National Report of Great Britain 2018

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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) and NERC Space Geodesy Facility.

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

1 Ordnance Survey activities

1.1 National GNSS network

The OS Net® network contains 118 stations, runs on the Trimble Pivot Platform (TPP)™ software and delivers RTK corrections via GSM and GPRS to approximately 250 Ordnance Survey surveyors. Public services are also available via Ordnance Survey commercial partners.

Commercial partners take the raw GNSS data streams from OS Net servers via NTRIP and use them to generate their own correction services.

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/business-and-government/products/os-net/index.html.

A complete receiver upgrade is being rolled out and, as of June 2018, is 50% complete. When complete half the network will be equipped with Septentrio PolarX5 receivers and the other half will be Trimble Alloy receivers. The receiver types will be mixed evenly across the whole network to mitigate against total network failure in the (rare) event of a problem effecting one type of receiver.

When the receiver upgrade is complete the entire network will stream and collect data for all four main GNSS constellations (GPS, GLONASS, Galileo and BeiDou).

Fig. 1 OS Net GNSS Network

Later in 2018 (around September) it is intended to replace approximately 30-40% of OS Net antennas. The replacement is due to corrosion of the current antennas (mainly coastal sites).

1.2 EPN data submissions

The current EPN submissions from GB are hourly data from:OS Net stations ADAR, ARIS, CHIO, DARE, EDIN, INVR, LERI, PMTH, SCIL, SHOE, SNEO and SWAS; Natural Environment Research Council (NERC) stations HERS and HERT; Newcastle University station MORP. University of Nottingham station NEWL contributes 24 hour files.

Once the receiver upgrade is complete (see section 1.1) all OS Net EPN stations will contribute GPS+GLO+GAL+BDS RINEX v3 format files along side the existing RINEX v2 (GPS+GLO) files.

Stations DARE, INVR, HERT and SHOE provide also real time data. Real time data from any other OS Net station is not possible due to conflict with OS Net partner's commercial operations.

2 BIGF – NERC British Isles continuous GNSS Facility

BIGF is operated from the University of Nottingham, and is funded by the UK Natural Environment Research Council (NERC). BIGF archives quality-assured RINEX data and creates 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 Ordnance Survey Northern Ireland. It also includes a number of 'scientific' stations established by: the UK Met Office; the University of Nottingham; the UK Environment Agency Thames Region; the NERC Space Geodesy Facility; Newcastle University; and the University of Hertfordshire, with the University of Nottingham's contribution being carried out in collaboration with the NERC National Oceanography Centre, Liverpool and the NERC British Geological Survey. Figure 2 shows the current network of around 150 continuous GNSS stations, which includes three stations (HERS, HERT, MORP) that are part of the IGS, and 21 stations (ADAR, ARIS, BELF, CHIO, CSTB/CASB, DARE, EDIN, ENIS, FOYL, HERS, HERT, INVR, LERI, MORP, NEWL, PMTH, SCIL, SHOE, SNEO, SWAS, TLLG) that are part of the EPN. In addition, ten stations at tide gauges (ABER, DVTG, LWTG, LIVE, LOWE, NEWL, NSTG/NSLG, PMTG, SHEE, SWTG) are included in the IGS TIGA Project, and all stations are included in the EUMETNET (Network of European Meteorological Services) GNSS water vapour programme (E-GVAP).

