



Mitigation of Ionospheric Scintillation Effects for Precise GNSS positioning at Low Latitudes

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Global Navigation Satellite Systems (GNSS, such as Global Positioning System (GPS), GLONASS, Galileo, Beidou) underpin a number of modern life activities, such as air/marine transport, autonomous vehicles/machinery control and in areas such as construction, agriculture and offshore operations. Techniques such as RTK (Real Time Kinematic) and PPP (Precise Point Positioning), exploiting the precision of the GNSS signal carrier phase measurements, are at the core of these applications. PPP is a carrier-based GNSS technique that enables high accuracy positioning by incorporating external information in the user solution. The external information typically includes highly accurate (satellites clock and orbit) products derived from global networks and available for free (e.g. <http://igs.org/rtk>) or commercially (e.g. <http://www.starfix.com>). Currently, the atmospheric correction is not normally part of the information available from the aforementioned global networks to assist the PPP solution, but rather has to be estimated through a start-up process that can take tens of minutes. Accounting for the ionosphere is critical in PPP, due to its high variability and to disturbances such as scintillation (characterized by fluctuations in signal amplitude and phase) that can affect the satellite signals propagation and thereby degrade the positioning accuracy.

Strong scintillation frequently occurs over the equatorial/low latitudes, where its occurrence is associated with the instability of structures on the edges of the Equatorial Ionization Anomaly (EIA). As a consequence, PPP can be significantly handicapped in these regions. Strong scintillation is capable of leading to loss of GNSS satellite signal tracking and especially phase tracking, which is crucial to high precision professional applications relying on a real time capability. On the other hand, low to moderate scintillation introduces additional biases appearing as double difference residual errors. The situation is particularly adverse in Brazil, a country located entirely across the magnetic equator, where the ionospheric behaviour is particularly dynamic and unpredictable. This paper describes a technique to mitigate the effects of ionospheric scintillation on PPP, whereby the variance of the output error of the GNSS receiver DLL (Delay Locked Loop) and PLL (Phase Locked Loop), respectively, are exploited to improve the least squares stochastic model used to compute position. The paper presents results of a study carried out at a low latitude station in Brazil, where this technique was applied and evaluated.