Federal Agency for
Cartography and Geodesy

EPN Analysis, Combination and Products

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Federal Agency for Cartography and Geodesy

- Survey of EPN analysis components
- Reference frame stability
- SINEX format options and LAC solution re-scaling
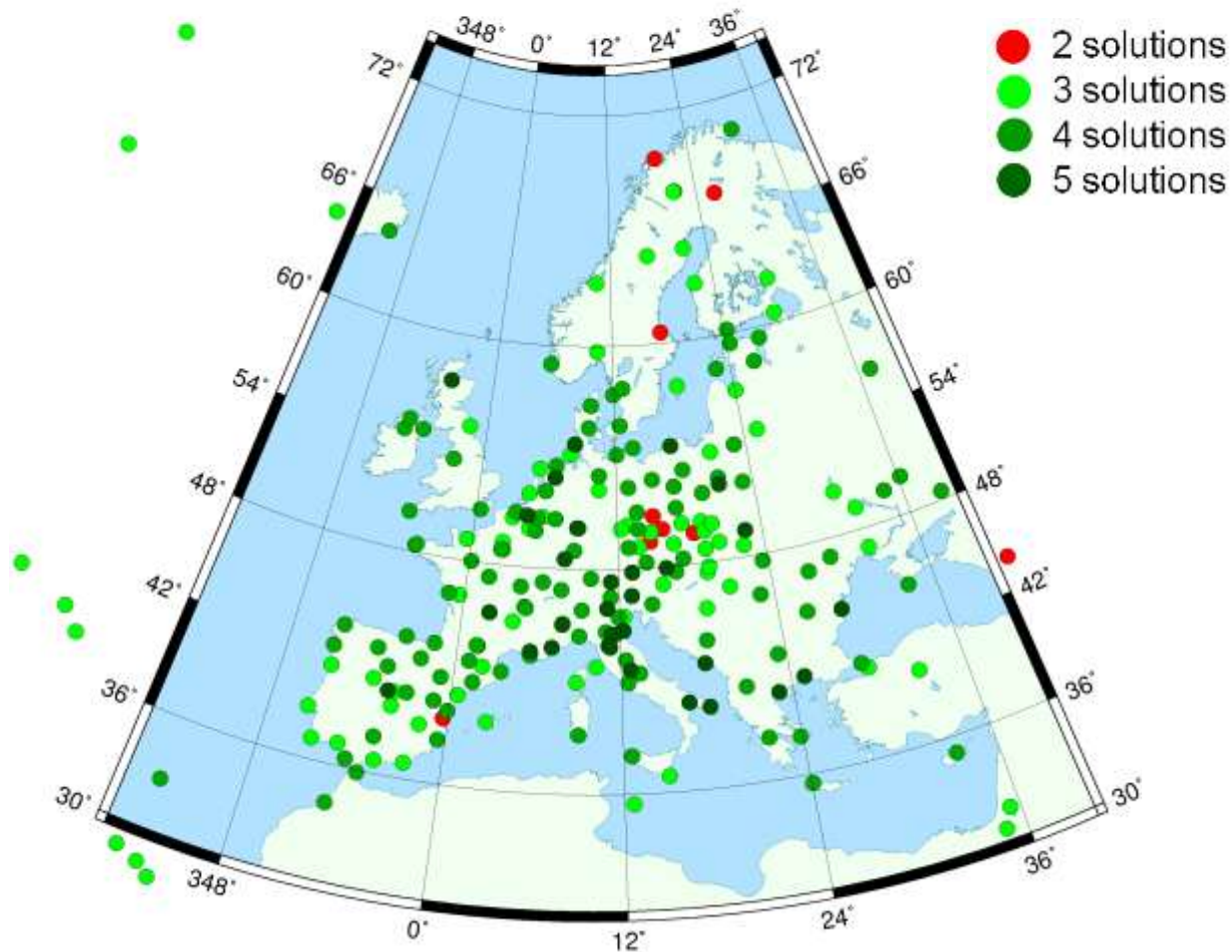- RINEX version 3

Guidelines for EPN Analysis Centres
- Analysis Components -

LAC Solutions		Coordinate Combination	
Final Weekly Coordinate Solution	mandatory	Final Weekly Coordinate Solution	
Final Daily Coordinate Solution	recommended	Final Daily Coordinate Solution	
Rapid Daily Coordinate Solution	recommended	Rapid Daily Coordinate Solution	
Hourly Coordinate Solution	optional	Hourly Coordinate Solution	
Final Daily Tropospheric Zenith Path Delays	mandatory	**Troposphere Combination**	
		Accumulated Coordinate Solution	
		EPN Projects	Re-Processing, Real-Time Analysis, GGOS

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Solutions Week 1600

● 1 solutions
● 2 solutions
● 3 solutions

Occurrence of Solutions
- Rapid Daily -

Solutions.Week 1600

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Coordinate Repeatability
North

