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Federal Department of the Environment, Transport,
Energy and Communications DETEC
Federal Office for the Environment FOEN
Air Pollution Control and Chemicals Division

REMOVES

**Remote Monitoring of Onroad Vehicle Emissions
in Switzerland**

**Research project of the Swiss Federal Roads
Office**

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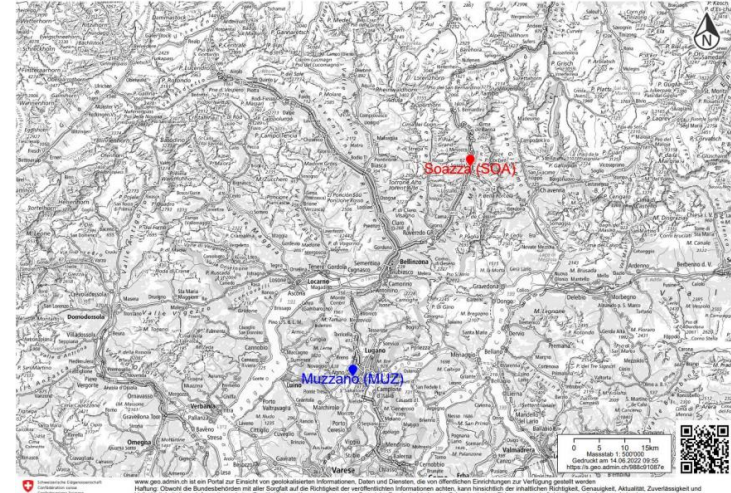
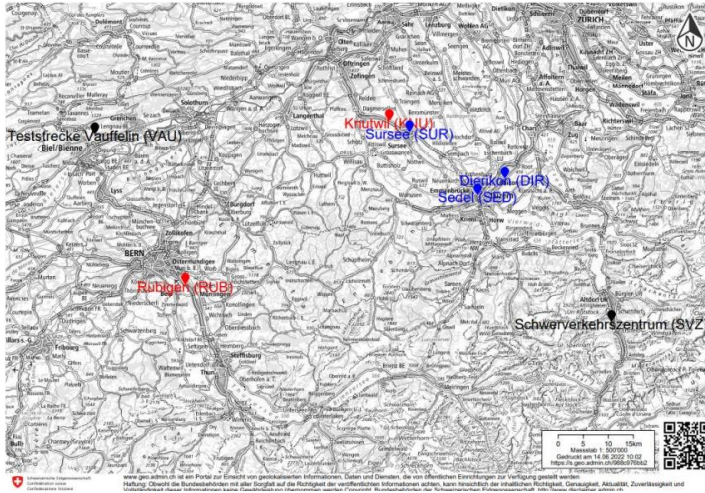


Objectives

- **Evaluating whether the RES measurement provides a sound basis for determining high emitters.**
- Comparing the two RES measurement concepts (HEAT and OPUS)
- Verifying the stability of RES measurement results and correlation to the RDE (Real Drive Emissions) measurement procedure using PEMS (Portable Emission Measurement System)
- Determining the percentage of vehicles (subdivided into the individual vehicle types) with significantly excessive emissions.
- Evaluating whether robust NO_x threshold values from the RES process can be defined as a basis for any further regulatory development.
- Evaluating a network of measurement locations.



WP1 Determination of measuring sites and measurements along roads



Tab. 1 Übersicht der Einsätze je Messgerät und Standort in der Messperiode von KW17 bis KW 24 im Jahr 2021

Kalenderwoche	KW 17 2021	KW 18 2021	KW 19 2021	KW 20 2021	KW 21 2021	KW 22 2021	KW 23 2021	KW 24 2021
Messwoche		1	2	3	4	5	6	7
Messgerät								
OPUS RSD 5500 #1	SED, DIR, SUR	SUR, SED, MUZ	SED, MUZ	VAU	VAU	SOA	SOA, KNU, SVZ	SED
OPUS RSD 5500 #2			SED, MUZ	VAU	VAU	SOA	SOA, KNU, SVZ	
EDAR 1					VAU	RUB	RUB	
EDAR 2					VAU	SOA	SOA	

- SED: Standort Sedel
- DIR: Standort Dierikon
- SUR: Standort Sursee
- MUZ: Standort Lugano-Muzzano
- VAU: Standort Vauffelin (Teststrecke)
- SOA: Standort Soazza (Parallelmessungen)
- KNU: Standort Knuttwil (High-Emitter Kampagne)
- SVZ: Standort Schwerverkehrszentrum Erstfeld (Fokus Lastwagen)



WP2 Comparing RES and SEMSZ/PEMS on a test track



Abb. 29 Fahrtrichtung der Fahrzeuge während der zweiten Woche.

