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Reply to Interactive comment by Anonymous Referee #1 from 10 November 2020 on the manuscript "Distribution of the Earth's radiation belts protons over the drift frequency of particles" *by* Alexander S. Kovtyukh

Deeply respected Referee #1,
I am very grateful to you for such an exclusively generous and thorough review. Thank you very much for these corrections! All these comments are very helpful for me and it is taken into account in the manuscript. I think that the manuscript now is much linear and easy to read.
A paragraph has been added to Sect. 2, which explain as I estimate the anisotropy of proton fluxes at $L > 6$ (highlighted in green).
With grand regard,
Alexander S. Kovtyukh

Line Comment

Line 1 Distribution of Earth's radiation belts protons …
AC: I agree. Text corrected.

Line 6-10 Thanks to the data on the proton fluxes of the Earth's radiation belts (ERB) with energy ranging from 0.2 to 100 MeV and drift L shells ranging from 1 to 8, their stationary distributions over the drift frequency f_d of protons around the Earth are constructed. For this purpose, direct measurements of proton fluxes of the ERB in the period 1961–2017 near the geomagnetic equator were employed.
AC: I agree. Text corrected.

Line 12 … and their distributions in the space … have a more regular shape than …
AC: I agree. Text corrected.

Line 16 … is disrupted in advantage of transport …
AC: I agree. Text corrected.

Line 17 … with increasing solar activity, overpowers …
AC: I agree. Text corrected.

Line 33 For the near-equatorial ERB protons, we have:
AC: I agree. Text corrected.

Line 36-37 … with increasing amplitude of particles oscillation.
AC: I agree. Text corrected.

Line 38-55 The frequency f_c is different for different L-shells (near the equatorial plane) and, as L increases (higher geomagnetic latitudes) the number of particles become less and less insignificant. For each given value of the frequency f_b if L increases, then particles become more and more energetic (…) and their number becomes smaller.

Compared to the frequencies f_c and f_b, the drift frequency f_d for one particle species has a narrower range of values; it does not depend on the mass of the particles and it very weakly depends on the amplitude of their oscillations (…); in this case, on each L-shell there are a significant number of particles corresponding to a certain value of f_d.

Therefore, it can be expected that the distributions of the ERB particles in the space $\{f_d, L\}$ will have a more regular shape than in the space $\{E, L\}$, and the main physical processes in these belts will manifest themselves more clearly in these distributions. Furthermore, it can also be expected that on these more ordered background more fine features can be revealed that would not appear in the space $\{E, L\}$.

Despite the importance of the drift frequency f_d for the mechanisms of the ERB formation, reliable and sufficiently complete distributions of particles in the ERBs (over the frequency f_d) have not been presented nor analyzed; indeed, this is the first time.

AC: I agree. Text corrected.

Line 56-61 The analysis presented in this paper is limited to the protons of the ERB during magnetically quiet periods of observations, when the proton fluxes and their spatial energy distributions were stationary. In the following sections, the distributions of the ERB protons over their drift frequency f_d are constructed from experimental data (Sect. 2), and analyzed (Sect. 3). Finally, the main conclusions of this work are given in Sect. 4.

AC: I agree. Text corrected.

Line 67 In my opinion the term generalized is out of context here (and in similar statements).

AC: I agree. Text corrected.

Line 67-75 From the data of averaged satellite measurements of the differential fluxes of protons with an equatorial pitch-angle …, aforementioned distributions are constructed in (Kovtyukh, 2020) during quiet periods. Such distributions, separately between periods near minima and maxima of the 11-year solar activity cycle, are constructed from satellite data also for other ionic components of the ERB (near the equatorial plane), but the most reliable and detailed picture was obtained in for protons (see Kovtyukh, 2020). In Fig. 1 one of these distributions is reproduced for periods near solar maxima (from 1968 to 2017); here, data of different satellites are associated with different symbols.

AC: I agree. Text corrected.

Line 77 … correspond to the …

AC: I agree. Text corrected.

Line 83-84 The red lines correspond to the drift …

AC: I agree. Text corrected.

Line 85-87 Only protons with energies less than some maximum values, determined by the Alfvйn's criterion: … plane) can be trapped on the drift shells.

AC: I agree. Text corrected.

Line 91 The distribution of the ERB proton fluxes shown in Fig. 1, refers to …

AC: I agree. Text corrected.

Line 109 … of these fluxes …

AC: I agree. Text corrected.

Line 111 … as red numbers.

AC: I agree. Text corrected.

Line 119 Figure 2 was written as Fig. 2 before.

AC: I agree. Text corrected.

Line 122 … energy-independent …

AC: I agree. Text corrected.

Line 123 … in Fig. 2 are due to the fact …

AC: I agree. Text corrected.

