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DISCUSSIONS

Comment on the Paper "CAWSES November 7–8, 2004, Superstorm: Complex Solar and Interplanetary Features in the Post-Solar Maximum Phase," B. T. Tsurutani, E. Echer, F. L. Guarnieri, and J. U. Kozyra, Geophys. Res. Lett. 35 (2008)

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Abstract—The solar sources of the magnetic storms of November 8 and 10, 2004, are analyzed. The preliminary results of such an analysis [Yermolaev et al., 2005] are critically compared with the results of the paper [Tsurutani et al., 2008], where solar flares were put in correspondence with these magnetic storms. The method for determining solar sources that cause powerful magnetospheric storms is analyzed. It has been indicated that an optimal approach consists in considering coronal mass ejections (CMEs) as storm sources and accompanying flares as additional information about the location of CME origination.

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1. INTRODUCTION

Tsurutani et al. [2008] studied the causes of the strong magnetic storm, which was generated by the series of three sporadic solar wind flows registered in the Earth's orbit on November 7–8, 2004. The solar and interplanetary sources of the geomagnetic storms of November 7–10, 2004, were previously discussed in detail in many papers (see, e.g. [Ishkov, 2005; Yermolaev et al., 2005; Wintoft et al., 2005; Gopalswamy et al., 2006; Chertok, 2006; Arkhangelskaya et al., 2006; Trichtchenko et al., 2007; Culhane et al., 2007; Harra et al., 2007]). However, these results were mainly ignored (or not mentioned at all) in [Tsurutani et al., 2008].

The initial stage of this period (from ≈ 0000 to ≈1000 UT on November 7, 2004) was characterized by the arrival of two shocks: FS1 (≈0155 UT, November 7) and FS2 (≈1000 UT, November 7). The sources of these shocks on the Sun were analyzed in [Tsurutani et al., 2008] and in the earlier papers [Wintoft et al., 2005; Yermolaev et al., 2005]. The conclusions on the solar sources of the FS1 and FS2 shocks drawn in [Tsurutani et al., 2008] substantially differ from the conclusions made in [Wintoft et al., 2005; Yermolaev et al., 2005]. In these comments we try to demonstrate the cause of this difference.

2. DATA ANALYSIS

According to [Tsurutani et al., 2008], FS1 was caused by one of two flares that occurred at close time instants: flare C1.8 that occurred at 0122 UT on November 2 in AR 693(S17E10) or flare C6.9 that was observed at 0143 UT on November 2 in AR 687 (N11W92); FS2 was caused by one of two flares: flare M2.8, 0128 UT, November 3, AR 691(N12W75) or flare M1.6, 0332 UT, AR 696(N09E45). According to [Wintoft et al., 2005; Yermolaev et al., 2005], FS1 and FS2 were probably caused by CME1 (November 3) and CME2 (November 4), respectively. A more detailed analysis performed in [Yermolaev et al., 2005] specifies the time of CME origination and the velocities of these ejections (V_c) in the solar corona: CME1 occurred at 1554 UT on November 3 ($V_c \approx 800$ km/s), and CME2 occurred at 0954 UT on November 4 ($V_c \approx 550$ km/s). The transit time of CME motion to the Earth calculated by Tsurutani et al. [2008] proved to be larger than such a time determined in [Wintoft et al., 2005; Yermolaev et al., 2005] by one day.

We assume that differences in the conclusions result from fundamentally different approaches to the determination of the solar sources of shock waves in the Earth's orbit in [Tsurutani et al., 2008] on the one hand and in [Wintoft et al., 2005; Yermolaev et al., 2005] on the other hand. The essence of the approach in [Wintoft et al., 2005; Yermolaev et al., 2005] is as follows: CMEs are considered as sources of shocks in the Earth's orbit, whereas flares give additional information about the location of CME origination. Such an approach is based on the following facts: (1) prediction based on flares is more ambiguous because the number of flares is pronouncedly larger than that of CMEs; (2) any justified method for finding the correspondence between flares and shocks in the Earth's orbit is absent, whereas such a method is available for CMEs. In [Tsurutani et al., 2008] shocks are assumed to be caused by flares and CMEs are not altogether considered. Taking the aforesaid into account, we will discuss in more detail the procedure for determining solar sources of FS1 and FS2.

2.1. The Source of FS1 (≈0155 UT, November 7)

Since CME that occurred at 1554 UT on November 3 ($V \approx 800$ km/s) was of the halo type and moved toward the Earth (because a flare with coordinates N04E37, related to this ejection, was observed at 1524 UT on November 3 on the visible solar disk), the shock generated by this ejection had to collide with the Earth. Based on the transit time, estimated using the known empirical relationships [Can and Richardson, 2003; Eselevich and Eselevich, 2004], we calculate the time of this CME arrival to the Earth's orbit for the indicated velocity: $tp \approx 1400$ UT on November 6.

Another candidate CME, which occurred at 0354 UT on November 3 ($V \approx 900$ km/s), is related to flare M1.6 with coordinates N03E45 observed at 0332 UT on November 3. The calculated time of arrival of this CME is $tp \approx 1800$ UT on November 5. According to this time, CME that occurred at 1554 UT on November 3 is a more probable source of FS1.

We now consider flare C6.9 with coordinates N11W92, which occurred at 0143 UT on November 2, as a source of FS1 (this flare was proposed in [Tsurutani et al., 2008]). Coronal mass ejection, which occurred at 0254 UT on November 2 at a position angle of PA = 269°, is related to this flare. The velocity of this CME is $V \approx 400$ km/s, and an angular dimension is $d \approx 9°$. Since this CME originated near the limb (W89), a shock generated by this ejection will pass far from the Earth at such a small angular dimension.

2.2. The Source of FS2 (≈1000 UT, November 7)

Coronal mass ejection that occurred at 0954 UT on November 4 ($V \approx 550$ km/s) is the most probable source of FS2 according to the calculations. At such a relatively low velocity, we can assume that $V \approx$ const along the Sun–Earth segment [Cane and Richardson, 2003; Eselevich and Eselevich, 2004]. We find that the calculated time of CME arrival to 1 AU is $tp \approx$ 1300 UT on November 7, which is close to the time of FS2. If flare M1.6 (0332 UT, November 3) was the source of FS2, as was indicated in [Tsurutani et al., 2008], this means that FS2 was caused by the considered CME, which occurred at 0354 UT on November 3 ($V \approx 900$ km/s), related to this flare. The calculated time of arrival of this ejection to 1 AU is $tp \approx 2300$ UT on November 5, which differs from the FS2 time by almost 1.5 days.

Coronal mass ejection that occurred at 0206 UT on November 3 ($V \approx 400$ km/s) probably corresponds to the second flare (M2.8, 0128 UT, November 3) indicated in [Tsurutani et al., 2008]. The calculated time of arrival of this ejection is $tp \approx 0000$ UT on November 6, which is also earlier than the instant of FS2 registration by almost 1.5 days.

3. CONCLUSIONS

At the present-day level of knowledge in the field on solar–terrestrial physics and abundant experimental information (first of all, the LASCO/SOHO data), the determination of solar sources of shock waves using only flares is not an optimal method and inevitably results in series errors. Therefore, the solar flares, presented in [Tsurutani et al., 2008] as sources of the interplanetary and geomagnetic disturbances of November 8–10, 2004, are not causes of these disturbances, which are factually related to CMEs that occurred at 1554 UT on November 3 and at 0954 UT on November 4, 2004.

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