

Interactive comment on “Measurements of greenhouse gases and related tracers at Bialystok tall tower station in Poland” by M. E. Popa et al.

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R: This paper fulfills a valuable role in documenting methods for measuring multiple gases (CO₂, CH₄, CO, N₂O, SF₆, O₂/N₂ from a tall tower site in Poland. The measurements were done as part of the European CHIOTTO project, which presumably ultimately has the goal of using such measurements to track surface fluxes using inverse calculations. Careful documentation of the methods is critical to establish the scientific credibility of these results and as a guide to others wishing to make high quality measurements elsewhere. The data are presented as simple time series, interpreted in terms of trends and cycles, as appropriate, which helps describe the basic phenomenology. One general issue is that the discussion needs to be sharpened to

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clarify if the detected phenomenology was expected based on prior work elsewhere, or if it entails novel findings. This is done in a few cases, but needs to be done more systematically. I recommend that the paper be published if this general concern can be addressed, as well as my minor comments below.

I would also welcome, but not require as a reviewer, additional analysis to explore for novel phenomenon. For example, the emphasis on cycles and trends of individual species, might profitably have been expanded to look more closely at correlations between species. The strongly (anti)correlated patterns in o₂/n₂ and Co₂ should allow a quite precise daily ratio to be computed. It would have been interesting to examine whether this ratio varied with season or on other time scales. Developing a monthly time series of this ratio should be easy based on the analysis done to prepare in Fig 9. Correlations in the synoptic variations between species, e.g. at the 300m elevation might have pointed to correlations in sources at the larger scale. How variable was the N₂O/CH₄ diurnal ratio with time of year? A thorough examination of all these topics would admittedly have made the paper unwieldy, considering the paper is designed mostly to describe methods. Nevertheless, the paper would probably have much more impact if it highlighted one or two such novel results.

A: We do agree with the reviewer, that a wealth of information can be extracted from these data by a more detailed analysis. The O₂:CO₂ ratios are particularly interesting in this sense, as are the correlations between CH₄ and N₂O. However a detailed discussion and interpretation would require ample background explanations, it would extend the paper beyond readable limits and it would move the focus outside the AMT topics. As with most methodology papers, we have given a few brief examples of data analysis, but we refrain from expanding on these here. We are planning however to carry out an extended analysis of the O₂:CO₂ ratios in a separated paper, for a differently oriented journal.

We extended, as recommended, the discussion and comparisons with other works.

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Minor comments.

1. Probably should replace ppm, ppb, and ppt with $\mu\text{mol mol}^{-1}$, nmol mol^{-1} , etc, or at least define them as such somewhere in the manuscript.

A: We added in introduction the following: "Throughout this paper, we use the common units of ppm, ppb, ppt, with the meaning of micro-, nano- and pico-mole per mole of dry air."

2. Page 1: The text needs to clarify that "measurements of O₂" and "measurement of O₂/N₂" are being used equivalently. At other sections, the term "oxygen" is also used to mean O₂. Better to stick with O₂.

A: In general, we use "O₂" when referring to the oxygen mole fraction, and "O₂/N₂" when referring to the oxygen to nitrogen ratio. We prefer to keep this difference, otherwise some sections might become confusing. We replaced where possible the word "oxygen" with "O₂".

3. Page 2, line 20: Delete text "at the moment"

A: The text "at the moment" has been deleted.

4. Page 3, line 26: In Europe, tall tower measurements were first brought into operation. . ."

A: The text has been changed.

5. Page 6, line 7, Air motion is highly variable, so it's not correct to state categorically that the air flow follows an average pattern.

A: The statement has been removed.

6. Page 6, Section 2.2. Need to clarify what material was used for sampling lines.

A: We use 12 mm OD Synflex 1300 tubing - this information has been added into the text.

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7. Page 7, line 15: Note inconsistent use of the term "standard" and "reference" between equation (1) and the text.

A: The word "standard" has been replaced with "reference"

8. Page 8, line 18: Use of the word "target" is confusing, in that it is used to describe the gas from a particular cylinder. The "target" is not something being targeted in any normal sense of the word. It might be less confusing to use the term "surveillance gas" (Note it's the gas that's being measured not the "cylinder").

A: "Target cylinder" is the common term used throughout Europe in our community, whilst "surveillance tank" is the term usually employed in the USA. Since AMT is a European journal, we choose to continue to use the word "Target".

We have inserted the first use of the word "Target" in parentheses indicating its somewhat colloquial usage. In order to avoid confusion with the normal use of the word "target", we have changed the text such that we consistently use a capital "T" in this particular context.

9. Page 8, line 25. O₂ tends to accumulate relative to N₂. . .

A: The text has been changed.

