The EPN Infrastructure: Status, Monitoring and Plan

C. Bruyninx, Q. Baire, J. Legrand, W. Aerts

EPN Central Bureau
Royal Observatory of Belgium

OUTLINE

- EPN Tracking Network
- Update of EPN Guidelines
- New@EPN CB
- Summary and Future Plans

EUREF PERMANENT NETWORK

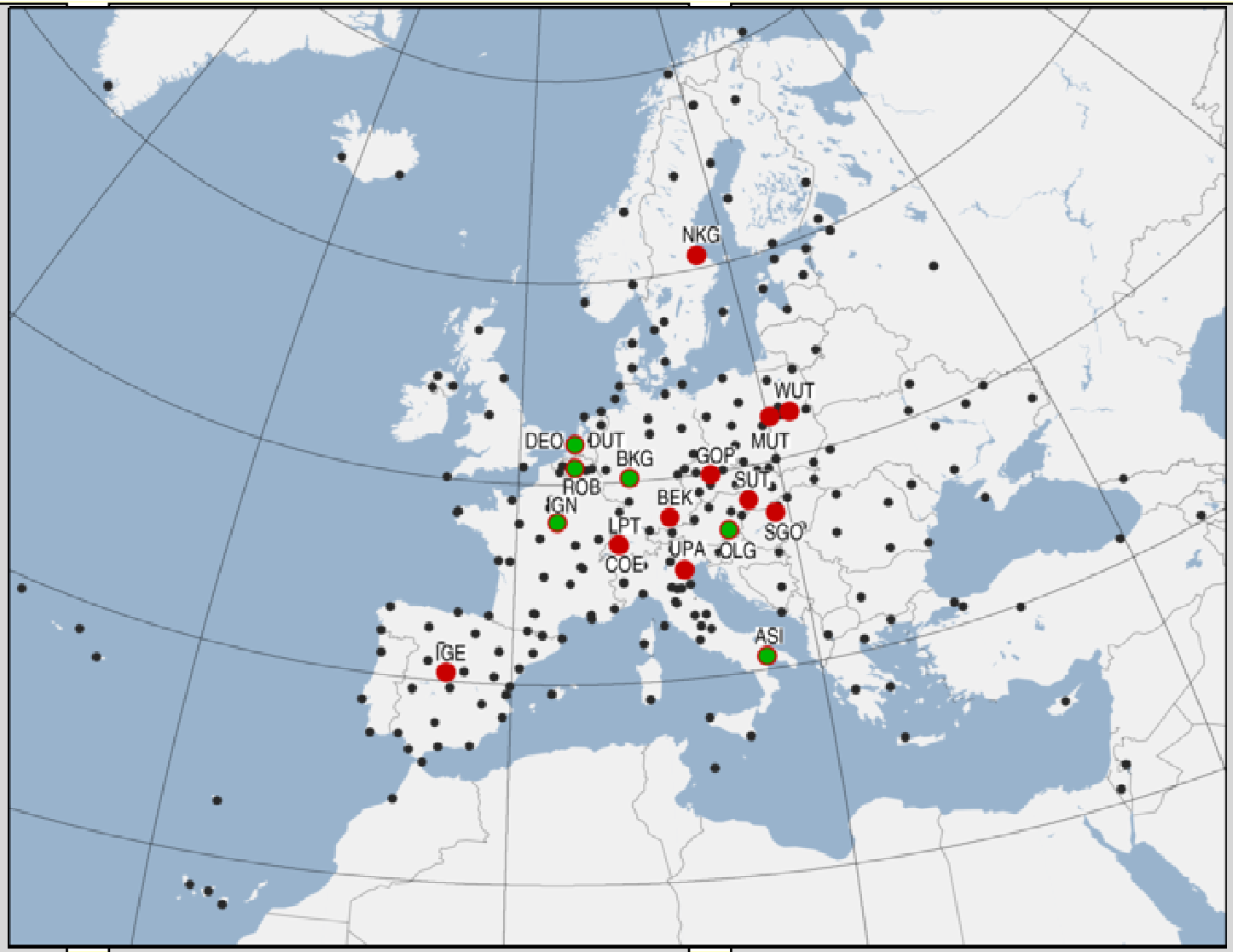
243 GNSS tracking stations

6 Data Centres

17 Analysis Centres

Special purpose data centres:

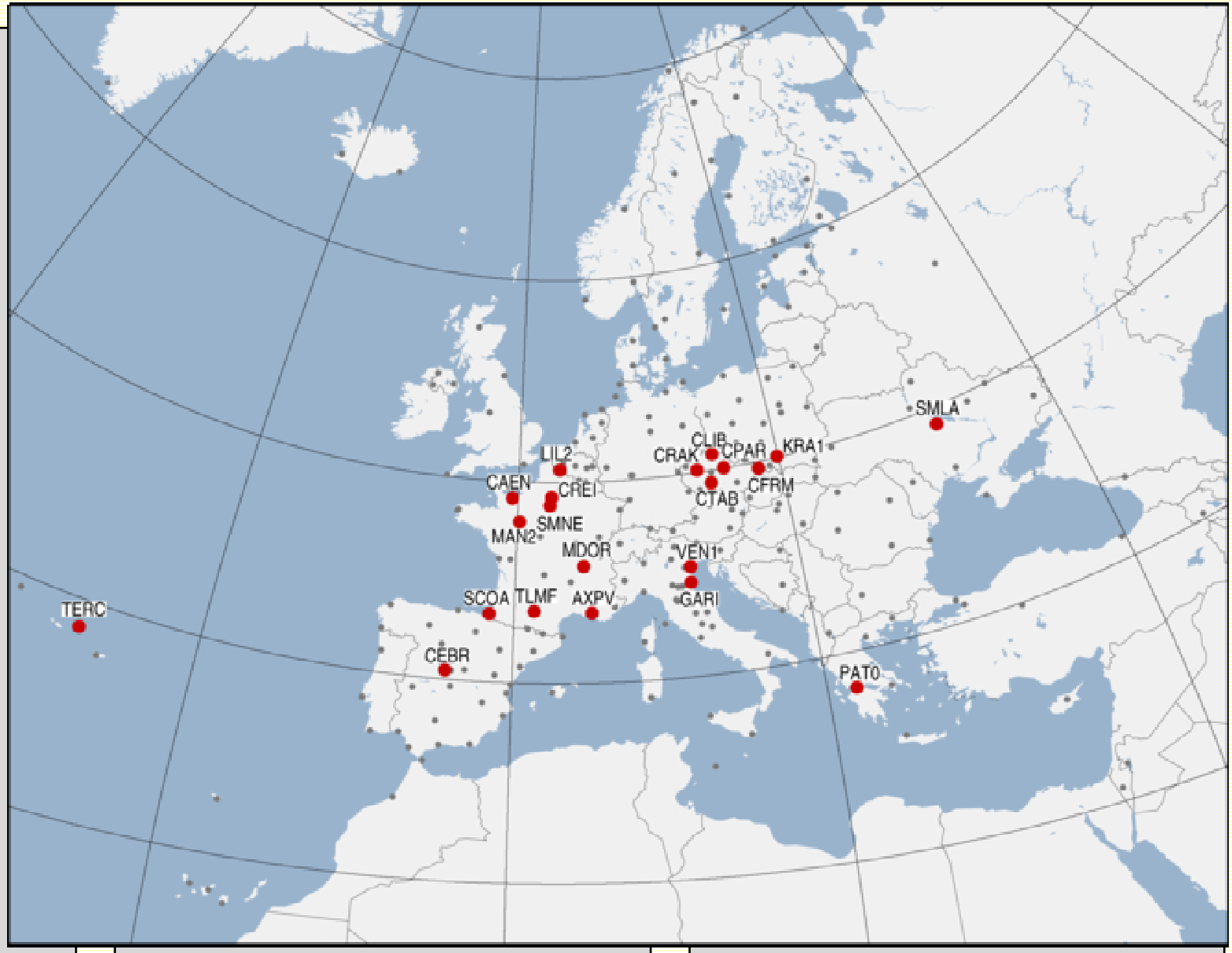
- Hourly data (GOP)
- High rate data centre (BKG)
- Historical data centre (ROB/EPN CB)



EPN TRACKING NETWORK

Since May 2009:

