# National Report of Great Britain 2013

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**Abstract** .. Activities of Ordnance Survey, the national mapping agency of Great Britain. Also activities from NERC British Isles continuous GNSS Facility (BIGF), NERC Space Geodesy Facility Herstmonceux and Newcastle University.

**Keywords**. Ordnance Survey, NERC British Isles continuous GNSS Facility (BIGF), NERC Space Geodesy Facility Herstmonceux, Newcastle University

## 1 Ordnance Survey activities

### 1.1 National GNSS network

The OS Net network is currently managed using the GPSNet™ software from Trimble and delivers RTK corrections via GSM and GPRS to approximately 130 Ordnance Survey surveyors. Public services are also available via Ordnance Survey commercial partners. Partners take the raw GNSS data streams from OS Net servers via NTRIP and use them to generate their own correction services.

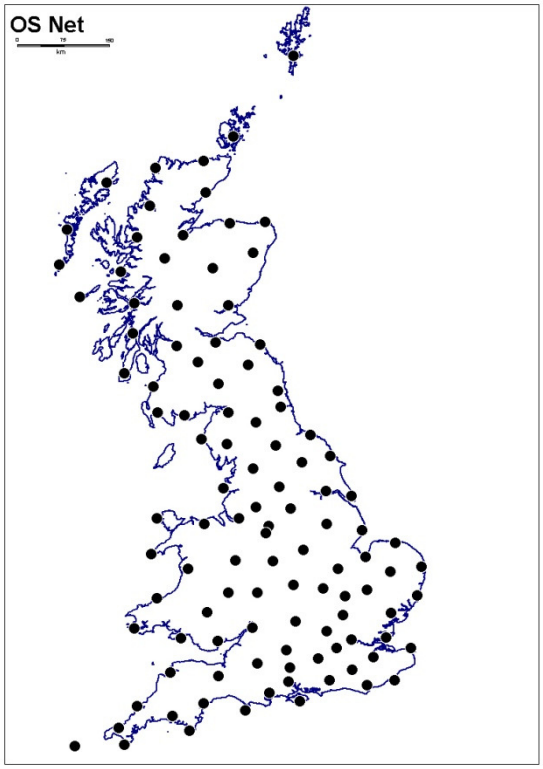


**Fig. 1** OS Net GNSS Network

Current commercial partners offering RTK service in Great Britain are AXIO-NET, Leica, Soil Essentials, Topcon and Trimble. Current partner details can be found at :
*http://www.ordnancesurvey.co.uk/oswebsite/products/os-net/index.html.*

A server and software upgrade is currently on going. New software will be Trimble "Pivot Platform" and it will be run off duplicated virtual server clusters – one at Ordnance Survey HQ and the other at an offsite facility. This will provide complete redundancy of all aspects of the service and also allow for quick resource scaling and testing of upgrades and changes.

### 1.2 EPN data submissions

Current EPN submissions from GB are hourly data from HERS, HERT (run by the Natural Environment Research Council, NERC) and MORP (run by Newcastle University) plus 24 hour files from DARE, INVR (OS Net stations), and NEWL (run University of Nottingham). It is still intended to ultimately submit all the OS Net stations that were part of EUREF GB/IE 2009 stations as EPN stations and submit hourly data from them as well. However this is currently on hold waiting for resources to work on the changes.

RTCM 3.0 data from EPN stations DARE, INVR and from OS Net station SHOE are streamed in real time via NTRIP. This is in addition to RTK data from HERT.

### 1.3 Geoid model improvement

Work to improve the geoid model is still on going. It was hoped to complete the new geoid model in 2010 but initial analysis showed some inconsistencies remained. Further test observations at bench marks are being taken to test the preliminary post-fit model surface. Depending on the outcome of these tests more GNSS observations may be required to improve the fit of the geoid model to Ordnance Datum Newlyn (ODN).

## 2 BIGF – NERC British Isles continuous GNSS Facility

BIGF is operated from the Nottingham Geospatial Institute (NGI, formerly IESSG) at The University of Nottingham, and is funded by the UK Natural Environment Research Council (NERC).

