IGS Real Time Service Status

Loukis Agrotis[2], Axel Ruelke[3], Werner Enderle[1]
[1]European Space Operations Centre (ESA/ESOC), Robert Bosch Str 5, D-64293, Darmstadt, Germany
[2]Symban @ ESOC, Robert-Bosch Str 5, D-64293, Darmstadt, Germany
[3]Bundesamt für Kartographie und Geodäsie (BKG), Richard-Strauss-Allee 11, 60598 Frankfurt am Main, Germany

Introduction

The IGS Real Time Service has been operational since April 2013, providing two GPS-only products (IGS01 and IGS02) and one experimental GPS+GLONASS product (IGS03). These are combination solutions generated by processing solution streams from a number of Analysis Centres (7 GPS and 3 GPS+GLONASS).

The GPS-only products have been available for several years within the Real Time Pilot Project and their performance is being monitored by making comparisons against IGS batch products and by continuous PPP solutions. GLONASS orbit and clock comparisons are generated against the ESA rapids in order to better assess the individual AC solutions and the IGS03 stream.

The poster gives details of the RTS products and recent performance, and highlights issues encountered during the operation of the service.

Product and Data Access

The RTS products are all provided using the RTCM standard. Observation streams use both the older RTCM 3.1 (RTCM 10403.1) formats for GPS and GLONASS and the newer RTCM 3.2 (RTCM 10403.2) standard that defines multi-signal and multi-constellation messages. Product streams for GPS and GLONASS use the SSR RTCM format which is defined in RTCM 3.2. The SSR formats for the other constellations have not yet been finalised, but some Analysis Centres are providing products based on a draft version of the standard. Dissemination is via Network Transport of RTCM by Internet Protocol (NTRIP).

Information on user access and software is provided on the RTS website at http://www.igs.org/rts/access. Users can register separately at one or more of the three agencies (IGS Central Bureau/UCAR, BKG, CDDIS) operating the IGS RT data centres, must accept the terms of service and complete the online subscriber registration. After a brief processing period, users will be contacted with login and further information for connecting to the RTS streams.

AC and Combination Solutions

A number of individual Analysis Centres (AC) process the Real Time observations and compute epoch-wise orbit and clock products. These are formatted using RTCM SSR encoding software and transmitted to the NTRIP casters at the IGS data centres. Orbit products are available either with respect to the satellite centre of mass (CoM) or the antenna phase centre (APC). The clock products are transmitted with an update interval of 5 seconds. The AC streams and NTRIP mountpoint designations are listed in Table 1 below.

Table 1. RTS Analysis Centre Products

Centre	Description	Mountpoint
BKG	GPS and GPS+GLONASS orbits and clocks using IGU orbits (CoM/APC)	CLK00/10 CLK01/11
CNES	GPS+GLONASS orbits and clocks based on IGU orbits (CoM/APC) GPS+GLONASS+GAL+BEI orbits and clocks (CoM/APC)	CLK90/91 CLK92/93
DLR	GPS orbits and clocks based on IGU orbits (CoM/APC) GPS+GLONASS orbits and clocks	CLKC0/A0 CLKC1/A1
ESOC	GPS orbits and clocks using NRT batch orbits every hour which are based on IGS batch hourly files (CoM /APC) GPS orbits and clocks using NRT batch orbits every hour which are based on RINEX files from RT streams (CoM /APC)	CLK50/51 CLK52/53
GFZ	GPS orbits and clocks and IGU orbits (CoM/APC)	CLK70/71
GMV	GPS+GLONASS orbits and clocks based on NRT orbit solution (CoM/APC)	CLK81/80
NRCan	GPS orbits and clocks using NRT batch orbits every hour (APC)	CLK22
WUHAN	GPS orbits and clocks based on IGU orbits (CoM/APC)	CLK15/16

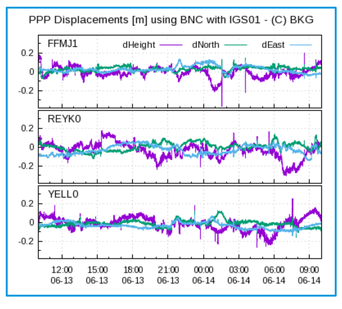
The coordination of the Analysis Centre activities is the responsibility of the Real Time Analysis Centre Coordinator (RTACC). This role has been fulfilled by ESOC since the start of the Pilot Project in 2008. The RTACC is responsible for monitoring the individual AC streams and for generating and assessing the quality of combined real-time orbit and clock products. Table 2 shows the combined product streams available within the RTS. Both a single epoch combination product developed by ESOC and a Kalman filter combined product, developed collaboratively by BKG and Czech Technical University (CTU), are available. A GPS+GLONASS Kalman filter combined product has also been developed at BKG and CTU.

