The radiation belt electron loss into the atmosphere: Initial analyses with LF radio observations at Ny-Ålesund

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A low-frequency wide-band radio receiver has been installed at the NIPR Rabben station in Ny-Ålesund, 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. Primary purpose of this radio system is to investigate the loss of trapped particles from the outer radiation belt into the atmosphere. The manmade standard radio signals transmitted in the VLF/LF range 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 is one of primary sources of the ionization in the lower ionosphere, the radio observation provide us information of the "real loss" of high energy electrons into the atmosphere. As the propagation path from mid-latitude transmitters to the receiver in Ny-Alesund crosses the aurora and sub-auroral regions (Fig. 1), it is possible to investigate the loss of trapped particles from the outer radiation belt into the atmosphere. Energetic electron precipitation has been studied using riometers, which observe the integrated absorption of cosmic radio noise through the ionosphere, with increased absorption due to additional ionization due to electron precipitation. Generally, the dominant altitude of the absorption is 70–100 km. The typical energy of the electron is biased toward lower energies (~30 keV electrons), because high altitude ionizations have more contribution to the absorption. On the other hand, the reflection of VLF and LF radio waves is more sensitive to ionization caused by electrons with relativistic energies, typically >100 keV, as these energies ionize the neutral atmosphere in the Earth-ionosphere waveguide at altitudes below ~70 km.

Three moderate magnetic storms were occurred on 5 Apr., 2 May, and 29 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 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 solar energetic particle events (Fig. 2). 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. We plan to examine relations between onet timings of substorm and the phase variation, and a dependence of the occurrence of the phase variation on local time.

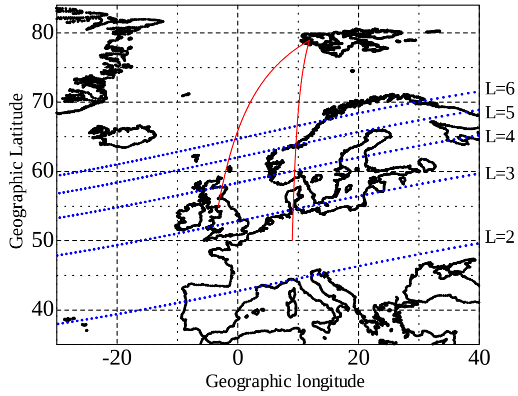

Fig.1: Radio propagation paths from transmitters (Anthorn, Cumbria, England, 60.0kHz and Mainflingen, Germany, 77.5kHz) to receiver (Ny-Ålesund).

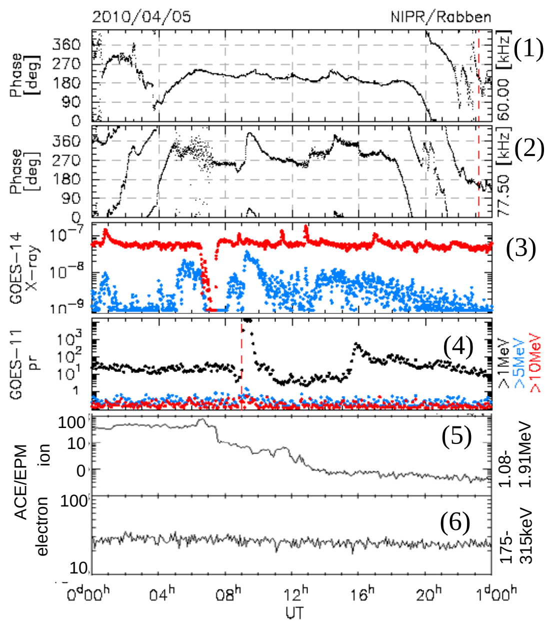

Fig.2: (1), (2) The phase variations during a storm main phase on Apr. 5 2010. (3) Intensities of the solar x-ray measured by GOES-14. (4) Energetic proton fluxes measured by GOES-11. (5), (6) Energetic ion and electron fluxes measured by ACE/EPME in the solar wind.