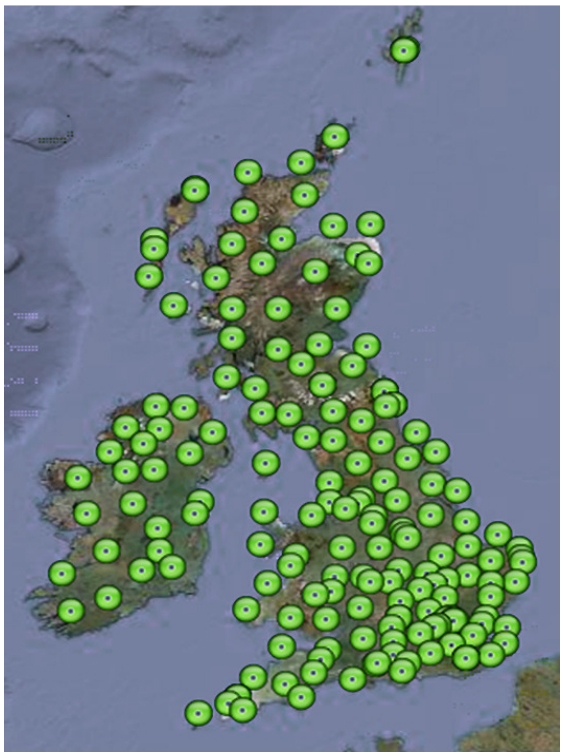

**Fig. 2** The BIGF Network 2013

Fig. 2 shows the current network of 161 stations, which includes six stations that are part of the IGS and EPN (DARE, HERS, HERT, INVR, MORP, NEWL) and ten CGPS@TG stations that contribute to the IGS TIGA Project (ABER, DVTG, LWTG, LIVE, LOWE, NEWL, NSLG, PMTG, SHEE, SWTG).

BIGF archives quality-assured raw data and generates derived products, based on a network of continuous GNSS stations sited throughout the British Isles. This network includes the active stations of OSGB plus those of Leica Geosystems, Ordnance Survey Ireland and Land and Property Services Northern Ireland. It also includes a number of 'scientific' stations established by: Defra; the UK Environment Agency; the UK Met Office; NERC National Oceanography Centre, Liverpool; NERC Space Geodesy Facility; Newcastle University, the University of Hertfordshire and the University of Nottingham.

Quality assured raw data can be requested from www.bigf.ac.uk. Cumulative demand on the archive, since inception in 1998, approaches 5.3m station-days and the number of scientists annually making use of the archive has risen steadily since then, with ongoing studies of land movement and sea level and atmospheric work in both the

ionosphere and troposphere facilitated by both historic data and ongoing daily data from this dense network.

Since 2009, BIGF has also started to generate a range of derived products from the quality assured raw data, with the aim of facilitating the scientific research of non-GNSS specialists. The initial derived products were station coordinates and velocities, building on previous University of Nottingham research on the use of CGPS and absolute gravity (AG), which was carried out in collaboration with the NERC National Oceanography Centre, Liverpool to provide: maps of current horizontal and vertical land movements based on about 30 CGPS stations for the period from 1997 to 2005 (Teferle et al. 2009); estimates of changes in land and sea levels at ten tide gauges (Woodworth et al. 2009); and constraints for models of crustal motion due to glacio-isostatic adjustment (Bradley et al. 2009).

A recent BIGF map of current vertical land movements is shown in Fig. 3. This map, and further iterations that have been produced since, are based on a re-processing of data from 1997 to present with an in-house modified version of Bernese Software version 5.0, connecting the BIGF network to the ITRF2008 via a global network of reference stations, and using IGS repro1 (CO1/C11) re-analysed satellite orbit and Earth orientation products, the VMF1G mapping function for the troposphere, and absolute models for antenna phase centre variations. The resultant map is generally consistent with maps of relative land level changes in the UK over the last ~1,000 years based on geological studies (Shennan and Horton, 2002; 2012).

In addition to station coordinates and velocities, other derived products that can be requested from www.bigf.ac.uk include near real-time tropospheric parameters (15 minute estimates of zenith total delay, zenith wet delay and integrated water vapour) and re-processed tropospheric parameters (as time series from 1997 to present).

