

Interactive comment on “Enhancement of N₂O during the October–November 2003 solar proton events” by B. Funke et al.

Anonymous Referee #1

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In the manuscript the authors report the first observations of N₂O enhancements in the polar upper stratosphere-lower mesosphere after Solar Proton Events. The authors propose the N₂O production to take place through enhanced production of N(⁴S), the ground state atomic nitrogen, and NO₂, which then react to form N₂O. To test their hypothesis, the authors use the Canadian Middle Atmosphere Model (CMAM) with and without the chemical reactions required for the proposed N₂O production, concluding that similar results to the measured N₂O values are obtained when the proposed mechanism is included in the model. The paper is very interesting and presents the first observed Solar Proton Event induced N₂O enhancements in the upper stratosphere - mesosphere region. As N₂O is the main stratospheric NO_x source these results are very interesting and suggest yet another mechanism for coupling of the middle atmo-

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sphere and the Sun.

The paper is very clear and well written. The figures were also quite clear, although the font size in the contour labelling in Figs 4-6 was somewhat small at places. I have listed some specific comments below that I would like the authors to consider.

Page 5, second full paragraph. Why is the NO data used only for one day but NO₂ for the full study period? Is this due to NO data availability?

Page 7 and Figure 4 The authors write that there seems to be an indication of aurorally enhanced N₂O in the October 26 MIPAS observations. This is not the focus of this paper but still I wish to point out that this enhancement appears to extend to very high latitudes, far beyond the location of the auroral oval where auroral particles would cause in situ ionization. Also the altitude (~60 km) is quite low for auroral energy particles.

Page 8, first para In addition to atomic nitrogen production EEP should surely also lead to NO₂ production. Is the descent from the MLT needed to have enough NO₂ for the N₂O production or might EEP production on its own be enough? Ionization by particle precipitation would also produce the excited state of nitrogen. Does the excited state of nitrogen (N²D) play any role in the proposed N₂O production?

Page 10, last para The NO_x production by EEP is not included in the CMAM modelling presented in this paper. However, Semeniuk et al. have published CMAM modelling results for the Halloween events showing that for sufficient enough NO_y production for these events the enhanced thermospheric ionization source is required. Why not include this source also in the modelling done for this paper?

Page 11, last para of section 3 "The ratio of both is about a factor of 5-6, very similar to the NH/SH ratio for N₂O of (6-7)/(1-1.2)." I'm not sure what this should mean. Should it be "The NH/SH NO₂ ratio is about 5-6, very similar to the NH/SH ratio for N₂O of (6-7)/(1-1.2)."

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Figure 1 and 2 Some of the diamonds show rather large values but similar values do not show in the smoothed field. Is this simply due to the 700 km smoothing?

Figure 6 Are the MIPAS averaging kernels used to produce the CMAM time series? I assumed so but the text does not mention it.

Figure 7 There is a clear peak in the MIPAS NO₂ at around 53 km above which the values decrease but the model values do not show this peak. The authors write that there is model overestimation at altitudes 55–65 km (i.e. the observed low values are close to the reality), is this verified by some other means?

Typos:

Page 4 line 7 "time 14.3 times a day." "time, 14.3 times a day."

Page 5, line 10 "In addition to N₂O we also use MIPAS data for NO₂ for that period and"
"In addition to N₂O we also use MIPAS data for NO₂ for the same period and"

Page 7, line 15 "for the following fews days" "for the following few days"

line 17 "precipitations" "precipitation"

Page 9 line 22 "(Fig. 5b) looks," "(Fig. 5b) look,"

Page 10 line 25 "precipitations" "precipitation"

line 26 "EPPs" "EPP"

Page 11 line 1 "precipitations." "precipitation."

4 Conclusions, last line of first para. "augmented" I would suggest a more commonly used word here, such as "increased".

4 Conclusions, second para. "High-energy electron precipitation are" "High-energy electron precipitation is"