Herstmonceux time bias system as a possible real-time QC tool

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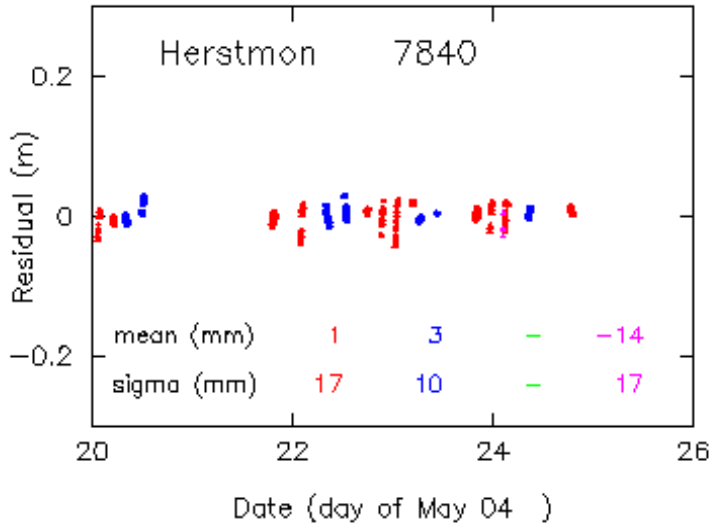
For some years the NERC Space Geodesy Facility has been operating a daily QC service based on long and short-arc analysis of most of the satellites tracked by the ILRS network. The results continue to be presented each day on the Facility website. In addition, every hour the system at Herstmonceux downloads the latest hourly file of Normal Points from CDDIS. These observations are then used in an orbital solution to form a time bias (TB) relative to all available prediction sets for each individual pass. These individual TBs are then added to the global set and a function fitted through them to produce the time bias functions that are made available to the ILRS network via a server at Zimmerwald, Switzerland. However, generation of these functions is sometimes complicated by the existence of poor data from one or more tracking stations. Much of the effort going into improving this TB service is currently centred on the development of an automatic system to detect and remove from the fit the poor data. As a bye-product and on a somewhat ad-hoc basis we pass the details of any poor data to HTSI who then report back to the station. We believe this system has the potential to send out a report automatically and directly to the station in near real-time and although not perfect would enable stations to detect gross problems quickly and complement our other QC tools.

Long-Arc

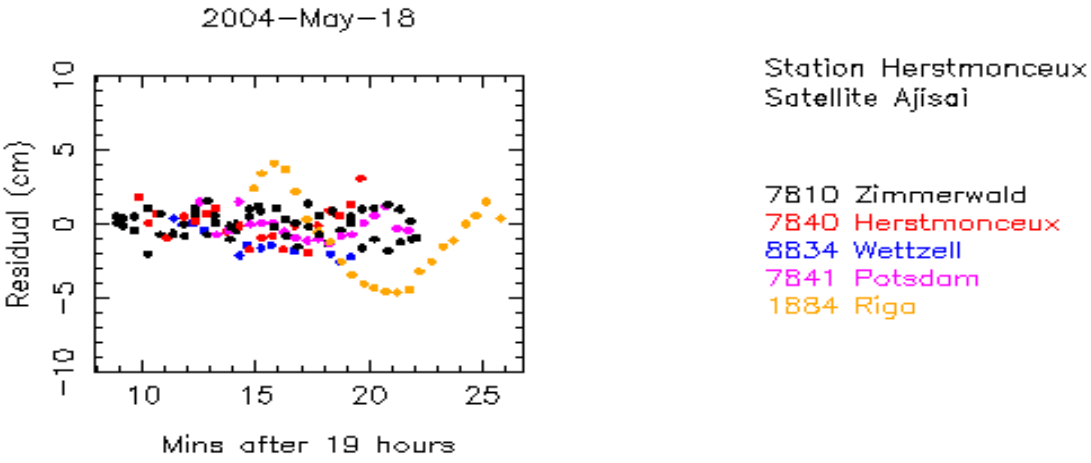
The long-arc solutions (six day orbits) are run once per day. Although we run the long-arc solutions for all satellites, we currently only place the solutions for the Lageos and Etalon satellites on the web. We do have plans to expand this to all satellites in the future. It is down to the station to look at the long-arc solutions for problems. Errors can be seen at the 10-20cm level. We could make an automatic system which would inform the station when any NPs have residuals above the 20cm level. Before we can do this we would need to devise a method of logging to avoid sending our message every day for the 6-day orbit. We also have to overcome the problem of poor orbits for satellites with sparse data sets.



