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Author(s):
Diamantidis, Periklis-Konstantinos; Klopotek, Grzegorz [iD]; Haas, Rüdiger; Johansson, Jan

Assessment of geodetic products from Multi-GNSS analyses at the Onsala site

Periklis-Konstantinos Diamantidis[1], Grzegorz Kłopotek[2], Rüdiger Haas[1], and Jan Johansson[1]

[1]Department of Space, Earth and Environment, Chalmers University of Technology, Gothenburg, Sweden

[2]Department of Civil, Environmental and Geomatic Engineering, Institute of Geodesy and Photogrammetry, ETH Zurich, Zurich, Switzerland

The dawn of Beidou and Galileo as operational Global Navigation Satellite Systems (GNSS) alongside Global Positioning System (GPS) and GLONASS as well as new features that are now present in all GNSS, such as a triple-frequency setup, create new possibilities concerning improved estimation and assessment of various geodetic products. In particular, the multi-GNSS analysis gives an access to a better sky coverage allowing for improved estimation of zenith wet delays (ZWD) and tropospheric gradients (GRD), and can be used to determine integer phase ambiguities. The Multi-GNSS Experiment (MGEX), as realised by the International GNSS Service (IGS), provides orbit, clock and observation data for all operational GNSS. To take advantage of the new capabilities that these constellations bring, space-geodetic software packages have been retrofitted with Multi-GNSS-compliant modules. Based on this, two software packages, namely GipsyX and c5++, are utilised by way of the static Precise Point Positioning (PPP) approach using six months of data, and an assessment of the derived geodetic products is carried out for several GNSS receivers located at the Onsala core site. More specifically, we perform both single-constellation and multi-GNSS data analysis using Kalman filter and least-squares methods and assess the quality of the derived station positions, ZWD and GRD. A combined solution using all GNSS constellations is carried out and the improvement with respect to station position repeatabilities is assessed for each station. Results from the two software packages are compared with respect to each other and the discrepancies are discussed. Inter-system biases, which homogenise the different time scale that each GNSS operates in, and are necessary for the multi-GNSS combination, are estimated and presented. Finally, the applied inter-system weighting and its impact on the derived geodetic products are discussed.