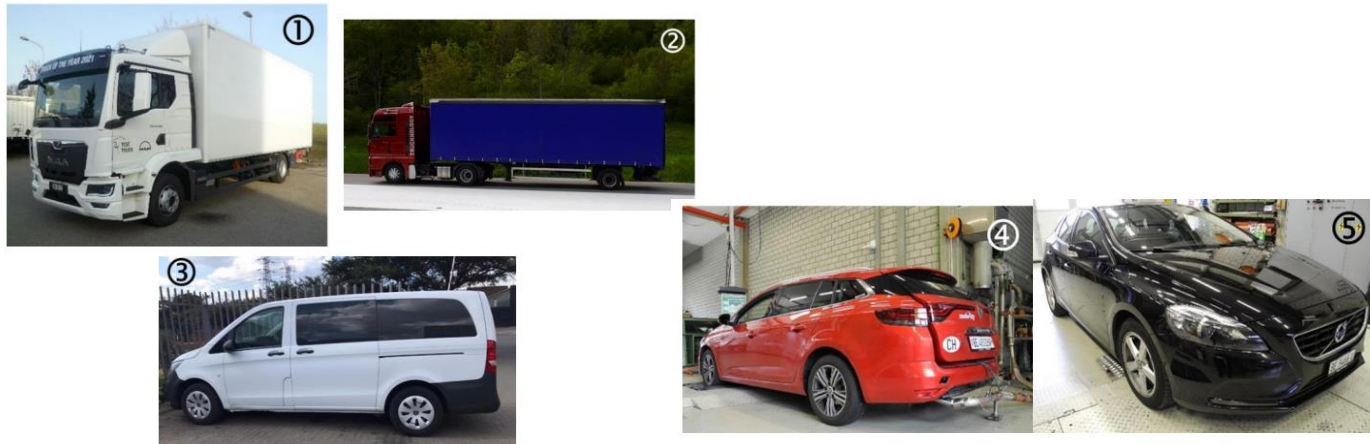


Abb. 34 MAN TGM 15.290 ①, MAN TGA 18.540 ② und Mercedes-Benz Vito ③

Abb. 35 Renault Mégane ④ und Volvo V40 D3 ⑤.



WP3 Analysis of the collected data

- 230'000 measurements from the road site
- 60% were valid and could be assigned to vehicles

- 6'000 measurements from the test track

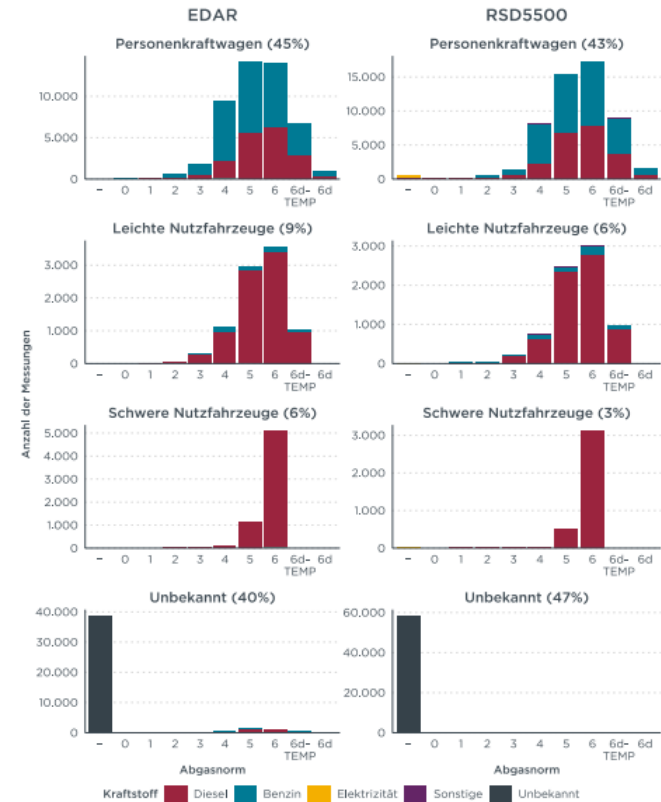


Abb. 55 Flottenzusammensetzung auf der Grundlage der Feldmessungen des EDAR-Systems (links) und des RSD 5500-Systems (rechts).



