Alfvénic disturbances generated by the ionospheric polarization and the convection reversal in the magnetosphere

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The ionospheric polarization due to conductance non-uniformities largely deforms the global ionospheric convection pattern [*Nakamizo and Yoshikawa*, 2019]. Then it is supposed that the ionospheric polarization should act as the internal driver of the magnetosphere and our succeeding study using global MHD model shows that the ionospheric polarization actually and largely affects the magnetosphere; When the ionospheric Hall conductance is distributed non-uniformly, regardless of IMF-By=0 condition, the whole magnetosphere shows dawn-dusk asymmetry and a kink-type structure appears in the near-earth convection field. The structure resembles the magnetospheric Harang Reversal reported by preceding model studies. It is also confirmed that the magnetosphere remains symmetric between the dawn and dusk sides and the near-earth convection field shows no kink-type structure for the uniform ionospheric Hall conductance (no Hall polarization field). The result for the near-earth region suggests that the Hall polarization is necessary not only for the ionospheric Harang Reversal but also for the magnetospheric one.

The process by which the ionospheric polarization affects the magnetosphere in the simulation space should be as follows: The ionospheric potential deformed by the ionospheric polarization is mapped back to the inner boundary (I.B) of simulation space. The bulk velocity is updated there, and the perturbation propagates in the magnetosphere, modifying the momentum and energy balance. The FAC is determined in the magnetosphere updated in this way and is inputted to the ionospheric solver, where the ionospheric potential mapped back again to the magnetosphere is calculated. The M-I system develops with the succession of this cycle [*Yoshikawa et al.*, 2010], in which the ionospheric polarization effect is accumulatively included.

In order to confirm[visualize] this process and understand how the ionospheric driven component modifies the magnetosphere, we implemented the parallel/anti-parallel Alfvén mode separation method proposed by *Yoshikawa et al.* [2011] in the global simulation. When this method is applied to satellite observational data, it enables us to separate Alfvénic disturbances into components propagating parallel and anti-parallel to the ambient magnetic field, that is, components propagating from/to the ionosphere to/from the magnetosphere. We apply the separation to the 3-D simulation data.

In this study, we focus on the Harang Reversal and corresponding region in the magnetosphere. In the case of the uniform Hall conductance distribution, the Alfvénic disturbance from the I.B. propagates to the magnetosphere symmetrically between the dawn and dusk sides with opposite signs, corresponding to the dawn-dusk symmetric 2-cell ionospheric convection pattern. Both the ionospheric and magnetospheric convection pattern stay symmetric, never showing reversal structures no matter how the M-I system is activated by the external driver (solar wind and IMF). In the case of the non-uniform Hall conductance distribution, the Alfvénic disturbances from the I.B. propagates to the magnetosphere asymmetrically between the dawn and dusk sides because of the ionospheric potential deformed by Hall polarization. The magnetospheric convection gradually shows a meandering. As the time proceed, the kink-type structure is formed corresponding to the Harang Reversal in the ionosphere. The result indicates that the cause of magnetospheric Harang structure is, at least in the global model, the ionospheric Hall polarization.

References:

Nakamizo, A., & Yoshikawa, A. (2019). Deformation of ionospheric potential pattern by ionospheric Hall polarization. Journal of Geophysical Research: Space Physics, 124, 7553–7580. https://doi.org/10.1029/2018JA026013

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