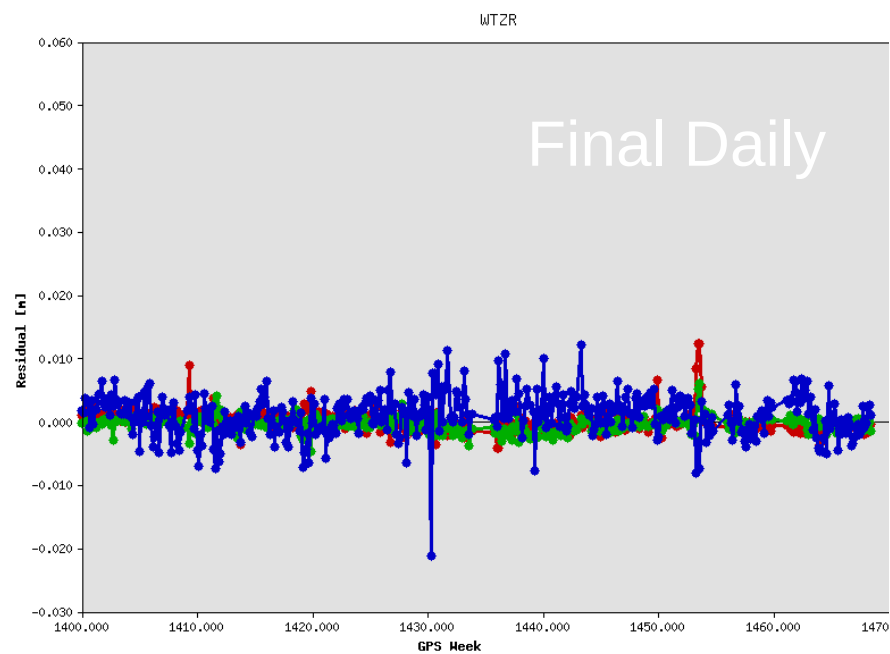
---

- Network solution:
  - Single bad performing stations may degrade a complete sub-network (LAC solution)
  - It is NOT possible to keep (significant) bad solutions in the combination for monitoring purpose
  - The combined solution validates coordinates of good performing sites, BUT no information for absent sites (possibility of no or bad data)
- Single point solution:
  - Provides even outstanding single station solutions for monitoring purpose (→ PPP discussion)



