IGS Real Time Service Products

Loukis Agrotis[2], Mark Caissy[3], Axel Ruelke[4], Georg Weber[5], 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]Natural Resources Canada (NRCan), Ottawa, Canada
[4]Bundesamt für Kartographie und Geodäsie (BKG), Richard-Strauss-Allee 11, 60598 Frankfurt am Main, Germany
[5]Ntrip Enterprise, Rotdornweg 98, D-60433 Frankfurt, Germany

Introduction

The IGS Real Time Service (RTS) has entered Initial Operational Capability during April 2013, providing two operational 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 (8 GPS and 4 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. Until recently, the GLONASS streams were only monitored in the PPP domain. GLONASS orbit and clock comparisons are now being generated against the ESA ultras in order to better assess the Real Time Analysis Centre (RTAC) solutions and the IGS03 stream.

This poster gives details of the RTS products and performance, and highlights issues encountered over the last year.

IGS Combination Solutions

From the three products mentioned above, the IGS01 solution is produced by ESA using an epoch-wise combination approach, while IGS02 and IGS03 are produced by BKG using a Kalman filter approach.

The BKG combination software is built into the BKG's NTRIP Client (BNC) software. The clock combination process for IGS01 is described in the block diagram in Figure 1. This also makes use of BNC to decode the RTCM binary orbit and clock streams from the RTACs, as well as a dedicated Broadcast Ephemeris stream. The resulting orbit and clock corrections are converted to SP3-like streams by a "Read Clock" (RC) task, decoded using the broadcast ephemeris information which is processed by a "Read Ephemeris" task (RE). The decoded streams are combined by the Combination (CO) software and the resulting combination stream is sent to a further instance of BNC by a "Write Clock" (WC) process. BNC then encodes the solution into RTCM messages, using broadcast ephemeris information from the RTCM ephemeris stream.

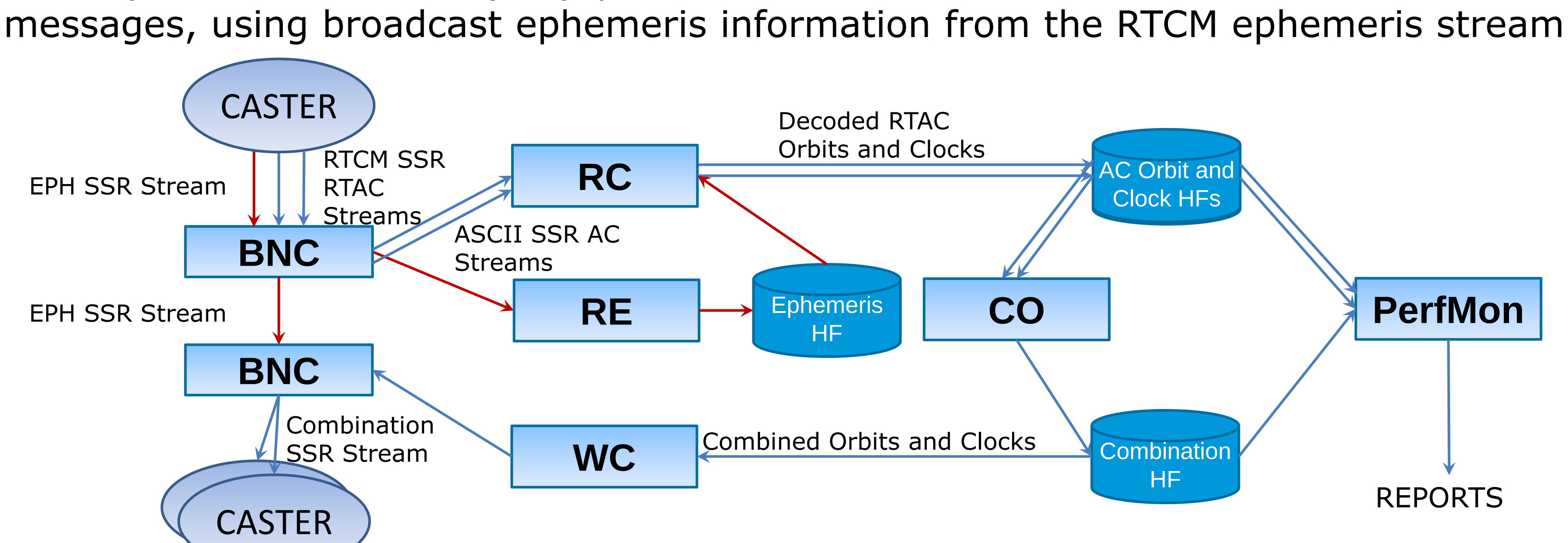
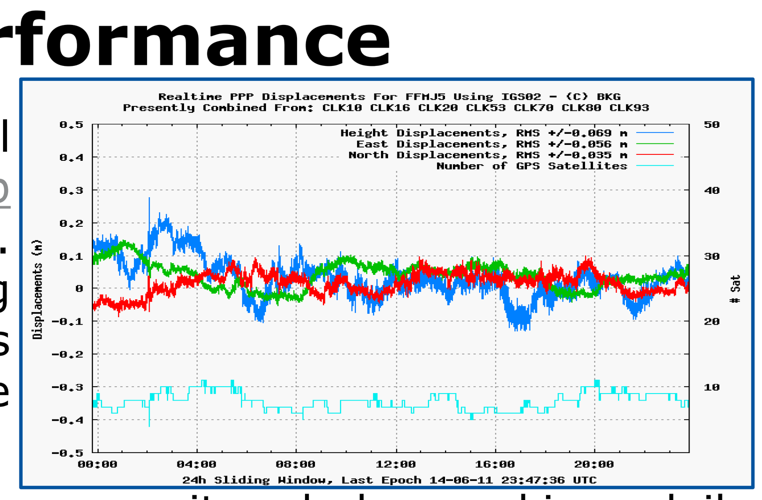