WP4 numerical simulation of the distribution of exhaust components in the vehicle wake flow

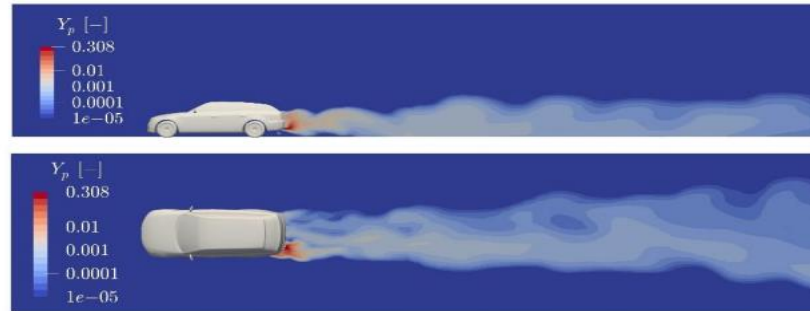


Abb. 94 Abgaswolke bei $y = -0,6$ m (oben) und $z = 0,3$ m (unten) für ein Fahrzeug mit dem Abgasrohr auf der linken Seite, horizontal ausgerichtet, Fahrgeschwindigkeit 50 km/h.

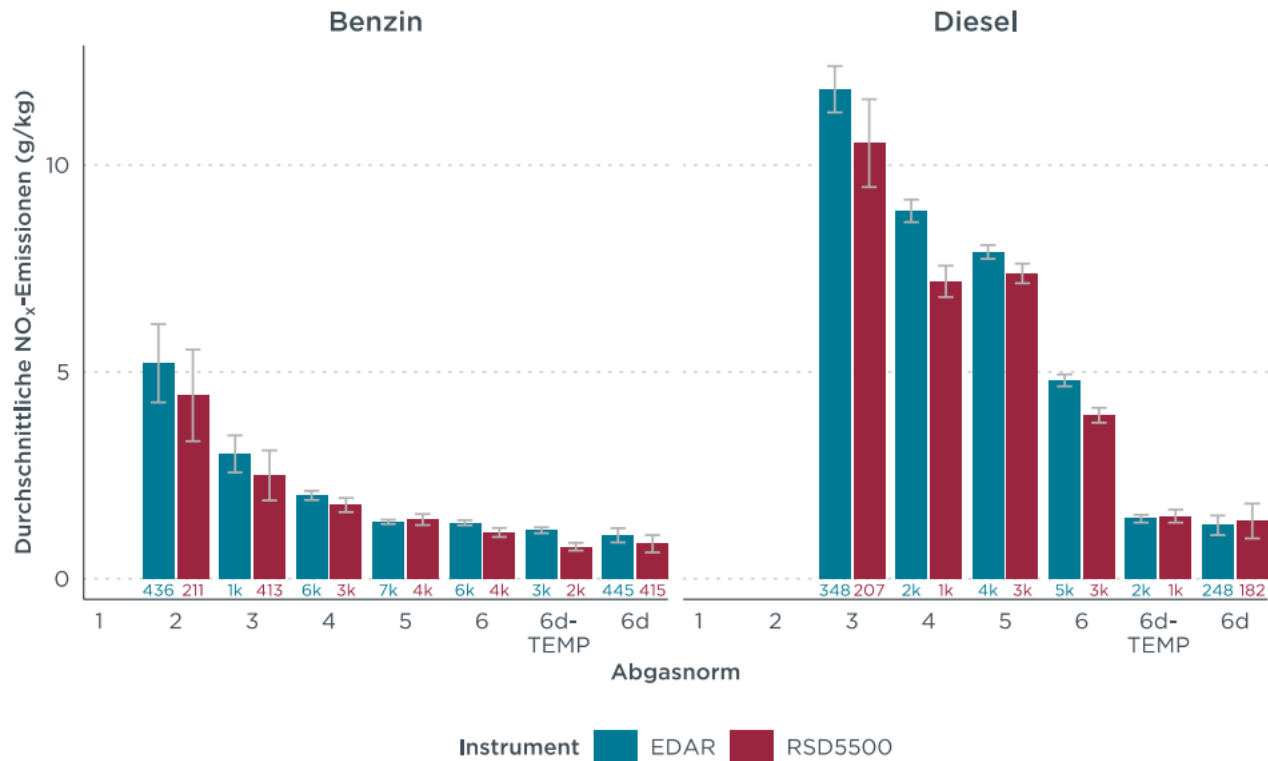
The goal is to understand

- the fundamental, physical processes and the resulting requirements, but also the limits for the measurement
- the distribution of exhaust gas components and their local and temporal concentration available to an RES system for measurement
