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Analysis of L5 phase variations in GPS IIF satellites by the raw observation PPP approach

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GPS modernization along with Glonass modernization and the emerging Galileo and Compass system has been highly anticipated by every GNSS user since several years. The third civilian L5 signal transmitted by the modernized GPS satellites brings us to the GNSS multi-frequency era. The first GPS IIF satellite was launched in May 2010, until now there are eight block IIF satellites in service and the remaining four IIF satellites are planned to be launched by 2016. The introduction of the third frequency to GPS and the usage of advanced atomic clocks not only provide the users more possibilities but also enable higher positioning accuracy. Nevertheless phase variations are found on the new L5 observation of GPS SVN62. Further investigations suggest that the variations of this satellite are strongly dependent on the satellite inner temperature variation caused by sun illumination.

Besides achieving precise positioning accuracy, PPP is also frequently used as a tool to analyze and evaluate various GNSS errors, for instance, tropospheric delays and receiver clock errors. Other than with differential GNSS, it is possible to separate different errors and to identify the error sources with PPP. Conventional PPP is based on the ionosphere-free linear combination, in order to eliminate the first-order ionospheric delays. However only dual frequencies can be used to build ionosphere-free linear combination, which leads to the waste of the information on the third frequency. Furthermore, the frequency dependent errors can not be separated and traced. A new PPP approach that avoids using any linear combination is proposed recently, which is called the raw observation PPP. One advantage of the raw observation PPP approach is that data of all frequencies and all GNSS systems can be jointly used. In addition, the frequency dependent errors are possible to be separated, identified and analyzed.

In this paper the raw observation PPP is utilized to analyze the phase variations on L5 for all available GPS IIF satellites. IGS MGEX stations with good global distribution are chosen to analyze this effect continuously. The L5 phase variations are detected in all 8 GPS block IIF satellites, the amplitude of the variations varies with the sun elevation angle above the satellite plane. The correction model proposed by Montenbruck is used to correct the variations. Finally, the influence of the L5 phase variations on PPP performance is investigated.

Keywords: GPS block IIF, L5 phase variation, PPP, raw observation PPP, MGEX station