

Multi-GNSS WG: Q-monitoring *contribution by GOP*

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EUREF TWG – fall meeting (October 22-23, 2013, Vienna)

Q-monitoring

- **Software development**

G-Nut library + Anubis end-user application

→ *Quantitative + Qualitative measures*

- **New algorithm development**

Multipath for multi-GNSS, multi-frequency, multi-signals

- **RINEX3.x monitoring & application testing**

EURv3 data pool

IGS M-GEX campaign

→ *Web-based image browser at <http://www.pecny.cz>*

→ *QC extractions on web/ftp*

Software development

- **G-Nut library**

- *PPP processing in offline & real-time/ultra-fast mode*
- *Multi-GNSS support*

- **End-user applications**

- ***Geb** – precise positioning (static/kinematic)*
- ***Tefnut** – troposphere monitoring (real-time/post-processing)*
- ***Anubis** – data Q-monitoring (and editing) tool*
- ***Shu** – tropospheric modeling based on Numerical Weather Models (other data)*

G-Nut/Anubis

Status

- Official release (for Linux) in August 18, 2013
- Open-source as end user applications (GNU GPLv3)
 - <http://www.pecny.cz> – GNSS – software – Anubis
 - No more dependency on Boost Library, easy to install (Simply try it ☺)

Functionality

- Decoding RINEX2.x/3.x (Nav, Obs); (RTCM2, RTCM3)
- Recently updated to RINEX 3.02
- Supporting GPS, GLONASS, Galileo Navigation messages
 - **Q-monitoring mode**

Next step

- Working on RINEX 3.x encoder (Nav, Obs)
 - **RINEX editing mode** (metadata, observation, navigation)



Main Menu

[Home](#)

GNSS

software

- ☐ G-Nut sw library
- ☐ Geb (app)
- ☐ Tefnut (app)
- ☐ Anubis (app)

observations

- ☐ data center
- ☐ troposphere
- ☐ precise orbits
- ☐ reference frame
- ☐ reprocessing
- ☐ EUREF-Czech-2009
- ☐ projects

DORIS

Gravimetry

Links

Search

positions

ANUBIS APPLICATION

Page 1 of 2

"Anubis" are called end-user applications designed to edit, splice and monitor GNSS observation and navigation files in various processing modes.

Below applications are implemented using the **G-Nut core library** developed at the Geodetic Observatory Pecny. A comparison of supported capabilities

is available in the **feature matrix**. All applications are released under the **GNU General Public Licence**. Figure shows an example of Anubis monitoring of the GNSS observation RINEX contents (find more figures at Anubis's Gallery).

- **Anubis** is an open source lite application aimed for the post-processing editing, splicing and QC mode.

The source code of lite application is available at the **download** area and example configuration and result at the **support** area.

- **Anubis-Plus** is an application providing enhanced capabilities in real-time and offline processing modes, advanced options and more flexible use. **The release is under preparation.**

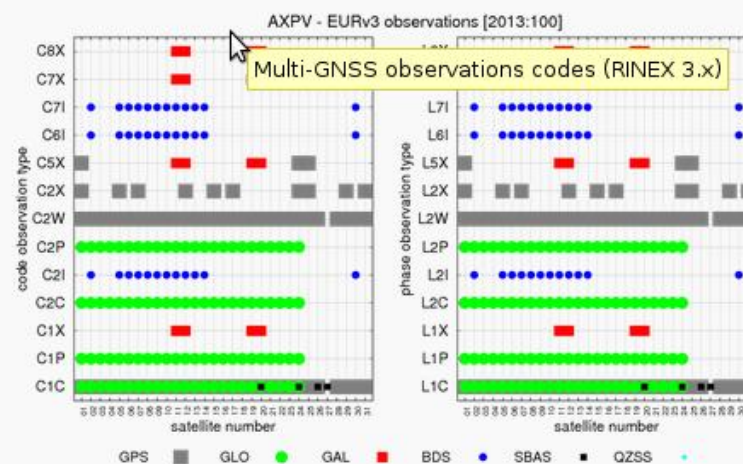
Support - the current lite version is provided as a beta release and still undergoes final consolidations of the core library. The software is provided "as is" and without warranty of any kind. The support is given on a best-effort basis only. However, if you find G-Nut/Anubis application(s) useful for your work, consider supporting its further development by ordering the enhanced version (Anubis-Plus) and we will try to give you a priority in the support.

Other related questions could be sent to gnss@pecny.cz (J.Dousa/P.Vaclavovic).

News - in order to keep informed about news you can join the **mailing list**.

- 2013-03-10 - Released Anubis 0.9.0 - beta version
- 2013-08-16 - Released Anubis 1.0.0 - multi-GNSS multipath capability

Anubis application
Anubis's Gallery
All Pages



Prev [Next >>](#)

Multipath algorithm (Anubis)

Linear combination

i, j, k .. frequencies – in the standard approach: **$k = i$** !

$$LC_{mp} = P_k - L_i - \beta(L_i - L_j) = P_k + \alpha L_i + \beta L_j$$

$$\alpha = - \frac{f_i^2}{f_k^2} \frac{(f_k^2 + f_j^2)}{(f_i^2 - f_j^2)} \quad \beta = \frac{f_j^2}{f_k^2} \frac{(f_k^2 + f_i^2)}{(f_i^2 - f_j^2)}$$

Preprocessing

- cycle-slips need to be identify at least (or repaired)
- simple CS identification incorporated within the algorithm
- all signals, all frequencies, all constellations, can be thus used!