Coordinate Repeatability
East
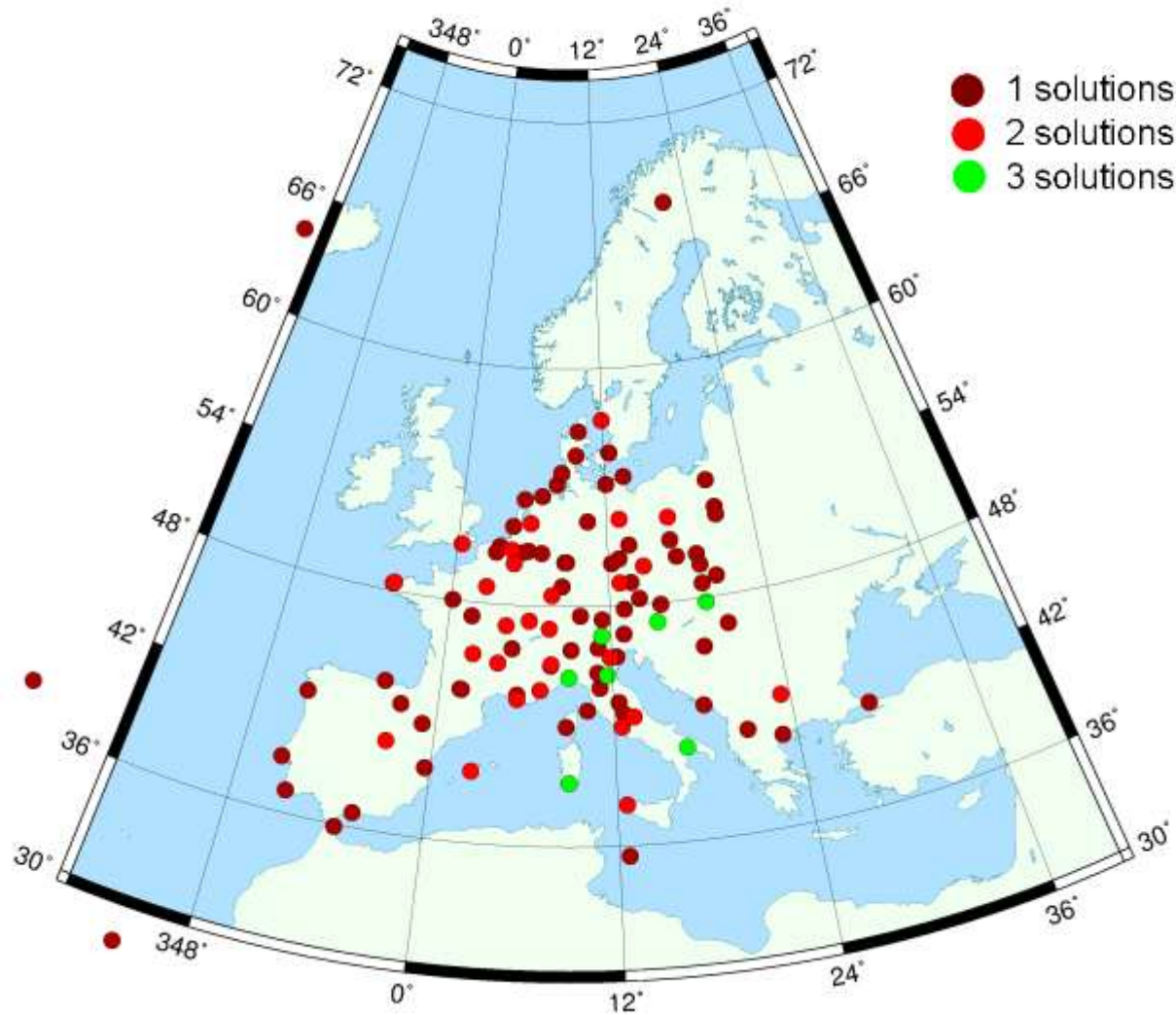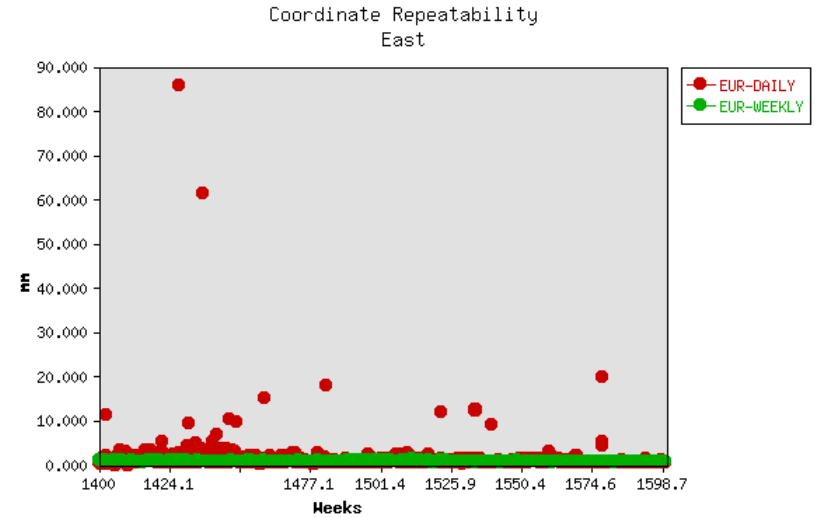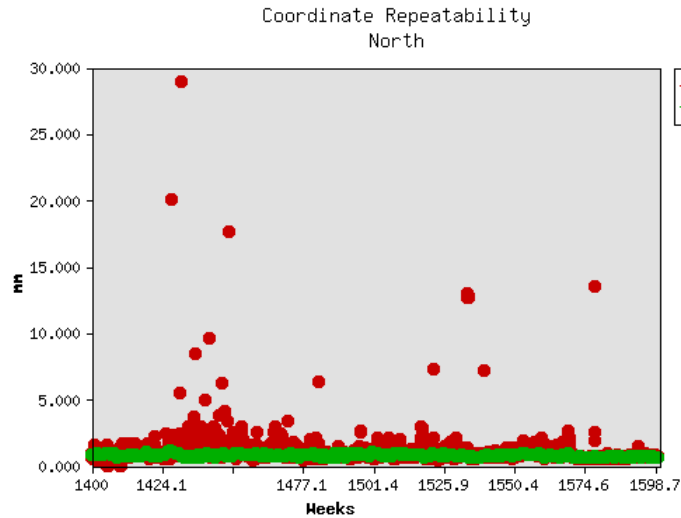
Solution: EUR

Type: DAILY

Inspected solutions: 1352

```
Median North:      0.81 mm
        East:      0.72 mm
      Height:      2.9 mm
```

Solution: EUR

Type: WEEKLY

Inspected solutions: 201

```
Median North:      0.74 mm
        East:      0.83 mm
      Height:      2.53 mm
```


Coordinate Repeatability
Height

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Coordinate Repeatability
North

Coordinate Repeatability
East
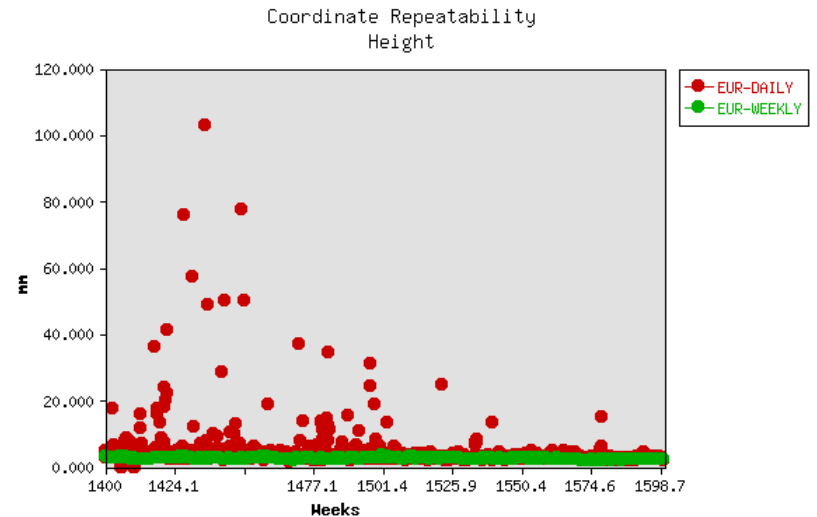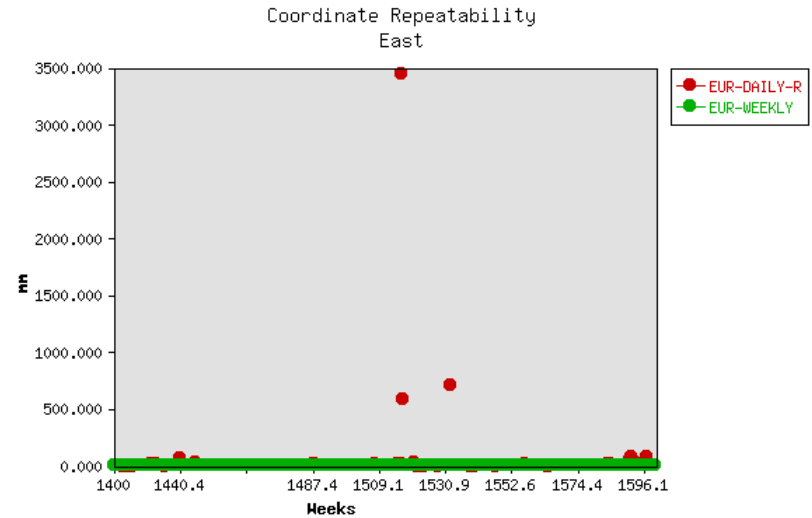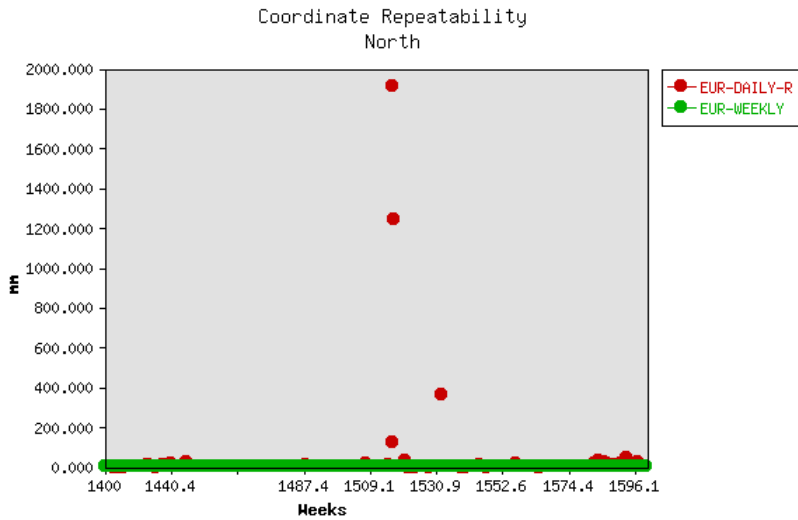
Solution: EUR

Type: DAILY-R

Inspected solutions: 1216

Median North: 1.49 mm

East: 2.54 mm

Height: 5.89 mm

Solution: EUR

Type: WEEKLY

Inspected solutions: 201

Median North: 0.74 mm

East: 0.83 mm

Height: 2.53 mm

Coordinate Repeatability
Height

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RMS of Helmert transformation

