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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 #1:

Referee #1's comment:

The paper presents a study that calculates Ti/Te ratio. The authors conclude that Ti/Te ratio would be preserved if reconnection only happens once. This conclusion is not supported, as outlined below. The biggest problem with the study is the methodology. The authors model reconnection by simply cutting the Tsyganenko magnetic field by half, ignoring the heating associated with reconnection. The authors claim that Ti/Te would be preserved if the magnetic field line is cut by half. Actually, given the methodology and assumptions, Ti/Te should still be preserved even when the reconnection happens more than once to the same field line. Can the authors show that using the same methodology, if reconnection happened more than once, Ti/Te would not be preserved? Why would the authors introduce reconnection? Is this necessary? Why not just try the methodology without reconnection?

Our response:

We are very grateful to Referee #1 for helpful comments.

There is a misleading in this matter. We did not state reconnection only happens once. Reconnection can happen more than once in our scenario in order to transport reconnected flux tube from far tail to the near-Earth tail by bursty bulk flows (BBFs). Eq. (23) shows Ti/Te is conserved after reconnection. But if considering the additional non-adiabatic acceleration of particle associated with the round trip from the mirror point (see Eq. (24)), then Ti/Te will not be conserved when the round trip happens more than once in a single reconnection. 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, which leads to the lower Ti/Te ratio close to the Earth. We will restate the "the non-adiabatic acceleration of particle happens no more than once in a single reconnection" as "the non-adiabatic acceleration of particle happens no more than once in each reconnection" in the revised version.

As we have described in Introduction, the reason we consider reconnection as one of the possible processes is based on the understanding established from previous studies: (1) the observed Ti/Te is correlated with AE levels, (2) AE levels are correlated with occurrence of BBFs, and (3) patchy reconnection can generate BBFs. If only consider the background slow earthward convection without reconnection generated BBFs, then it only results in adiabatic energization and Ti/Te ratio is conserved.

Referee #1's comment:

The authors claim that the comparison with the observations (Figure 4) is good, but upon close examination, there are some differences. The authors need to discuss these differences. Tsyganenko model is a time independent model with no reconnection built in. How do the authors model the field line after the reconnection in Figure 2? Tsyganenko magnetic field does not cross the equatorial plane at Xhalf in Figure 2. How do the authors force the model to bend the field lines so that they reconnect at Xhalf and how would the authors know what the field line configuration would look like after the reconnection?

It is not clear if the formalism presented by the authors can handle reconnection.

Our response:

We understand the limitation for comparing theoretical calculation with observations, thus we did not claim that the comparison as "good". We have also discussed the differences in the comparison, such as the dawn-dusk asymmetry shown in the observation. Since we did not include the particle's gradient and curvature drift in the calculation, there is no asymmetry of Ti/Te between the dawn and dusk as indicated by the observations. Asides from this difference, there is a difference of the exact values of Ti/Te between our theoretical results and the observations. This difference can be reduced by choosing more suitable parameters in our calculation.

Since the observations of Ti/Te are statistical results, to theoretically estimate the Ti/Te and compare with the observations, we need to use a statistical magnetic field model. Our theoretical estimate of Ti/Te has only statistical meaning. The equatorial magnetic field after reconnection is assumed more dipolar (associated with BBFs and DF) than the background field lines. As stated in the discussion part, the motion of particles in this dipolarized field is adiabatic. For the two large-scale magnetic field quantities, the field-line length and the flux tube volume, used in our theoretical calculation, their values are contributed most by the distance from the equatorial location to its ionosphere. Thus, even though the local magnetic field changes near the equator after reconnec-

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Discussion paper

tion should affect the two quantities, the effects are not expected to be substantial. Therefore, despite that Tsyganenko magnetic field is time independent and without reconnection built in, it can empirically provide us reasonable estimates of these two quantities for both the magnetic fields associated with a reconnected flux tube and with the background plasma sheet.

Our formalism is based on the classical picture of reconnection of Hill 1975 and Speiser 1965. They are first-order estimate.

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