Comment on acp-2021-167

Anonymous Referee #1

Referee comment on "Impact of stratospheric air and surface emissions on tropospheric nitrous oxide during ATom" by Yenny Gonzalez et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-167-RC1, 2021

This paper describes the global distribution of tropospheric N2O mixing ratios measured during the airborne Atmospheric Tomography (ATom) mission. Much of the paper focuses on the technical aspects of the retrieval method, while the last sections focus on the interpretation of the data, which involves many other co-measured species and complex comparison of profiles and scatterplots. Overall, this is an important dataset that definitely merits publication.

Below are some suggestions to help clarify and improve the presentation.

Abstract, Line 46-47 (and similar statements in the Conclusion). "This retrieval strategy improved the precision of our N2O measurements by a factor of 3, enabling us to recover the precision to that of previous missions." This sentence is confusing since it doesn't provide a reference point for the factor of 3 (e.g., is this relative to UCATS and PANTHER, to previous QCLS measurement on HIPPO, or something else?). Also, the use of "recover" implies, without providing context, that something was lost and needed to be recovered.

Line 71, "plus emissions related to human activities such as fertilization, biomass burning" Please delete fertilization, since this is already covered in the previous sentence about microbial production in soils under cultivation. Fertilizer provides substrate for the microbes to produce N2O, as opposed to biomass burning and industry, which are abiotic mechanisms.

Line 84-85. The Valentini source from African rivers seems large. Is this Tg N2O (as written?) or TgN2O-N?

Line 93. Should last "an" be "and"?

Lines 108-110 "we present a new retrieval strategy to account for the pressure and temperature dependence of laser-based instruments, specifically for the use of quantum cascade laser spectrometers on aircraft" Similar to my comments above about lines 46-47, does this imply uncertainties in previous campaigns (HIPPO, ORCAS) where this new strategy was not used? Or did something go wrong specifically during ATom that required the new strategy? Please clarify.

Section 2.2 and line 167. Again, it is unclear whether the "significant improvement in the precision and accuracy of the QCLS N2O data" was necessitated by the damage described in the previous paragraph, or would have been done anyway.

Line 231. Please clarify whether UCATS and PANTHER were also made during ATom.

Line 237. The term PFP is introduced here without explanation. Was PFP measured on ATom too?

Line 259, I would suggest a more formal or quantitative adjective than "great"

Line 290. Extra "and" in the sentence?

Line 300-302. This sentence is confusing because Antarctic vortex breakup usually occurs in November or December, not October. Second, what is the basis for claiming maximum STT in the NH is ending in October?

Lines 303-306. It seems like there are a lot of variables that might affect these percentages. For example, how are they affected by the altitude of the observations? Did each deployment have the same fraction of air sampled at higher altitudes?

Line 310 refers to Figures 3b,e as though they are March/April, but the panels are labeled on the panels as May (?) Similarly, Figures 3c,f are cited as representing Aug/Sep, but are labeled on the panels as October. Is line 310 just speculation or is it based on ATom data measured early on deployments 3 and 4 (lines 106-107 suggest some April and Sep data were collected)?

Line 319. Please clarify that the NH-SH gradient of N2O is much smaller than that of CO and SF6. Otherwise, lines 320-321 don't make much sense.

Line 322-323. Please explain in more detail. What kind of mixing is being described here?

Paragraph starting on 313. This paragraph could move less abruptly between each species (CO, O3, SF6, CFC12). Also, it's not clear why these 4 species were chosen for the Figure 4 scatterplots. Does each one illustrate a specific new point?

Figure 5. X-axis labels are overlapping and hard to read on N2O/CH3CN profile. Perhaps use same scale as N2O/CH4 panel.

Line 382. H2O2, PAA and CO profiles in Figure 5 are characterized by enhanced values at the surface. In contrast, N2O is lower at the surface than at 4 km.

Figure 6. Perhaps point out in second panel that the APO axis is reversed to illustrate the negative correlation to N2O.

Line 414 influences should be "influenced"

Line 416 "with higher APO and lower N2O" would be more meaningful written as "with lower APO and higher N2O" since this is a fall profile in which the ocean thermocline would be deepening, ventilating water enhanced in N2O and depleted in O2.

Line 423 contrasts should be "contrast"

Line 426 the decrease of CO2 seems consistent with the strong biological drawdown of CO2, especially in regions with intensive agriculture, during the spring/summer growing season (e.g., Schuh et al., Global Change Biology (2013) 19, 1424–1439, doi: 10.1111/gcb.12141). It might be interesting to show a CO2 profile (since so many other species are shown in Fig. 7).

Lines 430-434. This seems like a very complex mix of influences to disentangle. Is this even possible?

Line 436-438, why wouldn't this also be an ocean feature, e.g., from upwelling off the coast of Mauritania (as per Ganesan et al. 2020)? The N2O v. APO slope is similar in sign and magnitude to that shown in Figure 6, except that in the Fig. 6 panel, the APO axis runs normally (negative to less negative), whereas in the Fig. 7 (and Fig. 8) scatterplot, the APO is reversed to run from negative to more negative.

Line 448. Please elaborate "By using a profile specific background." Was an atmospheric transport model used in this exercise?

In general, could a common set of species and profiles for Figure 6-8 (or at least Fig 7-8) be chosen and displayed consistently? It would be easier for the reader to compare and contrast the different points being made with each of these multi-paneled figures.