Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)
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PEM10-29 会場:A01 時間:5 月 28 日 17:45-18:00

Height-dependent ionospheric variations in the vicinity of nightside poleward expanding aurora after substorm onset

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Polar ionospheric responses to a substorm onset are among the most widely studied phenomena of space physics. An initial brightening appears at the very first phase of the substorm and tends to take place at magnetic midnight or slightly earlier in the auroral oval or at its lower latitudes. After initial brightening of the aurora that is located at the most poleward side of the oval, near the polar cap boundary, the oval expands poleward and then a westward traveling surge forms.

Auroral morphology and some ionospheric parameters responding to substorm onsets have been studied with various instruments, such as the Super Dual Auroral Radar Network radars, incoherent scatter radars, and satellites, generally focusing on spatiotemporal developments of the auroral forms, the ionospheric plasma convection, and the auroral particle spectra. By contrast, this paper addresses other ionospheric parameters such as the electron density in the F region, electron and ion temperatures, and the relationships of the large-scale time-dependent aurora and electric-field structures. This approach is important for achieving further understanding of the energy budget in the magnetosphere-ionosphere-thermosphere coupled system. The analysis is directed to the height dependency of the ionospheric variations, because the ionization rate and the collision frequency significantly change with heights.

Statistical analysis was made of data from the European Incoherent Scatter UHF radar at Tromsϕ, Norway, and International Monitor for Auroral Geomagnetic Effects magnetometer for finding common features in electron density, ion and electron temperatures and relating these to currents and associated heating. This paper particularly focused on the height dependencies. Results show clear evidences of large electric field with corresponding frictional heating and Pedersen currents located just outside the front of the poleward expanding aurora, which typically appeared at the eastside of westward traveling surge. At the beginning of the substorm recovery phase, the ionospheric density had a large peak in the E region and a smaller peak in the F region. This structure was named as *C form* in this paper based on its shape in the altitude-time plot. The lower altitude density maximum is associated with hard auroral electron precipitation probably during pulsating aurora. We attribute the upper F region density maximum to local ionization by lower energy particle precipitation and/or long-lived plasma that is convected horizontally into the overhead measurement volume from the dayside hemisphere.

キーワード: 電離圏, サブストーム, 極域, 非干渉散乱レーダー, オーロラ, ジュール加熱
Keywords: ionosphere, substorm, polar region, incoherent scatter radar, aurora, Joule heating