EPN Status and New Developments

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Creation & Design

- EPN created in 1995 as initiative of the EUREF TWG
- Use existing permanent GPS tracking stations in Europe for maintenance of ETRS89
- Use principle of distributed processing to promote usage of common analysis procedures over Europe
- Structure based on the IGS example

EPN components

- Continuous GPS tracking stations
- Data Centres providing access to the observation data
- Analysis Centres computing station coordinates and by-products
- Combination Centre
- EPN Central Bureau

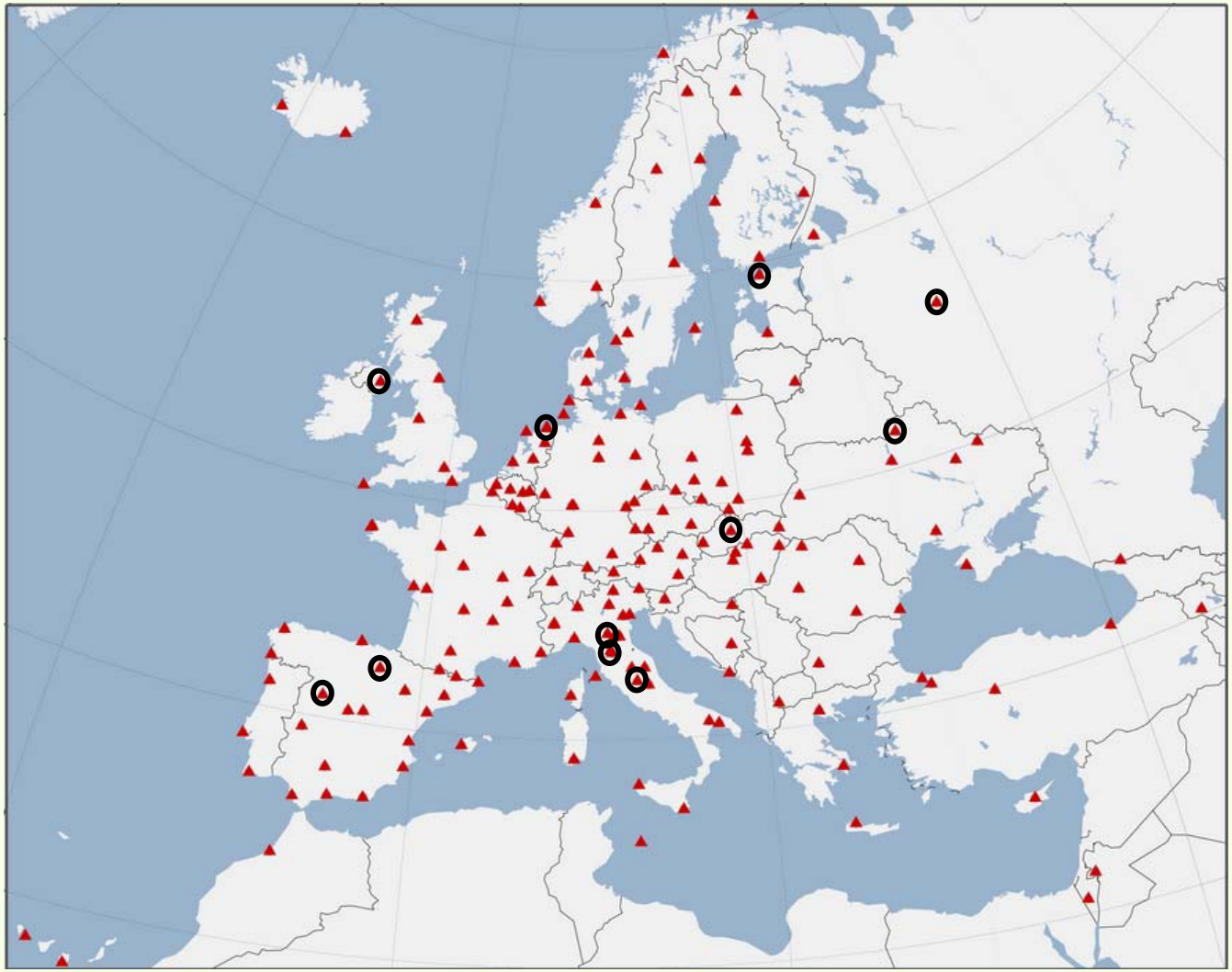
EPN products

- GNSS data from the tracking stations
  - Daily, hourly, and real-time
- Site coordinates
  - ETRS89, ITRS
- Tropospheric ZTD delays for each site
- Time evolution of site coordinates

Provides access to ETRS89/ITRS

Network

200 permanent stations (3 inactive DUBR, OSJE, FATA), 11 new, 1 withdrawn



New Stations

Station	4char-ID	Country	Date inc.				
Zaragoza	ZARA	Spain	25-June-2006	H	RT		ABS
Tallin	SUUR	Estonia	01-Oct.-2006	H			ABS
Chernihiv	CNIV	Ukraine	29-Oct.-2006	H			ABS
Salamanca	SALA	Spain	12-Nov.-2006	H	RT		ABS
Borkum	BORJ	Germany	04-Dec.-2007	H	RT	GLO	IABS
Belfast	BELF	United Kingdom	28-Jan.-2007	H			ABS
Firenze	IGMI	Italy	28-Jan.-2007	H		GLO	ABS
Banska Bystrica	BBYS	Czech Rep.	04-Feb.-2007	H			ABS
Mendeleevo	MDVJ	Russia	04-Mar.-2007	H		GLO	ABS
Terni	UNTR	Italy	04-Mar.-2007	H		GLO	REL
Modena	MOPS	Italy	23-Apr.-2005	H		GLO	ABS

Spain (2), Estonia (1), Italy (3), Germany (1),Czech Rep. (1),Russia (1), UK (1),Ukraine (1)

TODAY : 37 GPS+GLONASS stations (2006 – 29 stations)

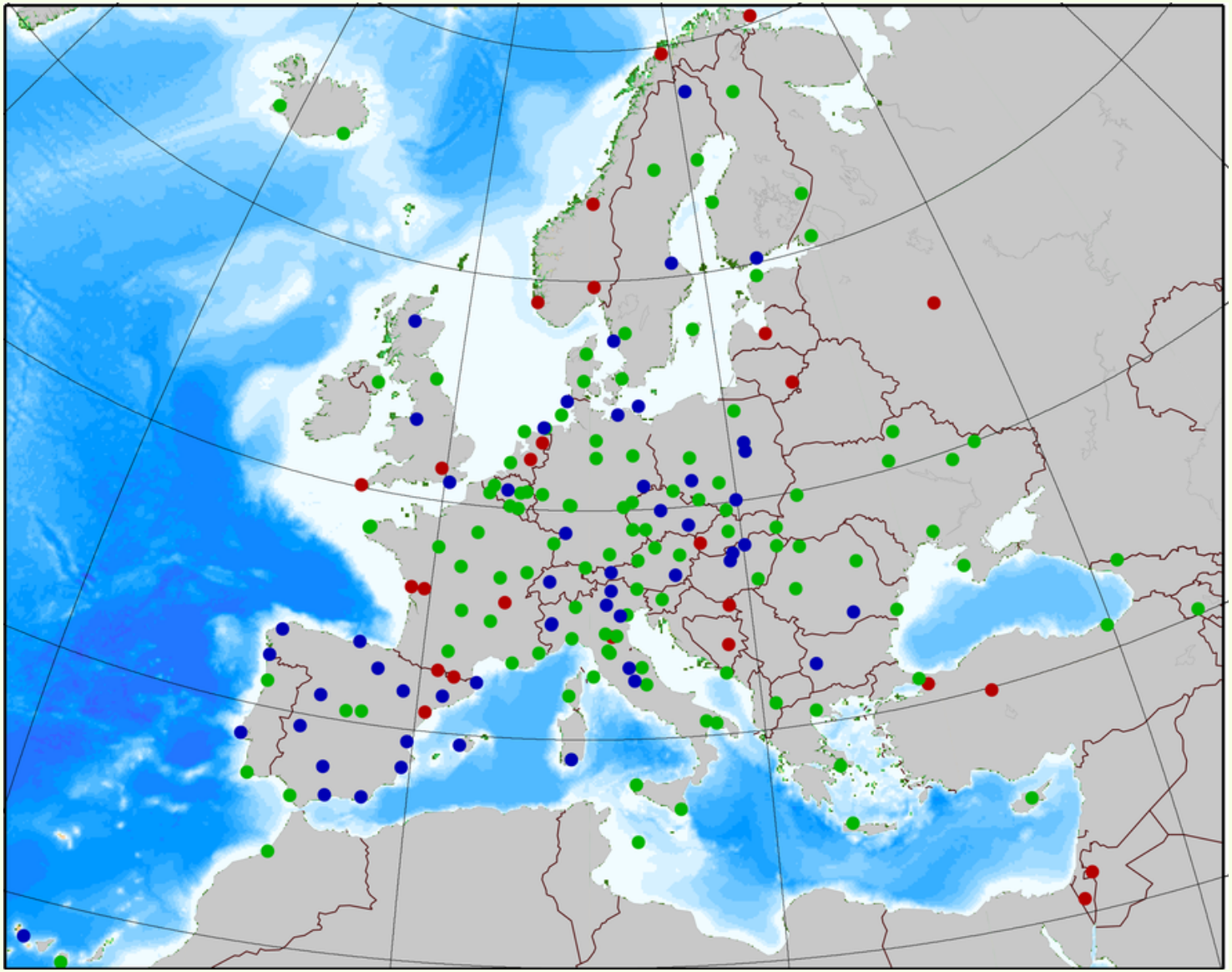
Data Flow

- Daily (RINEX): mandatory
  - Latency < availability of final IGS orbits (rapid monitoring…)
  - Meta-data checked by EPN CB
- Hourly (RINEX): 84% (2006 - 76%)
  - Latency < 10 minutes
  - Latency checked by EPN CB
- All data available through EPN regional data centres (BKG and OLG)

- Real-time: 26% (2006 – 20%)
  - Latency < 5 seconds
  - Meta-data and latency checked by EPN CB
- All RT data available through EPN regional broadcaster (BKG)

Data Flow

- Real-time
- Hourly
- Daily



Real-time Data

Extract of EPN Guidelines for Stations and Operational Centres:

1.1 Network Components

- **Local Broadcaster (LB):** It receives the real-time data streams from the stations in a local network and disseminates them, without changing them, on request to clients. Clients may be users, monitoring tools, data centers, or analysis centers.
- **Regional Broadcaster (RB):** It receives all the EPN real-time data streams and disseminates them, without changing them, on request to clients. Clients may be users, monitoring tools, data centers, or analysis centers.
- **High Rate Data Centre (HDC):** It collects the real-time data from all EPN stations, archives them in RINEX format and makes them available to the users.