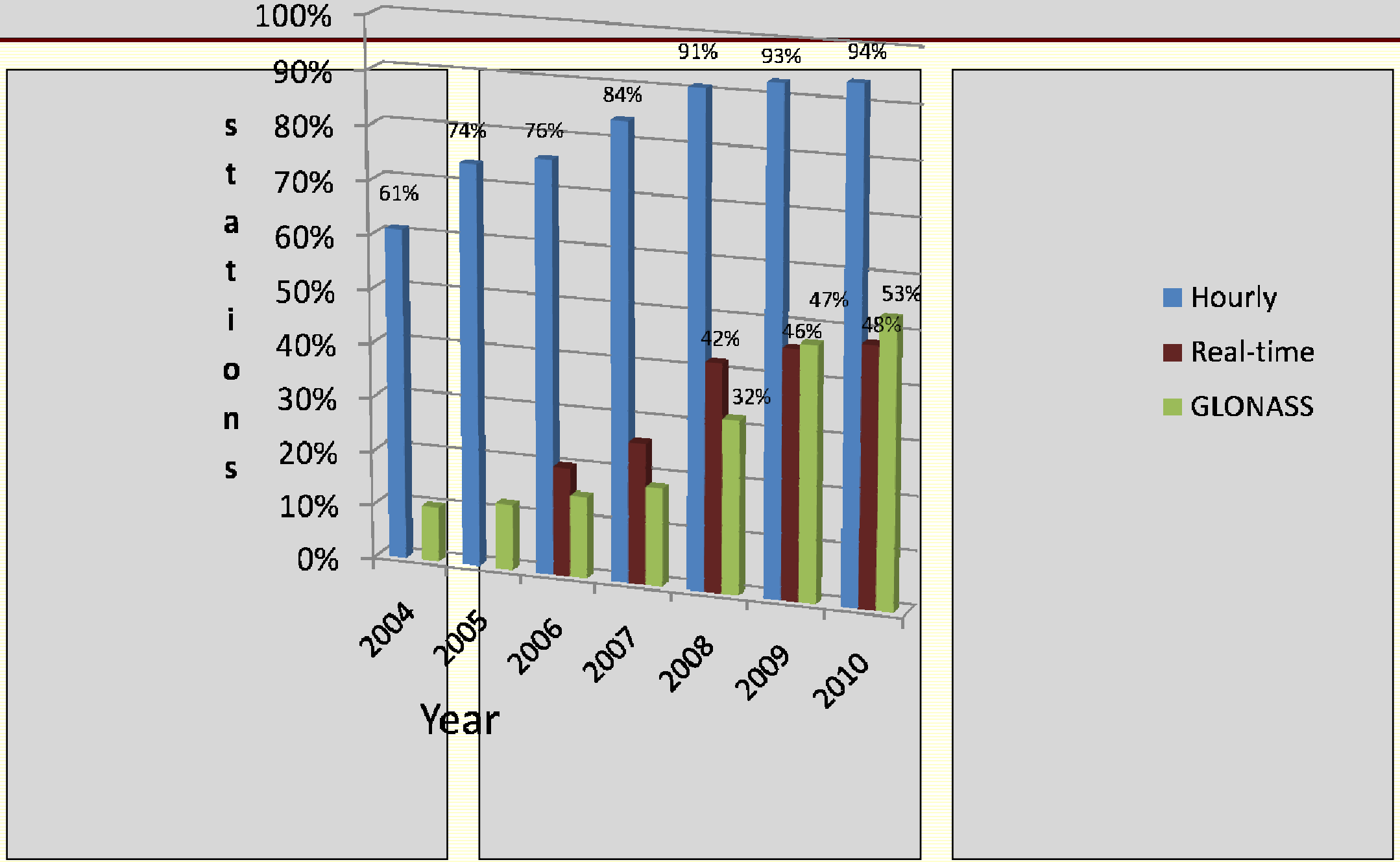
- 21 new EPN stations
- 1 station removed from network (SNEC, Czech Repubic)



21 NEW EPN STATIONS

4-CHAR ID	LOCATION	FUNCTION	CALIB	FROM
AIPV	Aix En-Provence, France	GLO	Type	28/03/2010
CAEN	Caen, France	GLO	Type	28/03/2010
CEBR	Cebreros, Spain	RT GLO	Type	11/04/2010
CFRM	Frydek Mistek, Czech Republic	RT	Type	21/03/2010
CLIB	Liberec, Czech Republic	RT	Type	21/03/2010
CPAR	Pardubice, Czech Republic	RT	Type	21/03/2010
CRAK	Rakovnik, Czech Republic	RT	Type	21/03/2010
CREI	Creil, France	GLO	Type	28/03/2010
CTAB	Tabor, Czech Republic	RT	Type	21/03/2010
GAVI	Porto Garibaldi, Italy	GLO	Type	08/11/2009
KRAS	Krakow, Poland	RT GLO	Type	21/03/2010
LIL2	Lille, France	GLO	Type	28/03/2010
MAN2	Le Mans, France	GLO	Type	28/03/2010
MDOR	Saint-Gildas-sur-Mont-d'Or, France	GLO	Type	28/03/2010
PATO	Patras, Greece	GLO	Type	14/06/2009
SCOA	Ciboure, France	RT GLO	Type	28/03/2010
SMLA	Smila, Ukraine	GLO	Type	01/11/2009
SMNE	Saint-Mande, France	GLO	Type	28/03/2010
TERC	Angra do Heroismo, Portugal	RT GLO	Type	03/01/2010
TLSF	Toulouse, France	GLO	Type	28/03/2010
VEN1	Venecia, Italy	RT GLO	Type	12/12/2009

EVOLUTION OF EPN TRACKING NETWORK



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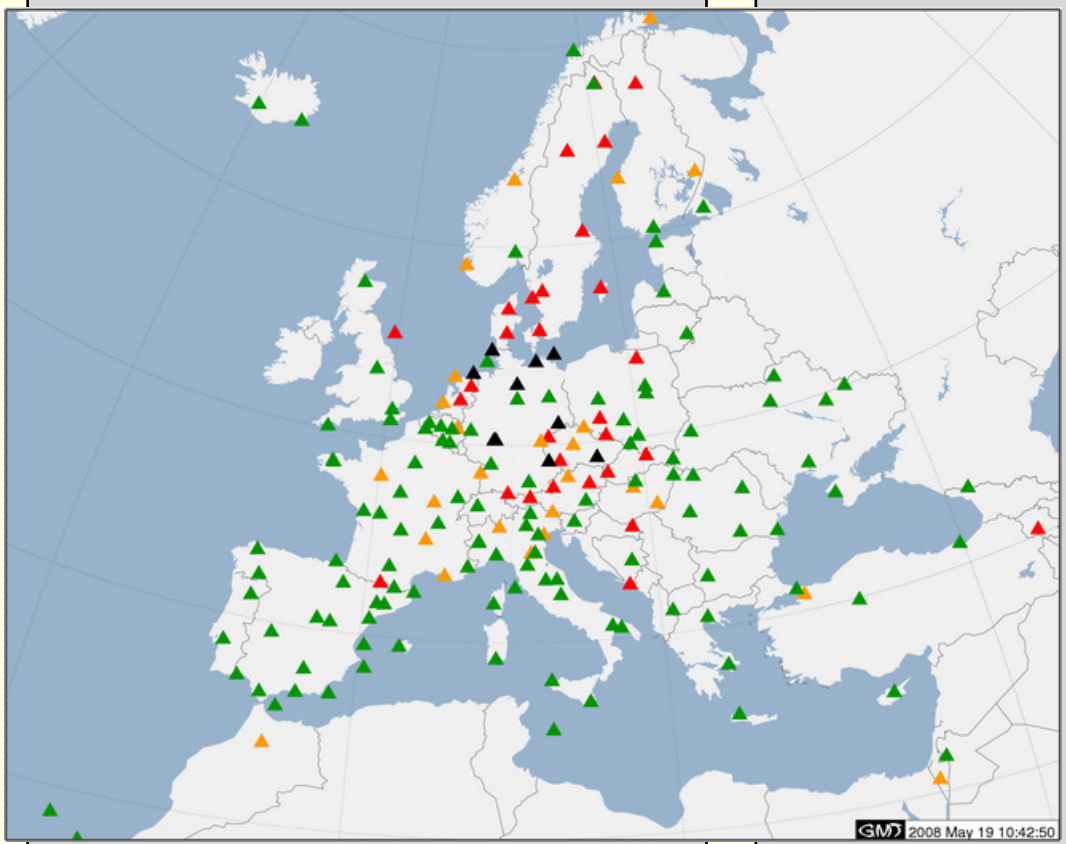
EPN ANTENNA CALIBRATIONS