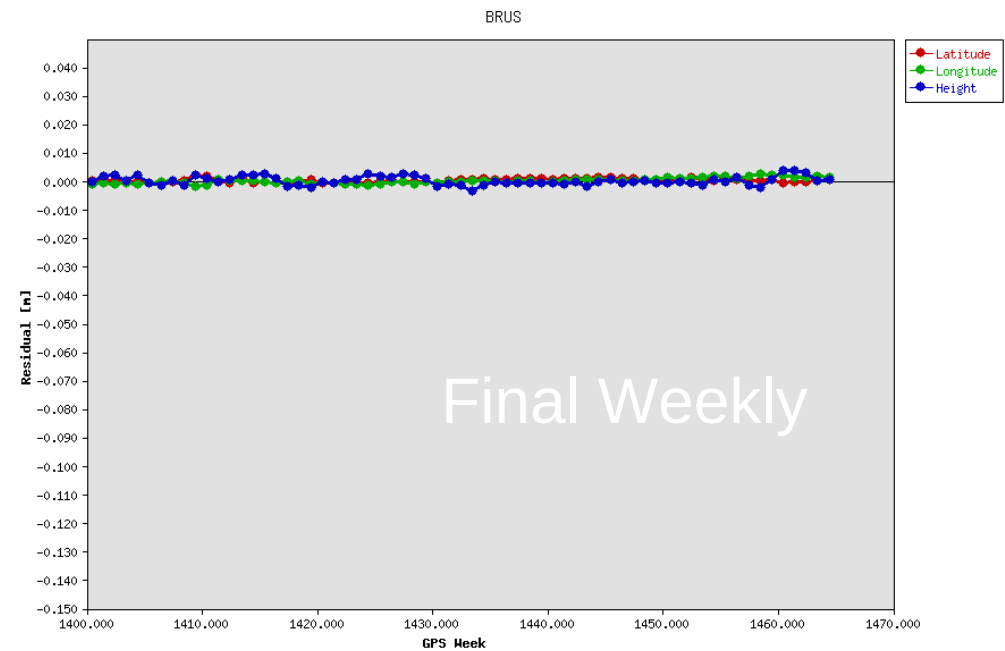
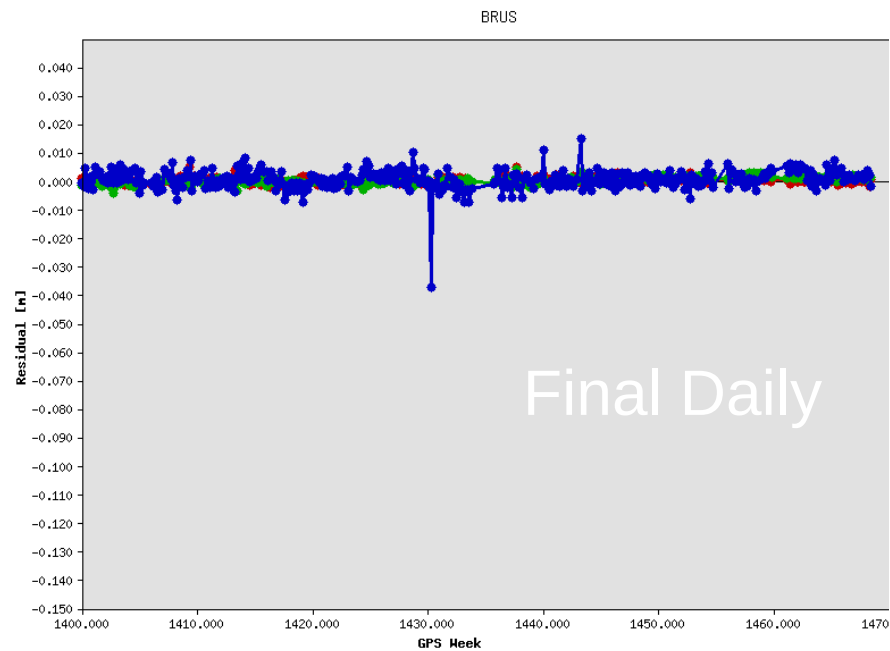
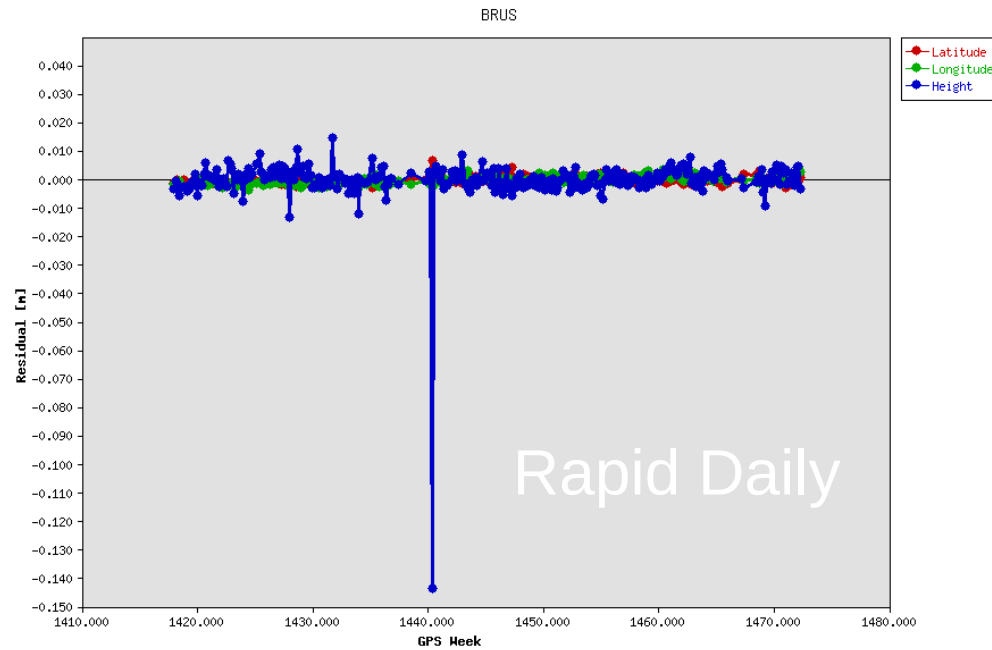
# WTZR Time Series

- daily/weekly vs. combined (NEQ stacking)