- EUREF regional broadcaster : www.euref-ip.net (BKG)
- High rate data centre : operational in near future (BKG)

Extract of EPN Guidelines for Stations and Operational Centres:

3.3 Real-time Data Flow

3.3.1 For standard operations the data should be sent in real-time using the Ntrip-client software (http://igs.bkg.bund.de/index_ntrip.htm) to the Regional Broadcaster. The minimal requirement for data submission is 1 Hz containing full code and carrier phase observations.

3.3.2 After a communication outage or reception of a NABU message, the data flow should be restored as quickly as possible, preferable using an automated procedure.

Additionally desired characteristics are:

3.3.3 In addition to the data upload to the Regional Broadcaster, stations are encouraged to upload their data to a Local Broadcaster.

Extract of EPN Guidelines for Stations and Operational Centres:

3.7 Format of real-time data

3.7.1 EPN real-time data streams must contain code and carrier phase observations and therefore only formats allowing this possibility are accepted, eg RTCM (2.1, 2.2, 2.3, 3.0 or 3.1, see http://www.rtcm.org/), some raw data formats or the SOC data format, developed by the IGSRT working group (see http://igscb.jpl.nasa.gov/projects/rtwg/). Raw data formats and the SOC data format are only accepted if the software to convert the format to RINEX is freely available for several platforms (eg teqc).

3.7.2 RTCM code and phase observations should not be corrected to refer to the antenna reference point (correction is typically known as the antenna phase center correction).

Real-time Data

Message type	Content
3	(X,Y,Z) coordinates of antenna phase center, cm-precision
18	Code data
19	Carrier phase data
22	(dX, dY, dZ) corrections to message 3 coordinates to achieve mm-precision for L1 and L2 antenna phase center + height of antenna phase center above marker
23	Antenna and radome type definition
24	(X,Y,Z) coordinates of the antenna reference point

Table 1: RTCM 2.x (x=1, 2, 3) message types

Message type	Content
1003	GPS code and carrier phase observations
1004	GPS code and carrier phase observations + code noise ratio + code ambiguity
1005	(X,Y,Z) coordinates of the antenna reference point
1006	(X,Y,Z) coordinates of the antenna reference point + height of antenna reference point above marker
1007	Antenna and radome type definition
1008	Antenna and radome type definition + Antenna serial number
1011	GLONASS code and carrier phase observations + code noise ratio + code ambiguity
1012	GLONASS code and carrier phase observations

Table 2: RTCM 3.0 message types

Meta-data

- Agreement of coordinates in stream with ETRS89 coordinates (need for set of official coordinates)
- If meta-data (antenna/radome type & height) are streamed, they should be in agreement with site log

Antenna/Radome

- IGS and EUREF ACs switched to using absolute phase centre models instead of relative in Nov. 2006
- Antenna + Radome
- Classification :

A. Absolute phase centre model based on robot calibrations

A1. Individual calibrations: valid for ONE antenna/radome with specific SN

A2. Type calibrations: valid for all antenna/radome pairs of a specific type

B. Absolute phase centre model based on relative model (only valid above 10° elev., no azimuthal dependency)

Antenna/Radome

Individual absolute calibrations (A1)

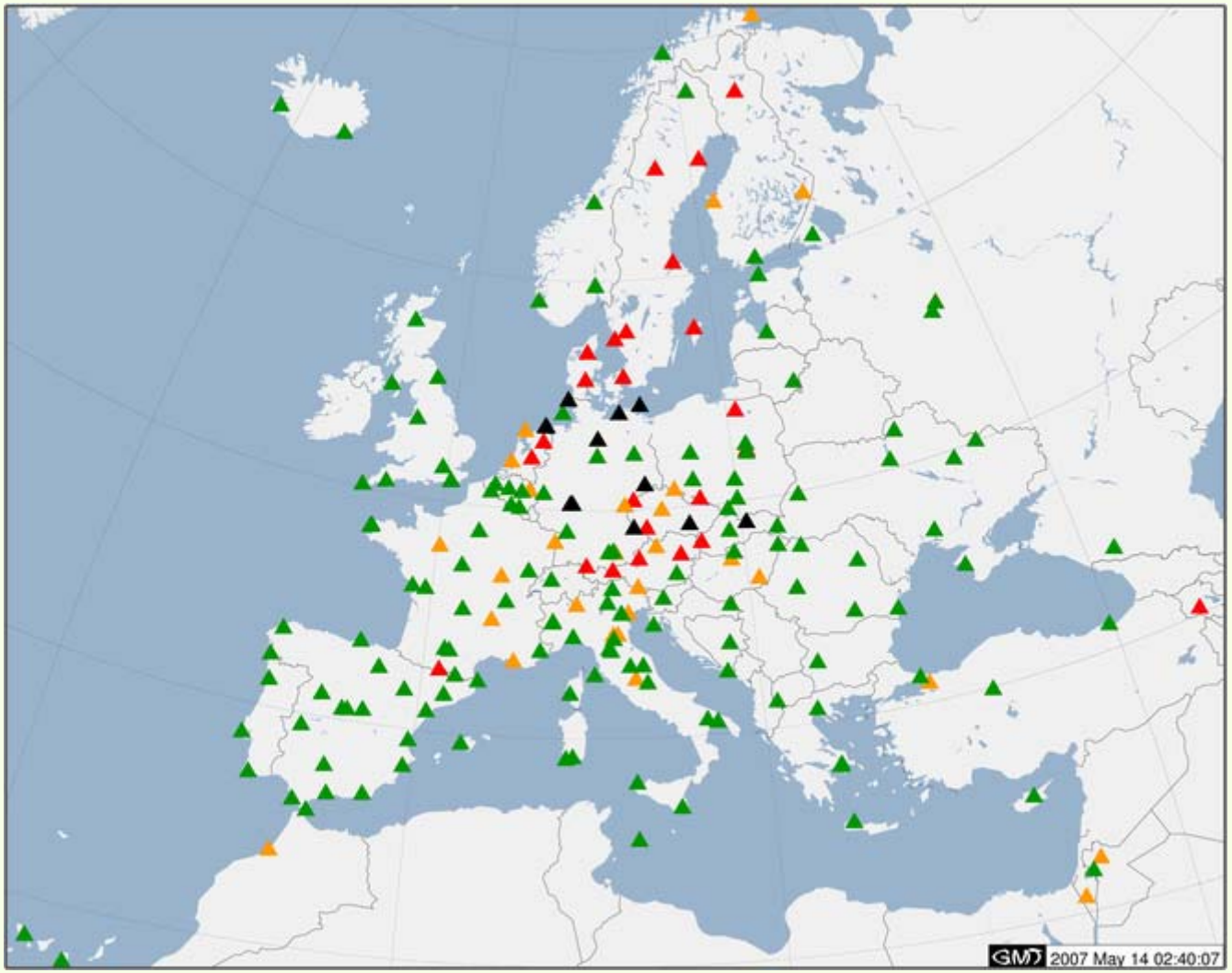
True absolute type calibrations (A2)

Absolute calibrations converted from relative values (B)

No calibration available because of radome

Calibrations from the corresponding antenna without the radome are used

BISK, BUDP, ESCO, HFLK, IAVH, JOZ2, KIR0, KOSG, LAMA, MAR6, MARJ, MOPI, NSSP, NYA1, ONSA, PFAN, SBGZ, SKE0, SMID, SODA, SPT0, SULD, THU3, TRFB, VACO, VIL0, VIS0, WROC, WSRT



Antenna/Radome

Antenna/radome combinations presently installed within the EPN must have absolute calibration (taking radome into account)

- converted from relative — from igs05.atx maintained by IGS
- robot calibrations
  - type — from igs05.atx maintained by IGS

  or
  - individual — from epnc_05.atx maintained by EPN CB (password protected at request of GEO++)

Antenna/radome combinations introduced within EPN station after Dec 5, 2006 must have TRUE (robot) absolute calibrations (taking radome into account).

