TESTING REAL-TIME GNSS DATA STREAMS FOR SUPPLYING THE GOP DATA CENTER

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MOTIVATION

Since 2002, the Geodetic Observatory Pecný (GOP) has operated the EUREF local data center (GOP LDC) oriented to the near real-time data and products. Hourly RINEX files of more than 150 permanent GNSS stations are routinely available at GOP LDC (ftp.pecny.cz/LDC). The data is used in GOP for the GPS-meteorology processing (Douša and Souček, 2004) in E-GVAP project (http://egvap.dmi.dk) and also in the determination of ultra-rapid GPS orbits (Douša and Mervart, 2005) for the International GNSS Service, IGS (http://www.igs.org). There have been three motivations behind the implementation of the real-time data archive for the hourly RINEX files at GOP. Firstly to provide an alternative source of GNSS data besides the standard IGS data centers, especially for the ultra-rapid GPS orbit determination at GOP relying on a good global data coverage. Secondly to speed up the collection of hourly data in our data center. Finally to get the experience with real-time data performance within two real-time distributing systems: EUREF-IP (http://epncb.oma.be) and RTIGS (http://www.igs.org).

IMPLEMENTATION

Two clients have been setup for the operational data center support. At first the open source BKG Ntrip Client (BNC, 2006) ready to decode the RTCM messages or RTIGS data collected via TCP/IP + NTRIP protocols and to save them directly into the sampled RINEX files. The BNC software has been modified to provide additional messages for monitoring the source of the errors and exceptions during the transfer. We enabled also to store even the other raw formats convertible by teqc (Estey and Meertens, 1999). The NTRIP and BNC have been developed within the EUREF-IP project (Weber 2003, BNC 2006). At second the RTIGSA (Archiver) to read the RTIGS streams (RTIGS, 2007) via UDP + RTIGS protocols and to store the files in RTIGS raw format. RTIGS protocol and relevant software have been developed within the IGS Real-Time Working Group (Caissy et al., 2006).

Both implemented clients are configured to read the data from about 20 sites. A global coverage was requested by the station selection and some stations available in both services were choosen for the comparison purposes. Real-time data collection is arranged in GOP LDC (Douša and Souček, 2005) before the standard procedure of downloading hourly RINEX files. The procedure is thus skipped in case of hourly files were successfully saved from the real-time data streams.

All data is primarily stored and evaluated in 1-Hz sampling rate (high-rate data). The RTIGS or other raw data is firstly converted into the RINEX file. The second step includes the data integrity checking in file. Finally the content is tested against the criterion of 90 percentage of all expected observations and for the presence of necessary header information. The BNC client usually includes the header information in output RINEX file using the skeleton file from the IGS or EUREF central bureau. The RTIGSA does not obtain such information in RTIGS format and we thus complete header during the conversion into the RINEX format (by teqc).

