Stability of the SGF, Herstmonceux site and SLR calibration

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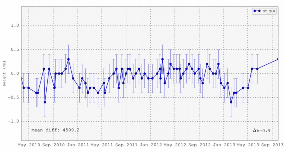
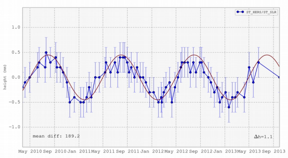
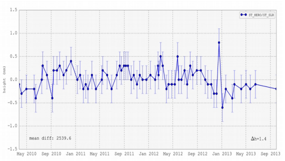
SGF, Herstmonceux. http://sgf.rgo.ac.uk

The NERC BGS Space Geodesy Facility, Herstmonceux operates a very precise, kHz-capable Satellite Laser Ranging station, two GNSS sites, one of which has contributed to IGS for over 15 years, and, since late 2006, an Absolute Gravimeter which provides a weekly time-series of local gravity acceleration. In line with GGOS recommendations, site inter-technique stability is of prime concern, and precise leveling and short-baseline GPS analyses are carried out at regular intervals and indicate only small site motions. In recent years, erroneous laser ranging calibration results were detected and were considered to be significant in magnitude. Steps were taken to minimize the effects of these anomalies in the laser range data and a subtle cause was identified and corrected.

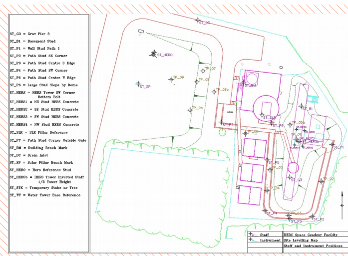






Digital Levelling of the SGF site.

Height changes due to movement at the local site will introduce errors in the time series of the geodetic techniques in operation at the SGF. Any such variations need to be closely observed with the end goal of modelling and removal if required. The SGF has over 3 years of repeated digital levelling runs using a Lecia DNA03, with instrumental accuracy of 0.3mm, at intervals of 2-3 weeks. A levelling run begins in the site basement on an absolute gravimetry pier and in steps of a few metres to several 10s of metres it then includes the SLR pillar (which is estimated to reach more than 10 metres deep in to the ground), several points on the HERS monument and points on the HERO, HERQ and HERT GNSS sites, see photos to right. In total 22 site heights are measured, indicated on the site map to the right, within approximately two hours.



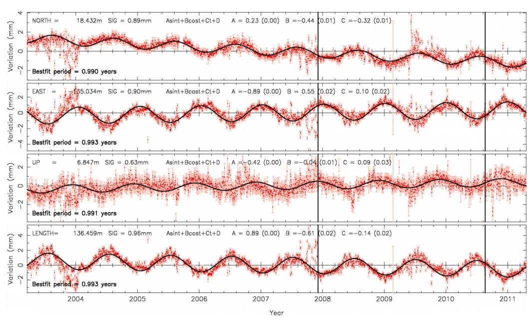
The top plot on the left shows the height difference between a gravimetry pier and the SLR pillar and does not exhibit any longterm signals of amplitude greater than the instrument error. This is a good result for the inter-technique comparisons at the SGF. However in the middle plot the height difference between the SLR pillar and a stud near the base of the steel HERS tower shows a very clear annual signal with an amplitude of 0.5mm. This annual signal could be driven by temperature changes in the steel tower or the concrete base or instead this may be caused by the soaking and drying of the ground clay soil. The bottom plot is the height change from the SLR pillar to the HERO GNSS monument, covering a different part of the SGF site and also shows stability within the instrumental variation.

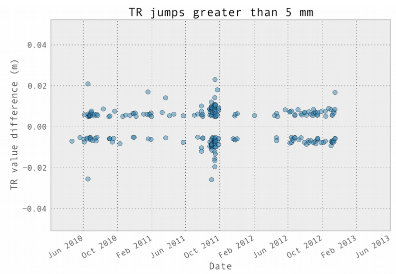
Differential GNSS Short Baseline Analysis.

Short baselines between GNSS sites are determined very precisely at the SGF, near to the 1 mm level, using the GAMIT analysis software. The SGF has four GNSS sites, two of which (HERS and HERT) are IGS sites. The close proximity of HERS and HERT means that they experience very similar ionospheric delay, satellite orbital errors and satellite antenna uncertainties. As a result, high precision baselines can be determined using a single GPS frequency.

Near-annual signals of amplitude 1-2 mm are present the HERS-HERT baseline components calculated using only the L1 GPS frequency and plotted on the right. Signals are clearly visible in each baseline component. Jumps in the time series, due to hardware changes are corrected for and marked with vertical black lines. It has not been possible to attribute the near-annual signal to the real motion or multipath environment of one site because similar signals are present in each baseline pair when the inbetween HERO site is included. Furthermore, analysis of short baselines away from the SGF, in the UK and internationally, found similar near-annual signals in at least one component for every short baseline analysed.

Short baseline between the HERS and HERT GNSS sites determined by GAMIT analysis





Calibration discontinuities recorded during the last three years. Only calibration jumps greater than 5 mm for calibrations taken within a 4 hour period (as plotted here) are considered a genuine anomaly. Significant environmental changes and system warm-up effects can cause jumps of a similar magnitude between observing sessions, which usually are spaced in time by several hours. The number of calibration jumps recorded during the three years is 241. To put this number in perspective, 12414 calibrations were performed during the same period.

SLR Calibration instability study.

Accurate and repeatable system calibrations to a terrestrial target are crucial to ensure the accuracy of laser ranging data. A SLR calibration range is the sum of the target distance and the system electronic and optical delays. Knowing the target distance from millimetre precise surveys allows the determination of system delays and their removal from subsequent satellite laser ranges. Calibration values are affected by environmental factors and physical changes to the system. Performing calibrations regularly ensuresthat the changes do not compromise the accuracy of the satellite data collected at the station.

During recent years, and at irregular intervals, short-lived centimetre-level excursions of the calibration values have been observed which could not be linked to environmental factors or known hardware changes. It became necessary to adopt a policy of discarding any satellite data that could potentially be affected by an unexplained calibration jump. While this ensured no spurious data were sent to the data centres, the situation was not satisfactory and there were several attempts at finding the cause of the problem.

Over time as this continued, all cables were replaced. This reduced the short-term scatter of repeated calibration measurements but did not stop the observed jumps. From summer 2012 onwards, the frequency of calibration-jump events increased and a new effort to understand their cause led to the discovery of a power supply unit with a slightly unstable output. This affected the response of a bank of signal discriminators in a difficult-to-predict manner. Replacement of the power supply appears to have eliminated the spurious calibration discontinuities completely (see figure left).

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Designing a new SLR Calibration Target.

The primary SGF SLR calibration target could be improved, particularly because it is difficult to identify its reference point from a survey point of view. A replacement calibration target, designed in-house, is in the process of being manufactured. This new design incorporates features to aid accurate surveying, namely a standard tribrach for GNSS antenna mounting and a thread for a reflective prism at the reference point. When completed, the target will be installed and tested and we anticipate adopting it as our primary calibration target.