Helmert translation parameter
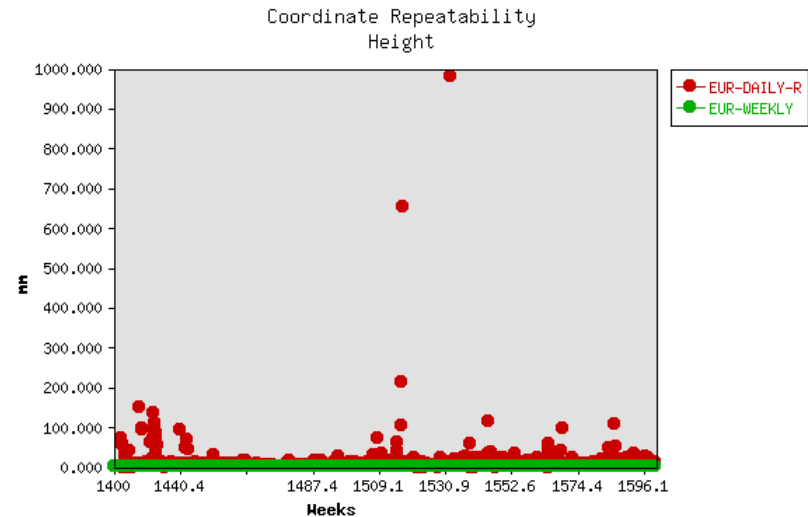
- Comparison of ITRF2005 vs. solved coordinates of reference sites
  (3 P Helmert transform.)

Number of Reference Sites

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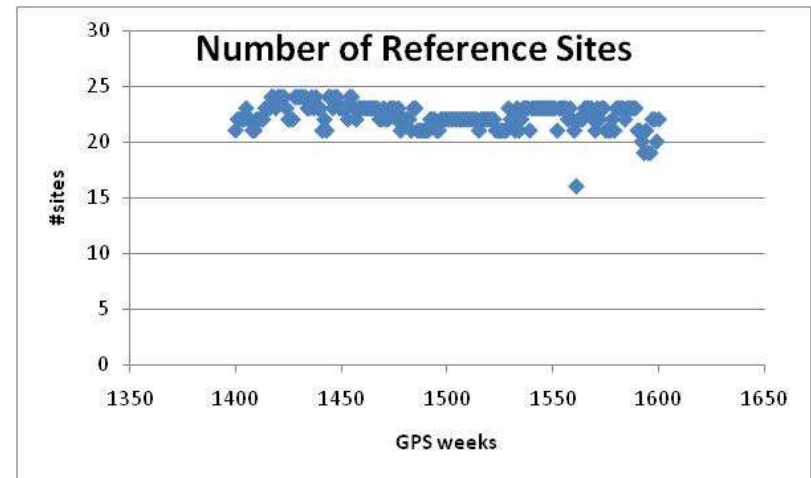
+SOLUTION/STATISTICS

+SOLUTION/EPOCHS

+SOLUTION/APRIORI

+SOLUTION/ESTIMATE

+SOLUTION/MATRIX_ESTIMATE L COVA and
+SOLUTION/MATRIX_APRIORI L COVA
or
+SOLUTION/NORMAL_EQUATION_VECTOR and
+SOLUTION/NORMAL_EQUATION_MATRIX L

Mandatory

1. Number of observation
2. Number of unknowns
3. Weighted square sum of o – c

"COV-SINEX" and "NEQ-SINEX "accepted

NEQ-matrix N and
NEQ-vector b

$$(\underbrace{A'PA}_{N}) \cdot \hat{p} = \underbrace{A'Pl}_{b}$$

or

$$\hat{\sigma}^2 \cdot (A'PA)^{-1}$$

COV-matrix and
a-priori COV-matrix

weighted square
sum of O-C

$$v'Pv = l'Pl - l'PA\ \hat{p}$$

$$\hat{\sigma}^2 = \frac{v'Pv}{n-u}$$

variance factor

- ## Type A)   *n, u* and *v'Pv* given in SINEX
  - correct calculation of variance factor
  - re-construction of original NEQ, e.g., for SINEX files generated by Bernese GNSS Software

- ## Type B)   *n, u* and *v'Pv* not available in SINEX
  - set *n = u* and *variance factor = 1*
  - empirical determination of re-scaling factor that fulfills *a-posteriori sigma of unit weight = 1 mm*

- NEQ-SINEX applied for submission of weekly sub-network solutions of the LACs since March 2010, COV-SINEX continued for EPN combined solution

- 14 LACs are submitting solutions in NEQ-SINEX

- More information about re-construction of NEQ in SINEX 2.02 (December 01, 2006) text document
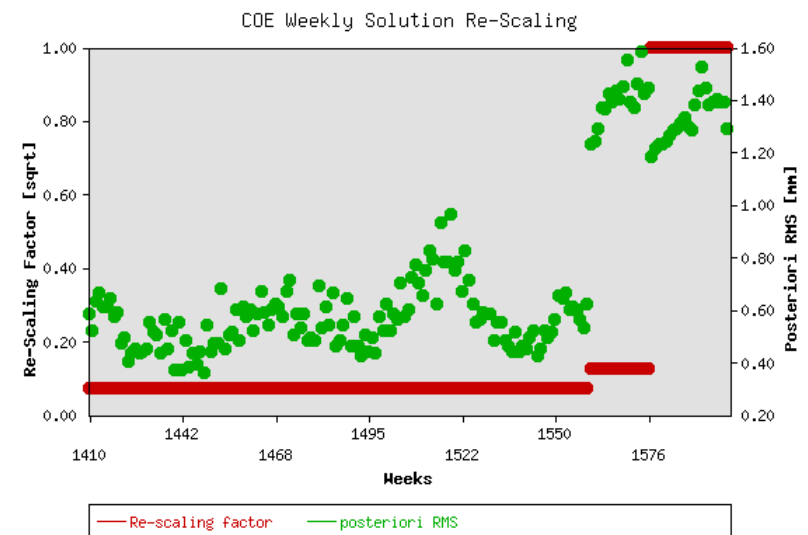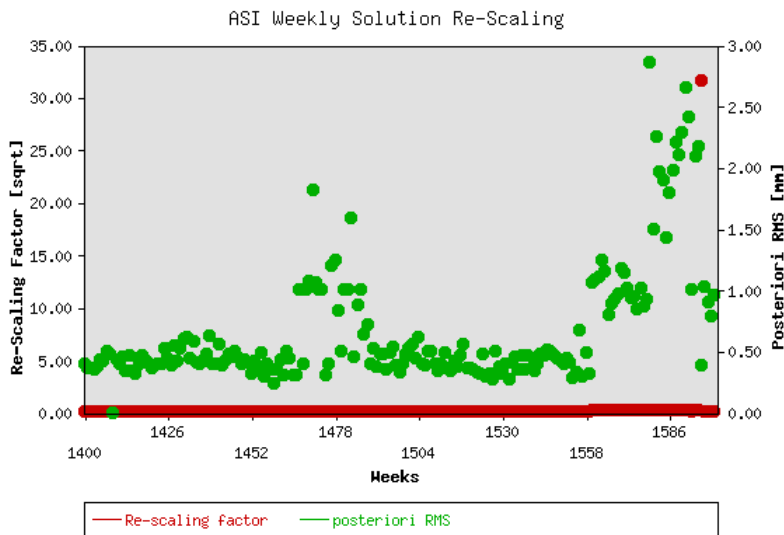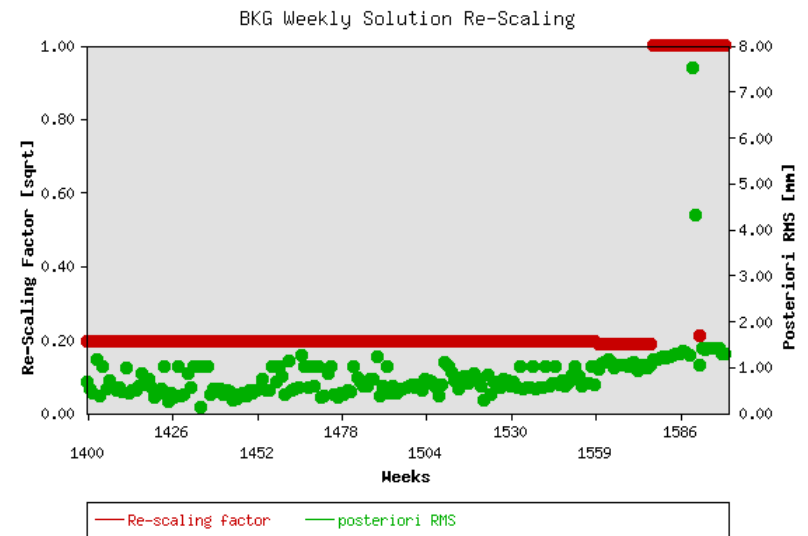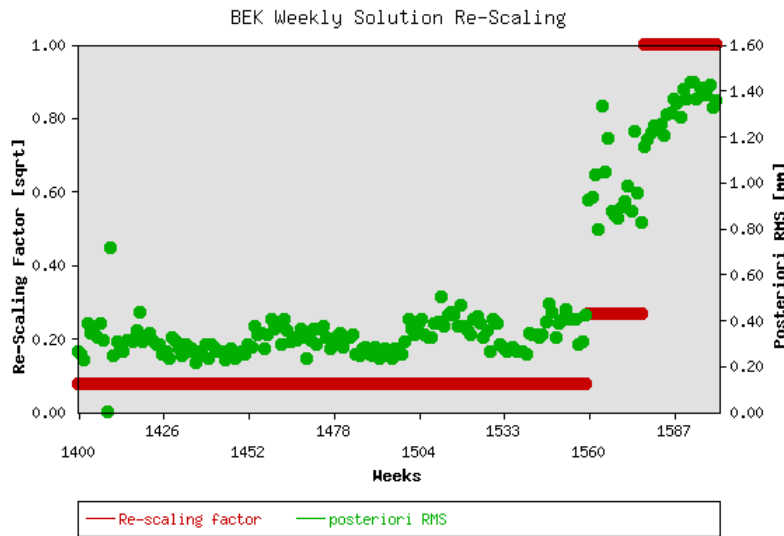
IGE Weekly Solution Re-Scaling