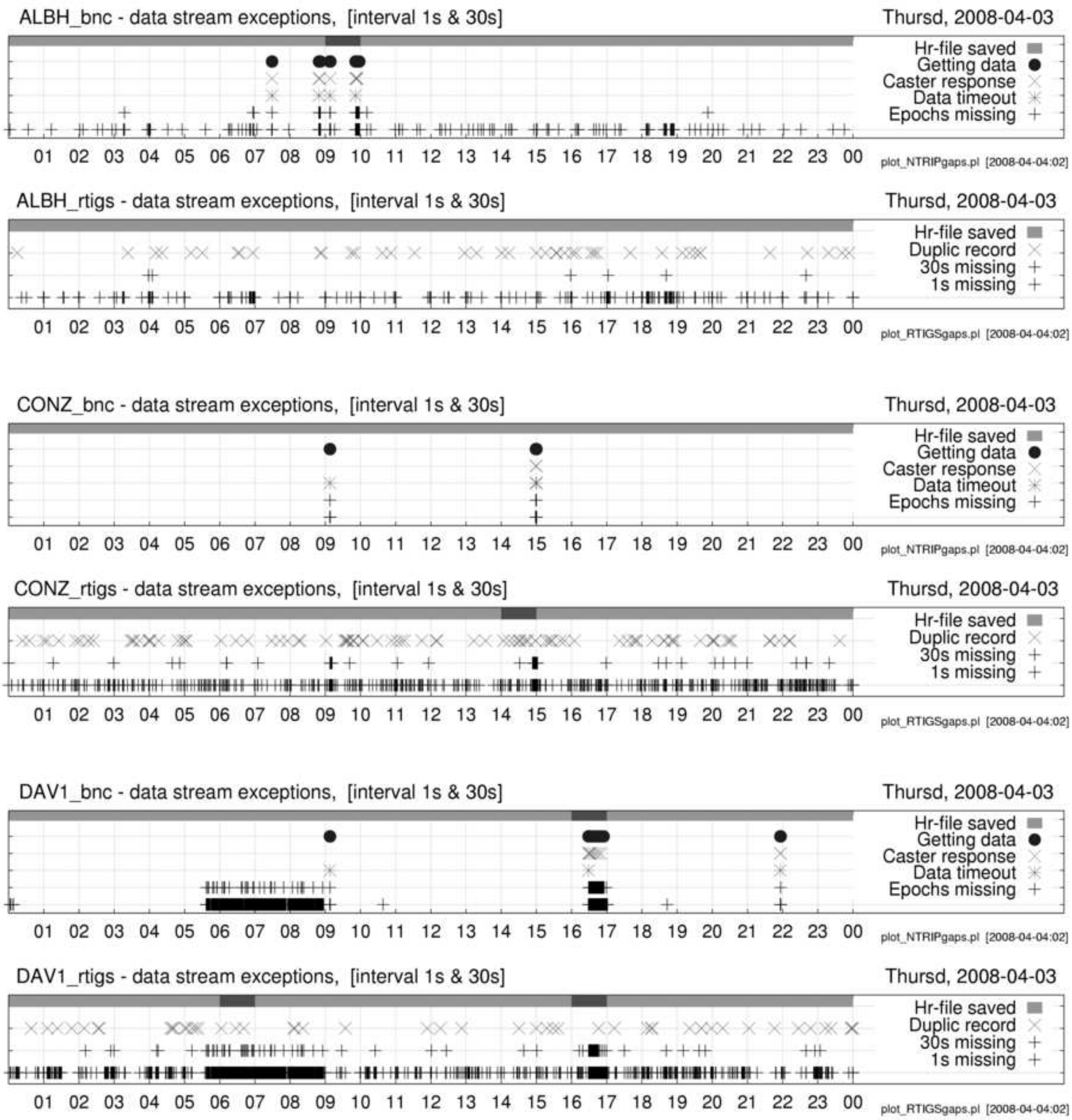


Fig. 1. Comparison of NTRIP (BNC) and RTIGS data distribution. CONZ and DAV1 stations show the difference in the performance for 1Hz epochs. NTRIP provides much better data volume, while RTIGS has slight advantage in smaller latency and transport burden. ALBH station is probably converted from RTIGS into NTRIP because the pattern of 1Hz missing data is very similar.

We use our skeleton file generated regularly form the site-log files of the EUREF/IGS stations. The high-rate RINEX file is sampled into the 30s standard hourly file and uploaded to a specific directory for a direct picking up by GOP LDC server. Resulted graphics and statistics are routinely provided at http://www.pecny.cz (GNSS → data center → real-time).

MONITORING

A specific software tool RinexMonitor has been developed for monitoring the content of the RINEX files. The software uses a GPSTK library (Harris and Mach, 2007) and it allows the testing of RINEX files for

- **missing epochs,**
- **number of satellites (GPS, GLONASS, …),**
- **important header information (receiver, antenna, radome, height).**

We routinely test high-rate as well as 30s sampling data providing statistics for decision of RINEX storage or removal. Resulted plots (Figure 1) shows the missing epochs together with the important events in the real-time traffic logged by the BNC client. Only last traffic segment between the caster and our NTRIP client can be thus monitored of course. Comparing the RTIGS and NTRIP approach for the same stations shows that NTRIP performance is better concerning overall data volume, which could be expected for applied TCP/IP transport protocol. Contrary, the RTIGS using a UDP protocol provides slightly better performance in the data latency and in transport burden, but usually resulted in many missing 1s epochs. There are also stations converted from one service to the other - station ALBH is such example showing very similar pattern of 1s data due to probably unique primary RTIGS source. Figure 2 finally shows the example of unstable data due to weak Internet connection and consequently deleted hourly files containing less than 90% of expected 30s data.