- the influence of various vehicle-specific and environment-relevant parameters on the measurement result.



Main results (I)

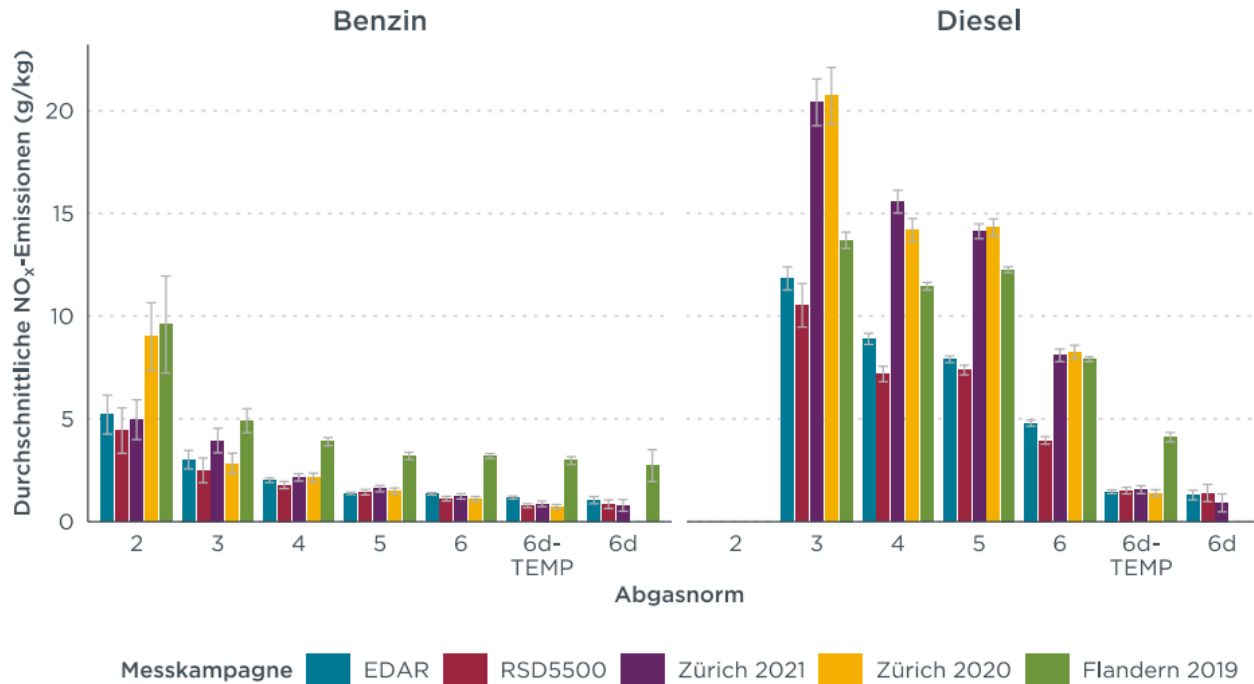
+ EDAR (HEAT) and RSD5000 (OPUS) showed comparable NO_x values for passenger cars and light delivery vans





Main results (II)

- Location has an influence on the results



The lower NO_x emissions from the RSD 5500 measurements can be partly explained by the higher VSP characteristic of Zurich passenger cars



Main results (III)

- Good correlation between RSD500 and SEMS possible but perfect conditions on the test track are necessary