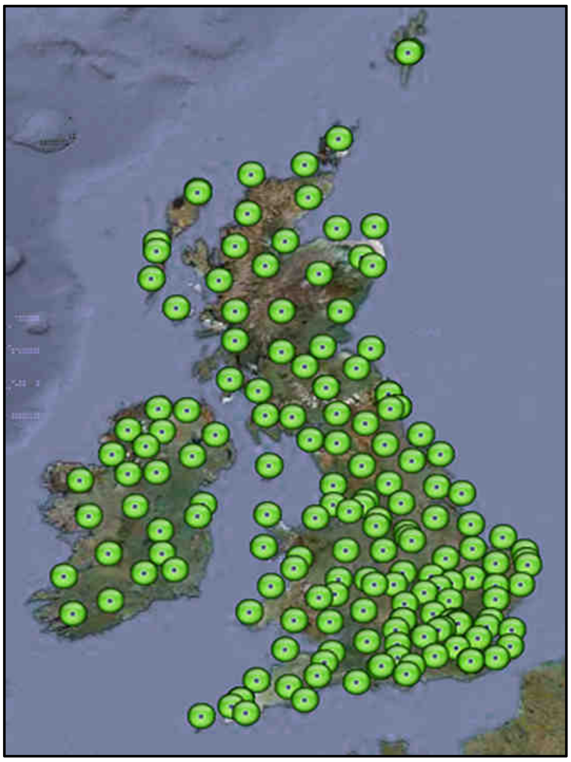

Fig. 2 The BIGF Network 2018

Quality assured RINEX data and derived products can be requested from www.bigf.ac.uk. Cumulative demand on the archive from 1998/9 to 2017/18 was approximately 17,363k station-days (47,536 station-years), comprising approximately 9,336k stations-days (25,559 station-years) of 30 second data, 76k station-days (209 station-years) of 1Hz data and 7,951k station-days (21,768 station-years) of derived products, with the 1Hz data and the derived products having been available for 7 years now, and with a broadening of the science annually making use of the archive, such as ongoing studies of land movement and sea level, e.g. [Bradshaw et al. 2016], and atmospheric work in both the ionosphere and troposphere, e.g. [Ahmed et al 2016], facilitated by both historic data and ongoing hourly and daily data from this dense network.

BIGF's derived products include re-processed station coordinates and velocities, near real-time tropospheric parameters (15 minute estimates of zenith total delay, zenith wet delay and integrated water vapour) and re-processed tropospheric parameters, and are aimed at facilitating the scientific research of non-GNSS specialists. The most recent BIGF map of current vertical station velocities is shown in Figure 3. This map is based on a re-processing of data from 1997 to 2015:273 with Bernese Software version 5.2, connecting the BIGF network to the IGB08 via a global network of reference stations, and using C13 (CODE repro2/repro_2013) re-analysed satellite orbit and earth orientation parameter products; mitigation of 1st and higher order (2nd and 3rd order and ray bending) ionospheric effects; a-priori modelling of troposphere effects using VMF1G and mitigation using zenith path delay and gradient parameters; I08.ATX models for antenna phase centre variations; and models for Solid Earth tides, ocean tidal loading and atmospheric tidal loading that are consistent with IERS (2010) conventions.

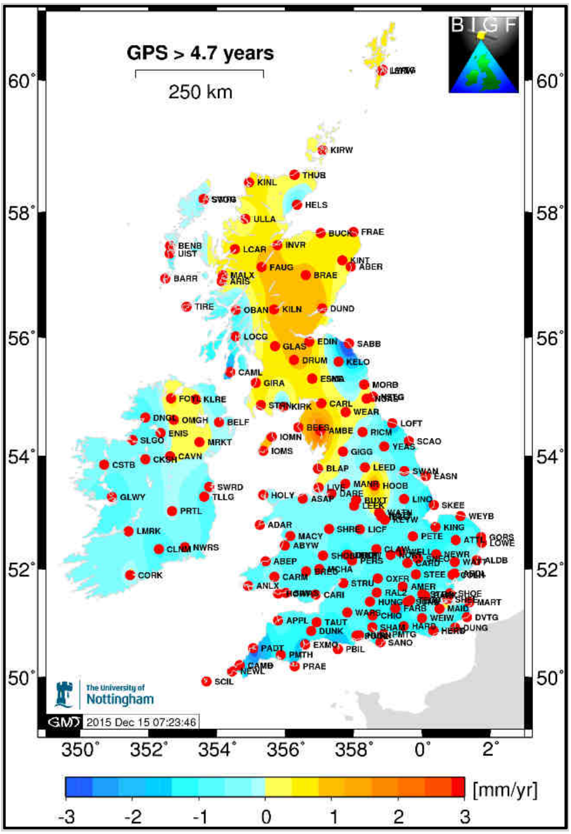

Fig. 3 Map of current vertical station velocities at 162 CGPS stations in the UK, based on CGPS measurements for the period from 1997 to 2015:273

In addition to EPN, IGS TIGA and E-GVAP, examples of research projects using BIGF quality-assured 30 second data in 2017/18 (UK unless otherwise stated) are:

