Observations of ionospheric scintillation and total electron content using Global Navigation Satellite System (GNSS) receivers in Tromsø, Norway

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In the terrestrial ionosphere, electron density irregularities may cause variations of signal strength and/or carrier phase in trans-ionospheric satellite transmission signals received on the ground, which are commonly called ionospheric scintillations. Scintillations are categorized into amplitude scintillations and phase scintillations. Amplitude scintillations are observed as fluctuations of the signal strength, which are caused by interference between signals diffracted by irregularities. The amplitude scintillations are normally quantified by S_4 index, which is standard deviation of the received power normalized by its mean value. Phase scintillations are detected as high frequency fluctuations in the carrier phase, which are caused by variations in the refractive index due to spatial and temporal variations in electron density. The phase scintillations are normally quantified by σ_ϕ index, which is the standard deviation of the carrier phase. Phase scintillations occur both in equatorial and polar regions. In contrast, it is known that the amplitude scintillations in the equator are larger than those in the polar region.
In this study, GPS scintillations at high latitude were compared and analyzed using dual frequency (L1 : 1575.42 MHz and L2 : 1227.60 MHz) Global Navigation Satellite System(GNSS) receivers in Tromsø, Norway. This measures the amplitude and phase of the received signals at a sampling frequency of 50Hz for each satellite and calculates scintillation indices. In the present study, phase scintillations are monitored by estimating ROTI (Rate of TEC change Index). ROTI is the standard deviation of ROT (Rate of TEC change), where ROT is differential of the TEC time-series. In previous studies, amplitude scintillations are remarkable in high latitude, however we observed weak amplitude scintillations at high latitude by using low noise receivers in this study. We researched seasonal variations of S_4 and ROTI from the measurement data for the last three years, from January 2013 to December 2015. Both S_4 and ROTI have larger values at night mainly in spring and summer, and their occurrence rates depend on the season and local time. These features indicate that, at night in winter in the polar region, irregularities exist in the polar cap patches from the dayside area across the central polar cap, while electron density becomes uniform due to ionizations by solar radiation in summer. However, the S_4 increases do not always coincide with the ROTI increases. Therefore, we compared increases of S_4 and ROTI on daily basis. In this study, we classified the S_4 and ROTI data into three cases and compared them: simultaneous increase of S_4 and ROTI, increase of only S_4 and increase of only ROTI. The simultaneous increase occurs mainly in the morning and daytime. the increase of either S_4 or ROTI is mainly in the nighttime. Duration of S_4 increases tends to be longer than that of ROTI. Moreover, only ROTI increase in the daytime of summer. In this work, we considered generation mechanisms of the ionospheric irregularities which result in scintillations in the polar region.

Keywords: GPS scintillation, ROTI, Ionospheric irregularities