Exceptions: - pairs where effect of radome on PC is negligible or which cannot be calibrated
- stations that provide a clear added-value to the EPN

New Stations

Station	4char-ID	Country	Date inc.				
Zaragoza	ZARA	Spain	25-June-2006	H	RT		ABS
Tallin	SUUR	Estonia	01-Oct.-2006	H			ABS
Chernihiv	CNIV	Ukraine	29-Oct.-2006	H			ABS
Salamanca	SALA	Spain	12-Nov.-2006	H	RT		ABS
Borkum	BORJ	Germany	04-Dec.-2007	H	RT	GLO	IABS
Belfast	BELF	United Kingdom	28-Jan.-2007	H			ABS
Firenze	IGMI	Italy	28-Jan.-2007	H		GLO	ABS
Banska Bystrica	BBYS	Czech Rep.	04-Feb.-2007	H			ABS
Mendeleevo	MDVJ	Russia	04-Mar.-2007	H		GLO	ABS
Terni	UNTR	Italy	04-Mar.-2007	H		GLO	REL
Modena	MOPS	Italy	23-Apr.-2005	H		GLO	ABS

Spain (2), Estonia (1), Italy (3), Germany (1),Czech Rep. (1),Russia (1), UK (1),Ukraine (1)

TODAY : 37 GPS+GLONASS stations (2006 – 29 stations)

Summary

- Procedure for Becoming an EPN Station
  Updated : Dec. 5, 2006

  New EPN stations must have an antenna/radome with known true absolute calibrations (from IGS or individual calibrations)

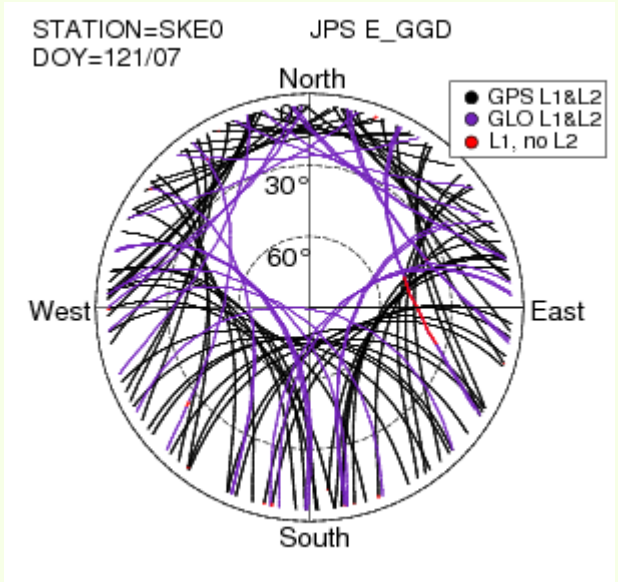
- Guidelines for EPN Stations and Operational Centres
  Updated : Dec. 5, 2006 + March 3, 2007

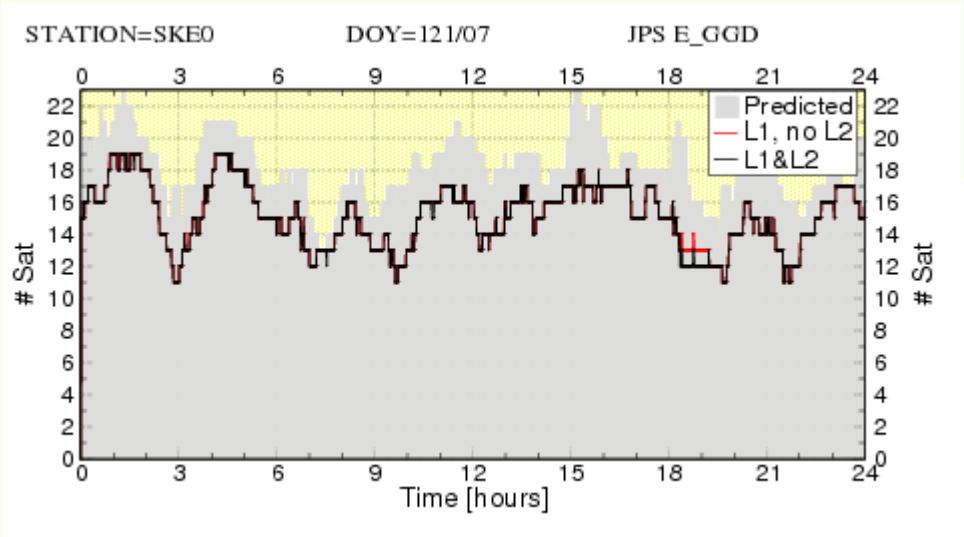
  – New antennae/radomes or antenna/radome replacements must have true absolute calibrations
  – Added guidelines for stations streaming real-time data
    - full code/carrier phase data
    - Agreement with ETRS89 coordinates (need for set of official coordinates)
    - Agreement of meta-data (antenna/radome type & height)
  – Promote usage of multi-GNSS equipment
  – Recommendation for connection to UELN/national levelling network

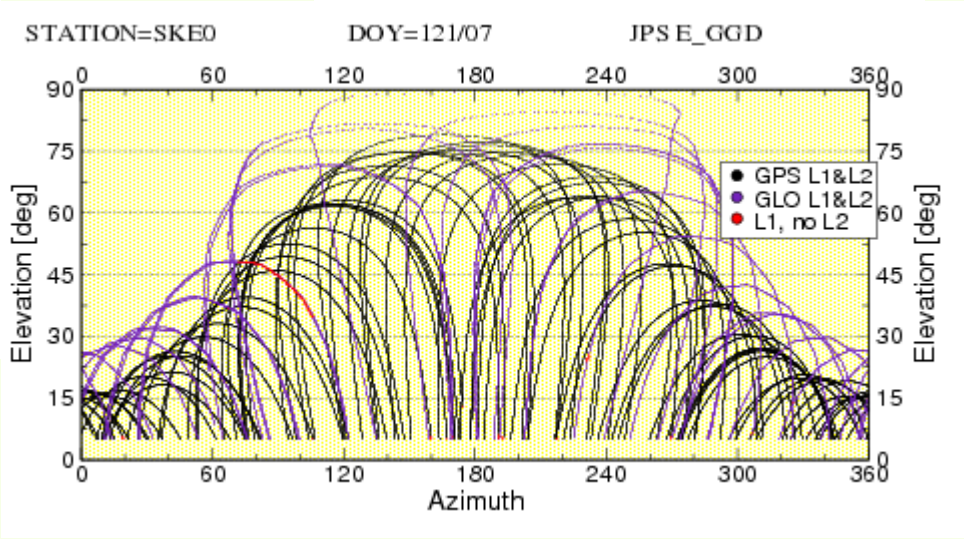
GPS/GLONASS

- 37 GPS/GLONASS stations
- 2 LAC submit GPS/GLONASS solutions

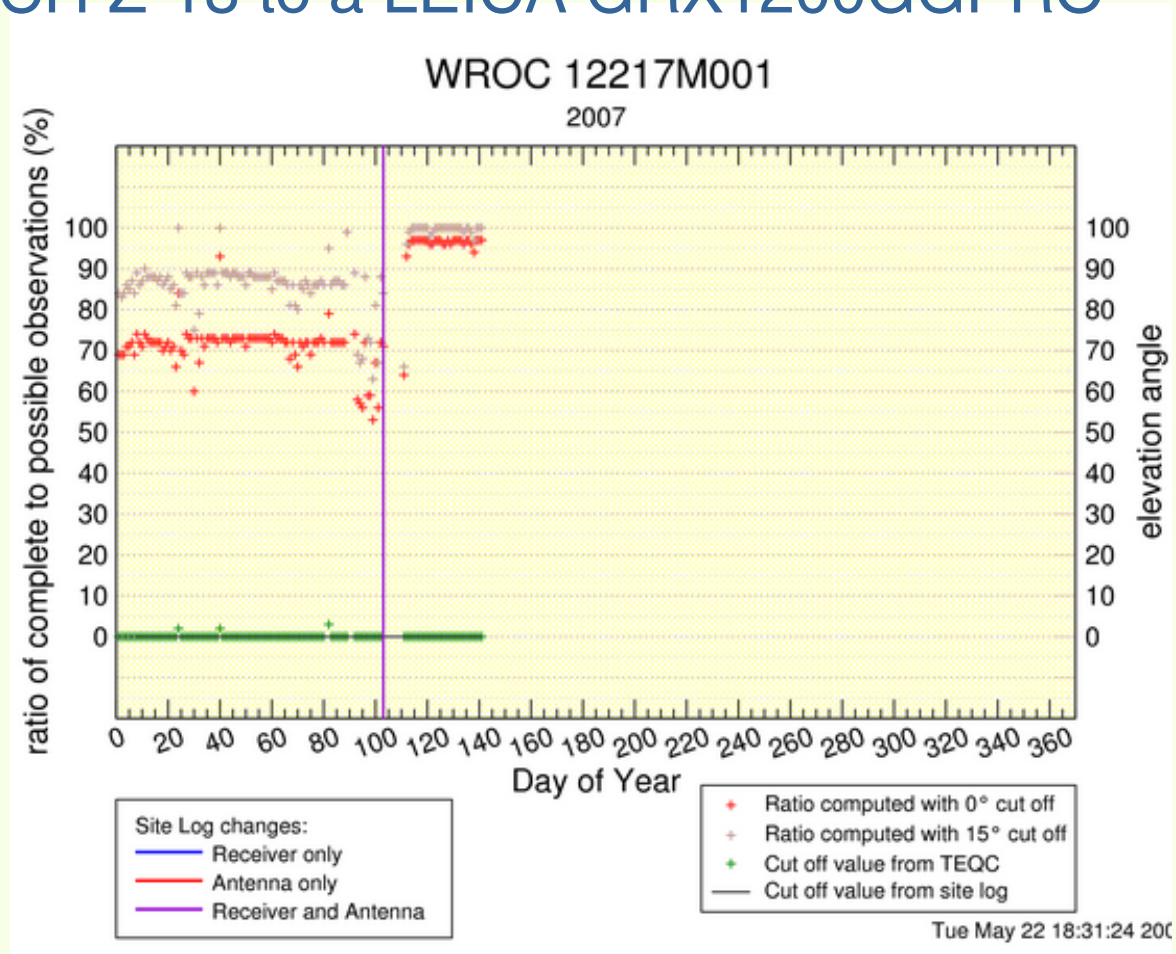
Upgrade of EPN CB quality check programs

