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Interactive comment on "A new scenario applying traffic flow analogy to poleward expansion of auroras" *by* Osuke Saka

Anonymous Referee #1

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The paper by O. Saka attempts to address why aurora expands poleward but plasma flows equatorward during the substorm expansion phase. The author provides an analytical theory and concludes that poleward expansion is caused by the shock front of density accumulation propagating poleward. As commented below, the author's approach is oversimplified and omits critical nature of the ionosphere during the substorm expansion phase, such as magnetic field dipolarization, precipitation, and two dimensional system. Currently I don't think that the theory provided here gives a solid answer to the poleward expansion but need a more sophisticated approach.

The author did not consider that magnetic field geometry changes during the expansion phase. As magnetic fluxes accumulate on closed field lines due to reconnection during the substorm expansion phase (together with earthward flows known as BBF), the

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Discussion paper

magnetic field becomes more dipolar and the mapping location of a certain geocentric distance moves poleward. This geometrical change can easily explain the discrepancy between the poleward aurora motion and equatorward plasma drift. Please consider how mapping location changes by depolarizing magnetic field will contribute to author's story.

Equations (2) and (6) assume that there is no source term in the continuity equation. This assumption is not valid during the substorm expansion phase because of intense particle precipitation and vertical transport. Thus the density accumulation that the author obtained will be substantially modified. From this standpoint, the traffic flow analogy does not accurately represent the expansion phase. Please consider the effect of the source term.

The author also assumes the one dimensional system. Expansion phase aurora including surges is two dimensional, where the electric field converges to the center of surges [Opgenoorth et al., 1983]. The distance between equipotential lines becomes larger when the electric field decreases. In this situation the density does not pile up but spreads azimuthally when the electric field decreases. The one dimensional assumption does not consider this effect.

The author provided an equation for the shock front propagation but did not estimate if the speed is consistent with poleward expansion and if the critical density is within a realistic level of density in the ionosphere. Please make a quantitative assessment of this argument using realistic ionosphere parameters. Figure 4 only provides the parallel velocity but what's important for poleward expansion is the poleward velocity.

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