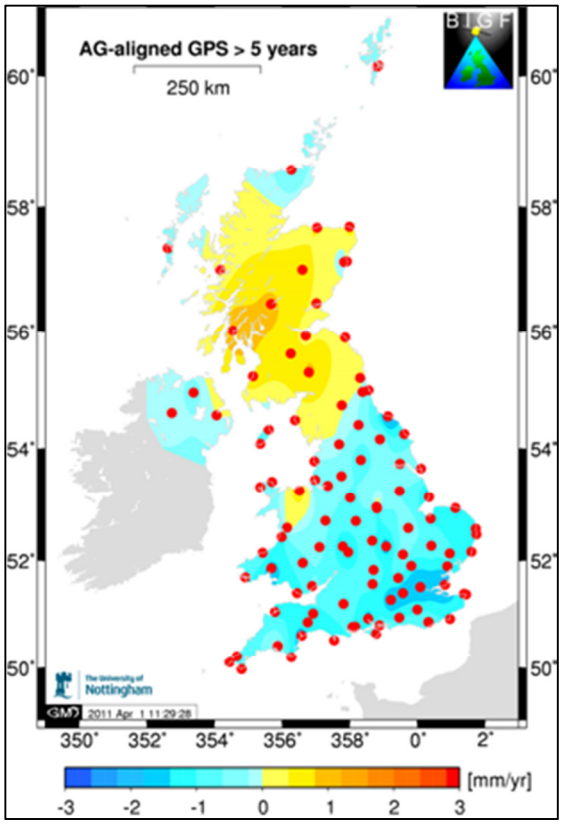


**Fig. 3** Map of current vertical land movements at 104 CGPS stations in the UK, based on CGPS measurements for the period from 1997 to 2010 and AG measurements for the period from 1995/6 to 2009

Examples of major research projects using BIGF quality-assured raw data in 2012/13:

- BESS (Biodiversity & Ecosystem Service Sustainability) Consortium, led by Cranfield University, for: Fragments, functions and flows - the scaling of biodiversity and ecosystem services in urban ecosystems.
- Japanese National Institute of Information and Communications, for: Ionospheric research using total electron content over Europe.
- Royal Observatory of Belgium, for: Densification of the European Permanent GNSS Network for ionospheric studies.
- Scottish Association for Marine Science for: Ireland, Northern Ireland and Scotland Hydrographic Survey Project (INIS).
- University of Leeds for: British Isles motion and rotation pole.
- University of Luxembourg for: The potential of precipitable water vapour measurements from

GNSS and their reprocessing of the TIGA GPS data set.

- University of Nevada, for: Towards a global ambiguity resolved precise point solution and time series, for studies of plate tectonics and global strain rate analysis.
- University of Wales, for: Sea water incursions and the palustrine Teifi Marsh – impact on wetland processes and dynamics.
- Examples of major projects that used BIGF derived products in 2012/13:
- University of Southampton for: Enhanced scientific value from remotely-sensed data through improved pre-processing methods and models: towards an integrated UK Environmental Change Observatory.

Examples of other research supported with BIGF quality-assured raw data in 2012/13:

- Annual beach monitoring project, sand movement and levels.
- Assessment of recent and historic coastal change along the western coast of South Uist.
- Cirencester Abbey test GPR survey.
- Coupling between GPS and INS.
- Fixed ambiguity precise point positioning using tropospheric corrections based on numeric weather modelling.
- Hydromorphological mapping of intertidal features by remote sensing.
- Investigations of GNSS antenna effects on high-precision GNSS positioning at GeoNet and two UK scientific GNSS stations.
- Multi-sensor fusion for driverless car technologies.
- Strategic Regional Coastal Monitoring Programme.
- Using remote sensing imagery to map habitats in the Pumlumon Mountains.

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## 3 Space Geodesy Facility at Herstmonceux

The Space Geodesy Facility is located at Herstmonceux, UK, with funding from the Natural Environment Research Council (NREC) and the UK Ministry of Defence. It is an observational and analytical facility with a highly productive and precise Satellite Laser Ranging system, two continuously operating IGS GNSS receivers, one of the UK Ordnance Survey GeoNet GNSS receivers, a permanent FG5 absolute gravimeter and one of BGS' broadband seismometers that automatically contribute in real-time to BGS' British Isles seismic network. Frequent, on-site automated meteorological and water table depth observations augment the geodetic observations. The Facility is also an International Laser Ranging Service (ILRS) Analysis Centre. In 2012 the facility was awarded 'new technology SLR site' status as part of the Global Geodetic Observing System (GGOS), [1]

### 3.1 Satellite Laser Ranging

The system is a core ILRS station, making daytime and night time range measurements to geodetic, gravity-field, altimeter and GNSS satellites at heights of from 300 to 23,000km. In addition during 2012 the SLR successfully obtained returns from COMPASS I5 at 42,000km, further extending the operational range of the system. The precision of the range normal points is a few millimetres, and the station is ranked among the top ten in the ILRS global network in terms of data productivity and accuracy. Recent problems with the reliability of our high repetition rate 2kHz laser system have now been addressed by the manufacturer and we have

resumed operation with both this and our 'legacy' 10Hz system in a dual configuration.