- Ecole Nationale Supérieure de Techniques Avancées Bretagne (France) - Diabatic processes during the North Atlantic Waveguide and Downstream impact experiment.
- École Normale Supérieure, Paris (France) - Intraplate deformation in western Europe.
- Met Office - Near real-time atmospheric water vapour for numerical weather prediction in the UK.
- National Institute of Information and Communications Technology (Japan) - Ionospheric research using total electron content over Europe.
- NERC British Geological Survey - Shallow geohazards and risks - characterising coastal landslides.
- NERC Space Geodesy Facility - South baseline comparison at the NERC Space Geodesy Facility, and of other baselines.
- Newcastle University - [PhD] Interferometric synthetic aperture radar atmospheric correction using a GPS-based Iterative tropospheric decomposition model.
- Royal Observatory of Belgium (Belgium) - Densification of European Permanent GNSS Network for ionospheric studies.
- University of Hull - Quantifying the effects of slump blocks on bank erosion rates across a range of flow stages.
- University of Leicester - Ardnamurchan Transitions Project.
- University of Luxembourg (Luxembourg) - The potential of precipitable water vapour measurements from GNSS in Luxembourg.
- University of Nevada, Reno (USA) - Towards a global ambiguity resolved precise point solution and time series.
- University of Tasmania (Australia) - [PhD] Probing the asthenosphere beneath the Australian region with surface GPS/GNSS.
- University of Wales, Bangor - Caernarfon and Milfortd Haven hi-res multi-beam echo sounder survey.
- University of Wales, Bangor - Shipwreck monitoring - studying the long-term impact that man-made objects have on the sea floor.
- Wuhan University (China) - GPS/GLONASS precise point positioning and undifferenced ambiguity resolution.

Examples of research projects using BIGF quality-assured 1Hz data in 2017/18 (UK unless otherwise stated) are:

- NERC National Oceanography Centre, Liverpool - Proof of concept: use of GPS reflection measurements for tide gauge levelling.

- Newcastle University - [PhD] Integrity and reliability analysis of PPP ambiguity resolution.
- University of Dundee - Will climate change in the Artic increase the landslide-tsunami risk to the UK?
- University of Leeds - EverDrill: Accessing the interior and bed of a Himalayan debris-covered glacier to forecast future mass loss.
- University of Liverpool - [PhD] Tidal measurements for coastal resilience and survey.
- University of Plymouth - South West Partnership for Environment and Economic Prosperity (SWEEP), locating a tide pressure sensor.

Examples of research projects using BIGF derived products in 2017/18 (UK unless otherwise stated) are:

- Imperial College London - [PhD] Monitoring ground deformation in London, UK.
- NERC British Geological Survey - PROTection of European Cultural HEritage from GeO-hazards (PROTHEGO) - Derwent Valley site.
- University of Hertfordshire - Aerosol and Clouds Consortium - cirrus climatology from ground-based remote sensing.

References

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3 NERC Space Geodesy Facility

The Space Geodesy Facility is located at Herstmonceux, UK, with funding through the British Geological Survey from the Natural Environment Research Council and the UK Ministry of Defence. It is an observational and analytical facility with a highly productive and precise Satellite Laser Ranging (SLR) system, two continuously operating IGS GNSS receivers, one of the UK Ordnance Survey GeoNet GNSS receivers, a permanent FG5-X and two on-loan FG5 absolute gravimeters and one of BGS' broadband seismometers that automatically contributes in realtime to BGS' British Isles seismic network. A very stable active hydrogen maser frequency source drives the timing systems of both the SLR and the long-running HERS GPS/GLONASS receiver. On-site automated meteorological and water table depth observations augment the geodetic observations. The Facility is an International Laser Ranging Service (ILRS) Analysis Centre.

Personnel: Rob Sherwood manages the SGF site and operations, Vicki Smith manages the gravity work, Jose Rodriquez and Graham Appleby are the ILRS AC analysts, with Appleby overall team leader for SGF.

