Answers to Comment on acp-2021-707
Anonymous Referee #1
16.12.2021

The referee's original comments are in *italics*. Our responses are written in plain black font. Changes to the manuscript text are shown in red.

We thank the referee for comments and suggestions that help to improve our manuscript.

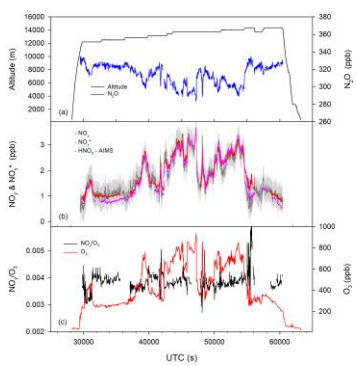
General comments

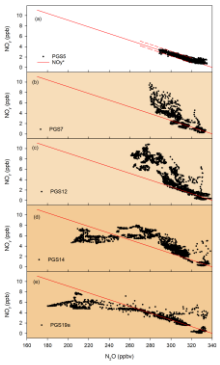
1) The discussion of tracer-tracer correlations (N2O – NOy) and in particular the comparison between NOy and NOy during the early phase of the campaign - before renitrification occurred - could be more quantitative. The results of a York-Fit (R2; slope (+- STD)) for the data in Figure 6a and Fig 7a could give a better understanding how accurate the relation between NOy and N2O is. In a similar way, a quantitative study on the deviations between NOy and NOy* in Figure 1b would give an indication on the smallest amount of NOy change that can be derived from the data.*

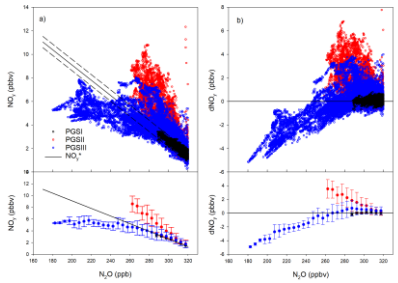
Answer: To quantify the linear least squares fit between NO_y and N_2O we added the uncertainty range of the slope arising from the regression as dotted lines to Figure 6a and 7a Also, I added the uncertainty range in Figure 1b as shaded area.
In parenthesis I added the value for R^2.

I added the following sentences to the text:

"… . Also included in this figure is the regression line resulting from a linear least squares fit (R^2=0.87). The range of its uncertainty is indicated by dashed lines. …"
…
"In Figure 1b measured NO_y values are shown along with calculated NO_y* values. Also shown is the uncertainty range of NOy*. During most of the time both curves agree well within the uncertainty range…"







2) As mentioned in the manuscript, the individual flights covered a large area from the mid- latitudes to the northern sub-vortex region, with the majority of the observation made at high latitudes. It would interesting to see, whether signatures of re- and denitrification occur exclusively below the polar vortex, or whether vortex processed air-masses are transported to the mid-latitudes. This could be done e.g. by classifying air masses with deviations in NOy relative to the vortex edge (e.g. using equivalent latitude).

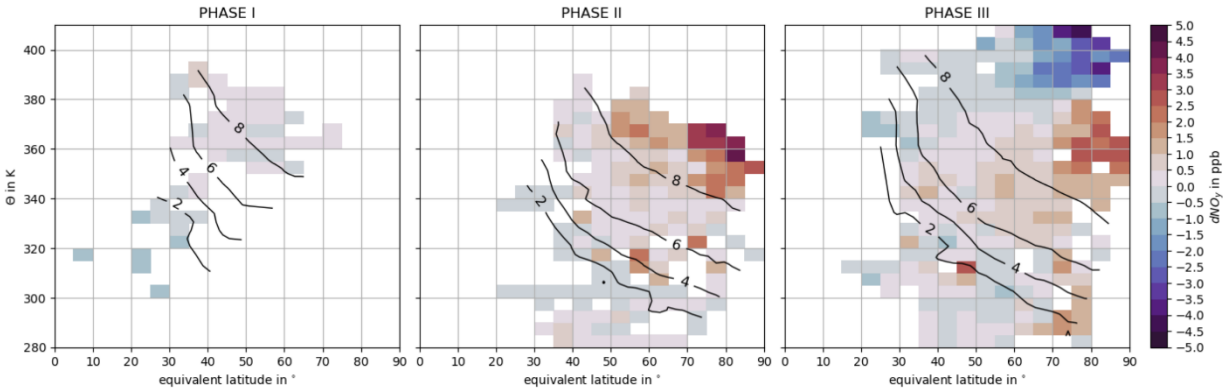
Answer: We added a new figure, Figure 9, to the manuscript where dNO_y is presented color coded in a theta – equivalent latitude coordinate system. We also added a describing text to the manuscript.

"Air masses processed in the polar vortex can also be transported to mid-latitudes. Figure 9 shows dNOy in coordinates of equivalent latitude and theta (potential temperature).

Equivalent latitude takes advantage of the adiabatically quasi-conserved nature of potential vorticity. It therefore removes the variability in trace gas distributions that originates from reversible deviations from the climatological mean due to Rossby and smaller scale waves (see e.g. Hegglin et al., 2006).The early-winter period shows a relatively undisturbed distribution of reactive nitrogen, the dNOy values are close to zero.
The mid-winter period is mostly characterized by positive dNOy values, particularly above 340 K and polewards of 50° equivalent latitude. The late winter period shows a nitrified region at the same location, but with weaker nitrification than in phase II. A denitrified region is located above, predominantly at potential temperature over 380 K and equivalent latitudes over 50°. However, weak denitrification with losses up to 1 ppb is also observed throughout the whole latitude range above 360 K, even outside the vortex. Similarly, at lower isentropes slightly positive values of dNOy at lower equivalent latitudes are consistent with export of former vortex air to lower latitudes (Hoor et al., 2004, Krause et al., 2018).These findings indicate transport and mixing of vortex processed air masses to the mid-latitude lowermost stratosphere in late winter and early spring."

The following sentence was added to the abstract to refer to these results:

"Further, indications of transport and mixing of these processed air masses outside the vortex have been found, contributing to the chemical budget of the winter lower most stratosphere."



3) Typo:

Line 602 should read, "winter 2002/2003".

Answer: Done.