Table 2. RTS Combination Products

Centre	Description	Mountpoint
ESOC	RT GPS epoch combination from NRCan, BKG, CNES, DLR, ESOC, GMV and GFZ streams	IGS01 (APC) IGC01 (CoM)
BKG	RT GPS Kalman-generated combination from NRCan, BKG, CNES, DLR, ESOC, GMV, GFZ and WUHAN streams	IGS02 (APC) IGC02 (CoM)
BKG	RT GPS+GLONASS Kalman-generated combination from BKG, CNES, DLR and GMV streams	IGS03 (APC)

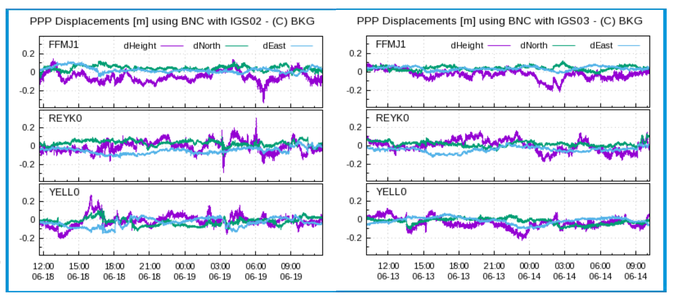
PPP Performance

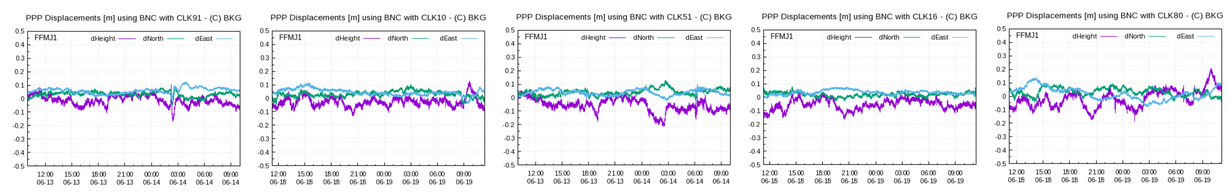
Continuous PPP performance results for all streams are available at https://igs.bkg.bund.de/ntrip/ppp and are displayed on a 24-hour sliding window. They are derived from the BNC PPP client, running in kinematic PPP mode and using observations from a number of receivers whose positions are precisely known. The chart on the right shows the PPP monitoring of the IGS01 combination from 3 sites over a 24-hour period.



Real Time Service web page: http://www.igs.org/rts

PPP results from the IGS02 Kalman–based solution and the IGS03 GPS+GLONASS experimental solution are shown on the right. The charts below show representative PPP results from a number of individual AC solutions. The plots clearly indicate horizontal accuracy of better than 10 cm.





Orbit and Clock Performance

The GPS individual AC and combination solutions are monitored by making daily comparisons of the decoded orbit and clock products against the IGS Rapid solution. The clock results for the individual ACs since November 2010 are shown in Figure 1 (left) while the right hand plot shows the performance of the IGC01 combination. It can be seen that there are significant daily variations in the statistics of the individual RTAC solutions. These are usually due to a problem in a single satellite, which distorts the daily statistics. These distortions are effectively removed by the combination outlier detection logic. The IGC01 clock standard deviation is normally at the 0.1-0.15 ns level. The best individual RTAC solution is normally better, but suffers from occasional outlier problems that the combination is designed to remove.