3.1 Satellite Laser Ranging

The system is a core ‘new technology’ ILRS station, making daytime and night- time range measurements to geodetic, gravity-field, altimeter and GNSS satellites at heights of from 500 to 30,000km and occasionally to synchronous heights. The precision of the range normal points is about 1mm, and the station is ranked among the top five in the ILRS global network in terms of data productivity and close to the top on accuracy. The two-laser (1kHz and 10Hz) system is unique in the ILRS worldwide network, with the kHz system being almost exclusively in use for standard LR. The original 10Hz laser remains in operation when required for specific applications such as the LiDAR capability.

Laser tracking of all the GNSS constellations except GPS is now a routine requirement for the network, with the SGF system proving particularly capable day and night. The ILRS is managing this major effort through various tracking campaigns, decided in agreement with the GNSS agencies, that for specific periods concentrate effort on a subset of the GNSS satellites. Laser tracking continues to add value for independent orbit QC and on-board clock monitoring and more importantly, ultimately for linking the GNSS orbits and navigational signals directly to the ITRF, with origin defined by SLR and scale by SLR and VLBI.

3.2 SLR Analysis

The Facility is an ILRS Analysis Centre (AC) and daily computes seven-day-arc, global station coordinates and Earth orientation solutions in support of the ILRS’ contribution towards ITRF realisation work and rapid Earth orientation results for the IERS. The activities of the SGF AC during the last few years have been focused around two main issues: the detection of and discussion within the wider geodetic community of systematic range errors to the LAGEOS and Etalon satellites of up to 10mm in observations from many of the global laser ranging stations, and research into improving our own models of the so-called centre-of-mass corrections that have to be used to refer range observations to the centres of the spherical geodetic satellites. Our systematic range error work, using the two LAGEOS satellites for the period 1993-2016, has halved the known discrepancy between the scale of the ITRF as determined from SLR and from VLBI by showing that the SLR scale is too small by 0.7ppb when employing the standard approach by ILRS of assuming zero systematic range error for many of the major stations [Appleby, Rodriguez, Altamimi, 2016]. This work was not used when ITRF2014 was realised, and the scale discrepancy remains, in common with previous realisations of the ITRF, with scale being defined as the mean value of those determined by the two techniques.

3.3 GNSS

The two IGS stations HERS and HERT remain in continuous operation, with HERT, a Leica GRX GG Pro system, also streaming GPS and GLONASS navigation data into the Internet in support of the EUREF-IP and IGS Real-time Projects. The Ordnance Survey GeoNet system HERO, installed by the OS close to the SOLA trig pillar, continues to be fully operational and has become useful as a third site for local stability monitoring work. The active hydrogen maser with its highly stable frequency source and one-second-tick pulse are driving both the HERS Septentrio receiver and the SLR event timer. As a result of the maser, the HERS data continues to be amongst the highest weighted receivers in the IGS final clock product.

3.4 Absolute Gravity

Regular operations of the FG5-X absolute gravimeter at Herstmonceux have continued since operations began in October 2006. Work continues to separate hydrological signals from station vertical motion, and intriguing tidal signals are also clearly present. The two FG5 absolute gravimeters from NOC (FG5#103 & FG5#222) are now on extended loan at Herstmonceux. The presence of all three AGs at SGF is seen as a major resource, and recent campaign work has been carried out in the UK, at Hartland and Eskdalemuir, and abroad in support of a variety of geophysical applications, with SGF as the UK calibration base.

During the IAG Joint Working Group 2.1.1 meeting at the European Geophysical Union 2018 establishment of a global absolute reference frame was discussed, to replace IGRN71. The naming convention of this new system was agreed to follow other reference frames used in geodesy and will therefore be known as the IGRF and IGFS (international gravity reference frame/system). Herstmonceux has been accepted into this new reference frame as a ‘core’ station, due to the co-location of other geodetic techniques and the high frequency AG data.

New gravity research effort at Herstmonceux this year has revolved around the testing of, and comparison with the SGF results, an Atom Gravimeter from Quantum Technology Hub in Sensors and Metrology & School of Physics and Astronomy at Birmingham University. The project remains a long-term prospect for testing with iterations of the prototype. Joint grant proposals are a possibility in the future, which would include the purchase of additional instrumentation to support gravimetry research.

3.5 VLBI

The case will continue to be made, and options explored, to add VLBI to the SGF’s capability. With its existing high-quality SLR and GNSS systems, there is growing interest among the international geodetic community to see the station become a core GGOS site.

Publications

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