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A Look at GPS Positioning Errors in Solar Cycle 24

Abstract:
Positioning errors in GPS receivers can be impacted by Equatorial Spread-F scintillations. These regions of reduced plasma density are characterized by smaller scale variations in plasma density which cause perturbations in the signal amplitude and phase as a radio wave passes through the ionosphere. Scintillations can affect GPS position accuracy through errors in the range and in the carrier phase along each link and, when intense scintillation occurs, it can lead to loss of lock on a specific satellite, further degrading the accuracy of the solution or even leading to loss of service.

We have carried out a survey of GPS positioning errors from our receivers at four stations at a range of magnetic latitudes around the equator. The magnetic latitude is important because scintillations at GPS frequencies vary considerably with this parameter.

We report case studies from Ascension Island, where scintillations are particularly intense and we show the correlation of scintillations there with positioning errors. We then examine worst cases that we have encountered in the current solar cycle, where we find errors exceeding 100 meters during the strongest scintillation periods. During these periods of strong scintillation and correspondingly high errors, we examine the number of satellites available for the position solution and find that the number decreases to 4 or fewer on several occasions.

Next, we examine the positioning errors in a statistical way from Ascension as well as for stations equatorward of the anomaly crest, where scintillations are less intense or nonexistent, thereby demonstrating the latitude effects. We find that positioning errors do to scintillation are virtually absent for receivers within about 10-deg of the magnetic equator.

We then compare Ascension data for the current solar cycle to data from another receiver taken during the previous cycle. The similarity indicates that these results may be somewhat receiver independent.

We also investigate the local time dependence of the positioning errors, finding that the local time effects follow the local time behavior of the scintillation itself, which is as expected.

Finally, we show the dependence of the errors on the sunspot number. This study has uncovered several interesting features in the relationship between GPS positioning errors and equatorial scintillations.