Evolution process of the theta aurora inferred from global MHD simulations

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The theta aurora sometime appears in the polar cap region when IMF Bz keeps northward.
There are many previous studies, but no unified theory to explain what happens in the ionosphere and magnetosphere during the theta aurora events.

We made MHD simulation by changing IMF By polarity from negative (-4.3nT) to positive (4.3nT) under the northward condition (Bz=4.3nT). Simulation results show there are three stages of the theta aurora evolution. First stage is characterized by the rapid change (within about several minutes) of the anti-clockwise convection to the clockwise one viewed from the north pole in the cusp region of the northern hemisphere. At the same time, upward Region 0 FACs in the post-noon region is exchanged with downward Region 1 FACs in the pre-noon region. Associated with the switch of the FAC polarity in the dayside ionosphere, the dynamo location is also shifted from the post-noon region to the pre-noon region in the dayside magnetosphere. Second stage is characterized by the detachment of high pressure region from the cleft. The detached region move to the high latitude lobe region in the night side and gradually becomes short. This stage lasta about 30 minutes. The high pressure region correspond to the moving front of the changing convection flow. A pair of upward and downward FACs in the ionosphere appears in association with the moving high-pressure region in the magnetosphere. The dynamo appears in the high-pressure region in the magnetosphere as noted below. The closed field line region breaking into the polar cap region associates the pair of the FACs in the ionosphere. We notice that the high-pressure region in the magnetosphere corresponds to the closed field line region. Third stage is given by the extension of the high pressure region to the dayside aurora region. Disturbances in the magnetosphere and in the ionosphere caused by the By change gradually disappear. The FACs become weak, but the closed field line region still beaks into the polar cap. The high-pressure region in the magnetosphere is located in the closed field line region in this stage, too.

It is strongly expected that high pressure region connect to the dynamo region($E \cdot J<0$), we have examined field aligned current signature in high pressure region for three stages. The results demonstrate that pressure region connect to the dynamo region($E \cdot J<0$),consistent with Watanabe et al.(2014). We will report a possible mechanism to generate the dynamo region and its relation to the theta aurora formation in the presentation. It is the final goal of this study to elucidate the state transition mechanism of the magnetosphere-ionosphere compound system caused by the IMF By change.