10. Page 9, line 3. The statement that no plastic is used in flow paths doesn't seem credible, because most seals use elastomers, and because the commonly used Synflex tubing has a polyethylene liner. The relevant point is that "plastic" is not used anywhere where it can present a significant permeation leak. path. Is the term "plastic" acceptably precise here? Perhaps there's a better term.

A: The text was changed as follows: "No plastic is used within the gas flow paths where it can present a significant permeation leak path (i.e. where it would be the only barrier between the sample air and the outside world), because the O₂/N₂ ratio could change due to differential permeation." We use "plastic" as a general term including rubber, synthetic or semi-synthetic polymers.

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11. Page 10 line 9. The term ArCH₄ is not clear.

A: By “ArCH₄” we mean a mixture of 5% CH₄ in Ar. We reformulated the text.

12. Page 12, line 5. Not entirely clear what is meant by “Target” measurement. Also, note early point about using “surveillance” versus “target”.

A: We changed to “Target gas measurement”

13. Page 12, line 9 and Table 2: The standard deviations are based on averages over what time frame. This is critical to understand achieved precision.

A: The standard deviations are computed from all individual Target measurement results over the whole measurement interval 2005–2008 (except for O₂/N₂, for which the interval June to November 2008 was excluded). Because we used more than one Target cylinder during this time, the procedure was as follows. For each cylinder we computed the average of all measurements; then, this value was subtracted from each measurement of that cylinder. By zero-ing in this way, we obtained a consistent time series over the whole measurement interval 2005 – 2008, independent of Target cylinder concentrations. We computed then for each species a single standard deviation of the whole time series. The standard deviation computed in this way accounts for the short term noise, but also for longer term instabilities.

14. Page 13, line 17. Sentence is hard to follow due to the word “with”. appearing twice.

A: First “with” has been replaced with “having”

15. Page 17, line 16. Not clear what is meant by “signal”. Synonymous with “concentration”?

A: In this situation, “signal” means “increase in mole fraction” - the text has been changed.

16. Page 17, line 23. Need to clarify if local time allows for resetting the clock for C1270

daylight savings.

A: We always used GMT - no daylight savings. Where we considered relevant, we added a conversion to local time; the local time does include daylight saving changes. For example, 11:00 – 16:00 GMT is 13:00–18:00 local time during summer and 12:00 – 17:00 local time during winter.

17. Page 25, line 10. How can midnight be at 2:00 local time? The use of two clocks here is confusing.

A: We referred to midnight GMT; we clarified in the text.

18. Page 26, line 4. Couldn't the similarity in the diurnal cycles in N₂O and CH₄ result simply from the fact that the sources are only weakly diurnally varying, so that the variations in the atmosphere are due to variations vertical mixing, common to both?

A: The vertical mixing is at least a partly responsible for the diurnal variations for each species (as mentioned at the beginning of Sect. 3.4.2). However, if vertical mixing were the only cause for the diurnal cycles of CH₄ and N₂O, and if the sources of these species were constant, then the night time increase would have been monotonous, similar to the one of CO₂. The existence of a similar midnight dip for CH₄ and N₂O (which does not appear in CO₂) suggests that there are other contributing factors to the diurnal variations, which have similar temporal evolution for the two species. We interpret this feature as a reduction of anthropogenic emissions (e.g. industry, traffic) between the evening and morning peaks. This would be consistent with the larger dip observed in CO, which has in larger proportion anthropogenic sources. (see also answers to reviewer 2, points 12 and 22)

The entire paragraph has been rewritten.

19. Page 26, line 25. Need to cite prior work on CO₂ diurnal cycle, as this cycle is well described elsewhere in the literature.

A: We added references.

20. Figure 1: What is meant by $\text{min.m}^2.\text{kg}^{-1}$? If this is a units, one needs to delete the period marks and also clarify in the caption that this is the unit that applies to the concept of “footprint”. Also, the meaning of “min” doesn’t seem very clear.

A: An explanation has been inserted in the caption, and the period marks have been deleted.

21. Figure 5. This figure doesn’t seem very successful, given that the overlapping symbols reveal only broad limits of the data ranges. It would be good to try using smaller symbols.

Also, the O₂/N₂ plot reveals a period in 2008 that looks like that data is bad, at least at 300m, judging from the persistent high variability unlike previous years.

A: The figure was redone with smaller symbols and better resolution.

The O₂/N₂ was indeed very noisy between June and November 2008 (see also Sect. 3.1.1). We added this information to the figure caption.

22. Figure 6. Confusing the color scheme is reversed for APO versus CO₂ & O₂/N₂.

A: The legend was incorrect; this has been corrected.

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