DEO Weekly Solution Re-Scaling

GOP Weekly Solution Re-Scaling

IGN Weekly Solution Re-Scaling

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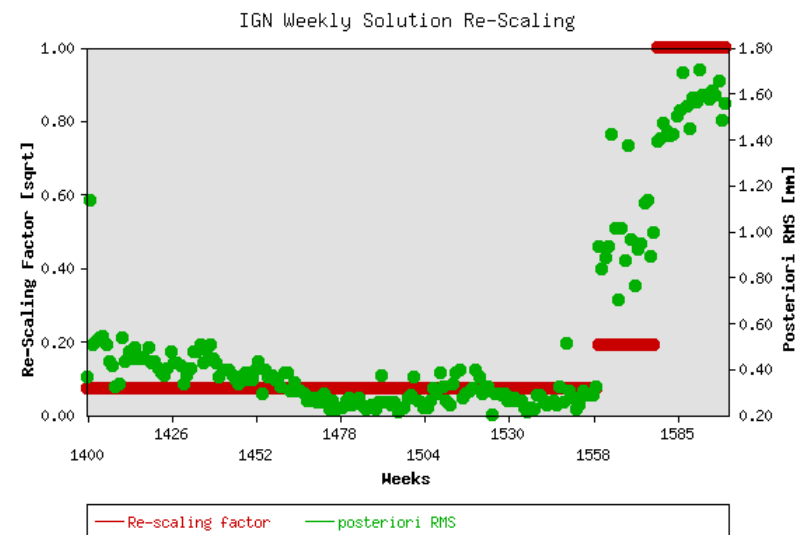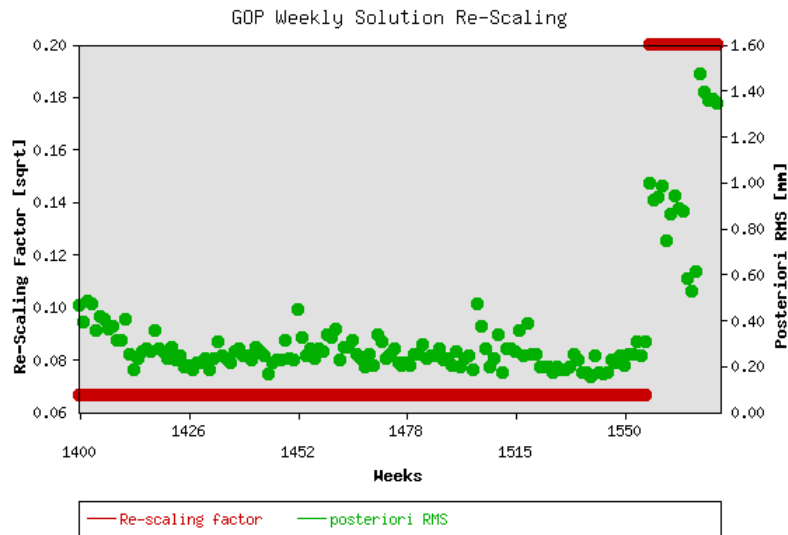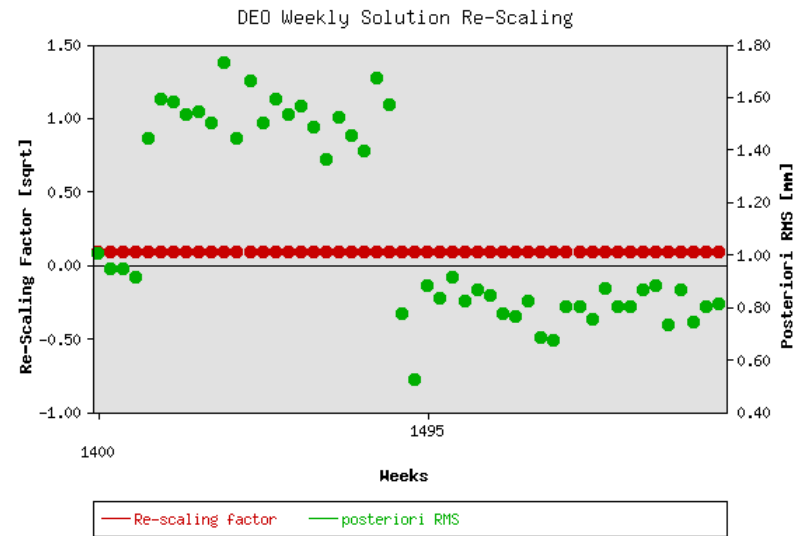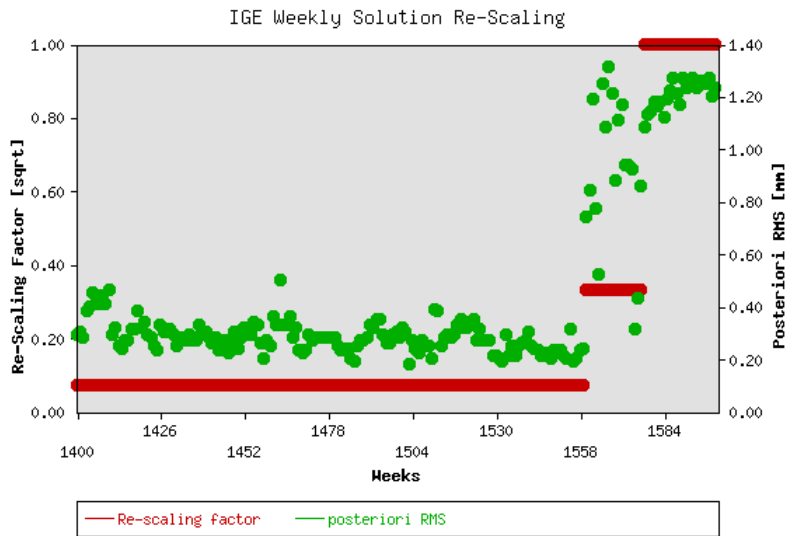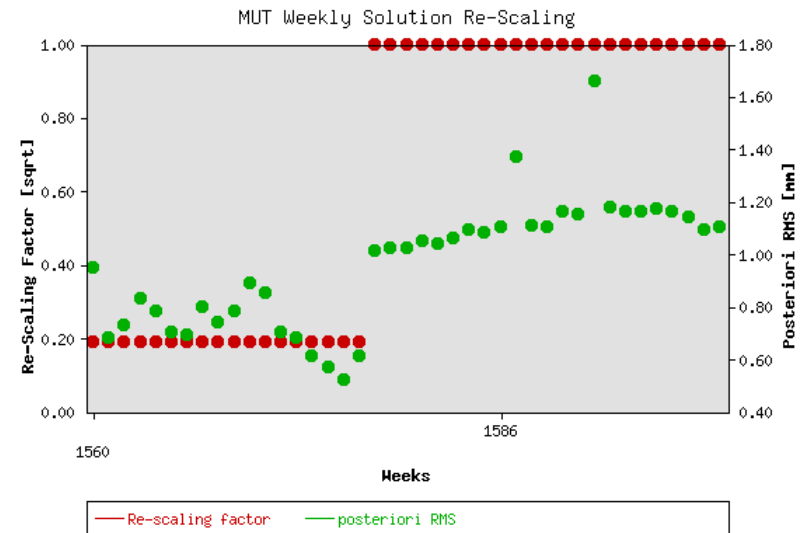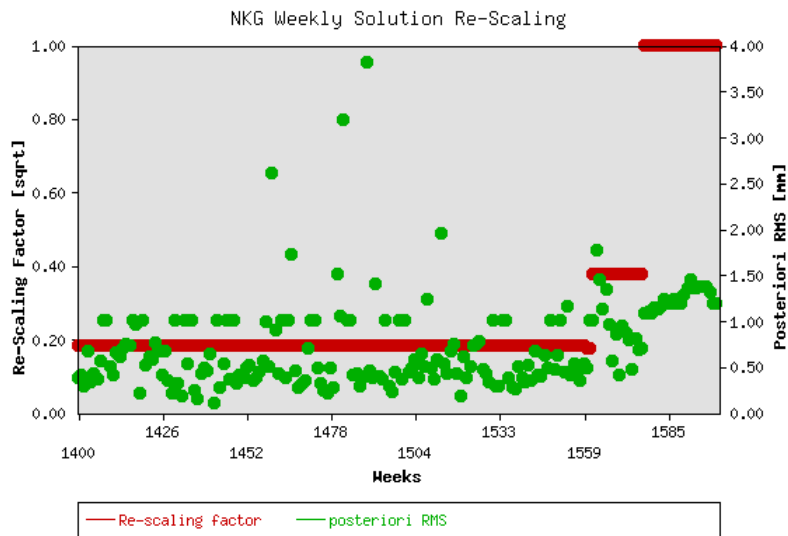