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Doing Space Weather by Using Ground-based Optical Instruments in the Polar Region

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Various ground-based optical observations have been carried out in the polar ionosphere for a long time. Those observations have been done mainly for the purpose of detailed understanding of the plasma physics in the magnetosphere-ionosphere coupling system (physics of aurora etc.). However, such optical data are also helpful for doing space weather studies in the high-latitude part of the Earth. In this talk, we introduce two examples of optical observations in the high-latitude region and discuss those cases in terms of space weather applications in that region.

One example is optical observations of polar cap patches, which are regions high-density plasma in the F region ionosphere streaming from the daytime sunlit region into the dark hemisphere. Ground-based all-sky imager can detect such structures as enhancements of 630.0 nm airglow intensity. Patches are known to be accompanied by smaller scale plasma density irregularities; thus, they would be sources of ionospheric scintillations on the satellite signals in the polar cap region. Within polar cap patches, an enhancement of total electron content (TEC) is also observed, which could be a source of ranging inaccuracy in the satellite-based navigation system such as GPS. In this sense, studies of polar cap patches, in particular understanding of their structuring process (i.e., generation of density irregularities), are fairly important for the space weather applications in the highest latitude part of the Earth.

The other example is ionospheric scintillations on the GPS signal in the auroral latitudes. We often observe such aurora-induced scintillations in the phase of the GPS signal received on the ground at the time of auroral breakup (substorm). An enhancement of TEC of ˜10 TECU tends to be observed when the ray path of the GPS signal passes through an intense auroral arc. Such enhancements of phase scintillation and TEC are considered to be manifestations of increase and fluctuation in the electron density at the E region altitude. In this talk, we show how typical GPS receiver responds to the dynamical behavior of breakup aurorae during a relatively large geomagnetic storm, and then demonstrate the impact of the electron density variation in the E region due to the auroral particle precipitations to the satellite-based navigation system.

Keywords: Aurora, Polar cap patches, Satellite Navigation, Ionospheric scintillation