Storm time loss of radiation belt electrons into the atmosphere: initial results from VLF/LF observation at Ny-Alesund

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Observation of manmade standard signals transmitted in the very low frequency (VLF) and low frequency (LF) ranges is a useful remote-sensing tool to detect ionization change in the lower ionosphere (D-region). The VLF/LF waves propagate between the earth’s surface and the lower ionosphere, and the received radio signal suffers phase and amplitude modulations when the ionization changes occur on the radio propagation path. As precipitations of high energy electrons from the magnetosphere are considered to be one of primary sources of the ionization in the night time lower ionosphere, the radio observation provide us information of the "real loss" of high energy electrons into the atmosphere. We have set up a radio receiver at the NIPR Rabben station in Ny-Alesund, Norway (78 56’ N, 11 52’ E) on Mar. 2010 to measure amplitude and phase of the standard signals in the frequency range of 20 to 100 kHz. As the propagation path from mid-latitude transmitters to the receiver in Ny-Alesund crosses the sub-auroral region, it is possible to investigate the loss of trapped particles from the outer radiation belt into the atmosphere. A goal of this study is to investigate a contribution of the atmospheric loss of trapped electrons in the outer radiation belt during the magnetic storm. A purpose of this paper is to shows that the electron precipitation actually causes the phase variation during the magnetic storm. Three moderate magnetic storms were occurred on 5th Apr., 2nd May, and 29th May 2010 and significant phase variations in the received signals which were transmitted from Anthorn, England (60.0 kHz) and Mainflingen, Germany (77.5 kHz) were detected during the main phase of these storms. For all three cases, the phase variations occurred in the dayside sector and the time scale of the variation was a few hours. Comparisons of the phase variations with the GOES x-ray and the ACE/EPM energetic particle data obtained in the solar wind showed that the phase variations were not accompanied by the solar x-ray and energetic particle events. Therefore, it is interpreted that the real loss of radiation belt particles into the atmosphere occurred in the storm main phase and causes significant phase variations in the LF signals.