Line 129 … each other and to the energy axis …

AC: I agree. Text corrected.

Line 129 … refers to protons …
AC: I agree. Text corrected.

Line 138 … motions (these issues were most fully …
AC: I agree. Text corrected.

Line 139-140 Both the local maximum at … and the region of low anisotropy at … in Fig. 2, are related to the ionization losses of protons.
AC: I agree. Text corrected.

Line 145 … which were obtained at …
AC: I agree. Text corrected.

Line 157 I believe that the unit of measurements for the B field is Gauss, G not Gs.
AC: I agree. Text corrected.

Line 161 … , it increases by only …
AC: I agree. Text corrected.

Line 198 … calculated using the formula (1) together with Figs …
AC: I agree. Text corrected.

Line 205 … of maximum solar activity …
AC: I agree. Text corrected.

Line 208 see Line 205
AC: I agree. Text corrected.

Line 211 … during minimum periods of solar activity …
AC: I agree. Text corrected.

Line 222 … of the ERB protons is the radial …
AC: I agree. Text corrected.

Line 225 Figs. 1 and 2 …
AC: I agree. Text corrected.

Line 228 The iso-lines of the proton fluxes in Fig. 1 at sufficiently large E …
AC: I agree. Text corrected.

Line 230 The use of the verb “to reject” is extremely unclear here, please clarify.
AC: I agree. Text corrected.

Line 237 … the radial diffusion is decreased very rapidly …
AC: I agree. Text corrected.

Line 247 … have much less steeper outer edges and …
AC: I agree. Text corrected.

Line 252 This effect is mainly connected to the large …
AC: I agree. Text corrected.

Line 268 … is driven by increase in the …
AC: I agree. Text corrected.

Line 270 This sentence here is rather unclear. Maybe it would be better to put it like: “Fig. 5 demonstrates the closeness to the adiabatic transformations of the spectra …
AC: I agree. Text corrected.

Line 291 … have a power-law tail …
AC: I agree. Text corrected.

Line 297 … become gradually increasingly rigid with decreasing L, and …
AC: I agree. Text corrected.

Line 304 Fig. 5 show that at …
AC: I agree. Text corrected.

Line 311 The word “but” here seems to be written with a smaller font with respect to “protons” and “the power”.
AC: I agree. Text corrected.

Line 313 … are established at lower …
AC: I agree. Text corrected.

Line 316 With decreasing *E* (and …
AC: I agree. Text corrected.

Line 318 … observed …
AC: I agree. Text corrected.

Line 318 … with decreasing solar activity …
AC: I agree. Text corrected.

Line 319 … we see in Fig. 5 the opposite effect …
AC: I agree. Text corrected.

Line 328 Under the influence of …
AC: I agree. Text corrected.

Line 331 … activity is overpowered by a more …
AC: I agree. Text corrected.

Line 333-339 According to numerous experimental data, during magnetic storms, a wide variety of complex spectra of powerful pulsations of magnetic and electric fields in the considered frequency range (ULF) can be generate in the geomagnetic trap, which are non-regularly distributed over *L*; these pulsations can lead to local acceleration and losses of the ERB particles (…). Such effects will violate the regular characteristics of the protons distributions shown in Fig. 4 and 5. However, during quiet periods, the amplitudes of such pulsations are small and they lead only to radial diffusion of particles.
AC: I agree. Text corrected.

Line 341-343 Starting from the data on near-equatorial ERB proton fluxes (with energy from 0.2 to 100 MeV and drift *L* shells ranging from 1 to 8), their stationary distributions … were constructed.
AC: I agree. Text corrected.

Line 344 … of the ERB protons within …
AC: I agree. Text corrected.

Line 345 … for periods of maximum solar activity …
AC: I agree. Text corrected.

Line 348-352 … only one maximum that shifts toward… In comparison to the proton fluxes … have steeper inner edges and flatter outer edges. However … have inner and outer edges with only slightly difference from each other for what concerns the steepness of their profiles.
AC: I agree. Text corrected.

Line 354 … are weakly dependent on …
AC: I agree. Text corrected.

Line 355 … power-law shape …
AC: I agree. Text corrected.

Line 358 … have a more regular shape than …
AC: I agree. Text corrected.

Line 359 In these regions, there is the majority of the ERB protons, and their radial diffusion overpowers …

AC: I agree. Text corrected.

Line 366 With increasing solar activity, the number of protons …

AC: I agree. Text corrected.

Line 371 … is mainly formed by the mechanism …

AC: I agree. Text corrected.

Line 372-373 … that with increasing solar activity, the average rates of radial diffusion of protons increase as well.

AC: I agree. Text corrected.

Line 374-375 … with increasing solar activity is overpowered by the increase of the rates of radial …

AC: I agree. Text corrected.