National Report of Great Britain 2015

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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 Newcastle University.

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

1 Ordnance Survey activities

1.1 National GNSS network

The OS Net network has successfully been migrated to 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.

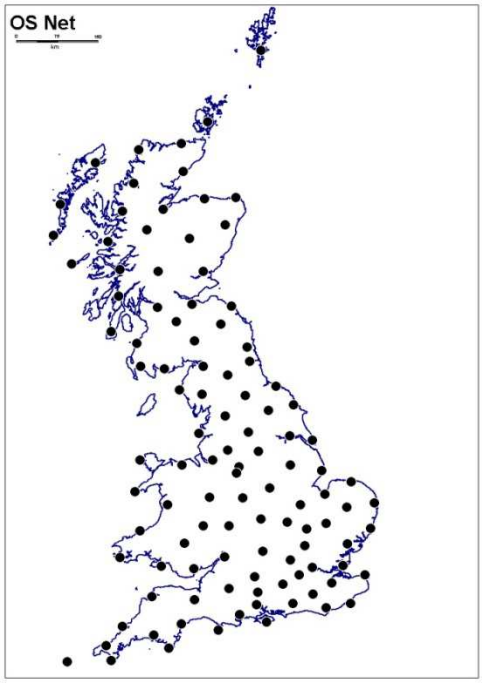

Fig. 1 OS Net GNSS Network

A server and software upgrade was completed last year. Initially the TPP software was run on duplicated virtual server clusters – one at Ordnance Survey HQ and the other at an offsite facility. During the initial running in phase of the new system it became clear that the virtualisation of the servers was contributing to unacceptable latency delays in the delivery of raw data to our commercial partners. A considerable amount of effort then had to go into reconfiguring the entire system to run on

physical servers. Each OS Net server site now runs a single, high powered, physical server. This has greatly improved the system performance. In addition there is a 3rd server site for testing and development of upgrades. The dual server site configuration provides complete redundancy of all aspects of the service.

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) and now also files from DARE, INVR (OS Net stations, previously 24 hour files). Station NEWL (run by University of Nottingham) contributes 24 hour files. 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. It was hoped to do this in the last year but the extra work involved in moving from virtual to physical servers has meant a delay.

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 is still ongoing to improve the geoid model is almost complete. A collaboration between Ordnance Survey Ireland and Land & Property Services Northern Ireland has been established to produce a new piece of software incorporating the new model.

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). Figure 2 shows the current network of 158 continuous GNSS stations, which includes three stations (HERS, HERT, MORP) that are part of the IGS, and eleven stations (BELF, CSTB, DARE, ENIS, FOYL, HERS, HERT, INVR, MORP, NEWL, 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).

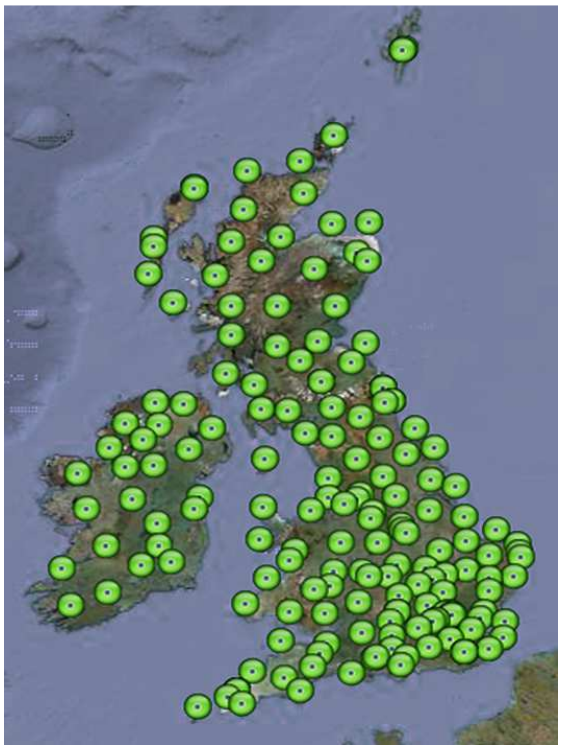

Fig. 2 The BIGF Network 2015

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.

Quality assured RINEX data can be requested from www.bigf.ac.uk. Cumulative demand on the archive from 1998/9 to 2014/15 was approximately 9,419k station-days (25,788 station-years), comprising of approximately 5,697k stations-days (15,598 station-years) of 30 second data, 15k station-days (41 station-years) of 1Hz data, and 3,707k product-days (10,149 station-years) of derived products, with the 1Hz data and the derived products having been available for 4 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, and atmospheric work in both the ionosphere and troposphere, facilitated by both historic data and ongoing hourly and daily data from this dense network.

BIGF's derived products are aimed at facilitating the scientific research of non-GNSS specialists. The initial derived products are 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).

The most recent BIGF map of current vertical land movements is shown in Figure 3. This map is based on a re-processing of data from 1997 to 2014:180 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.

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 et al., 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).