Quantitative and Qualitative outputs/plots

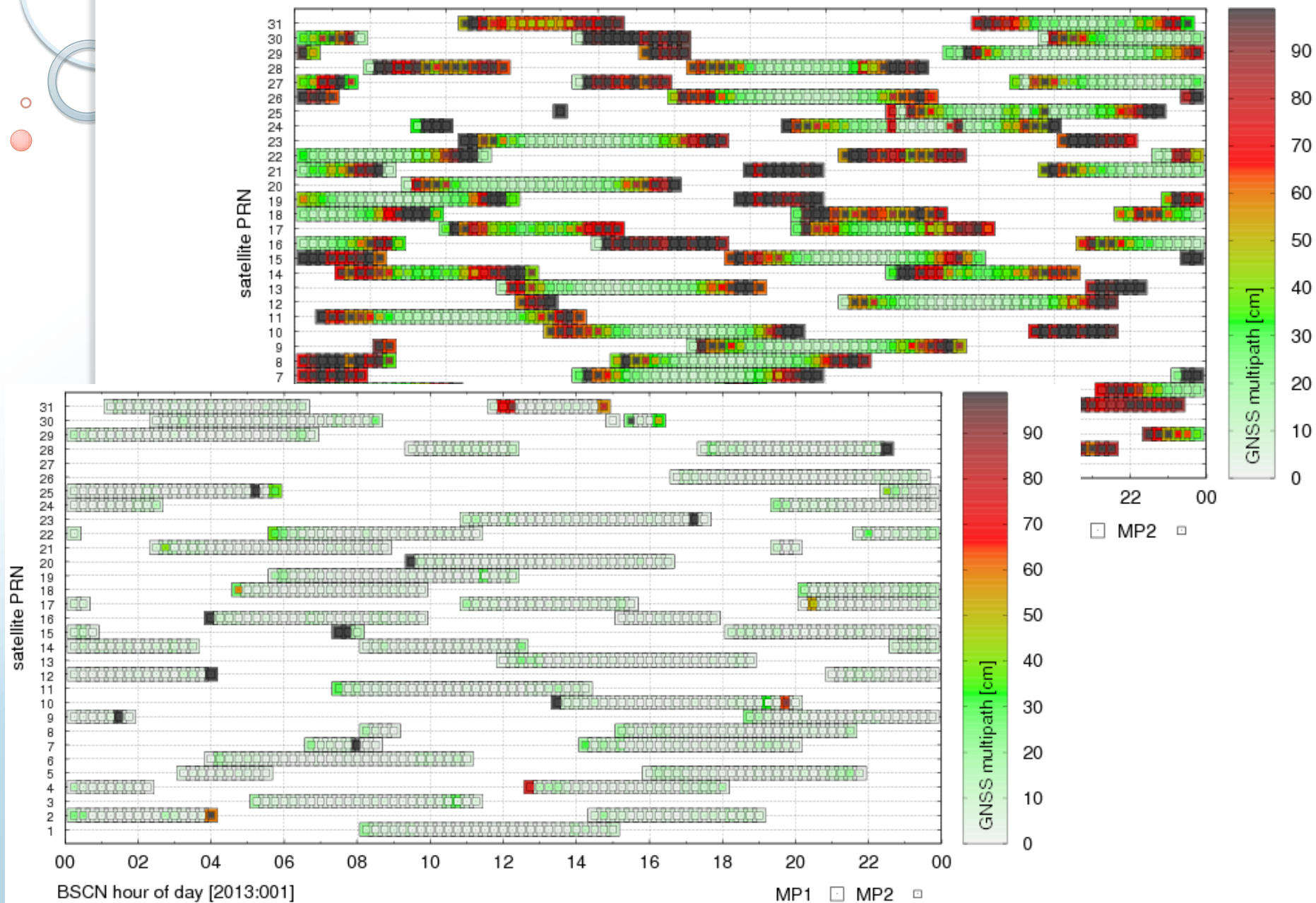
Outputs

- XTR – detail extractions (incl. epoch-wise results)
 - ASCII - easy to process (by grep, awk, perl) and prepare plots
 - Sections: Summary, Header, Estimates, Statistics, Ele/Azi, Gap, Pieces, Bands, Multipath
- XML – summary extractions (supporting CODE format)
 - Suitable for metadata exchange, e.g. supporting remote RINEX file comparisons (similarly used in UNAVCO's GSAC)