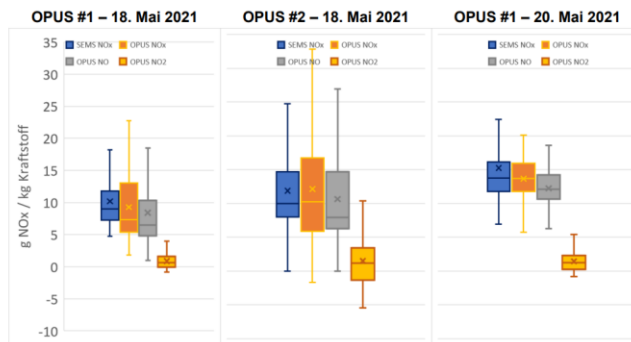


Abb. 49 Verteilung der instantanen Emissionskonzentrationen für den Euro 5 Pw (Volvo V40) zwischen SEMS und den OPUS RSD 5500-Messgeräten #1 und #2 an den beiden Messtagen. Zur Erinnerung: Von den Messfahrten am 20. Mai liegen nur Messwerte vom Gerät #1 vor, weil Gerät #2 ausgefallen war.

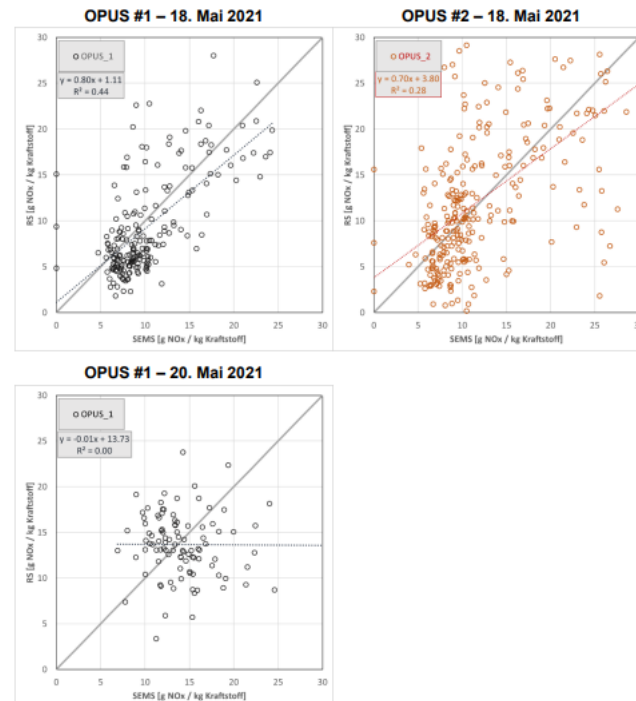


Abb. 51 Korrelationsplot der instantanen NO_x -Emission für den Euro 5-Pw (Volvo V40) zwischen SEMS und den OPUS RSD 5500-Messgeräten #1 und #2 an den beiden Messtagen. Zur Erinnerung: Von den Messfahrten am 20. Mai liegen nur Messwerte vom Gerät #1 vor, weil Gerät #2 ausgefallen war. In den Grafiken sind auch die jeweiligen Korrelationsgeraden mit ihren Formeln und der R^2 -Güte ausgewiesen.



Main results (IV)

- Good correlation between EDAR and SEMS possible but perfect conditions on the test track are necessary