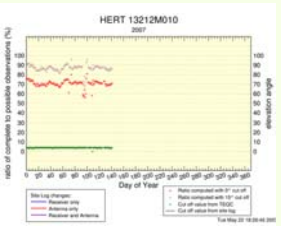






From an ASHTECH Z-18 to a LEICA GRX1200GGPRO

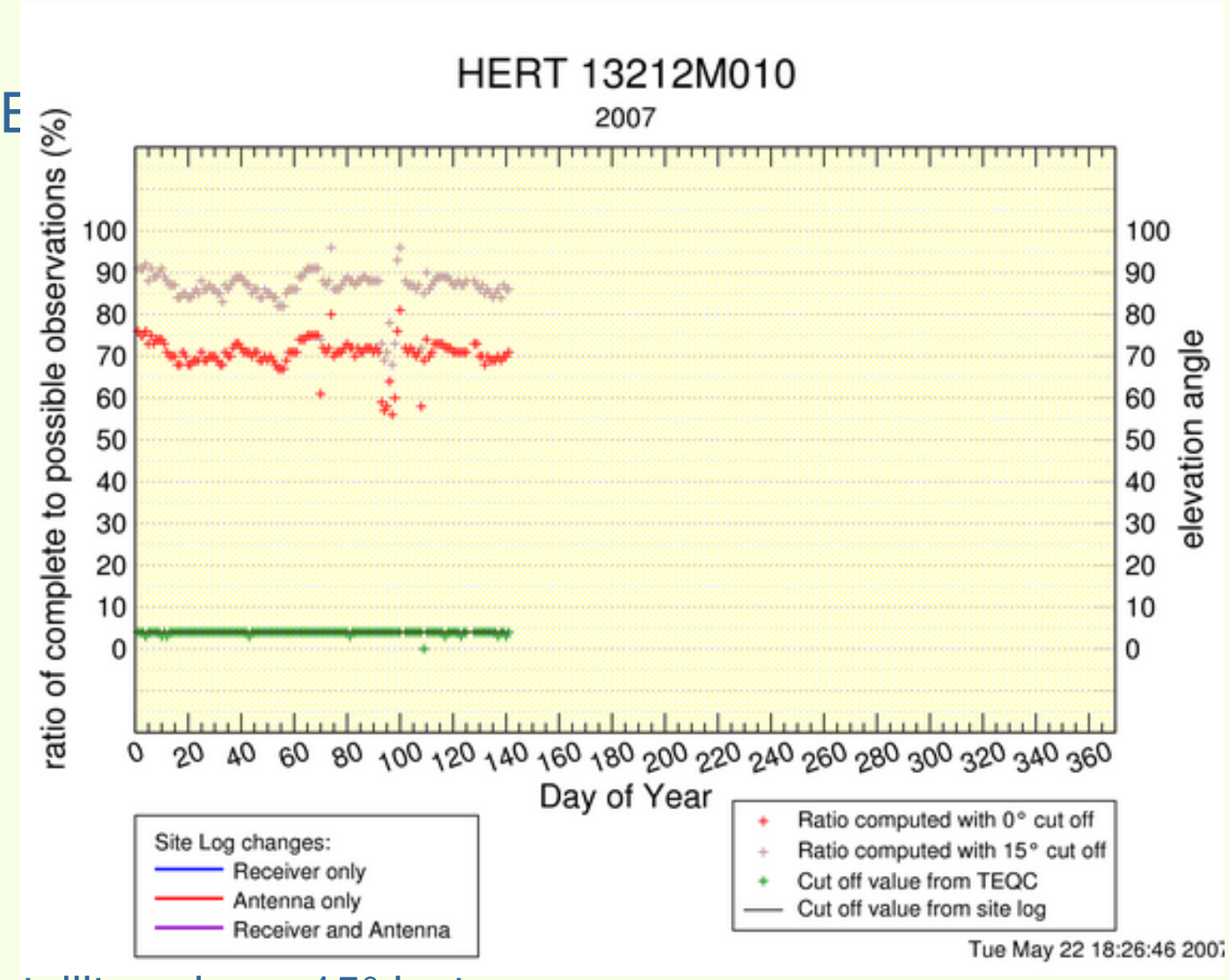




- 10% of the GPS satellites above 15° lost
- 30% of the GPS satellites above horizon lost