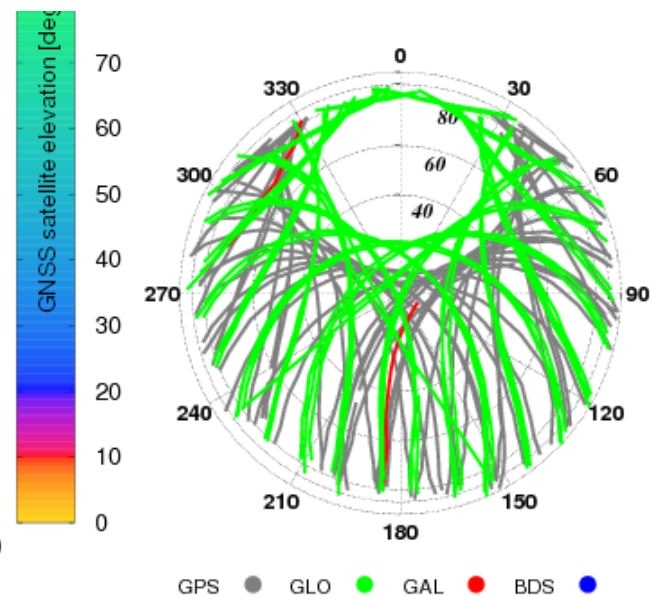
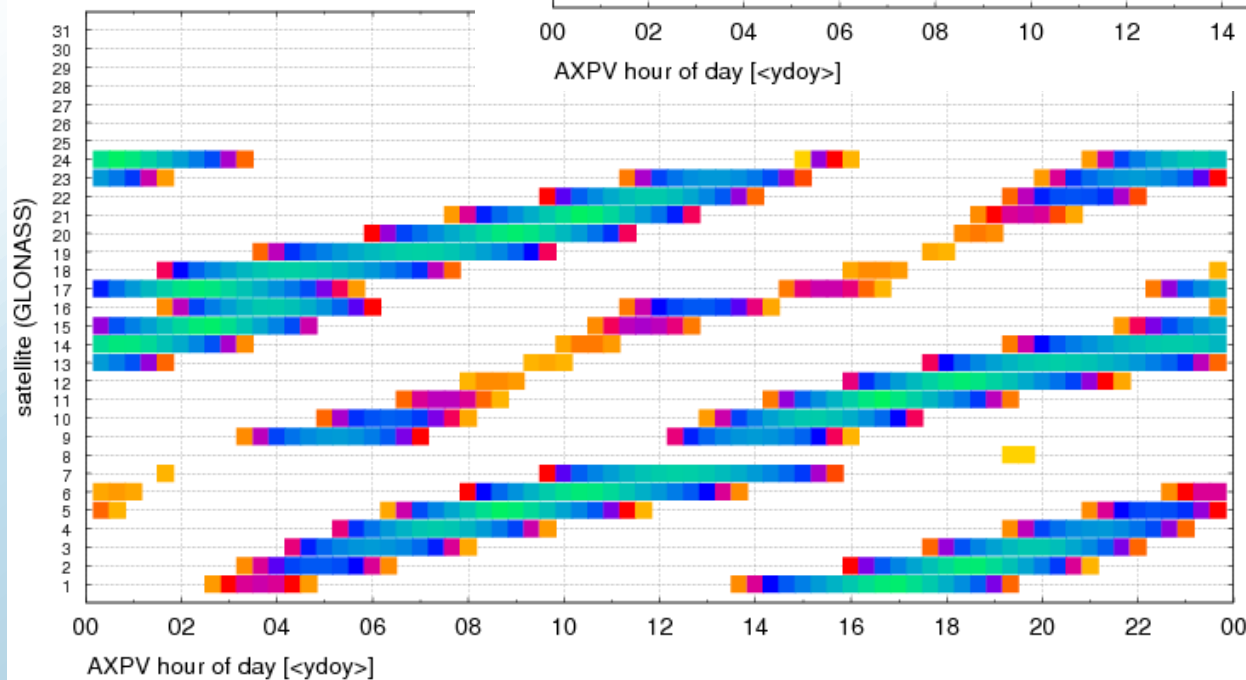
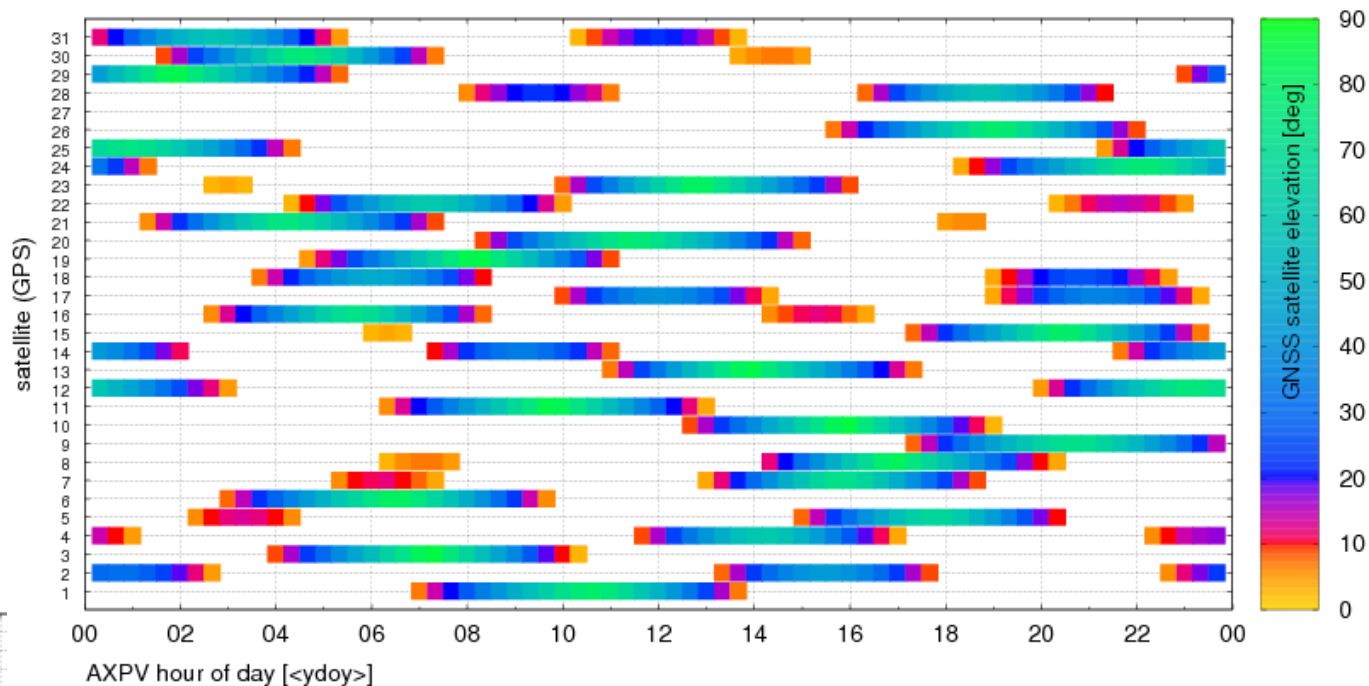
Plots/monitoring – directories: YEAR/DOY

- 1-site/1-day – for a single extraction (Anubis XTR)
- 1-site/x-days – for a whole directory with extractions
- x-sites/1-days – over a directories for specified period (site XTR)
- (x-sites/x-days) ?

1-day/1-site multipath (sat-specific and epoch-wise)



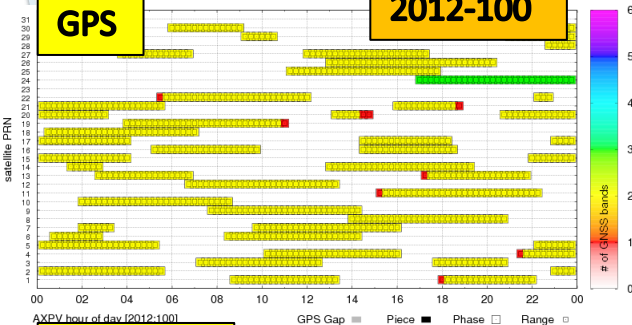
1-day/1-site multipath (elevation plots/skyplot, AXPV)



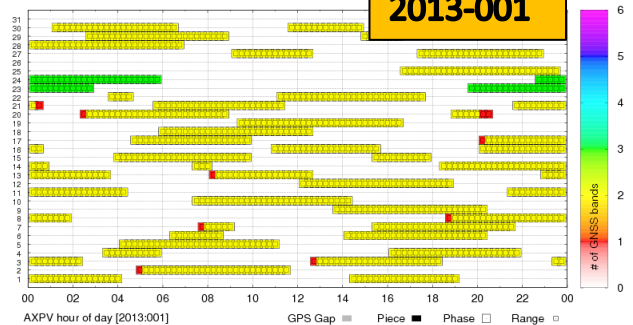
1-day/1-site constellation bands/freqs (AXPV)

