NERC Space Geodesy Facility

Appendix to Annual Report for 2006/07

Report on operations for the period 2006 May to 2007 April

1. Overview

1.1 Summary of Development work

Our main development work this year can be summarized as follows:

- Event Timer and KHZ.
  - With the completion of the Event Timer (ET) in July we have been able to
    - Verify the performance of ET
    - Back calibrate the errors within the SR620 timers
    - Collect data at 14Hz for all satellites using old laser
    - Start on khz ranging
- Gravimeter
  - Installation was completed in May 2006
  - Regular data has been collected since Oct 2006
- Lidar
  - Testing of concept

At the same time we have continued

- Full coverage of SLR tracking for all ILRS objects
- Analysis of GPS data produced by HERT and HERS
- Analysis of SLR data as an ILRS analysis centre
- Glonass observations and other requested observations for MoD
- Continued monitoring of GNSS status for MoD

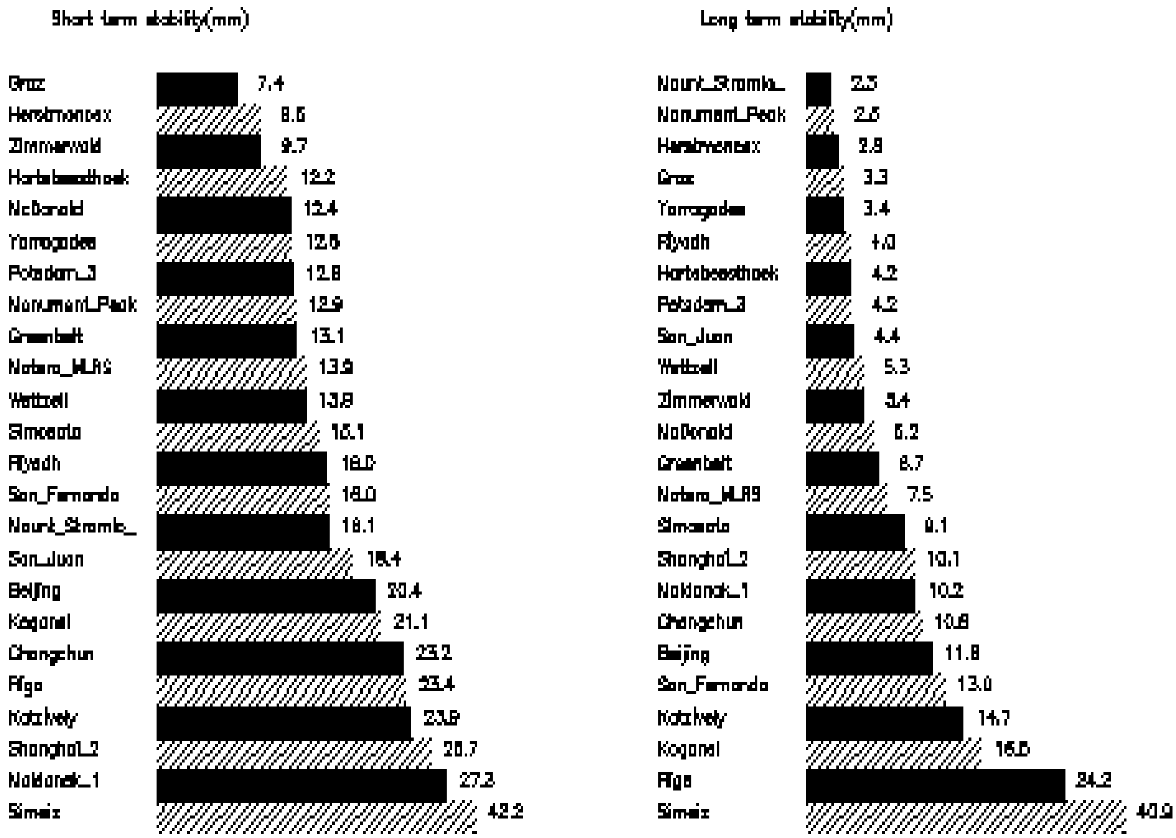
2. SLR Observations

2.1 Annual SLR passes statistics

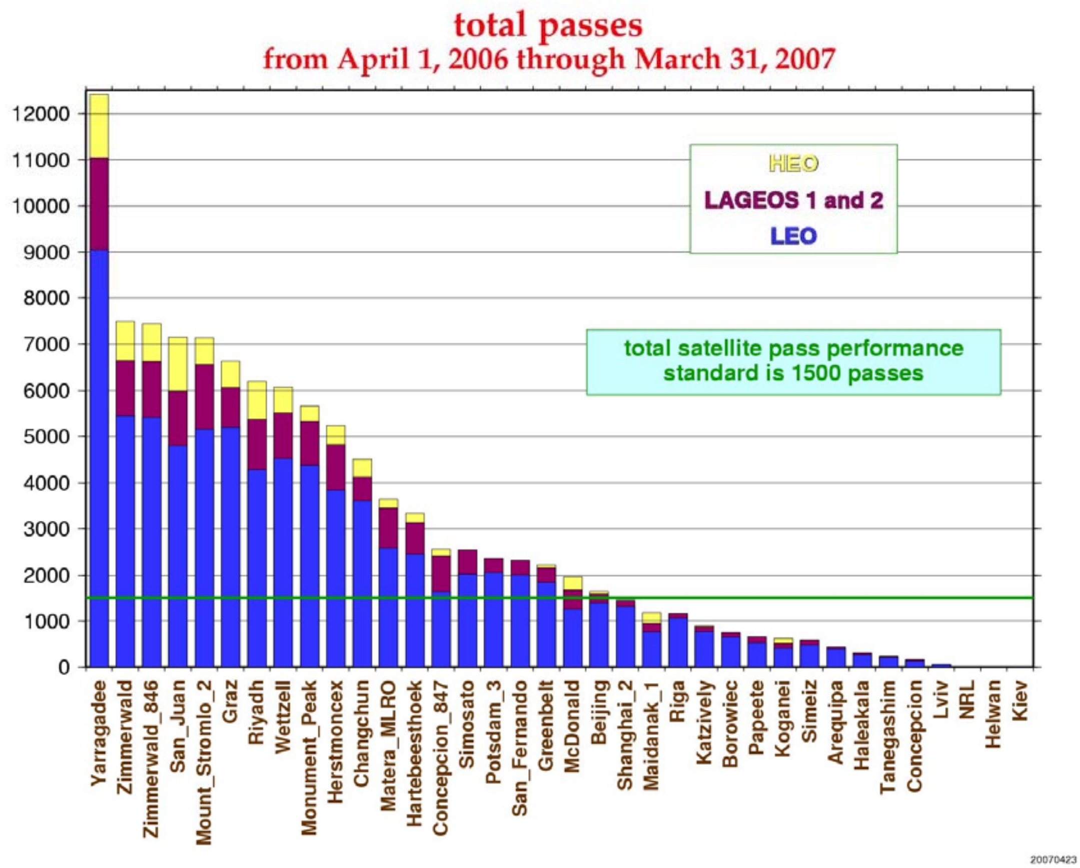
Pass totals for the year 2006 April to 2007 March

