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Large-scale FAC pattern and SW-M-I coupling

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The distribution of large-scale FAC shows different patterns depending for example on the IMF clock angle, basically reflecting the large-scale solar wind-magnetosphere (SW-M) interaction and magnetospheric convection. However, as with the ionospheric convection pattern, various asymmetries can be seen in the patterns. For example, the well-developed FAC distribution during the southward IMF Bz does not necessarily show a perfect dawn-dusk symmetric pattern.

As for the ionospheric potential pattern, the deformations and their causes are understood relatively well. For example, it is well known that the pattern rotates clockwise when IMF By is positive and anti-clockwise when IMF By is negative. In addition, Nakamizo & Yoshikawa [2019] pointed out that there is a bias of clockwise rotation that cannot be explained by the IMF By effect (external effect) alone, and they show that the bias is due to the Hall polarization field generated by the latitudinal conductance gradient, based on a test calculation using an ionospheric potential solver. In contrast, as for the FAC pattern, little is known so far about its asymmetry and its causes. So, we numerically investigate how and why the large-scale FAC pattern exhibits asymmetries. Since the large-scale FAC is generated by the solar wind-magnetosphere-ionosphere (SW-M-I) coupling, we use a global MHD model, which is a dynamic model whereas the ionospheric potential solver used in the ionospheric convection pattern study is a static one.

In the simulation runs, we set the y-components of solar wind velocity and IMF to zero, in order to eliminate external factors for the large-scale asymmetry. First, we perform simulation with ionospheric polarization effects turned off (with a finite constant ionospheric conductance) to extract the effects of SW-M interactions. Next, we perform a normal simulation (with normal non-uniform ionospheric conductance) and compare the results with those for the no ionospheric effect to extract the effect of M-I coupling (ionospheric polarization). Furthermore, we try to identify the effect of the M-I coupling process itself on the FAC pattern by comparing the simulation results of cases with the conventional coupling scheme and Alfvenic coupling scheme as the M-I coupling in the global MHD model.