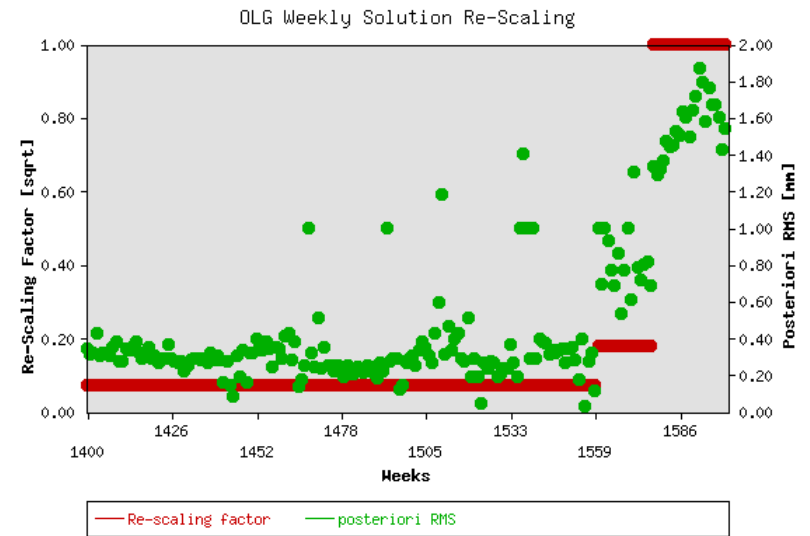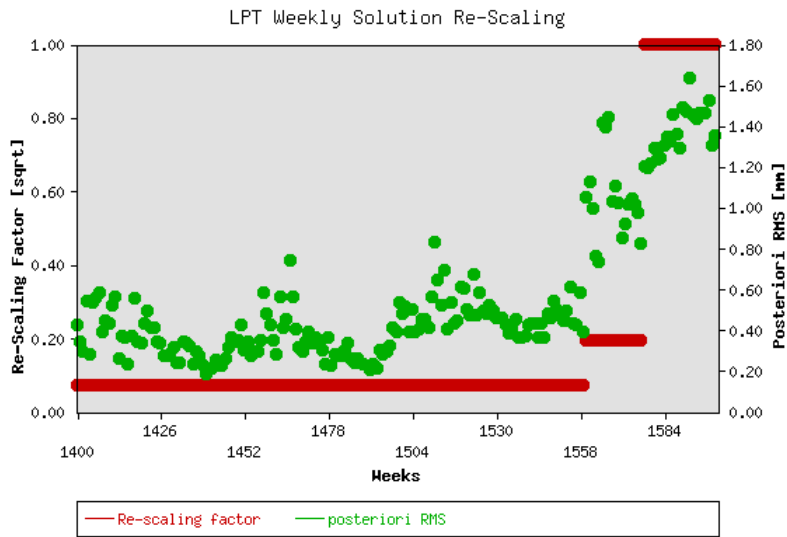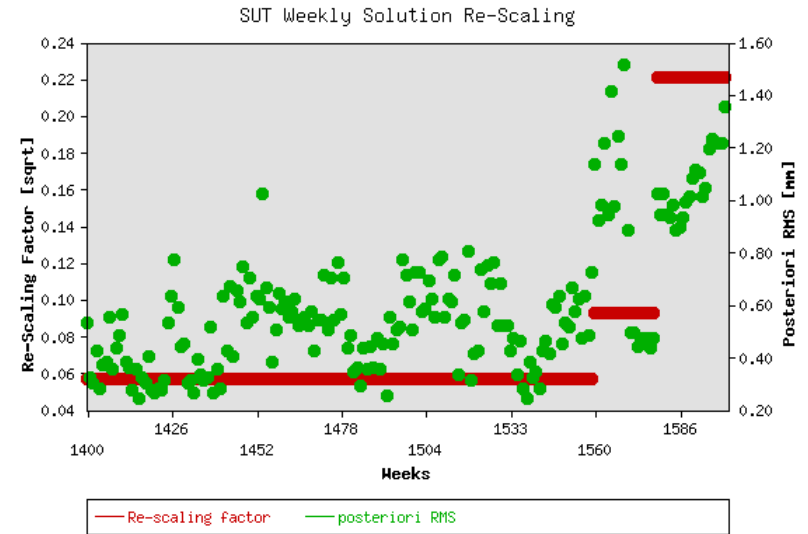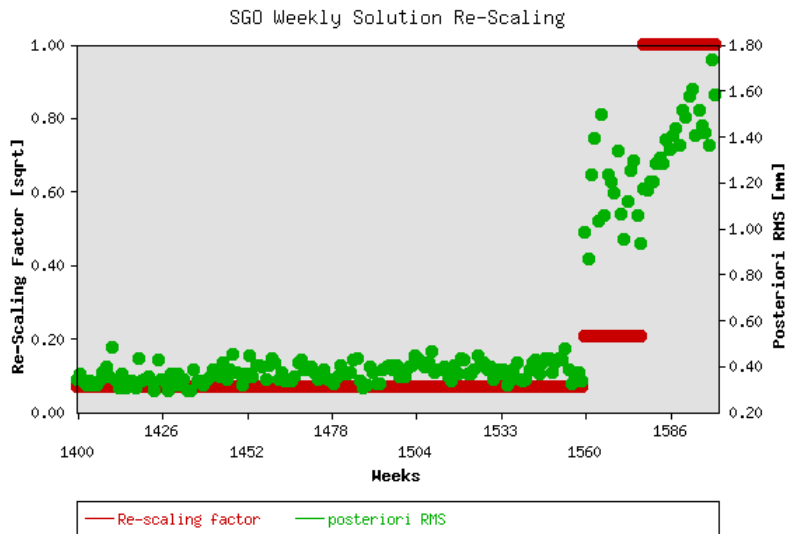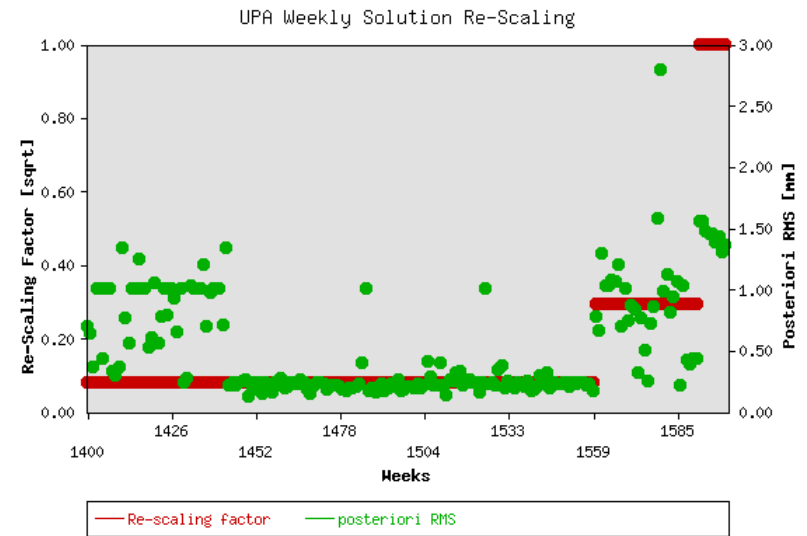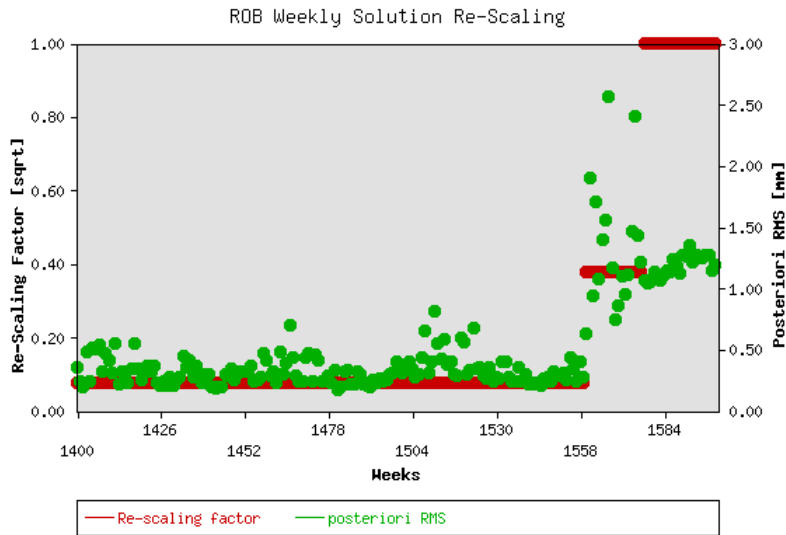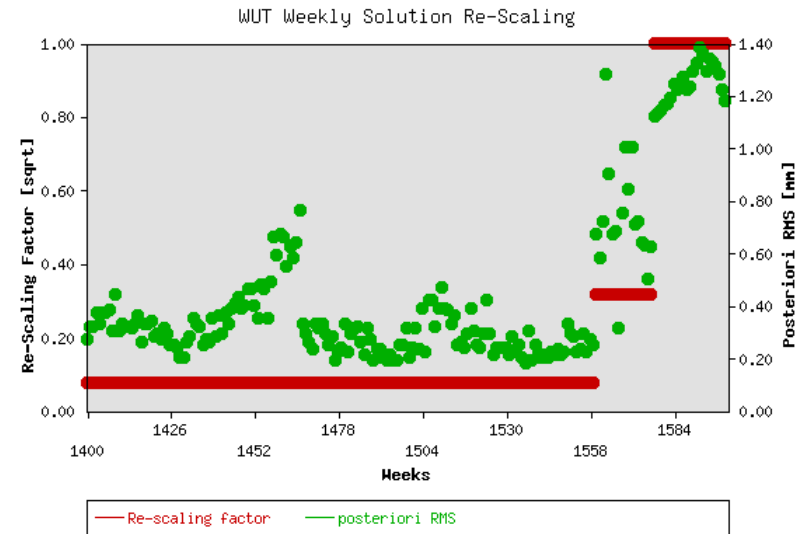
- Ask EPN station operators to send RINEX version 3 observation files in addition to RINEX version 2

