We gratefully thank all reviewers for the careful reading and valuable comments. Below we provide our point-by-point responses to the reviewers' comments. In the following context, raised comments/suggestions are marked in **black**, responses are presented in **red**, and changes to the manuscript/supplement information are indicated in **blue**.

Reply to Anonymous referee #3

The paper deals with a specific issue of emission factor determination using plume chasing. Typically, the emission factors of the pollutants are determined by assuming dilution factors based on CO2 measurements. In special cases (e.g. downhill driving, engine motoring, hybrid operation) or for non-exhaust emissions, where CO2 emissions are low or non-existent, this approach fails. To overcome this problem, the authors present two methodologies, one based on a multivariate regression algorithm and a second model-based approach that takes into account speed, exhaust mass flow, vehicle shape, and fuel used. The methods have been tested against conventional methods using experimental data from a designated measurement campaign.

The methods developed in this work are important for remote emission sensing and address relevant scientific issues within the AMT, namely the determination of exhaust plume dilution factors also in the absence of CO2 emissions for individual vehicle emission factor measurements.

We thank the referee for these positive comments towards our manuscript.

However, the paper only deals with particulate emissions, which is not mentioned in the title or abstract.

We thank the reviewer for pointing this out. We added that this study deals with particulate emissions to two sentences in the abstract:

… "This problem is also encountered when studying non-exhaust ***particulate*** emissions, e.g., from electric vehicles." … "We show that emission factors for ***particulate emissions*** calculated with both methods are in line with the current methods with vehicles producing CO_2." …

It would be very interesting for the reader to know if the methods are also applicable to gaseous emissions and, if so, what the limitations are.

Even though this paper is focusing on particulate emissions, the dilution of the exhaust should be applicable also to gaseous variables. It needs to be assumed, as in this paper have been assumed, that CO_2 and particles/gaseous emissions are diluted similarly in turbulent exhaust plume. This is a common assumption also in earlier studies, such as Jayaratne et al. (2005) for particulate emissions.

It is mentioned, but not described, how the methods could be applied to non-exhaust emissions.

We added the following text to the conclusions section to describe our reasoning for that:

"For NWD, the method is based on the estimated slope κ of the vehicle. For example, for tire emissions, if the emission from the tires is C_{raw} and mass exhaust flow rate of the emission is Q, then $EF = C_{raw} * Q$. On the other hand, it was assumed that $DR = \kappa * v/Q$. Then $C_{raw} = C_{meas} * DR = C_{meas} * \kappa * v/Q$. For EF, we get that $EF = C_{raw} * Q = C_{meas} * \kappa * v$. Hence, an explicit value of mass exhaust flow rate Q is not needed to calculate EF of non-exhaust emission. The κ value can be estimated from the other vehicle with similar estimated dilution of emissions, or in case of hybrid vehicle, the κ can be determined during the time when the combustion engine is running. For MARS the basic idea is that from the test dataset of measurements, the dilution ratio of emissions could be estimated in different driving situations. Then in the new dataset, the DR is estimated based on splines estimated from the test dataset.

In both methods, the emission factor of the non-exhaust emission can be determined during the times when the vehicle is running with electric engine only. For the non-exhaust emissions, some correcting coefficient for the dilution ratio might be needed."

In particular, it would be interesting to know whether the dilution of exhaust and non-exhaust emissions is comparable.

Dilution ratio of non-exhaust emissions can be different than for the exhaust emissions as the location of the emissions are different (e.g., brakes and tires vs. tailpipe). This should be considered in the emission factor calculations. If the DR for exhaust emissions is not valid for non-exhaust emissions, in most simple case, extra coefficient for non-exhaust emissions could be constant for all non-exhaust emissions, i.e. for dilution ratio $DR_{non-exhaust} = a_{non-exhaust} * DR_{exhaust}$. Other option would be to determine separate coefficients for different types of non-exhaust emissions, depending on the location of the emissions sources.

We added the sentence "For the non-exhaust emissions, some correcting coefficient for the dilution ratio might be needed." to conclusions section to highlight the possible differences in dilution ratios of exhaust and non-exhaust emissions.

It would also be interesting to know how the methodologies deal with hybrid operation of vehicles.

Please revise accordingly.

For chase without OBD data, hybrid vehicles are probably the hardest class of vehicles to estimate EFs, as the information about use of the exhaust engine and electric engine are not available. However, both methods determine the dilution of emissions on test dataset and hence the dilution ratio is not dependent on the operation of the hybrid vehicle. With OBD-data available, hybrid vehicles could be used to estimate non-exhaust emissions. The hybrid drive with using of electric engine only should produce only non-exhaust emissions. As mentioned in the comment about applicability of the methods to non-exhaust emissions, estimating the dilution of emissions in both methods should not be a problem for hybrid vehicles.

Minor:

Line 172: particle concentration: abbreviation N is missing

Corrected.

Line 204: typo: without no

Changed to ‘without a need to’. In the same sentence, there was also ‘determinethe’. That was corrected to be ‘determine the’.

References

Jayaratne, E. R., Morawska, L., Ristovski, Z. D., and Johnson, G. R.: The use of carbon dioxide as a tracer in the determination of particle number emissions from heavy-duty diesel vehicles, Atmos. Environ., 39, 6812–6821, https://doi.org/10.1016/J.ATMOSENV.2005.07.060, 2005.