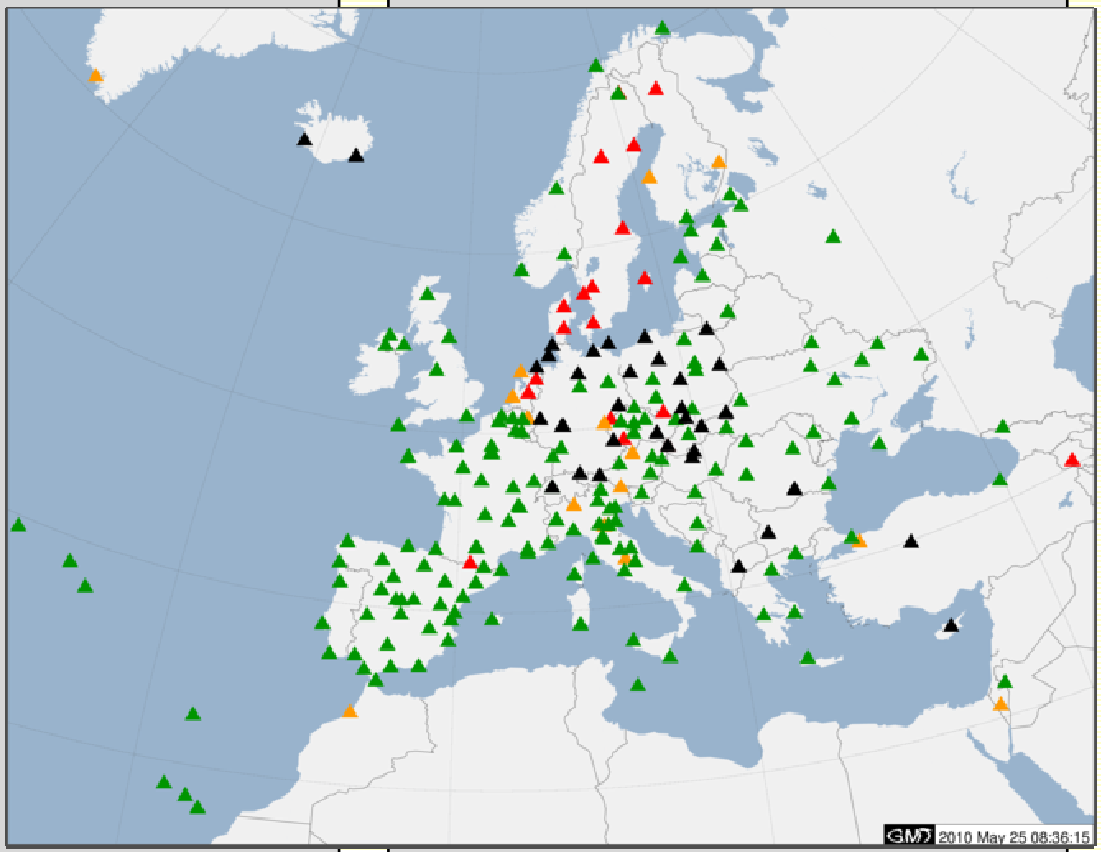
Dec. 2006

Indiv. abs. calib.	5 %	
True abs.calib	64 %	69%
Abs. calib. from field	14 %	
No abs. calib.	17 %	



June 2010

Indiv. abs. calib	14 %	
True abs. calib	70 %	84%
Abs. calib. from field	7%	
No abs. calib.	9%	



OUTLINE

- EPN Tracking Network
- **Update of EPN Guidelines**
- New@EPN CB
- Summary and Future Plans

EPN STATION GUIDELINES

Aproved by EUREF TWG on March 8, 2010

- Data flow & format
- Network topology
- Long-term stability
- Satellite tracking

EPN STATION GUIDELINES

Data Flow & Format

- Minimal requirement: Hourly data submission
- All daily and hourly data delivery within 10 min.
- Real-time data:
  - Stream GLONASS data
  - Stream GPS and GLONASS ephemerides

EPN STATION GUIDELINES

The *<<Parent/Funding Agency>>* proposes the inclusion of the GNSS station *<<Station/Marker Name>>* (*<<City, Country>>*) in the EUREF Permanent Network (EPN).

Describe

- *the station location compared to other EPN stations,*
- *the collocated instruments (tide gauge, meteo sensor, seismometer, gravity, ...)*
- *the connection to the national levelling network and UELN*
- *the receiver and antenna(+radome) type, indicate if the receiver is tracking other GNSS next to GPS and if the antenna/radome pair is absolutely calibrated (type mean calibration from the IGS or individual calibration)*
- *the planned data flow (primary and secondary data centre) and latency (hourly, daily, real-time)*

The station *<<Station Marker/Name>>* has been installed following EPN guidelines and once accepted in the EPN, the *<<Parent/Funding Agency>>* commits to continuously maintain and operate this station following the EPN guidelines for a period of at least 5 years.

EPN STATION GUIDELINES

Long-term stability

- Antenna change only when malfunctioning
  - Failure of existing antenna
  - GPS-only antenna does not perform well after installation of multi-GNSS receiver
- Only radomes directly connected to the antenna are allowed (calibration)
- If antenna change is necessary, install
  - multi-GNSS antenna (even if receiver is not yet multi-GNSS) - *recommendation*

EPN ANTENNA REPLACEMENTS

42 antenna replacements (including new stations)

(16 with radome!)

GPS	GPS/GLONASS	GPS/GLONASS/GALLEO
1 AOA/M_T	11 LEIAT504GG	4 LEIAR25
1 ASH700936E	1 NOV702GG	2 LEIAR25.R3
1 ASH701945B_M		2 TPSCR3G
5 LEIAT504		1 TRM59800.00
4 TRM29659.00		9 TRM55971.00
12	12	18

EPN STATION GUIDELINES

Long-term stability (cont.)

- For sites with different stable monuments:
  - If GPS → multi-GNSS, then install multi-GNSS on new monument
  - Propose new multi-GNSS site to EPN
  - Keep old monument as long as possible in EPN

EPN STATION GUIDELINES

Satellite tracking

- Track
  - L5 and multiple GNSS (at least GPS)
    - PRN01, first Block II-F launched May 27
  - Unhealthy satellites !!

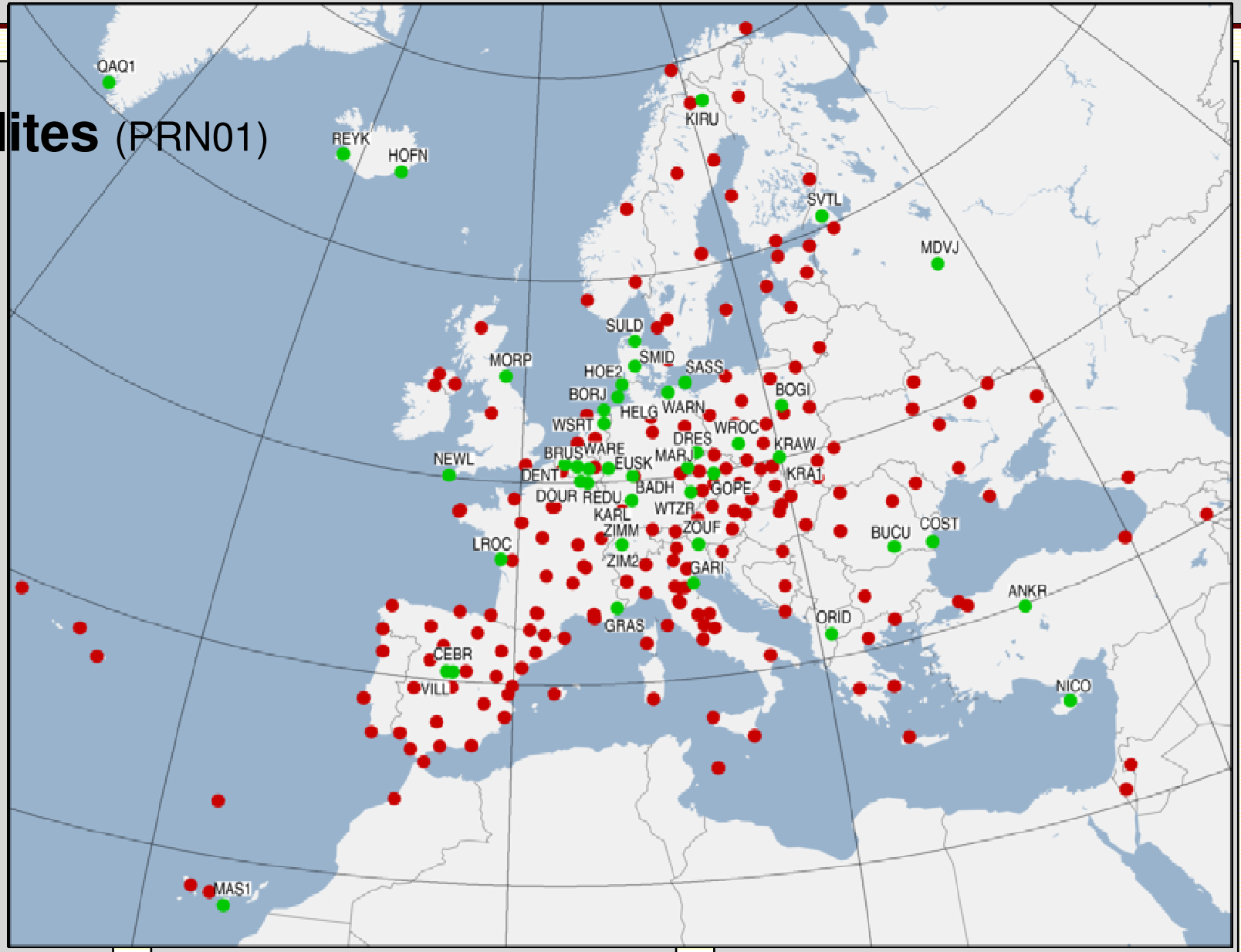
    EUREF mail 5160 (May 25, 2010)