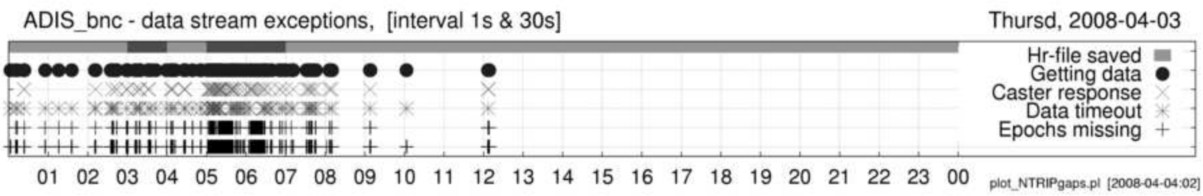
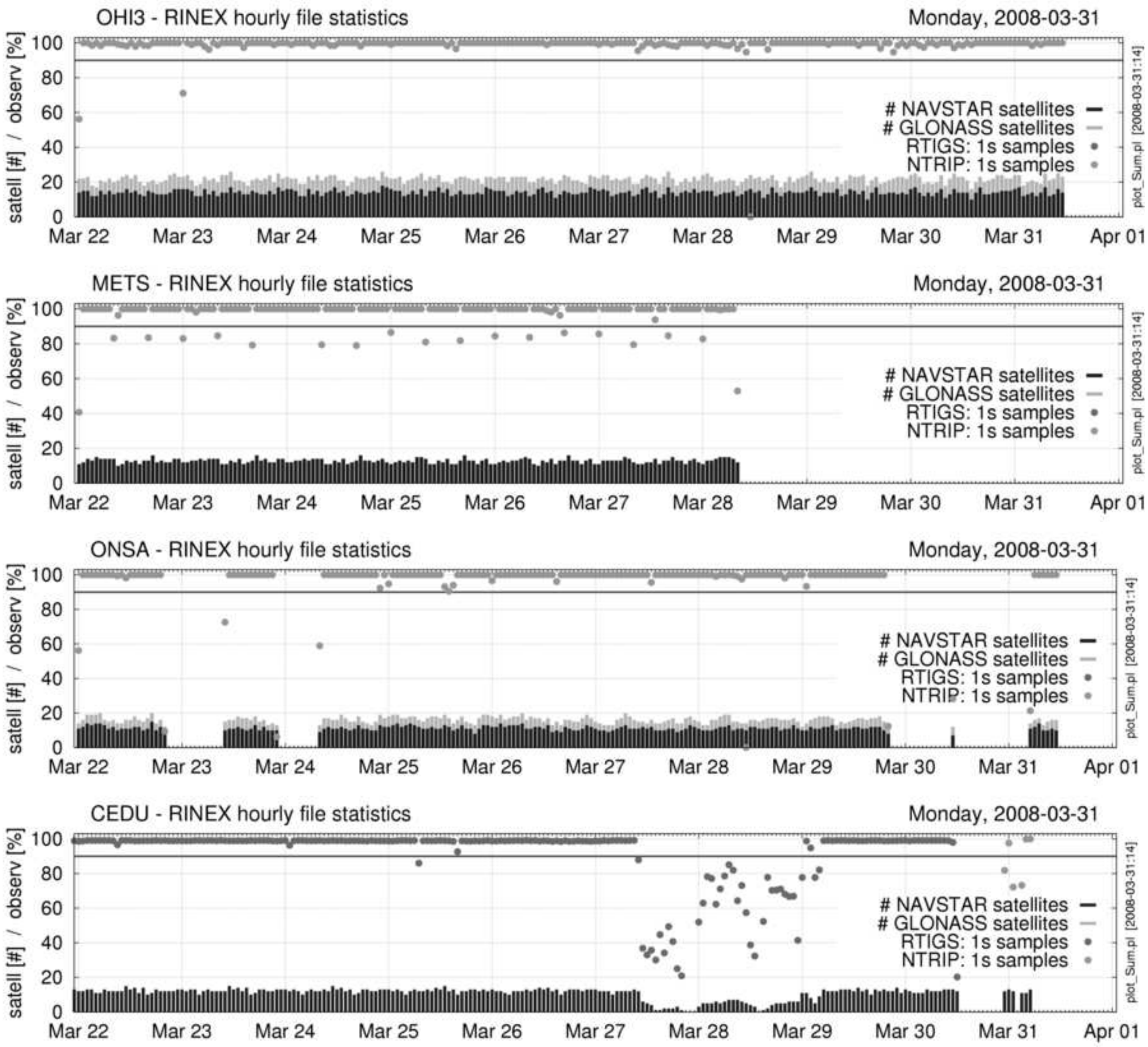


Fig. 2. Example of weak data transfer. Hourly files are consequently removed because of less than 90% of all available 30s observation.

QUALITY CLASSIFICATION

The individual station performance from prospect of 10 days has been routinely monitored. The station plots (Figure 3) show the percentage of successfully collected 1Hz observations during one hour as well as the number of all the satellites providing the data. Only NTRIP implementation is able to provide also GLONASS observations, satellites are then pictured in addition to the GPS satellites. The plots distinguish the short- and long-term problems in any station performance. Comparing the plots in Figures 1, 2 and 3 all the stations could be flagged from e.g. weekly prospect for their performance using these criterions:

1. **occasional periods of long data gaps (G)**
2. **steadily 1Hz missing epochs (E)**
3. **periodical pattern in data volume (P)**
4. **inconsistent data (I)**
5. **predominantly unusable data (U)**



