Federal Agency for Cartography and Geodesy

Multi-GNSS Working Group

Status Data Centres, Real-Time, RINEX 3

Wolfgang Söhne

Federal Agency for Cartography and Geodesy

- **What's new on the MGEX homepage of IGS (http://igs.org/mgex)**
  - **94 stations (78 with GAL (announced …))**

    35 in Europe – but EUREF has more stations …
  - **CNAV data from test campaign June, 15-29, 2013 available**

    (ftp://cddis.gsfc.nasa.gov/gnss/data/campaign/cnav/2013/06/) (Montenbrucket al., GPS World August 2013)
- **Which data centres are involved?**
  - **CDDIS, IGN, BKG (TUM, JAXA, …)**
- **What is the directory structure, are there deviations?**
- **Where do the data come from?**
  - **Mainly from the stations, few from BNC (converted from streams)**

- **Which DCs are providing Multi-GNSS ephemeris?**
  - **ftp://cddis.gsfc.nasa.gov/gnss/data/campaign/mgex/daily/rinex3/*yyyy*/brdm→ GPS, GLO, QZS, GAL, BDS, SBAS**
  - **ftp://igs.ign.fr/pub/igs/data/campaign/mgex/daily/rinex3/*yyyy*/*ddd*/**
  - **http://igs.bkg.bund.de/NTRIP/→brdc→ GPS, GLO (GAL)**

- **Which DCs are providing Multi-GNSS ephemeris?**
  - **ftp://cddis.gsfc.nasa.gov/gnss/data/campaign/mgex/daily/rinex3/*yyyy*/brdm→ GPS, GLO, QZS, GAL, BDS, SBAS**
  - **ftp://igs.ign.fr/pub/igs/data/campaign/mgex/daily/rinex3/*yyyy*/*ddd*/**
  - **http://igs.bkg.bund.de/NTRIP/→brdc→ GPS,GLO, GAL (again available since yesterday)**

Which DCs are providing Multi-GNSS observations?

- ftp://cddis.gsfc.nasa.gov/gnss/data/campaign/mgex/→ daily, hourly,highrate→ raw, rinex2, rinex3
- ftp://igs.ign.fr/pub/igs/data/campaign/mgex/→ daily, hourly,highrate→ raw, rinex2, rinex3
- ftp://igs.bkg.bund.de/MGEX/→ highrate_v3, nrt_v3, obs_v3

  ftp://igs.bkg.bund.de/IGS/→ BRDC_v3 (GPS, GLO), highrate_v3, nrt_v3, obs_v3

  ftp://igs.bkg.bund.de/EUREF/→ BRDC_v3 (GPS, GLO), highrate_v3, nrt_v3, obs_v3

  ftp://igs.bkg.bund.de/NTRIP/→ highrate_v3

- **Which DCs are providing Multi-GNSS products?**
  - **ftp://cddis.gsfc.nasa.gov/pub/gps/products/mgex/→*wwww*→erp, sp3,clk,bia,dcb**
  - **ftp://igs.ign.fr/pub/igs/products/mgex/→*wwww*→ sp3**
  - **https://www.iapg.bv.tum.de/mgex**
  - **http://qz-vision.jaxa.jp/USE/en/finalp**
  - **ftp://igs.bkg.bund.de/MGEX/products → (empty)**

MGEX real-time activities

- **What is the status of real-time (RTCM MSM, …)?**
  - **http://igs.bkg.bund.de/ntrip/mgexobs→ description**
  - **http://mgex.igs-ip.net/home→ 150 data streams (RAW and MSM) → 78 RTCMMSM**
  - **Last RTCM meeting in September**
    - **Draft for BDS MSM**
    - **Proposal for phase biases andionosphericcorrections (SSR)**

Federal Agency for Cartography and Geodesy

Multi-GNSS Working Group

Processing Tests EUREF-MGEX

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Federal Agency for Cartography and Geodesy

