UK national report to EUREF 2016 – Newcastle University contribution

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Global Navigation Satellite Systems (GNSS) positioning

Palamartchouk *et al.* (2015) examined the use of dual-polarisation GNSS observations for the detection and resulting mitigation of multipath in carrier phase GNSS positioning. Morales Maqueda *et al.* (2016) have applied Precise Point Positioning techniques to GPS data from a wave glider, and shown that it is able to detect short-wavelength variations in water surface topography and the geoid. Webb (2015) used a unique kinematic GPS+GLONASS dataset gathered on a repeated trajectory through nearly 1 km altitude range to test the positioning accuracy of kinematic multi-GNSS; this dataset is available online (Webb *et al.*, 2015).

Penna *et al.* (2015) used continuous GPS data from across western Europe to demonstrate the ability to recover harmonic displacements at semi-diurnal tidal periods with ~0.2 mm accuracy, and in doing so showed the need to estimate residual tropospheric zenith delays simultaneously with these sub-daily position variations, contrary to previous studies elsewhere.

Synthetic Aperture Radar (SAR) data processing

Du *et al.* (2015) reviewed two advanced machine learning methods for polarimetric SAR image classification, and showed distinct advantages of the Random Forest approach.

Satellite Laser Ranging (SLR) analysis

Spatar *et al.* (2015) examined the sensitivity of SLR solutions to the geocentre coordinates, and showed that the inclusion of Stella, Starlette, Ajisai and LARES (but not Etalon) data in addition to LAGEOS could improve the ability of SLR to sense geocentre motion.

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 sites 'MORP' (Morpeth, England) and 'ROTH' (Rothera, Antarctica) and TIGA site 'NSLG' (North Shields Tide Gauge, England). MORP and NSLG both contribute to the NERC 'BIG F' data repository www.bigf.ac.uk; the former is also part of the EUREF Permanent Network.

Glaciological and cryospheric geodetic applications

Andrews *et al.* (2015) developed and validated a mascon approach for the recovery of basin-scale Antarctic ice mass trends from GRACE range-rate data. Martín-Español *et al.* (2016) reprocessed continuous and campaign GPS data from across Antarctica and assimilated this along with ice sheet altimetry and GRACE gravity products to obtain an empirical model of glacial isostatic adjustment and present-day ice mass change for the continent.

In Greenland, Murray, Selmes *et al.* (2015) and Murray, Nettles *et al.* (2015) used data from a semi-autonomous network of low-cost GPS receivers temporarily installed on the Helheim Glacier to infer the dynamics of iceberg calving episodes.

Geodetic measurement of tectonic strain

Feng *et al.* (2016), Li, Shen *et al.* (2016), Lin *et al.* (2015) and Li, Feng *et al.* (2015) used InSAR to observe co-seismic and inter-seismic strain associated with fault movements at locations in Nepal, Pakistan and USA.

Other geodetic deformation monitoring

Dai *et al.* (2015), Li, Zhang *et al.* (2016) and Liu *et al.* (2016) used InSAR imagery to observe vertical land motion associated with hydrocarbon extraction in China. Featherstone *et al.* (2015) used GPS to investigate local subsidence associated with groundwater extraction near to the tide gauge at Fremantle, Australia. Tomás *et al.* (2015) used InSAR observations to identify the triggering factors of landslides with the assistance of wavelet tools.

Bos *et al.* (2015) used the GPS tidal harmonic displacement estimation method developed by Penna *et al.* (2015) and applied it to a 259-site network of continuous GNSS receivers spanning western Europe (many of them being EUREF Permanent Network sites). They showed that modelling of ocean tide loading (OTL) using a standard elastic Earth model derived from seismology, such as PREM, leads to residual vertical errors at the dominant M2 period of up to several millimetres around the British Isles and near the Atlantic coasts of continental Europe. These errors, which cannot be explained by plausible ocean tide model uncertainties, can be reduced to below the noise floor if anelastic dispersion in the asthenosphere is incorporated into the Earth response model.

Atmospheric studies in geodesy

Lu *et al.* (2016) developed a procedure to employ static multi-GNSS to precisely retrieve high-resolution tropospheric gradients. Webb (2015) and Webb *et al.* (2016) used a unique kinematic GPS+GLONASS dataset gathered on a repeated trajectory through nearly 1 km altitude range to demonstrate the ability of kinematic multi-GNSS to accurately recover tropospheric zenith wet delay parameters. The dataset is available online (Webb *et al.*, 2015).

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