Equatorial and Low-Latitude Ionospheric Effects on GPS Signals in Space and on Ground Based Augmentation System Operations

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Ground Based Augmentation Systems (GBAS) have been developed to meet the safety requirements of air navigation,using differential corrections to provide higher accuracy during aircraft approach and landing operations. However, ionospheric delays and scintillation cause positioning errors that degrade the accuracy, performance and availability of Air Navigation Systems that operate using the Global Positioning System (GPS), particularly in the equatorial and low-latitude regions. The propagation and degradation of GPS signals in space due to ionospheric effects are the focus of this work, which describes a simulation model of the GPS observables.

For each active communication channel between a satellite and a reference ground receiver or aircraft,the pseudorange PR, carrier phase Φ and received power C for the GPS L1 signals were simulated, considering the clock errors, ionospheric and tropospheric delays, multipath, amplitude and phase scintillation, random errors, free-space loss and antenna gains.

Ionospheric delays were estimated through statistical distributions of residuals between the vertical Total Electron Content (vTEC) at associated 400-km ionospheric pierce points (IPP)estimated from the data recorded by the dual-frequency GPS receivers of the RBMC/IBGE network,and the relative vTEC estimated by the latest version of the International Reference Ionosphere (IRI). Samples of amplitude and phase scintillation were generated according to α - μ probability distributions, conforming to data collected by receivers of the CIGALA/CALIBRA network, located in different geomagnetic latitudes.

Next, the results from the above model were processed by algorithms to detect possible degradations in the GPS signals, isolate failures, smooth and correct acceptable ones, and transmit correction messages to aircrafts through the VDB

(VHF Data Broadcast).GBAS availability was also evaluated by computing the Vertical Protection Levels (VPL).

This contribution will present and discuss statistical analyses of position errors resulting from the simulation of GPS observables and GBAS operations for different combinations of geophysical parameters(solar and geomagnetic activity, geomagnetic latitude, local time and season) and scenarios.

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