High-emitting vehicles in laboratory and on-road measurements

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Measurements of vehicle exhaust emissions at roadsides through remote sensing techniques have repeatedly found that "a small number of high emitting vehicles is responsible for a disproportionately large fraction of mobile emissions" (e.g. Zhang et al. 1995). Further, it is often postulated that average emission factors used e.g. for inventories do not sufficiently represent such high emitters and hence underestimate emissions from the real vehicle fleet (e.g. Smit and Bluett 2011).

In this paper we first demonstrate why the first assertion above may overestimate the share and contribution of high-emitting vehicles. Second, we propose a new method to identify the share of high-emitters. Third, we apply the method to a comprehensive set of remote sensing sites across Europe and across various times. Fourth, we discuss the match between average emission factors (notably PHEM/Handbuch EFA) and the real-world measurements. Finally, we demonstrate how to conclude from measurements at a single site on general driving, and hence on the impact on emission inventories.

The conventional analysis of remote sensing measurements makes no reference to the emission characteristics of "clean" vehicles. In our approach we first establish such a reference for clean vehicles; the data also contain a few high emitting vehicles. Data are taken from 72 vehicles that were measured second-by-second over the Common Artemis Driving Cycle (CADC) on a chassis dynamometer. In total there are more than 200'000 instantaneous emissions factors. Relative to this reference set we compare the instantaneous emission factors measured during nineteen remote sensing campaigns in Zurich/Switzerland, Gothenburg/ Sweden, and in four cities in the UK. We additionally simulate with the PHEM model the average emission factors expected under the driving conditions at each of the remote sensing sites. We compare emission factors for CO and NOx for gasoline and diesel passenger cars certified up to Euro 5 emission standards.

Preliminary findings based on the chassis dynamometer data and the remote sensing data from the Swedish and Swiss sites suggest for gasoline cars:

- One cannot conclude from single remote sensing measurements neither on the emission characteristic of the measured individual vehicles nor on emissions under different driving conditions.
- A share of a few percent high emitting vehicles at the sites, with higher shares for CO than for NOx.
- The extra CO emissions from high emitters can be twice as high under urban as under highway driving conditions. Vice versa, the extra NOx emissions seem much higher under highway compared to urban driving.
- Average NOx emission factors modelled by PHEM reproduce trends observed by remote sensing quite well, but are sometimes higher, sometimes lower than real world emissions apparently depending on site and fleet characteristics.
- Average CO emissions modelled by PHEM are much higher than real-world emissions for Euro 2 cars onwards.

The analysis continues with the UK sites and diesel cars.

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