Availability and Completeness of IGS Tracking Data

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Motivation

Availability and completeness of consistent GNSS tracking data is a basic condition for the generation of best possible analysis products. The steadily increasing number of observation types is monitored for each individual station (and each relevant GNSS). The statistics show among others things that the homogeneity of the reported types is no longer ensured. Particular problems and anomalies concerning IGS observation files are highlighted.

Database

For the data processing (and monitoring) at the Center for Orbit Determination in Europe (CODE), near real-time (hourly) and daily observation files are downloaded from IGS, EUREF, MGEX and other data sources. This includes RINEX-2 and RINEX-3 files from more than 440 stations.

Availability of daily files

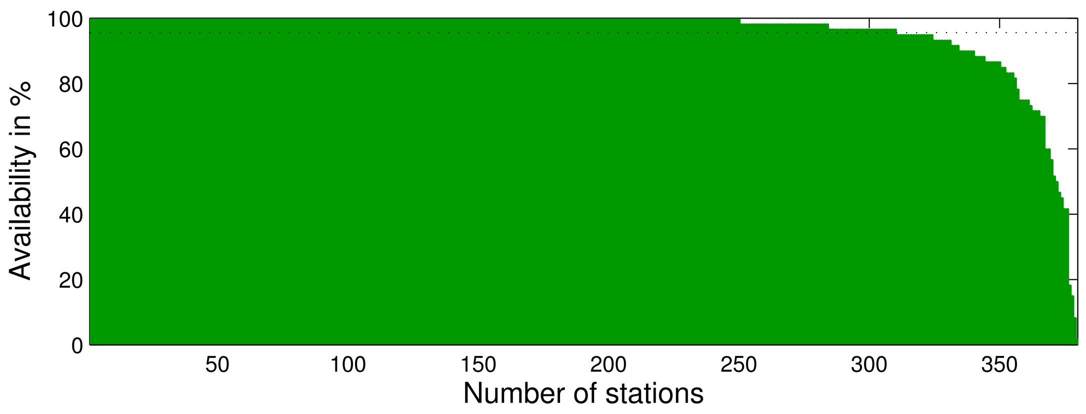

Figure 1: Looking at a 60-day period, most of the stations have uninterrupted time series of daily RINEX-2 observation files: 379 stations with an average file availability of 95.8 %.

`ftp://ftp.unibe.ch/aiub/igsdata/rnxdata.sum`
`ftp://ftp.unibe.ch/aiub/igsdata/rnxdata_more.sum`

XML meta-database

A meta-data based monitoring of the availability and completeness of RINEX observation files has been developed. It is currently in use for the RINEX-3 files of the Multi-GNSS-Experiment (MGEX) and allows for an optimized update of the data pool and for flexible and fast generations of summaries. Basic features are:

- Perl routines for reading the entire RINEX files and for writing extensive meta-data files in XML format (standard packages).
- Evaluation and comparison of the RINEX data as part of the download procedures.
- Generation of daily and monthly summaries (much faster than data extraction directly from the original database).
- Possibility to filter stations according to given criteria (equipment, satellite systems, observation types, etc.).

Fig. 2 visualizes examples of straightforwardly generated summaries. The plots show, for all MGEX stations over a period of 30 days, the number of tracked satellites for each satellite system. See also: `ftp://ftp.unibe.ch/aiub/mgex/README.TXT`
It is planned to use the developed procedures to establish soon an XML meta-database for the monitoring of RINEX-2 files for the IGS processing at CODE.

Variety of observation types

Together with new signals emitted by the GNSS satellites, the stations' tracking capabilities have been extended. The table (left) shows the variety of observation types in RINEX-2 files from 30 days and for all GPS (G), GLONASS (R), Galileo (E), and SBAS (S) tracking stations, respectively. The table (right) shows the situation for GPS observations in RINEX-3 files collected as part of MGEX.