Altimetry							
ERS-2	359	Envisat	370	GFO-1	334	Jason-1	568
Geodetic/Gravity							
Lageos-1	556	Lageos-2	334	Etalon-1	64	Etalon-2	75
Champ	131	Grace A	124	Grace B	123	Beacon-C	203
Starlette	414	Stella	198	Ajisai	444	Larets	322
Navigation							
GPS35	35	GPS36	45	Glonass	922	GIOVE	11
Other support							
Anderra	18	Anderrp	25	Icesat	226		

The diagrams below show the mean short and long-term stability of the global ILRS data as determined by the ILRS associate analysis centres NICT, Japan, MCC, Russia and SHAO, China. Also shown is the number of observations from the entire ILRS network as held in the CDDIS archives for each station.



Short term stability(mm)
Graz 7.4
Herstmonceux 8.6
Zimmerwald 9.7
Hartebeesthoek 12.2
McDonald 12.4
Yarragadee 12.6
Potsdam_3 12.8
Monument_Peak 12.9
Greenbelt 13.1
Matera_MLRS 13.9
Wettzell 13.9
Simosato 15.1
Riyadh 16.0
San_Fernando 16.0
Mount_Stromlo_ 16.1
San_Juan 18.4
Beijing 20.4
Koganei 21.1
Changchun 23.2
Riga 23.4
Katzively 23.9
Shanghai_2 25.7
Maidanak_1 27.3
Simeiz 42.2
Long term stability(mm)
Mount_Stromlo_ 2.3
Monument_Peak 2.5
Herstmonceux 2.9
Graz 3.3
Yarragadee 3.4
Riyadh 4.0
Hartebeesthoek 4.2
Potsdam_3 4.2
San_Juan 4.4
Wettzell 5.3
Zimmerwald 5.4
McDonald 6.2
Greenbelt 6.7
Matera_MLRS 7.5
Simosato 9.1
Shanghai_2 10.1
Maidanak_1 10.2
Changchun 10.8
Beijing 11.8
San_Fernando 13.0
Katzively 14.7
Koganei 16.5
Riga 24.2
Simeiz 40.9



2.2 New launches

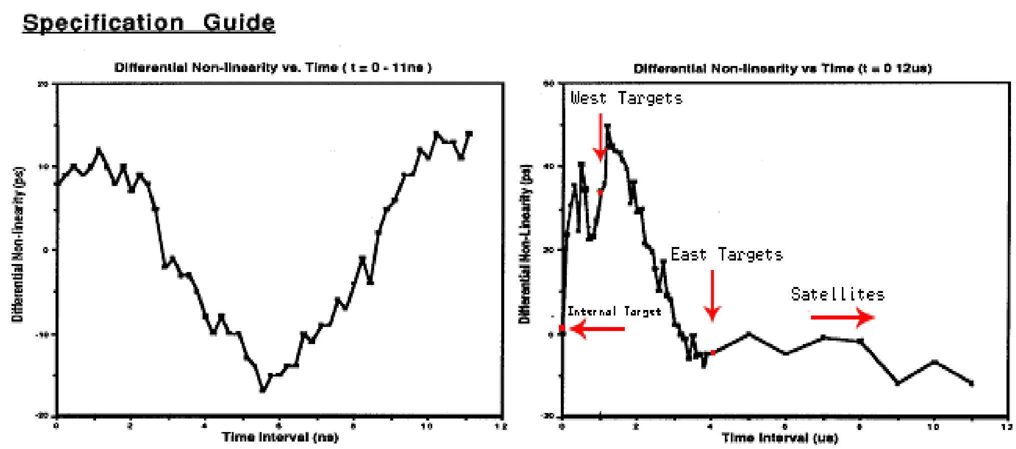
There were three new GLONASS satellites launched during the period (Numbered 101,102,103). There was also an experimental pair of satellites ANDERR-A and ANDERR-P. These have been difficult to track as the operator does not appear to be able to produce good predictions for them.

2.3 Herstmonceux Event Timer (ET)

ET was completed in July 2006. We then began the process of verifying that the performance of the device was what we expected.
Tests included

- Sending a split cable to the start and stop. This gave a jitter of 7ps which if we assume comes equally from both start and stop means individual readings have a jitter of 5ps. This is the Spec given by the manufacturer
- Simultaneous collection of data with our current epoch device and both ET channels. This gave perfect agreement and confirmed that our existing epochs are accurate to better that 100ns and that the new ET epochs will also be accurate to the same level.
- Taking 1pps data continuously over several days to monitor the stability of both channels. The stability of both channels was shown to be excellent.
- Collecting satellite data for both ET and SR620 interval timers. The differences we saw over the full range of SLR satellite distances (1ms – 180ms) agreed with the comparisons made previously using our SR620s and the Czech PPET (portable pico-sec event timer). This gave confidence that ET was producing accurate results and that the errors of the SR620s were stable over time and thus could be removed.

- Collection of data between 100ns and 4000ns (the range covered by the calibration targets) using both ET and SR620s. This was by far the most important series of tests we carried out as it allowed us to quantify the known but hitherto unmeasured errors in calibrations since 1994; this goal was one of the strong reasons for developing the ET. Our error plots as a function of time (range) agreed in structure with the crude plots shown in the Stanford manual.



Graph 1: Differential Non-linearity for time differences of 0 to 11 ns. This shows the residual non-linearity of the time-to-amplitude converters.

