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Interactive comment on "Multisatellite observations of the magnetosphere response to changes in the solar wind and interplanetary magnetic field" *by* Galina Korotova et al.

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Dear Referee 3, Thank you very much for your comments and suggestions. Here is our reply. Instead of GSE coordinates, a field-aligned coordinate system might be able to show in a more clear way the radial and azimuthal directions of propagation as well as the direction of the electric field with respect to the magnetosphere. For example, in Figure 6 the azimuthal components are discussed but Ey GSE is plotted.

We used GSE coordinates because the magnetic field data were already available in these coordinates. Our results suffice to show clearly a pattern for the radial and azimuthal directions of propagation as well as the direction of the electric field in GSE

coordinates. We replaced "azimuthal" with Ey.

It is mentioned that "In the solar wind Cluster 2 observed the shock earlier then and Cluster 1, respectively, that is the shock moved dawnward". Was this supposed to mean "earlier than Cluster 1"? If yes, in Figure 2, C2 appears to be located dawnward of C1, so the shock should be moving duskward. Please clarify.

Yes. We believe that the shock moved dawnward across the magnetosphere. The reason for this is that we have used both Wind and Cluster observations to make numerous coplanarity calculations of the normal to the IP shock for a wide variety of observed upstream and downstream input parameters. After a useful online discussion with Prof. Owen we chose a very typical normal that pointed in the (x, y, z) direction [-0.8, -0.4, -0.3]. From this, we conclude that the shock propagated dawnward and antisunward and struck the duskside magnetopause first, precisely consistent with the picture that we drew in the paper. We avoided discussing the nz component we get very mixed results for sense of this component depending on the input parameters chosen.

The referee is correct. From timing considerations and the Cluster observations, it appears that the shock should propagate duskward from C2 to C1. However, we are examining 3s time resolution observations from Cluster, the two spacecraft are very close together, and the times corresponding to the observations differ for the two spacecraft. The apparent lag from C2 to C1 is an artifact of the times when 3s observations are available. When we use C1 and C3, located further apart, the lag time is most definitely consistent with dawnward and antisunward shock propagation.

It is written that "In the outer magnetosphere the propagation velocity for the disturbance was about 1348 km/s between Goes 13 and 15 but only about 390 km/s between Van Allen Probes B and A". These are greatly inconsistent, and this discrepancy is not discussed in the paper. To my understanding, this can only be reconciled if a different propagation direction is assumed for the red arrows of Figure 2, which might also re-quire a reconsideration of the shock front propagation. A possible orientation could be an arrow that originates from the pre-noon region (e.g. 0900 LT) and points towards the Earth, which is different from the results of the paper. Please discuss. In the reply to Dr, Foster we wrote: The exact value of the fast mode wave speed in the magnetosphere depends on the direction of its propagation. For propagation perpendicular to B, the phase velocity VF is (VA2+CS2), where VA is Alfven velocity and CS is the sound velocity. To calculate VA we used the Carpenter and Anderson density profile obtained from a least squares linear fit to 25 ISEE dayside saturated plasmasphere profiles [J. Geophys. Res., 97, A2, 1097-1109, 1992]. Figure 1a shows their reference density profile given by ne =10(-0.3145L+3.9043) for L increments of 0.5. Figure 1b and Figure 1c show the values of the magnetic field obtained from a CCMC run for the Tsyganenko geomagnetic field model for the solar wind conditions on February 27, 2014 and the corresponding Alfven velocity, respectively. Then we set the plasmapause at L = 6 and took the density ne as 4 cm-3 beyond this distance to obtain the corresponding Alfven velocity presented in Figure 1d. The values for the Alfven velocity at the locations of Van Allen Probes A (L=5.1) and B (L=5.5) are about 284 km/s whereas at the GOES location it is 1240 km/s. Because the temperature is very low, the fast mode velocity is the same as the Alfven velocity in the plasmasphere [Takahashi et al., J. Geophys. Res. 115, 2010] and is only $\sim$100 km/s greater in the outer magnetosphere. These model values for the fast mode velocities are in good agreement with the values obtained in our paper.

- Please discuss in greater detail the methodology used in order to determine spiral and orthospiral orientations of the shock normal, and the expected errors in these estimates. The Finnish IP shock data base gives the coordinates of the normal vector to shocks as calculated from the magnetic field data and velocities using the mixed mode method of Abraham-Shrauner and Yun [1976]. When there is data gap in the velocity components, the normal is calculated using magnetic field coplanarity [Colburn and Sonett, 1966]. Abraham-Shrauner [1972] suggested the “mixed mode method as an alternative to other methods when the accuracy of the magnetic field used in the calculations is uncertain. She noted that, for example, if the magnetic field is exactly

normal or tangential to the shock front, magnetic coplanarity fails to give an expression for the shock normal. Our list of interplanetary shocks contains events for which the determination of the values of the magnetic field ahead and behind the shock was not very complicated (no strong oscillations). We also removed some events with IMF radial orientation, so we can always use magnetic field coplanarity to calculate the shock orientations. Though our calculations sometimes give different values for the normal vectors and depends on the choice of intervals chosen for the calculation, we repeatedly obtain the same sense of normal orientation for all the calculations and pairs of upstream and downstream values: dawnward or duskward for each of our calculations. We also found that the sense of our shock orientations (spiral or orthospiral) agrees well with the shock parameters in the Finnish database.

The association of the four groups with ongoing processes could be further discussed. E.g., Pi pulsations and substorms are not mentioned at all in the paper

We added a paragraph and a new Figure 11 in the paper. The ULF electric field pulsations of Pc and Pi types produced by IP shocks are observed at all local times and in the range of periods from several tens of seconds to several minutes. We believe that the magnetic field as well the electric field pulsations initiated by IP shocks are generated by a wide variety of mechanisms including plasma instabilities, transient reconnection, pressure pulses, and often correspond to field line resonances. Their characteristic features are determined to large extent by local time. In the dayside magnetosphere typical pulsations are of the Pc5 type. Sometimes they last for more than twenty wave cycles without noticeable damping which could be explained by a continuous input of the solar wind energy into the magnetosphere. In the nightside magnetosphere during substorms, the generation of Pi2 pulsations is more common. They exhibit an irregular form, last 3-5 wave cycles, and often exhibit damping. Figure 10 presents periods of the pulsations (measured for the first wave cycle of oscillations) as a function of radius and shows that periods increase with increasing radius. A simple explanation for this behavior of pulsation frequencies with radial distance can be given in terms of standing Alfvén waves along resonant field lines (Sugiura and Wilson, 1964). The length of the field lines, the magnetic field strength, and the plasma density distribution determine the Alfvén velocity, and the periods of the pulsations. This plot indicates that electric field pulsations of the Pc5 type in the dayside magnetosphere at L < 6 are produced by field line resonances. Thank you again for your help with improving the paper. Regards, Galina Korotova.

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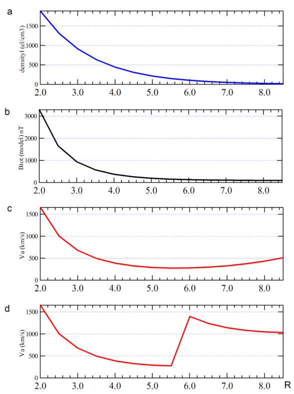

Fig. 1. Figure 1. Radial profiles: (a) reference density profile given by ne =10(-0.3145L+3.9043) for L increments of 0.5, (b) values of the magnetic field obtained from a CCMC run for the Tsyganenko geomag