SGF tracking of GNSS

Matthew Wilkinson (matwi@nerc.ac.uk), NERC Space Geodesy Facility, Herstmonceux, UK

Introduction

The SGF has changed its operational practices to adapt to the expected significant increase in the number of retro-reflector target carrying GNSS satellites orbiting the Earth, potentially placing an increased demand on SLR tracking.

GNSS tracking at Herstmonceux

Herstmonceux, like many ILRS stations, has over many years gained a significant amount of experience of tracking high orbiting satellites, at altitudes of approximately 20 000km. These remain the most challenging targets that need high quality telescope pointing, minimal beam divergence and clear and cloud-free skies. At night the targets are easily tracked using a camera to display the telescope iris, which allows the beam and possibly the sunlight satellite to be positioned at the centre of the field of view. Searching for the best relative alignment between the satellite image and the laser beam or for invisible satellites in shadow may also require small azimuth and elevation offset searches. In the clearest skies, GNSS satellites can also be tracked at Herstmonceux during daylight hours. This requires a small iris, a very narrow daylight spectral filter (~0.2nm, centred on 532nm), close gating of the SPAD detector and a daytime camera system to see and align the laser beam to the centre of the iris. Daylight tracking of GNSS satellites is not always successful at Herstmonceux as the sunlit telescope is open to non-uniform heating which introduces error into the telescope pointing model.

The Herstmonceux SLR station tracks all ILRS GNSS and Etalon satellites and in addition now tracks all of the remaining operational GLONASS satellites. As there are 24 operational GLONASS this increases the number of GNSS altitude satellites being tracked by 2.5 times. This scenario could be similar to that requested of the ILRS from GNSS missions in the future.

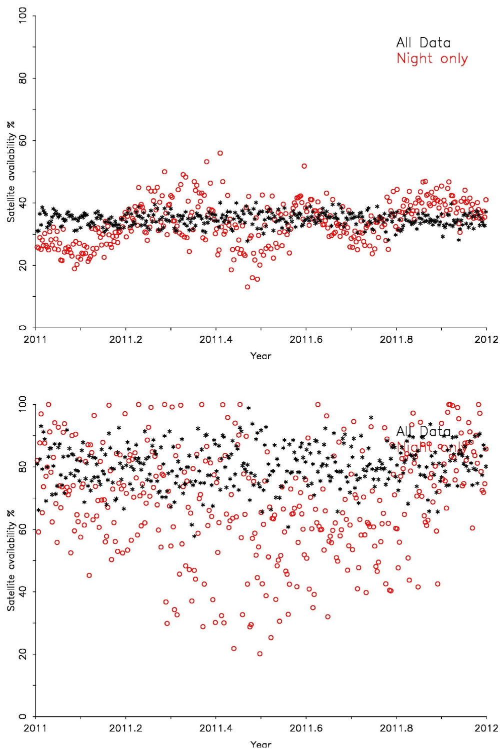

Figure 1. The top plot shows the percentage during which LAGEOS or LEO satellites can be tracked for the whole day (in black) and for night hours only (in red). The bottom plot shows the percentages for the LAGEOS, LEO, Etalon, GIOVE, COMPASS-M1 and GPS. This work was in collaboration with P. Gibbs.

Figure 1 contains the results from an investigation that used the predicted SGF schedule for 2011. Firstly the top plot was for all satellites at LAGEOS altitudes and below, finding the total time each day that the telescope is required for SLR. This is then repeated including the Etalon, GIOVE (Galileo validation satellites), COMPASS-M1 and GPS satellites, which gave the bottom plot. On an average day the SLR facility is only required for approximately 35% of the time for LAGEOS or lower altitude satellites. The bottom plot shows this demand increase to 80% of the day with the addition of the high altitude satellites. There is a large amount of spare capacity in the LAGEOS and LEO schedule. Adding the high orbiting satellites significantly reduces the spare capacity, but this is only the case because it includes the entire high altitude satellite passes, which last for many hours. Reducing the tracking of a GNSS satellite to 5-10 minutes when it is ascending, overhead and descending reduces this demand considerably.

