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Interactive comment on "Contribution of patchy reconnection to the ion to electron temperature ratio in the Earth's magnetotail" *by* Chuxin Chen and Chih-Ping Wang

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Reply to Referee #2:

Referee #2's comment:

The manuscript deals with ion to electron temperature ratio in the Earth's magnetotail. The authors present an analytical model to investigate the role of patchy reconnection from the near-Earth tail to mid-tail.

Specific comments:

1) Heating in reconnection I have significant concerns about how the authors treat

(or actually seem to neglect) plasma heating in reconnection. The authors state on p5, lines 3-4: "Equation (23) indicates that the ratio Ti/Te is preserved after a patchy magnetic reconnection. However, this is only true when the temperature of both the ions and electrons in Eqs. (16) and (20) are constant during the patchy reconnection." Plasma temperature does not stay constant during reconnection, patchy or extended. Heating (i.e., increase in temperature) during reconnection has been the focus of several previous studies. For example, Drake et al. (JGR 2009; see also references therein) considered how ions get heated when they enter a reconnection exhaust (BBF). This has been further investigated by, e.g., Haggerty et al. (GRL 2015). I don't think this aspect of reconnection can be ignored when considering the ion to electron temperature ratio.

Our response:

We are very grateful to Referee #2 for helpful comments.

There is a misleading in this matter. The statement "when the temperature of both the ions and electrons in Eqs. (16) and (20) are constant during the patchy reconnection" really describes that ions and electrons sequentially entering the reconnection site during a patchy reconnection are of same temperature. Considering Eq. (24), when ions and electrons reentering the reconnection site are those accelerated in previous passing through the reconnection site and reflected back from the ionosphere, the ratio Ti/Te would not be preserved. The heating associated with reconnection is considered in our calculation as Eqs. (11) and (12). It is the difference of the heating between ions and electrons at each reconnection site leads to the lower Ti/Te ratio close to the Earth.

We will delete the statement "However, this is only true when the temperature of both the ions and electrons in Eqs. (16) and (20) are constant during the patchy reconnection" in a revised version to avoid confusion.

Referee #2's comment:

2) Discussion on the limitations of the model The present discussion is not comprehensive enough. Topics that should be discussed in much more detail than in the present manuscript include: a) dawn-dusk asymmetry The discussion on asymmetry should include both the exclusion of particle drifts in the model (already mentioned, but more detail needed), as well as the observational fact of “dusk side is more active” (more reconnection and reconnection-related phenomena are observed to take place on the duskside than on the dawnside, but this difference of occurrence rates is also not included in the model; (Raj et al., JGR 2002; Frey et al., JGR 2004; McPherron et al., JGR 2011; Nagai et al., JGR 2013; Liu et al., JGR 2013; Genestreti et al., JASTP 2014; Gabrielse et al., JGR 2014; Kiehas et al., JGR 2018)).

Our response:

We will include a more detail discussion about dawn-dusk asymmetry in a revised version as following. The finite cross-tail width of the plasma sheet and particle’s gradient and curvature drift cause depletions of energetic ions on the dawn magnetopause and electrons on the dusk magnetopause, which is likely the main reason for the observed asymmetry of Ti/Te ratios with higher Ti/Te ratio on the duskside. Observations have suggested a dawn-dusk asymmetry with reconnection occurring more often on the dusk side (e.g., Raj et al., 2002; Kiehas et al., 2018). This asymmetry is not considered in our current model. Since our model shows a reconnection would lead to a lower Ti/Te ratio, such dawn-dusk asymmetric reconnection occurrence frequency is expected to reduce the dawn-dusk asymmetry caused by particle’s gradient and curvature drift.

Referee #2’s comment:

b) scattering Waves are not included in the model, but what would be scattering’s likely effects?

Our response:

Wave scattering would mix the heated particles with those without in the same flux tube. By writing Eqs. (23) and (32), we implicitly include such effect of wave scattering in our model.

Referee #2’s comment:

Technical corrections:

Figure 1: Does the x-axis in Figure 1 point towards the Earth or away from the Earth? In other words, is the flux tube shown in the figure Earthward or tailward of the X-line?

Our response:

The x-axis in Figure 1 points away from the Earth. The flux tube shown in the figure is earthward of the X-line.

Referee #2’s comment:

Figure 3: The figure requires several improvements so that comparisons could be made with the observations in Figure 4. The axis limits should match those of Fig. 4, and matching colors added. Furthermore, the labels should be bigger and overall resolution higher.

Our response:

We will improve Figure 3 in a revised version.

Referee #2’s comment:

page 7, line 25: much -> very page 8, line 15: moving -> moves

Our response:

We will make corrections in a revised version.

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