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ORIGINAL ARTICLE

On the distribution of GPS signal amplitudes during low-latitude ionospheric scintillation

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Abstract Ionospheric scintillations are fluctuations in the phase and/or amplitude of trans-ionospheric radio signals caused by electron density irregularities in the ionosphere that affect the performance of Global Navigation Satellite Systems receivers. We used an entire month of high-rate (50 Hz) measurements of the GPS L1 (1.575 GHz) signal amplitude to investigate the statistics of L-Band signals during ionospheric scintillation events. The scintillation measurements used in this study were made by a GPS-based scintillation monitor installed in Sao Jose dos Campos, Brazil, near the equatorial anomaly peak. The observations were made over 32 days during high solar flux conditions when typical values of F10.7 were above 150×10^{-22} W/m^2/Hz. This data set allowed us to test the Nakagami-*m* and Rice probability density functions (PDFs) in the description of the distribution of L-Band scintillating signals with better statistical confidence than previously possible. In addition, we parameterized and tested the ability of the α–μ distribution, which is a more general and yet simple and flexible fading model to describe the distribution of signal amplitudes during scintillation events. The results show a slight advantage of the Nakagami-*m* PDF over the Rice distribution. We also show that the α–μ PDF outperforms the Nakagami-*m* and Rice PDFs in the statistical characterization of amplitude scintillation. The reason for such a performance is the fact that the α–μ model was specially tailored to the ionospheric scintillation events, resulting in a better fit with experimental data, specifically in the region of small amplitudes, which is particularly interesting for scintillation studies.

Keywords Ionospheric scintillation · α–μ distribution · Fading distributions · Propagation channel modeling

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Introduction

While the ionosphere provides an opportunity for studies of quiescent and turbulent plasmas, it also causes difficulties for Global Navigation Satellite Systems (GNSS). For instance, the departure of the ionospheric index of refraction from unity causes errors in the estimates of the satellite-receiver pseudoranges used for positioning estimation. These errors can be mitigated using dual-frequency receivers that are able to estimate the ionospheric delay. Dual-frequency receivers, however, are more expensive than their single-frequency counterparts. Ionospheric errors may also be mitigated with the proper specification of the ionospheric delay. Accurate modeling of the ionospheric plasma for scientific and technological applications, however, still is a very active topic of research and development.

In addition to range errors caused by the quiescent ionospheric plasma, the ionosphere can also affect the