**Reply to the reviewers' comments on "Observation and modeling of high-$^{7}$Be events in Northern Europe associated with the instability of the Arctic polar vortex in early 2003" by Erika Brattich et al.**

Manuscript Ref: acp-2020-1121

We thank the reviewers for their useful comments. Below are the reviewers' comments in italic followed by our replies in blue text.

***Anonymous Referee #2***

*The manuscript has been improved by the authors and can be recommended for publication subject to a minor revision. The authors have addressed most of the previous comments and are now requested to address only one remaining, namely that about the production model.*

*The authors did not properly reply to the previous concern regarding the use of the obsolete production model by Lal & Peters (1967, LP1967) nor regarding the validity of the application of the results of 1958 to the epoch of 2003. The new text in lines 193-203 is not correct and should be rewritten. Presently it sounds as if the LP1967 model was more accurate than all the subsequent models, that is, of course, not correct. References to Koch et al. (2001) and O'Brien et al. (1991) are irrelevant here as they do not cover recent full models. This reviewer thanks the authors for pointing to the recent work of Golubenko et al. (2021) that doesn't compete with the present work but excellently shows the validity of the modern models (particularly that by Poluianov et al. 2016) as no bias between the measured data and modelled ones was found for different locations. Moreover, previous works of Usoskin et al. (2009) or Heikkila et al. demonstrated quantitative agreements between measured and modelled 7Be activities. Thus, the recent models do not produce any notable bias to the data. contrary to what the authors claimed. Thus, the authors did not properly address earlier questions. On the other hand, this reviewer agrees that precise production modelling is not crucial for this work. Thus, the reviewer suggests the following change, which would lead to a correct and acceptable text:*

*1) The new addition (lines 193-203) should be removed.*

*2) A statement ought to be added that the LP1967 model embedded into the climate model was used. While there are more accurate modern models (e.g., Masarik & Beer, 1999; Webber et al., 2007; Usoskin & Kovaltsov, 2008; Poluianov et al., 2016) the rougher one by LP1967 is sufficient for the present work where mostly atmospheric transport features are studied. Such formulation would be acceptable.*

*3) It should be clearly stated that, while the LP1967 model is used here for the time-variability studies, it is not applicable for quantitative studies of the 7Be activities.*

We thank the reviewer for his/her comments. We have followed the suggestions and revised the text (section 3.1, second paragraph).

***Anonymous Referee #3***

*General remarks In my first review I stated that the case study of high 7Be events observed in Northern Europe in early 2003 combined with a model simulation constitutes a good scientific study of interest to the readership of ACP. This is still true. The authors have invested considerable work in improving their manuscript in response to the comments by both reviewers. In summary, I think this is an interesting paper the revisions have certainly improved it. I have a few remaining comments (see below) that I recommend considering when providing a final version of the paper. I suggest that the paper should now be accepted subject to technical corrections.*

We thank the reviewer for his/her comments. Below are our point-by-point replies to each specific comment raised by the reviewer.

***Remaining detailed comments***

ˆ *Title: the title was changed in response to my comment, but I think "surface high-7Be" is still not good. Perhaps "high surface 7Be. . . " or "high-7Be events at the surface" or similar.*

We have modified the title to "Observation and modeling of high-$^{7}$Be concentration events at the surface in Northern Europe associated with the instability of the Arctic polar vortex in early 2003" as suggested.

ˆ *l 55: "followed by gradual movement into the ground-level" is not really clear; do you mean the boundary layer here?*

We have modified the sentence to "…. the transfer of stratospheric air into the upper troposphere was at its maximum in March followed by descending to the ground-level during late spring and early summer".

 *l 86: "temporal variability of the Arctic vortex includes the SSW": includes is not the best word: perhaps 'SSW, a major mode of the temporal variability of the Arctic vortex', or similar.*

We have modified the sentence as suggested.

ˆ *l 233: The paper states "Computation used the vertical velocity field contained in the meteorological input file" – it is still not clear which vertical velocity field you are using. I guess ω = ˙p, or are you using a vertical velocity field in units of length over time? Please clarify.*

We have revised the sentence to "Computation used the vertical velocity (m/s) field contained in the meteorological input file"..

ˆ *l 241-243: These lines do not provide a lot of discussion on downward transport and the use of backward trajectories. I still think that consideration (e.g. plotting) of time/altitude cross sections for the backward trajectories could be helpful to the arguments put forward in the paper.*

Our analysis of back-trajectories arriving at the sampling sites during the two periods of low and high $^{7}$Be values confirms the presence of two distinct circulation patterns, namely, a westerly provenance in the first period as opposed to the clockwise circulation from atmospheric upper levels (as shown from the bottom panels which present the trajectory average altitude plot, as added in the revised caption) during the second period. While this analysis alone cannot confirm the link between SSW and the $^{7}$Be increase recorded at the sampling site, we believe that when used together with the model simulations it complements and supports our major findings with an independent method.

ˆ *l. 441-446: These lines in the new manuscript do not really talk about PV; regarding your comment; note that for adiabatic conditions not only PV is conserved (neglecting friction) but also potential temperature (which might have implications for downward transport). You do not have to change your paper necessarily based on this comment.*

We thank the reviewer for this comment. No changes have been made to these texts.

ˆ *line 445: this line does not contain a discussion of omega in contrast to what is stated in the reply.*

We have added more details on the omega values in the revised version: ”,,,,, especially for the northernmost sites (Figure 12) where omega is largely positive with near-surface values up to 0.3-0.4 Pa $s^{-1}$ around 18-19 February”.

ˆ *l. 631: check authors list – does not seem to be correct.*

The author list has been revised.

ˆ *l. 777: check the year of the reference; 2006?*

The year of the reference was added.

ˆ *Figure 12: The caption is extended but the meaning of the black lines in the panels of Fig. 12 is still not explained in the caption.*

Now the caption of Figure 12 states that the black lines are contours of omega values.

ˆ *Fig. 13: the omega values in the boundary are perhaps not most relevant for the downward transport from the stratosphere. Have you considered other levels as well? For example, there is a large ‘red’ area over Greenland (but not over the ocean surrounding Greenland); would you expect to find strong 7Be enhancements in Greenland but not so much over the ocean?*

Thanks for pointing this out. Indeed, the omega values in the boundary layer are not directly related to the downward transport from the stratosphere. Rather, positive vertical pressure velocity as seen over both Fennoscandia and Greenland (Figure 13) during 18-25 February 2003 indicates descending motions that can facilitate the transport of stratospherically influenced air, if present, to the ground-

level. This explains why Fennoscandia saw increased stratospheric influence on surface $^{7}$Be concentrations during this period (Figure 14), but Greenland did not see much. However, on monthly average, Greenland is a region with significant stratospheric influences in February 2003 (middle right panel, Figure 3). This discussion has been added to Lines 443-448.