GPS

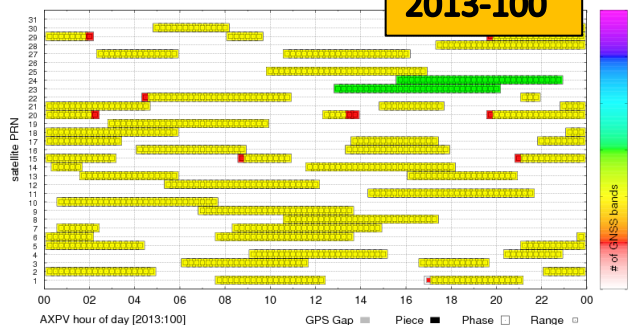
2012-100



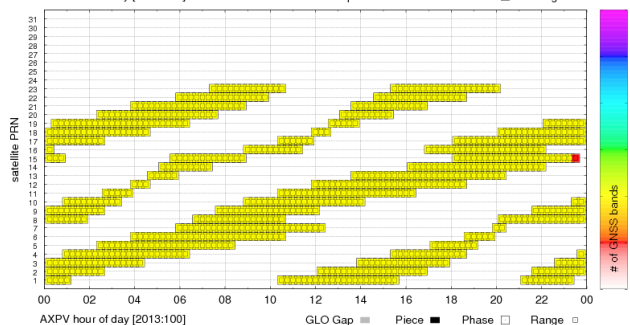
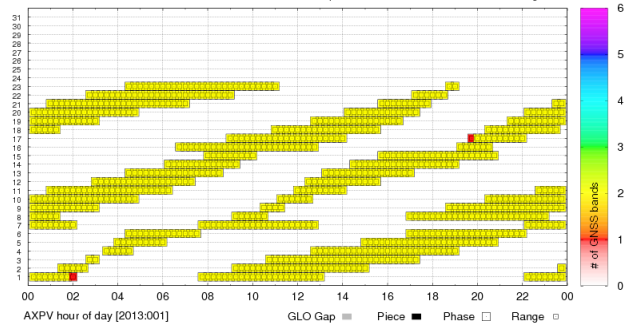
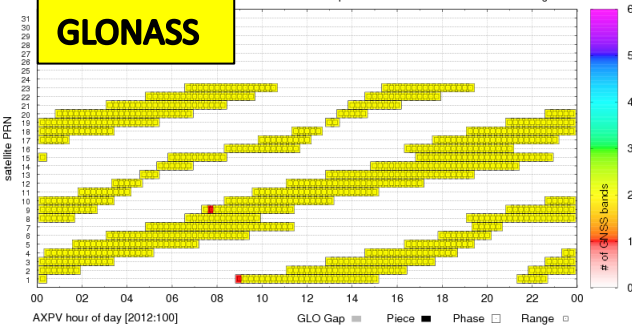
2013-001



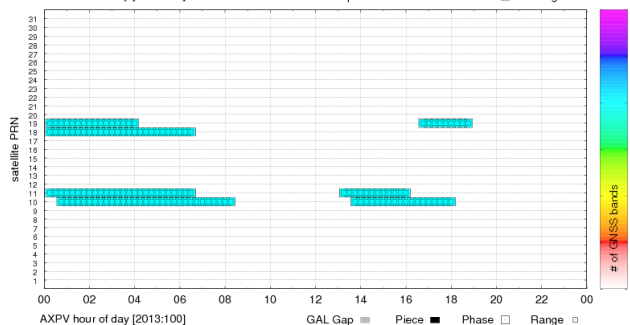
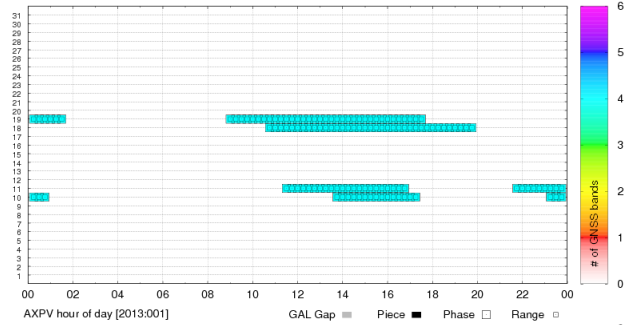
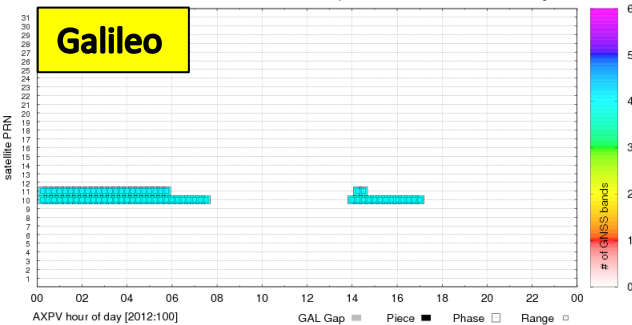
2013-100



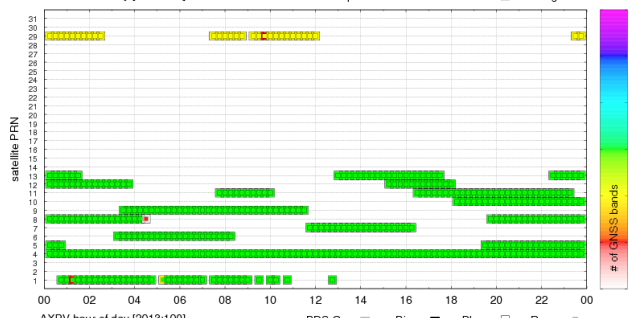
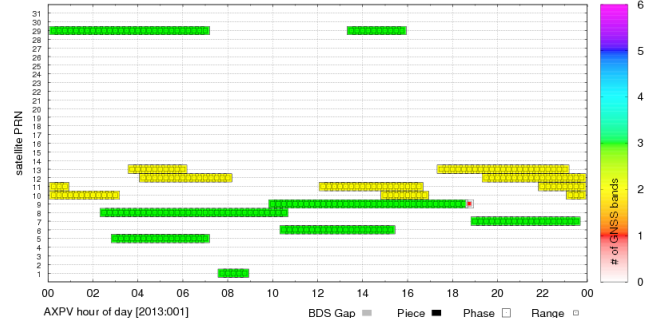
GLONASS



Galileo



BeiDou



Sample output

#===== Summary (v.1)

