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Interactive comment on "Characteristic study of double substorm onsets in response to IMF variations" *by* Ching-Chang Cheng et al.

Anonymous Referee #1

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This paper describes four substorms that the authors describe as double onset substorms. All four events have been analyzed in previous publications, two of them (which receive cursory treatment here) in a paper recently submitted to another journal by the first author, the other two by different authors. This study adds auroral and ground magnetometer data to what was presented in the previous papers on the other two events. The authors claim that these substorms are examples of double onset substorms, and that the second onset occurs poleward (and hence tailward) of the first onset and that it is triggered by a northward turning of the IMF. I did not find the evidence for this claim, as presented in the figures, very convincing. I also find that there is insufficient that is new in this paper to warrant publication.

Substorms are complex natural events involving magnetic reconnection in what we are

learning is a highly structured geomagnetic tail. Like most complex natural events, no two substorms are the same, nor should we expect them to be, but they do have many features in common. Many if not most substorms include multiple auroral brightenings that can both precede (pseudobreakups) and follow (intensifications) the primary onset of the substorm. These are usually accompanied by Pi2 pulsations observed on the ground and by fast flow bursts and dipolarizations in the tail if a spacecraft happens to be in the right position to observe them. (Part of the problem with this field is that the terminology is not universally agreed upon, but I have tried to use commonly used terms.) This is the case with the four events presented here.

Figures 2-5 present summary plots of the four events. (For two of the events this is in only data presented.) The authors do not explain how the times of the vertical lines marking particular events were chosen, nor is it obvious from the data (which is hard to make out given the size of the figures). However, the only line important to this paper's argument is the last (rightmost) one in each figure, and the important data is presented in the righthand panel. In each case after the initial breakup the aurora expand poleward and include a number of brightenings. The magnetometer traces have clear bays and Pi2s accompanying the initial onset, but thereafter contain many variations confused by the waves also present. I could see no features in either the auroral or magnetometer data that clearly differentiate the time of the second vertical line. Figures 6 and 7 present the auroral data for the second two events, concentrating on the times of auroral brightenings. The presentation of the figures is far from ideal; I found it very difficult to see much in them. However the auroral keograms in figures 4 and 5 show that there are other auroal brightenings not shown here. Figure 9 presents mid and low latitude magnetometer data. These show the clear bays accompanying the initial onset and a number of Pi2s, but again I see no particular features associated with the rightmost line.

The evidence for the second conclusion, that the second onsets are triggered by northward turnings of the IMF, is contained in figures 9 and 11. Here the authors run into the notorious problems of the lack of uniformity of the IMF (different spacecraft see somewhat different signatures) and of timing the IMF's arrival at the magnetopause and its subsequent effects in the tail. All I can say is that I found the evidence presented here to be unclear, and certainly not compelling.

My conclusion is that this paper does not support its conclusions with clear evidence and that it does not present enough that is new to merit publication.

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