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Statistics and Modeling of Ionospheric Scintillations in the European Arctic Region

Yaqi Jin* [(1)], Knut Stanley Jacobsen[(2)], Daria Kotova[(1)], Lasse B.N. Clausen[(1)], and Wojciech J. Miloch[(1)]
(1) Department of Physics, University of Oslo, PO Box 1048, Blindern, 0316 Oslo, Norway; e-mail: yaqi.jin@fys.uio.no; daria.kotova@fys.uio.no; lasse.clausen@fys.uio.no; w.j.miloch@fys.uio.no
(2) Norwegian Mapping Authority, PO 600 Sentrum, 3507 Hønefoss, Norway; e-mail: Knut.Stanley.Jacobsen@kartverket.no

Our modern society heavily relies on the Global Navigation Satellite System (GNSS) applications that utilize trans-ionospheric radio waves. However, these applications can be highly affected by ionospheric scintillations. When a satellite signal passes through irregularities in the ionosphere, the signal received on the ground exhibits random fluctuations in both amplitude and carrier phase, termed ionospheric scintillation. In the presence of scintillation, the satellite-based communication and navigation systems can be severely degraded. Therefore, it is of great importance to characterize and predict ionospheric scintillation. Ionospheric scintillations are prevalent near the magnetic equator and at high latitudes. This present study aims to investigate scintillations in the polar region. We make use of a network of 11 GNSS scintillation receivers of type Septentrio PolaRxS, which is operated by the Norwegian Mapping Authority. The network covers a wide latitudinal range, from the polar cap to auroral and subauroral regions. Thus, it can capture the scintillation effect associated with variable phenomena at high latitudes, such as polar cap patches, plasma blobs, auroral precipitation, and ionospheric trough. To study the long-term variations, we collect the amplitude and phase scintillation data during 2014-2022. The climatological maps of phase and amplitude scintillations are constructed using bins of 1 degree in magnetic latitude and 1 hour in magnetic local time. The climatological maps reveal temporal variations of different scales such as solar cycle and seasonal variations. In addition, the scintillation activity is also responding to geomagnetic storms and substorms. We develop an empirical model based on the climatological maps by fitting the maps with appropriate geophysical proxies in four main categories (namely, solar radiation, magnetic indices, interplanetary magnetic field, and solar wind coupling function). The scintillation model can also be used for the forecasting and mitigation of the scintillation effect caused by ionospheric irregularities.

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