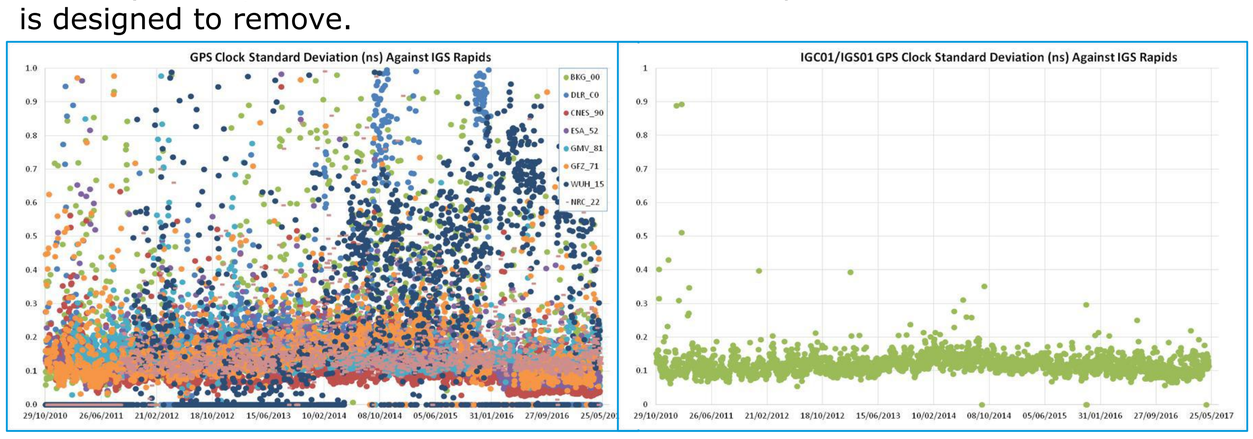


Figure 1 – RT AC and Combination Clock Standard Deviation against IGS Rapids

Figure 2 shows the orbit comparison results of the AC solutions and the IGC01 combination. The plots are of the daily 1-D RMS difference between the RT solutions and the IGS rapids. Typical current results for the combined orbit product are at the 20-25 mm level.

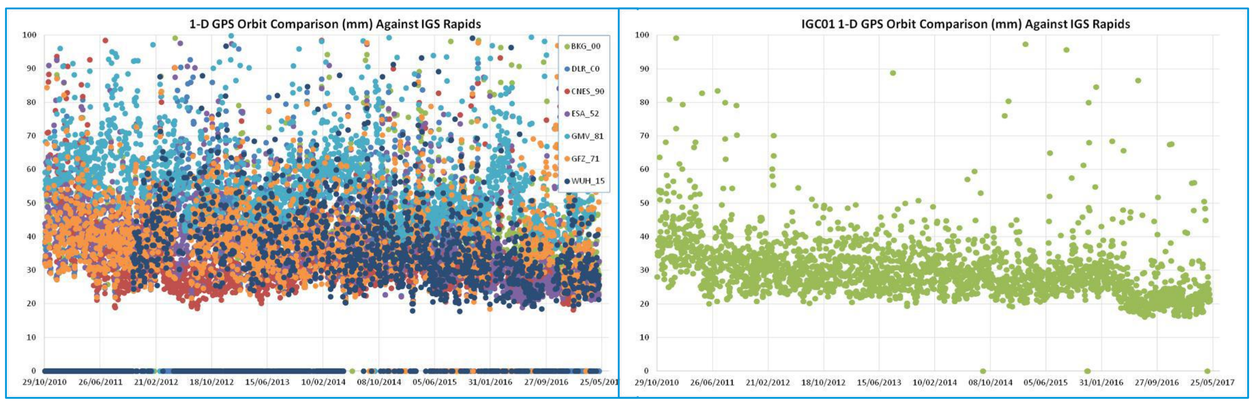
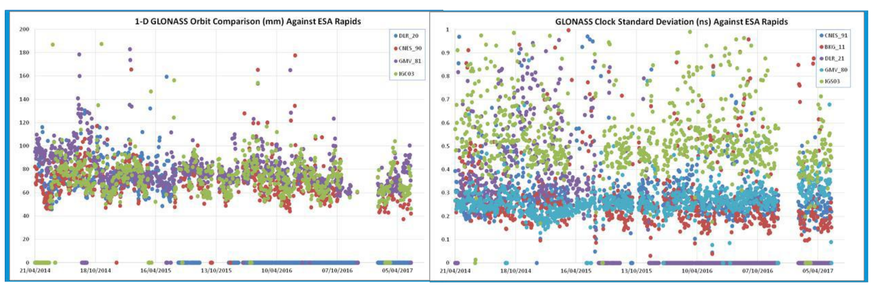


Figure 2 – RT AC and Combination Orbit 1-D RMS Comparison against IGS Rapids

Three Analysis Centres, BKG, CNES and GMV, are generating GPS+GLONASS Real Time solutions. The IGS03 combination stream has been available from the outset of the RTS. Solution monitoring relies on comparisons with the ESA or CODE daily rapid solutions. The charts on the left show plots from the GLONASS clock and orbit comparisons.



Main Issues

The majority of issues encountered during the operation of the service have been minor in nature. A common problem is occasional loss of orbit accuracy for the GPS Block IIF satellites during eclipse seasons and when in non-nominal attitude.

In the past there have been some issues with RTCM encoding and decoding. These are now almost exclusively confined to GLONASS and more recently only affect satellite R24 in the CNES solution. The cause of such issues is mainly related to the use of outdated ephemeris during encoding of the RT stream.

GPS solution availability has been excellent, with no recorded outages in the last year. The GLONASS combination solution is currently based on only 3 ACs, which means that the loss of a single AC will result in disruption of the GLONASS service.

Conclusions

The RTS products offer a reliable and highly available IGS service for a wide variety of applications.

Acknowledgements

The authors wish to acknowledge the efforts of all the entities involved in providing the IGS Real Time Service, including station operators, Analysis and Data Centres and the staff of the IGS Governing Bureau.

European Space Agency