Herstmonceux: towards kHz ranging and multi-technique status

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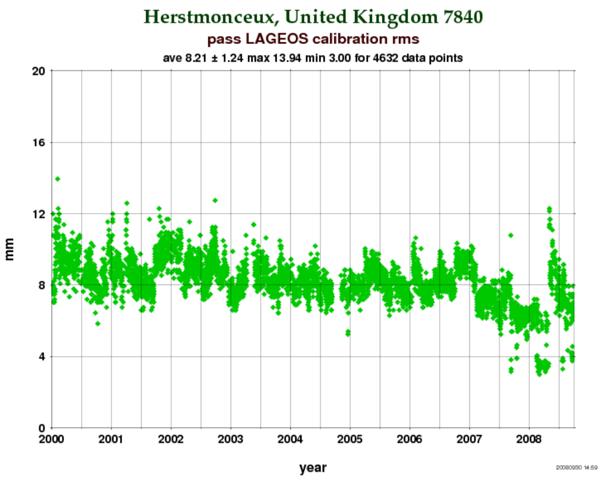
Abstract

The NERC Space Geodesy Facility (NSGF) at Herstmonceux, UK has developed a kHz satellite ranging system alongside the traditional 10 Hz ranging ability without any disruption to continuous observation. This report highlights some of the important steps along the way and reports on 2 years of kHz ranging experience. The NSGF also manages two IGS systems, an absolute gravimeter and an emerging LIDAR programme to run simultaneously with laser ranging.

1.Upgrades to the Herstmonceux SLR system

The newly installed event timer and high repetition rate solid state laser are the two major upgrades to the SLR system. The event timer came online at the beginning of 2007 and improved the accuracy and precision of all observations. The new laser fires a 10ps, 0.42mJ pulse at 2kHz. First test observations were made in October 2006 and data was first submitted in the spring of 2007. Both upgrades have given clear improvement to the calibration RMS as seen in the Lageos calibration RMS plot for Herstmonceux available from the ILRS website and shown left. There is a clear drop in RMS at the beginning of 2007 on the installation of the event timer. A further drop in RMS is present for later passes, indicating kHz observations. The later higher RMS passes are due to the temporary use of an older SPAD detector.



The NSGF now operates a dual laser system. A movable mirror installed in the laser bed allows easy selection of either laser. Alignment between the two lasers must be closely matched as once beyond this mirror both lasers share the same optical path. In the near future, switching from kHz to Hz and back again will be controlled by software. This will involve automatically switching the start diode, laser fire and directing the safety systems, including the radar, telescope switches and observer control, to the appropriate laser.

To date the 2kHz laser has not met expectations with regard to a high enough return rate and ease of satellite acquisition. We are therefore investigating potential loses to the outgoing laser energy using a set of energy monitors which can take measurements of the laser energy at any point in the optical path. We aim to identify any losses due to any individual optic or orientation of the telescope. Initial results were presented in Grasse in 2007 and showed an 8% variation in a 360° azimuth rotation.

A further difficulty experienced in kHz ranging is that a lot of daylight noise can appear in the range gate window. Any noise that triggers the C-SPAD detector before the satellite return pulse arrives prevents an observation being made. This effectively reduces the firing rate of the SLR system. A faster gating system is being investigated which involves either introducing a very fast shutter in the form of a Pockels Cell or switching detectors to and MCP-PMT.

The telescope detector box was recently upgraded and now has 3 working ports for the light to either go to the C-SPAD detector, the daytime camera or a LIDAR photometer. Switching between these ports will eventually be automatically driven. The LIDAR photometer was originally situated to detect reflections from the dichroic, but this was determined to be too weak a signal.

The Linux secondary observing PCs were upgraded to SUSE 11.0. The new package provides gfortran, which gives more decimal places to a real number variable (REAL*12). This was enough to give the necessary precision for the new CRD format, 1 picosecond for epoch.

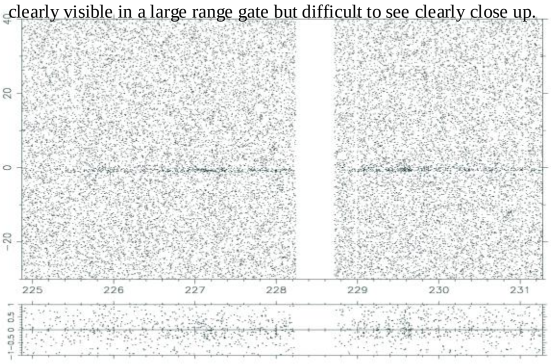
2.Problems overcome and remaining from switching to kHz SLR

The kHz system was in operation less than 50% of the time in 2008. Different reasons for this include the loss of energy due to the burnout of optics, problems with the frequency doubler crystal, damage to the C-SPAD detector, failure of the daytime intensifier and general work needed on the laser. To avoid critical damage of the ND filters from the laser intensity incident at the eyesafe filter the beam path was increased by about 2m to allow the beam to naturally diverge and better disperse the energy.