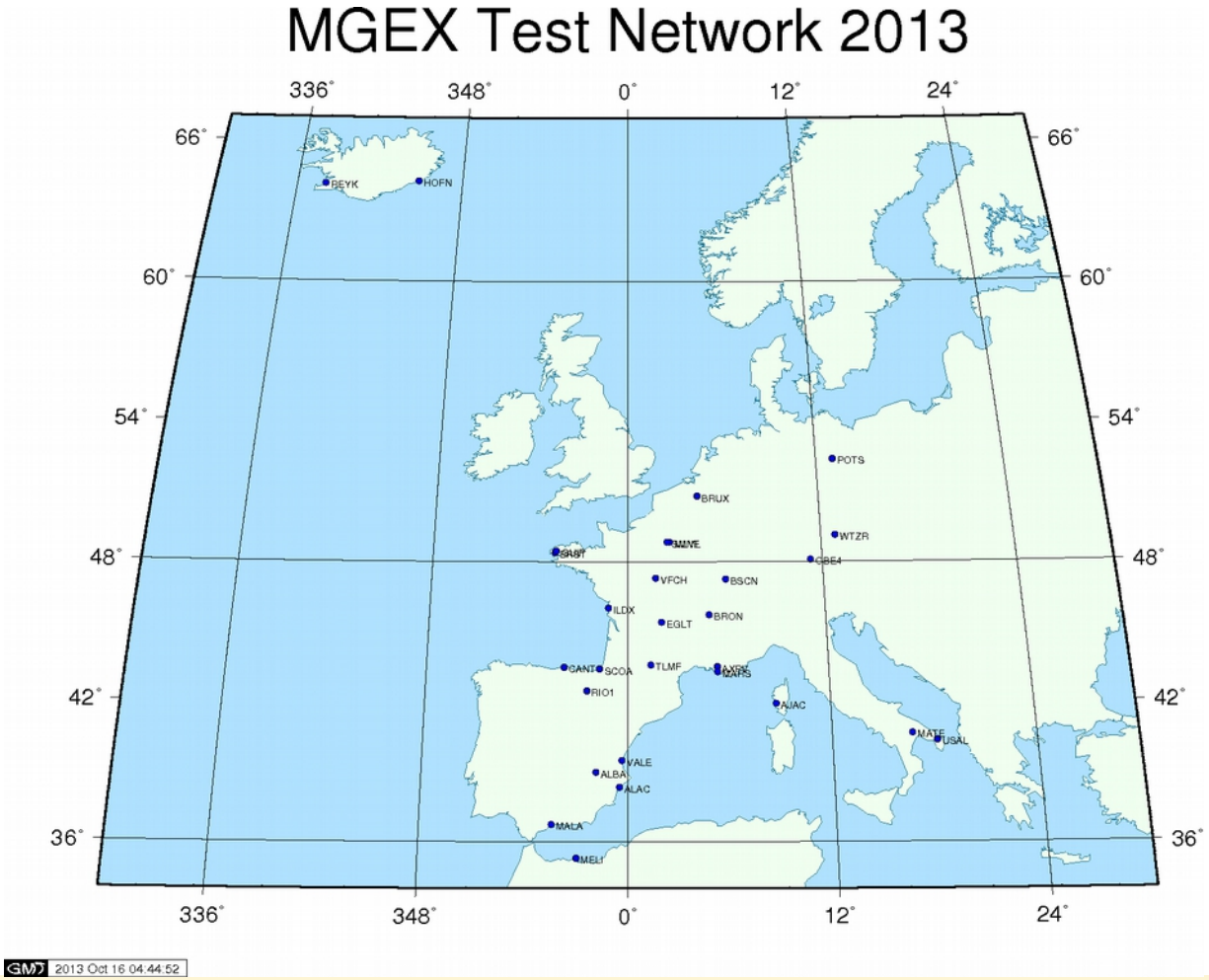
Motivation

- **Working with the new version 5.2 of Bernese GNSS Software**
- **Testing of RINEX V3.02 files in the modified RNX2SNX processing scheme**
- **Testing of processing Galileo IOV observations**
- **Testing of Galileo IOV final orbits**

Test processing

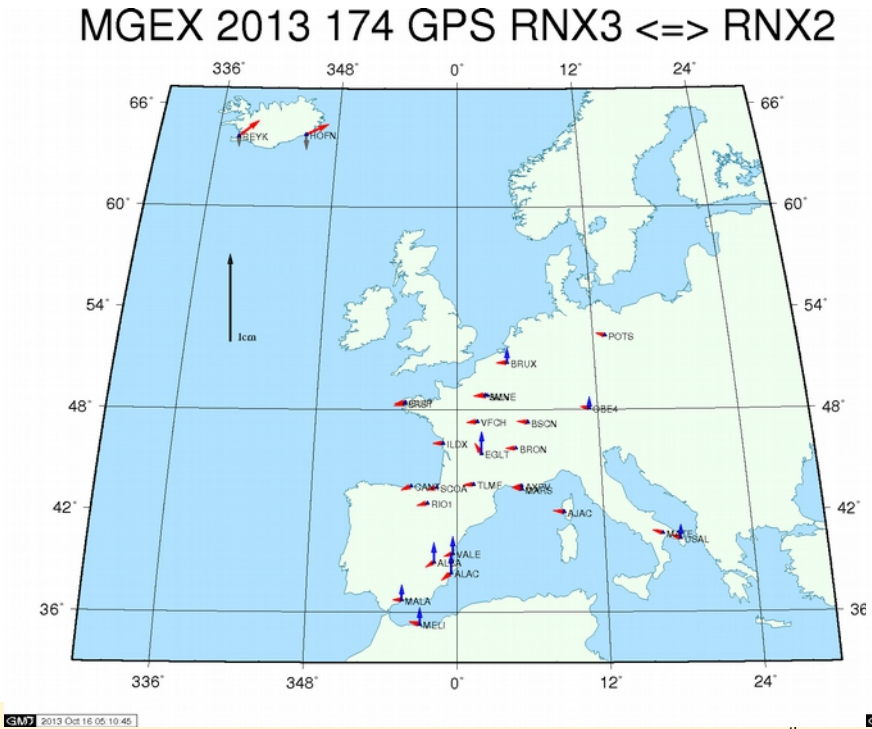
- **Testing of the new version 5.2 of Bernese GNSS Software**
  - **For GPS+GLO using RINEX V2.11 files BSW5.2 already introduced for routine operation since GPS week 1730→few mm differences to BSW5.0 results**
- **Testing of RINEX V3.02 files in the modified RNX2SNX processing scheme**
  - **Usage of RINEX V3 files instead of RINEX V2 files with GPS-only→coordinate differences on the mm level: 2.0 / 4.1 / 5.7 (N/E/U) (20 stations used,doy130-137)**

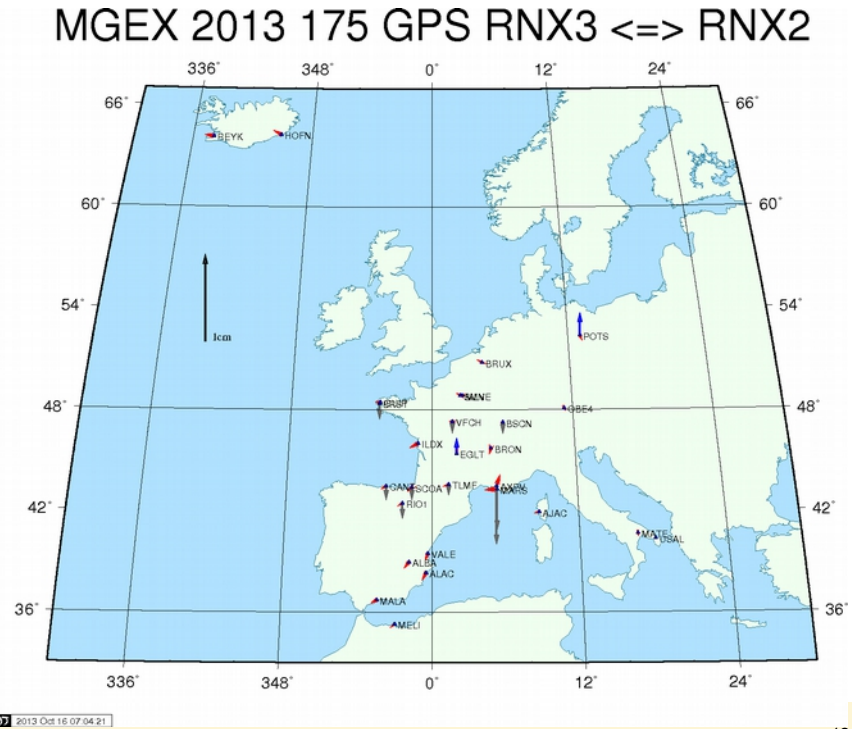
- **MGEX stations used for BKG Tests (doy174 – 180)**