TRACKING OF UNHEALTHY SATELLITES

Unhealthy satellites (PRN01)

Tracked

Not tracked

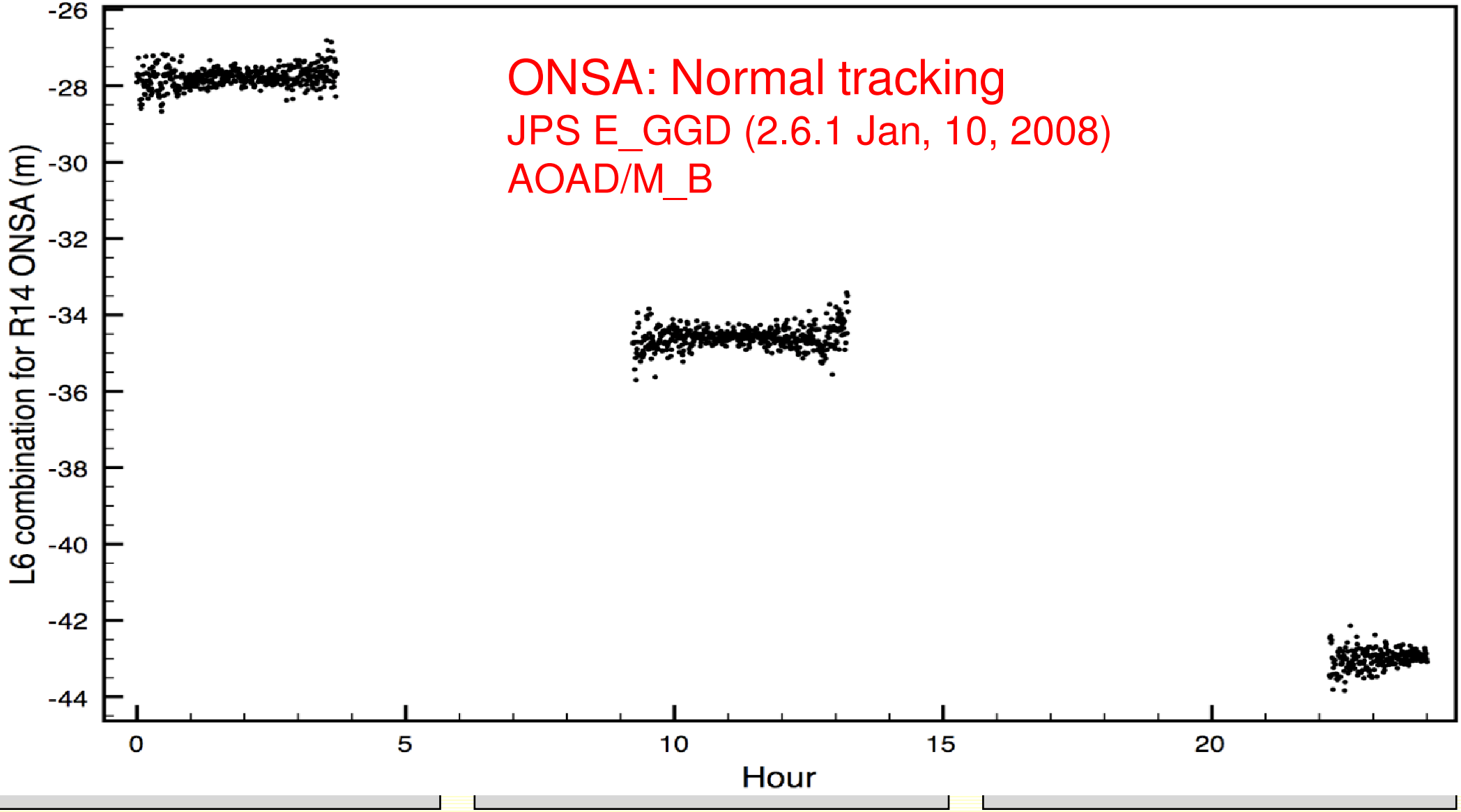


GLONASS TRACKING

- BISK/VACO: neg. freq. channels ASHTECH Z-12 (equipment problem)
- OSJE: reports mixed RINEX, but delivers only GPS (TRIMBLE NETR5)
- NAY1, OSLS, STAS,TRDS, TRO1, VARS: GPS+GLONASS equipment, but GPS-only RINEX
- SPT0: …

GLONASS TRACKING

- Melbourne-Wubbena combination: noise + cycle slips



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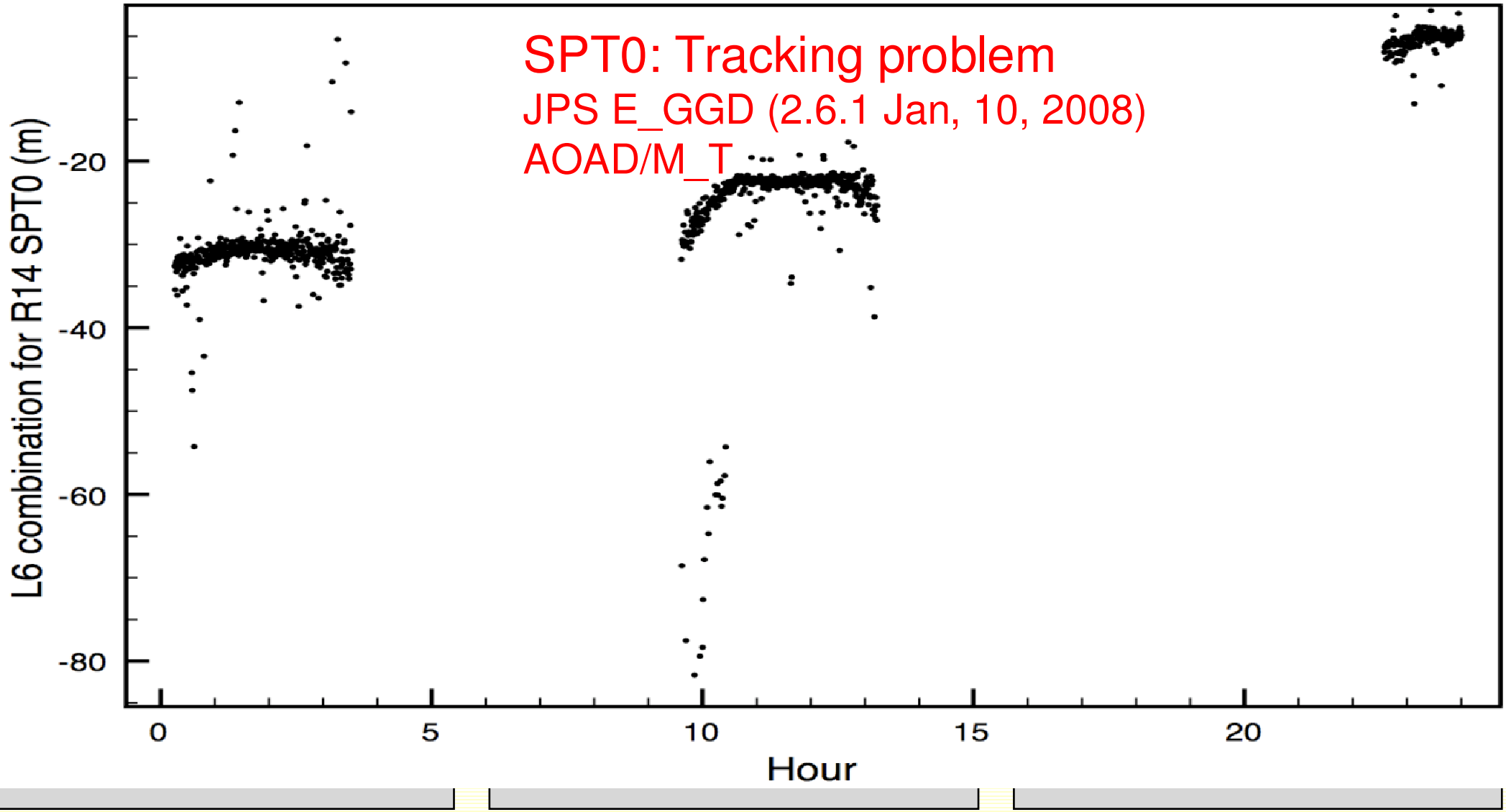