#GNSSUM	2013-04-15 00:00:00	ExpEp	HavEp	UseEp	xCoEp	xPhEp	xCoSv	xPhSv	nSlp	nJmp	nGap	nPcs	mp1	mp2	mp5	mp6	mp7	mp8
=GPSSUM	2013-04-15 00:00:00	2880	2880	2877	3	3	430	424	1892	0	0	0	36.2	31.1	30.3	-	-	-
=GALSUM	2013-04-15 00:00:00	2880	2880	974	0	0	2	2	0	0	0	0	18.4	-	23.3	-	23.3	8.6
=GLOSUM	2013-04-15 00:00:00	2880	2880	2880	0	0	162	156	0	0	0	0	45.6	43.3	-	-	-	-
=QZSSUM	2013-04-15 00:00:00	2880	2880	96	0	0	0	0	0	0	0	0	-	-	-	-	-	-
=SBSSUM	2013-04-15 00:00:00	2880	2880	2880	0	0	10226	10226	0	0	0	0	-	-	-	-	-	-

#===== Header (v.1)

#LEGEND	2013-04-15 00:00:00	_RINEX_HEADER_	_USER_REQUEST_
=MARKER	2013-04-15 00:00:00	GOP7 11502M006	
=RECEIV	2013-04-15 00:00:00	JAVAD TRE_G3TH DELTA3.5.0	00723
=ANTENN	2013-04-15 00:00:00	LEIAR25.R4 LEIT725071	
=POSXYZ	2013-04-15 00:00:00	3979319.2600 1050312.8800 4857064.4800	0.0000 0.0000 0.0000
=ECCXYZ	2013-04-15 00:00:00	0.0000 0.0000 0.0000	0.0000 0.0000 0.0000
=ECCENU	2013-04-15 00:00:00	0.0000 0.0000 0.0653	0.0000 0.0000 0.0000
=BEGEND	2013-04-15 00:00:00	2013-04-15 00:00:00 xxxx-xx-xx xx:xx:xx	2013-04-15 00:00:00 2013-04-15 23:59:30

#===== Estimated (v.1)

=XYZEST	2013-04-15 00:00:00	3979330.6514 1050314.3358 4857079.7111
=BLHEST	2013-04-15 00:00:00	49.91367782 14.78559577 611.5918
=BEGEND	2013-04-15 00:00:00	2013-04-15 00:00:00 2013-04-15 23:59:30



Sample output – Obs statistics, Azi/Elev

#===== Observations (v.1)

```
=GNSSYS 2013-04-15 00:00:00      5 GPS GAL GLO QZS SBS

=GPSSAT 2013-04-15 00:00:00      32 G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12 G13 G14 G15 G16 G17 G18 G19 G20 G21 G22 G23 G24
=GALSAT 2013-04-15 00:00:00       2  -  -  -  -  -  -  -  -  -  -  - E11 E12  -  -  -  -  -  -  -  -  -  -  -  -
=GLOSAT 2013-04-15 00:00:00      24 R01 R02 R03 R04 R05 R06 R07 R08 R09 R10 R11 R12 R13 R14 R15 R16 R17 R18 R19 R20 R21 R22 R23 R24
=QZSSAT 2013-04-15 00:00:00       1 J01  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
=SBSSAT 2013-04-15 00:00:00       4  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  - S20  -  -  - S24

=GPSOBS 2013-04-15 00:00:00      25 C1C C1W C2L C2W C2X C5Q C5X L1C L1W L2L L2W L2X L5Q L5X D1C D2W D2X D5X S1C S1W S2L S2W S2X S5Q
=GALOBS 2013-04-15 00:00:00      29 C1C C1X C5Q C5X C7Q C7X C8Q C8X L1C L1X L5Q L5X L7Q L7X L8Q L8X D1X D5X D7X D8Q D8X S1C S1X S5Q
=GLOOBS 2013-04-15 00:00:00      20 C1C C1P C2C C2P XXX L1C L1P L2C L2P XXX D1C D1P D2C D2P XXX S1C S1P S2C S2P XXX
=QZSOBS 2013-04-15 00:00:00      27 C1C C1X C1Z C2X C5X XXX C6X L1C L1X L1Z L2X L5X XXX L6X D1C D1X D1Z D2X D5X XXX S1C S1X S1Z S2X
=SBSOBS 2013-04-15 00:00:00       8 C1C C5I L1C L5I D1C D5I S1C S5I
```

#===== Elevation & Azimuth (v.1)