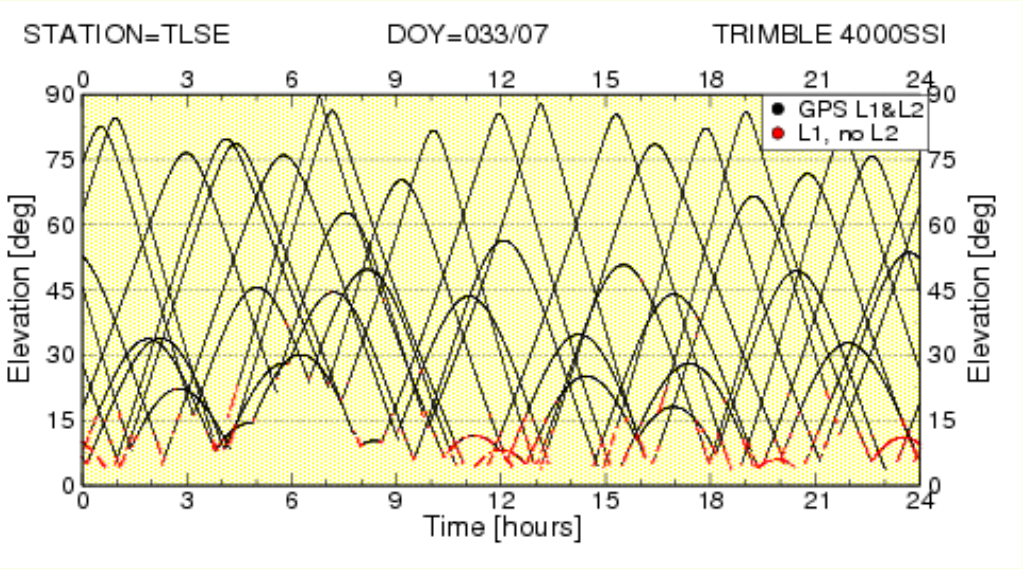
GPS/GLONASS

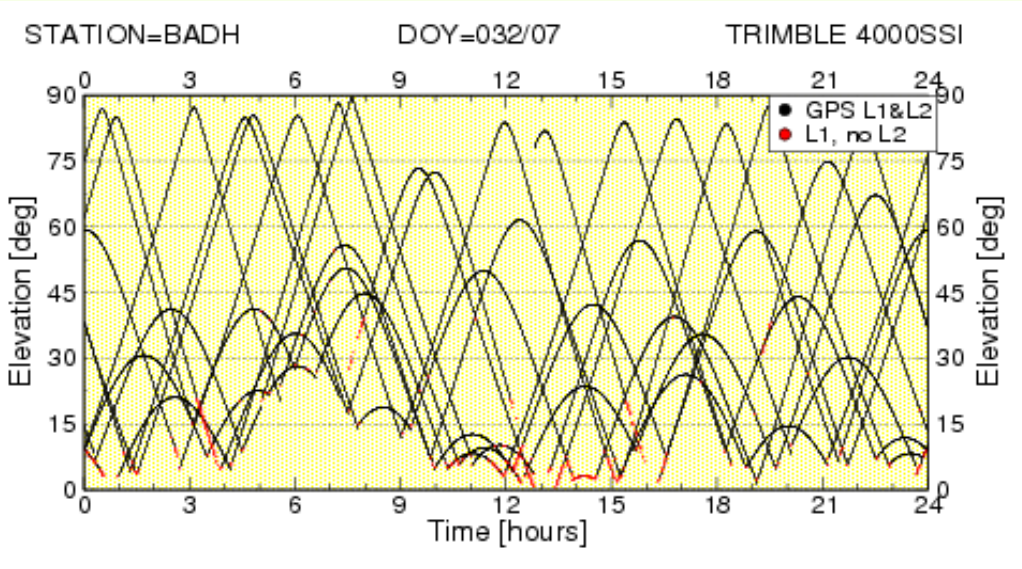
From an ASHTE

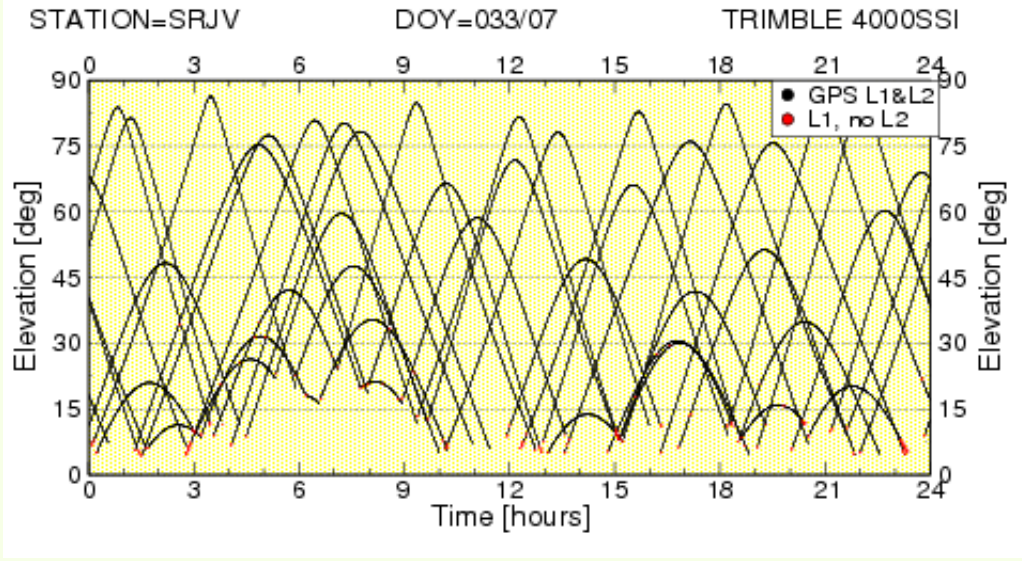


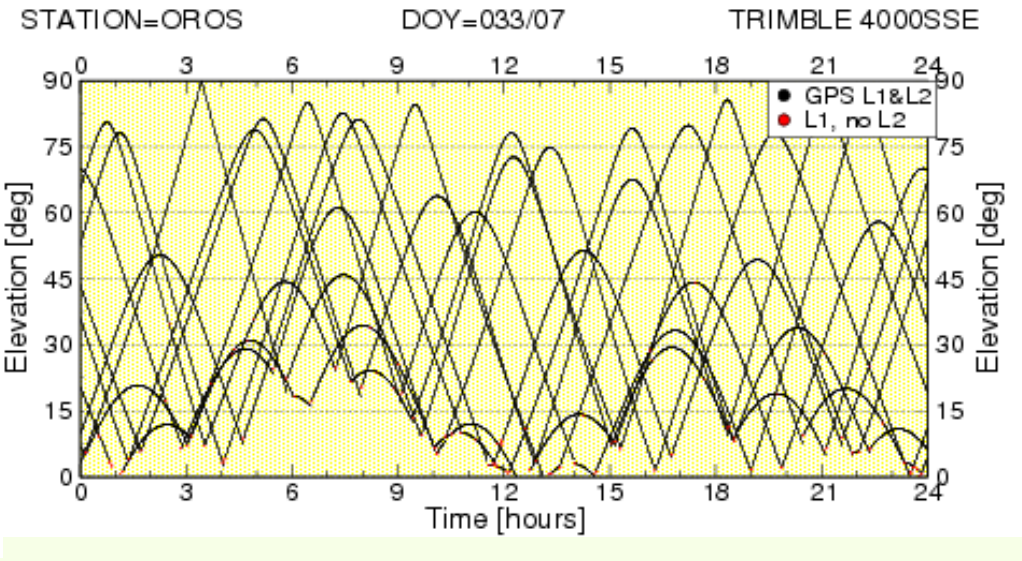
- 10% of the GPS satellites above 15° lost
- 30% of the GPS satellites above horizon lost