Figure 1 – IGS01 Generation Block Diagram

GPS Real Time Solution Performance



Continuous PPP performance results for all streams are available at 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 receiver located in Frankfurt, Germany. The chart on the left shows an example for IGS02.

The GPS RTAC and combination solutions are monitored by making daily comparisons of the decoded orbit and clock products against the IGS Rapid solution. The results for the individual RTACs since November 2010 are shown in the top two charts of Figure 2. The lower two charts show the performance of the IGS01 combination, with the clock results extended to the start of the Real Time Pilot Project in July 2008.

Figure 2 shows 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. The bottom two charts show that these distortions in both clock and orbit are effectively removed by the combination outlier detection logic. The IGS01 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.

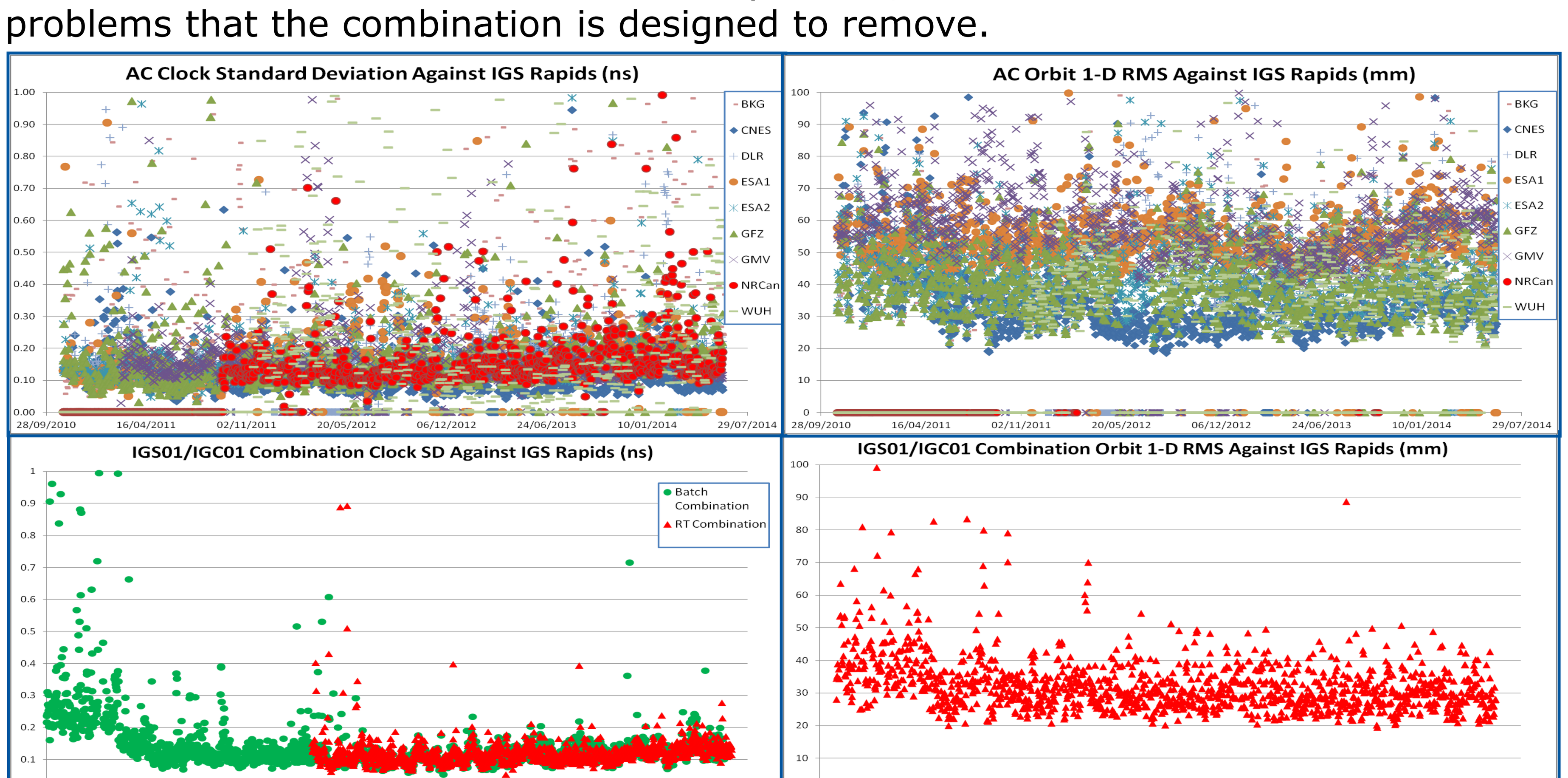


Figure 2 – RTAC and IGS01 Clock and Orbit Performance Against IGS Rapids

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

Figure 3 shows the clock comparison residuals between the combination solutions and the IGS Rapids over a 24-hour interval. The IGS01 results on the left chart suffer from occasional jumps of the order of 0.1-0.2 ns. These are caused by variations in the number of RTACs between epochs and the fact that the individual RTAC solutions have significant biases. Such jumps are also seen in IGS02 (right-hand chart), but they are generally smaller, as the effect is smoothed by the use of a Kalman filter for the IGS02 generation. However, it can be seen that the IGS02 solution exhibits rather large biases with respect to the IGS time scale. These do not affect PPP solution results but may be detrimental to some applications.