- *Objective:* Provide real data in new format to support software developments

- *Here:* RINEX version 3 data holding at **BKG data center**

```
ssssdddf.yyt
| | | | | |
| | | | | +-- t: file type:
| | | | | O: Observation file
| | | | | N: GPS navigation message file
| | | | | M: Meteorological data file
| | | | | G: GLONASS navigation message file
| | | | | L: Galileo navigation message file
| | | | | P: Mixed GNSS navigation message file
| | | | | H: SBAS Payload navigation message file
| | | | | B: SBAS broadcast data file
| | | | | (separate documentation)
| | | | | C: Clock file (separate documentation)
| | | | | S: Summary file (used e.g., by IGS, not a standard!)
| | | +--- yy: two-digit year
| | +----- f: file sequence number/character within day.
| | daily file: f = 0 (zero)
| | hourly files:
| | a = 1st hour: 00h-01h; b = 2nd hour: 01h-02h; . . . x = 24th hour:
| | 23h-24h
| +------- ddd: day of the year of first record
+----------- ssss: 4-character station name designator
```

- extended for Galileo and mixed GNSS navigation message files
- no identifier for the RINEX version number

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- Issues to be considered
  - from file name one could not distinguish between version 2 and 3
  - identical file names for both versions my lead to mismatch in data center operation
  - *BUT,* RINEX filename convention deeply established in user community

- Approach BKG data center
  - read content of RINEX file header to identify version ("RINEX version number" test implemented, "OBS type" as additional indicator in planned)

- Store RINEX version 3 in dedicated directory
  - daily files → "obs_v3"
  - hourly files → "nrt_v3"

- Potential of overwriting one version with the other
- Sequential submission recommended !
- Issue under investigation
  - does overwriting really happen ?
  - concept of versioning under discussion