Testing of RINEX V3.02 files in the modified RNX2SNX processing scheme

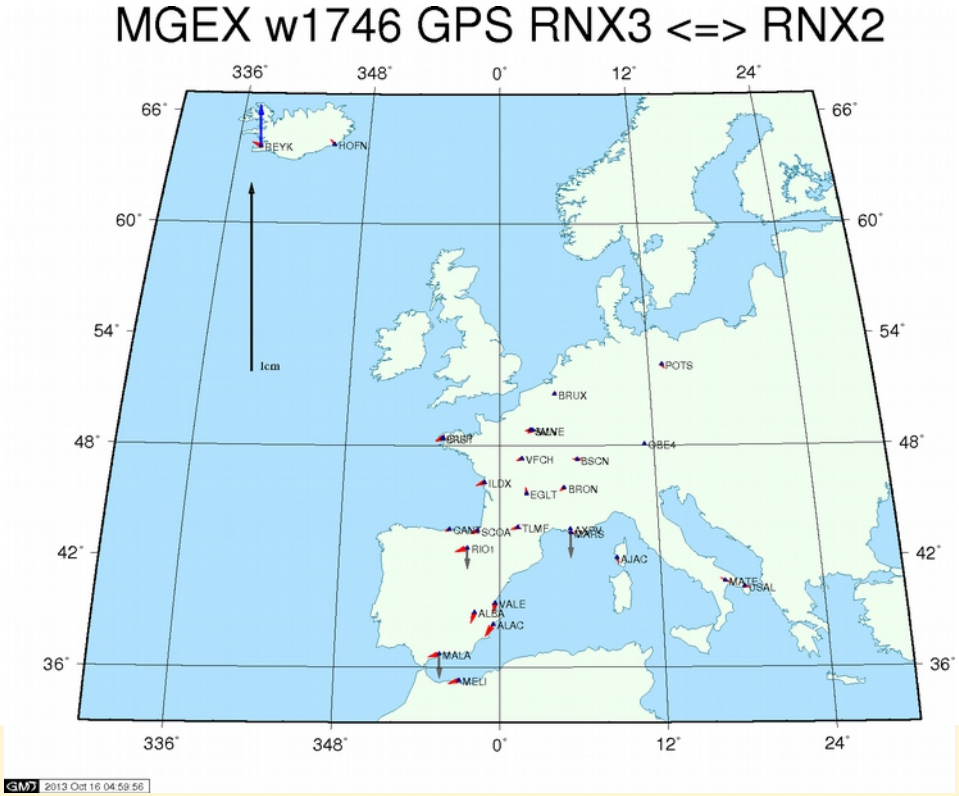
- Usage of RINEX V3 files instead of RINEX V2 files with GPS-only→coordinate differences on the mm level, with few exceptions(daily solutions 23-JUN-2013 + 24-JUN-2013)





Testing of RINEX V3.02 files in the modified RNX2SNX processing scheme

- Usage of RINEX V3 files instead of RINEX V2 files with GPS-only→coordinate differences on the mm level, with few exceptions(weekly solution 1746 (23-JUN-2013 - 29-JUN-2013)



- **Testing of processing Galileo IOV observations**
  - **~30 EPN stations available (plus few other, non-EPN European stations)**
  - **Processing of GPS-only vs. GPS+GAL vs. GPS+GLO+GAL**
  - **Galileo-only processing possible?→ yes, but (sub-) meter accuracy**
- **Testing of Galileo IOV final orbits**
  - **TGVF orbits (restricted) vs. MGEX orbits**
  - **Used with regular RINEX 2.11 data for GPS-only→coordinate repeatability on (sub)-mm level**

- **Testing of processing Galileo IOV observations**
  - **~ 35 EPN stations available (plus few other European stations)**

    Processing of GPS-only vs. GPS+GAL vs. GPS+GLO+GAL(Daily solution 23-JUN-2013,Orbits from CODE for GPS + GAL (COD + COM), RNX 3, GAL-Freq. E1 + E5, Ant.PCV GAL = GPS

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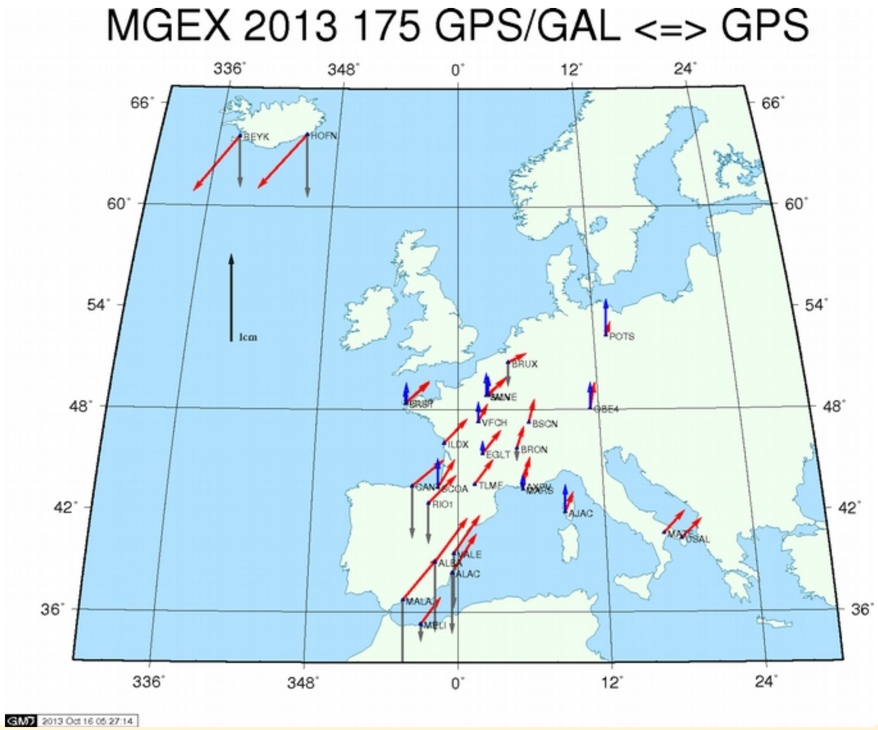
================================================================================
RNX2SNX BPE PROCESSING SUMMARY FOR YEAR-SESSION 13-1740
================================================================================

