Geophysical Research Abstracts
Vol. 19, EGU2017-17276, 2017
EGU General Assembly 2017
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Galileo FOC Satellite Group Delay Estimation based on Raw Method and published IOV Metadata

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In December 2016, the European GNSS Agency (GSA) published the Galileo In-Orbit Validation (IOV) satellite metadata. These metadata include among others the so-called Galileo satellite group delays, which were measured in an absolute sense by the satellite manufacturer on-ground for all three Galileo frequency bands E1, E5 and E6. Therewith Galileo is the first Global Navigation Satellite System (GNSS) for which absolute calibration values for satellite on-board group delays have been published. The different satellite group delays for the three frequency bands lead to the fact that the signals will not be transmitted at exactly the same epoch. Up to now, due to the lack of absolute group delays, it is common practice in GNSS analyses to estimate and apply the differences of these satellite group delays, commonly known as differential code biases (DCBs). However, this has the drawback that the determination of the “raw” clock and the absolute ionosphere is not possible. The use of absolute bias calibrations for satellites and receivers is a major step into the direction of more realistic (in a physical sense) clock and atmosphere estimates.

The Navigation Support Office at the European Space Operation Centre (ESOC) was from the beginning involved in the validation process of the Galileo metadata. For the work presented in this presentation we will use the absolute bias calibrations of the Galileo IOV satellites to estimate and validate the absolute receiver group delays of the ESOC GNSS network and vice versa. The receiver group delays have exemplarily been calibrated in a calibration campaign with an IFEN GNSS Signal-Simulator at ESOC. Based on the calibrated network, making use of the ionosphere constraints given by the IOV satellites, GNSS raw observations are processed to estimate satellite group delays for the operational Galileo (Full Operational Capability) FOC satellites. In addition, “raw” satellite clock offsets are estimated, which are free of the ionosphere-free bias, which is inherent to all common satellite clock products, generated with the standard ionosphere-free linear combination processing approach. In the raw observation processing method, developed by the Navigation Support Office at ESOC, no differences or linear combinations of GNSS observations are formed and ionosphere parameters and multi-signal group delay parameters can be jointly estimated by making use of all available code and phase observations on multiple frequencies.