Figure 2. The number of normal points collected at the Herstmonceux station for all the GLONASS and Etalon satellites tracked from the beginning of 2010 to mid-2011.

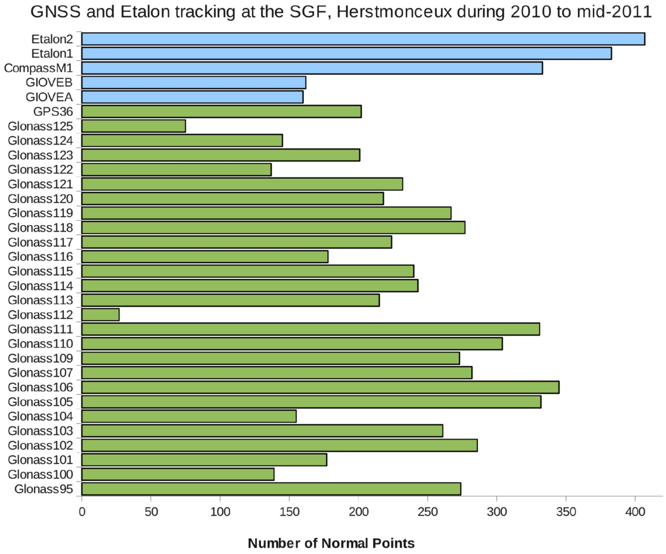

Figure 2 shows the total number of GNSS and Etalon normal points acquired by the SGF from the beginning of 2010 to mid-2011. At the top of the plot are the higher priority Etalon targets with subsequently higher yield. The next satellite normal point total is Compass-M1 and then follows the GIOVE and GPS totals, which are comparatively fewer due to these being more difficult targets. Then in green are the GLONASS satellites which show a reasonably even distribution of normal point for each satellites, with fewer normal points recoded if a satellite is newly launched or has reached the end of its operational lifetime. This plot shows the successful tracking of all GLONASS by SGF, Herstmonceux, over this period.

Real time precision and efficient satellite switching

The SGF has implemented a real-time estimation of normal point precision for display and when the precision reaches 1mm the observer is advised to move to another satellite. This is particularly useful when the observer has, for example, 5 or 6 GNSS satellites to be tracked and only a short gap between observing higher priority satellites. Figure 3 shows an attempt to track a high number of coinciding satellite passes and to minimise the time spent on one satellite with efficient satellite switching. Working in this manner requires the observer to be closely aware of which satellites have recently been tracked and which satellites should be the next priority for SLR.

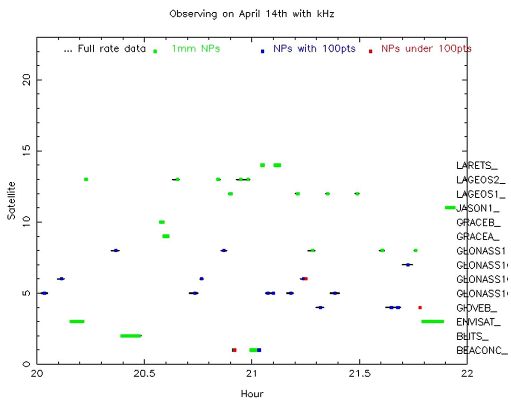

Figure 3. Supporting many satellites with efficient satellite switching using the 2kHz system. This work was carried out by P Gibbs.

Conclusion

Should the ILRS decide to support all future GNSS satellites this will mean a significant jump in the number of satellites tracked. The experience of the Herstmonceux station shows that there is sufficient capacity in the SLR station schedule to observe many GNSS, and at present all GNSS, without impacting on the priority LAGEOS and LEO tracking.

Correspondence

Matthew Wilkinson
NERC Space Geodesy Facility
Herstmonceux Castle
Hailsham
East Sussex
BN27 1RN
United Kingdom

matwi@nerc.ac.uk