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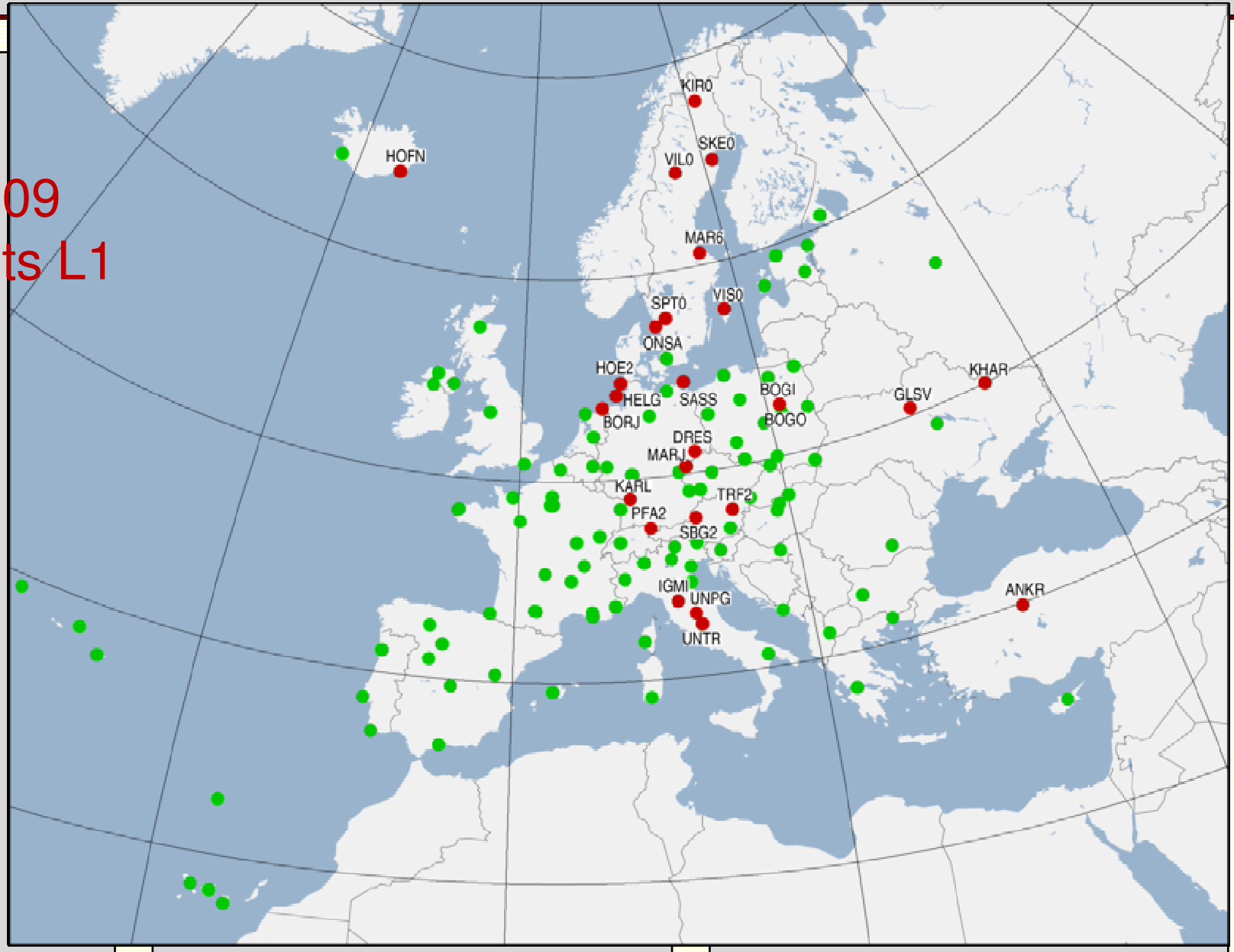
- SPT0: …
- Tracking of L2 on GLONASS R09 only emmiting L1…

GLONASS TRACKING

Tracking L2 on R09
Which only emmits L1



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- NAY1, OSLS, STAS,TRDS, TRO1, VARS: GPS+GLONASS equipment (), but GPS-only RINEX
- SPT0: …
- Tracking of L2 on GLONASS R09 only emmiting L1…
- + others with reduced GLONASS tracking on some satellites

EPN STATION GUIDELINES

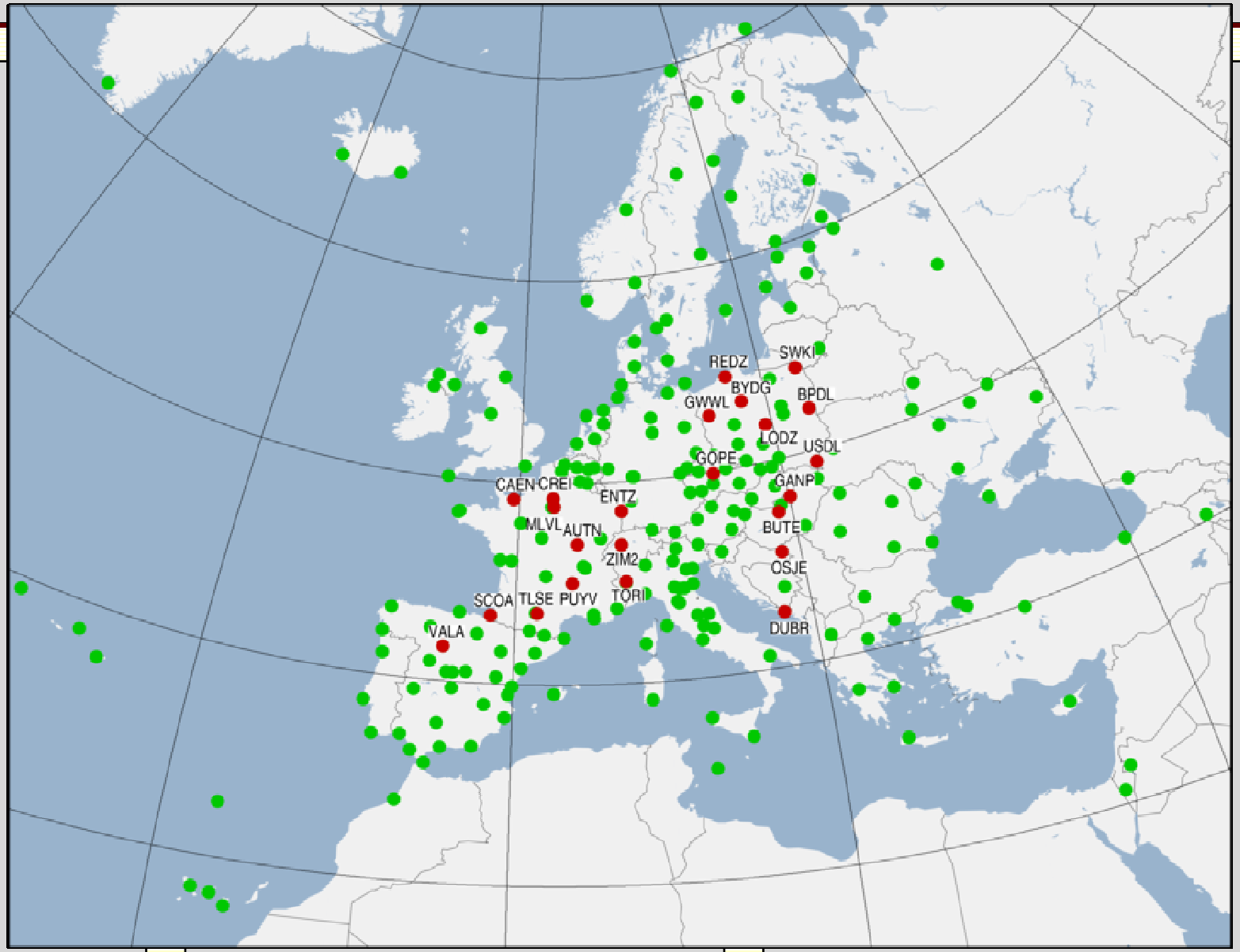
Satellite tracking

- L2C (civil code on L2, C2 in RINEX 2.11)
  - Block IIR-M (7 sat.)
  - L2 carrier phase: L2(C) - L2(P) = ¼ cycle
  - RINEX : ~~C2~~, P2

TRACKING OF C2

C2 not tracked

C2 tracked



EPN STATION GUIDELINES

Satellite tracking

- No code smoothing (often default activated)
- Format: RINEX V2.11

OUTLINE

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- Summary

NEW "FORMATS" WEB-PAGE

FORMATS

Here is a collection of the formats currently within the EPN/IGS.

