

Interactive comment on "Impact of energetic particle precipitation on stratospheric polar constituents: an assessment using MIPAS data monitoring and assimilation" by A. Robichaud et al.

Reply:

We acknowledge and thank anonymous referee 2 for his/her time and favorable comments.

Referee 2:

The authors discuss the results of assimilation model computations, which are used to evaluate the impact of energetic particle precipitation (EPP) on high latitude stratospheric chemistry. They use the coupled stratospheric chemistry-meteorology 3-D model GEM-BACH together with MIPAS observations for these computations. The model can be used in passive (without chemical assimilation) and active (with chemical assimilation) modes and can help delineate the EPP effects on the stratosphere after the events. Their results have been used to track increases of NO₂ and HNO₃ due to EPP and subsequent decreases, which provides some information about the atmospheric chemistry. This information appears to imply that gas-phase chemistry cannot explain all the variation of HNO₃. The authors also analyzed the associated EPP-caused ozone losses and derived total ozone losses of 5-6 DU caused by the EPP indirect effect (IE) in the Antarctic winter of 2003 and a solar proton event (SPE) caused total ozone loss of about 1 DU in the Arctic fall of 2003. The paper is generally well written and contains valuable information and analysis of EPP effects. It offers the capability of using assimilation models in quantitative analysis of large atmospheric perturbation events. Also, their analysis of the derived total ozone losses due to either EPP-IE or SPE allows comparison with other total ozone variations, whether they are due to natural or humankind-related influences. My primary concern about the paper is the quality of the figures, which could be improved. In total, I have listed 6 "Specific comments" and 2 "Technical corrections". The paper should be ready for publication in ACP after moderate revision.

Reply:

We have substantially improved the quality of the figures using IDL scripts and followed the given advice of both referees 1 and 2 (see point 6 below).

Referee 2:

Specific comments:

1. p. 22461, line 28; p. 22462, lines 1-2: "EPP-IE in this case is linked with ionized particles trapped in the magnetosphere which precipitate into the upper atmosphere ejected by the solar wind or solar disturbances." Comment: I suggest a re-write of the sentence to "EPP-IE in this case is linked with ionized particles trapped in the magnetosphere, which precipitate into the upper atmosphere. Such particles originated in the solar wind or were ejected during solar disturbances".

Reply:

The text has been modified accordingly and also in agreement to referee 1 who also commented about this sentence.

Referee 2:

2. p. 22463, line 13: *“When downward transport of excess NO_y or HO_x occurs.”*
Comment: HO_x constituents have a relatively short lifetime (hours) in the lower mesosphere and upper stratosphere, thus are not influenced much by transport.

Reply:

This is correct. The reference to HO_x, which is not necessary in our context, has been removed.

Referee 2:

3. p. 22466, lines 16-18: *“The vertical resolution is about 3 km in the stratosphere but lower in the mesosphere (Fischer et al., 2008).”*
Comment: I think that authors are implying that there is a lower vertical resolution in the mesosphere (Is that correct?). As written, it is a bit confusing is the vertical resolution is larger or smaller in the mesosphere. I suggest a re-write as “The vertical resolution is about 3 km in the stratosphere, but is larger than 3 km in the mesosphere (Fischer et al., 2008).”

Reply:

We followed the suggestion and replaced the old version accordingly. We also corrected the reference to Fischer et al., 2008 (instead of 2007).

Referee 2:

4. p. 22475, lines 17-19: *“The latter is attributed to the misrepresentation of denitrification and sedimentation in the model, which is otherwise well captured by the MIPAS instrument.”*
Comment: I don’t quite understand this sentence. I thought the MIPAS measurements were accepted as reasonable. Did the authors mean to write “The latter is attributed to the misrepresentation of denitrification and sedimentation in the model, which is otherwise well captured by the model.”? If not, could they clarify the sentence?

Reply:

We agree that this sentence is confusing. The MIPAS measurements are reasonable there but the model has a problem of misrepresentation in the lower stratosphere which is corrected by assimilation. Therefore, we suggest replacing the above by the following: “The latter is attributed to the misrepresentation of denitrification and sedimentation in the model. Note that with MIPAS assimilation, the HNO₃ bias disappears (Fig. 3c)”. We

also added up some additional comment to be able to address referee 1 in the revised version.

Referee 2:

5. p. 22481, lines 3-4: *“upper stratopause/upper stratosphere region (0.5-2 hPa)”*
Comment: This seems more like the “lower mesosphere/upper stratosphere region (0.5-2 hPa)” to me. I did not realize that the stratopause had an “upper” region.

Reply:

That has been corrected to “lower mesosphere/upper stratosphere”

Referee 2:

6. Figures, pp. 22494-22504: Figure 1, 6, 10, 11 *“Please use larger font for abscissa and ordinate labels. Figures 2, 3, 4, 5, 7, 8, 9 “The labels for the colored lines are nearly unreadable since the font is so small. Also, the abscissa and ordinate labels could use a larger font. It seems like color fill between contour lines could help a lot.*

Reply:

The figures have been redone taking into account the above comments and also those of referee 1 concerning that matter. We would like to thank referee 2 for providing helpful specific details for each figure.

Referee2:

Technical corrections:

- 1) p. 22474, line 22: *“anomalies persist persisting”* Suggest changing to *“anomalies continue persisting”*
- 2) p. 22504, Fig. 11 caption: Change *“1585 hPa”* to *“1.585 hPa”*

Reply:

These two points have been corrected in the revised version.