

Reply (large font) to comments of Referee # 2 (in smaller font):

Minor comments (note that page and line numbers refer to the original manuscript):

Page, line 36: The respective theta levels should be added.

Page 2, line 43 and 45: The respective pressure levels should be added.

Page 2, lines 36 and lines 43-45—Theta levels are about 580 K and 530 K for 21 and 28 hPa, respectively. The theta levels of 550 K and 450 K correspond to 31.6 and 46.4 hPa.

Page 5, line 114: Which models are you referring to? The models should be named in the text.

Page 5, line 122: Could you be more precise than 7+ months? How many months exactly were LIMS measuring?

Page 5, line 131: Here you mention “cirrus clouds”, but these are not mentioned in the abstract and introduction and are also not mentioned again later in the manuscript.

Page 5, line 114—Wording has been changed to “from thermodynamic equilibrium calculations of the uptake...”

Page 5, line 122—7 and ¼ months.

Page 5, line 131—Mention of cirrus cloud detection has been deleted. Later, at line 153 the reference to “effects of the clouds” has been changed to “cirrus clouds”.

Page 8, line 211: “.....orbital tangent-path locations and at p(z) levels spaced about every 0.88 km”. This is a mixture of pressure and altitude levels. I would suggest to give the spacing in pressure and then adding the corresponding altitude spacing in brackets.

Page 8, line 211—Changed to “at 18 levels per decade of pressure, or at a spacing of about 0.88 km.

Page 9, line 232-233: Same here. Since the data is on pressure levels the spacing should be first given in terms of pressure and then the corresponding altitude spacing should be added.

Page 9, line 232—At 6 levels per decade of pressure, having a vertical spacing of about 2.7 km.

Page 12, line 308: This paragraph is somewhat confusing. First, the formation of ice is discussed and then the formation of PSCs in general. The paragraph should be revised so that the PSC formation mechanism become clear. Note that the NAT threshold temperature is not the NAT formation temperature, it's the NAT “existence” temperature. For the formation of NAT also temperatures close to T_{ice} are required, but NAT particles can exist up to temperatures of T_{NAT} .

Page 12, line 308—Thank you for pointing out our imprecise terminology. We have rewritten this paragraph, citing the relevant findings chronologically and focusing on temperatures for PSC existence rather than particle formation. Temperature threshold for STS is mentioned on p. 14.

Page 12, line 327 and 328: instead of “lighter blue” it would be better to just give the corresponding temperatures.

Page 12, lines 327-328—Color references have been removed.

Page 16, line 438: change wording to . . . “ and of temperature for 15 November through the end of February” to make clear that the second part of the sentence refers to the temperature shown in Fig. 9.

Page 16, line 438—The change was made.

Page 19, line 520: What is SSU? What is the abbreviation standing for?

Page 19, line 520—Acronym was defined on p. 7, line 172, but will be given again here as the Stratospheric Sounding Unit on the NOAA operational satellites.

Page 20, line 544: As mentioned before the NAT threshold temperature is the existence temperature of NAT. Thus, I would suggest to generally refer here to PSC formation and not NAT formation specifically since for the formation of NAT much lower temperatures (around T_{ice}) are required.

Page 20, line 544—We are substituting “existence” for “formation” in this context.

Page, line 548ff: Is gas phase HNO_3 shown or liquid HNO_3 shown? This anticorrelation is quite confusing (when thinking about gas phase HNO_3). I would expect that HNO_3 has a minimum where the cold regions and the PSCs are found since PSC particles take up HNO_3 and thus deplete the gas phase.

Page 20, line 548ff—In this instance the anti-correlation comes about because of the conversion of N_2O_5 to the reservoir species HNO_3 in the cold, wintertime vortex that is also in polar night conditions, when the vortex is centered on the Pole. That chemical conversion occurs on surfaces of background, sulfuric acid aerosols; the strictly, gas phase processes are not as efficient (see Austin et al., JGR, p. 5447, 1986). We agree though that the anti-correlation should be less pronounced, once the threshold temperatures for NAT and STS are met. We now make that distinction in the revised text. The middle panel of Figure 11 is for retrieved (gas phase) HNO_3 . Thus, the last part of the sentence at line 577 has been changed to say “and then followed by HNO_3 values of less than 10 ppbv that indicate a loss or uptake of 1-3 ppbv of gas phase HNO_3 just after the occurrence of the large numbers of PSCs of 8-10 January.”

Page 21, line 591-592: This sounds a bit contradictory and does not become clear to me. I would suggest to rephrase the sentence.

Page 21, lines 591-592—The sentence is revised to say “Still, because that excess emission from the PSCs was also within the center of the vortex it is difficult to distinguish an uptake (decrease) of any HNO₃ vapor at the same locations.”

Page 23, line 635ff: Please motivate why 6 ppmv has been chosen as threshold.

Page 23, line 628 and lines 635ff—Excess emissions from PSCs translate to larger values of retrieved HNO₃, which can mask a true decrease of the vapor resulting from any uptake. This ambiguity should only be present for temperatures less than about 193 K. Our choice of 6 ppmv of ozone is based on the ozone panel of Figure 11 and denotes instances when the retrieved HNO₃ is likely contaminated, as well. Accordingly, that paragraph has been revised to clarify our choice of an ozone threshold of 6 ppmv. We have replaced original Figure 13 with new Figures 13 and 14 (in our separate Reply to John Austin). We now report indications of HNO₃ uptake of 1-3 ppbv, based on the findings in new Figure 14 and also as described in Section 7.

Page 23, line 644: Rephrase as follows: “The above likely uptake of HNO₃ by PSCs is.....”.

Page 23, line 645: I would suggest to replace “vapor” by “gas phase”.

Page 23, line 644 and line 645—Your suggestions have been followed.

Page 24, line 656ff: From my experience of lidar measurements and box model simulations of Arctic PSC, STS forms first and then NAT and ice. HNO₃ is taken up by the particles as soon as temperatures drop below T_{NAT} and STS PSCs form as soon as the temperatures stay that low for several hours.

Page 24, lines 656ff—This paragraph has been revised based on your remarks and on the findings reported by Pitts et al. (2013).

Captions:

Figure 3 caption: Instead of “at right” and “at left” I would suggest to use the colors of the lines, thus to write “in black” and “in red”.

Figure 5 caption: Same as for Figure 3, I would suggest to write “in black” and “in red” rather than “at left” and “at right”.

Figure 7 caption: Same comment as above.

Figure caption 8: Mention also in the Figure caption that this is an example for the “false positives”.

Figures 3, 5, 7, and 8—Changes have been made.

Figure 4 caption: Why is here 46 hPa shown instead of 31.6 hPa as in Fig 2 and Fig 6?

Figure 4—On page 12, line 323, we say now that perturbations in ozone due to PSCs are enhanced at the lower level of 46 hPa; temperatures are also perturbed slightly at that level.

Figure 10: As mentioned in one of my previous comments I am quite confused about this anti-correlation. It would only make sense to me if total or liquid HNO_3 is shown.

Figure 10—See our responses to the same concerns that you raised about the text.