High Accuracy Navigation Techniques under Scintillation Conditions

***Presenter**:*

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Abstract:

Global navigation Satellite System (GNSS) provides different kinds of applications and accuracies, having an increasing demand for precise navigation and positioning. Examples of applications requiring high accuracy are civil engineering, mapping and surveying, agricultural uses, mining, marine navigation.

The Scintillation is one of the most challenging problems in GNSS navigation. This phenomenon appears when the signal pass through ionospheric irregularities, producing rapid changes on refraction index and, depending on the size of such irregularities, also diffractive effects affecting the signal amplitude and can produce cycle slips. In this work, we show that the scintillation effects on GNSS signal are quite different in low and high latitudes.

For low latitude receivers, the main effects from the point of view of precise navigation, are the growing of the carrier phase noise (sigma-phi) and a fading on the signal intensity (S4) that can produce cycle-slips in the GNSS signal. The detection of these cycle-slips is a challenging problem for precise navigation. Indeed, 1 cycle jump in the L1 carrier represents a jump of 48 cm in the ionosphere-free combination (the combination used in PPP), which, if it is not corrected, would derive in meters of position error.

In high latitude receivers the situation is not the same. In this region, the size of the irregularities is typically larger than the Fresnel scale, so the main effects are related with the fast change on the refractive index associated to the fast movement of the irregularities (which can reach up to several km/s). Consequently, as we will show in the presentation, the main effect on the GNSS signal is a fast fluctuation of the carrier phase (large sigma-phi), but with a moderate fading in the intensity (moderate S4). Thus, on one hand, this rapid fluctuation of carrier phases is mostly proportional to the inverse squared frequency of the signals, being the effect quite limited (practically null) on the ionosphere-free combination. On the other hand, these fluctuations do not usually produce cycle-slips. These two characteristics make feasible the use of the ionospheric free combination for high accuracy navigation in high latitudes, also during high ionospheric activity.

In this work, we assess the high accuracy navigation in both scenarios, showing that in high latitude, dual-frequency users can navigate, also during high ionospheric activity, as the scintillation is mostly refractive and does not produce frequent cycle-slips. Nevertheless, due to the large spatial-temporal gradients, it is a more challenging for single frequency users. Low latitude is a more difficult scenario where scintillation can lead frequent cycle-slips and loss of GNSS signals. Moreover, the carrier noise is increased, but high accuracy is still possible for dual-frequency users, if the cycle-slips were detected in a reliable way.