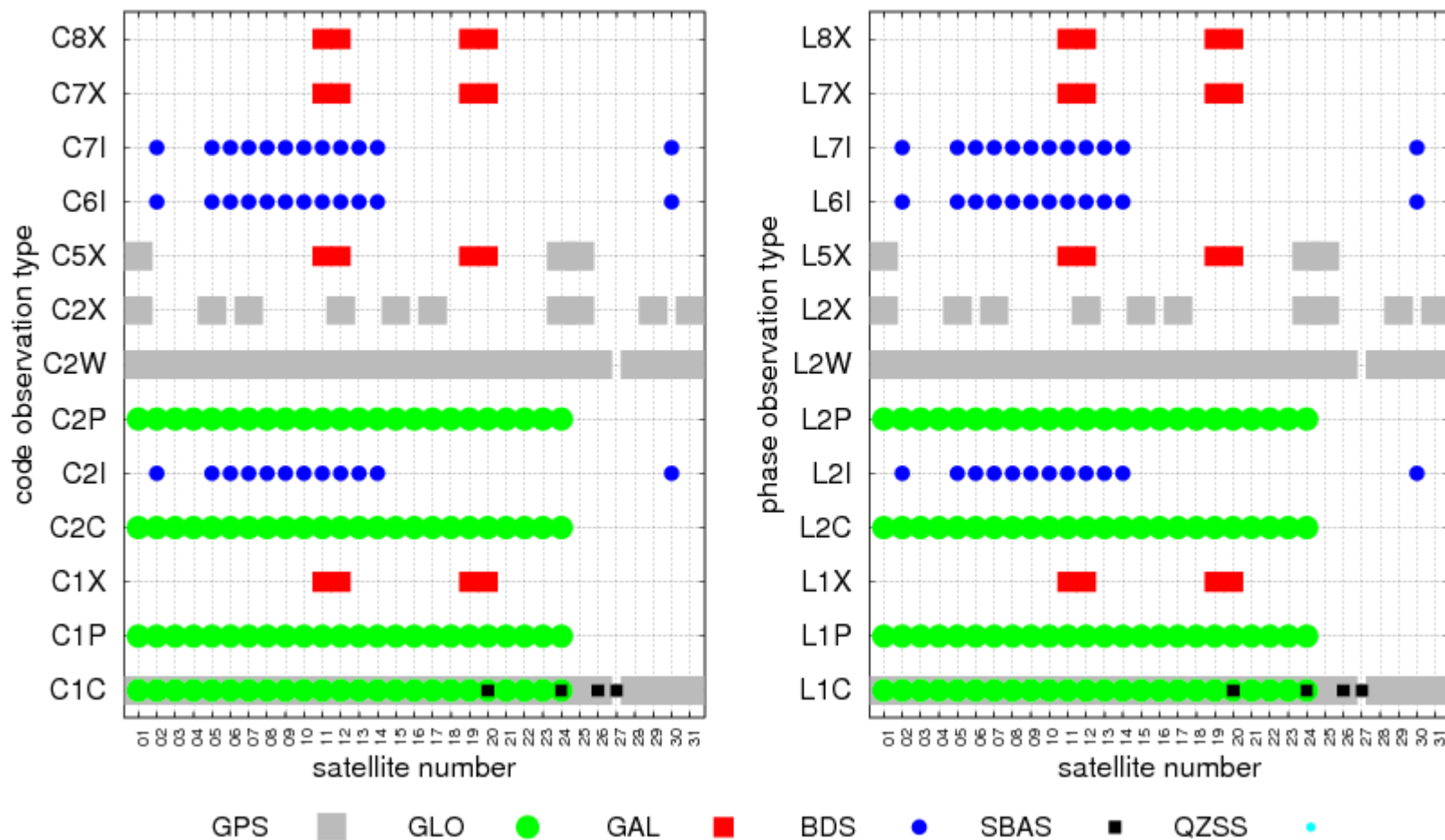
```
#GNSELE 2013-04-15 00:00:00      Mean x01 x02 x03 x04 x05 x06 x07 x08 x09 x10 x11 x12 x13 x14 x15 x16 x17 x18 x19 x20 x21 x22 x23 x24
GPSELE 2013-04-15 00:00:00       36  -  -  46  -  -  67  11  -  -  -  -  -  -  10  61  -  51  24  -  56  34  -  -
GPSELE 2013-04-15 00:15:00       40  -  -  53  -  -  74  11  -  -  -  -  -  -  12  57  -  55  30  -  49  41  -  -
GPSELE 2013-04-15 00:30:00       40  -  -  60  -  -  80  11  -  -  -  -  -  -  13  51  -  56  36  -  43  48  -  -
GPSELE 2013-04-15 00:45:00       35  -  -  67  -  -  85   9   9  -  -   3  -  -  -  14  44  -  56  43  -  37  54  -  -
GPSELE 2013-04-15 01:00:00       34  -  -  73  -  -  81   7   9  -  -   9  -  -  -  13  38  -  54  49  -  31  60  -  -
GPSELE 2013-04-15 01:15:00       35  -  -  77  -  -  74   4   8  -  -  14  -  -  -  11  31  -  50  56  -  25  64  -  -
```

...

Observation/satellite statistics

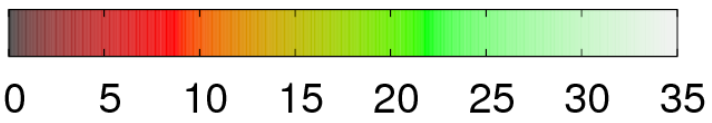
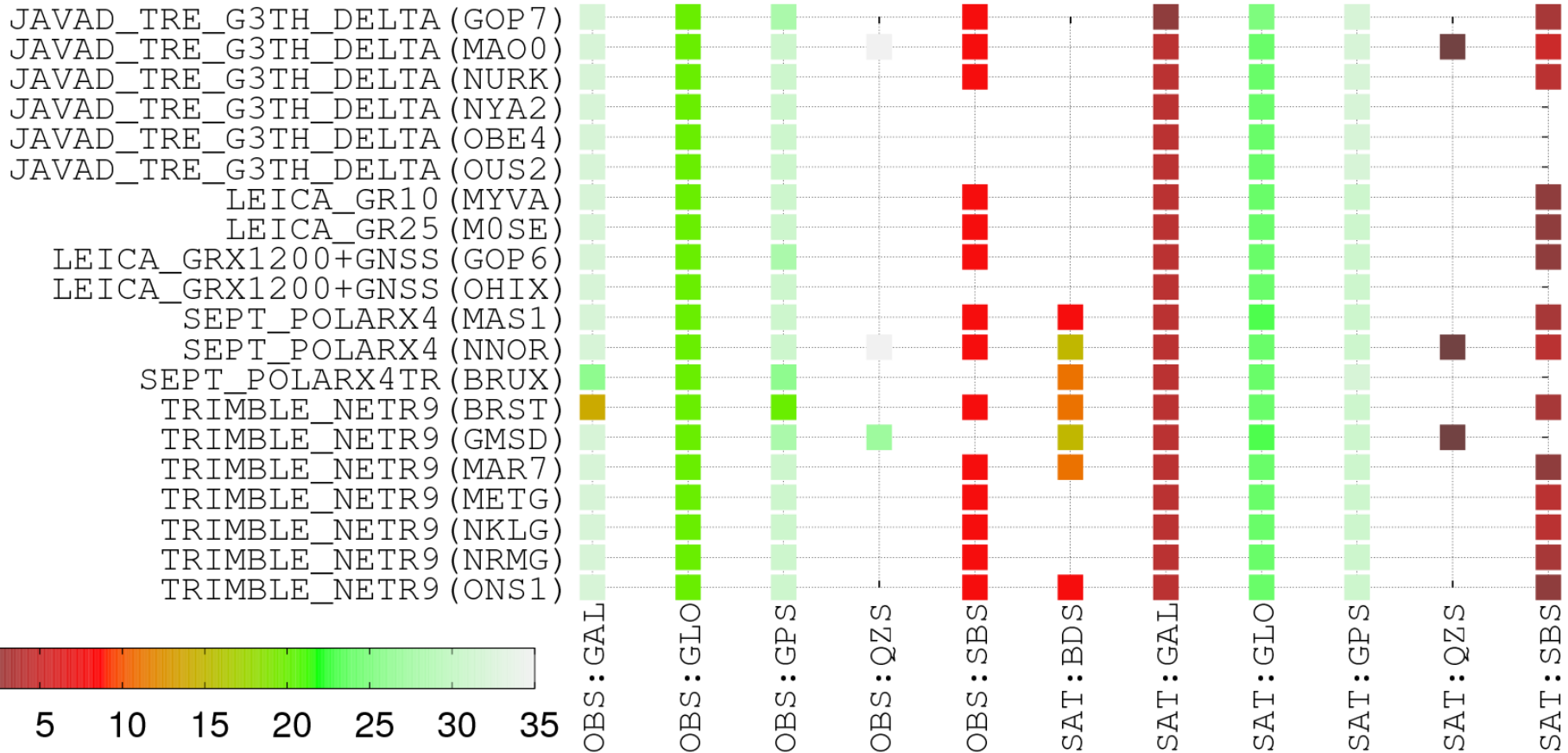
(EURv3 campaign, AXPV 2012:200/2013:100)

