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Interactive comment by Anonymous Referee #2 from 25 May 2023 on the manuscript "Ion's ring current: regularities of the energy density distributions on the main phase of geomagnetic storms" *by* Alexander S. Kovtyukh

Deeply respected Referee #2,

I am very grateful to you for an exclusively generous and thorough review. All these comments are very helpful for me and it is taken into account in the manuscript.

With grand regard,
Alexander S. Kovtyukh

GENERAL COMMENT

RC2: The author aims to determine the characteristics of the ring current, by analyzing the spatial distributions of the energy density of energetic ions during the main phase of magnetic storms. According to Table 1 of this manuscript, the data used in this study are obtained from those presented in published papers. It seems to me that the author has read the data values (Universal time, Magnetic local time, L-value, and Dst index, all of which correspond to the satellite observation time of the maximum energy density) from the figures in the papers. However, the manuscript does not adequately describe from which figure the author extracted the data values (see Specific Comments #1 below). It is difficult for me to evaluate the author's analysis and interpretations until the data values used in the manuscript are enough reliable.

AC: Yes, I agree. The numbers of the corresponding figures from the cited papers have been added to the last column of Table 1 (see Appendix AC6). In addition, Appendix AC7 contains all the main figures which were used in my work. Only Fig. 2 from Fritz et al. (1974), corresponding to Line 2 in Table 1, unfortunately have a poor quality, a gray background, low resolution, and it is slightly tilted to the left.

In addition to the figures given in Appendix AC7, full information from the corresponding papers has been used to link these figures to UT, MLT, and *L*. The corresponding D_{st} index values were taken from wdc.kugi.kyoto-u.ac.jp/dst_final/index.html.

SPECIFIC COMMENTS

RC2: 1. The author should mention about the figures and/or tables that she/he used to extract all the data values, UT, MLT, Lm, and |Dst|, listed in Table 1.

I have checked two of the listed references: Yue et al, 2018 and Keika et al., 2018; and found it difficult for me to extract the data and even find some data.

For example, in the paper by Yue et al., 2018, pressure was at maximum at ~13:30 UT, which is different from UT in Table 1. The SYM-H index is presented in the paper, but the Dst index is not presented. The L value is not presented in the paper; Lm (L for the maximum energy density) is not mentioned.

In the paper by Keika et al., 2018, Lm is presented, but the corresponding UT and MLT are not presented/mentioned.

If the author obtained those data partly from the published figures/tables and partly by her/himself from the original data files provided by the mission teams, please elaborate on the processes.

AC: I have added to the Table 1 numbers of the main figures used in my work (see Appendix AC6). The corresponding figures are given in Appendix AC7. Text also will be corrected.

With data binding by Yue et al. (2018) I have been the biggest difficulties and here I was wrong. You are right: the pressure have maximum at ~13.30 UT (more precisely, at 13.10), and not at 16.30 UT. The L scale is not given in this work, and it is possible to determine the RC parameters for $L > L_m$ only with large errors, but the L_m value may be found in the Supporting Information for this work. The UT value in Line 13 of the Table 1 changed to 13.10, and $|D_{st}|$ value changed from 72 to 58 nT; a position of point 13 in Figs. 1a and 2a on the scale $|D_{st}|$ are also corrected. The D_{st} index values were taken from wdc.kugi.kyoto-u.ac.jp/dst_final/index.html.

The work Keika et al. (2018) provides, although in a very complex form, all the necessary information. Pass A4 and B5 were used (the UT intervals for them are shown in Figs. 4 and 8 of this work), and the MLT values were calculated from the orbits of the satellites shown in Fig. 2.

RC2: 2. The early part of Introduction (Lines 30-46) and latter part (lines 66-72) have not cited any published papers, although the paragraphs contain our current understanding based on a large number of previous studies.

AC: Many hundreds of references would have to be cited here. In this section, the problem statement for this work is given, and I limited myself here only to links to the main reviews on the RC. Citations of the original works on the RC go already at the beginning of the next section and continue until the end of this manuscript.

RC2: 3. The dipole magnetic field is used to calculate w_Bd, but it is well accepted that the magnetic field configuration on the night side is significantly deviated from the dipole during a storm, particularly during the main phase. In addition, magnetic field data are available at the time of the maximum energy density (i.e., at Lm) for most of the storms listed in Table 1. The author should use either a better magnetic field model or in-situ observations.

AC: Calculations of β_{md} values for the simplest model of a dipole magnetic field are given only in column 4 of Table 2 and are not used in Fig. 2. These values are given only for comparison with the values of β_m given in column 5 of Table. 2.

When calculating the values of β_m given in columns 5, 6, and 7 of Table 2, the magnetic effect of the RC is taken into account, which is the main correction for the magnetic field in the region of the RC maximum (see, e. g., Cahill, 1973; Cahill and Lee, 1975; Berko et al., 1975; Lyons, 1977; Krimigis et al., 1985; Lui et al., 1987).

In addition, for most of the storms considered here, there are current values of the magnetic field in the orbits of the corresponding satellites. These values of the magnetic field are also used here to correct the calculations of the parameters β_m, although I do not always refer to these publications (I did not want to make the bibliography larger than the main text).

RC2: 4. The author says that the ring current ion energy density is well approximated by an exponential function. It is important to present quantitatively to what extent it can be approximated.

AC: Such an approximation is illustrated by figures supplementing Fig. 3 and given in Appendixes AC3 and AC4.

RC2: 5. An important storm that occurred on March 17, 2013 is missing. The storm was extensively analyzed by Gkioulidou et al., 2014.

AC: The results on the RC ions during this storm (March 17, 2013) are very important for my work. They are presented in rows 7, 8, 9, 10, and 11 in Tables 1–3 (and in Fig. 1–6) and are derived from Menz et al. (2017).

The work of Gkioulidou et al. (2014), which analyzes this storm in details, is very interesting and important for understanding the dynamics of RC and it is mentioned in the several places of my manuscript. However, the results on the energy density of the RC ions obtained for this storm onboard the Van Allen Probes satellites are presented in Menz et al. (2017) more fully.

In connection with the work of Gkioulidou et al. (2014), it can be noted that hot plasma convection plays the most important role in the *formation of the general patterns in the distributions of the RC parameters during the main phase of storms*, and the work of Gkioulidou et al. (2014) focuses mainly on the analysis of a fast-variable and more localized hot plasma injection processes in the outer near-midnight regions of the RC.

Fast processes in the RC investigated in Gkioulidou et al. (2014) also appear in the figures presented in my manuscript; they are one of the main reasons for the scatter of points in these figures and the deviation of these points from general patterns (this is noted in the several places of my manuscript).

Kind regards,
Alexander Kovtyukh