Shown here is a typical long-arc plot for Lageos 1&2 and Etalon 1&2

Short-arc

The short-arc solutions are run once a day and require the long-arc orbit and simultaneous observing from at least two core stations. Currently there is no feedback – it is up to each station to check the short-arc on a daily basis. Errors can be seen at the 5-10cm level. We could make an automatic system which would inform the station when any NPs have residuals above the 10cm level. Before we can do this we would need to devise a method of logging to avoid sending our message every day for the 6-day orbit. We also have to overcome the problem of poor orbits for satellites with sparse data set As simultaneous data is required the amount of passes checked is limited, particularly for stations that have no other station near enough to get simultaneous tracking for all satellites



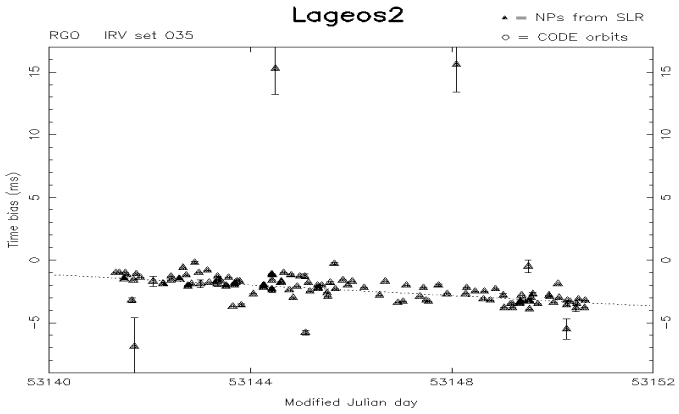
Shown above is a typical short-arc plot for Ajisai. The scatter in their data would indicate that they are all near single photon level. The above plot would indicate that there may be a problem with the data for 1884 for this pass.

Herstmonceux Time Bias Service.

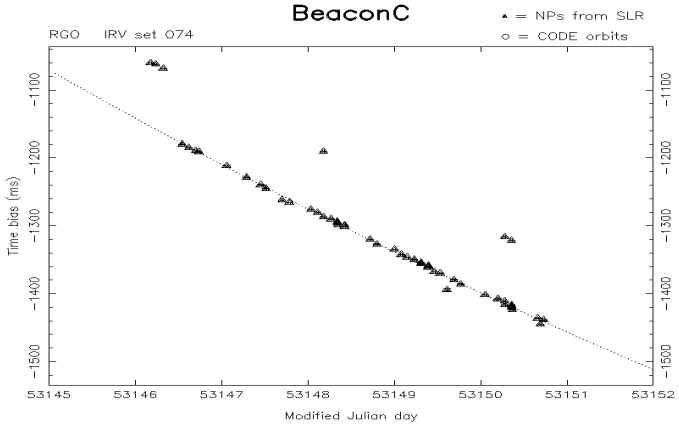
To maintain an up-to-date time bias function for predictions, the automatic system at Herstmonceux generates an individual time bias, using a cut down version of the orbit fitting program SOLVE, for every observation as soon as it becomes available.
Data becomes available in the following ways
–Herstmonceux data is available immediately after a reduction.
–Through E-mail – many stations send us data directly to speed up the TB process.
–Hourly downloads from CDDIS

Once new NP data is available a time bias is generated and a new function is calculated. These functions are made available through the Berne ftp system every 15 minutes. A poor time bias can easily corrupt the time bias function (as can a poor IRV set). To try to get the best time bias function we need to be able to detect and remove outliers. It is this process of detecting the “bad” passes that we are proposing to use as a general QC tool.

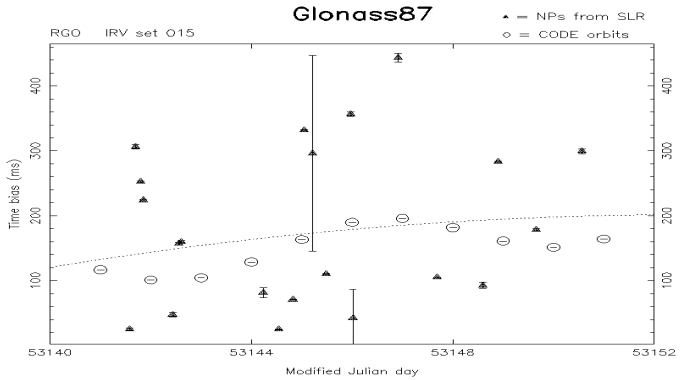
Pros	Cons
-Once an hour all new data is downloaded from CDDIS. This means stations can be informed in near real-time of potential problems. -Being near real-time, it allows us to correct the data (remembering to increment version number) or withdraw it quickly (we really should be able to do this), hopefully before the users have downloaded the data they require, as users rarely go back and re-collect data. -Well-tuned monthly IRVs allow us to see many potential errors clearly in the time bias data.	-As the system only solves for two orbital parameters (along, across track) it can have trouble separating the two, thus giving spurious tb values. This is particularly true when a pass contains only a few NPs or has very little change in Az/El. -The system has problems around manoeuvres. -There are some satellites which the system has problems getting time biases for – Glonass, Etalon, Champ, Grace. -We have to generate monthly IRVs - this is only a very minor problem



