REFRACTION OF GPS SIGNALS IN DISTURBED IONOSPHERE

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We have studied the refraction of dual-frequency GPS signal refraction in the disturbed ionosphere. The following cases have been considered: (a) high-latitude ionosphere disturbed by electron and proton precipitation (computer simulation results and tomographic data from Chatanika ISR); (b) mid-latitude ionosphere under the strong magnetic storm; (c) equatorial ionosphere (both based on the computer simulation). Apparently, the effects of the terminator have been studied. All calculations have been done with the newly developed code for UHF signal propagation for steady-state receiver on the Earth surface as well as for the mobile receiver (1000 km/hr). The results can be summarized as follows:

1. GPS simulation using experimental Chatanika data have shown that refraction causes the error in angle between visible and real satellite positions about $3 \times 10^{-4}..10^{-3}$ rad for 1.6 and 1.2 GHz respectively. The difference between phase and group delay time is as large as 30 nsec for 1.6 GHz and 53 nsec for 1.2 GHz resulting in 10..15 meters error in positioning. The effect of fast growth of the positioning error has been found when the signal propagates under the small angle to large inhomogeneities in the ionosphere. The last is interpreted as a kind of a caustic effect and it can give errors as large as 100 meters.

2. Calculations using simulated ionosphere for low- and mid-latitudes have shown that deviations of the ray are of the same order of magnitude as in the high latitudes. Under terminator passing we observed irregularities in the ray deviations depending on the relative angles of receiver position.

3. In the case of a mobile receiver (airplane) the refraction depends on the direction of relative motion. Counter motion reduces the time interval of minimal positioning error at 1-1.5 hours on the route 6000-10000 km.

Ionosphere corrections based on the model of a multilayered spherical ionosphere or on the TEC can not be considered as successful. Precise ionosphere simulations must be used in order to calculate refractive corrections to GPS.

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