34.34%	G:L1	G:L2	G:C1	G:P1	G:P2			
33.80%	G:L1	G:L2	G:C1		G:P2			
7.23%	G:L1	G:L2	G:C1	G:P1	G:P2	G:C2	G:L5	G:C5
6.82%	G:L1	G:L2	G:C1		G:P2	G:C2		
5.55%	G:L1	G:L2	G:C1	G:P1	G:P2	G:C2		
4.37%	G:L1	G:L2	G:C1		G:P2	G:C2	G:L5	G:C5
4.14%	G:L1	G:L2	G:C1		G:P2		G:L5	G:C5
3.48%	G:L1	G:L2	G:C1	G:P1	G:P2		G:L5	G:C5
0.28%	G:L1	G:L2	G:C1		G:P2		G:L5	
42.14%	R:L1	R:L2	R:C1	R:P1	R:P2			
31.46%	R:L1	R:L2	R:C1		R:P2			
15.83%	R:L1	R:L2	R:C1	R:P1	R:P2	R:C2		
9.09%	R:L1	R:L2	R:C1		R:P2	R:C2		
0.65%	R:L1		R:C1	R:P1				
0.42%	R:L1	R:L2	R:C1			R:C2		
0.39%		R:L2	R:C1		R:P2	R:C2		
69.24%	S:L1	S:C1						
30.76%	S:L1	S:C1	S:L5	S:C5				
59.81%	E:L1	E:C1	E:L5	E:C5				
23.86%	E:L1	E:C1	E:L5	E:C5	E:L7	E:C7	E:L8	E:C8
12.02%	E:L1	E:C1						
4.30%	E:L1	E:C1	E:L5	E:C5	E:L7	E:C7		

29.76%	G:L1C	G:C1C			G:L2X	G:C2X	G:L2W	G:C2W			G:L5X	G:C5X
21.62%	G:L1C	G:C1C			G:L2S	G:C2S	G:L2W	G:C2W			G:L5Q	G:C5Q
20.41%	G:L1C	G:C1C	G:L1W	G:C1W	G:L2X	G:C2X	G:L2W	G:C2W			G:L5X	G:C5X
10.47%	G:L1C	G:C1C		G:C1W	G:L2L	G:C2L	G:L2W	G:C2W			G:L5Q	G:C5Q
3.80%	G:L1C	G:C1C					G:L2W	G:C2W			G:L5Q	G:C5Q
3.18%	G:L1C	G:C1C					G:L2W	G:C2W			G:L5X	G:C5X
3.04%	G:L1C	G:C1C			G:L2X	G:C2X	G:L2W	G:C2W				
2.20%	G:L1C	G:C1C			G:L2P	G:C2P						
1.47%	G:L1C	G:C1C					G:L2W	G:C2W				
0.76%	G:L1C	G:C1C			G:L2D	G:C2D					G:L5Q	G:C5Q
0.76%	G:L1C	G:C1C			G:L2D	G:C2D						
0.73%	G:L1C	G:C1C				G:C2X	G:L2W	G:C2W			G:L5X	G:C5X
0.60%	G:L1C	G:C1C			G:L2S	G:C2S	G:L2P	G:C2P	G:L2W	G:C2W	G:L5Q	G:C5Q
0.45%	G:L1C	G:C1C			G:L2C	G:C2C	G:L2P	G:C2P				
0.39%	G:L1C	G:C1C	G:L1P	G:L1W	G:L2X	G:C2X			G:L2W	G:C2W	G:L5X	G:C5X
0.24%	G:L1C	G:C1C			G:L2S	G:C2S			G:L2W	G:C2W		
0.08%	G:L1C	G:C1C			G:L2S	G:C2S		G:C2P	G:L2W	G:C2W	G:L5Q	G:C5Q
0.03%	G:L1C	G:C1C						G:C2P	G:L2W	G:C2W		

Observation types in red should not appear in the regular RINEX-2 archive of the IGS, only for MGEX.

GNSS tracking problems

The following table describes incomplete tracking of operational satellites, missing phase observations on L1 and/or L2 and, furthermore, detected GLONASS frequency channel number anomalies. It includes tracking problems for a total of 31 (about 8 %) of 376 stations for a time window of 30 days in May/June 2014.