Old Equipment

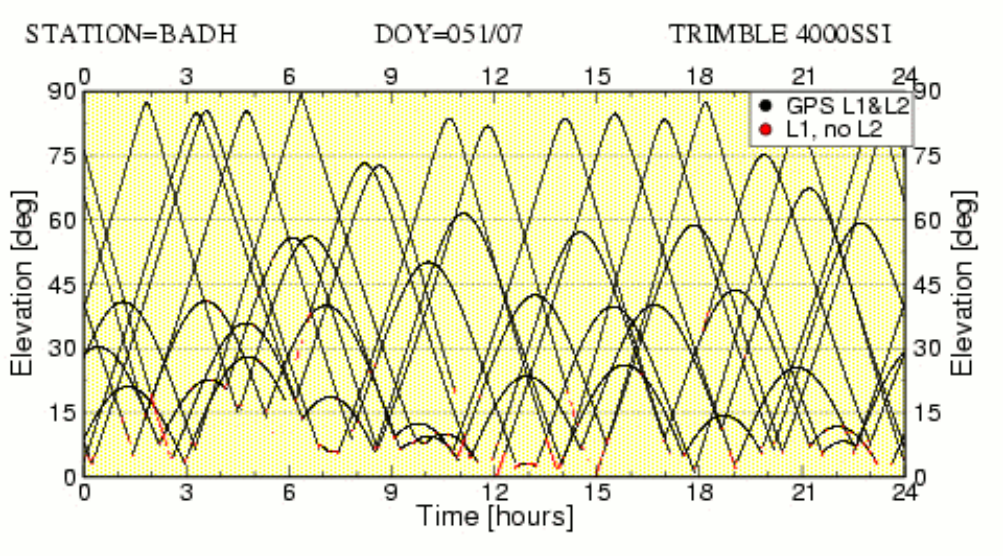


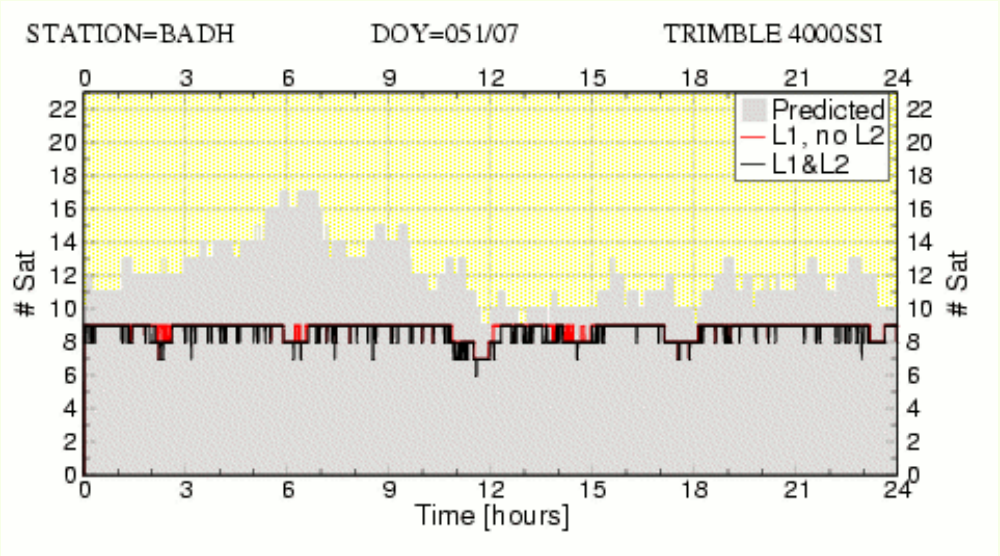




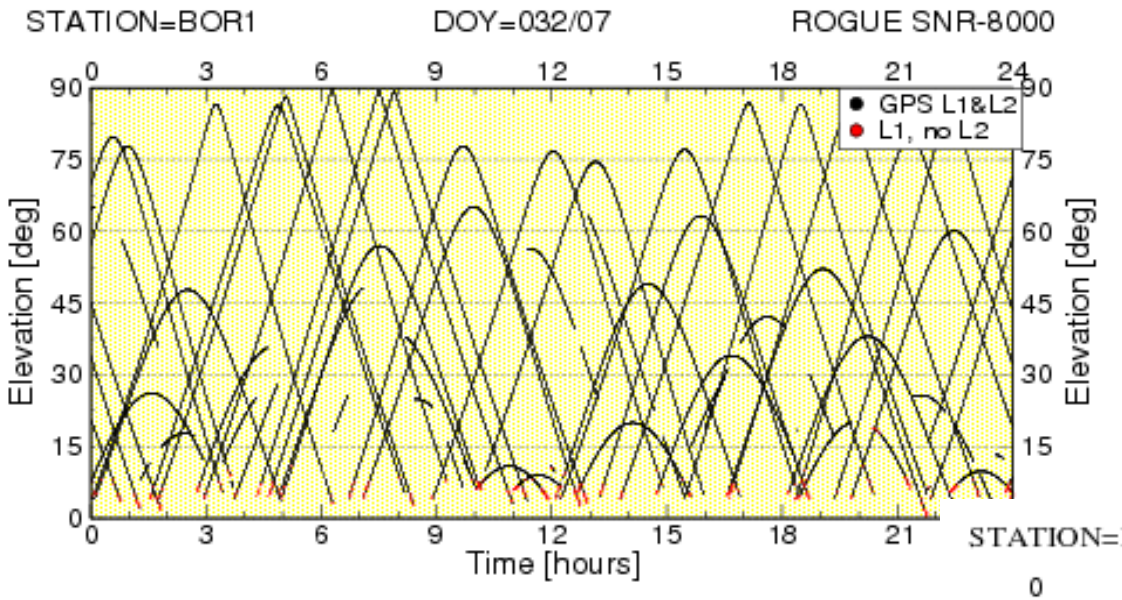


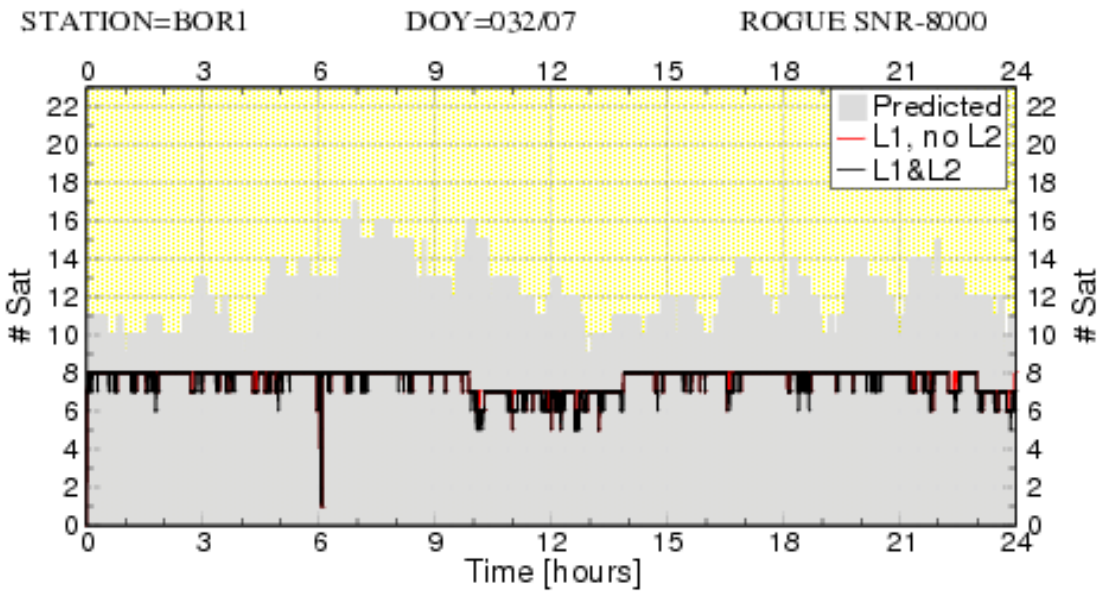
Old Equipment





Old Equipment





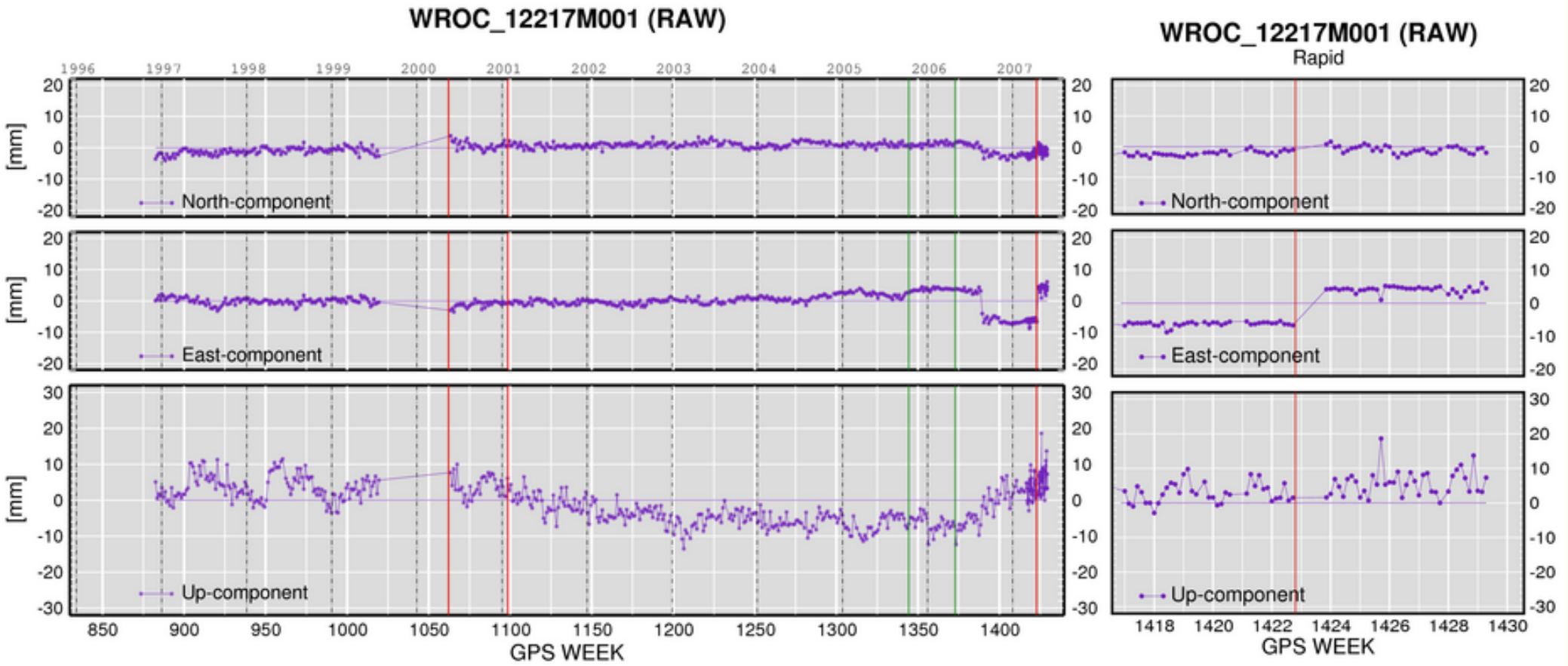
Coordinates

- Latency of combined weekly EPN solutions : 1 to 3 Months
  - Unsuitable for rapid coordinate monitoring

- Combined *daily* solution generated at BKG
  - 30 days of delay (final orbits) - 7 LAC
  - 1 day of delay (rapid orbits) – 4 LAC

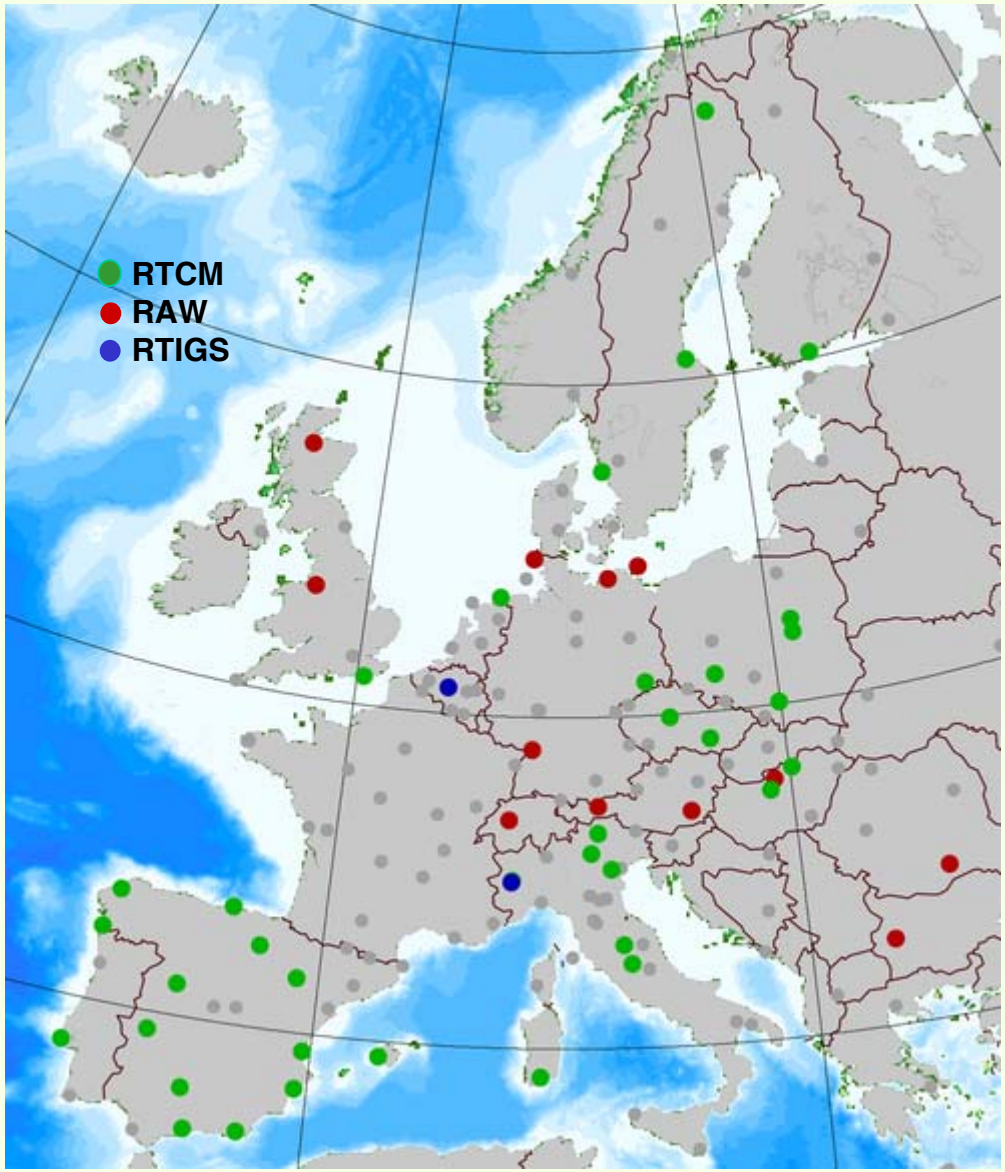
- Daily solutions used at EPN CB to complement weekly EPN solutions in raw time series

Coordinates



Real-time

ACOR0 ALAC0 ALME0
BELL0 BOGI0 BORJ0
BRUS0 BUCU0 BUTE1
BZRG0 CACE0 CAGZ0
CANT0 CASC0 COBA0
CREU0 DARE0 DRES0
GANP0 GOPE0 GRAZ0
HERT0 HFLK0 HOE20
IENG0 INVE0 JOZ20
KARL0 KIR00 KRAW0
LPAL0 MALA0 MALL0
MAR60 METS0 ONSA0
PADO0 PENC1 RIOJ0
ROVE0 SALA0 SASS0
SOFI0 TORI0 TUBO0
UNPG0 UNTR0 VALE0
VIGO0 WARN0 WROC0
ZARA0 ZIMM0 (53)



Real-time

The directory ftp://epncb.oma.be/pub/station/real_time/ contains the results of a regular monitoring (typically each 2 hours) of the latency and the meta-data of the EPN real-time data streams available from www.euref-ip.net.

- ***monitor.ant*** (for RTCM data streams) : the agreement of antenna/radome information contained in the stream with the site log information
- ***monitor.coord*** (for RTCM data streams) : the agreement of the coordinate and antenna height information contained in the stream with the official EPN coordinates + antenna height information
- ***monitor.latency***: the latency of the code and phase
- ***monitor.rec*** : comparison of the receiver type input in the caster source table and the receiver type in the site log.