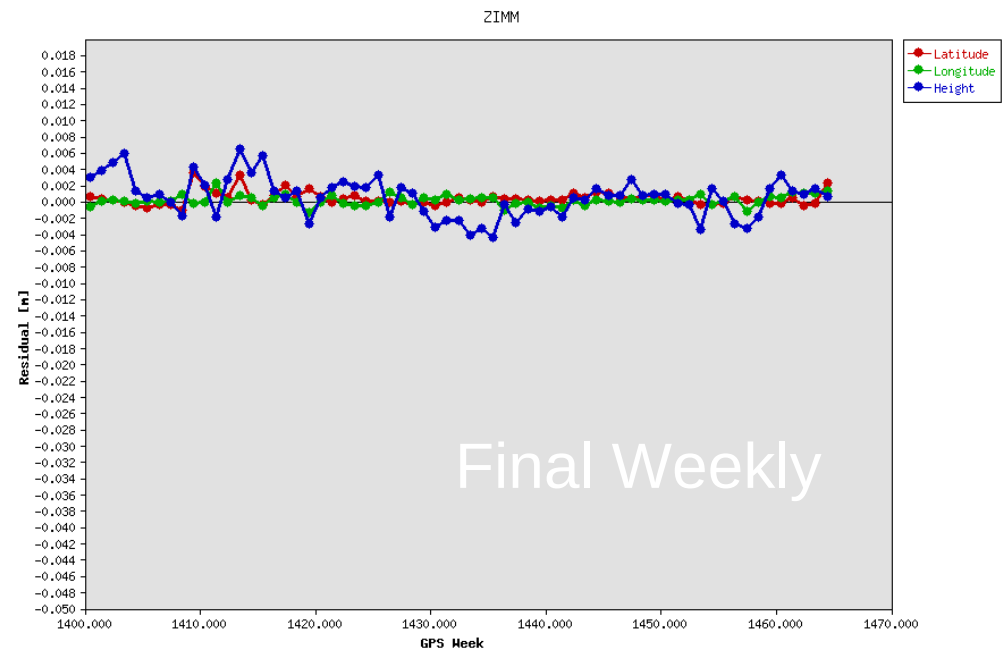
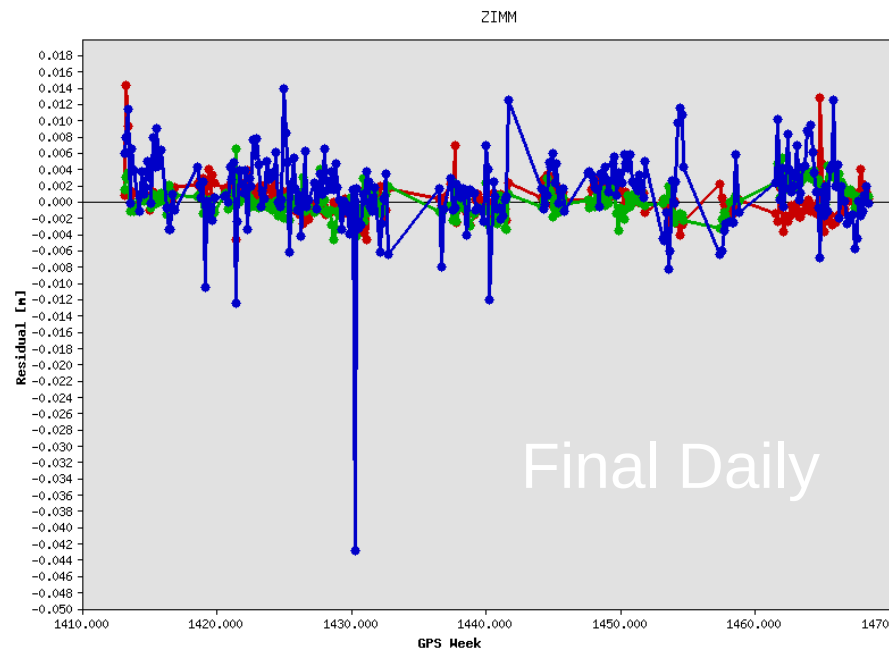
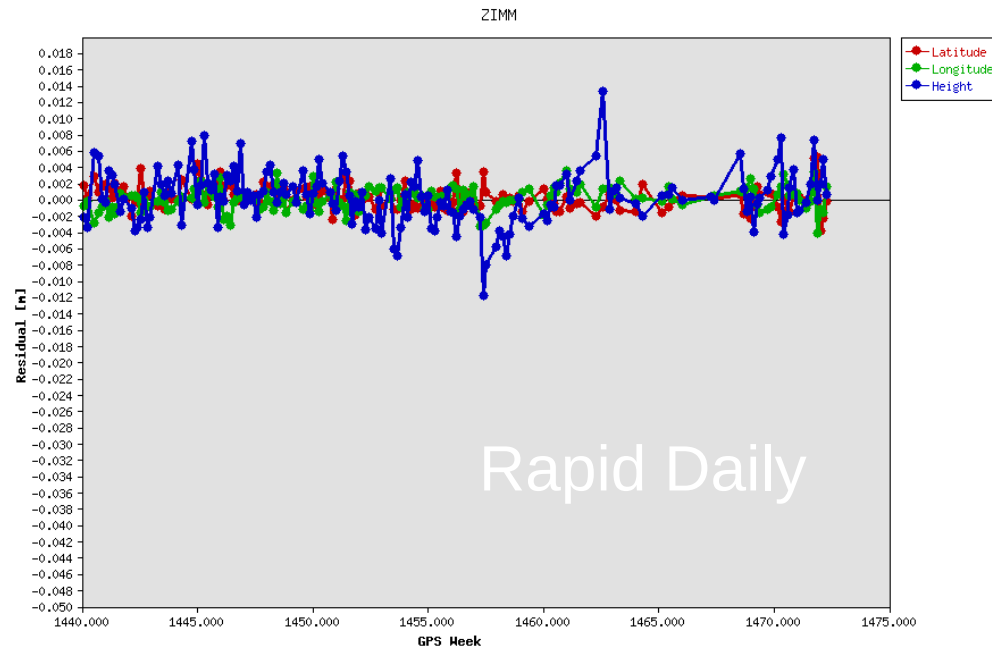
# BRUS Time Series