AXPV - EURv3 observations [2013:100]



Observation/satellite statistics

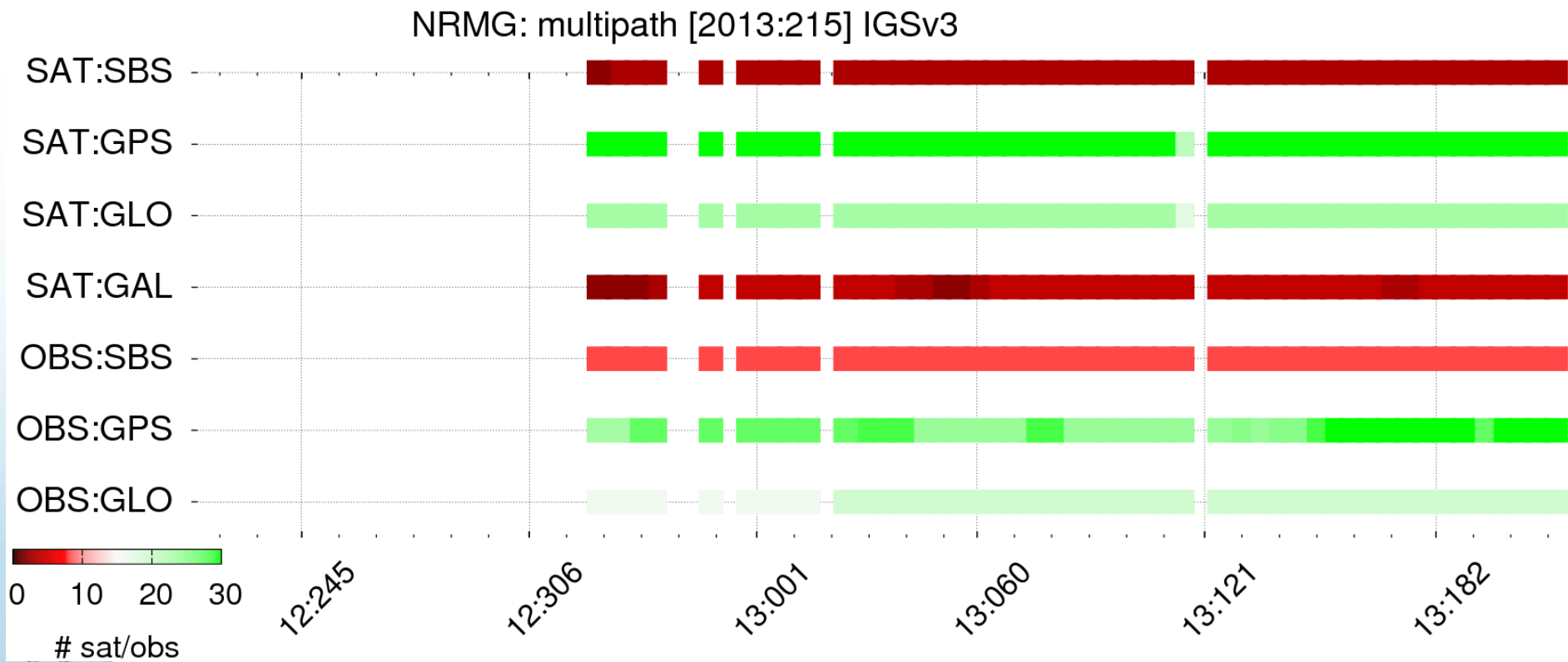
(M-GEX campaign, 2013:150)



of satellites/observations

Quantitative statistics - history

(M-GEX campaign, NRMG)

