Ionospheric Scintillation Climatological Modelling with ground-based GNSS receivers

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The interest about the impact of the ionosphere on the propagation of Global Navigation Satellite Systems (GNSS) signals is experiencing a constant growth. This follows from the high demand of precise positioning applications and services (with positioning error down to the few centimetre level). The presence of ionospheric irregularities, i.e. plasma density unevenly distributed within the ambient ionosphere, induce diffraction and refraction effects. Irregularities having the typical scale size below the Fresnel's scale for L-band signals (order of few hundreds of meters) cause diffraction effects, which result into an interference at the receiver level that causes the so called "scintillation", i.e. stochastic fluctuations of the amplitude and phase of the received signal. Scintillation causes signal fading which directly impacts positioning performance. Beside scintillation, deterministic fluctuations on the GNSS phase measurements are induced by irregularities covering the full ranges of scales. Although the 1st order diffraction effects can be treated by using combinations of GNSS observables, the phase fluctuations may lead to cycle slips and losses of lock with the satellites. These create tracking issues that are a further source of GNSS positioning degradation.

The occurrence of scintillation and phase fluctuations is highly variable in space and time, revealing the complex phenomena involved in the formation, evolution and decay processes of ionospheric irregularities and related triggering mechanisms, such as plasma instability processes. Occurrence depends on local time, season, solar and magnetic activity. Scintillations are frequent at low latitudes, where, generally, they occur daily during the post-sunset hours as due to the small-scale irregularities embedded in the Equatorial Plasma Bubbles. Scintillations and phase fluctuations occur in the high-latitude ionosphere mainly during active geospace conditions, as the direct consequence of the solar wind-magnetosphere-ionosphere coupling. Under peculiar geospace conditions, occurrence of ionospheric irregularities may be also detected in the mid-latitude ionosphere.

Scintillation and phase fluctuations can be monitored by using special GNSS receivers called Ionospheric Scintillation Monitor Receivers (ISMRs), which provide the amplitude and phase scintillation indices, S4 and σ_Φ, on a 1 minute-basis. The purpose of this talk is to provide insights on the scintillation phenomenon and review the main features of ionospheric irregularities that can be depicted by using climatological techniques, such as the Ground-Based Scintillation Climatology introduced by INGV, and provide hints on how this can be done by leveraging on the PITHIA-NRF e-Science centre.

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