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WARN,
SASS,
BOGI

```
     3.00               OBSERVATION DATA    M (MIXED)            RINEX VERSION / TYPE
BNC 2.0               weber                 20101023 000002 UTC  PGM / RUN BY / DATE
warn                                                             MARKER NAME
GEODETIC                                                         MARKER TYPE
14277M002                                                        MARKER NUMBER
AF2ETZ85Y4G          JPS LEGACY            2.6.1 JAN,10,2008     REC # / TYPE / VERS
09050002             LEIAR25.R3     LEIT                         ANT # / TYPE
  3658785.9300   784470.8400   5147870.5600                     APPROX POSITION XYZ
        0.0690        0.0000        0.0000                       ANTENNA: DELTA H/E/N
matthias.groeschel@ BKG                                          OBSERVER / AGENCY
PORTIONS OF THIS HEADER GENERATED BY THE IGS CB FROM            COMMENT
SITELOG warn_20100915.log                                       COMMENT
G   10 C1C C1P L1C S1C C2X C2P L2X S2X L2P S2P                   SYS / # / OBS TYPES
R   10 C1C C1P L1C S1C C2C C2P L2C S2C L2P S2P                   SYS / # / OBS TYPES
S    3 C1C L1C S1C                                               SYS / # / OBS TYPES
  2010    10    23    00    00   00.0000000     GPS              TIME OF FIRST OBS
RTCM_3 141.74.33.12/WARN1                                        COMMENT
                                                                 END OF HEADER
```

```
     2.11               OBSERVATION DATA    M (MIXED)            RINEX VERSION / TYPE
teqc  2010Mar17                             20101024 00:22:54UTC PGM / RUN BY / DATE
WARN                                                             MARKER NAME
14277M002                                                        MARKER NUMBER
NTRIPS05-487470-46  BKG                                          OBSERVER / AGENCY
AF2ETZ85Y4G          JPS LEGACY            2.6.1 JAN,10,2008     REC # / TYPE / VERS
09050002             LEIAR25.R3     LEIT                         ANT # / TYPE
  3658786.1050   784470.6700   5147870.3950                     APPROX POSITION XYZ
        0.0690        0.0000        0.0000                       ANTENNA: DELTA H/E/N
    1    1                                                       WAVELENGTH FACT L1/2
    7    C1    P1    P2    L1    L2    S1    S2                   # / TYPES OF OBSERV
  30.0000                                                        INTERVAL
    0                                                            RCV CLOCK OFFS APPL
Forced Modulo Decimation to 30 seconds                          COMMENT
  2010    10    23    0    0    0.0000000     GPS                TIME OF FIRST OBS
   15                                                            LEAP SECONDS
Linux 2.4.20-8|Pentium IV|gcc -static|Linux|486/DX+            COMMENT
MAKERINEX 1.140     WARN                2010-10-23 01:01        COMMENT
                                                                 END OF HEADER
```

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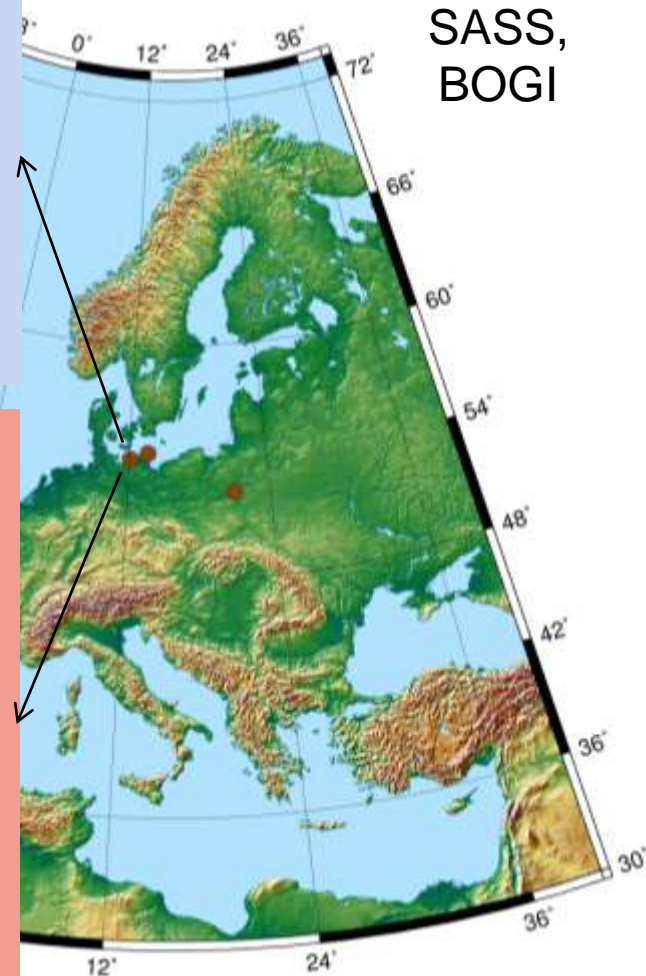
```
     3.00              OBSERVATION DATA    Mixed(MIXED)        RINEX VERSION / TYPE
cnvtToRINEX 2.03.0   Droscak               08-Nov-10 09:04 UTC PGM / RUN BY / DATE
GANP                                                          MARKER NAME
11515M001                                                    MARKER NUMBER
GEODETIC                                                     MARKER TYPE
SKPOS               GKU BRATISLAVA                            OBSERVER / AGENCY
35438               TRIMBLE NETR8        Version 4.03         REC # / TYPE / VERS
37385               TRM55971.00      NONE                     ANT # / TYPE
  3929181.8490  1455236.5102  4793653.6959                   APPROX POSITION XYZ
      0.3830         0.0000         0.0000                    ANTENNA: DELTA H/E/N
G   12 C1C C2W C2X C5X L1C L2W L2X L5X S1C S2W S2X S5X        SYS / # / OBS TYPES
R    9 C1C C1P C2P L1C L1P L2P S1C S1P S2P                    SYS / # / OBS TYPES
  2010    11     7     0     0    0.0000000     GPS           TIME OF FIRST OBS
  2010    11     7    23    59   30.0000000     GPS           TIME OF LAST OBS
     0                                                        RCV CLOCK OFFS APPL
    15                                                        LEAP SECONDS
    50                                                        # OF SATELLITES
   G02  1024  1012     0     0  1024  1012     0     0  1024PRN / # OF OBS
   G03   902   899     0     0   899   896     0     0   902PRN / # OF OBS
…
```

```
     2.11              OBSERVATION DATA    M (MIXED)           RINEX VERSION / TYPE
teqc  2009Jul14                            20101107 00:08:10UTCPGM / RUN BY / DATE
GANP                                                          MARKER NAME
11515M001                                                    MARKER NUMBER
SKPOS               GKU BRATISLAVA                            OBSERVER / AGENCY
35438               TRIMBLE NETR8        4.03/3.60            REC # / TYPE / VERS
37385               TRM55971.00      NONE                     ANT # / TYPE
  3929181.8492  1455236.5107  4793653.6956                   APPROX POSITION XYZ
      0.3830         0.0000         0.0000                    ANTENNA: DELTA H/E/N
    1     1                                                   WAVELENGTH FACT L1/2
   11    L1    L2    L5    C1    P1    C2    P2    C5    S1# / TYPES OF OBSERV
       S2    S5                                               # / TYPES OF OBSERV
   30.0000                                                    INTERVAL
  2010    11     6     0     0    0.0000000     GPS           TIME OF FIRST OBS
    15                                                        LEAP SECONDS
                                                             END OF HEADER
```
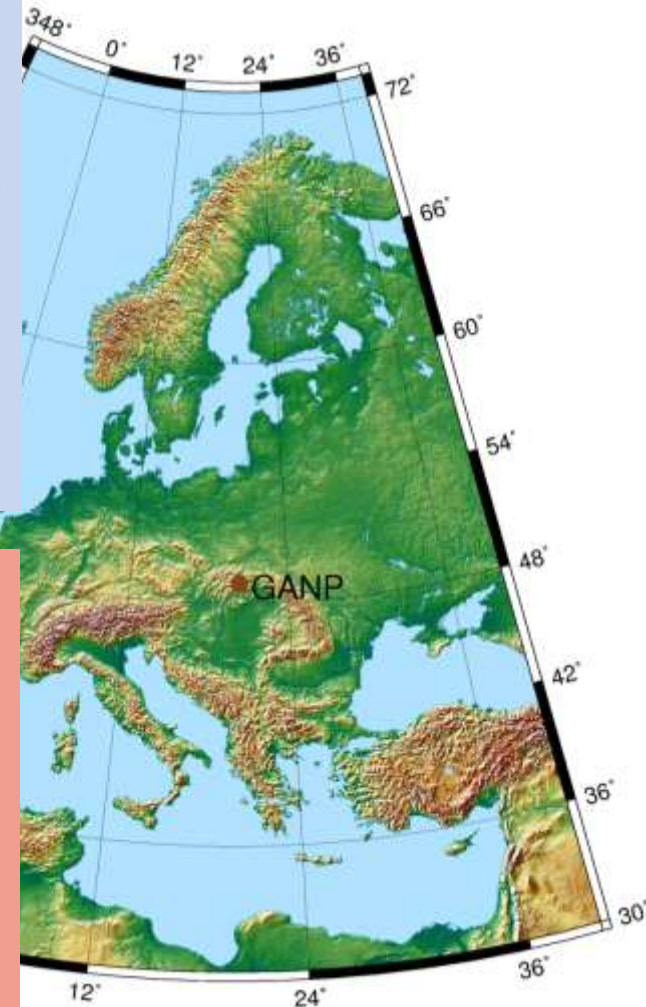
```
     3.00                O                    G              RINEX VERSION / TYPE
S2R                      ROOT              20101106 011116 UTC PGM / RUN BY / DATE
                                                              MARKER NAME
NONE                                                          MARKER TYPE
DSF GSTBV2               ESA                                  OBSERVER / AGENCY
                         GETR                                 REC # / TYPE / VERS
003                      GAL-EXP-ANT-2    NONE                ANT # / TYPE
  4476536.1163    600429.0850   4488763.0335                 APPROX POSITION XYZ
        0.0000         0.0000          0.0000                 ANTENNA: DELTA H/E/N
  2010    11    06    00    00   00.000                       TIME OF FIRST OBS
  2010    11    06    23    59   59.000                       TIME OF LAST OBS
G   10 C1C L1C D1C S1C C1P S1P C2P L2P D2P S2P                SYS / # / OBS TYPES
E   16 C1B L1B D1B S1B C5Q L5Q D5Q S5Q C7Q L7Q D7Q S7Q C8Q   SYS / # / OBS TYPES
       L8Q D8Q S8Q                                           SYS / # / OBS TYPES
    30.000                                                    INTERVAL
                                                              END OF HEADER
```
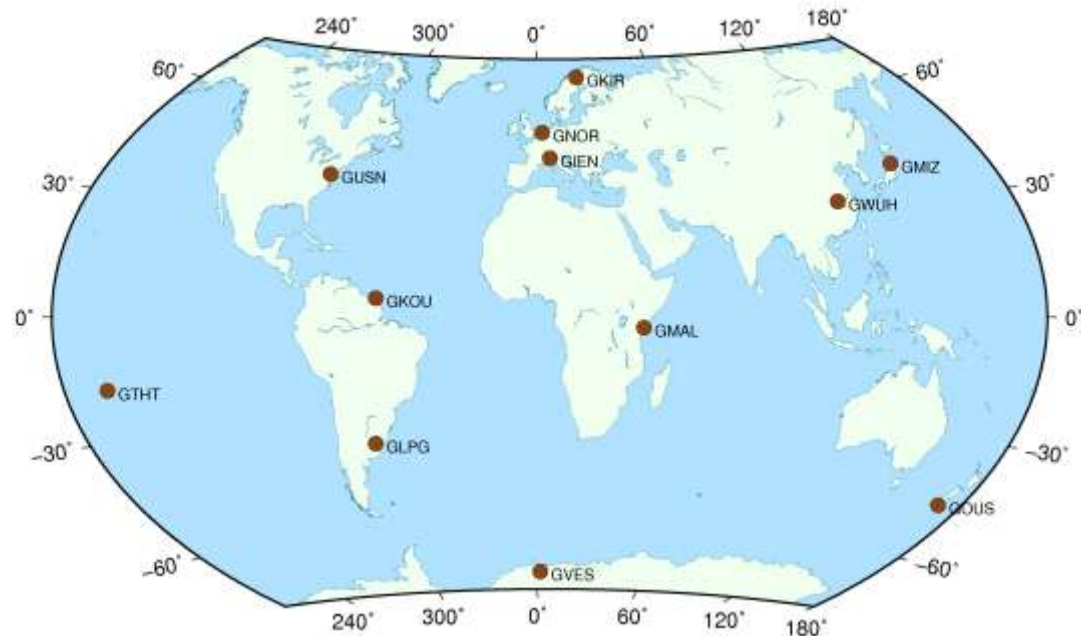

