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Interactive comment on "Quasi-separatrix Layers Induced by Ballooning Instability in Near-Earth Magnetotail" *by* Ping Zhu et al.

Ping Zhu et al.

pzhu@ustc.edu.cn

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We thank the referee Dr. Andrei Runov for the encouraging evaluation and recommendation on our work and manuscript. Below we clarify each of the points raised by the referee:

1."In line 19, page 7 the Authors stated: "... the reconstruction of the 3D QSL geometry may provide an alternative means for identifying the location and timing of 3D recon- nection sites in magnetotail from both numerical simulations and satellite observations." It is very interesting statement, and I would ask the Authors to comment possible applications of their methods to in-situ observations. If my understanding of the method is correct, the Jacobian transformation matrix and the norm should be de-

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fined within the entire region of space to calculate QSL. Am I correct? In the other words, the knowledge of the magnetic field lines connectivity is required. Obviously, it is not the case for single-point spacecraft measurements. May the requirement be fulfilled in a case of multi-point observations? Would 4-points observations (Cluster, MMS) be sufficient when the probe tetrahedron crosses the region of interest?"

Reply: Yes, it is correct that the knowledge of the magnetic field lines connectivity is required for the calculation of QSL. The in-situ observation data from both single-point and multi-point spacecraft measurements, with additional assumptions and modeling, have been used in various reconstruction methods for the magnetic field line geometry in magnetotail. These include the global MHD simulations of magnetotail evolution calibrated using the in-situ observation data in general (e.g. [Raeder et al 2008]), the Grad-Shafranov (GS) method for two-dimensional (2D) magnetohydrostatic structure based on single-spacecraft data analysis technique (e.g. [Hasegawa et al 2013]), and the magnetic field rotation analysis (MRA) method based on four-point measurements of the magnetic field (e.g. [Shen et al 2007]). The reconstructed region of interest using these methods and in-situ observation data can then be subject to the calculation of QSL.

Raeder, J., Larson, D., Li, W., Kepko, L., and Fuller-Rowell, T., OpenGGCM Simulations for the THEMIS Mission, Space Sci. Rev., 141, 535Â■555, doi:10.1007/s11214-008-9421-5, 2008.

Hasegawa, H., B. U. Ö. Sonnerup, Q. Hu, and T. K. M. Nakamura (2014), Reconstruction of an evolving magnetic flux rope in the solar wind: Decomposing spatial and temporal variations from single-spacecraft data, J. Geophys. Res. Space Physics, 119, doi:10.1002/2013JA019180.

Shen, C., X. Li, M. Dunlop, Q. Q. Shi, Z. X. Liu, E. Lucek, and Z. Q. Chen (2007), Magnetic field rotation analysis and the applications, J. Geophys. Res., 112, A06211, doi:10.1029/2005JA011584.

We have added the above comment and references to the revised manuscript.

2. "Later the Authors state: "Whereas the near-Earth magnetotail can become ballooning unstable under substorm conditions, the nonlinear evolution of ballooning instabilities, by themselves, may not lead to the near-explosive substorm onset." This statement is somewhat out of context. Do the Authors mean that coupling between ballooning and reconnection is necessary for explosive-like process?"

Reply: No, here we only meant to suggest that the coupling between ballooning and reconnection could be an alternative, though not necessary, route to the near-explosive substorm onset. We do not mean to completely rule out the possibility of explosive growth of nonlinear ballooning instability alone, however, its condition and in particular demonstration has remained a subject of research.

To avoid potential confusion, we have revised the statement as “Whereas the near-Earth magnetotail can become ballooning unstable under substorm conditions, the nonlinear evolution of ballooning instabilities, by themselves, may not always lead to the near-explosive growth. The coupling between ballooning and reconnection could be an alternative, though not the necessary, route to substorm onset." in the revised manuscript.

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