Using IGS products for near real-time comparison of UTC(k)'s

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ABSTRACT

The time-transfer technique based on Precise Point Positioning (PPP) has proved to be a very effective technique allowing the comparison of atomic clocks with precision at the level of hundred picoseconds, with latency of less than a few days. Using satellite orbit and clock information from the IGS ultra-rapid and real-time products, or from the NRCan Ultra Rapid products (EMU), it is now possible to compute very precise time transfer solutions in near-real-time mode (latency down to some minutes), using both code and carrier phase measurements in a PPP approach. This capability could be considered quite interesting for the National Metrology Institutes, provided with an additional mean to fulfill their aim of generating an accurate and reliable national time scale and comparing their primary frequency standards. Using the software tool named "Atomium" developed at ORB, we set up an operational service for the National Metrology Institutes, providing a near-real time comparison o f their local realizations of UTC, named UTC(k)'s. The poster presents this application and a quantification of the quality of the clock monitoring so-obtained.

UTC(k) monitoring in near-real time using GNSS PPP

The ORB website proposes near-real-time comparisons of UTC(k)'s based on GNSS time transfer.

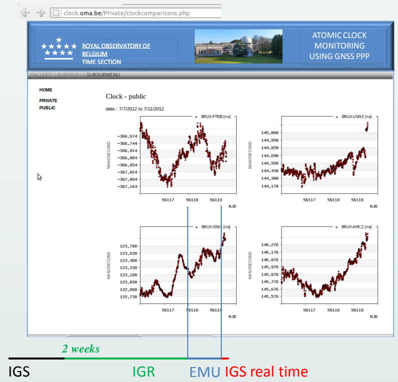
The clock solutions are computed in Precise Point Positioning (PPP) with the software tool Atomium developed at the ROB (Defraigne et al., EFTF 2007). Only data from the GPS constellation are used.

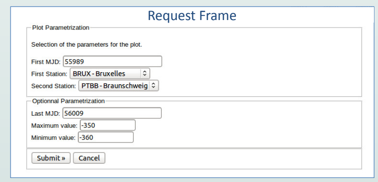
By default the solutions are presented for the previous three days plus the present day up to the beginning of the current hour. The plots are updated each hour.

A different period of time can also be visualized for a comparison between two stations of the proposed list using the request frame appearing in the bottom of the page.

The near real-time solutions are computed each hour using hourly RINEX files. Each computation is done on a 24h data batch. The computation done with real-time IGS products uses 24h data ending at the current hour. After 2 hours, the solutions in the database (and hence in the pictures) are replaced by new solutions computed with the ultra rapid products EMU produced by the NRCan IGS analysis center. This run indeed uses 24h data ending 2h before the current hour. Two days later, the solutions in the data base are replaced by those computed with the rapid IGS orbits, and 2 weeks later by the solutions computed with the final IGS orbits. The solutions proposed on the website are therefore those obtained using

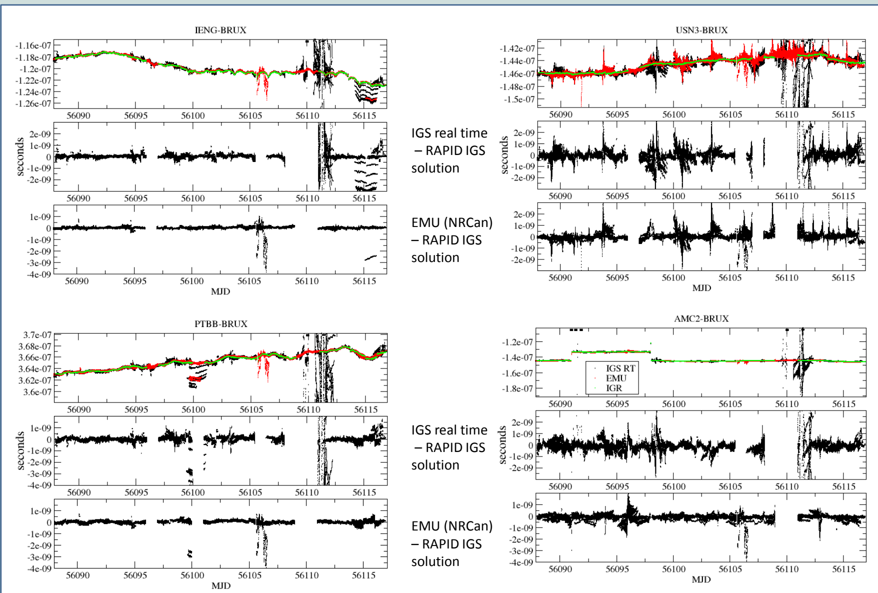
- Precise IGS orbits and clocks for dates prior to two weeks before the present week.
- Rapid IGS orbits and clocks for the two previous weeks and up to two days before the present day.
- Ultra-rapid products from the NRCan Analysis Center for the previous day and the present day up to the end of current hour –3.
- IGS real-time clocks and IGU orbits for current hour –2 and current hour –1, using the RTCM streams provided by BKG (stream ICG01).





