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Influence of the substorm precipitations and polar cap patches on the GPS signals at polar latitudes

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This study investigates the influence of substorm-related energetic particle precipitations and polar cap patches (PCP) on GPS signal scintillations in the high-latitude ionosphere. These ionosphere disturbances are a most powerful at the high-latitude region. A number of events in 2010-2017 are analyzed when the EISCAT radar data on Svalbard was available. We use data collected by the GPS scintillation receiver (University of Oslo) at Ny-Ålesund. Substorms are identified through IMAGE magnetometer data as well as optical observations in Ny-Ålesund. Occurrence of polar cap patches is determined by using electron density data from the EISCAT 42m radar (as a density increase above 200 km) and by considering optical observations at Ny-Ålesund station at 630.0 nm emission line. For some events, we show the onset of PCPs on the dayside and their propagation into the nightside, where the GPS receiver is located, by considering data from the Resolute Bay (Canada) incoherent scatter radar (RISR) and the SuperDARN radars. Our analyze shows that GPS amplitude scintillation index (S4) practically have no changes during considered events.

We demonstrate that substorm-associated precipitations can lead to a strong GPS phase (σ_ϕ) scintillations up to ~2 radians which is much stronger than those usually produced by PCPs. On the Figure 1(left panel) it is shown the substorm growth at 16 UT which lead to the strong phase scintillations (1.5 radian). On the other hand, PCPs can lead to a much faster ROT (rate of total electron content) variations. On Figure 1 (right panel) the PCPs during the substorm development are shown. Substorm at 19 UT leads to a strong phase scintillations (0.9 radian) while PCPs lead to stronger ROT variations at 20-21 UT. Our observations suggest that the substorms and PCPs, being different types of the high-latitude disturbances, lead to the development of different types and scales of ionospheric irregularities.

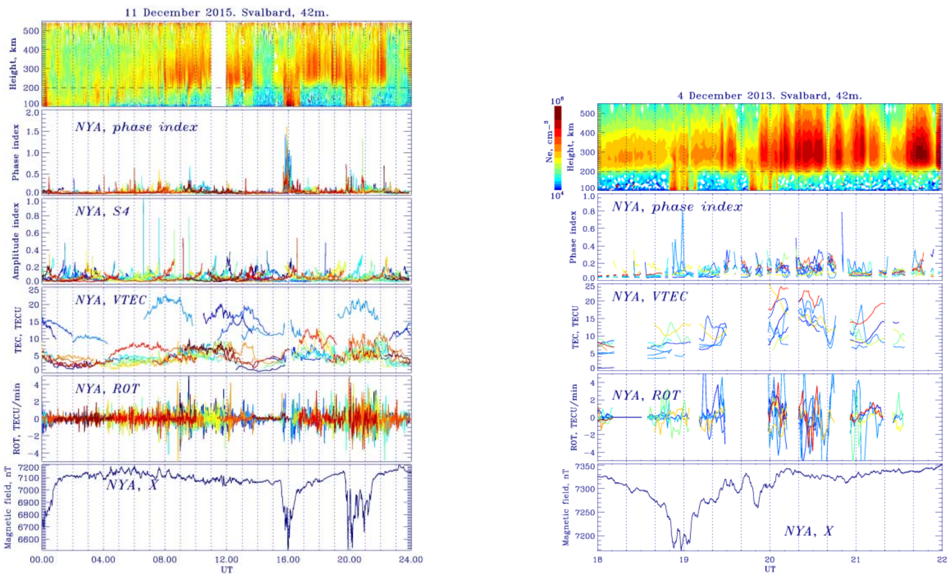

Figure 1. The ionosphere plasma density according to the EISCAT 42m radar data on Svalbard; phase, amplitude scintillation indexes from the NYA station; total electron content and rate of TEC from the NYA station; geomagnetic field variations (X-component) on NYA station for the 11 December 2015, 00-24 UT (left panel) and for the 4 December 2013, 18-22 UT (right panel).

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