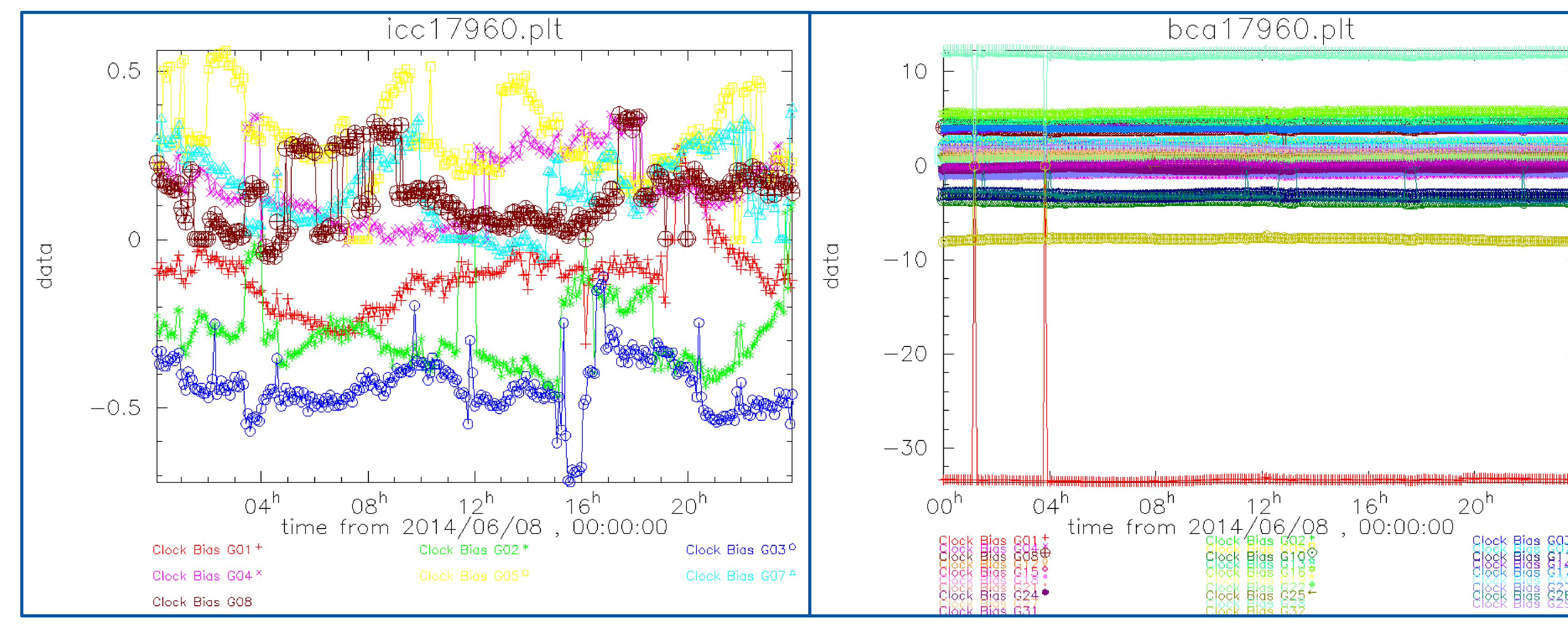


Figure 3 – IGS01 (left) and IGS02 (right) Clock Residuals from IGS Rapids

Solution sample availability for the RTAC and combination solutions is shown in Figure 4. In the general case of 30 available satellites, full availability requires 8640 samples. The combination solutions exhibit good availability but have fewer samples than the maximum, because of satellite rejections as a result of outlier detection. The IGS02 solution was not monitored for the entire period, which is why the number of samples drop to zero for significant intervals.

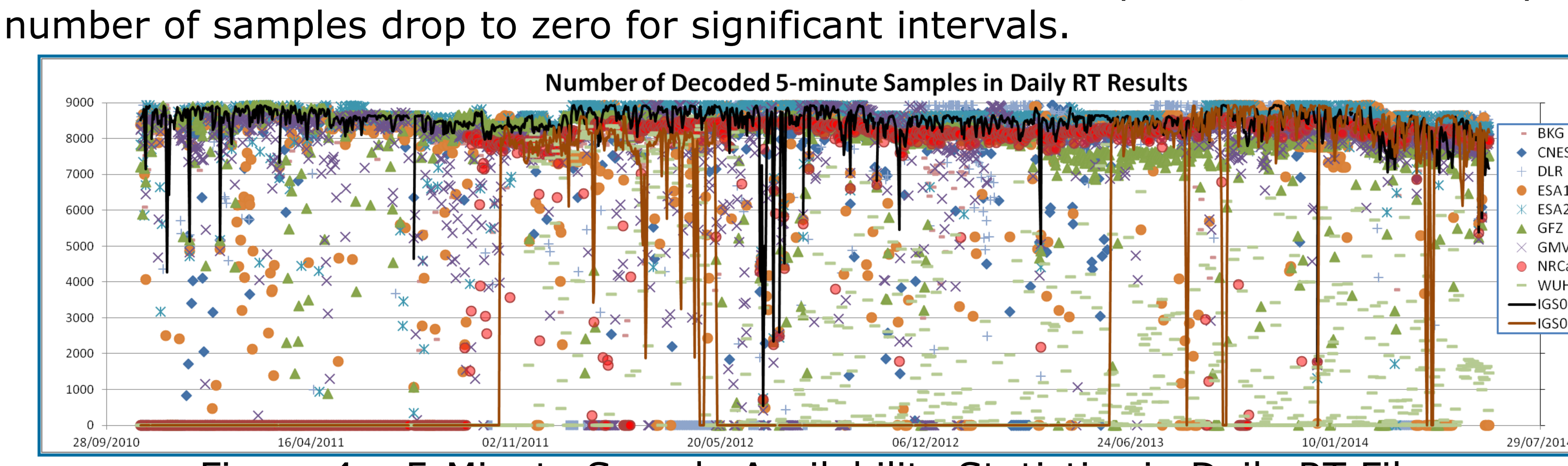


Figure 4 – 5-Minute Sample Availability Statistics in Daily RT Files

GPS+GLONASS RT Solution Performance

Four Analysis Centres, BKG, CNES, DLR and GMV, are generating GPS+GLONASS Real Time solutions. The IGS03 combination stream has been available from the outset of the RTS in April 2013. It was treated as an experimental product because there was no monitoring in the orbit and clock domain to validate the results at the time. This monitoring is now in place and relies on comparisons with the ESA rapid solution. Figure 5 shows summary plots from these comparisons. The monitoring has uncovered a number of issues that have now been corrected:

- A corruption in the GLONASS part of ephemeris stream RTCM3EPH was resulting in incorrect RTCM encoding and decoding of the GLONASS solutions. This can be seen in the left chart of Figure 5, where the clock solution of most RTACs has a high standard deviation during the first half of May. The problem did not affect the DLR and GMV solutions, which were using a different ephemeris stream.
- Incorrect treatment of the relativistic correction term resulted in erroneous RTCM encoding of the solution from some RTACs.
- The IGS03 combination and the BKG solution were showing reduced availability since the beginning of May (right chart in Figure 5).