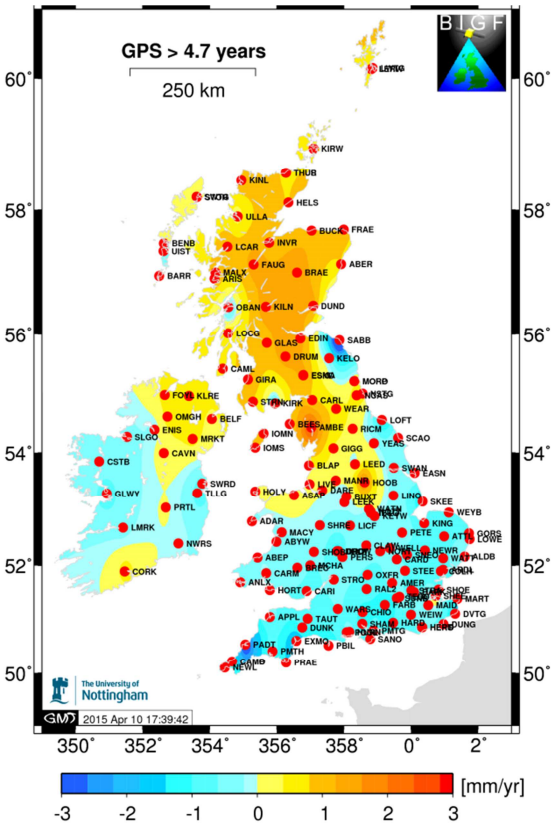

Fig. 3 Map of current vertical land movements at 158 CGPS stations in the UK, based on CGPS measurements for the period from 1997 to 2014:180

In addition to EPN, IGS TIGA and E-GVAP, examples of research projects using BIGF quality-assured data in 2014/15 (UK unless otherwise stated) are:

- Cranfield University - Remote sensing of vegetable crops.
- James Hutton Institute - Scoping out the usefulness of aerial image data for assessments of peatland condition.
- National Institute of Information and Communications Technology (Japan) - Ionospheric research using total electron content over Europe.
- NERC British Geological Survey - Cliff recession and mass movements at Burton Bradstock cliffs; Shallow geohazards and risks - characterising coastal landslides.
- NERC National Oceanography Centre, Liverpool - Proof of concept: use of GPS reflection measurements for tide gauge levelling.

- Newcastle University - Global loading and deformation at tidal timescales; Integrity and reliability analysis of PPP ambiguity resolution.
- Royal Observatory of Belgium (Belgium) - Densification of EUREF Permanent Network for ionospheric studies.
- Scottish Association for Marine Science - Ireland, Northern Ireland and Scotland Hydrographic Survey Project (INIS).
- University of Bournemouth - Erosion of glacial landforms by intensive agriculture.
- University of Cambridge - Division of Archaeology training excavation.
- University of Edinburgh - Brattleby field campaign (part of the GREENHOUSE project).
- University of Exeter - Using microclimate to adapt conservation to climate change.
- University of Hull - Dynamic Humber.
- 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 York - The effects of storminess on coastal ecosystem services and wellbeing.

Examples of research projects using BIGF derived products in 2014/15 (UK unless otherwise stated) are:

- Belgian Federal Research Institute for Space Aeronomy (Belgium) - Potential of GNSS data to detect atmospheric structure.
- Satellite Geodetic Observatory (Hungary) - EUREF Permanent Network densification project.
- University of Durham - Evaluating BIGF product suitability for undergraduate project work.
- University of Hertfordshire - Aerosol and Clouds Consortium - cirrus climatology from ground-based remote sensing.
- University of Luxembourg (Luxembourg) - International GNSS Service TIGA (GPS tide gauge benchmark monitoring) project.
- University of Nottingham - Investigating the effect of constellation geometry on precise point positioning; Sub-surface feature detection using the Sub-SAR technique; Validation of interferometric synthetic aperture radar (InSAR) results using GNSS time series; Validation of an InSAR Survey of Manchester.
- University of Southampton - Enhanced scientific value from remotely-sensed data through improved pre-processing methods and models: towards an integrated UK Environmental Change Observatory.
- University of Ulster - Will climate change in the Arctic increase the landslide-tsunami risk to the UK? - modelling seismicity due to ice loading and unloading.

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3 Newcastle University

3.1 Global Navigation Satellite Systems positioning

[1] developed a low-cost semi-autonomous GPS receiver/antenna/telemetry/power system suitable for rapid deployment in extreme environments, and demonstrated its use for the study of glacial calving events on the Helheim Glacier, SE Greenland.

3.2 National and international geodetic networks

Newcastle University has continued to contribute to the International GNSS Service as an Associate Analysis Centre, providing daily and weekly global coordinate combinations in parallel with the official IGS product. We continue to operate IGS site 'MORP' (Morpeth) and TIGA site 'NSLG' (North Shields Tide Gauge), both of which contribute to the NERC 'BIGG F' data repository; the former is also part of the EUREF Permanent Network.

3.3 Glaciological and Cryospheric Geodetic Applications

[2] produced a refined empirical model of glacial isostatic adjustment in Antarctica, using a combination of altimetric ice elevation data and GRACE gravity change data. [3] used GNSS data at local scales to investigate seasonal changes in ice flow in Antarctica.

3.4 Geodetic Measurement of Tectonic Strain

[4,5] used InSAR to observe co-seismic and post-seismic strain associated with fault movements at locations in Turkey and south-east Asia.

3.5 Other Geodetic Deformation Monitoring

[6] used InSAR imagery to observe vertical land motion associated with hydrocarbon extraction in SE Asia.

3.6 Other Geodetic Applications

[7] used retracked radar altimetry data to observe inland water level changes at a number of sites in Africa, and compared these with surface water mass changes inferred from GRACE gravity data. [8] reviewed methods of determining such surface mass changes from GRACE data, and showed distinct advantages of the mascon approach.

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