================================================================================
PART 1: RINEX PSEUDO-GRAPHICS
================================================================================

GALILEO SATELLITES :

ajac|1222223333332221111-           -1112222222222211111111-
alac|2223333333333322211-           -111222222221111111-
alba |2223333333333322211-            -1222222222211111111
axpv|333333333333222111l        -1112222222222222211111111
bron|2222223333332221111-            -11121122222211111111-
brst|3333333333322221-          --1122222222222221111111-
brux|233333333333222111-          -111122222222221222211-
bscn|22222333333322111-            -1111222222221111111-
cant |22222223333322221-             -1122222222111111l-
eglt|22222233333222111-              -112222221111111-
guip|22233333333332221-            -1111222222221111111-
hofn|3333333333222221-              -111222222222222222211-
ildx|333333333333322211-        -112222222222222221111111-
mala |22222333333332221-          -1112222222221111111-
mars |2222223333332221111-           -122222211111111-
mate |
meli|
mlvl|22223333333222111-             -122222222211111l-
obe4 |33333333333332221111-       -1112222222222222222221111-
pots |23333333333322211111-       -1111222222222222232222111-
puyv|
reyk|333333333322222-               -1222222222112222111-
rio1 |22333333333333322211-         -11222222222211111111-
scoa|22223333333322211l-                -11111111111-
smne|33333333333333222111-      -111222222222222221111111-
tlmf|22222222333332221-           -1111222222221111111
usal|
vale |22333333333333322211-        -22222222222221111111-
vfch|2222223333322221-              -111222222111111l-
-----+-----------------+-----------------+-----------------+-----------------+
0                                12                                    24
```



- **Testing of processing Galileo IOV observations**
  - **~ 35 EPN stations available (plus few other European stations)**

    Processing of GPS-only vs. GPS+GAL vs. GPS+GLO+GAL(Daily solution 24-JUN-2013, Orbits from CODE for GPS + GAL (COD + COM), RNX 3, GAL-Freq. E1 + E5, Ant.PCV GAL = GPS, Bernese 5.2 RNX2SNX routine

```
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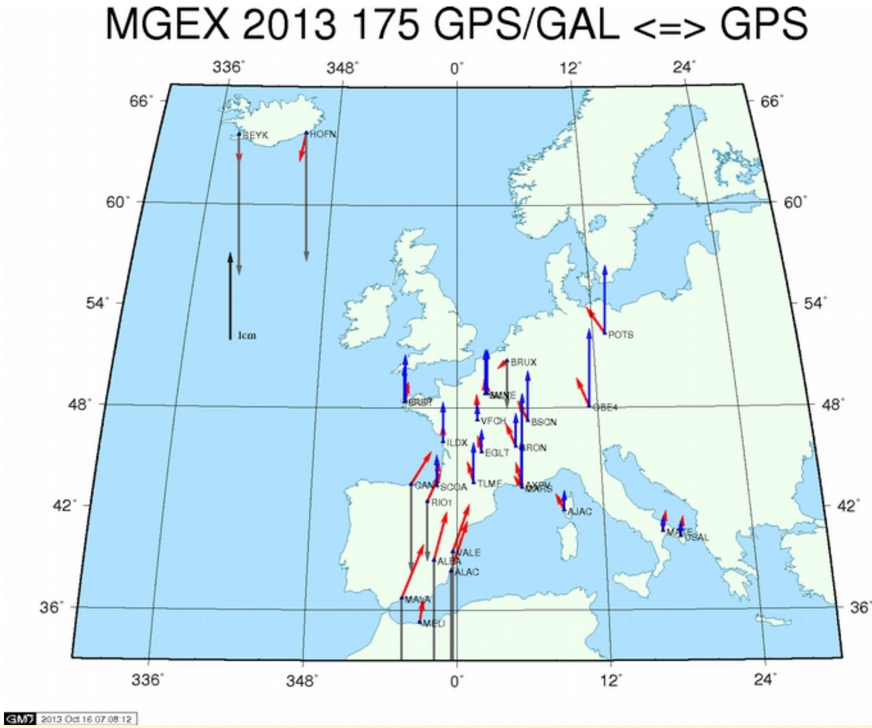
RNX2SNX BPE PROCESSING SUMMARY FOR YEAR-SESSION 13-1750
================================================================================

================================================================================
PART 1: RINEX PSEUDO-GRAPHICS
================================================================================

GALILEO SATELLITES :

