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Reply

Bruce Tsurutani
Jet Propulsion Laboratory, California Institute of Technology, Pasadena

Walter D. Gonzalez
Instituto National Pesquisas Espaciais, Sao Jose dos Campos, Sao Paulo, Brazil.

Frances M. Tang
Solar Astronomy, California Institute of Technology, Pasadena

The main result of the ***Tsurutani et al. [1995a]*** (hereafter T1 995]) paper is that corotating streams emanating from coronal holes during the descending phase of the solar cycle (1973- 1975) do not cause major ($D_{st} \leq$ -100 nT) magnetic storms, but only moderate, weak, or even no (significant) storm activity, where storms are defined by D_{st} decreases ***[Gonzalez et al.,*** 1994],

Although, there are typically large 20-30 nT magnetic field magnitudes created by the fast stream-slow stream (heliospheric current sheet plasma sheet) interactions, the B_z directionality is typically highly fluctuating within the high-field proto-corotating interaction region (we call this a PCIR because at 1 AU, the distance of the Earth from the sun, fast forward and reverse shocks are typically not formed), and thus the empirical criteria for intense storms (during solar maximum) of $B_s \geq 10$ nT and $\tau > 3$ hours ***[Gonzalez and Tsurutani,*** 1987] is not satisfied, A mechanism explaining these highly fluctuating fields has been presented by ***Tsurutani et al. [*** 1995 b], These fluctuations may be (reverse) shock-compressed or simply stream-compressed (without a shock) Alfvén waves from the high-speed streams (Figure 1). A second result from the T1 995 paper is that the B_z fluctuations associated with Alfvén waves in the corotating streams can cause continuous auroral activity called HILDCAAs (High-Intensity Long-Duration Continuous AE Activity), The presence of two high-speed streams during 1974 led to an extremely high yearly average of AE (283 nT), even higher than the following solar maximum years 1979 and 1981 (221 nT and 237 nT, respectively). Thus, it should be noted that geomagnetic activity can be higher during the declining phase of the solar cycle, depending on what type of geomagnetic activity is being discussed!

The issue that Cliver raises is tertiary in the T] 995 paper but is a very important one and very worthy of discussion [this issue]. We commend Cliver on delving into this in depth, The three intense magnetic storms during 1974 were all associated with small streams led by fast forward shocks (and not corotating streams), These impulsive streams occurred very close to the corotating (coronal hole) streams and the heliospheric current sheet (HCS). In T1 995 we speculate that these interplanetary events may be associated with expansions of the coronal holes,

One mechanism for the opening (and closing) of coronal hole magnetic field lines is through the interconnection of fields between different magnetic active regions and interconnection between fields from magnetic active regions and open coronal hole fields *[Harvey et al.* 1986; *Sheeley et al., 1989; Wang and Sheeley, 1990; Wang et al., 1996* and references therein] respectively, Recently, *Gonzalez* et *al, (1996)* and *Bravo* and *Cruz-Abeyo (1996)* have postulated that coronal hole streams and embedded fields interact with active region fields/HCS fields to create coronal mass ejections (CMEs) during solar maximum, One should note, however, that if the magnetic active regions contain an equal amount of "positively" and "negatively" directed fluxes, the mechanisms discussed above do not lead to a net opening or closing of magnetic field lines, but only to a reconfiguration of the local magnetic topology. What is needed to expand coronal holes is the emergence of net flux of the same polarity as that in the coronal hole, and contraction must be accomplished by the emergence of net flux of the opposite polarity, Whether this occurs in or near magnetic active regions or not is presently unknown, Also, the overall global picture should be taken into account as well. As more flux opens in one hemisphere, equal flux should open in the other solar hemisphere. How is this overall balance maintained and what are the corresponding photospheric processes/signatures?