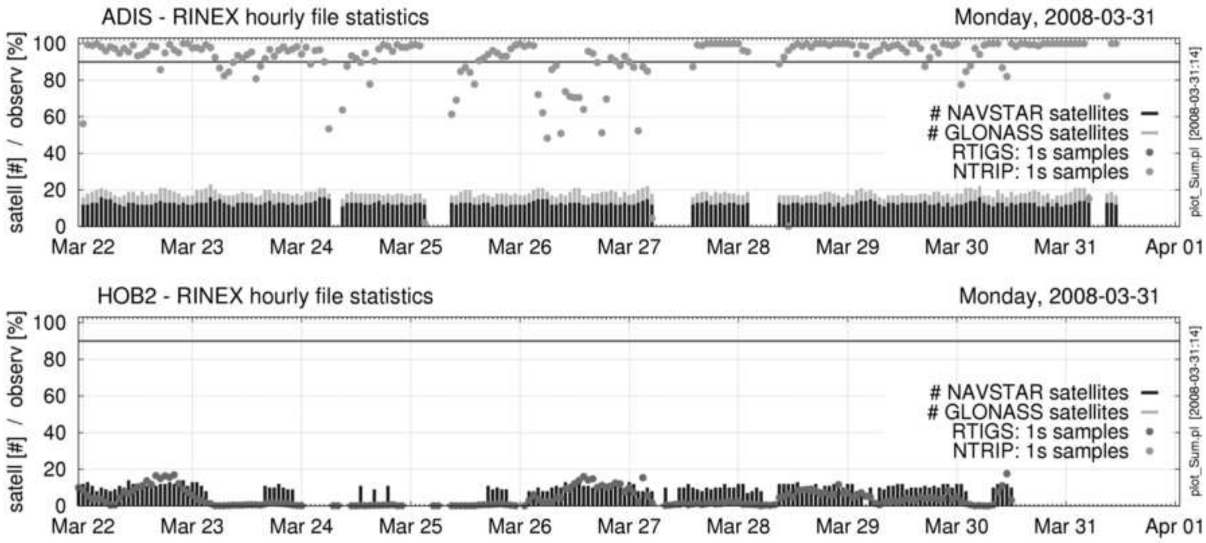


Fig. 3. Station summary plots for the last 10-day data performance show some problems in data collection. It is necessary to monitor the integrity of data when used for providing the hourly RINEX files. Such monitoring can provide a relevant feedback for the station operators or for marking with flags.

Figure 3 shows the examples for the stations: OHI3 – no flag, METS (P), ADIS (G,I), ONSA (G), CEDU (G,I) and HOB2 (U). Flag 'E' is usually common for data from RTIGS source (sometime even gathered using NTRIP/BNC), which can be observed only in Figures 1 or 2.
Naturally, in a long-term perspective some of the station characteristics changes, but some remains stable. The monitoring and flagging can provide a feedback to the station operators as well as for the actual use in (near) real-time.

SUMMARY

Both - RTIGS and EUREF-IP – implementations can be successfully used for supporting the hourly observation RINEX files in GOP data center. In general, there is no significant difference in the performance with respect to 30s hourly RINEX data, though EUREF-IP and RTIGS use different protocols: TCP and UDP transport protocols, NTRIP and RTIGS application protocols, respectively. The NTRIP implementation usually provides a little more data because frequent missing 1s epochs in RTIGS, but traffic expenses are slightly higher. The NTRIP implementation seems to be better for batch data storage for near real-time applications, while RTIGS implementation has minimal real-time latency and good performance even in low communication bandwidth.
Both services support also the navigation messages. While BNC stores concatenated navigation RINEX files more time in one hour, RTIGSA stores them in a single station-based raw RTIGS files. Until now, only the NTRIP protocol supports also GLONASS (or other) observation/navigation data. There is currently no RINEX header information support in RTIGS service while BNC NTRIP implementation together with the IGS and EUREF CB skeleton files allow to complete the RINEX headers when created. While RTIGS needs a specific port (e.g. 20000) enabled in firewall, NTRIP as a simple extension of HTTP protocol uses standard port 80 usually not restricted.

We can state, it is always important to implement an integrity checking procedure before storing and providing RINEX files through a data center. Monitoring of the stations has revealed frequent missing 1s epochs especially in RTIGS streams, which should be accounted for in real-time applications too.
From a prospect of e.g. weekly period the stations could be flagged with respect to following criterions: a) occasional periods of long data gaps, b) steadily 1Hz missing epochs, c) periodical pattern in data volume, d) unstable data and e) predominantly unusable data.

ACKNOLEDGEMENTS

The work was supported by the Czech Science Foundation (2005/09/0696) and the Czech Ministry of Education, Youth and Sports (LC506).

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