

Interactive comment on “Ionization effect of solar particle GLE events in low and middle atmosphere” by I. G. Usoskin et al.

Anonymous Referee #1

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General comments

The manuscript presents the calculated ionization rates caused by major GLE (Ground Level Enhancement) events obtained with the state-of-the-art model and reconstructed solar proton energy spectra. The manuscript is well written and organized. The authors made several interesting conclusions. In particular, they pointed out that the effect of proton flux enhancement can be overcompensated by the depression of galactic cosmic rays (Forbush decrease) leading to actual decrease of ionization rates in the lower atmosphere. I think that the paper can be published in ACP after some minor revisions specified below.

Specific comments

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1. I suggest adding some notes about the applicability of the obtained results to the introduction. It would be helpful also to clarify which community will be the most interested in the provided ionization rates. I think that the results can be applied for the calculation of the middle atmosphere response to strong solar proton events.

2. It would be interesting to compare the calculated ionization rates with the results of other models. I recall that similar calculations for several events have been made by several groups (e.g., Ch. Jackman et al. and Wissing and Kallenrode, 2009). In particular Wissing and Kallenrode (2009) emphasized that the electrons can substantially contribute to the total ionization rate in the mesosphere. As far as I understood the ionization by electrons was not taken into account by the authors, so this comparison will help to understand the uncertainties of the applied approach.

3. It also of interest to discuss the possibility of the extension of the provided tables to the past. Would be possible to apply some proxies and reconstruct ionization rates back to the beginning of 20th century and even further back?

Minor comments and technical corrections

1. Page 30382, Line 15: “... the main source ...”. I would add “of ionization”

2. Page 30383, Line 3: “... changes little ...”. I would use “... is rather stable...”

3. Page 30384, Line 12: “... can be significant ...”. If it is convincingly shown by Mironova et al., 2008, then it is better to formulate it more definitely. Otherwise, this statement is vague.

4. Page 30384, line 23: Frobush is a typo.

5. Page 30384, line 26: “..summary..” is not good, consider “total” or “combined”

6. Page 30385, line 19: better to say “given by Usoskin and Kovaltsov (2006) and Usoskin et al., (2010).”

7. Page 30386, second paragraph: I suggest adding a little bit more information about

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satellite data. In particular, what time periods are covered by different satellite and how homogeneous the time series are.

8. Page 30387, equations: I could not find what stands for γ_1 , γ_2 , R_0 and J_0 .

9. Page 30389, lines 18-19: It would be interesting to compare with the results of AIMOS model, which shows some ionization rates even in the low latitude area.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 30381, 2010.

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