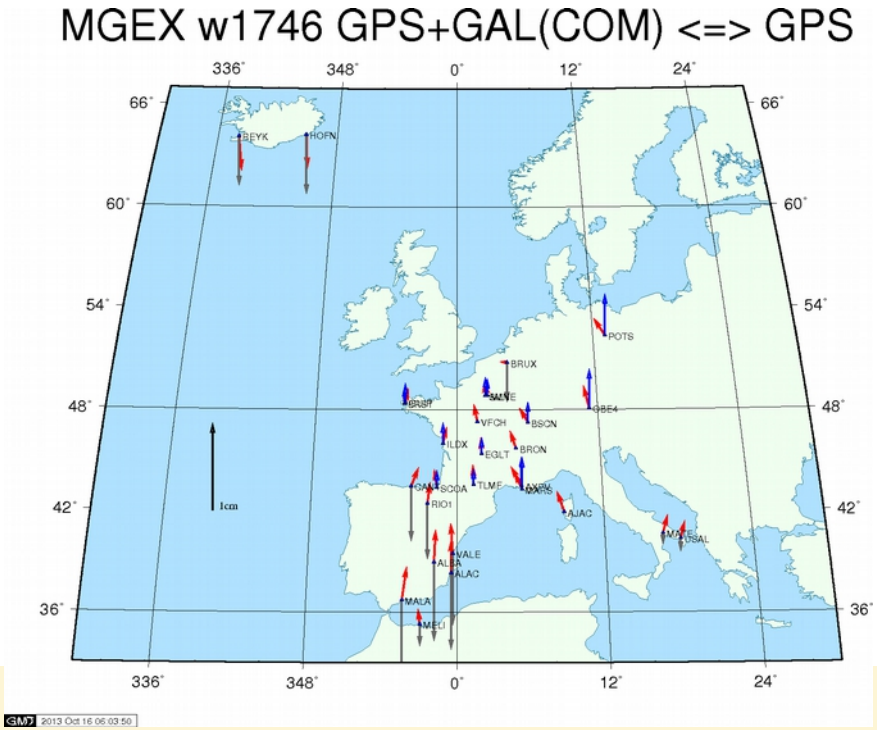
ajac|            -1111111111111111111-       -111111122222333333221111111
alac|         -11111111111111111111111-    -1111122222233333333222211111111
alba |         -111111111111111111111-     -11111222222233333333222111111111
axpv|      -2222221111111111111111111-   -111111222223333333333333221111111
bron|            -11111111111111111-         -11111122222223333332111111
brst|     -2222222332111111111111111-   -1111112222222333333333331111111-
brux|      -12222232211111111111111-     -1111122222333333333333211111-
bscn|             -111111111111111-          -1111222222223333331111111111-
cant |         -11111111111111111111-     -11111222222222222222221111111-
eglt|           -1111111111111111111-        -112222222222222222221111111-
guip|          -111111111111111111111-        -111122222222223333321111111-
hofn|   -111222233333222111111111-           -112222222222333333222111-
ildx|    -1222223333211111111111111-    -1111122222223333333333331111111-
mala |          -11111111111111111111111-  -11111112222222222223333222111111111
mars |           -11111111111111111-         -1111122222222222332221111111111
mate |
meli|
mlvl|           -111111111111111111111-       -11111222222233333332111111-
obe4 |      -12222212111111111111111-     -11111122223333333333333331111111
pots |      -11222322111111111111111-      -111111222333333333333333111111-
puyv|
reyk|    -1122233333322221111111-           -111112222222333333222111-