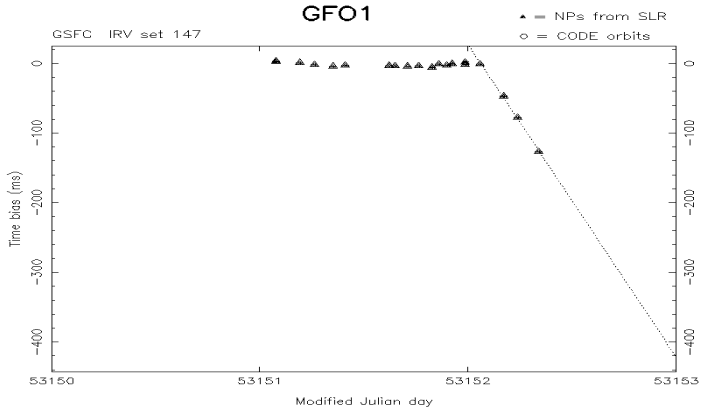
A typical time bias plot. There would appear to be 2 clear outliers at 15ms (both in value and RMS- each point has error bars plotted but they are generally <0.1). There are also a few difficult to define points.



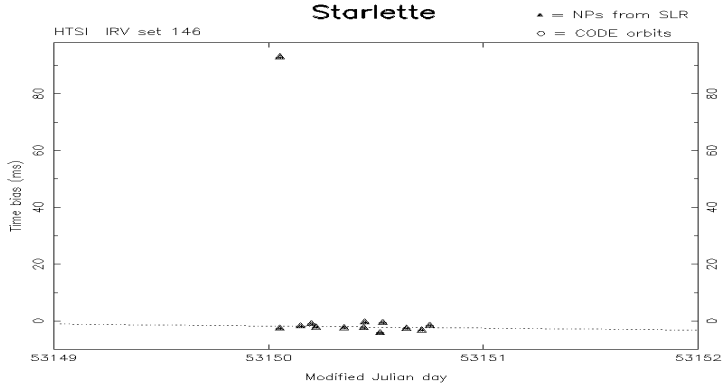
The plot shown for BeaconC shows a number of clear outliers. Note the large value of the time biases - although this IRV set is a month old we can still clearly see the outliers.



Shown here is a typical Glonass set of data. The range of time biases (some 500ms) is due in the main to stations only getting a few normal points when the satellite is at its closest approach. Detecting bad data is almost impossible



Shown here is a data set around a manoeuvre. When not informed in advance of a manoeuvre the system will probably send out all post-manoeuvre passes out as errors.



Why do we use monthly IRV sets instead of daily IRV sets? When collected in chronological order this data set would have one good and one bad pass on which to make a judgement. With a monthly set it knows which is wrong

Summary

We can detect outliers and advise the stations, for satellites up to Lageos (apart from Champ & Grace) at about the 10ms level with some certainty, although we may have problems if we are not advised of manoeuvres.
We can advise stations when the orbit fit gives a poor (large) RMS.
We will expand the long-arc to include all of the satellites.

Conclusion

We can implement reporting bad data directly to the station to give near real-time QC

If we implement any of these systems as QC checks we would like feedback – hopefully we will be able to improve the detection criteria from the feedback.

Stations should make every effort to stop bad data from being released – not rely on QC to detect problems.

To implement any of these systems we need an e-mail address for each station to send the information to – we would also inform EDC/CDDIS

We are happy to offer this service (for TBs) to any station even if it is not used as an official ILRS QC check – just let us know the e-mail address to send the feedback to.

Implementation

After running offline tests to look at the flagged errors to resolve any false alarms we started the system in August 2004. At this point some fifteen stations have taken up the offer to receive an e-mail if a potential problem is detected within their data.
It may well be coincidence but shortly after the system was introduced the number of bad data points dropped off markedly.