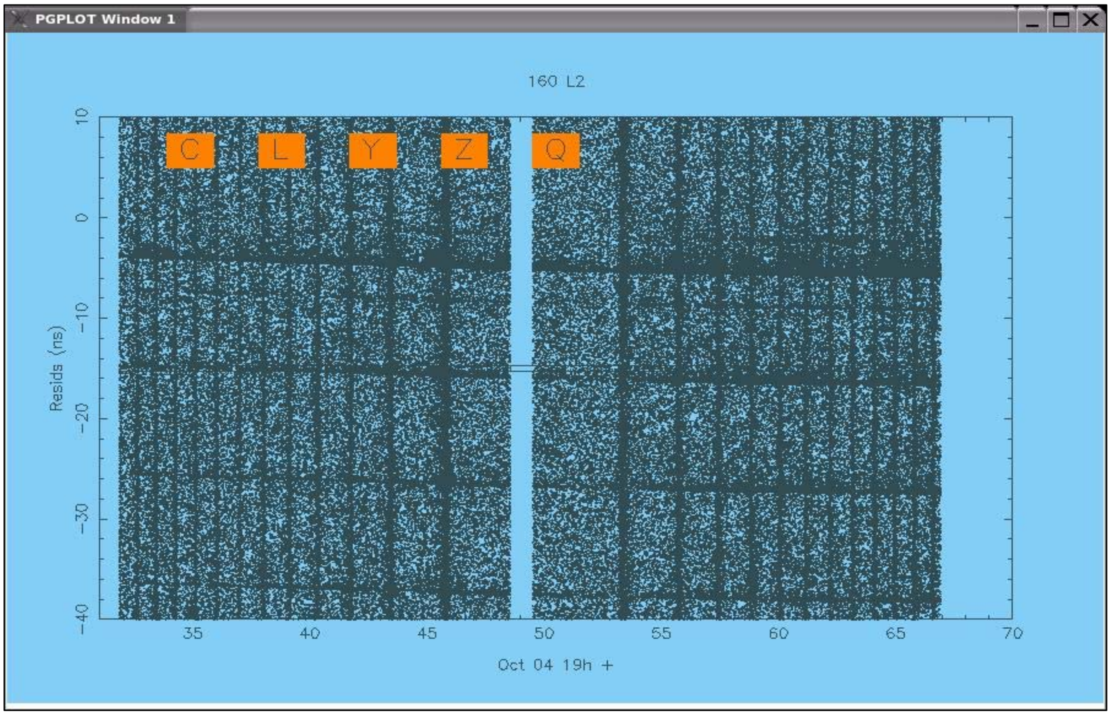
Graph 2: Differential Non-linearity for time differences of 0 to 11μs.

Using our results for the errors at close range in the Stanford data and our archived data, we found that in order to back calibrate all our satellite ranges from 1993 we should subtract 5.5 ±2mm. This correction is in addition to the positive, range-dependent correction that we determined and published in 2002; as a result, for example for LAGEOS observations made in the period 1993-2002, 2.5mm should be added to the range. A more detailed report will appear in Gibbs *et al* in the proceedings of the 15th ILRS workshop.

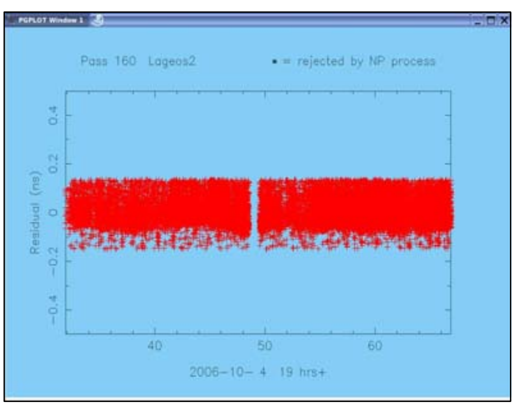
2.4 KHz Laser

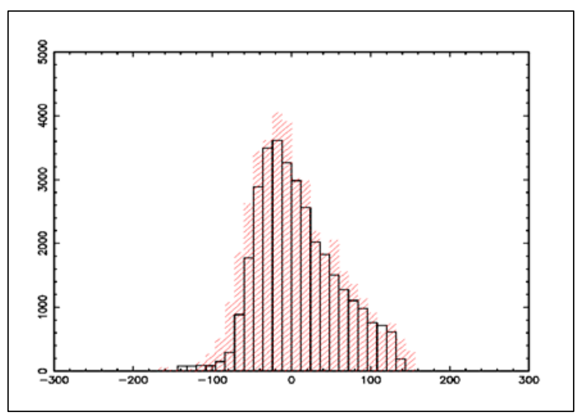
With ET successfully installed we were able to start integrating the software that had been developed for kHz ranging and our first kHz returns appeared early in October 2006. Although we knew there would be a lot more data and noise per unit time at this high rate, it was still a shock to see the display screen fill with points compared with the few dots we routinely see at 10Hz. This effect was made worse because of something we hadn't anticipated – the C-SPAD detector is ~7 times noisier at kHz rates than it is at 10Hz. However the software we had developed for detecting the anticipated low return signal has proved robust enough to cope with this large decrease in signal to noise. The new TCP/IP-based data transfer and archiving across the network also has proved a success.

Shown below is one of the first Lageos passes obtained. The various tracks in the x direction are due to spurious pulses in the laser. A realignment of the laser has since removed all of these apart from a pulse 3ns before the laser, which would appear to be a feature of the laser since our colleagues in Graz also see such a ghost pulse. The vertical lines are caused when the SPAD is gated on at the same time as an outgoing laser pulse is leaving the telescope and flooding the sky with green light. We have overcome this 'clash' by varying the firing rate of the laser to avoid such coincidences



Crucial to the value of the new data from Herstmonceux is to develop a pre-processing strategy that does not cause a discontinuity relative to the 24 years of 10Hz data from the site. Shown below is the data extracted from the noise and plotted as post-fit orbital residuals against time. At first glance there appears to be a large quantity of noise below the track, but when plotted in histogram form (black) and compared to a 10Hz data set (in red) scaled to match, it is seen that the shape of both is very similar. This investigation is at a very early stage, and will involve, primarily for LAGEOS, the development of a theoretical model from which an accurate centre of mass correction and a processing strategy will follow.





Listed below is a summary of the first observations with the kHz system showing a comparison of range precision (RMS) between the 10Hz and KHz systems. For the large-array satellites (LAGEOS, Ajisai) satellite signature effects dominate the error budget at our single photon return levels.

TARGET	10Hz single shot RMS	2kHz single shot RMS	No. of data points
Calibration	**8mm**	**4mm**	
Lageos	**16**	**14**	**33K**
Icesat	**10**	**6**	**12k**
ERS2	**10**	**6**	**70k**
Envisat	**10**	**6**	**65k**
Gfo-1	**11**	**8**	**10k**
Larets	**9**	**6**	**11k**
Stella	**14**	**10**	**10k**
Jason	**10**	**6**	**50k**
Ajisai	**40**	**42**	**57k**

2.5 Analysis

SGF, in its role as an ILRS Analysis Centre (AC), computes a weekly four-satellite station coordinate and EOP solution as a contribution towards the combined ILRS weekly product. In a major re-analysis effort, weekly solutions from 1992 to 2006 were computed and contributed to the ILRS submission towards the development by the IERS of ITRF2005 during 2006. The AC is working with other groups to resolve the current scale anomaly in ITRF2005, manifested as a scale difference of about 1ppb between the ILRS and IVS solutions, which may be related to the treatment of the ILRS data. As part of this re-analysis effort, we have developed a table of corrections for those, mainly European, stations that have used Stanford counters based upon the detailed work on our own devices as reported above. An invited talk at EGU 2007 was given on centre of mass and counter correction issues.