RINEX v. 2.10	GPS and GLONASS observations, meteorological data, and navigation files.
RINEX v. 2.11	GPS and GLONASS observations, meteorological data, and navigation files. *Currently considered as the **standard**.*
RINEX v. 2.12	GPS and GLONASS observations, meteorological data, and navigation files. *Used for GNSS receivers reporting the C2 observable, currently considered experimental by EUREF/IGS. Data accepted on test basis only, contact EPN CB for more information.*
RINEX v. 3.0.1	GPS, GLONASS and Galileo observations, meteorological data, and navigation files. *Used for GNSS receivers reporting the C2 observable, currently considered experimental by EUREF/IGS. Data accepted on test basis only, contact EPN CB for more information.*
SINEX	station position and velocity solutions.
Hatanaka compact RINEX	GPS and GLONASS observations.
sp3 version c	GPS and GLONASS orbit solutions.
sp3 version a	GPS and GLONASS orbit solutions. *Discontinued January 2006.*
clock RINEX	station and satellite clock solutions.
IONEX	ionospheric TEC grid products.
tropo SINEX	zenith path delay products.
site log	history of site installation.
ANTEX	antenna calibrations.

NEW INTERACTIVE SITE MAP

SITE MAPS

Interactive map

Legend

Station status (active, inactive, former)

Active Inactive Former

Locate site on map

- Select a station -

Site criteria selection

Receiver manufacturer:
AOA
ASHTECH
JAVAD

Antenna manufacturer:
3S NAVIGATION
AOA
ASHTECH

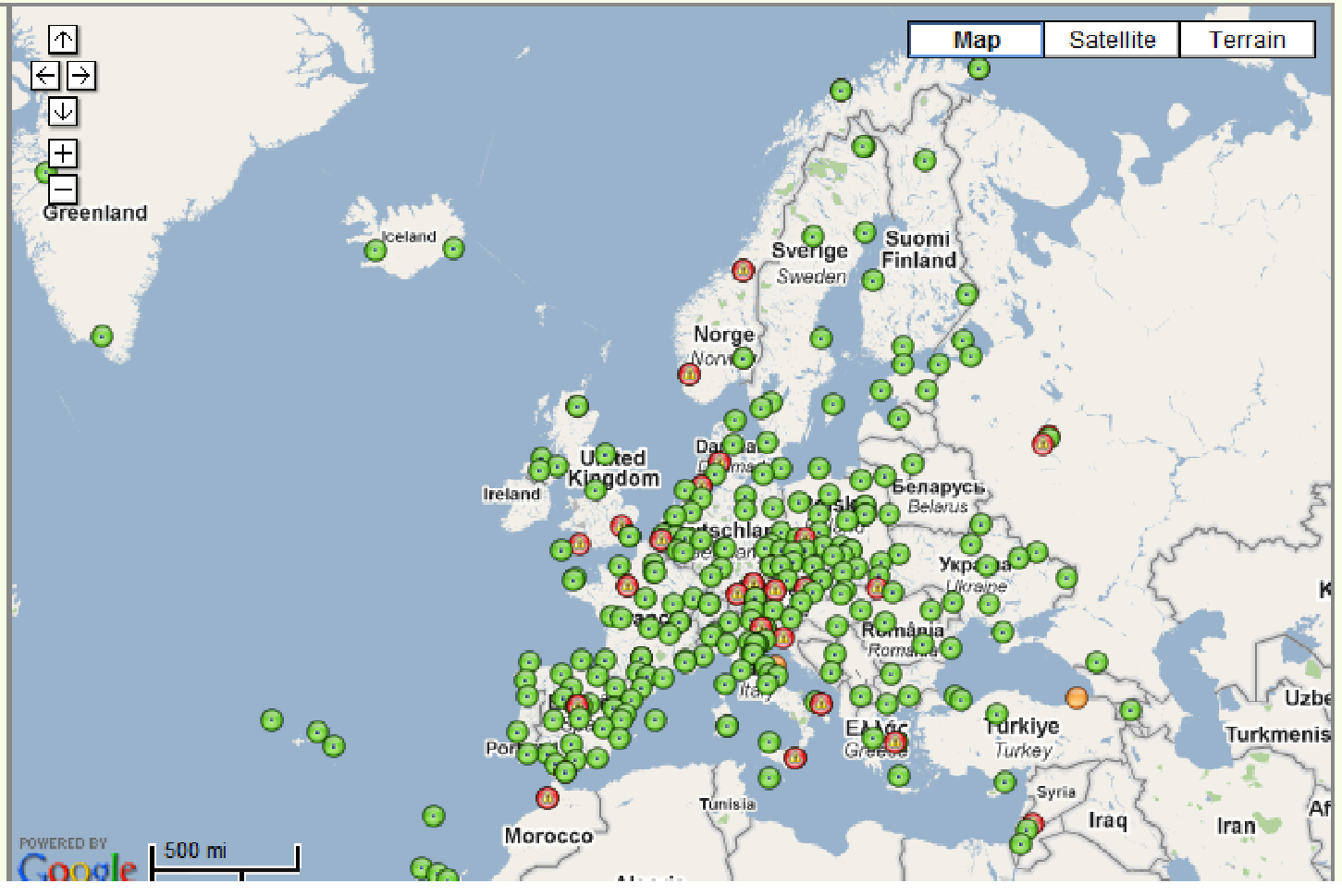
Satellite system:
GPS
GLONASS
GALILEO

Status:
ACTIVE
INACTIVE
FORMER

Data:
DAILY
HOURLY
REAL-TIME

hold down CTRL for multiple selection

Update map



Interactive map

Legend

Data flow (real-time, hourly, daily)

Real-time Hourly Daily

Locate site on map

- Select a station -

Site criteria selection

Receiver manufacturer:

AOA
ASHTECH
JAVAD

Antenna manufacturer:

3S NAVIGATION
AOA
ASHTECH

Satellite system:

GPS
GLONASS
GALILEO

Status:

ACTIVE
INACTIVE
FORMER

Data:

DAILY
HOURLY
REAL-TIME

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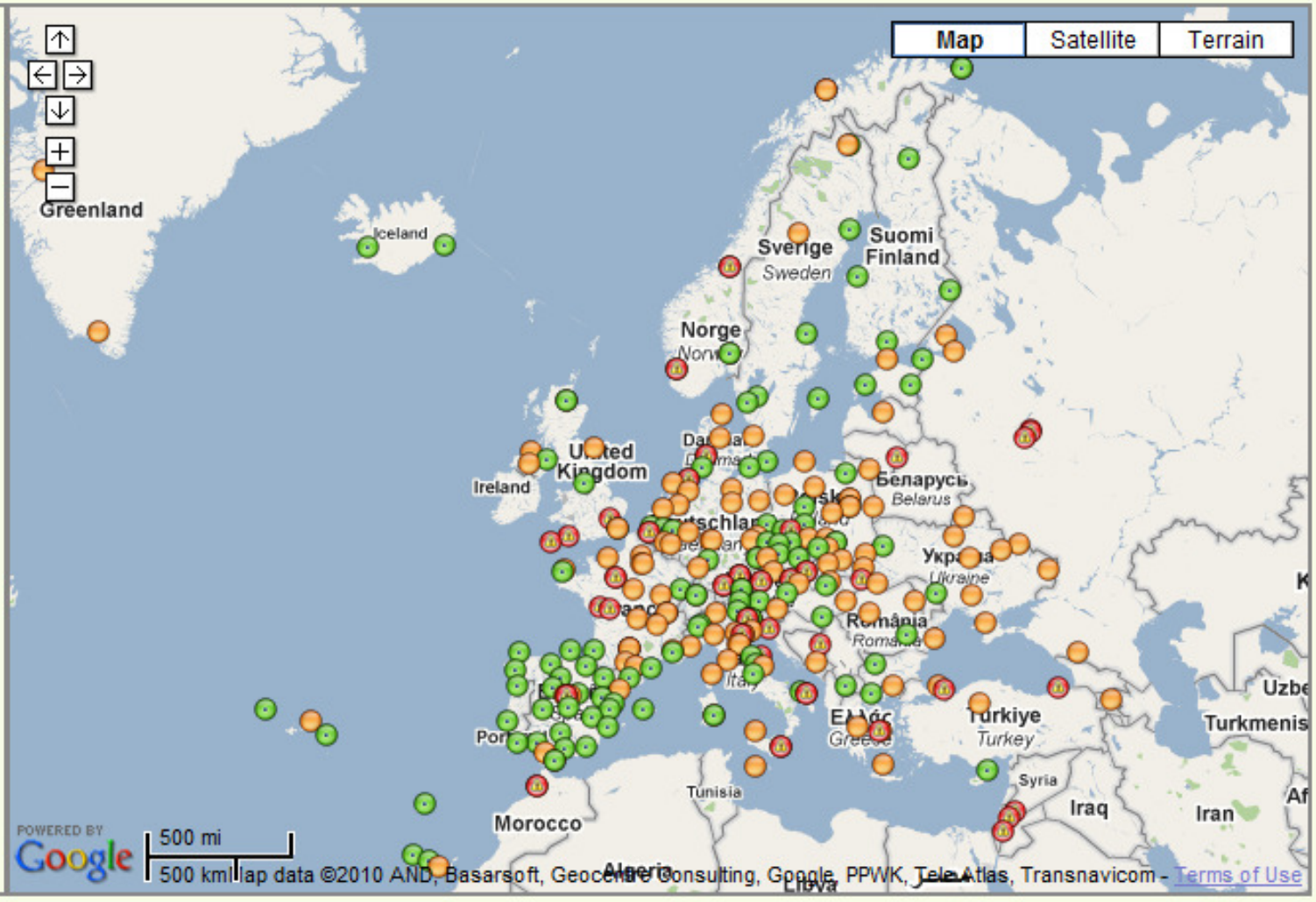
Update map