	MESS	REF	X	Y	Z	MRK->APC	MRK->ARP			
ACOR0	REF	EPN ARP	4594492.0819	-678368.3294	4357067.9896	3.1344	3.0460	http://epncb.oma.be/stations/log/acor		
ACOR0	STR	3+22 APC	4594492.1557	-678368.3756	4357068.0617	3.1560		DIFF(STR,REF)= 0.0399 m (-0.0023,-0.0350, 0.0191)		2007/05/23 07:42
ACOR0	STR	24 ARP	4594492.0666	-678368.3639	4357067.9862		3.0460	DIFF(STR,REF)= 0.0379 m (0.0045,-0.0364,-0.0097)		2007/05/23 07:42
ALAC0	REF	EPN ARP	5009053.7807	-42072.4885	3935059.3788	3.1270	3.0350	http://epncb.oma.be/stations/log/alac		
ALAC0	STR	3+22 APC	5009053.8569	-42072.4987	3935059.4469	3.1450		DIFF(STR,REF)= 0.0151 m (0.0061,-0.0096, 0.0100)		2007/05/23 07:42
ALAC0	STR	24 ARP	5009053.7606	-42072.4979	3935059.3686		3.0350	DIFF(STR,REF)= 0.0244 m (0.0044,-0.0096,-0.0220)		2007/05/23 07:42
ALME0	REF	EPN ARP	5105222.7255	-219278.9030	3804388.7047	3.1360	3.0440	http://epncb.oma.be/stations/log/alme		
ALME0	STR	3+22 APC	5105222.7919	-219278.9035	3804388.7643	3.1540		DIFF(STR,REF)= 0.0088 m (0.0079, 0.0024,-0.0031)		2007/05/23 07:42
ALME0	STR	24 ARP	5105222.7040	-219278.9097	3804388.6984		3.0440	DIFF(STR,REF)= 0.0234 m (0.0077,-0.0076,-0.0207)		2007/05/23 07:42
BELL0	REF	EPN ARP	4775849.6714	116814.1111	4213018.7726	0.1459	0.0540	http://epncb.oma.be/stations/log/bell		
BELL0	STR	1005 ARP	4775849.6534	116814.1020	4213018.7609			DIFF(STR,REF)= 0.0233 m (0.0033,-0.0087,-0.0214)		2007/05/23 07:42
BOGI0	REF	EPN APC	3633815.7663	1397453.9595	5035280.9127	0.1433	0.0534	http://epncb.oma.be/stations/log/bogi		
BOGI0	STR	3+22 APC	3633815.7703	1397453.9545	5035280.9215	0.0000		DIFF(STR,REF)= 0.0109 m (0.0038,-0.0061, 0.0082)		2007/05/23 07:42
BORJ0	REF	WEEK ARP	3769403.3128	440564.0337	5109098.9421	0.1065	0.0450	http://epncb.oma.be/stations/log/borj		
BORJ0	STR	1006 ARP	3769403.2700	440564.0200	5109098.8700		0.0449 *	DIFF(STR,REF)= 0.0850 m (-0.0073,-0.0086,-0.0842)		2007/05/23 07:42
BUTE1	REF	EPN ARP	4081882.3598	1410011.1501	4678199.3863	0.0552	0.0000	http://epncb.oma.be/stations/log/bute		
BUTE1	STR	3 APC	4081882.4200	1410011.1300	4678199.4200			DIFF(STR,REF)= 0.0414 m (-0.0143,-0.0387, 0.0036)		2007/05/23 07:42
BUTE1	STR	24 ARP	4081882.4236	1410011.1305	4678199.4245		0.0000 *	DIFF(STR,REF)= 0.0769 m (-0.0139,-0.0394, 0.0646)		2007/05/23 07:42
BZRG0	REF	EPN ARP	4312657.9287	864634.4590	4603844.3842	0.3004	0.2120	http://epncb.oma.be/stations/log/bzrg		
BZRG0	STR	3+22 APC	4312658.0057	864634.4687	4603844.4451	0.3220		DIFF(STR,REF)= 0.0346 m (-0.0131, 0.0002, 0.0320)		2006/12/11 16:33
BZRG0	STR	24 ARP	4312657.9214	864634.4438	4603844.3553		0.2119	DIFF(STR,REF)= 0.0335 m (-0.0125,-0.0135,-0.0279)		2007/05/23 07:42
CACE0	REF	EPN APC	4899866.8947	-544567.5863	4033769.8431	0.0956	0.0000	http://epncb.oma.be/stations/log/cace		
CACE0	STR	3 APC	4899866.8800	-544567.5900	4033769.8300			DIFF(STR,REF)= 0.0200 m (-0.0011,-0.0053,-0.0193)		2007/05/23 07:42
CAGZ0	REF	EPN APC	4893380.3804	772650.2405	4004179.9119	0.1953	0.0945	http://epncb.oma.be/stations/log/cagz		
CAGZ0	STR	3+22 APC	4893380.3830	772650.2319	4004179.9171	0.0000		DIFF(STR,REF)= 0.0203 m (0.0068, 0.0001, 0.0192)		2007/03/12 11:59
CAGZ0	STR	3 APC	4893380.3800	772650.2300	4004179.9100			DIFF(STR,REF)= 0.0107 m (-0.0002,-0.0103,-0.0028)		2007/05/23 07:42
CANT0	REF	EPN ARP	4625926.8998	-307096.9105	4365773.2678	3.1410	3.0490	http://epncb.oma.be/stations/log/cant		
CANT0	STR	3+22 APC	4625926.9754	-307096.9287	4365773.3391	3.1590		DIFF(STR,REF)= 0.0183 m (-0.0010,-0.0132, 0.0127)		2007/05/23 07:42
CANT0	STR	24 ARP	4625926.8858	-307096.9234	4365773.2534		3.0490	DIFF(STR,REF)= 0.0239 m (-0.0014,-0.0138,-0.0194)		2007/05/23 07:42
CASC0	REF	EPN ARP	4917537.9069	-815726.6022	3965857.7874	1.1122	1.0210	http://epncb.oma.be/stations/log/casc		
CASC0	STR	3+22 APC	4917537.9881	-815726.6181	3965857.8132	1.1303		DIFF(STR,REF)= 0.0301 m (-0.0284, 0.0091,-0.0039)		2007/03/10 17:59
CASC0	STR	24 ARP	4917537.9134	-815726.5960	3965857.7466		1.0210	DIFF(STR,REF)= 0.0418 m (-0.0352, 0.0072,-0.0213)		2007/05/21 15:59
CEUT0	REF	EPN ARP	5150601.9595	-478834.6761	3718884.6004	0.0956	0.0000	http://epncb.oma.be/stations/log/ceut		
CEUT0	STR	3+22 APC	5150602.0445	-478834.6601	3718884.6663	0.1100		DIFF(STR,REF)= 0.0264 m (0.0046,0.0238, 0.0104)		2006/12/08 11:33
CEUT0	STR	24 ARP	5150601.9558	-478834.6619	3718884.5918		0.0000	DIFF(STR,REF)= 0.0170 m (-0.0040,0.0138,-0.0091)		2006/12/08 11:33

GNSS Data (RINEX, RTCM, ...)

DAILY

FORMAT : RINEX, 30 sec, Hatanaka compressed
ACCESS : free

DOWNLOAD DATA

<<	<	May 2007				>	>>
Wk No	Sun	Mon	Tue	Wed	Thu	Fri	Sat
1425			01 (121)	02 (122)	03 (123)	04 (124)	05 (125)
1426	06 (126)	07 (127)	08 (128)	09 (129)	10 (130)	11 (131)	12 (132)
1427	13 (133)	14 (134)	15 (135)	16 (136)	17 (137)	18 (138)	19 (139)
1428	20 (140)	21 (141)	22 (142)	23 (143)	24 (144)	25 (145)	26 (146)
1429	27 (147)	28 (148)	29 (149)	30 (150)	31 (151)		

DATA CENTRES STATUS

BKGE (primary)	Online.
IGNI	Online.
OLG (secondary)	Online.

META DATA ERRORS

Header of the RINEX observation files

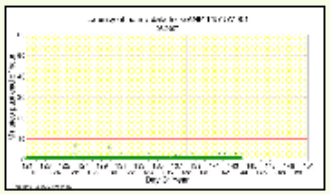
HOURLY

FORMAT : RINEX, 30 sec, Hatanaka compressed
ACCESS : free

DOWNLOAD DATA

BKGE
CDDIS
GOP
IGNI
OLG

DATA LATENCY

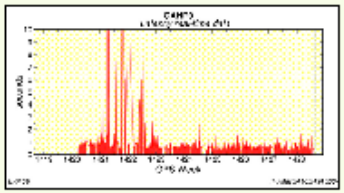


REAL-TIME

STREAM : GANP0
FORMAT : RTCM 3.0 - 1004(1),1005(5),1007(5),1012(1),1019(1)
ACCESS : free
DOWNLOAD :available from www.euref-ip.net:2101

Download software.
Full list of EPN stations providing real-time data available from EUREF-IP web page.