- daily/weekly vs. combined (NEQ stacking)



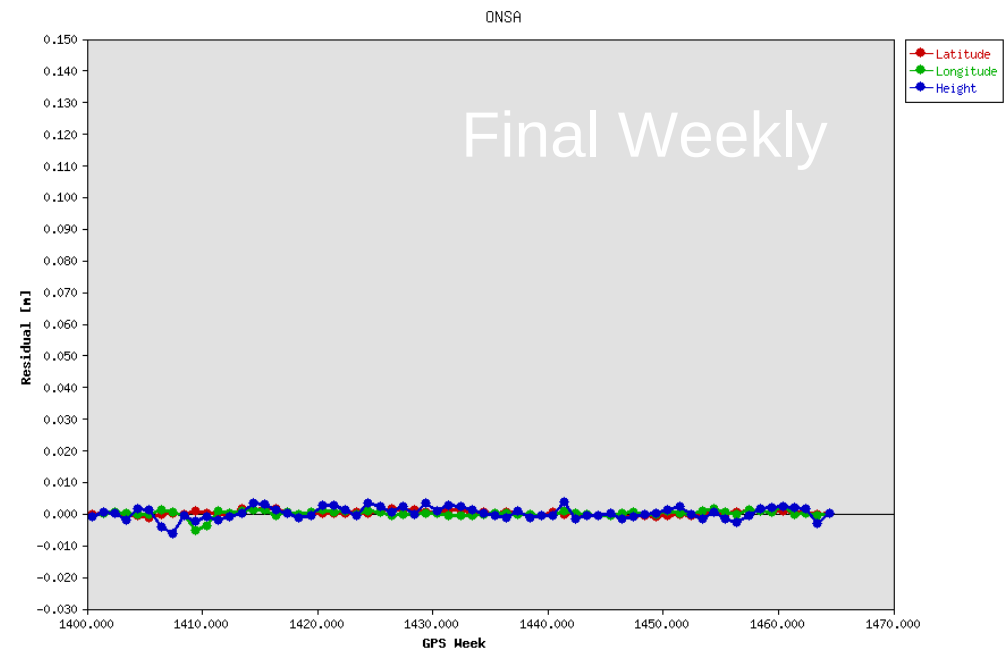
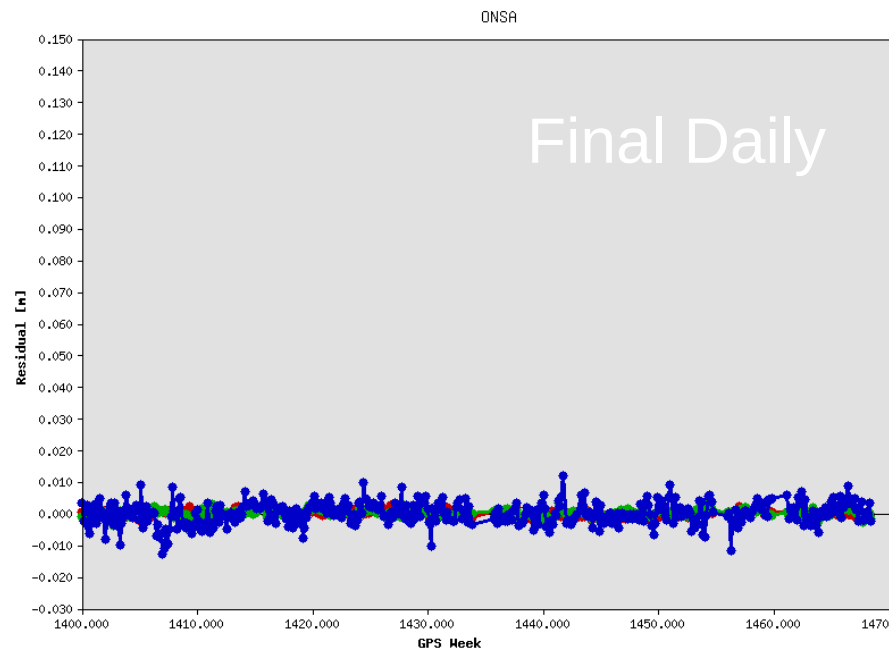