For coronal hole streams in interplanetary space, the interaction with the slow speed streams does not form forward shocks by 1 AU because the stream-stream interaction is a glancing one [*Smith and Wolfe, 1976; Pizzo, 1985],* (T1995); (however, T1995 did indicate that during 1974, some (--20%) reverse shocks were detected at 1 AU), The velocity of the high-speed streams is -750-800 km s-' [*Phillips et al.,* 1995], whereas the velocity of slow speed streams is -300-350 km s“’. In the case of coronal hole expansions, plasma associated with the newly opened flux will interact with the upstream (slow) plasma in a more direct way. Since the stream speed differential (assuming there are only two basic types of solar winds) is much greater than the magnetosonic wave speed (V_{MS}~ 70 km s“’), a forward shock is created by 1 AU. This is indicated in Figure 1, Note that the presence of the forward shock is independent of the particular mechanism for opening the coronal hole magnetic flux.

However, the nature of the solar ejects sunward of the shock is not known, and therefore T1995 did not speculate on it. The ejects could be the same as those during solar maxima (note the magnetic cloud in the C event), or they could be at times different. A systematic study should be performed to address this important topic,

As pointed out in T] 995, solar ejecta/magnetic clouds [*Burlaga et al.,* 1981] were not detected for the A and B events (the two largest magnetic storms), but were for the C event. The meaning of these observations is not clear at this time. It is possible that for the first two cases, the solar ejects were relatively small in scale and did not cross the spacecraft trajectory. Thus they may have been present but were unfortunately missed,

Regarding the possible flare association to the three storm events, we have the following specific comments,

Event A in T1995 (page 21,730, line 3), the second flare should have been listed as occurring at 0801-0840-0928 UT day 184 and not 185, With this error corrected, an acceptable speed for the July 6 (day 186) shock would be obtained,

We agree that by applying the *Cliver et al. [1990]* empirical relationship for the deceleration of plasma from the Sun to 1 AU, more flares may be considered as possible sources for the shocks. However, it is also true that none of these flares have the characteristic long duration signature that is statistically associated with solar ejects. The X ray long-duration events also have the unique *Ha* signature of postflare loops.

A second, long-standing problem is the reverse correlation, In Figure 1 from *Cliver* [this issue], there are three large X ray flares on July 5 and 6 produced by the same active region at W26", 35", and 40", respectively, An important unanswered question is, why don't all of these flares produce detectable interplanetary events? There is clearly a present lack of understanding of why so few solar events have corresponding interplanetary/geomagnetic analogs.

For event B, the *Ha* flare of September 13 was nearly 3 hours long. The soft X ray plot does show a characteristic long-duration signature. Using the *Cliver et al,* [1990] solar wind deceleration assumption, this flare fits the event quite well.

We find that the Cliver comment has clarified some of the apparent lack of obvious solar sources for the T 1995 interplanetary A, B, and C events, and we thank him for it. However, even with this improvement, there is still the C event which remains unidentified,

In closing, we would also encourage solar scientists to examine coronal hole data to try to determine the mechanism(s) for coronal hole expansions and contractions, This is an important scientific topic yet to be addressed in any depth, It is probable that the process is relevant to geomagnetic activity at the Earth,

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W. D. Gonzalez, Instituto National Pesquisas Espaciais, 12200 Sao Jose dos Campos, Sao Paulo, Brazil. (e-mail: gonzalez@dge.inpe.br)

F. M. Tang, Solar Astronomy, California Institute of Technology, Pasadena, CA 91125. (e-mail: ft@sundog.caltech.edu)

B. T. Tsurutani, Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, (e-mail: btsurutani@jplsp.jpl.nasa.gov)

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Figure Caption

Figure 1. A solar ejecta event associated with newly opened coronal magnetic fields (coronal hole expansion) headed toward the Earth. Theunidentified driver gas is denoted by a question mark, Thedriver gasisledby a fast forward shock, The configuration of the solar eject fields is not well understood at this time, A CIR bounded by a forward shock (FS) and reverse shock (RS) is denoted by shading. The fast stream-slow stream interface (IF) is indicated. The B_z fluctuations within the trailing portion of a CIR are believed to be compressed Alfvén waves,