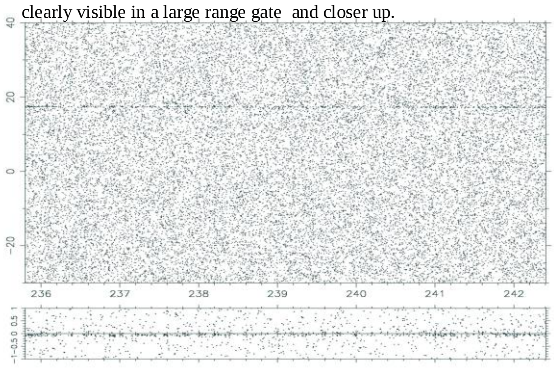
A new TCP-IP communication ability was incorporated into the system in anticipation of a large increase in data volume. Data epochs from the event timer are matched by the primary observing PC and this data is sent to two secondary PCs by TCP-IP communication for the displaying and recording of data. Occasionally this flow has been fallen behind the continuous sending of data and PCs have crashed. A congested data display port is now 'flushed' for continuous operation should it get behind.

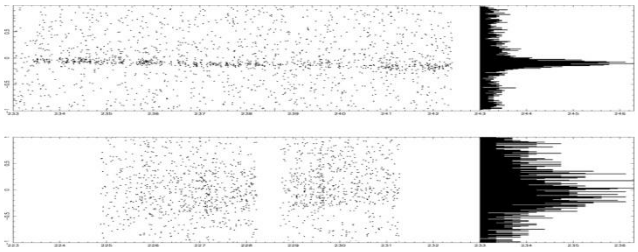
Once data has been collected for a pass, the satellite data needs to be extracted and formed into normal points. The NSGF reduction system now uses a single software program for both Hz and kHz data. The main difference between the two data set types is the signal to noise ratio, which is significantly less for the kHz data. Satellite track is identified in real time by software and this serves as a starting point for the reduction. It is important that enough satellite observations are present in any part of the data set used. This is particularly a problem for Etalon satellites which have large array sizes. A comparison between the satellite track of an Etalon pass and that of a GPS satellite shows a much greater spread of range measurements for the Etalon satellite. Consequently the range data from the Etalon satellite it is much more difficult extract from the background noise.

Etalon 1. The plot shows 6 minutes of an Etalon 1 pass. The satelli
clearly visible in a large range gate but difficult to see clearly close up.

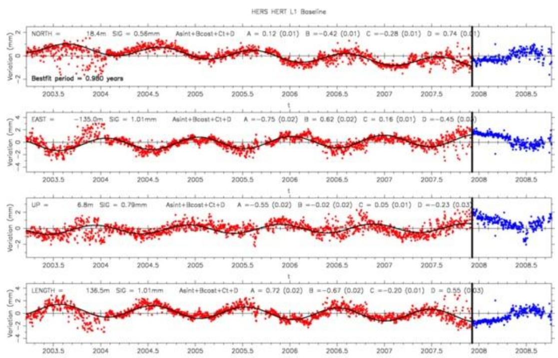


GPS 36. The plot shows 6 minutes of an GPS 36. The satellite is clearly visible in a large range gate and closer up.

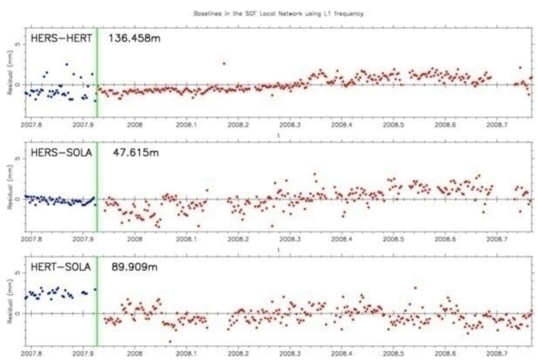




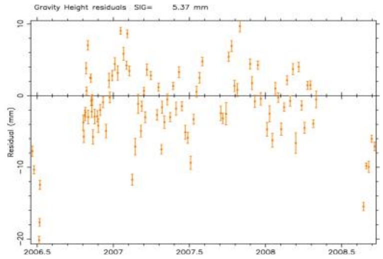
3.Other Techniques at Herstmonceux



The NSGF has two IGS GPS receivers, HERS and HERT, and recently installed a third on a nearby solar pillar situated between the two. HERS and HERT are approximately 136.5m apart. Their close proximity allows single frequency (L1 or L2) baselines to be calculated because they share the same atmospheric delays. Using the freely available GAMIT GPS analysis software, a daily baseline is calculated between the HERS and HERT sites. The resulting baseline plots show a close to annual variation with an amplitude of about 3 mm.



The new site between HERS and HERT, locally called SOLA, identified the poor data quality from the HERT Z-18 receiver. A new Lecia receiver was initially sited on the SOLA pillar and then later switched with the HERT Z-18 receiver bringing the observed signal noise to the SOLA site. Hopefully in time this additional site will also explain the annual variation in the baseline.



The NSGF permanently installed an absolute gravimeter in the facility basement and it has been operational since October 2006. The gravimeter is routinely run mid week for 24 hours and gives a gravity reading to ±2μGal, with 1μGal being equivalent to ~3mm. This produces an ongoing time series of local gravity shown right.

In November 2007, the gravimeter was taken to the intercomparison in Walferdange, Luxembourg and was found to agree within specification with other gravimeters. At the GGEO conference in Crete this year, the very close proximity of the NSGF gravimeter to the SLR telescope and GPS receivers was highlighted as important for future GGOS developments.

4.Conclusions

The NSGF is Herstmonceux is now a more accurate laser station with better precision thanks to an event timer and a kHz laser. Not only does a dual system allow SLR to continue during development periods but retaining the original 10Hz system means that the station is suitable to take part in the LRO satellite and T2L2 missions. At present the kHz system still needs to prove itself as a fully capable SLR system.