Comment on "Sizes and relative geoeffectiveness of interplanetary coronal mass ejections and the preceding shock sheaths during intense storms in 1996-2005" by J. Zhang et al.

Yu. I. Yermolaev and M. Yu. Yermolaev

Space Plasma Physics Department, Space Research Institute, Russian

Academy of Sciences, Profsoyuznaya 84/32, Moscow 117997, Russia

---

Yu. I. Yermolaev Space Plasma Physics Department, Space Research Institute, Russian Academy of Sciences, Profsoyuznaya 84/32, Moscow 117997, Russia. (yermol@iki.rssi.ru)

M.Yu. Yermolaev Space Plasma Physics Department, Space Research Institute, Russian Academy of Sciences, Profsoyuznaya 84/32, Moscow 117997, Russia.

(No abstract for comment)

Recently *Zhang et al.* [2008] presented a statistical study of sizes and relative geoeffectiveness of ICMEs (bodies of magnetic clouds) and preceding sheaths for 46 events responsible for intense (Dst < -100 nT) geomagnetic storms in 1996-2005 in which only a single ICME was responsible for generating the storm. Here we would like to comment several results and conclusions of this paper.

Durations and sizes of sheath and ICME

Zhang et al. [2008] found that average durations and sizes are 10.6 hr and 0.13 AU for sheaths and 30.6 hr and 0.37 AU for ICMEs.

First of all it is necessary to note that the average duration of geoeffective sheaths is not new result. For instance, *Huttunen et. al.,* [2006] found that at 1 AU geoeffective sheaths has average duration 11 hours. Recently, *Yermolaev et. al.,* [2007a] have published that durations of sheaths, magnetic clouds (MCs) and corotating interacting regions (CIRs) generating magnetic storms with Dst < -60 nT during 1976-2000 were 9 ± 4 (for 22 events), 28 ± 12 (113) and 20 ± 8 (121) hours, respectively. We believe that the authors of paper by *Zhang et al.* [2008] should discuss the earlier published results.

There is difference between durations of ICMEs of 0.37 AU and 0.25 AU obtained by *Forsyth et. al.* [2006] and *Lepping et. al.,* [2006] and *Zhang et al.* [2008] discuss the possible reason of difference of their results from earlier published ones: *"The difference may be a selection effect due to the fact that all the 46 events used in this study produced major geomagnetic storms, and thus may possess different properties, including perhaps a larger physical size that may help to sustain geoeffective solar wind conditions, than the general population of ICMEs".* In our paper [*Yermolaev et. al.*,, 2008] we estimated durations for all (independent on generating storm) events and they are 15.7 ± 10.1 (642 events) for sheath, 29.8 ± 20.5 (1127) for ejecta, 28.2 ± 13.4 (101) for MC and 20.6 ± 12.2 (718) for CIR. Therefore, our results show that average duration of geoeffective sheaths is less than one for all sheaths while durations for geoeffective MC (and ejecta) and all MC (and ejecta) are the same. So, difference in ICMEs durations cannot be explained by study of stronger (with lower Dst index) storms in paper by *Zhang et al.* [2008]. Thus, average duration and size of ICMEs obtained by *Zhang et al.* [2008] are not in agreement with earlier published results and require further investigations and explanations.

Relative Geoeffectiveness of Sheaths and ICMEs

Effectiveness of any process (also as well as geoeffectiveness) is defined as the ratio of "output" to "input". The authors write: *"To estimate the geoeffectiveness of the sheaths and ICMEs, we use the well-known epsilon-parameter, which is a good proxy of the rate of energy input to the magnetosphere [Akasofu, 1981]"*. They calculated epsilon-parameter and compare "total energy input": *"the total energy input during a certain period is obtained by integrating epsilon during the period of interest"* and finally conclude that *"The percentage due to ICMEs ranges from 2% to 99% with an average (median) value of 71% (80%). While ICMEs are the dominant transient features producing major geomagnetic storm, sheaths are also important, contributing about 29% of the total energy input into the magnetosphere during these storms"*.

1. *Zhang et al.* [2008] calculated energy input *"by integrating epsilon during the period of interest"*. On the one hand, the derivative of Dst-index is proportional to rate of energy injection into the ring current [*Burton et al.*, 1975; *O'Brien and McPherron*, 2000].

Therefore authors should explain what physical reason requires integrating epsilon. On the other hand, it is necessary to use real duration of event for integrating epsilon. As we already have shown above the durations of events may be defined incorrectly, therefore there are serious doubts that the integrated values of epsilon-parameter have been counted correctly.

2. *Zhang et al.* [2008] have compared only "input", but have not compared "output". This approach does not allow one to compare geoeffectiveness. At approximately equal "outputs" the obtained data can testify in favour of a hypothesis that sheaths are more geoeffective than ICMEs.

3. The mentioned above hypothesis that sheaths are more geoeffective than ICMEs has been confirmed by several publications briefly discussed below.

Huttunen and Koskinen [2004] studied 53 intense (Dst < -100 nT) magnetic storms for which they could identify the solar wind cause. They *"classified the drivers of storms in the following categories: post-shock stream or sheath region (shock/sheath), magnetic cloud (MC), CME ejecta without the magnetic cloud structure (ejecta) and solar wind causes not associated with shocks or CME ejecta (other)"* and *"found that postshock streams and sheath regions were the most important storm drivers, causing nearly half (45%) of the storms"*. This question also is in detail discussed in the review by *Koskinen and Huttunen* [2006].

