Ionospheric Polarization: Deformation of Ionospheric Convection and Effects on Magnetosphere

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Recently [Nakamizo and Yoshikawa, 2019], we showed that the ionospheric polarization can deform the high-latitude ionospheric convection field, which is widely considered to be a manifestation of the convection field in the magnetosphere.

We performed in a potential solver 'the Hall polarization field separation' modified from the complete separation theory/method by Yoshikawa et al. [2013a,b]. We adopted dawn-dusk and north-south symmetric distributions of conductance and region 1 (R1) field-aligned current (FAC) to understand the essential effects of the conductance nonuniformity on the potential pattern eliminating asymmetries arising from that of the conductance and FAC distributions themselves.

The pair of the primary field of the R1 system and each gradient of Hall conductance generates the Hall polarization field and consequently causes potential deformations as follows. (a) The equatorward gradient causes clockwise rotation. (b) The gradient across the terminator, together with the effect of the equatorward gradient, causes the dawn-dusk asymmetry. (c) The high conductance band in the auroral region causes kink-type deformations. In particular, a nested structure at the equatorward edge of the band in the midnight sector well resembles the Harang Reversal. (It was also found that the Pedersen polarization is important because it determines the formation of the primary field, which is the source for the secondary field (Hall polarization field)).

Result (a) explain the clockwise bias inexplicable by the IMF-By effect alone, the combination of (a) and (b) explain the clearness and unclearness in the round or crescent shapes of the dawn-dusk cells depending on the IMF-By polarity, and (c) suggests that the ionosphere may not need the upward-FAC for the formation of the Harang Reversal.

The above result suggests that the final structure of the ionospheric potential is established by the combined effects of the magnetospheric requirements (external causes) and ionospheric polarization (internal effect). Our next question is how and in what way does the ionospheric polarization play a role in the convection and dynamics of the magnetosphere-ionosphere system through the coupling process?

We show that the ionospheric polarization actually controls the magnetospheric configuration/dynamics in a global MHD model. The topic includes the dawn-dusk asymmetry of the magnetosphere, formation of the Harang Reversal in the magnetosphere, and the NENL formation. We also show the effects of north-south conductance asymmetry due to the precession between the rotation and magnetic axes of Earth on the magnetosphere. We will discuss the results, revisiting the M-I algorithm of current global models.