Giove Stations

```
     3.00              OBSERVATION DATA   M (MIXED)          RINEX VERSION / TYPE
BNC 2.5              Weber                 20101113 202603 UTC PGM / RUN BY / DATE
WILDBD_MSM7                                                   MARKER NAME
unknown                                                       MARKER TYPE
unknown             unknown                                   OBSERVER / AGENCY
unknown             unknown             unknown              REC # / TYPE / VERS
unknown             unknown                                   ANT # / TYPE
        0.0000          0.0000          0.0000               APPROX POSITION XYZ
        0.0000          0.0000          0.0000               ANTENNA: DELTA H/E/N
G   10 C1C C1P L1C S1C C2W C2P L2W S2W L2P S2P               SYS / # / OBS TYPES
R   10 C1C C1P L1C S1C C2C C2P L2C S2C L2P S2P               SYS / # / OBS TYPES
E    6 C1X L1X S1X C5X L5X S5X                                SYS / # / OBS TYPES
S    3 C1C L1C S1C                                            SYS / # / OBS TYPES
  2010    11    13    20    26   00.0000000     GPS          TIME OF FIRST OBS
RTCM_3 ntrip.dgpsonline.eu/WILDBD_MSM7                        COMMENT
                                                             END OF HEADER
```

- Trimble BC982 receiver on facilities of "Alberding GmbH", Germany

- based on stream data

- 6 Galileo observation types

```
     3.00              OBSERVATION DATA    M (Mixed)          RINEX VERSION / TYPE
NtripJPStoRnx         congo               20101108 235946 GMT PGM / RUN BY / DATE
Source NTRIP stream 141.74.33.12/WTZX3                        COMMENT
WTZX3                                                         MARKER NAME
14201M015                                                     MARKER NUMBER
Hauschild            DLR/GSOC                                 OBSERVER / AGENCY
Delta_00049          JAVAD TRE_G3TH DELTA 3.1.6b1             REC # / TYPE / VERS
10020020             LEIAR25.R3      LEIT                     ANT # / TYPE
  4075535.2070   931822.4470  4801609.2000                   APPROX POSITION XYZ
        0.0560        0.0000        0.0000                    ANTENNA: DELTA H/E/N
G   20 C1C L1C D1C S1C C2C L2C D2C S2C C1W L1W D1W S1W C2W    SYS / # / OBS TYPES
       L2W D2W S2W C5X L5X D5X S5X                            SYS / # / OBS TYPES
R   16 C1C L1C D1C S1C C2C L2C D2C S2C C1P L1P D1P S1P C2P    SYS / # / OBS TYPES
       L2P D2P S2P                                            SYS / # / OBS TYPES
E    8 C1X L1X D1X S1X C5X L5X D5X S5X                        SYS / # / OBS TYPES
S    8 C1C L1C D1C S1C C5X L5X D5X S5X                        SYS / # / OBS TYPES
 21 R01  1 R02 -4 R03  5 R05  1 R07  5 R08  6 R09 -2 R10 -7   GLONASS SLOT / FRQ #
    R11  0 R12 -1 R13 -2 R15  0 R16 -1 R17  4 R18 -3 R19  3   GLONASS SLOT / FRQ #
    R20  2 R21  4 R22 -3 R23  3 R24  2                        GLONASS SLOT / FRQ #
Smoothed pseudoranges                                         COMMENT
Carrier-to-Noise ratios (SA,S1,S2) in [dB-Hz]                 COMMENT
All observations are referred to receiver time               COMMENT
Giove-A/B PRN codes mapped from E01/E16 to E51/E52            COMMENT
  2010    11    9    0    0    0.0000000                      TIME OF FIRST OBS
                                                              END OF HEADER
```

- Javad TRE_G3TH Receiver in Wettzell

- 8 Galileo observation types listed, but actually none included in example file

- Adjustment of EPN analysis to new models and references, e.g., ITRF2008

- Increase of GNSS activity (GLONASS, Galileo), more test for RINEX version 3

- Integration of real-time analysis into EPN analysis (e.g. prduct combination as IGS RT-WG is doing)

- EPN Re-Processing already started

- Should we better consider user requirements in the discussion about future analysis products? Feedback from users?