# Effects of Ionospheric Hall Polarization Field on Magnetospheric Structure and Dynamics in Global MHD Simulation

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In some settings and parameterizations in global MHD magnetosphere models, we especially place importance on the descriptions for low-altitude region, that is, the magnetosphere-ionosphere (M-I) coupling and boundary conditions imposed on MHD variables, and we expect that they largely control the M-I system. In order to advance our understanding of the M-I system from the viewpoints of the above interest and to simulate accurately the magnetosphere, we are investigating the responses of magnetosphere for different treatments of low-altitude region.

The science question of the present study is how and in what way the ionospheric Hall polarization field generated by the Hall conductance inhomogeneity impacts the convection and dynamics in the magnetosphere. The background of this challenge is a recently proposed concept of ionospheric control based on generalized theory for ionospheric polarization/Cowling channel formations [*Yoshikawa et al.*, 2008; 2013; 2017]. This challenge is important for practical use as well because at the present uncertainties in the conductance estimation remains both in the observational and simulation studies.

We perform simulations for the following pairs of conductance setting and upstream boundary conditions. As for the conductance setting, we test four cases; Hall part of conductance set by $R_H$ = 3.5 (the default setting), 2, 5, and uniform distribution (1.0 [S]), where $R_H$ is the ratio of Hall to Pedersen conductance. As for the upstream condition, we test three cases of IMF-By polarity; positive, negative, and 0-By. The solar wind parameters and IMF-Bz are common to all cases. IMF-Bz is changed from northward to southward during the course of simulation runs.

The results are summarized as follows.
(a) Asymmetry / symmetry of the large-scale structure: As for the cases of uniform Hall conductance, the magnetosphere is completely symmetric with respect to both the XY and XZ-planes under 0-By. Under the finite IMF-By, the magnetosphere shows asymmetry consistent with the By-polarity. As for the cases of non-uniform Hall conductance, the magnetosphere shows global asymmetry even under the condition of 0-By. The asymmetry becomes severe for larger $R_H$. This result indicates that the ionospheric Hall polarization field obviously one of the important factors to deform the magnetospheric structure.
(b) Location and timing of the Near-Earth Neutral Line formation: Location becomes closer to the earth and timing becomes earlier for larger $R_H$, compared to the cases of uniform Hall conductance. The deference seems to be related to combined effect of twist of magnetic field lines due to the Hall polarization field and energy/current closure between the magnetosphere and ionosphere.
(c) Near-earth convection field during the growth phase: In the cases of non-uniform Hall conductance, an inflection structure of equatorial convection is formed around premidnight sector inside R = 10 $R_E$. Considering that the region 2 FAC is not sufficiently developed in MHD models, the structure is considered to be a convection reversal often shown in the Rice Convection Models. Previous studies regard the structure as Harang Reversal in the magnetosphere. On the other hand, in the case of uniform Hall conductance with 0-By, such structure is not formed and the convection is completely symmetric. This result indicates that Harang Reversal may not be formed without the effect of ionospheric Hall polarization field.

The above initial research strongly suggests that the ionospheric Hall polarization plays a significant role in the M-I system definitely. In this presentation, we will report the detailed analysis for the above items.