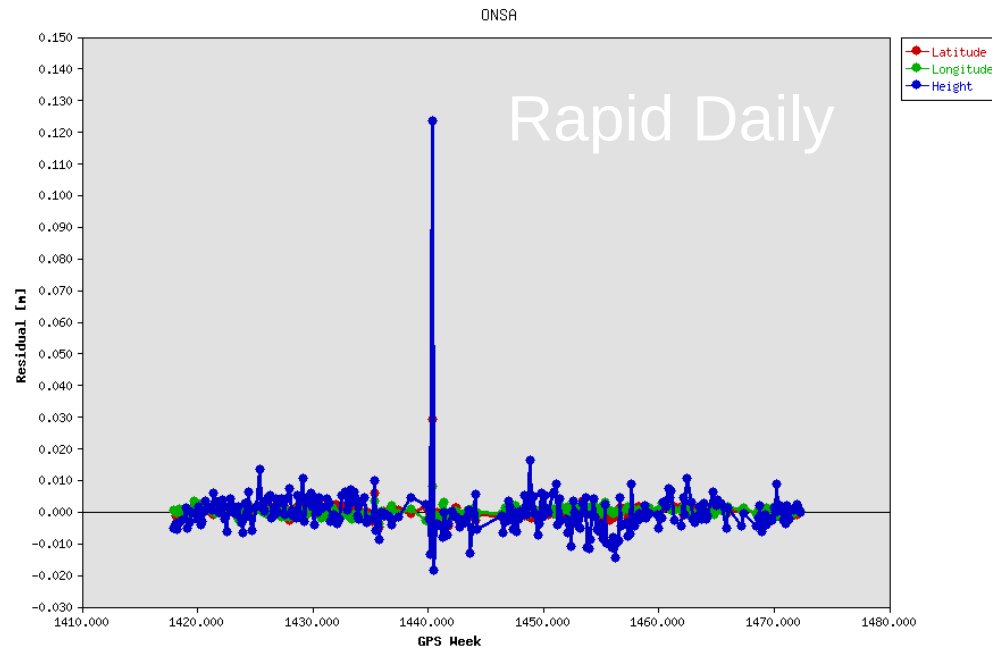
# ZIMM Time Series

- daily/weekly vs. combined (NEQ stacking)