Interactive map

Legend

Data flow (real-time, hourly, daily)

Real-time | Hourly | Daily

Locate site on map

- Select a station -

Site criteria selection

Receiver manufacturer:

ASHTECH
JAVAD
LEICA

Antenna manufacturer:

3S NAVIGATION
AOA
ASHTECH

Satellite system:

GPS
GLONASS
GALILEO

Status:

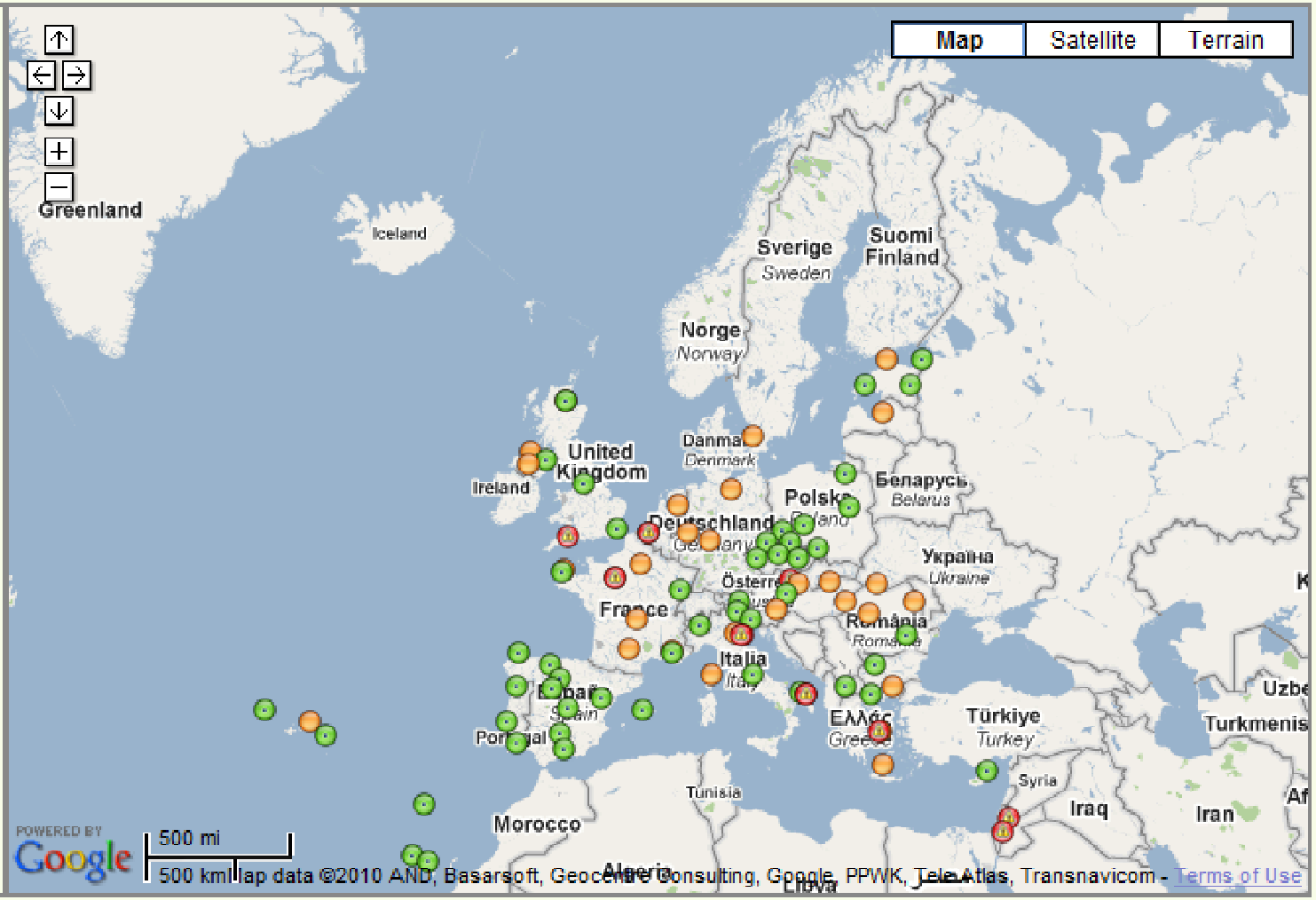
ACTIVE
INACTIVE
FORMER

Data:

DAILY
HOURLY
REAL-TIME

hold down CTRL for multiple selection

Update map



NEW INTERACTIVE SITE LIST

SITE LIST

As of 27 May 2010, 243 permanent GNSS tracking stations (including 2 inactive) are part of the EUREF Permanent Network.

For a better understanding of the table, see the legend.

Site Identification	Site Location	Data	Receiver Information	Antenna Information	Meteorological Instrumentation	Additional Information
☑ Marker Name	☑ City	☑ Quality	☐ Type	☐ Type/Radome	☐ Meteo data	☐ Primary data centre
☐ Marker Number	☑ Country	☑ Availability	☑ Satellite system	☐ Serial number	☐ Humidity sensor	☐ Secondary data centre
☐ Site log	☐ Tectonic plate	☑ Latency	☐ Serial number	☐ Height	☐ Pressure sensor	☑ Networks
☐ Site name	☑ Lat, long, h		☐ Firmware version	☐ Reference point	☐ Temperature sensor	☑ Remarks
	☐ X, Y, Z		☐ Frequency Standard		☐ Water vapor radiometer	

Submit

Marker Name	City	Country	Lat.	Long.	H.	DQ (%)		Availability (%)					Latency			Receiver			Networks			Remarks
						0°	15°	Daily		Hourly		RT	Hourly (%)		RT (s)	Sat. System			IGS	TOS	ECGN	
								BKG	OLG	BKG	OLG		BKG	OLG		G	R	E				
ACOR	A Coruna	Spain	43.36	-8.40	67.0	90	100	100	100	96	94	79	87	88	0.9	✔	_	_	_	_	✔	
AJAC	Ajaccio	France	41.93	8.76	99.0	90	99	100	100	88	98	_	80	1	1.0	✔	✔	_	✔	✔	_	
ALAC	Alicante	Spain	38.34	-0.48	60.0	89	99	100	100	95	94	79	88	89	1.8	✔	_	_	_	_	✔	
ALBA	Albacete	Spain	38.98	-1.86	751.8	88	100	100	100	95	95	70	88	90	2.8	✔	_	_	_	_	_	
ALCI	Alchevsk/Mikhailovka	Ukraine	48.46	38.91	152.1	86	99	100	100	99	99	_	89	93	_	✔	_	_	_	_	_	
ALME	Almeria	Spain	36.85	-2.46	127.0	88	100	100	100	96	95	79	89	90	1.8	✔	_	_	_	_	✔	
~~AMMI~~	~~Ammae~~	~~Jordan~~	~~32.02~~	~~35.88~~	~~1055.8~~											✔			✔			Former

NEW INTERACTIVE SITE LIST

Site Identification	Site Location	Data	Receiver Information	Antenna Information	Meteorological Instrumentation	Additional Information
☑ Marker Name	☑ City	☑ Quality	☐ Type	☐ Type/Radome	☐ Meteo data	☐ Primary data centre
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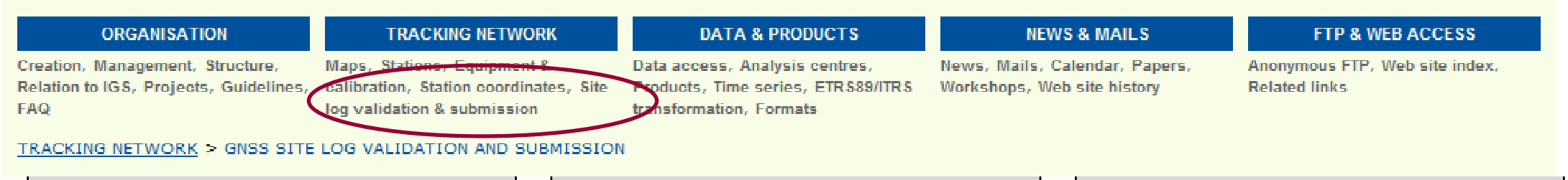
☐ Site name	☑ Lat, long, h		☐ Firmware version	☐ Reference point	☐ Temperature sensor	☑ Remarks
	☐ X, Y, Z		☐ Frequency Standard		☐ Water vapor radiometer	