We continue to deliver daily, via the SGF website, an automatic, orbit-based quality check on SLR data from the Herstmonceux system and from the global tracking network. This service enables rapid, independent feedback of SLR data quality and quantity for the benefit of both the SGF and the wider community. The Facility also generates daily orbital predictions of the geodetic satellites, as an official back-up contribution to the ILRS prediction efforts.

2.6 Global SLR network.

The NASA systems at Arequipa, Peru and at Haleakala, Maui, Hawaii, are both back in operation after two-year closures. A new Russian system at the Baikanour satellite launch site is now operational, as plans to develop a significant number of new stations over the next few years continue. The relocated Chinese system that commenced operation at the beginning of 2006 at San Juan, Argentina, has rapidly established itself as a very accurate and prolific station, adding a very useful southern hemisphere capability to the network.

2.7 Local Target.

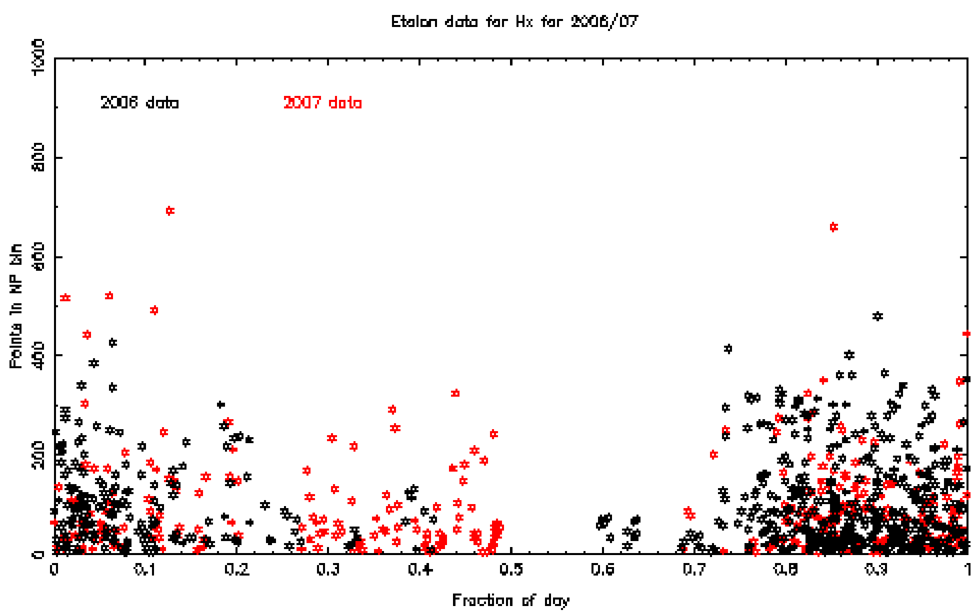
Range observations using the ET to the in-dome calibration target provide for the first time, and at a level of accuracy of 1mm, an independent check on the standard range calibration value derived from the external calibration target. Non-linearities present in the Stanford counters had previously confused this issue, despite our confidence in the survey (OS and UCL) distance to the external target. In addition, a new laser calibration target has been installed 200m south of the Facility on an ex Met-Office tower. The stability of this platform still needs to be confirmed. A survey will be required to link this target into the local frame.

2.8 Photometric observations.

The laser ranging tracking system was used by request from MoD to monitor reflected sunlight variations from several satellites. The observations were reduced and communicated to MoD as short reports

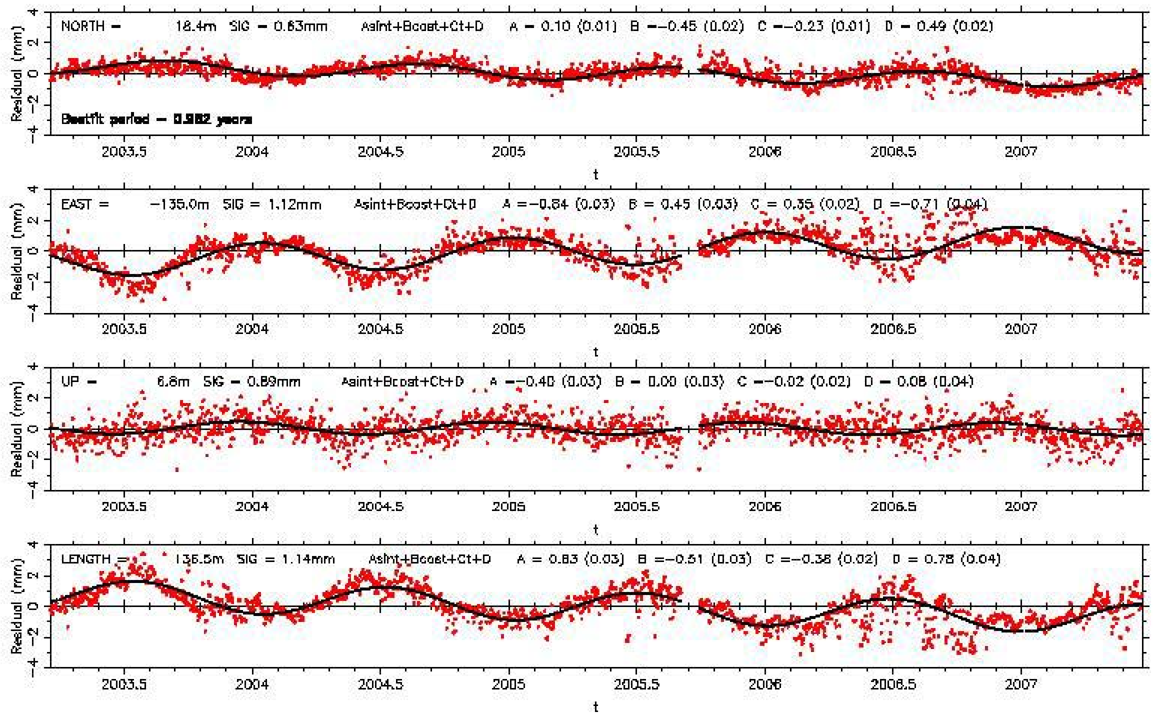
2.9 Improved HEO tracking in daytime.

