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A New Ground Based Augmentation Strategy for Centimetric PPP Solution with GNSS Single Frequency Receiver

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In the last few years, GNSS single frequency receivers have turned up more and more in marketing for their very low cost with respect to high level of performances, comparable to those of geodetic class dual-frequency receivers for some applications in differential positioning over short baselines (e.g. long term ground or infrastructures monitoring). Nevertheless, a still open problem concerns their use for PPP applications, since standard algorithms are based on dual frequency observations to remove ionospheric delay through ionosphere-free combination. The aim of this work is to introduce a new ground based augmentation strategy to obtain PPP at centimetric accuracy level working with single frequency low-cost receivers.

The developed algorithm, starting from the observations of a unique dual frequency “reference” receiver, is able to reconstruct L2 synthetic observations for any single frequency receiver located in its surroundings. The algorithm computes the epoch-by-epoch time variations of the ionospheric delay for each satellite in view at the reference receiver, through the geometry-free (L4) linear combination applied to its dual frequency phase observations; these ionospheric delays variations are then mapped to the satellites in view at the single frequency receiver, accounting for its position. L2 synthetic observations for the single frequency receiver are therefore obtained summing the mapped ionospheric delays variations to the L1 variations.

Overall, the proposed augmentation strategy enables PPP with standard dual frequency algorithms starting from single frequency receiver observations complemented with L2 synthetic observations.

A number of tests were performed to demonstrate the effectiveness and accuracy of the proposed augmentation strategy, both as regards positioning and tropospheric delay estimation.

In particular, PPP daily positions using 30-seconds data from single frequency receivers situated at different distances from M0SE – IGS/EUREF permanent station in Rome – have been estimated with RTKLIB software. Considering as reference the single frequency differential positioning daily solution in the case of very short baseline, the repeatability analysis, derived from a processing with PPP without ambiguity fixing, shows a RMSE lower than 1 cm in the horizontal components and lower than 2 cm in the vertical component, even at distance of about 14 km from reference station.

As regards tropospheric delay, absolute zenith total delays (ZTDs) estimation from single frequency receivers can represent a significant plus in GNSS meteorology for the possible relevant densification of permanent networks using low-cost receivers. In this case, single frequency receivers at different distance from M0SE station have been simulated from original dual frequency receivers of Lazio GNSS network, considering their L1 observations only. The comparison with reference data, represented by ZTDs estimated from the analysis of the original dual frequency observation files, confirms that an accuracy better than 7.5 mm can be achieved, even at distance of 50 km from the reference station used for the proposed augmentation strategy. The obtained results are encouraging and further real scenarios, with ionospheric high activity, are currently under investigation.