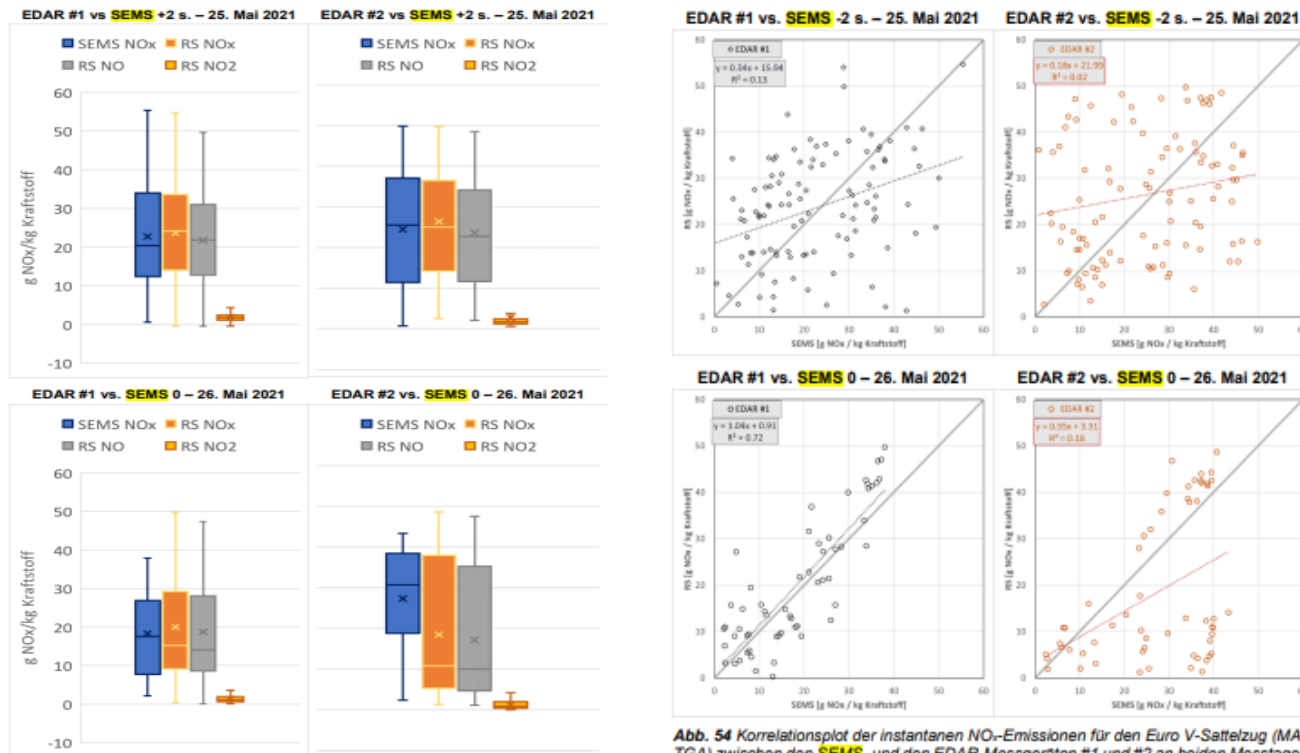


Abb. 53 Verteilung der instantanen Emissionskonzentrationen für den Euro V-Sattelzug (MAN TGA) zwischen SEMS und den EDAR-Messgeräten an den beiden Messtagen.

Abb. 54 Korrelationsplot der instantanen NO_x-Emissionen für den Euro V-Sattelzug (MAN TGA) zwischen den SEMS- und den EDAR-Messgeräten #1 und #2 an beiden Messtagen. In den Grafiken sind auch die jeweiligen Korrelationsgeraden mit ihren Formeln und der R²-Güte ausgewiesen. Außerdem ist die Einheitsgerade als Ideallinie eingezeichnet.



Main results (V)

- For all the various driving and ambient conditions, a concentration peak of the exhaust gas forms less than 0.5 m downstream from the vehicle
- The exhaust gas cloud dilutes fast in the near wake flow of the vehicle, which means that no significant amount of exhaust gas is measurable 3 m downstream of the vehicle. High measurement frequency needed
- no significant increase in concentration was detected in the exhaust cloud of the rear vehicle due to the emissions of the first vehicle



Main results (VI)

- The first vehicle can have a big influence on the exhaust distribution of the second vehicle, where the core exhaust cloud is much more concentrated