With ET in place we have been able to range at 14Hz (the YAG laser's maximum repetition rate) since of course the new system can cope with multiple in-flight laser pulses and is therefore not restricted to ranging at ~5Hz as was the case with the Stanford counters for HEOs. This improvement should greatly assist tracking of HEOs during the day when the signal to noise ratio is much lower and indeed we already have seen a useful increase in the amount of daytime Etalon data for 2007 compared with that during 2006, as shown in the plot below.



3. GPS and GLONASS Continuously Operating Receivers.

The Ashtech Z-12 operating at IGS site HERS has continued to run smoothly this year. While the receiver is aging, there does not appear to be any problem with the data quality that it produces. As our main IGS site with the longest occupation we would like ultimately to upgrade this location to a Galileo compatible system as and when this seems sensible. In the meantime we are having continuing problems with our Z-18 (IGS site HERT). In common with many other Z-18 systems across Europe, HERT suffered a tracking anomaly in early April that caused it to lose data for a large part of day. This error was fixed by changing some internal settings (disabling an inactive slot) but the receiver remains vulnerable to this type of problem as it is entirely unsupported by the manufacturer. The device also seems to be failing (communication errors typically) more often as time goes by, each time requiring a power cycle and causing data loss. We have taken advice on what would be a suitable replacement and modern GPS/GLONASS 'all in view' types would seem to offer several benefits. Obviously better reliability and support would be a large advantage but in addition the tracking of unhealthy satellites and compatibility with new GPS signals would make the data from this site more useful both to us and the wider user community. To this end we are currently involved in obtaining quotes for suitable replacement systems.



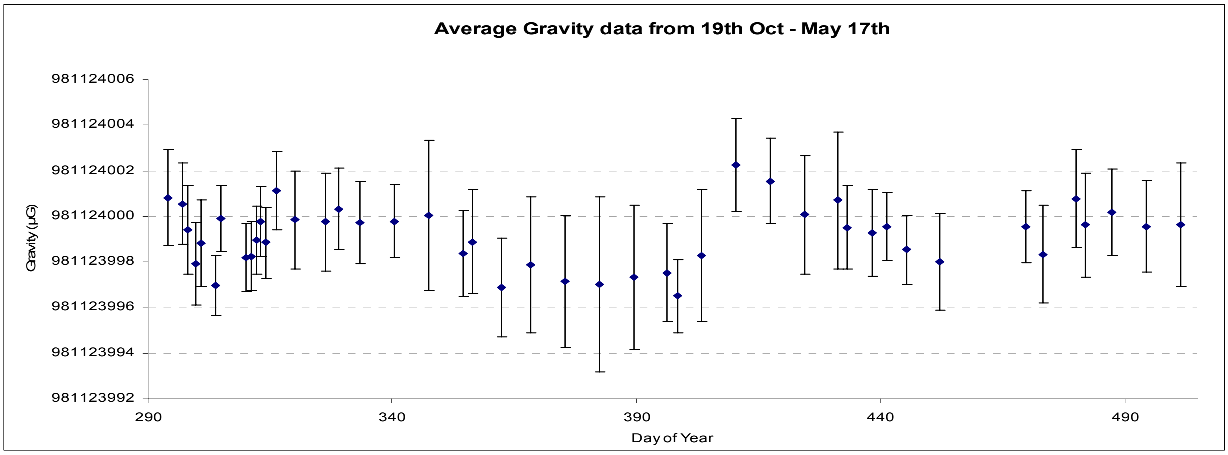
The HERS-HERT baseline has been re-analysed using the GAMIT software in differential mode. The close to annual variation (~358 day period, ~1mm amplitude) in the plot above was not previously visible in our standard global analyses. A significant secular decrease of about 0.4 ± 0.02mm/yr is also evident in the baseline distance. The causes of these signatures are unknown, but recent literature does suggest that pseudo-annual periods can result from the near-diurnal GPS constellation repeat patterns. The secular decrease is under investigation using more that 10 year’s laser data taken from the co-mounted calibration target.

4. Absolute Gravimeter

The gravimeter has been fully operational since mid-October 2006 running once a week, with data sets covering the 24hr period centred on mid-GPS week. A good time series of data is beginning to build up and analysis has begun on the data. Currently this has involved looking at the differences in treatment of ocean loading implicit in the supplied Micro-g Lacoste programme and that used by the SATAN SLR analysis software, plus an investigation into the effect of local environmental conditions on the gravimetry results.

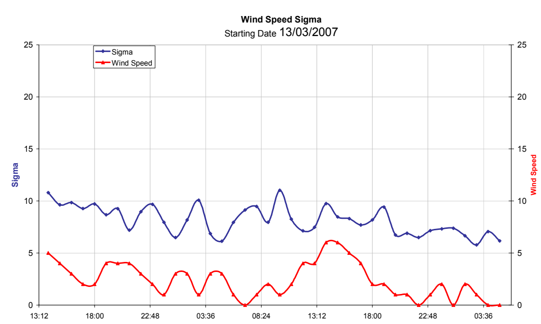
The gravimeter room now has locations for up to three visiting gravimeters which have been defined by floor studs which have been surveyed into the local network by the Ordnance Survey. Two SGF staff members are now also trained to run the gravimeter for the weekly data collection.

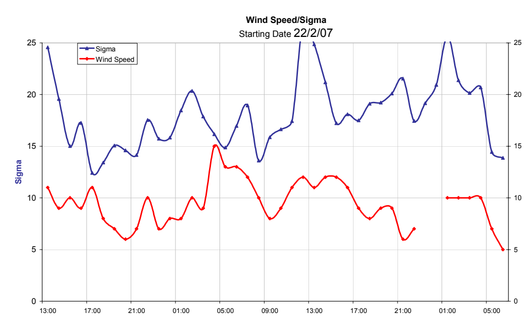
The time series of data October 2006 – May 2007 is shown below, with the standard deviation for each average value shown as error bars on the graph. It should be noted that the initial gravimetry data (days 290 – 350) is likely to have been affected by major buildings work taking place on site (100m away).