Vieira et. al., [2004] studied the storm-time ring current evolution of 20 intense (Dst/SYM < -100 nT) magnetic storms driven by different interplanetary structures from 1998 to 2001 (they classified the magnetic storm events according to the region in which was observed the Bz driving structure as: (1) sheath events; (2) magnetic cloud events; (3) corotating interaction regions; and (4) complex events and sub-divided the clouds into groups with magnetic field rotation from southward to northward (SN) or vice versa (NS)) and *"found that the energy injection rate is different for different interplanetary structures. The energy injection rate is higher for sheath events and lower for NS magnetic clouds. The main consequence is that the magnetosphere assumes different configurations depending on the energy injection rate, leading to a different evolution and decay of the symmetric and the partial ring current"*.

In our papers [*Yermolaev et. al.*,, 2007a, b] we studied 22 sheaths and 113 magnetic clouds during 1976-2000 resulting in magnetic storms with Dst < -60 nT and found that *"Though the lowest values of the Bz-component of the IMF are observed in the MC, the lowest values of the Dst-index are achieved in the Sheath. Thus, the strongest magnetic storms are induced during the Sheath rather than during the MC body passage, probably, owing to higher pressure in the Sheath."* We have also indicated that higher geoeffectiveness of sheath may be connected with higher level of variations of density and magnetic field in the sheaths.

Thus, without discussion earlier obtained results the paper by *Zhang et al.* [2008] presents only limited interest as their results do not allow one to see a full physical picture in the discussed area of the modern science.

Acknowledgments. Work was in part supported by RFBR, grant 07-02-00042.

References

Akasofu, S.-I. (1981), Energy coupling between the solar wind and the magnetosphere, Space Sci. Rev., 28, 121.

Burton, R.K., McPherron, R.L., Russell, C.T., (1975) An empirical relationship between interplanetary conditions and Dst. J. Geophys. Res, 80, 4204-4214.

Forsyth, R. J., et al. (2006), ICMEs in the inner heliosphere: Origin, Evolution and propagation effects, Space Sci. Rev., 123, 383, doi:10.1007/s11214-006-9022-0.

Huttunen K. E. J. and Koskinen H. E. J. (2004), Importance of post-shock streams and sheath region as drivers of intense magnetospheric storms and high-latitude activity, Annales Geophysicae 22: 1729-1738

Huttunen, K. E. J., H. E. J. Koskinen, A. Karinen, and K. Mursula (2006), Asymmetric development of magnetospheric storms during magnetic clouds and sheath regions, Geophys. Res. Lett., 33, L06107, doi:10.1029/2005GL024894.

Koskinen, H. E. J.; Huttunen, K. E. J. (2006) Geoeffectivity of Coronal Mass Ejections, Space Science Reviews, Volume 124, Issue 1-4, pp. 169-181

Lepping, R. P., D. B. Berdichevsky, C.-C. Wu, A. Szabo, T. Narock, F. Mariani, A. J. Lazarus, and A. J. Quivers (2006), A summary of Wind magnetic clouds for years 1995 - 2003: Model-fitted parameters, associated errors and classifications, Ann. Geophys., 24, 215.

O'Brien, T.P., R.L. McPherron (2000) Forecasting the ring current index Dst in real time, Journal of Atmospheric and Solar-Terrestrial Physics 62 1295-1299

Vieira L. E. A., Gonzalez W.D., Echer E. and Tsurutani B. T.(2004), Storm-intensity criteria for several classes of the driving interplanetary structures, , Solar Physics 223: 245-258

Yermolaev, Yu.I., Yermolaev, M.Yu., Nikolaeva, N.S., Lodkina, I.G. (2007a) Interplanetary conditions for CIR-induced and MC-induced geomagnetic storms, Bulgarian J.Phys., v.34, N 2, 2007, 128-135

Yermolaev, Yu. I., M. Yu. Yermolaev, I. G. Lodkina, and N. S. Nikolaeva (2007b), Statistical Investigation of Heliospheric Conditions Resulting in Magnetic Storms, ISSN 0010-9525, Cosmic Research, 2007, Vol. 45, No. 1, pp. 1-8., Pleiades Publishing, Ltd., 2007. Original Russian Text, Yu.I. Yermolaev, M.Yu. Yermolaev, I.G. Lodkina, N.S. Nikolaeva, 2007, published in Kosmicheskie Issledovaniya, 2007, Vol. 45, No. 1, pp. 3-11.

Yermolaev, Yu. I., M. Yu. Yermolaev, I. G. Lodkina, and N. S. Nikolaeva (2008), Catalog of large-scale phenomena of solar wind during 1976-2000, Cosmic Research, Vol. 46, No. 5, (in press)

Zhang, J., W. Poomvises, and I. G. Richardson (2008), Sizes and relative geoeffectiveness of interplanetary coronal mass ejections and the preceding shock sheaths during intense storms in 1996-2005, Geophys. Res. Lett., 35, L02109, doi:10.1029/2007GL032045.