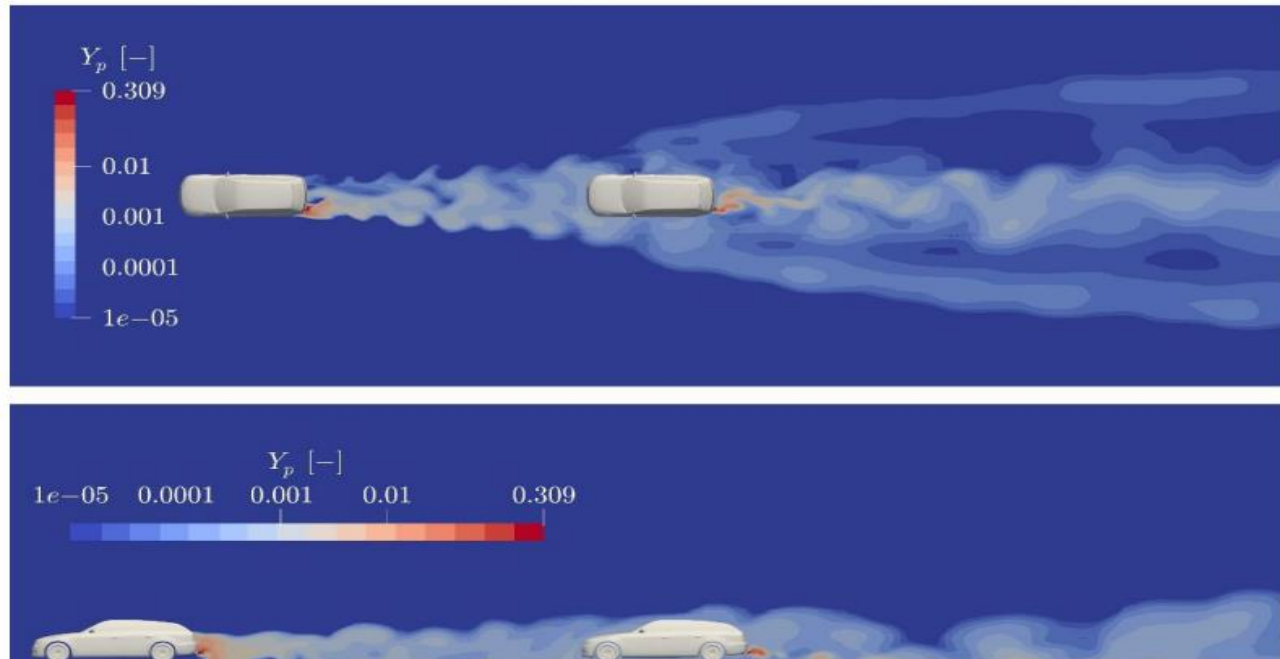


Abb. 113 Zwei Fahrzeuge die im Abstand von 10 m mit einer Geschwindigkeit von 50 km/h fahren, $Y_p = 0,309$ am Abgasendrohr. Die Schadstoffverteilung ist in der $z = 0,3$ m Ebene (oben) und $y = -0,6$ m Ebene (unten) dargestellt.



Main results (VII)

- + Both instruments can be used as a selection tool for detecting suspiciously high emitting vehicles, but conditions for measurement site and meteo are demanding
- + Threshold values for “high emitters” (manipulated or defect exhaust treatment systems) can be defined for vehicles Euro VI and Euro 6dtemp and younger based on RDE requirements. A value of three times the RDE confirmation factor is recommended. A threshold for heavy duty vehicles of 3.5g NO_x/kWh would result in that almost 5% of the measured Euro VI vehicles would be identified as «high emitters» . For light duty vehicles a threshold value of 300mg NO_x/km would result in identifying 5% of Euro 6 Diesels and less than 5% of Euro 6 gasoline vehicles as «high emitters» in Switzerland



Main results (VIII)

- In Switzerland it is difficult to find locations that allow the installation of the devices easily, that have access to electricity, enough traffic but not too much traffic and that ensure that the engine runs on load
- The rather unstable weather conditions in Switzerland (rain and wind) are a problem
- The data of both systems had to be reprocessed
- In order to avoid false positive results and to survey the proper functioning it is recommended to measure with two devices
- A certification procedure for the systems would be needed if the systems should be used as official control systems (like speed control)



Reference source

<https://www.mobilityplatform.ch/de/research-data-shop/product/1740>

The screenshot displays the 'Research+DATA-Shop' interface. At the top, the 'mobility PLATFORM' logo is on the left, and navigation links for 'VSS-Shop', 'RESEARCH+DATA-Shop', and 'REGnorm-Shop' are in the center. User and shopping cart icons are on the right. The main search area has a dark blue background with a search bar containing 'removes' and a 'SUCHE' button. Below the search bar are four filter sections: 'Sprachen' (Deutsch, Französisch, Italienisch, Englisch), 'Status' (Aktiv, ausser Kraft), 'Herausgeber' (ASTRA-FB), and 'Ausgabejahr' (1900 to 2023). A 'ZURÜCKSETZEN' button is centered below the filters. At the bottom, there are three product cards, each for 'ASTRA-FB' documents. The first card lists 'FB 1740 ZUSATZDOKUMENT HERSTELLER OPUS' and 'ASTRA 2019/003' from 2022. The second card lists 'FB 1740 ZUSATZDOKUMENT HERSTELLER HEAT' and 'ASTRA 2019/003' from 2022. The third card lists 'FB 1740' and 'ASTRA 2019/003' from 2022. The page footer shows 'Sortieren nach:' and 'Seite 1 von 1'.