Though a shift in the average data value for the data from the day of year 410 (2007 Feb 13) seems apparent there is currently no explanation to account for this. It can be seen that on average over the 'winter' period the standard deviation of a day's data appears to increase dramatically. Following this increase and advice from Dr Williams some initial investigations have begun into possible correlation between local wind speed conditions and gravimetry standard deviation values. The wind speed data were taken from the Herstmonceux Meteorological Office outstation. Hourly averaged wind speed/direction data was compared to set-averaged hourly gravity data in an effort to define any trends. A couple of examples are given here:

It is clear that in general a high wind speed leads to a noisier gravity measurement (RHS plot) compared to the 'calm' results on the left below. A more detailed, higher time-resolution cross-correlation analysis may be hampered by the fact that the met station is over two miles away from the SGF.





4.1 Outlook

In the upcoming months the gravimeter will be moved around the three other 'pier' studs to obtain a nominal gravity value for each site.

A standard gravity gradient is currently being used for data analysis but it is hoped a relative meter will be available in the coming months to make a definite measurement, which can then be applied to all data.

The gravimeter is also due to participate in a European inter-comparison study to be held in Luxembourg in November, during which around 20 or so gravimeters will be run alongside each other with members from Micro-g Lacoste on hand for assistance should it be required.

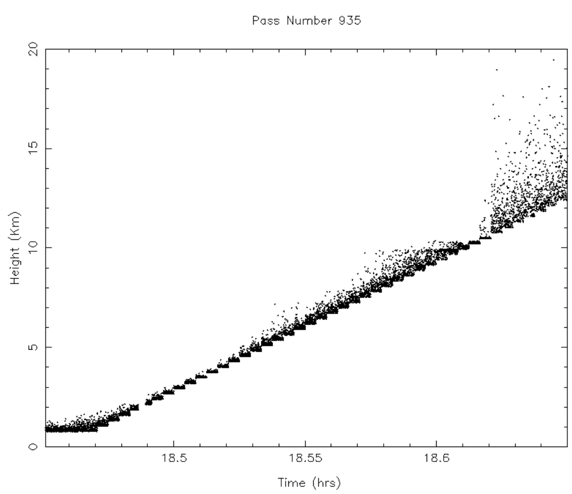
Following this inter-comparison the gravimeter will be due to be sent back to the manufacturers Micro-g for its bi-yearly service (early 2008).

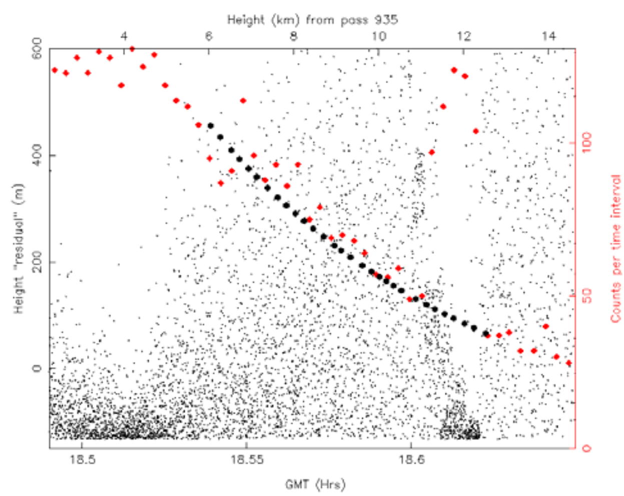
4.2 Equipment

Furthering the wind speed and direction studies and to aid in the definition of forces affecting the SGF site we would like to propose the purchase of an anemometer with wind direction recording, a rain fall metre and a multi-gang soil moisture probe.

5. LIDAR

We are developing a LIDAR capability, ultimately to run concurrently with standard satellite laser ranging measurements. Our interest is in monitoring atmospheric pollution, boundary layer heights and cirrus properties over the site, in a collaboration with the chemistry department at Cambridge University. For preliminary testing we have developed a modified version of the laser ranging software and used the existing laser ranging hardware to detect backscatter at a range of heights of from one to 14 km vertically above the site. During experimental runs the CSPAD detector is gated in few-hundred metre increments from close to the telescope to beyond the tropopause, and time-tagged single-photon backscatter events are detected. Over the experimental period of a few minutes a vertical profile of atmospheric response is mapped and various layers detected. Some analyses of these preliminary results are shown below and plans for future enhancement include an additional dedicated detector system to allow LIDAR and SLR to be carried out simultaneously.





With the telescope set towards the zenith, we gate the C-SPAD for say 30-seconds at each height above the site, from 1000 to 14,000m and collect backscatter events. The plot above shows the ‘stepladder’ that results when the raw event-height results are plotted against time.

We carry out a preliminary analysis of the backscatter measurements by plotting return density against height. A haze layer can be seen at about 4-5Km above the site, followed by a further layer at 12 km, probably identified with the tropopause. We have further fitted an exponential decay curve to the data above the haze layer, and determine an atmospheric scale height in the region of 6km.

6. Meetings, etc.

6.1 ILRS workshop in Australia.

G Appleby and P Gibbs attended the 15th International Workshop in Canberra and presented papers on kHz ranging, a reassessment of SGF range accuracy and a poster on the new LIDAR work. Various working groups were contributed to and attended, Gibbs primarily the Network and Engineering WG on counter calibration and Appleby the Analysis WG on TRF solutions. Trip reports have been written.

6.2 EGU 2007.

A solicited oral presentation on systematic effects in laser ranging data was given in the Geodesy Techniques session, and a poster presented on Site Stability from analysis of SGF's GNSS, SLR and Gravity data.

7 Funding

7.1 Ministry of Defence

The MoD programme manager Dr David Holland retired during the year, handing over the interaction with SGF to Mr Simon Walker, who has subsequently visited the Facility on a number of occasions. During May 2007 a MoD management team visited Herstmonceux for a presentation on SGF's work for MoD and a site tour. Prior to Dr Holland's retirement, the PIMS telescope in the dome at SGF and a spare unit stored on site had been handed over to NERC/SGF to supplement its operational capability. Further use of that system for the current MoD programme was discussed and welcomed by MoD.

The MoD management team expressed its wish to continue to fund what it viewed by MoD as an important Facility.

7.2 BNSC

BNSC gave notice at the end of FY2006/07 that it is unlikely to continue co-funding the Facility.

8 Infrastructure

8.1 Computer LAN.

The current LAN is showing signs of aging, and its multi-epoch Ethernet systems are likely responsible for observed 'bottleneck' effects. R Sherwood in consultation with ITSS is working on a proposal to upgrade the network. The upgrade will include facilities ultimately to host the SGF website, which is currently managed at Monks Wood.

8.2 Meeting Room.

Shortly after the June 2006 meeting of NSGFSC in the new basement room, a large water leak was discovered in the ceiling. The contractors have carried out several repair attempts, but the problem remains to be resolved. The makers of the membrane have inspected the problem, and it is hoped that it will be fixed very soon. NERC Estates' Management team is thanked for its ongoing support of this protracted project.