rio1 |         -11111111111111111111111-     -11111112222223333312332111111111-
scoa|            -11111111111111111-                -122222222222221111111-
smne|     -122222232111111111111111-    111111222222333333333333331111111-
tlmf|            -11111111111111111-         -11111112222223333333211111-
usal|
vale |         -11111111111111111111111-     -11111111222333333333221111111
vfch|            111111111111111111-         -1111112222222222223311111111-
-----+----------------+----------------+----------------+----------------+
0                               12                               24
```



Testing of processing Galileo IOV observations

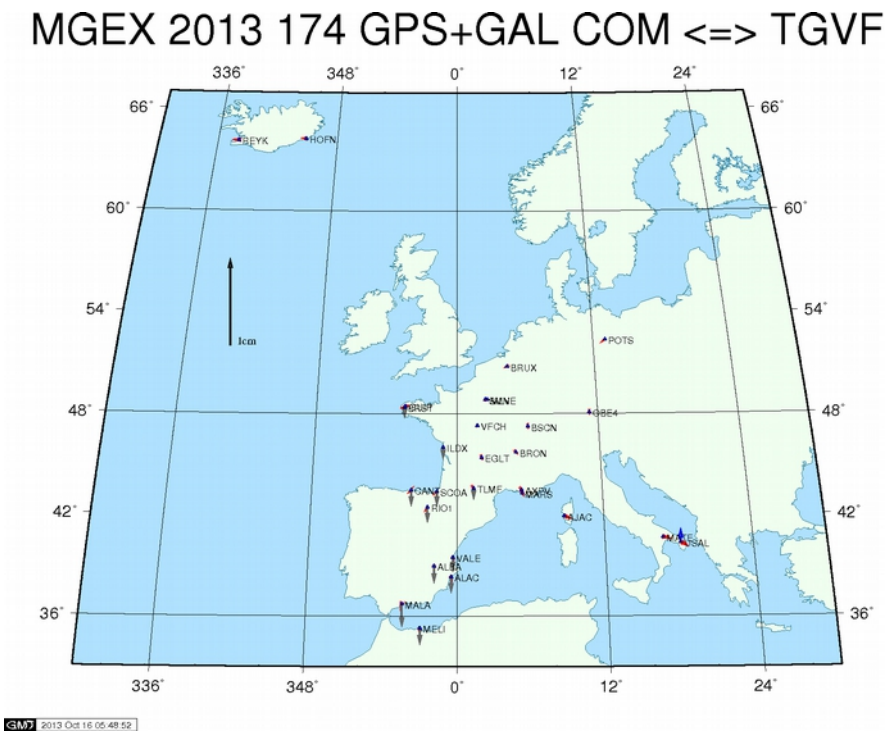
- ~30 EPN stations available (plus few other European stations)
- Processing of GPS-only vs. GPS+GAL vs. GPS+GLO+GAL
- Galileo-only processing possible?

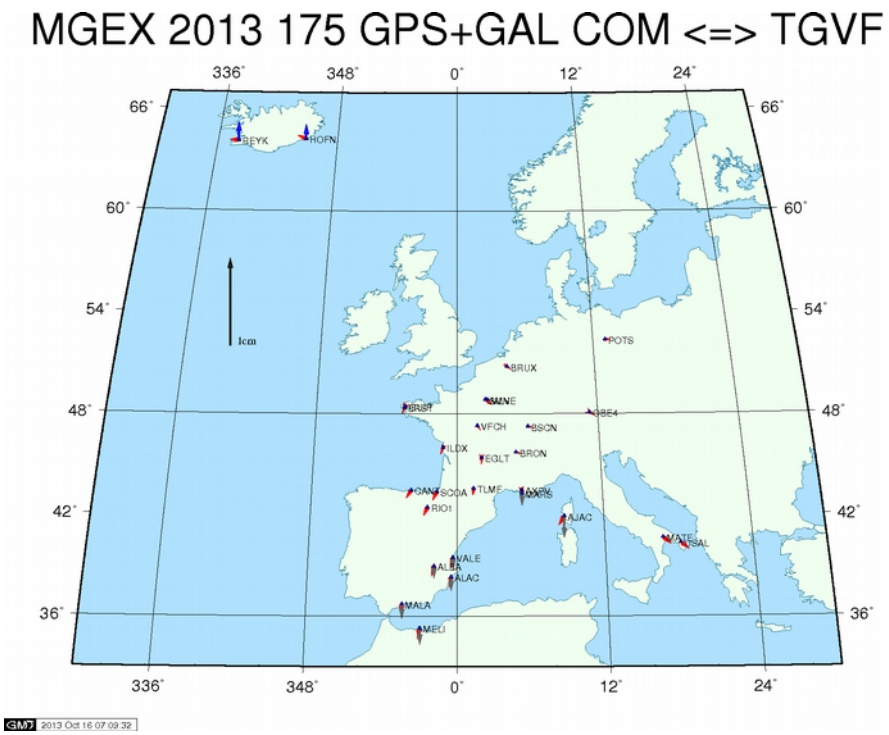
Weekly solution 1746 (23-JUN-2013 - 29-JUN-2013) Orbits from CODE (GPS + GAL)



Testing of Galileo final orbits

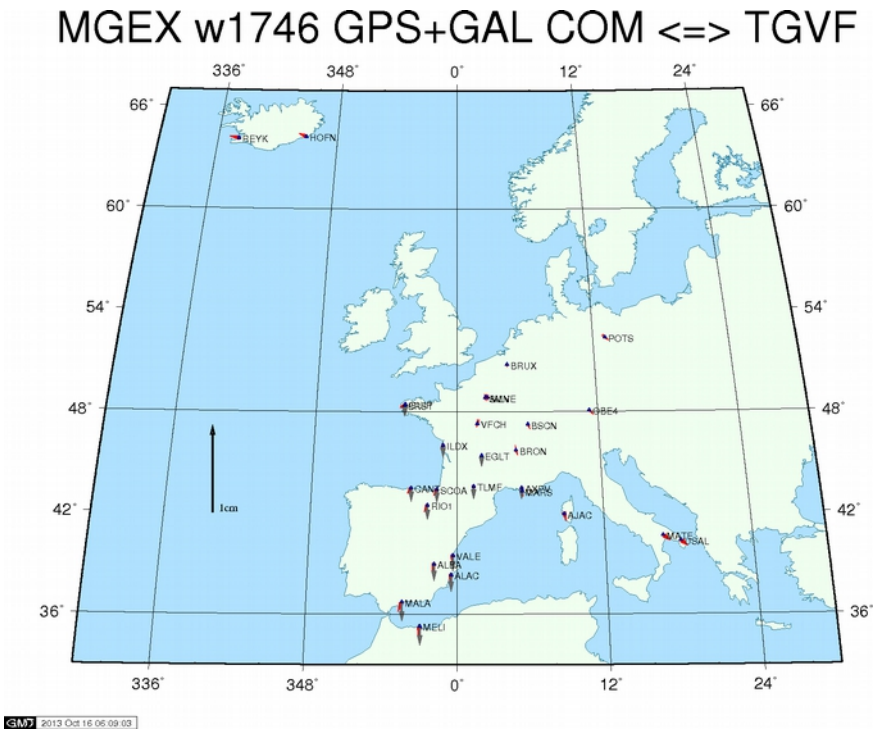
- **TGVF orbits (restricted) vs. MGEX orbits** **(daily solutions 23-JUN-2013 + 24-JUN-2013 Orbits from CODE (GPS + GAL) vs. TGVF)**





Testing of Galileo final orbits

- **TGVF orbits (restricted) vs. MGEX orbits** **(weekly solution 1746 (23-JUN-2013 - 29-JUN-2013) Orbits from CODE (GPS + GAL) vs. TGVF**



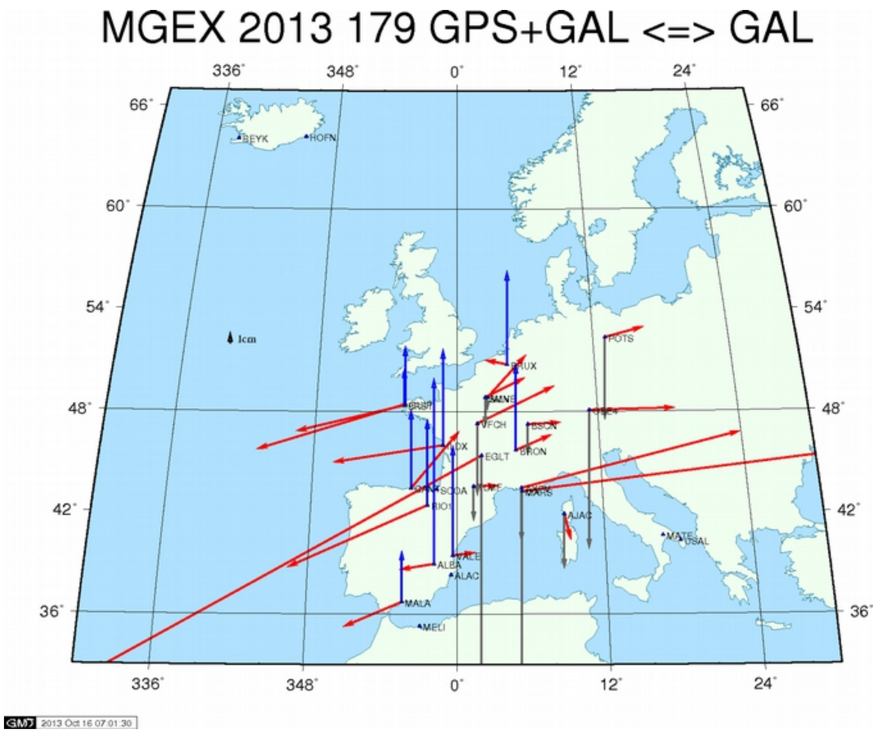
- **Testing of processing Galileo IOV observations**
  - **Galileo-only processing possible?(doy179 (28-JUN-2013),**

    3 hours (20:00 – 23:00 h))

