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## Comment on angeo-2021-32

Anonymous Referee #3

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Referee comment on "Dynamics of variable dusk–dawn flow associated with magnetotail current sheet flapping" by James H. Lane et al., Ann. Geophys. Discuss., <https://doi.org/10.5194/angeo-2021-32-RC4>, 2021

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### General comments:

This is a very clear, well-written paper, in which the authors present observations of a local flow signature which they argue persuasively is associated with plasma sheet flapping. The authors also argue that the sense of the flow and  $B_y$  component is acting against a global-scale untwisting that arises following IMF  $B_y$  effects. This part of the argument is much less persuasive - as the authors note quite late on in the paper (line 425), a spacecraft is only situated on the "wrong" convection cell within a certain distance from midnight MLT, whereas this event is quite far from midnight. Comparing the  $B_x$  and  $B_y$  components of C2, C3 and C4 (e.g. at 00:00UT in Fig 2), the spacecraft on either side of the neutral sheet observe opposite signs of  $B_y$ , in a sense that is consistent with the flaring of the tail which is expected to be dominant further away from midnight. I think this is then ultimately confirmed by the TA15 model results plotted in Figure 5. However, the generally negative values of  $V_{\text{perp}_y}$  observed by C1 through the interval in Figure 3 are inconsistent with the expected duskward convection expected at this location (which in turn is observed by C3, and also earlier by C1). I therefore recommend that the paper is restructured to reduce the early discussion of asymmetric tail untwisting, and not to interpret the observations as a departure from that (since the spacecraft seem to be in a location where the tail  $B_y$  component is dominated by flaring, rather than IMF penetration), but instead to frame the interpretation in terms of the negative  $V_{\text{perp}_y}$  values departing from the expected duskward convection at this location. I have expanded on this point more specifically in several of my detailed comments below.

### Detailed comments:

Lines 65-8: This is the predominant behaviour, but it is location dependent (i.e. flaring dominates away from midnight).

Line 218: This is the first sign that flaring may be dominant, as I think the  $B_y$  sign reversal here is not what is expected in the tail twist scenario (near to midnight)? Similarly for the observations described at lines 223-5.

Line 220: I think it is important to mention in the text that the solid lines in Fig 2b iv-vi are the field-perpendicular component, and the dotted lines are the total velocity components. This information is in the figure caption, but it only becomes apparent in the

main body of the text at line 242.

Lines 258-62: Here, you are again describing observations that are consistent with flaring.

Line 278: I think it might be worth rewording this slightly, as the periods of positive  $B_x$  also include observations of  $V_{\text{perp}_y}$  that are close to zero or even negative (particularly from 00:30-00:31 UT).

Line 280: To my eye, the positive enhancements in  $V_{\text{perp}_y}$  do not seem to be associated with negative enhancements in  $B_y$ . They mostly seem to be associated with either no particular  $B_y$  signature, or a reduction in negative  $B_y$  or positive  $B_y$  turning.

Lines 357-9: Emphasising the expectation from IMF penetration here seems inappropriate, as the observations so far seem to establish that tail flaring is the dominant source of  $B_y$  at this location.

Lines 420-3: I was confused by this sentence, as surely even when untwisting happens, the convection cell to which a spacecraft is connected also depends on its local time? Even with untwisting, there are two convection cells (i.e. some field lines return via dawn, and others via dusk), it's just they're asymmetric.

Lines 440-2: I don't think this statement is correct. The northern hemisphere footprints map close to the boundary between the dusk and dawn cells, and the lack of scatter at the northern hemisphere footprint makes it hard to be specific about which convection cell the footprints actually lie in. The authors seem to acknowledge this as a possibility in the lines that follow, but I think the sentence here is too definite. I do agree, though, that the duskward flow seen at the southern hemisphere footprint conflicts with the generally negative  $V_{\text{perp}_y}$  observed by C1 in Figure 3 (though it agrees with the generally positive  $V_{\text{perp}_y}$  observed by C3, and also by C1 earlier, in Figure 2).

Lines 464-8: Just to note that the duskward flow observed by C3 is also consistent with the duskward convection that would be expected in the absence of tail twisting, given the spacecraft location. But I agree with the statement on lines 468-72 that the difference between C3 and C1 means something more local is happening at C1.

Lines 477-8: Since C2 and C4 are in the northern hemisphere (from  $B_x$ ), their negative  $B_y$  seems to be consistent with flaring.

Line 537: I think the word "crossing" is superfluous here.

Line 696: Do the authors mean Figure 7d?

The final paragraph of the Discussion section (Lines 698-710) summarises the observations/interpretation, and provides a good opportunity to summarise my points above:

- Point 1 (lines 700-2) says that the IMF, ionospheric convection and plasma sheet observations all lead to the expectation of an IMF  $B_y > 0$  asymmetry. This is true (with respect to the IMF and ionospheric convection) on a global scale, and indeed the ionospheric observations do show asymmetric flows across midnight. But I feel the sentence is a bit misleading, as the IMF and ionospheric observations do not give us grounds to suggest we observe distinct tail untwisting at the location of Cluster (because the northern hemisphere footprint cannot be confidently placed on the dawn cell, given its proximity to the dusk cell and the lack of local scatter, and the southern hemisphere footprint is at a location that would observe duskward flow even without untwisting). Furthermore, I think the sentence is incorrect in saying that the plasma sheet

observations show a large-scale asymmetry - the magnetic field observed by C2/C3/C4 (and also C1 before the flapping) seem entirely consistent with flaring and do not show evidence of the penetrated By component being dominant here. Likewise, the convective flows observed by C3 (and C1 before the flapping) are duskward, consistent with the spacecraft being far enough from midnight that flaring is the dominant cause of By, and hence the field lines convect sunward in the same sense as they would in the symmetrical case.

- I think that referring to magnetotail untwisting specifically in point 2 (lines 702-6) is not justified, because of the fact that IMF penetration does not seem to be the main cause of the By components observed at the location of Cluster. But this is easily remedied by reducing the emphasis on tail twisting, and instead comparing with the duskward convection that is expected (and observed, by C3) at this location.

- I agree with point 3 (lines 706-8), but this is really with respect to the general duskward convection that would be expected at this location, given the local time, TA15 modelling, and the fact that Cluster observes predominantly By components consistent with flaring. I see no reason why, given the authors' results, similar local processes should not be observed nearer to midnight, and therefore act against the tail untwisting process, but I think that is a matter for suggestion for a future study.

Figures (general): There is a standard colour legend for Cluster line traces, which does make it easier to keep track of which trace corresponds to which spacecraft. I would encourage the authors to use that in those figures with Cluster data or footprints, as it really does aid a reader who is familiar with Cluster data. Some of the figures would benefit from being larger.

Figure 6: The y axis labels are somewhat crowded in some panels. Also, the green boxes (a) and (c) don't quite line up with the features that are discussed in the text - I think the features being highlighted here are the negative excursions in By, so I think both boxes should move a little to the right?