Harang discontinuity and ionospheric polarization field by Hall current divergence

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The ionospheric electric potential shows global asymmetries and localized structures. Whereas these structures have been mainly discussed as the projection of magnetospheric convection (or the distribution of driving source, FACs, generated in the solar wind-magnetosphere system), we have proposed that it is also possible to explain them purely by ionospheric polarization effects due to conductivity inhomogeneities. Our study has been based on a part of the M-I coupling theory [e.g., Yoshikawa et al, 2013a,b] including the idea of Pedersen/Hall divergence/polarization effect [e.g., Yoshikawa et al., JpGU, 2009]. Although the possibility of ionospheric effect had been reported [Wolf, 1970; Atkinson and Hutchison, 1978; Tanaka, 2001; Ridley et al., 2004], we have for the first time shown and addressed correctly the underlying physics.

By applying a simplified version of 'Hall conjugate method [Yoshikawa et al., JpGU, 2008]' to a 2D ionospheric potential solver, we separate the total field (Phi, ionospheric total potential) into the primary field (Phi$_0$, including the background and Pedersen polarization field) and secondary field (Phi$_{Hall}$, the polarization field generated by Hall current divergence).

In the previous meetings [Nakamizo et al., SGEPSS, 2012-2014], we have specified one-to-one correspondence between characteristic spatial gradients of conductivity and characteristic deformations of potential, as follows; (a) For simplicity we consider dawn-dusk symmetric R1-FAC as the driving source. As the reference field, we calculate the potential with the uniform conductivity distribution. This reference field is symmetric with respect to both the noon-midnight and dawn-dusk axes. From this condition we gradually add spatial structures on the conductivity distribution. (b) Equatorward conductivity gradient generates positive/negative Hall polarization field (Phi$_{Hall,eq}$) around pre-noon/pre-midnight sectors. As the result the total field (Phi) rotates clockwise. (c) Day-night conductivity difference not only shifts the potential centers toward night due to Pedersen polarization effect (in other words, current continuity), but also generates Hall polarization fields (Phi$_{Hall,te}$) along day-night terminators due to sharp conductivity gradients there, resulting in the convex/concave of total field (Phi) along terminators. (d) Auroral conductivity enhancement generates Hall polarization fields (Phi$_{Hall,ao}$) around edges of conductivity band. Thus in the total field (Phi) a conspicuous structure appears around the midnight oval, resembling 'Harang discontinuity.'

This presentation gives a detailed analysis of point (d). Interesting point here is that we get Harang-like structure with simplified distribution of FAC, dawn-dusk symmetric R1-FAC, noted above. We will discuss the result in relation to the characteristics of 2D solver (perfect current confinement condition) and the advanced M-I coupling theory [Yoshikawa et al., 2013a,b].