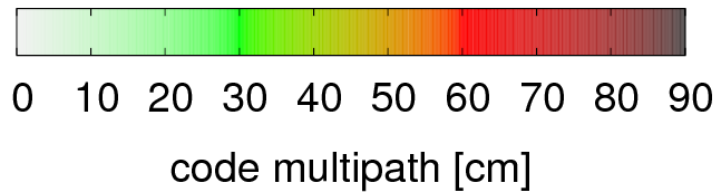
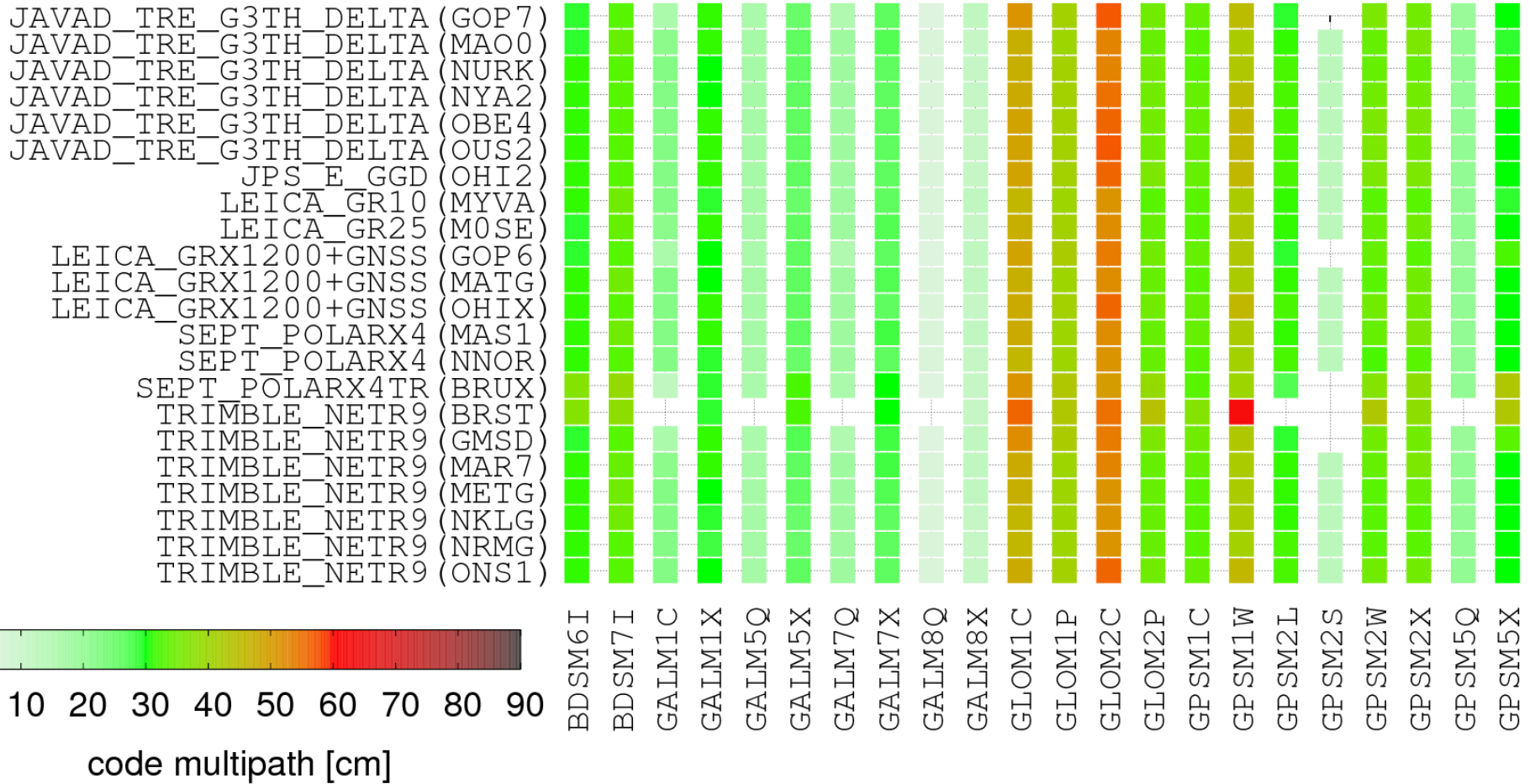




#	GSMxx	2013-04-15	00:00:00		mean	x01	x02	x03	x04	x05	x06	x07	x08	x09	x10	x11	x12	x13	x14	x15	x16	x17	x18	x19	x20	x21	x22	x23	x24
=GPSM1C	2013-04-15	00:00:00		33.48	34	34	33	34	33	30	36	34	31	34	30	33	32	37	33	32	35	34	34	30	39	32	32	36	
=GPSM1W	2013-04-15	00:00:00		39.00	36	40	53	45	36	32	37	39	32	49	34	28	36	47	37	45	32	49	48	29	50	41	35	34	
=GPSM2L	2013-04-15	00:00:00		27.50	22	-	-	-	29	-	29	-	-	-	-	25	-	-	31	-	30	-	-	-	-	-	-	24	
=GPSM2W	2013-04-15	00:00:00		32.78	30	32	38	34	32	29	35	35	31	37	31	28	32	33	31	33	30	36	36	28	39	33	33	31	
=GPSM2X	2013-04-15	00:00:00		32.92	31	-	-	-	34	-	35	-	-	-	-	33	-	-	34	-	33	-	-	-	-	-	-	32	
=GPSM5Q	2013-04-15	00:00:00		24.10	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	
=GPSM5X	2013-04-15	00:00:00		36.46	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43	
=GALM1C	2013-04-15	00:00:00		12.91	-	-	-	-	-	-	-	-	-	-	15	13	-	-	-	-	-	-	12	13	-	-	-	-	
=GALM1X	2013-04-15	00:00:00		23.81	-	-	-	-	-	-	-	-	-	-	22	25	-	-	-	-	-	-	26	22	-	-	-	-	
=GALM5Q	2013-04-15	00:00:00		18.74	-	-	-	-	-	-	-	-	-	-	22	18	-	-	-	-	-	-	17	19	-	-	-	-	
=GALM5X	2013-04-15	00:00:00		27.84	-	-	-	-	-	-	-	-	-	-	26	27	-	-	-	-	-	-	32	27	-	-	-	-	
=GALM7Q	2013-04-15	00:00:00		18.30	-	-	-	-	-	-	-	-	-	-	22	18	-	-	-	-	-	-	18	17	-	-	-	-	
=GALM7X	2013-04-15	00:00:00		28.20	-	-	-	-	-	-	-	-	-	-	26	28	-	-	-	-	-	-	31	28	-	-	-	-	
=GALM8Q	2013-04-15	00:00:00		4.96	-	-	-	-	-	-	-	-	-	-	5	5	-	-	-	-	-	-	5	5	-	-	-	-	
=GALM8X	2013-04-15	00:00:00		12.23	-	-	-	-	-	-	-	-	-	-	11	12	-	-	-	-	-	-	13	12	-	-	-	-	
=GLOM1C	2013-04-15	00:00:00		48.10	46	44	50	50	45	45	53	50	44	43	52	49	45	54	48	53	47	43	46	59	54	43	47	44	
=GLOM1P	2013-04-15	00:00:00		43.10	44	43	43	43	43	42	46	43	40	40	48	47	39	43	42	42	44	41	42	45	49	41	44	40	
=GLOM2C	2013-04-15	00:00:00		51.39	59	64	44	47	47	48	48	45	47	62	67	58	45	62	49	49	47	48	47	45	62	50	49	48	
=GLOM2P	2013-04-15	00:00:00		35.24	35	39	34	33	34	38	38	34	39	36	34	37	33	33	31	38	35	35	35	33	36	37	36	31	
=BDSM2I	2013-04-15	00:00:00		40.91	-	35	-	26	-	39	41	44																	

Multipath for all receivers

(M-GEX campaign, 2013:215)



Outlook

- **Software development**

RINEX 3.x Obs, Nav decoders → editing mode

Multi-GNSS pre-processing (GLONASS, Galileo, ..)

Real-time capability

- **Monitoring**

continue with EURv3, M-GEX monitoring (still optimizing)

→ feedback to data providers

→ exercise for sw debugging/modifications, updates tracking,...

- **XML format**

Standardization for future visions?

Potential use in design of the EPOS-like services?