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Assessment of ionospheric corrections for PPP-RTK using regional ionosphere modeling

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The integer ambiguity resolution-enabled precise point positioning (PPP) method, the so-called PPP-RTK, is a state-of-the-art Global Navigation Satellite Systems (GNSS) technique that allows to determine position solutions with high accuracy in a short amount of time. The main idea behind PPP-RTK is to extend the PPP technique by providing single-receiver users with external information (satellite phase biases, ionospheric and tropospheric corrections) so as to enable integer ambiguity resolution with fast convergence.

Several methods have been formulated in the past to recover the integerness of the user ambiguities, therefore enabling the PPP-RTK method realization. However, the unknown spatially correlated ionospheric errors still affect the GNSS observables and the user's solution convergence time, since the ionosphere-float PPP-RTK model (unknown parameters for the ionospheric delays are estimated by the user) is rather weak in terms of integer ambiguity resolution. A great shortening in the convergence times is expected in case ionospheric corrections are available to PPP-RTK users.

The accurate prediction of the state of the ionosphere and the correction of its effects on GNSS signals is one of the main objectives of TREASURE. The TREASURE (Training REsearch and Applications network to support the Ultimate Real time high accuracy EGNSS solution) project is a Marie Skłodowska-Curie Actions (MSCA) Innovative Training Network (ITN), funded through the European Union's Horizon 2020 Research and Innovation Programme. The project aims at the development of a new service that will improve the current and introduce advanced models and algorithms to provide real-time positioning accuracy of a few centimeters using signals from all available GNSS systems, including GPS, GLONASS, Galileo and BeiDou.

This paper presents an analysis of the ionospheric corrections required to get a significant improvement in PPP-RTK performance. The main aim was to determine the improvement in the positioning accuracy, time-to-first-fix and the convergence time in the PPP-RTK user side using ionospheric corrections computed from a network. The study consists of two main steps. The first one includes an empirical investigation of the ionosphere model precision necessary to greatly improve the PPP-RTK performance in a simulated environment in terms of precision and convergence time. In the second one, an optimal ionosphere representation was developed to provide precise ionospheric corrections by parameterizing the ionospheric slant delays directly within (1-step approach) or after (2-step approach) the PPP-RTK network processing in terms of ionosphere model coefficients and differential code biases (only in the 2-step approach). To this end, GNSS data of a regional CORS network in North Carolina (US) was used in a PPP-RTK network processing employing a Kalman filter. The ionospheric delays were modelled with polynomial functions and finite Fourier series to determine the model coefficients for the region and interpolated at the user's location in order to be used as prior corrections at the user side to improve integer ambiguity resolution and shorten the convergence time.