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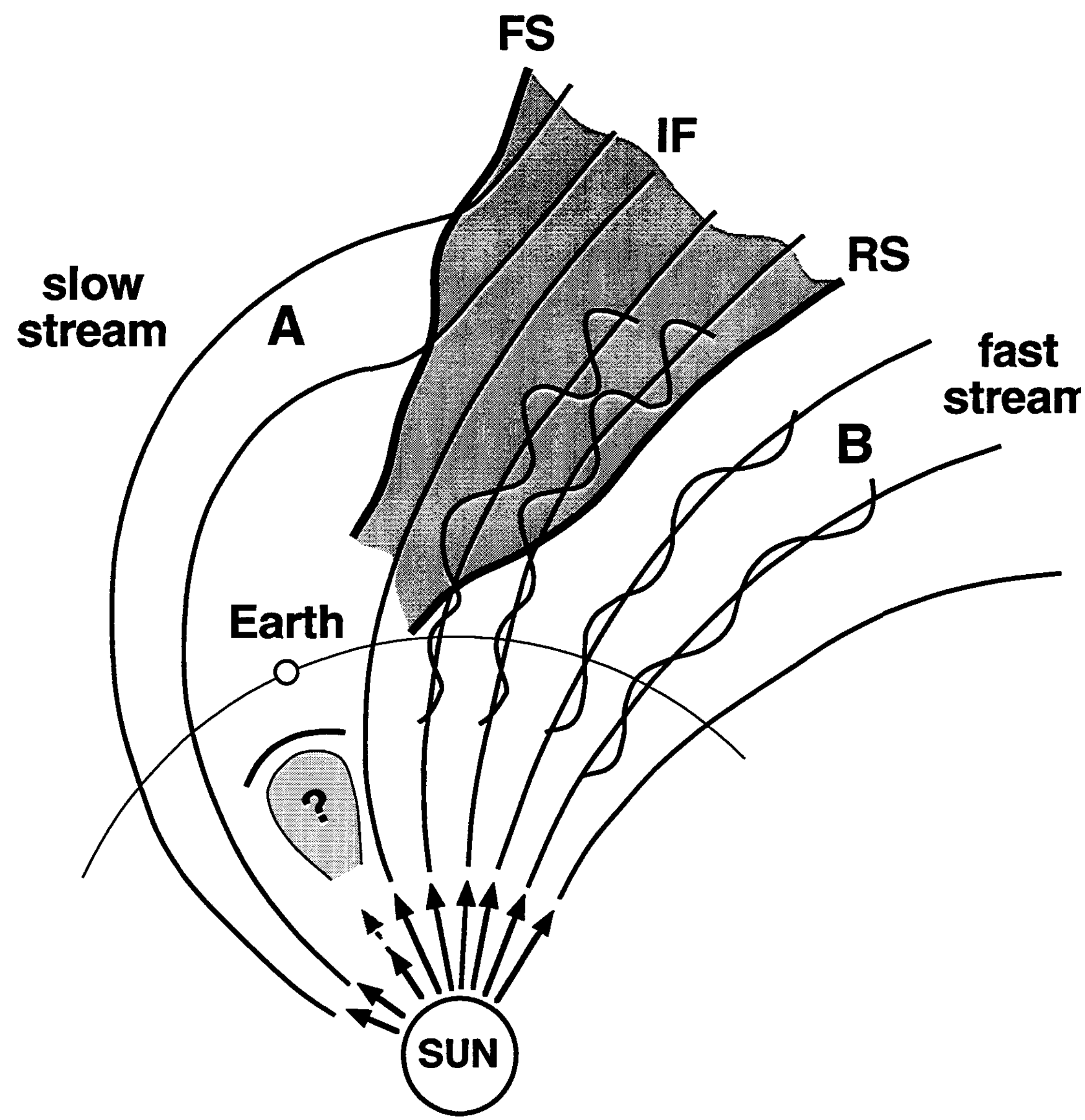

Figure 1