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Scale-dependent reflection process of shear Alfven wave coupling to the 3D-ionospheric current system

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Interaction between shear Alfven wave and 3-dimensional ionosphere coupling to the auroral acceleration region (AAR) is discussed. In the conventionally established global M-I coupling process via shear Alfven wave, the ionosphere had been treated as a height-integrated conducting layer. This assumption can be validated under the condition that the ionospheric potential structure has no altitudinal dependence. However as shown by Lesserd and Knudsen [2002], the small scale shear Alfven wave (of which scale length is several km) incident from the magnetosphere to the ionosphere is almost absorbed into the ionosphere for any realistic condition of ionospheric conductances. Furthermore, existence of AAR also brings about scale-dependent reflection process of shear Alfven wave when the scale length is smaller than the resistive scale length (that is roughly 1000km for typical ionospheric conditions).

Composite effect of AAR and 3-dimensional current closure is very important because it is closely related to the physics of confinement of Hall current divergence in the ionosphere. From theoretical analysis, we found that characteristic scale length of effective conducting layer is controlled by the ratio of Pedersen to parallel conductivity. When the horizontal scale length of FAC is smaller than this characteristic scale, an effective ionospheric conductivity becomes small and FAC only closed via small fraction of ionospheric current. This means that the FAC closure is accomplished at the upper ionospheric E-layer or F-layer not at the all over the E-layer.

Our results strongly suggest that in a large scale M-I coupling process that is larger than ˜1000 km, the confinement of Hall current divergence in the ionosphere is controlled by the ratio of Alfven conductance to Pedersen conductivity but for small scale M-I coupling smaller than 1000 km is effectively confined in the ionosphere, which means the polarization electric field is efficiently produced for generation of Cowling effect.

Keywords: Alfven wave, 3 dimensional ionosphere, Magnetosphere-Ionosphere coupling