Sta.	Receiver	Firmware	Both frequencies affected	Just one frequency affected
AUCK	TRIMBLE NETR9	4.46	G01 G08 G28 R01 R02 R03 R06 R07 R08 R20	
BJNM	SEPT POLARX3ETR	2.1	R18	
BNDY	TRIMBLE NETR5	4.03	R03 R04 R09 R20	r01 r02 r03 r04 r05 r06 r07 r08 r09 r10 r11 r12 r13 r14 r15 r16 r17 r18 r19 r20 r21 r22 r23 r24
BRAZ	TRIMBLE NETR8	4.70		g01 g05 g07 g12 g15 g17 g24 g25 g27 g29 g31
BRFT	LEICA GRX1200PRO	8.20/2.127	G01	
CEDU	TRIMBLE NETR8	4.48		g01 g24 g25 g27 g30
CGGN	ASHTECH UZ-12	CQ00	G07 G13 G22	
COCO	TRIMBLE NETR8	4.42		r01 r02 r03 r04 r05 r06 r07 r08 r09 r10 r11 r12 r13 r14 r15 r16 r17 r18 r19 r20 r21 r22 r23 r24
EBRE	TRIMBLE NETRS	1.15	G32	
FALE	TRIMBLE NETRS	1.2-0	G32	
HERS	SEPT POLARX3ETR	2.1	R18	
KGNI	TRIMBLE NETRS	1.2-0	G32	
KSMV	TRIMBLE NETRS	1.2-0	G32	
MAL2	SEPT POLARX4	2.5.1P1	G17	
MCIL	TRIMBLE NETR9	4.61	G32	
NTZ1	JAVAD TRE_G3TH DELTA	3.5.2	G07 G20	
NVSK	TRIMBLE 4700	1.30	G03 G15 G29	
PARC	TRIMBLE NETR8	4.85		r01 r02 r03 r04 r05 r06 r07 r08 r09 r10 r11 r12 r13 r14 r15 r16 r17 r18 r19 r20 r21 r22 r23 r24
POUS	TPS GB-1000	3.5 DEC,24,2010	R02 R06 R18 R22	
POVE	TRIMBLE NETR5	3.84	R20	
STHL	TPS NET-G3A	3.4P1	G01 G24	
SVTL	JAVAD TRE_G3TH DELTA	3.2.7 MAY,16,2011	R18	
THTI	TRIMBLE NETR8	4.85	R20	g01 g24 g25 g27 g30
TID1	TRIMBLE NETR8	4.43		g01 g24 g25 g27 g30
UNBN	NOV OEMV3	3.901		g02 g04 g10 g11 g13 g14 g16 g18 g20 g21 g22 g26 g28
USNO	ASHTECH Z-XII3T	1L01-1D04	G20 G25 G32	
VACO	ASHTECH Z-XII3	ZT16 0065	G13 G27 G32	
VITH	TRIMBLE NETRS	1.3-2	G32	
WUHN	TRIMBLE NETR9	4.80	R12 R16	
YIBL	TRIMBLE NETR9	4.62	G32	g01 g05 g07 g12 g15 g17 g24 g25 g27 g29 g30 g31
YONS	TRIMBLE NETR9	NAV 4.43 BOOT 4.	G17	

How to read this table:

- A capital letter for the GNSS-ID ("G" or "R") means a problem related to both frequencies.
- A small letter for the GNSS-ID ("g" or "r") means that the satellite was tracked only on either L1 or L2.
- Colors indicate frequency of occurrence, 100 %, ≥50 %, <50 %, or a GLONASS frequency channel number anomaly.
- Examples: "G32": completely unobserved G32; "r01": single-frequency tracking for R01 (and thus actually unusable); "R18" recorded with inconsistent GLONASS frequency channel number.

