

***Interactive comment on “Atmospheric electric field anomalies associated with solar flare/coronal mass ejection events and solar energetic charged particle “Ground Level Events”” by E. A. Kasatkina et al.***

**E. A. Kasatkina et al.**

shumilov@inep.ksc.ru

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Final Author Comments on behalf of all co-authors

Reply to Referee #1, 27 Oct 2009

In general one could have agreed with remarks on the paper that atmospheric Ez variations around the events are small, the behavior of Ez is not identical at all stations, and there is no unambiguous definition of physical reasons (Why in some cases the atmospheric electric field variations were observed before the onset of Ground Level

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Event itself?). It is true and the authors should agree with it.

Moreover, we have to note:

1. The number of the known GLE events is very small (less than 70 events up to date). They are very important being analogous to galactic cosmic rays (GCR), which permits us to use them in some model simulations, for example, in the process of ion nucleation in the atmosphere. The last one is very important in climatic application of the problem of external factor (solar activity and GCR) influence on the climate.
2. Concerning the measurements of atmospheric electricity we may add that it is very difficult to find simultaneous Ez measurements in the polar cap, auroral latitudes and middle latitudes and moreover, to find them under fair weather conditions.
3. The combination of points 1 and 2 makes the problem of comparison even more difficult.
4. We are aware of fair weather conditions and, of course, of bad weather conditions. But it is very difficult to define a sharp boundary between these two types of weather conditions. Most of atmospheric phenomena occur under "grey weather conditions". This makes the problem even more ambiguous.
5. The list of references demonstrates that there were very many attempts to interpret the pre-event (pre-flare) activity in atmospheric phenomena. Up to date there seems to be no such interpretation, and there are many physical reasons for it. But the experimental facts do exist. Sometimes atmospheric disturbances were observed before solar flares.

We as well only give information on the experimental fact and give a list of physical interpretation, which exists. However the results presented in the paper demonstrate that sometimes before and during GLEs, solar flares and CMEs one can observe atmospheric Ez variations in the polar cap, auroral zone and at middle latitudes. This means that the response of atmospheric Ez to GLEs is global. Taking into account that

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direct penetration of GLE particles takes place inside the polar cap the last conclusion seems to be important in the light of the problem of "Space climate".

We are grateful to the unknown reviewer for correct and interesting comments. Interactive comment on Atmos. Chem. Phys. Discuss., 9, 21941, 2009.

Reply to Referee #2, 25 Jan 2010

1. We assume that the main effect seen at three stations is on the background of some local peculiarities.

2. Seems there are some other reasons of Ez fluctuations in these cases (for example, SC, local meteo conditions. We investigate our main effect, because it took place on roughly undisturbed background.

3. Wind speed less than 6 m/s, absence of snowstorms, absence of low cloudiness – all these conditions satisfy "fair weather" phenomena. Both our own measurements (wind speed and visible observations) and data from two nearest meteorological stations demonstrate that at 15 April 2001 the "fair weather" conditions existed at Apatity. It turned out that the wind speed had been nearly constant since early on 14 April 2001, typically between 5 and 6 m/s, at Vostok station. At Apatity, there was a smooth increase of wind speed on the morning 15 April 2001, but for the period of interest the wind speed was generally less than 5 m/s. The cloud base was 1750 m at 06.00 UT, and 3000 m at 12 UT (during the period analyzed).

We are grateful to unknown Referee for very careful remarks.

Reply to Referee #3, 2 Feb 2010

1. We've added to abstract the lower phrase recommended: "Only the April 15, 2001 shows clear evidence for Ez variation associated to SF/CME events and the other two events may support this hypothesis as well although for them the meteorological data were not available".

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2. Page 3-4. It is very difficult to comment these positive increases (not very large, and at the level of fluctuations) taking into account that Vostok data are hourly ones opposite to Apatity and Voeikovo. We didn't analyzed these additional variations. We intend to do it in the next paper to ACPD.