Submit

Marker Name	City	Country	Lat.	Long.	H.	DQ (%)		Availability (%)					Latency			Receiver			Networks			Remarks
						0°	15°	Daily		Hourly		RT	Hourly (%)		RT (s)	Sat. System			IGS	TOS	ECGN	
								BKG	OLG	BKG	OLG		BKG	OLG		G	R	E				
TRAB	*Trabzon*	*Turkey*	*40.99*	*39.78*	*99.2*	_	_	*0*	*0*	*0*	*0*	_	*0*	*0*	_	✔	_	_	✔	_	_	*Inactive*
CAME	*Camerino -Rocca Di Varano-*	*Italy*	*43.12*	*13.13*	*506.9*	_	_	*0*	*0*	*0*	*0*	_	*0*	*0*	_	✔	_	_	_	_	_	*Inactive*
RAMO	Mitzpe Ramon	Israel	30.60	34.76	893.1	63	72	100	100	0	0	_	0	0	_	✔	_	_	✔	_	_	
UZHL	Uzhgorod	Ukraine	48.63	22.30	232.0	64	94	100	100	91	100	_	77	38	_	✔	_	_	✔	_	_	
PTBB	Braunschweig	Germany	52.30	10.46	130.2	66	95	100	100	91	100	_	84	0	_	✔	_	_	✔	_	_	
MORP	Morpeth	United Kingdom	55.21	-1.69	144.4	66	98	100	100	100	100	_	85	91	_	✔	_	_	✔	✔	_	
TRF2	Pernitz	Austria	47.93	15.86	1092.5	69	96	100	100	98	98	_	96	97	_	✔	✔	_	_	_	✔	
BISK	Zlate Hory	Czech Republic	50.26	17.43	950.9	71	89	100	100	98	98	_	94	88	_	✔	✔	_	_	_	_	
JOZE	Jozefoslaw	Poland	52.10	21.03	141.4	71	99	100	100	88	97	_	81	94	_	✔	_	_	✔	_	_	
RIGA	Riga	Latvia	56.95	24.06	34.7	72	96	100	100	91	100	_	86	98	_	✔	_	_	✔	_	✔	
MOPI	Modra-Piesok	Slovak Republic	48.37	17.27	579.0	72	98	79	79	0	0	_	0	0	_	✔	_	_	_	_	_	
VACO	Vacov	Czech Republic	49.13	13.72	799.4	72	88	100	100	100	100	_	96	93	_	✔	✔	_	_	_	_	
PULK	St.Petersburg	Russian Federation	59.77	30.33	101.2	73	97	100	100	100	100	_	93	98	_	✔	_	_	_	_	_	
MARJ	Jachymov	Czech Republic	50.36	12.89	904.7	73	97	100	100	100	100	_	93	90	_	✔	✔	_	_	_	_	
ROVE	Rovereto	Italy	45.89	11.04	261.7	74	100	100	100	100	100	99	42	99	1.9	✔	✔	_	_	_	_	
SPTO	Boras	Sweden	57.71	12.89	219.9	75	99	100	100	91	100	98	84	93	0.6	✔	✔	_	✔	_	✔	
PRAT	Prato	Italy	43.89	11.10	119.9	76	97	96	96	91	92	_	86	91	_	✔	_	_	_	_	_	
BRUS	Brussels	Belgium	50.80	4.36	149.7	76	99	100	100	90	100	96	86	100	1.7	✔			✔			

ON-LINE SITE LOG SUBMISSION

- **Operational since July 2, 2009**
- **Create** a new site log
- **Upload** a site log from the local disk or from the EPN CB
- **Update** the site log
- **Save** the site log on the local disk or in the EPN CB data base (all in IGS/EPN site log format)



ON-LINE SITE L

This on-line site log validation and submission allows to:

- Create a new site log conform the IGS/EPN site log format
- Upload, update, validate and save a site log on your local disk
- Upload, validate and save a site log in the EPN data base (only for EPN operational centres)

LOGIN

Operational centre : ROB (Belgium)

Password:

Request (or forgot ?) password

Security code:

Select station from ROB OC form: BRUS

(send updated ROB.OC to EPN CB for missing stations)

Upload the log from EPN CB (blank if log file does not exist)

Upload site log from disk Browse...

Submit

```
                                EUREF OPERATIONAL CENTRE

Agency acronym          : ROB

Institution             : Royal Observatory of Belgium

Mail Address            : avenue Circulaire, 3
                        : B-1180 Brussels

Country                 : Belgium

Primary Contact
Contact Name            : Bruyninx Carine
Telephone               : 32-2-3730292
Fax                     : 32-2-3749822
E-Mail                  : C.Bruyninx@oma.be

Secondary Contact
Contact Name            : Dominique Mesmaker
Telephone               : 32-2-3730245
Fax                     : 32-2-3749822
E-Mail                  : D.Mesmaker@oma.be

Third Contact
Contact Name            : Moyaert Ann
Telephone               : 32-2-3730201
Fax                     : 32-2-3749822
E-Mail                  :

Central computer (CC): PC
Operation system        : Linux / Ubuntu

Data uploaded to        : ROB, BKGI, BKGE, OLG, GOP and CDDIS
Link                    : Internet
Upload time             : between XX:01 and XX:03m, each hour
Upload duration         : 30 seconds max.

General remarks         :

Report generated        : 2003-03-26
Report updated          : 2008-01-23
```

ON-LINE SITE LOG SUBMISSION

RECOMMENDATIONS:

- Read the instructions, guidelines and FAQ's
- Do not upload the site log from disk, but from the EPN CB data base instead and then update it on-line. This will guarantee that no information (e.g. due to bad formatting) will be lost during the upload.
- Enter in the OC form the contact(s) responsible for the site log submission
- First submit the site log (successfully) to the EPN CB before sending a EUREF mail related to the site log modification
- Complete a maximum of information, even missing fields giving only a warning message
- Send new pictures related to hardware changes

ON-LINE ETRS89 – ITRS TRANSFORMATION

Operational since Nov. 23, 2009

ETRS89/ITRS TRANSFORMATION

The following tool allows to transform coordinates (position and velocity) from any ETRFxx to any ITRFyy (or ITRFyy to ETRFxx). In case input and output coordinates are requested at different epochs, then site velocities are mandatory.

Input

Frame : ITRF2005

Epoch : 2006 . 00

```
# Lines starting by # are treated as comments
# Fields (in decimal format) should be separated by at least one space
#
# Example with velocity - StationName(no space character) X[m] Y[m] Z[m] VX[m/yr] VY[m/yr] VZ[m/yr] :
StationName 4027894.006 307045.600 4919474.910 0.01 0.2 0.03
```

Output

Frame : ETRF96

Epoch : 1995 . 45

```
StationName 4027894.0387  307043.4240 4919474.4772  0.0230  0.1825  0.0178
```

Options

☐ show intermediate steps

Change epoch format: Decimal Year: YYYY.DDD

Transform

ON-LINE ETRS89 – ITRS TRANSFORMATION

Operational since Nov. 23, 2009

ETRS89/ITRS TRANSFORMATION

The following tool allows to transform coordinates (position and velocity) from any ETRFxx to any ITRFyy (or ITRFyy to ETRFxx). In case input and output coordinates are requested at different epochs, then site velocities are mandatory.

Input

Frame : ITRF2005

Epoch : 2006 . 00

```
# Lines starting by # are treated as comments
# Fields (in decimal format) should be separated by at least one space
#
# Example with velocity - StationName(no space character) X[m] Y[m] Z[m] VX[m/yr] VY[m/yr] VZ[m/yr] :
StationName 4027894.006 307045.600 4919474.910 0.01 0.2 0.03
```

Output

Frame : ETRF96

Epoch : 1995 . 45

```
StationName 4027894.0387  307043.4240 4919474.4772  0.0230  0.1825  0.0178
```

Options

☐ show intermediate steps

Change epoch format: Decimal Year: YYYY.DDD

Transform

OUTLINE

- EPN Tracking Network
- Update of EPN Guidelines
- New@EPN CB
- **Summary & Future Plans**

SUMMARY & FUTURE PLANS

- 243 EPN stations, 53% GPS+GLONASS
- Update EPN guidelines:
  - C2 tracking not allowed
  - Tracking of unhealthy satellites is mandatory
- New at EPN CB: interactive site map & list, on-line ETRS89/ITRS transformation
- Future:
  - On-line of site pictures management system
  - Query-based data retrieval