```
===============================================================================
===============================================================================
RNX2SNX BPE PROCESSING SUMMARY FOR YEAR-SESSION 13-1790
===============================================================================

GALILEO SATELLITES :

ajac|                       -1111111122222211-                -1123333344444 3333
alac|                     -11111122222222222111-           -111-13322344 13332333
alba |                   -1111111222222222222111-            -1122333333444333333
axpv|                   -1111111222222222222111-          -12223333444444444443333
bron|                      -1111111222222222111                -1222334444443333
brst|                  -111111122222222222221111-       -111222344444444444433333
brux|                   -1111111222222222222111-           -122233344444444443333
bscn|                       -1111111122222211-                 -22333344444 3333
cant |                      -11111122222222111-                -122333444444 33333
eglt|                     -1111111112222211 1-               -1112333334444 3333
guip|                    -111111111122222222111-              -11112334444443333
hofn|                  -111112444433322222211111-          -11122344444444444333
ildx|                  -111111122222222222222111-       -111222334444444444443333
mala |                      -1111112222222222222111-      -11111223333344433333 3
mars |                        -111111112222221 1-            -12223333443333333
mate |
meli|
mlvl|                     -1111111222222211 1-               -1222234444444333
obe4 |                  -1111-1222222222222111-        -1122333344444444444333
pots |                    1121223222222222211-          211223333444444444433
puyv|                                                                    333
reyk|               -1111122344443332222 21111-    -11111113334444443 44333
rio1 |                    -11111112222222222111-        -122333444444433333
scoa|                     -11111112222222 2111-               -1222333333333
smne|                  -111111122222222222111-       -11222334444444444443333
tlmf|                     -1111111222222222111-           -2223333444443333
usal|
vale |                       -11111122222222222111-      -1122333344444433333
vfch|                      -11111112222222111-            -11133344444 33333
-----+-----------------+-----------------+-----------------+-----------------+
0                                  12                18                24
```



- **Second testing period : 2013,doy130-138**
  - **MGEX / RINEX V3 stations without Galileo observations: AIRA, BBYS, CCJ2, CONZ, LHAZ, MAT1, MATE, MATG, MELI, MLVL, OHI2, STK2, TSK2, USAL, VEN1, WTZR, ZIM2**
  - **Modification of $X/GEN/OBS.SEL (observation selection) needed, at least for each manufacturer (L2Q vs. L2X, etc.)**
  - **Few stations (METG, NYA2) with problems (MAUPRP)**

Test processing – GPS-only, V2.11

```
fs073:GPS_V211$ cat COMPAR.SUM

 Comparison of apriori coordinate files
 ---------------------------------------------------------------------------
 Total number of stations:    20
 ---------------------------------------------------------------------------
                      Weekday  Repeatability (mm)
 Station        #Days  0123456     N     E     U
 ---------------------------------------------------------------------------
 AJAC 10077M005     8  WWWWWWW    0.62  0.64  2.54
 ALAC 13433M001     8  AAAAAAA    0.70  1.07  3.46
 ALBA 13452M001     8  AAAAAAA    0.98  0.67  1.64
 AXPV 10057M001     8  AAAAAAA    1.16  1.15  4.50
 BRST 10004M004     8  AAAAAAA    0.44  0.50  3.32
 BRUX 13101M010     8  WWWWWWW    0.48  0.39  1.84
 BSCN 10028M007     8  AAAAAAA    0.47  0.70  4.09
 EGLT 10032M001     8  AAAAAAA    0.51  0.83  3.72
 GUIP 10004M501     8  AAAAAAA    0.38  0.63  3.82
 M0SE 12772M001     8  AAAAAAA    0.80  0.60  4.60
 MARS 10073M008     8  AAAAAAA    1.16  1.51  4.48
 OBE4 14208M007     8  AAAAAAA    0.90  0.55  2.18
 POTS 14106M003     8  WWWWWWW    0.64  0.41  2.56
 SCOA 10088M002     8  AAAAAAA    0.71  0.76  2.35
 SMNE 10001M007     8  AAAAAAA    0.76  0.34  4.19
 TLMF 10003M010     8  AAAAAAA    0.57  0.43  4.27
 TLSE 10003M009     8  AAAAAAA    1.15  0.96  4.18
 VFCH 10046M001     8  AAAAAAA    0.67  0.50  4.47
 WTZZ 14201M014     8  WWWWWWW    0.77  0.46  1.15
 ZIMJ 14001M006     8  AAAAAAA    0.43  0.47  2.51
 ---------------------------------------------------------------------------
 # Coordinate estimates:   160    0.71  0.69  3.25
fs073:GPS_V211$
```

Test processing – GPS-only, V3.02