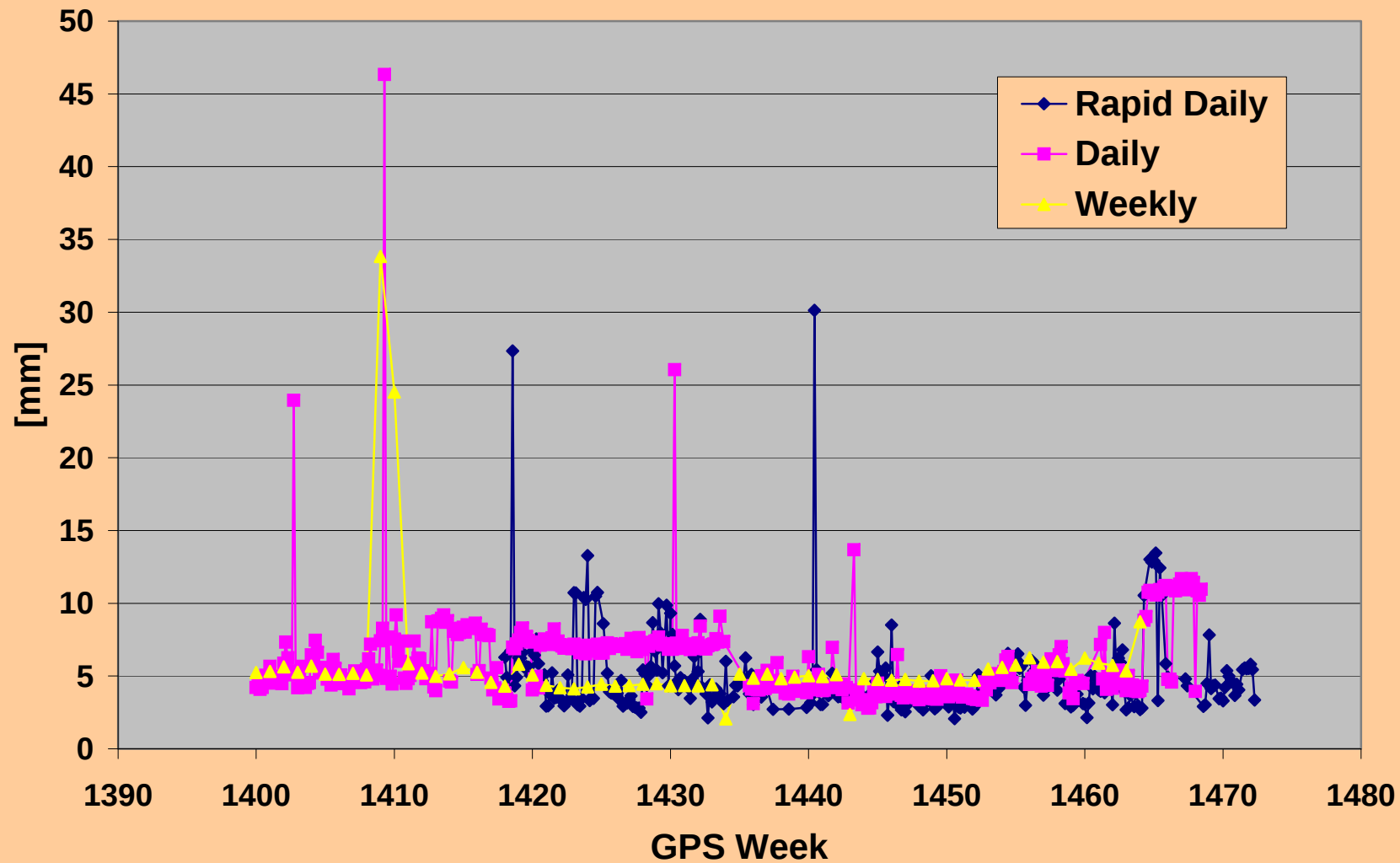
# ONSA Time Series

- daily/weekly vs. combined (NEQ stacking)