Verification of GLONASS frequency channel numbers

GLONASS frequency channel numbers are verified regularly for all tracking data collected at CODE. A data screening procedure is performed in a dedicated mode for the complete range of possible GLONASS frequency numbers. It is assumed that the frequency number with the biggest number of valid observations (after the screening procedure) has been used by the receiver. Each thus obtained number is then compared to the default/reference frequency number (as defined in our given satellite information). By this verification procedure, common switches in the GLONASS frequency channel numbers and also anomalies with respect to particular tracking stations (and receiver models) may be detected with short latency.
Fig. 3 reveals two prominent events: the GLONASS constellation change for R18 (from #801 to #743) on 22-Feb-2013. A specific receiver group (principally JAVAD) continued collecting data from the previous SV #801 (see IGS Mail #6734). The second "line" corresponds to the most recent constellation change (for R18) on 11-Apr-2014, where 3 receivers continued to record data with the old frequency channel number, namely SVTL (JAVAD TRE_G3TH DELTA) as well as HERS and BJNM (both SEPT POLARX3ETR), where the problem disappeared not until the reset of the receiver (requested from our side).

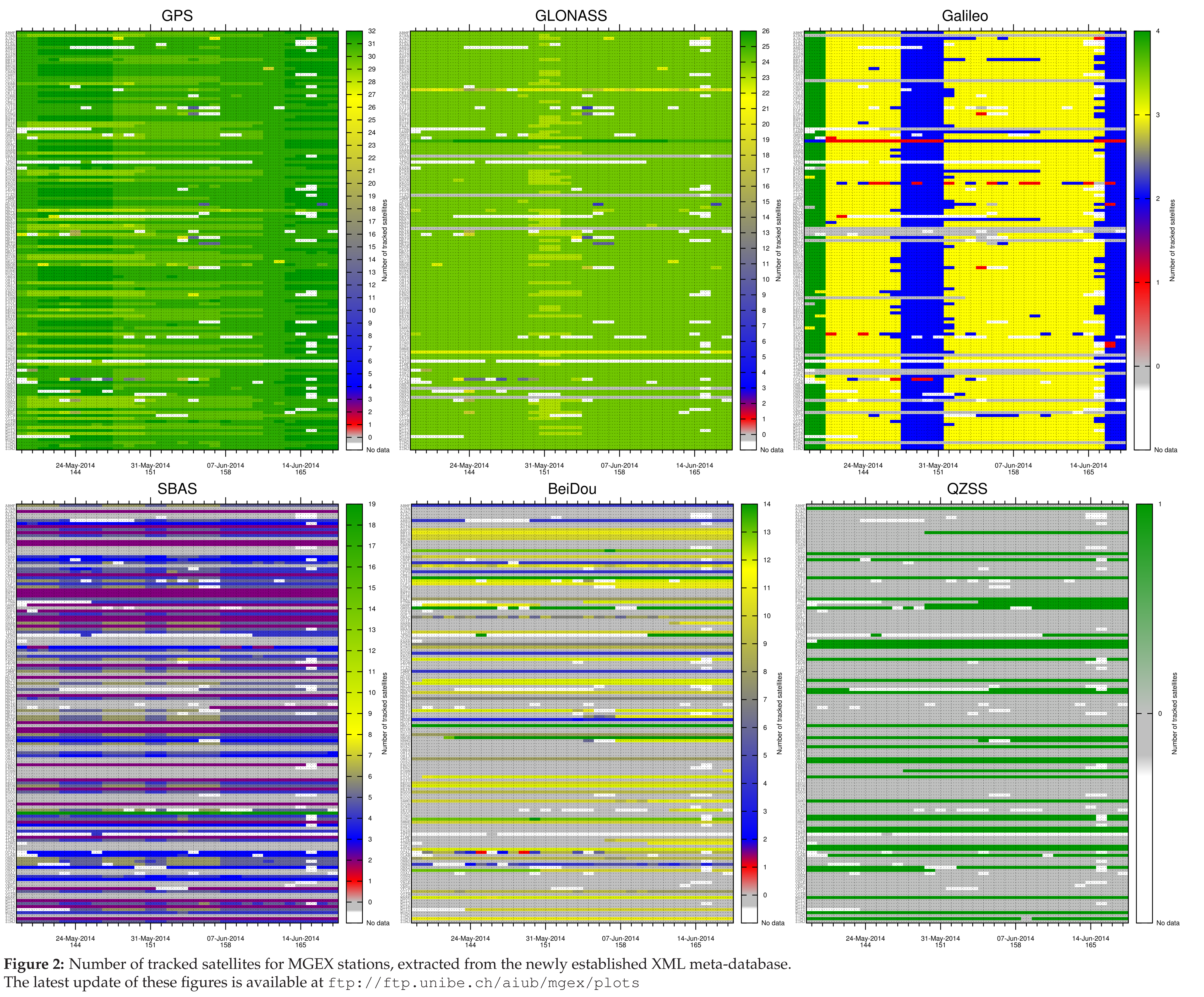

Figure 2: Number of tracked satellites for MGEX stations, extracted from the newly established XML meta-database.
The latest update of these figures is available at `ftp://ftp.unibe.ch/aiub/mgex/plots`

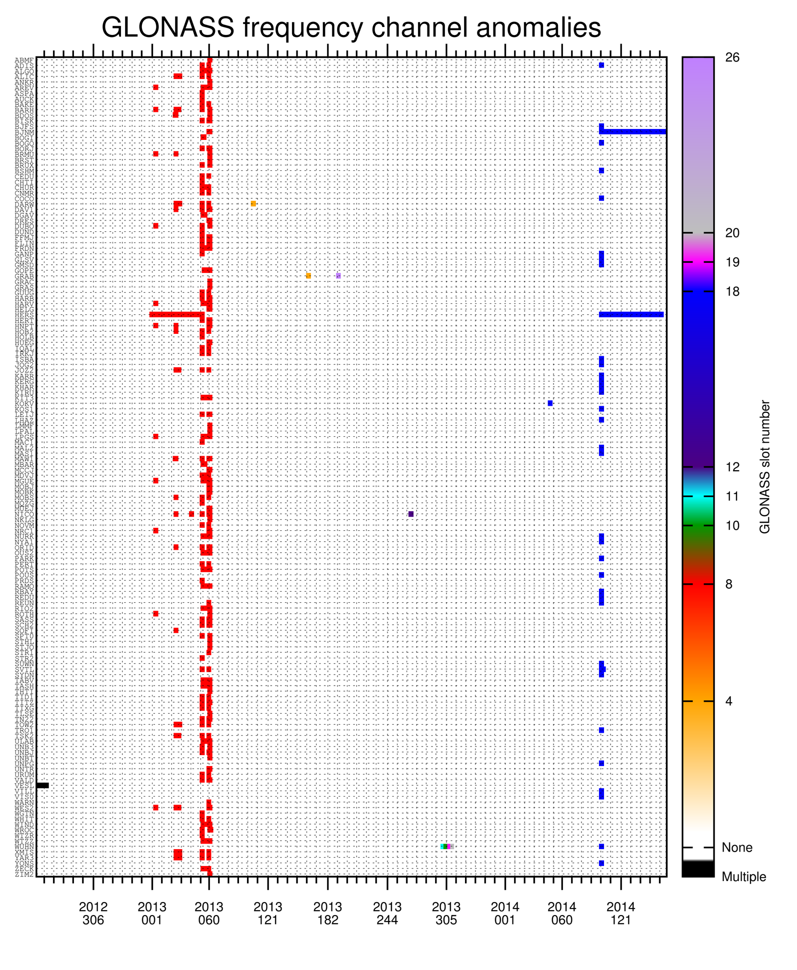

Figure 3: IGS stations with GLONASS frequency channel anomalies (out of 243 stations tracking GLONASS).

Summary and conclusions

Systematic quality control for GNSS tracking data is indispensable to ensure best possible analysis products. To keep the running receiver firmware (version) up to date may help to improve the data quality and completeness.
We are confronted with an increasing number of signals, frequencies and satellite systems. This is asking for a new level of details in reporting on the data generation (frequency *and* tracking mode), otherwise derived GNSS analysis products may become biased.
We developed an XML-based meta-data monitoring of our data pool, allowing for fast, flexible and efficient extraction of information necessary for station selection and processing. It allows even for complex queries and is thus offering a powerful tool for detection and detailed monitoring of irregularities in the IGS tracking data.

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