```
fs073:GPSonly$ cat COMPAR.SUM

 Comparison of apriori coordinate files
 ---------------------------------------------------------------------------
 Total number of stations:    20
 ---------------------------------------------------------------------------
                      Weekday  Repeatability (mm)
 Station        #Days  0123456     N     E     U
 ---------------------------------------------------------------------------
 AJAC 10077M005     7  WWWWWWW    1.10  2.59  5.15
 ALAC 13433M001     7  AAAAAAA    1.31  2.57  5.35
 ALBA 13452M001     7  AAAAAAA    1.37  2.10  3.44
 AXPV 10057M001     7  AAAAAAA    1.43  2.74  7.12
 BRST 10004M004     7  AAAAAAA    1.55  3.75  6.49
 BRUX 13101M010     7  WWWWWWW    0.95  1.71  2.38
 BSCN 10028M007     7  AAAAAAA    1.24  2.46  3.16
 EGLT 10032M001     7  AAAAAAA    1.78  4.44  6.54
 GUIP 10004M501     7  AAAAAAA    1.05  3.90  8.29
 M0SE 12772M001     7  AAAAAAA    2.08  4.63 10.33
 MARS 10073M008     7  AAAAAAA    2.53  5.50  6.36
 OBE4 14208M007     7  AAAAAAA    1.50  3.66  4.20
 POTS 14106M003     7  WWWWWWW    3.04  5.62  5.86
 SCOA 10088M002     7  AAAAAAA    1.36  2.29  8.70
 SMNE 10001M007     7  AAAAAAA    0.93  1.78  3.65
 TLMF 10003M010     7  AAAAAAA    2.05  3.16  8.72
 TLSE 10003M009     7  AAAAAAA    2.05  1.87  3.56
 VFCH 10046M001     7  AAAAAAA    1.90  3.49  2.08
 WTZZ 14201M014     7  WWWWWWW    2.88  4.48  4.68
 ZIMJ 14001M006     7  AAAAAAA    1.05  2.61  3.85
 ---------------------------------------------------------------------------
 # Coordinate estimates:   140    1.64  3.22  5.52
fs073:GPSonly$
```

Test processing – GPS+GAL, V3.02

```
Comparison of apriori coordinate files
--------------------------------------------------------------------------------
Total number of stations:    35
--------------------------------------------------------------------------------
                      Weekday  Repeatability (mm)
Station        #Days  0123456     N     E     U
--------------------------------------------------------------------------------
AJAC 10077M005     8  WWWWWWW    0.87  0.73  4.64
ALAC 13433M001     8  AAAAAAA    2.07  1.53  5.66
ALBA 13452M001     8  AAAAAAA    2.73  2.04  3.36
AXPV 10057M001     8  AAAAAAA    2.01  1.21  4.62
BRST 10004M004     8  AAAAAAA    1.08  1.42  6.79
BRUX 13101M010     8  WWWWWWW    0.97  0.45  2.63
BSCN 10028M007     8  AAAAAAA    0.80  1.02  6.45
CANT 13438M001     8  AAAAAAA    1.92  1.78  4.30
DLF1 13502M009     3       AA    2.31  1.24  5.56
DYNG 12602M006     2  AA         2.73  1.98 12.30
EGLT 10032M001     8  AAAAAAA    0.88  1.52  4.75
GANP 11515M001     6  AAA AA     0.75  1.11  3.60
GOP6 11502M006     7  AAA AAA    0.73  0.79  7.98
GOP7 11502M006     8  AAAAAAA    0.71  0.60  4.57
GRAC 10002M010     8  AAAAAAA    2.08  1.26  5.30
GUIP 10004M501     8  AAAAAAA    0.77  1.65  6.20
HOFN 10204M002     3    AAA     13.25  4.29  2.31
ILDX 19724M001     6  AAAAAA     1.18  1.14  5.22
M0SE 12772M001     8  AAAAAAA    1.56  1.18  5.08
MALA 13443M001     8  AAAAAAA    3.10  2.76  8.69
MAR7 10405M003     2        A    4.64  2.17  4.18
MARS 10073M008     8  AAAAAAA    1.85  1.55  7.32
MYVA 10205M001     1             0.00  0.00  0.00
OBE4 14208M007     8  AAAAAAA    0.96  0.77  3.01
POTS 14106M003     8  WWWWWWW    0.95  0.54  2.78
RIO1 13448M002     8  AAAAAAA    1.62  1.65  4.79
SCOA 10088M002     8  AAAAAAA    1.14  1.16  4.61
SMNE 10001M007     8  AAAAAAA    1.04  0.48  4.89
TLMF 10003M010     8  AAAAAAA    1.25  0.88  6.43
TLSE 10003M009     8  AAAAAAA    1.14  1.19  4.00
VALE 13439M001     8  AAAAAAA    2.39  1.59  3.14
VFCH 10046M001     8  AAAAAAA    1.01  1.23  5.85
WTZZ 14201M014     8  WWWWWWW    1.06  0.76  3.48
ZIM3 14001M008     8  AAAAAAA    0.36  0.46  3.98
ZIMJ 14001M006     8  AAAAAAA    0.41  0.62  3.82
--------------------------------------------------------------------------------
 # Coordinate estimates:   246    1.85  1.26  4.81
fs073:GPSGAL$
```

- **Processing RINEX V2.11 daily files coming from the stations**
  - **~83 global stations used inRTNet**
  - **For station monitoring purposes**
  - **IGR products**
  - **Since 08/2011**

- **Processing RINEX V2.11 daily files sampled (30 seconds) from data streams with BNC**
  - **Same ~83 global stations as above**
  - **For data stream monitoring**
  - **Since 10/2013**
  - **Some stations show strange behaviour, e.g. CUT0, or have larger discrepancies (few cm)w.r.t. using station RINEX files**

- **Processing RINEX V3.02 daily files sampled from MGEX data streams with BNC**
  - **~73 global stations**
  - **For MGEX data stream (e.g.,raw data conversion) & coordinate monitoring**
  - **Since 11/2013**
  - **GPS+GLO**

Questions

- **Which meta data for Galileo (satellite info, antenna PCV, DCB, …) could be used? What is publicly available?**
- **Regular processing of Galileo IOV final orbits within MGEX?**
- **Periodic processing of Multi-GNSS data at an early stage useful for EUREF?**