# Network Comparison

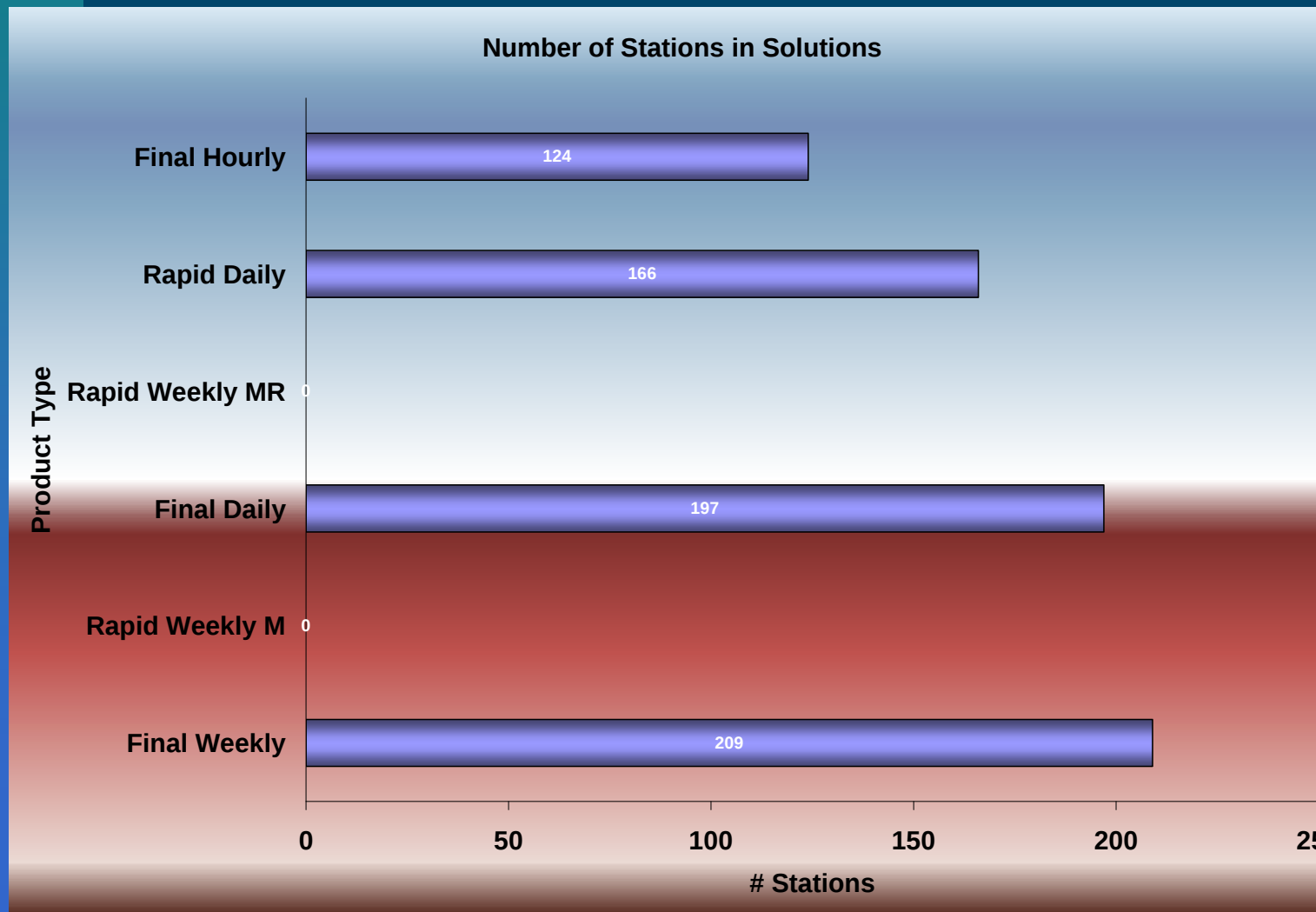
RMS Helmert Transformation daily/weekly vs. combined



# Usage of products

| Station Coordinates<br>Product Type      | Proposed Usage                                    |
|------------------------------------------|---------------------------------------------------|
| Final weekly                             | Final reference                                   |
| Final weekly M (final daily combination) | Contribution to IGS Associate Analysis Centres ?? |
| Final daily                              | High resolution final reference                   |
| Rapid daily                              | Short latency, high quality coordinates           |

# Station Counting since week 1400



# EPN Rapid Analysis - *Next Steps*

---

- Extension to all EPN sites
- Product announcement and feedback from users
- Discussion of monitoring objective
  - Improvement of outlier handling
  - Harmonisation of hourly analysis specifications
  - Establishment of „alert system“ ?

# EPN LAC-Workshop 2008

---

- Date/Venue:
  - October 22 – 23, 2008
  - Frankfurt at Main, Germany
- EPN Re-Processing
  - Relation to IGS re-processing
  - Establishment of new reprocessing facility? Call for participation?
  - Data holding / replacement
- ETRS89 Realisation through EPN
- Others topics

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

**heinz.habrich@bkg.bund.de**

*Thank you*