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Precise orbit and clock determination for new BDS3, Galileo and QZSS satellites

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Currently, GPS and GLONASS are providing continuous service globally, and BDS2 is providing Asia-Pacific regional service. Since March 2015, five new-generation BDS3 satellites including two IGSO and three MEO have been launched, followed by the launch of two BDS3 FOC MEO satellites on November 2017. As for Galileo, there are currently 18 satellites including 4 IOV and 14 FOC satellites. In addition, three QZSS satellites namely J02, J07 and J03 have been brought into orbit in 2017. Meanwhile, new metadata for Galileo and QZSS satellites are available from European GNSS Service Centre and Japan national space policy secretariat. In this contribution, we focus on precise orbit and clock determination of new BDS3, Galileo and QZSS satellites with the iGMAS+MGEX data and the new metadata. Moreover, the precise point positioning (PPP) performances with the new satellites are also evaluated.

With the datasets of 230 days from iGMAS and MGEX networks, several critical issues about BDS3 POD are investigated in detail, including the frequency selection, ISB between BDS3 and BDS2, combined POD of BDS3+BDS2+GPS, BDS3 POD with different networks, ambiguity resolution, and BDS3 attitude mode. By comparing receiver clock biases and DCBs, we confirmed that there is no obvious systematic bias between BDS3 and BDS2. With iGMAS and MGEX networks, orbit accuracy of 11.2, 5.1 and 3.1cm can be achieved for BDS3 satellites in along, cross and radial components, which is comparable to BDS2. The 230-days SLR validations of C32, C33 and C34 show mean offsets of -3.48, 7.81 and 8.19cm. The SLR results and 230-days overlap comparisons demonstrate that the attitude mode of C32, C33 and C34 is yaw-steering mode instead of the yaw-steering/orbit-normal switch mode which is applied for BDS2. Furthermore, BDS3 clocks show a better performance compared with the same type of BDS2 satellites.

With the new metadata of Galileo and QZSS satellites, several important issues about Galileo/QZSS POD can be investigated, including PCO/PCV corrections, yaw attitude control modes and solar radiation pressure (SRP) modeling. Using the PCOs/PCVs from the new metadata instead of MGEX values, the POD accuracy in radial component shows improvements of 14.0% for IOV satellites, 19.0% for the two FOC-e satellites (E14 and E18 at eccentric orbits), 36.5% for J01 and 5.4% for J02, respectively. Using ECOM-2 SRP model instead of 5-parameter ECOM-1 model, the orbit accuracy is improved by 4.5%, 85.3%, 8.7%, 61.5% and 16.3% for IOV, FOC-e, FOC, J01 and J02 satellites. The standard derivations of SLR residuals are 1.20cm, 2.28cm, 1.16cm, 2.50cm and 3.25cm smaller than those using ECOM-1 model. The STD values of clock differences compared with CODE products are 0.18, 0.23, 0.17 and 0.20ns for Galileo IOV, FOC-e, FOC and J02 satellites, respectively, while J01 shows a worse performance with STD of 0.54ns. The PPP performance with new BDS3, Galileo and QZSS satellites are also investigated with the improved orbits and clocks.