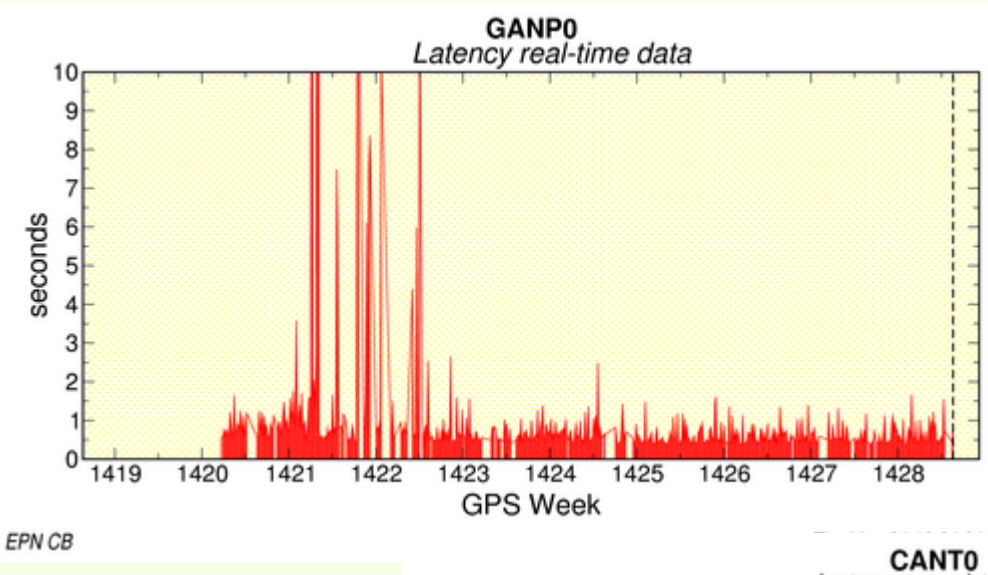
DATA LATENCY

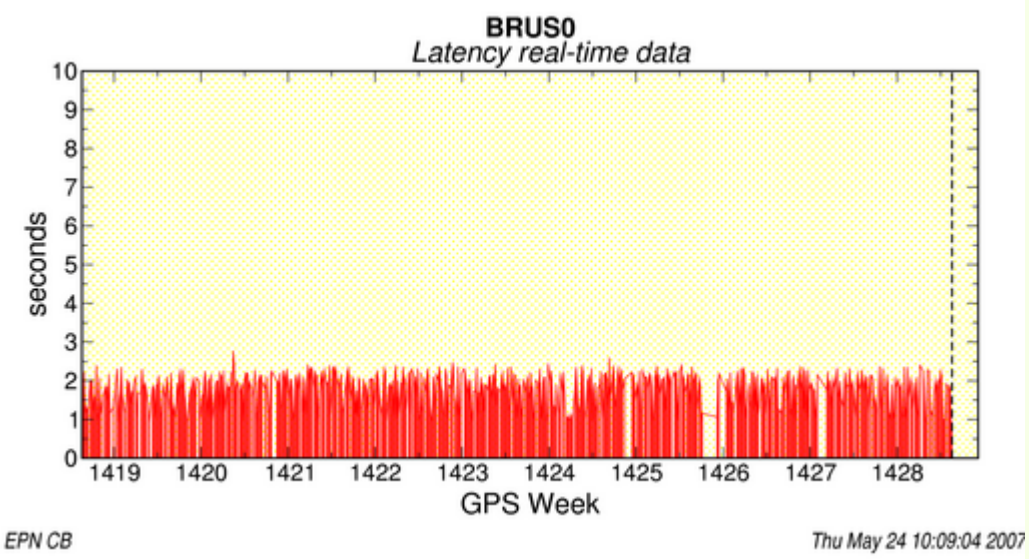


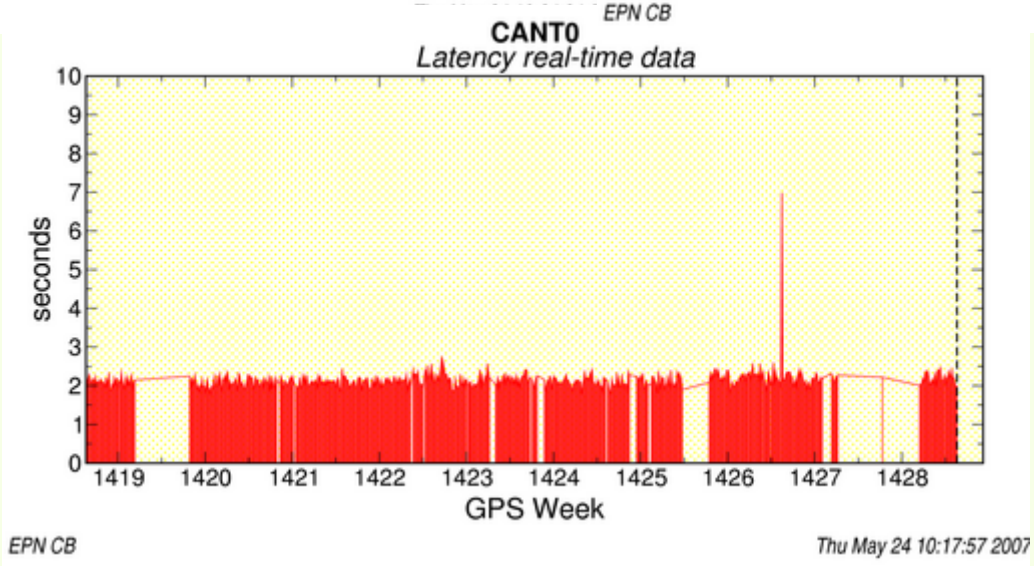
METEO

None

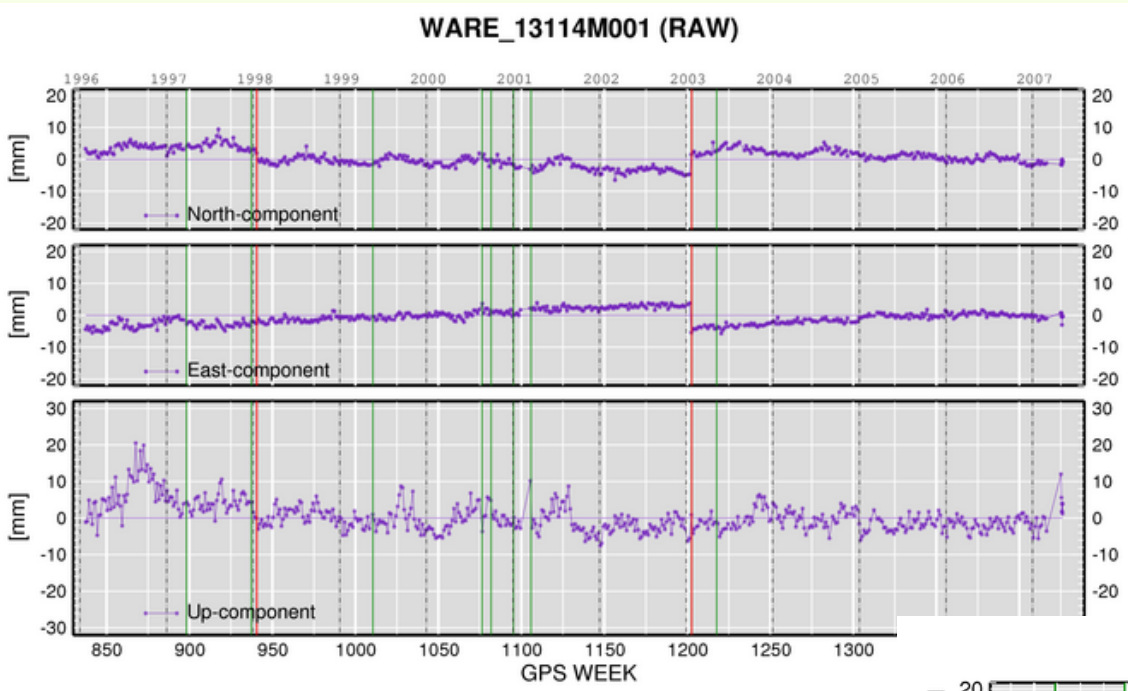
Real-time


GANP0
Latency real-time data
seconds
GPS Week
EPN CB


BRUS0
Latency real-time data
seconds
GPS Week
EPN CB
Thu May 24 10:09:04 2007

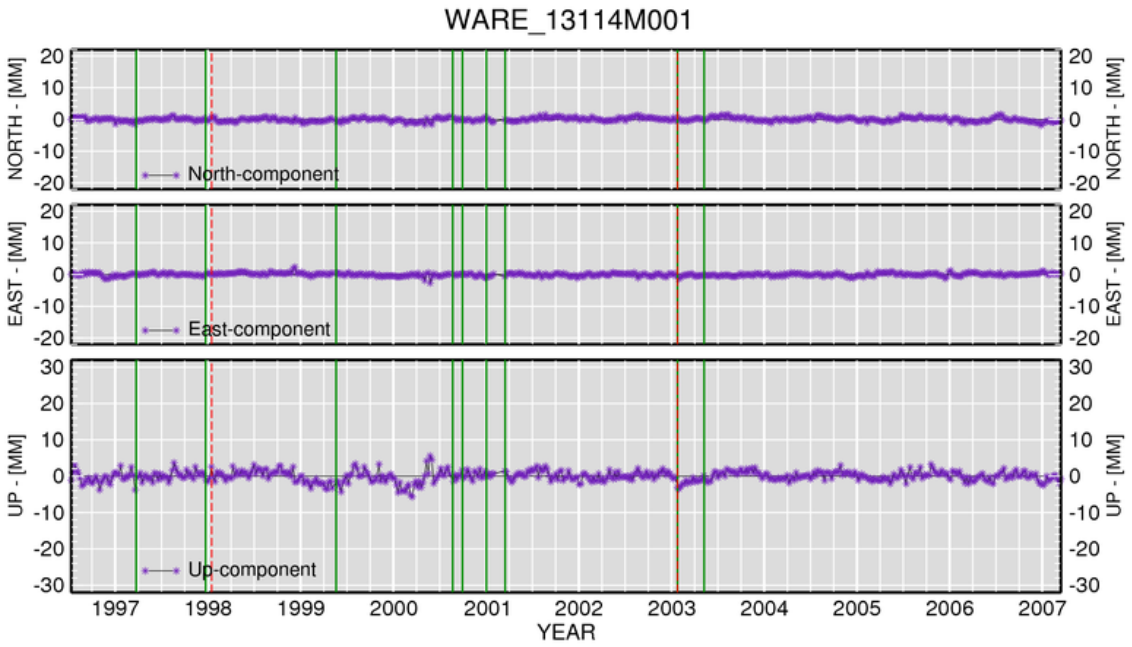

CANT0
Latency real-time data
seconds
GPS Week
EPN CB
Thu May 24 10:17:57 2007

Results



EUREF solution

Reprocessed solution



- 11 new EPN stations
- Examples of tracking problems
- GPS+GLONASS data quality checks
- Rapid EPN solution is now part of RAW time series
- Monitoring of real-time data streams

Thank You

To all Station operators, Data centres,
Analysis centres and their agencies

For your support to the EPN Activities

Please submit site pictures to EPN CB: BELL BOGI BZRG CREU DRES DUBR EBRE ESCO HELG HOFN JOEN KOSG LLIV METS NSSP OBE2 OSJE OSLS POTS QAQ1 RABT REYK SFER SODA THU3 TUBI VLNS