8.3 Greening. Several suggestions to conserve energy on site have been put to the NERC Greening initiative. The proposals primarily involve insulation of the main building to reduce work required of the air-conditioning plants and insulation of the offices to conserve heating energy. This work will likely be funded within the recurrent operational budget.

8.4 Forward Look. A five-year FL of proposals for short, medium and long-term developments for SGF has being developed at the request of the NSGFSC chair and NERC S&F management. A draft is included in the papers for comment by the Committee at its meeting to be held on 27th June 2007.

9 SGF Staff

David Benham, SGF Mechanical Engineer, retired from full-time employment in February 2007. He has since been re-employed part-time and is working on several ongoing mechanical projects. Approval was given by NERC S&F to recruit a Band 7 'trainee' mechanical engineer both to maintain a mechanical capability on site and provide primarily daytime observing assistance. Interviews have taken place and the new staff member is expected to start in June 2007.

10 Public relations

We continue to host evening visits from various astronomical societies. We also gave a number of tours of the site, arranged through the Herstmonceux Science Centre. Students and Faculty members from the International Study Centre, Queen's University at Herstmonceux are regular visitors to the SGF.
Three lectures on space geodesy and the work of the SGF were given to ISC students taking undergraduate astronomy and geography options.
We are involved in the school work-experience project and take in a few 15-year-old students for a week's work experience. Work done by one of the work experience students in March on Gravity/Wind Speed plots was included in the poster presentation given at the EGU in Vienna in 2007.

11 Publications (in house)

Appleby, GM; Gibbs, P; Sherwood, R; Wilkinson, M. Streaming GNSS Data via the Internet from the NERC Space Geodesy Facility, Herstmonceux, UK. *Proceedings of the NTRIP Symposium and Workshop, BKG, Frankfurt, Germany, February 2006.*

Appleby, GM; Wilkinson, M. Local Surface Deformation at Herstmonceux from SLR and GPS analyses, *Geophysical Research Abstracts*, *Vol 8, EGU, 2006*.

Appleby, GM; Otsubo, T. Monitoring the Accuracy of IGS GNSS Orbital Solutions using ILRS Laser Range Observations, *Geophysical Research Abstracts*, *Vol 8, EGU, 2006*.

Otsubo, T; Appleby, GM; Gotoh, T; Kubo-oka, T. Potential TRF Improvements through Better Understanding of Laser Ranging Target Signature Effects, *Geophysical Research Abstracts*, *Vol 8, EGU, 2006.*

Appleby, GM; Gibbs, P. "First Laser Range Measurements to GIOVE-A", *Inside GNSS*, May/June 2006

Gibbs, P; Appleby, GM; Potter, P. A reassessment of laser ranging accuracy at SGF Herstmonceux. In press, Proc. *15th Int. Laser Ranging Workshop, Canberra, October 2006.*

Gibbs, P; Potter, P; Sherwood, R; Wilkinson, M; Benham, D; Smith, V; Appleby, GM. Early Results of Kilohertz Laser Ranging at Herstmonceux. . In press, *Proc. 15th Int. Laser Ranging Workshop, Canberra, October 2006.*

Appleby, GM; Jones, R; Potter, P; **Gibbs, P.** LIDAR experiments at the Space Geodesy Facility, Herstmonceux, UK. *In press, Proc. 15th Int. Laser Ranging Workshop, Canberra, October 2006*.

UK Geodesy-related Publications for calendar year 2006.

Andersen O B; Butts M; Jakobsen F; Lemoine F G; Lutcke S B; Berry P A M; Freeman J A. Flooding in Bangladesh from satellite altimetry and GRACE gravimetry, International workshop on coast and land applications of satellite altimetry, Beijing, China, July 21-22, 2006.

Andersen O; Knudsen P; Berry P A M; Kenyon S; Knudsen P. The DNSC05 high-resolution global marine gravity field. "15 Years of Progress in Radar Altimetry" Symposium, Venice Lido (Italy), March 13-18, 2006.

Anderson O B; Berry P A M; Freeman J A; Lemoine F; Luthcke S. Water Storage in the Amazon Basin from GRACE gravity and Satellite Altimetry "15 Years of Progress in Radar Altimetry" Symposium, Venice Lido (Italy), March 13-18, 2006.

Andersen O; Berry P A M; Freeman J A; Lemoine F G; Lutcke S B; Butts M; Jakobsen F; Smith R. Investigating GRACE gravimetry and satellite altimetry for studies of large scale hydrological signal and flooding in Bangladesh. EGU 06, Vienna (Austria), April 2-7 2006.

Berry P A M; Freeman J A; Garlick J D; Smith R G; Benveniste J. A Decade of Global River and Lake Heights from ESA Altimeter Missions. "15 Years of Progress in Radar Altimetry", ESA Pub. SP-614. 2006.

Bingham R J; Hughes C W. Observing seasonal bottom pressure variability in the North Pacific with GRACE Geophysical Research Letters, 33(8): L08607 2006.

Bradley S L; Shennan I; Milne G; Brooks T; Teferle F N; Bingley R M; Waugh A J. Constraining the Evolution of the British Isles Ice Sheet Using Observations of Sea-Level Changes and 3D Crustal Motions, Geophysical Research Abstracts, 8, 08134, EGU06-A-08134, 2006.

Edwards S J; P Moore. A GPS and cold ocean brightness temperature calibration of the ERS-2 and TOPEX/Poseidon microwave radiometer, Marine Geodesy, 29(1): 65-84. (2006).

Fratepietro F; Baker T F; Williams S D P; Van Camp M. Ocean loading deformations caused by storm surges on the northwest European shelf Geophysical Research Letters, 33(6): L06317 2006.

Freeman J A; Berry P A M. A new approach to re-tracking ocean and coastal zone multi-mission altimetry, "15 Years of Progress in Radar Altimetry", ESA Pub. SP-614. 2006.

Greaves M; Bingley R M; Baker D F; Appleby G. National report of Great Britain, 2006. Report on the Symposium of the IAG Subcommission for the European Reference Frame (EUREF), June 2006.

Hide C D; Moore T; Hill C J; Park D W G. Journal of Navigation,: Low Cost, High Accuracy Positioning in Urban Environments. , Vol: 59(3), pp:365-380, 2006.

Hughes C W; Meredith M P. Coherent sea-level fluctuations along the global continental slope Philosophical Transactions of the Royal Society of London, A, 364(1841): 885-901 2006.