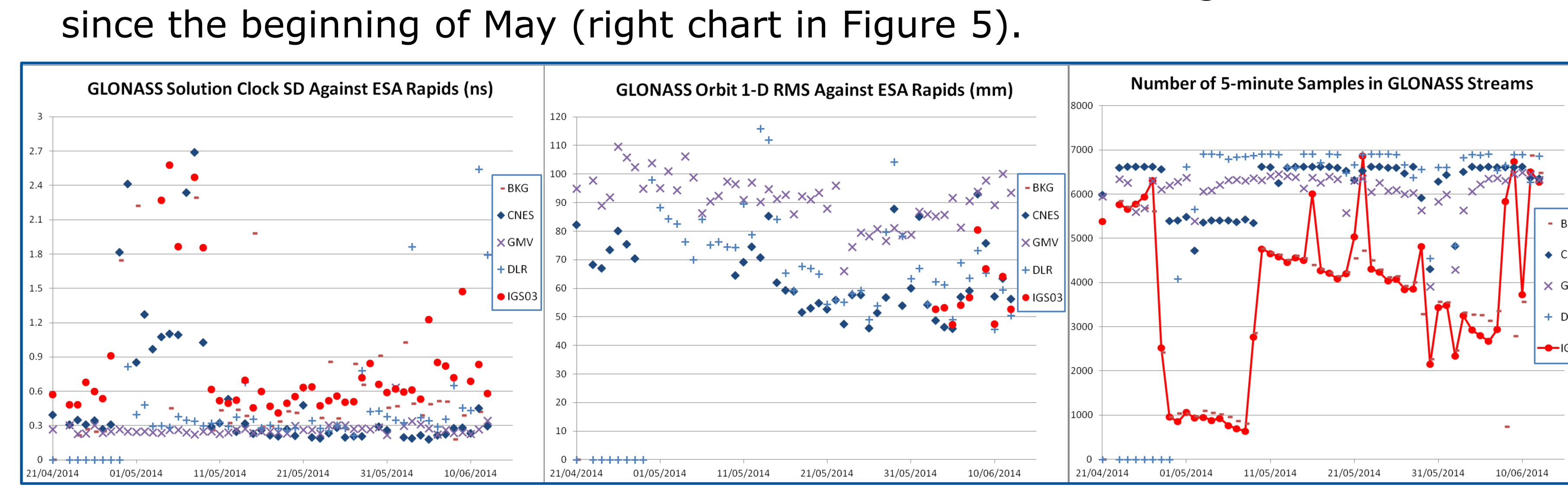
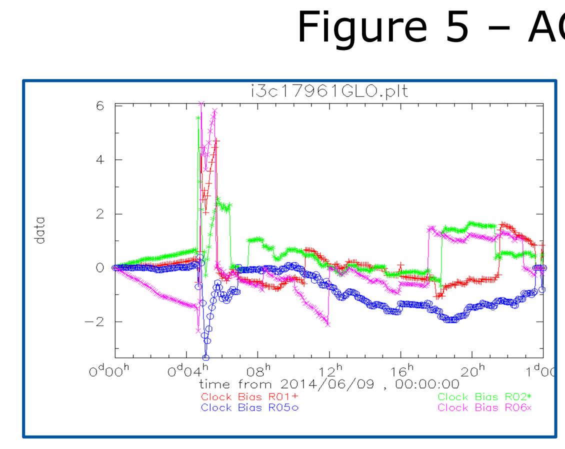


Figure 5 – AC and IGS03 GLONASS Performance Statistics



The plot on the left shows an example of the IGS03 solution residuals from the ESA rapid comparison. The residuals are after the removal of a common offset per epoch and an initial offset per satellite. The plot shows the existence of discontinuities in the solution at the level of a few ns. This issue will be investigated and resolved before IGS03 can be declared an operational product of the RTS.

CONCLUSIONS

The GPS RTS combination products offer a reliable and highly available IGS service for a wide variety of applications. The GPS+GLONASS combination will be declared operational as soon as the final outstanding issue is resolved.

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