3. Page 4. We agree with your comments, revised the text and included some your comments in the Paper.

4. Page 5. To our mind the physical picture for 18 April and 4 November seems to be more complicated than those based on idea of Nolte and Roelof (1973 a,b).

5. Page 7. You are quite right. The pre-CME streamer was seen only at 11:54 UT image. Other two images demonstrate the temporal development of SF/CME event. We assume that it would be interested to readers.

6. Page 7. We changed the text according to your remarks.

As we had agreed with comments and used some of them in the text we ask the unknown Referee to join to our paper as a co-author. Anyway, we are strongly grateful to unknown Referee for very careful remarks.

Reply to V. Savin, 23 Dec 2009

All comments considered that weather conditions "were not observed on April 15, 2001" do not correspond to the real weather situation at that time.

1. According to the official meteorological data [<http://meteo.infospace.ru>] during 15.04.2001 never it was detected so called "drifting snow" (in Russian "metel", "zanosi") and "snowstorms" (in Russian "metel", "purga"). At 00.00 GMT and 06.00 there were no any specific meteorological phenomena at all. At 12.00 and 18.00 it was detected very weak "pozemka" – blizzard accompanied by very weak ground wind. Wind velocity was equal to 3m/s that time. The average wind velocity was 4 m/s. Moreover taking into account that our measurement site was located at the distance of about 3-3.5 km from the nearest meteorological station we watched very carefully for any snow

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and precipitation phenomena. In the case of their appearance all Ez measurements would have been immediately stopped. However, during our measurements we have not detected such events.

2. The author of comments very shortly mentioned that during the period analyzed “The cloud base was about 450 m”. It is again wrong. The cloud base at 00.00 was 3000 m, at 06.00 it was 1750 m, at 12.00 it was again 3000 m, and only at 18.00 (after nearly all the period analyzed) it was 450 m.

3. For the all period analyzed the official meteorological data on wind velocity were 5 m/s at 00.00, 6 m/s at 06.00, 3 m/s at 12.00 (close to the maximum of the event considered) and at 18.00 it was again 3 m/s. Our own wind velocity measurements aside of Ez measurement point again demonstrate that at 00.00 15.04.2001 wind velocity was about 1 m/s, then it step-by-step increases up to 5 m/s at noon, and then step-by-step decreases up to 1.5 m/s to the end of day. Again at such very slow wind velocity one could hardly expect of any “snowstorm”.

4. The data from the other neighbor meteorological station at airport (Álĭj 14 km from our site) demonstrate the similar situation. The cloud bases were 2400 m at 06.00, and at 12.00 wind velocity was about 6 m/s. Taking all above mentioned we consider that fair weather conditions at 15.04.2001 were observed and all critical remarks inconsistent and are slightly juggled.

Reply to V. Savin, 4 Jan 2010

For the analysis we used only original data from AARI. Unfortunately “Meteoinfospace” website is wrong for 15 April 2001. Figure reproduces the wind velocity and vertical electric field for the period of interests. 1-min data were used for this figure. Only few points in wind velocity are exceeded 6 m/sec. More over it is well known that the wind velocity at Vostok position is very low as a rule and the maximal wind velocity observed at Vostok is less than 20 m/sec.

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Reply to V. Savin, 20 Jan 2010

We used only our own data (wend speed and visible observations). We did not use “Meteoinfospace” data for analysis in the paper. We used this information only in discussion. According to our own measurements and data from two nearest meteorological stations demonstrate that at 15 April 2001 the “fair weather” conditions existed at Apatity. It turned out that the wind speed had been nearly constant since early on 14 April 2001, typically between 5 and 6 m/s, at Vostok station. At Apatity, there was a smooth increase of wind speed on the morning 15 April 2001, but for the period of interest the wind speed was generally less than 5 m/s. The cloud base was 1750 m at 06.00 UT, and 3000 m at 12 UT (during the period analyzed).

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Interactive comment on Atmos. Chem. Phys. Discuss., 9, 21941, 2009.

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