Jevrejeva S; Grinsted A; Moores S P; Holgate S J. Nonlinear trends and multiyear cycles in sea level records Journal of Geophysical Research, 111(C9): C09012 2006

King M A; Moore P; Clarke P J; Lavallée D A. Choice of optimal averaging radii for temporal GRACE gravity solutions, a comparison with GPS and satellite altimetry, Geophysical Journal International, 166(1): 1-11, doi:10.1111/j.1365-246X.2006.03017.x. (2006).

Kreemer C; Lavallee D A; Blewitt G; Holt W E. On the stability of a geodetic no-net-rotation frame and its implication for the International Terrestrial Reference Frame, Geophysical Research Letters, 33(17), L17306, doi:10.1029/2006GL027058. (2006).

Lavallee D A; van Dam T; Blewitt G; Clarke P J. Geocenter motions from GPS: A unified observation model, Journal of Geophysical Research - Solid Earth, 111(B5), B05405, doi:10.1029/2005JB003784. (2006).

Li Z; Fielding E J; Cross P A; Muller J-P. Interferometric synthetic aperture radar atmospheric correction: GPS topography-dependent turbulence model. Journal of Geophysical Research - Solid Earth, 111, B02404, doi:10.1029/2005JB003711, 2006.

Marshall D P; Johnson H L; Hughes C W; Williams R. Hydrographic variations along the sloping western and eastern boundaries of the Atlantic: observations, theory and a monitoring array Eos, Transactions, American Geophysical Union, 87(36 (Supplement)): OS45F-02 [Abstracts] 2006.

Meng X; Dodson A H; Roberts G W; Andreotti M. Prototype Internet RTK GPS for Bridge Deformation Monitoring., Survey Review, 38(299): 348-357, 2006.

Milne G A; Shennan I; Youngs B A R; Waugh A I; Teferle F N; Bingley R M; Bassett S E; Cuthbert-Brown C; Bradley S L. Modelling the Glacial Isostatic Adjustment of the UK Region. Philosophical Transactions of the Royal Society, Part A, 364, 931-948, 10.1098/rsta.2006.1747, 2006.

Moore P; Zhang Q; Alothman A. Recent results on modelling the spatial and temporal structure of the Earth's gravity field, Philosophical Transactions of the Royal Society A - Mathematical Physical and Engineering Sciences, 364(1841): 1009-1026. (2006)

Rietbroek R; LeGrand P; Wouters B; Lemoine J -M; Ramillien G; Hughes C W. Comparison of in situ bottom pressure data with GRACE gravimetry in the Crozet-Kerguelen region Geophysical Research Letters, 33(21): No L21601 2006.

Roberts G W; Meng X; Brown C J; Dallard P. GPS Measurements on the London Millennium Bridge, ICE Bridge Engineering Journal, 159(BE4):153-161. 2006

Teferle F N; Bingley R M; Williams S D P; Baker T F; Dodson A H. Using continuous GPS and absolute gravity to separate vertical land movements and changes in sea-level at tide-gauges in the UK Philosophical Transactions of the Royal Society of London, A, 364(1841): 917-930 2006.

Tsimplis M N; Shaw A G P; Flather R A; Woolf D K. The influence of the North Atlantic Oscillation on the sea-level around the northern European coasts reconsidered: the thermosteric effects Philosophical Transactions of the Royal Society of London, A, 364(1841): 845-856 2006

Woodworth P L; Hughes C W; Blackman D L; Stepanov V N; Holgate S J; Foden P R; Pugh J; Mack S; Hargreaves G W; Meredith M. Antarctic peninsula sea levels: a real time system for monitoring Drake Passage transport Antarctic Science, 18(3): 429-436 2006.

Woodworth P L. Some important issues to do with long-term sea level change Philosophical Transactions of the Royal Society of London, A, 364(1841): 787-803 2006.

Williams S; Willis P. Error Analysis of Weekly Station Coordinates in the DORIS Network, Journal of Geodesy, 1-15 2006.

NERC SERVICES & FACILITIES

NERC SPACE GEODESY FACILITY

MISSION STATEMENT

- To make laser range measurements to the special satellites that carry retro-reflectors, according to priorities assigned by the NERC Space Geodesy Steering Committee, and in accordance with international projects and priorities.
- To ensure that the range measurements are of the highest possible accuracy.
- To contribute the data promptly to the international SLR data centres.
- To operate geodetic GPS and GLONASS receivers on the site and contribute the data regularly to the international GPS/GLONASS data centres
- To maintain and develop the software and hardware of the systems in order to give high reliability and to keep the precision of the systems at the current state of the art.
- To achieve a high productivity level of numbers of satellite passes tracked.
- To assist and collaborate with UK analysts in their use of satellite tracking and related data.

In order to fulfil its mission the Space Geodesy Facility will :

- maintain an up-to-date knowledge of international developments of hardware and software in satellite tracking technology
- contribute to the international advancement of the technology, particularly in the areas of orbital predictions, software data processing, and the use of photo-diode detectors
- maintain a constant vigilance for sources of measurement error
- participate fully in UK and international co-ordination of SLR and GPS/GLONASS activities
- carry out data analysis and research, in order to maintain a real awareness of what the users require from the data

User Communities :

The observations from the facility are contributed to international data centres, together with data from other geodetic facilities around the World. The data are used in combination with data from all precise space geodetic techniques by analysis groups world-wide and within the UK for a variety of studies, including oceanography, glaciology, the gravity field of the Earth, tides in the Earth and oceans, a global reference frame, and crustal motion. These data products are used widely by the oceanographic and solid earth science groups within the UK and world-wide.

SGF Inventory 2006/07

Range Finding Ny:YAG Laser System (JK Lasers)
KHz Laser system (Hi-Q Lasers)
Controlled Atmosphere Tent
Laser Emitting & Receiving Telescope (Contraves)
Telescope Control Unit (Heasons)
Tip/Tilt Mirror Mounting And Controller
Compensated SPAD Detector (PESO)
Spare SPAD (PESO)
CCD TV Camera + Frame Grabber
ISIS Camera

S Band Radar System
Oscilloscope For Radar
4x Oscilloscopes

FG5 Absolute Gravimeter (Micro-G)

Z12 GPS Receiver (Ashtech)
Z18 GPS Receiver (Ashtech)

3x Timing Modules (Stanford)
2x Four Channel Digital Time Interval Generator
Event Timer (Thales, SGF)
Disciplined Frequency Standard
2x Universal Time Interval Counters (Stanford)

2xLINUX PC servers
Laptop
Digital Projector

Workshop lathe

CCTV Security System