Web page for near-real time clock monitoring, available upon request at the Royal Observatory of Belgium.

Quality of the PPP clock solutions obtained with NRCan EMU products and IGS real time products.



Comparison between the time transfer solutions obtained with Atomium, using the EMU products and the IGS Real-Time products (IGC01) over one month, with the IGS Rapid solution Big outliers were not plotted for visibility, but are indicated as small filled boxes.

	Mean (ns)	Sigma (ns)	Max (ns)	Nb of data in the solution	Nb of data > 1 ns	% of data > 1ns
	IGS Real Time – RAPID IGS solution					
IENG-BRUX	-0.080	1.701	149.582	152245	11135	7.31 %
PTBB-BRUX	-0.061	2.021	484.076	144211	7157	4.96 %
USN3-BRUX	-0.156	3.363	257.481	145435	11120	7.65 %
AMC2-BRUX	-0.253	3.655	630.034	158486	8161	5.15 %
	EMU (NRCan) – RAPID IGS solution					
IENG-BRUX	0.036	0.189	4.483	165676	507	0.31 %
PTBB-BRUX	0.024	0.269	4.688	157856	592	0.38 %
USN3-BRUX	0.036	0.481	5.143	158342	3666	2.32 %
AMC2-BRUX	-0.078	0.333	4.545	171570	985	0.57 %
	RAPID Atomium solution – RAPID IGS solution					
IENG-BRUX	-0.029	0.088	0.236	8871	0	0.00 %
PTBB-BRUX	-0.028	0.144	0.411	8593	0	0.00 %
USN3-BRUX	0.050	0.099	0.277	8293	0	0.00 %
AMC2-BRUX	0.034	0.081	0.307	8880	0	0.00 %

Statistics over the differences between the Atomium solutions obtained using the EMU or IGS Real-Time products (IGC01) over one month, and the IGS Rapid solution.

Conclusion

A new service for monitoring atomic clocks connected to a GNSS receiver is available at ROB, based on PPP computation using the Atomium software and a webpage where the solutions are plotted at each request.
The clock comparisons are provided with a delay of less than 1 hour using IGS real time products; this solution is used to monitor the two last hours . The quality of this solution depends on the baseline: the std. dev. of the differences between this solution and the IGR solution are 2 to 3 times larger for inter-continental baseline than for intra-continental ones. The number of outliers however depends more on the station than on the baseline.
After 2 hours, the solutions in the database (and hence in the pictures appearing on the web page) are replaced by new solutions computed with the ultra rapid products EMU produced by the NRCan IGS analysis center. This new solutions is very close to the IGS rapid solution, the std. dev. of the differences is between 0.2 and 0.5 ns. As when using the real time IGS clocks, the differences are larger for longer baselines. This can be explained by the errors in orbits/clocks affecting the PPP clock solution in similar ways for nearby stations, due to the common visibility of the satellites in that case. The number of outliers is also significantly smaller than when using the real time IGS clocks.
Two days later the solutions obtained with the ultra rapid products EMU are replaced by the solutions computed with the rapid IGS orbits. In order to quantify the quality of this solution, we computed some statistics over one month of comparison with the rapid IGS solutions for 5 IGS stations (see the table).No significant bias is observed and the std. dev. Of the differences is at the level of 100 ps.

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