

We thank both referees for their positive assessment of our paper and the useful comments.

Anonymous Referee #1

Overall quality

The paper presents an application of atmospheric measurements performed in the road tunnel to characterise traffic emissions of CO₂, CO, CH₄, N₂O as well as isotopic signature of CO₂ and CO typical for West-European vehicle fleet and representative for typical regional not disturbed traffic. An independent methods of characterisation of traffic emissions with respect to greenhouse gases is very important because of uncertainty of bottom-up estimates based on traffic statistics and emission factors obtained in most cases in the laboratory conditions and not reflecting real situations. On the other hand UNFCC partners are obliged to report GHG emissions (eg. CH₄, N₂O) from the traffic. The paper is well structured and includes an interesting and novel dataset, description of the sampling site and methodology is clear and well referenced. The authors put special attention on the measurement procedures applied in the study including inter-laboratory comparisons providing high quality of the data. Overall, the interpretation of the results is very sound and the authors include an extensive explanation for the possible mechanisms influencing obtained isotopic results. Besides the few minor issues, the paper is generally of high quality, interesting and fulfills the criteria of publication in ACP.

General comments:

1. In the introduction authors discuss the influence of Euro 3 and Euro 4 standards on the reduction of CO from cars. While Euro 5 standard is effective since 2009 it would be good to reference and discuss emission limits defined by this regulation.

Author answer:

We used as an example the difference between Euro 3 and Euro 4, because Euro 5 (and Euro 6) does not revise the CO emission limits. We added Euro 5 in the text.

Technical comments:

Page 23557 line 15: please change “. . . second most important greenhouse gas. . .” to “. . . second most important anthropogenic greenhouse gas. . .”

Author answer:

Done.

Anonymous Referee #2

General Comments: The manuscript by Popa et al., describes measurements of multiple greenhouse gases, and selected stable isotopes, O₂, and CO for three week days in summer 2011. Measurements were made near the entrance and exit of an uphill tunnel run in Switzerland. Results are used to estimate enhancements of the various gases relative to CO₂ and are reported to provide an update on emission factors for European motor vehicles. The study was carefully executed and proves useful new information relevant to ACP.

In terms of exposition, the paper is well-written and could be published with minimal revision. The title accurately describes the content of the paper, the paper provides useful references to related work, the scientific method and assumptions are sufficient described so that future work can repeat or extend the work to other areas to examine the generality of the results. The results provide updated emissions factors and somewhat novel (for this reader) results of isotopic fractionation from combustion processes.

I would recommend publishing with minor revisions.

I offer the following questions/comments:

General comments:

- The automated traffic counts measured for this tunnel and other roads provides an opportunity to examine the generality of traffic present in the tunnel. The authors might arguably increase the value of the paper by including a brief discussion of how tunnel traffic conformed or differed from other roads/areas where traffic data was available.

Author answer:

We included additional information on traffic in Section 2.1.

- The enhancement ratios for N₂O:CO₂ are quite variable and appear to change with time of day (from 0.005 early in day to 0.025 ppb/ppm 10:00 local time). Could it seem likely that the early N₂O:CO₂ ratios might be due to a ponding effect similar to that observed for CH₄ (higher mixing ratio at entrance than exit). I would consider using data from more well-mixed periods.

Author answer:

We could not explain the reason of this variability in N₂O:CO₂ ratios, and indeed, the morning ratios could be influenced by sources of N₂O outside of the tunnel entrance. The N₂O:CO₂ ratio using only the data after 8:30 (which removes the three low data points in the morning) is $(2.1 \pm 0.1) \times 10^{-2}$ ppb:ppm. We included this information in the paper.

Specific Comments:

pp 23550, line 17. Perhaps add, "of O₂ depletion per CO₂ enhancement".

Author answer:

Done.

pp 23551, line 9. Please consider adding reference to UNFCCC emissions factor documents here.

Author answer:

Done.

pp 23559, line 5. What was the average slope of the tunnel (m/km). Is this atypical of road slopes? Would the uphill grade lead of unusual load or emissions from the vehicles?

Author answer:

The average slope of the tunnel is 1.3% (13 m/km), which is not an atypical slope. An uphill slope does indeed influence the emissions; in general emissions increase with the slope, although decreasing N₂O emissions for higher slopes have been reported (Lipman and Delucchi, 2002). We consider however that our results are not much affected by the road slope because: (1) a slope of 1.3% has a relatively small influence on emissions; (2) we do not report absolute emissions, but ratios to CO₂, and it is likely that these are less affected by the road slope (emissions per unit of fuel consumed are less sensitive to the road slope than emissions per distance travelled, e.g. Pierson et al., 1996).

pp 23567, line 11-15. Could meteorological conditions produce wind blowing into the tunnel exit that drive flow back toward the tunnel entrance under conditions of low traffic flow ?

Author answer:

Back flow is in principle possible, indeed, under conditions of low traffic. We think that this did not happen during the measurements presented in this paper. During night, when the back flow would be possible, we see high CH₄ values at the entrance of the tunnel. These high values cannot come from traffic (because we know that traffic methane emissions are low, Section 3.6) thus they have to come from outside, from the tunnel entrance. These values are steadily growing, which suggest that the flow at the tunnel entrance was from outside into the tunnel consistently. In these conditions, we could perhaps have momentary back flow at the exit of the tunnel, but not persistent.

pp 23574, line 7. Perhaps you might consider replacing monotonously with monotonically?

Author answer:

Done.

References

- Lipman, T. E., and Delucchi, M. A.: Emissions of nitrous oxide and methane from conventional and alternative fuel motor vehicles, *Climatic Change*, 53, 477-516, 10.1023/A:1015235211266, 2002.
- Pierson, W. R., Gertler, A. W., Robinson, N. F., Sagebiel, J. C., Zielinska, B., Bishop, G. A., Stedman, D. H., Zweidinger, R. B., and Ray, W. D.: Real-world automotive emissions - Summary of studies in the Fort McHenry and Tuscarora Mountain Tunnels, *Atmos Environ*, 30, 2233-2256, 10.1016/1352-2310(95)00276-6, 1996.