Response to referee #2:

We would like to thank the referee for his/her thoughtful comments and suggestions, which helped us greatly to improve the paper. In the following we quote the referee's comments in italics, followed by our response. Annales handles the process a little bit different than most other journal such that they only ask for our response at this point, but not for a revised manuscript. We therefore include new figures and text in the response and will include them in the final manuscript when the editor asks us to do so.

This paper presents the locations and dynamics of polar cap boundary during the five magnetic storm periods by using OpenGGCM-CTIM-RCM simulation together with the DMSP observations. The polar cap boundary and area are crucial parameters for the energy features in the solar wind-magnetosphere coupling, which are strongly related to solar wind and interplanetary magnetic field conditions. Therefore, the topic is very important. This papar shows the simulation and observation results of IMF clock angle dependence of the polar cap boundary mainly are consistent with each other, eventhough the simulation overestimates the latitude of boundary. Moreover, it shows the MLT of the largest polar cap expansion closely correlates with the IMF clock angle and the simulation can remedies observation limitation in local time. These results give new insights into the dynamics of polar cap expansion during storm time, and this paper is of course suitable to be publish in Annales Geophysicae. However, before it is published, I recommend the authors address the following points:

Major comments:

In Lines 91-92, the authors mentioned "the coupled numerical model is driven by observed solar wind and IMF data at Lagrangian 1 (L1)" and "…are obtained from OMNIWeb". These seem to confuse the readers where the interplanetary data you used in your model are, L1 or nose of bow shock? Please make it clear in the text. Here I assume your input data have been shift to the nose of bow shock from OMNIWeb. If so, have you considered any time delay for the solar wind and IMF data propagating from the bow shock to the dayside magnetopause and the polar ionosphere? As we know the solar wind and IMF need several minutes to reach the dayside magnetopause by crossing the magnetosheath, and need 1-2 minutes to affect the dayside polar ionosphere when the solar wind-magnetosphere coupling happened at the dayside magnetopause. Thus, the time delay is very important when you compare the IMF with your observation and simulation results. I suggest the authors to consider these time delays at least for the delay for the solar wind and IMF crossing through the magnetosheath.

The NASA web site for the OMNI data describes the time shifts in great detail, see section 12 in: https://omniweb.gsfc.nasa.gov/html/ow_data.html. In particular, the data are shifted (by ballistic propagation, which is the best one can do with the available information) to 30 RE upstream of Earth. Although OpenGGCM has its own internal algorithm for time-shifting solar wind inputs (similar to the OMNI procedure) it also has the inflow boundary at 30 RE on the sunward side, so no further time shift is necessary.

I remember that there is a debate for a long time: whether the whole polar ionosphere (convection pattern) immediately responses the IMF variation or need some time for the IMF effect propagating from dayside cusp region to nightside auroral oval through the polar cap. Fear and Milan (2012) argued the convection of magnetic field lines should take a number of hours from the dayside to the nightside after statistically analyzed the formation of the transpolar arcs. Zhang et al. (2015) suggested that cross-cap transit time of the field line is about 1-2 h from noon to midnight in MLT and is 3 h for the convection of the full Dungey cycle by tracing the polar cap patches. Browett et al. (2017) suggested that the timescale varied from 1 to 5 h for the penetration of IMF By into the magnetotail depending on the IMF orientation and solar speed. I think the OCB in different MLT may need different time to response the IMF variations. Thus, we may need to be careful when we compare the OCB at all MLT with the IMF clock angle, such as in Figure 6. I suggest the authors make any clarification of these in the text, because this is related to your main results.

We agree that the convection across the polar cap takes some time. However, as soon as a closed field line reconnects it expands the polar cap, so that process is instantaneous. Still, convection redistributes open flux, so some delay can be expected. That may be the cause of the still significant scatter in the MLAT-CLK plots (see our response to the other reviewer.) We will add some discussion addressing this point and in particular refer to the references. On the other hand, the cases presented in this paper have for the most part prolonged intervals (several hours) of fairly constant IMF or slowly changing IMF, thus such time delays should have only a minor impact. Close inspection of the MLAT versus MLT/time figures shows streaks at a much smaller time scale (~30 min) that seem to be associated with polar cap reconfiguration. We will study this in more detail in forthcoming work.

Small suggestions and typos:

How do the authors identify the OCB from the DMSP spectrograms? Although the authors cited some references, I suggest to make a briefly interpretation about it for the readers easily following, because the OCB is the main topic of this manuscript.

We addressed this point in the response to reviewer #1.

Line 130: "in Fig. 1 through ??" Please check.
Page 6, the caption of Figure 1 line 1: There is an extra space in DMSP.
Lines 186-190: These sentences are not clear to me. Could you please explain how the northward IMF influence on the behavior of OCB?
Line 215: PC-> polar cap (PC). When an abbreviation of term first appears in the manuscript, the term should have a full name first.
Lines 219-220: please tone down of the express “five strong geomagnetic storm events”, because there is an event with a minima Dst of -39 nT, and an event with a minima Dst of -65 nT in your events list.

We appreciate the suggestions and will rephrase those statements in the final manuscript accordingly.

References mentioned above:

Browett, S. D., R. C. Fear, A. Grocott, and S. E. Milan (2017), Timescales for the penetration of IMF By into the Earth’s magnetotail, J. Geophys. Res. Space Physics, 122, 579–593, doi:10.1002/2016JA023198.

Fear, R. C., and S. E. Milan (2012), The IMF dependence of the local time of transpolar arcs: Implications for formation mechanism, J. Geophys. Res., 117, A03213, doi:10.1029/2011JA017209.

Zhang, Q.-H., M. Lockwood, J. C. Foster, S.-R. Zhang, B.-C. Zhang, I. W. McCrea, J. Moen, M. Lester, and J. M. Ruohoniemi (2015), Direct observations of the full Dungey convection cycle in the polar ionosphere for southward interplanetary magnetic field conditions, J. Geophys. Res. Space Physics, 120, 4519–4530, doi:10.1002/2015JA021172.

The end.