Recent new satellite launches being supported by SGF include two new Galileo GNSS vehicles, as well as the experimental LARES mission, where SLR data is used to measure the Lense-Thirring effect. [2].

In March 2013 the facility celebrated 30 years of satellite laser ranging at Herstmonceux, with the night of 31st March/ 1st April being the anniversary of the first successful returns obtained by the system. [3].

The Facility is an ILRS Analysis Centre and computes daily, seven-day-arc, global station coordinates and Earth orientation solutions in support of the ILRS' contribution towards ITRF realisation and rapid Earth orientation results. Over the last year the analysis centre participated in a pilot project to test the effect of including ITRS/GGFC modelling of non-tidal atmospheric loading.

### 3.2 GNSS

The two IGS stations HERS and HERT remain in continuous operation, with HERT also streaming GPS and GLONASS navigation data to the internet in support of the EUREF-IP and IGS Realtime Projects. The new calibrated Septentrio timing receiver has been in operation at the HERS site since August 2010, being supplied a reference 1PPS and frequency by our active H-Maser. The quality of the data from this combination has proved to be very high and HERS data is now a highly weighted contributor to the IGS rapid and final clock products, regularly in the global top ten of such H-Maser driven systems.

### 3.3 Absolute Gravimetry

Regular weekly operations of the FG5 absolute gravimeter have continued since operations began in October 2006. The baseline observational programme is a 24-hour session centred on mid-GPS week, resulting in hourly average gravity values of precision about 1-2 μgal, equivalent to a daily vertical precision of around 1mm. During 2012 the gravimeter was upgraded to an FG-5X with a new longer dropping chamber for improved precision. [4].

### 3.4 Site stability

A programme of precise digital leveling surveys linking the monumentation heights of the different geodetic techniques has now been continuously undertaken for the last three years. Along with short baseline GPS analysis of the 3 reference stations on site, this data provides useful information for investigating the possible effects on reference frame determination of any local deformation at important multi technique sites like Herstmonceux. [5].

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[1] SGF awarded by GGOS 'New Technology' status. http://sgf.rgo.ac.uk/news.html

[2] LARES mission information. http://www.lares-mission.com/

[3] 30 years of SLR at Herstmonceux. http://sgf.rgo.ac.uk/news.html

[4] Upgraded Gravimeter FG-5X arrives back on site. http://sgf.rgo.ac.uk/news.html

[5] 'Monitoring Site Stability at the Space Geodesy Facility, Herstmonceux', M. Wilkinson, G. Appleby, R. Sherwood, V. Smith, Reference Frames for Applications in Geosciences International Association of Geodesy Symposia Volume 138, 2013, pp 95-102


## 4 Newcastle University


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### 4.1 National and international networks

Newcastle University has continued to contribute to the International GNSS Service as an Associate Analysis Centre, providing weekly global coordinate combinations in parallel with the official IGS product. At present (May 2013) this activity is suspended while essential software modifications are carried out. These modifications have been delayed due to staff movements and maternity leave, but it is expected that activity will resume by summer 2013.

### 4.2 Mean Sea Level Studies

[1] have investigated effects of local and regional vertical land movements on tide gauge estimates of regional sea level rise. [2] have used a GPS-validated model of Antarctic glacial isostatic adjustment to provide improved estimates of the Antarctic ice sheet's contribution to present-day sea level change, derived from GRACE time-variable satellite gravity measurements. Work described in section 4.3.2 has also contributed to this overall topic.

### 4.3 Geophysical, Glaciological, and Oceanographic Applications of GNSS

At Newcastle, applications of GPS in particular have been made to a wide range of global geophysical and glaciological problems.

#### 4.3.1 Cryospheric geodesy

[3] and [4] have used a combination of geodetic and remote sensing techniques to study glacier mass balance in Antarctica and Svalbard respectively.

[5] (and also [2]) combined GRACE data with GIA models that had been calibrated using Newcastle-reprocessed GPS data, to achieve improved estimates of continental-scale ice sheet mass balance over Antarctica.

#### 4.3.2 Glacio-isostatic adjustment

[6] examined the effect of century-timescale ice sheet mass balance on present-day vertical land movement in the Antarctic Peninsula and showed that this could perturb site velocities significantly from the "long-term" GIA rate. [7] used previously-published Newcastle GPS estimates of land movement in Antarctica to calibrate and test a new model of Antarctic GIA which appears to be considerably more accurate than previous models.

#### 4.3.3 Volcanology

[8] used data from a GPS network established on Santorini volcano (Greece) to examine the evolution of the volcano in terms of the timing and location of magma fluxes.

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