NOx emissions measurement from Euro 6d light duty vehicles using on board sensors

PEMS conference 2022

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Background - MaSu

- Dieselgate in September 2016 → Development of new regulations:
  - 2018/858, framework Regulation establishing **EC Market Surveillance obligations** (in force since September 2020) e.g. for **testing**, **risk assessment** in support to the selection of vehicles, audit of Technical Services and Type Approval Authorities
  - 2018/1832, ("RDE4") In-Service Conformity (parallel to the U.S. "in-use verification") of light-duty vehicles opening the **possibility** for the EC JRC e.g. to check vehicles or families of vehicles, provided that the JRC is **accredited** (ISO IEC 17025 and 17020).

Ma. Su.

Some "research" freedom within prescribed boundaries.
Identification of suspicious samples.
Performed by Ma. Su. authorities in cooperation with research labs.

ISC

No freedom. Performed by manufacturers and National Authorities with the help of designated TS and accredited labs.

Why On-Board Monitoring?

Fast screening of vehicles	MaSu	• Fast approach to select potential interesting vehicles to be tested in MaSu/ISC programmes
Identification of malfunctioning	PTI	• Tool to identify malfunctioning or intentional tampering?
Real time monitoring	Euro7/VII	• Advanced real time monitoring of vehicle fleet?

OBM in the Market Surveillance framework

- OBD checks are regularly performed during market surveillance tests at JRC.
- Preliminary OBM tests have been performed in the last year to check their applicability to Market Surveillance tests. We report here an example.

Methods

Tested vehicle

Fuel	**Diesel**
Traction	ICE
Segment	Light commercial
Emission control system	DOC, DPF, SCR, ASC
Registration	2019
Mileage (km)	51380
Euro standard	Euro 6d-TEMP-EVAP-ISC
ICE size (cm^3)	1968

Instruments

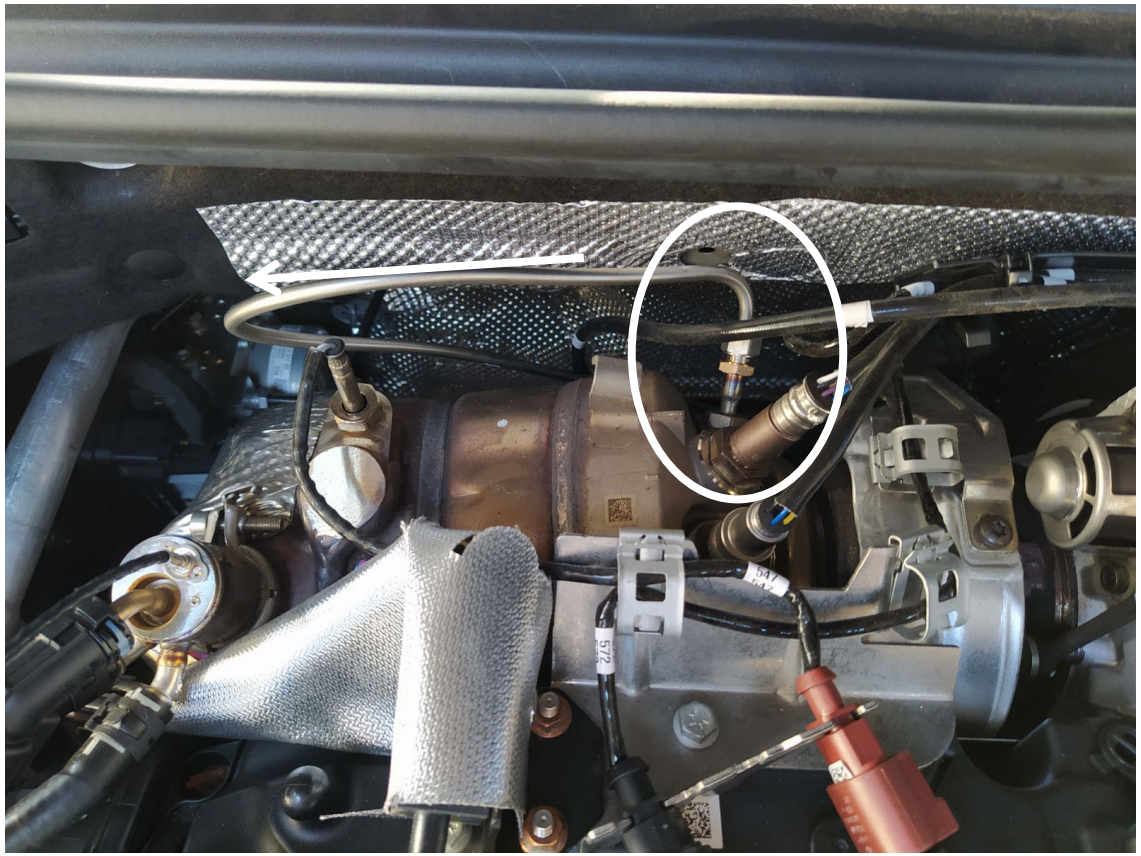
- CVS flow – dilution air flow (flowrate)
- HORIBA MEXA (NOx) – engine out
- HORIBA MEXA (NOx) – tailpipe out
- AVL MOVE (NOx, flowrate) – tailpipe out
- Custom CAN / OBD signal acquisition

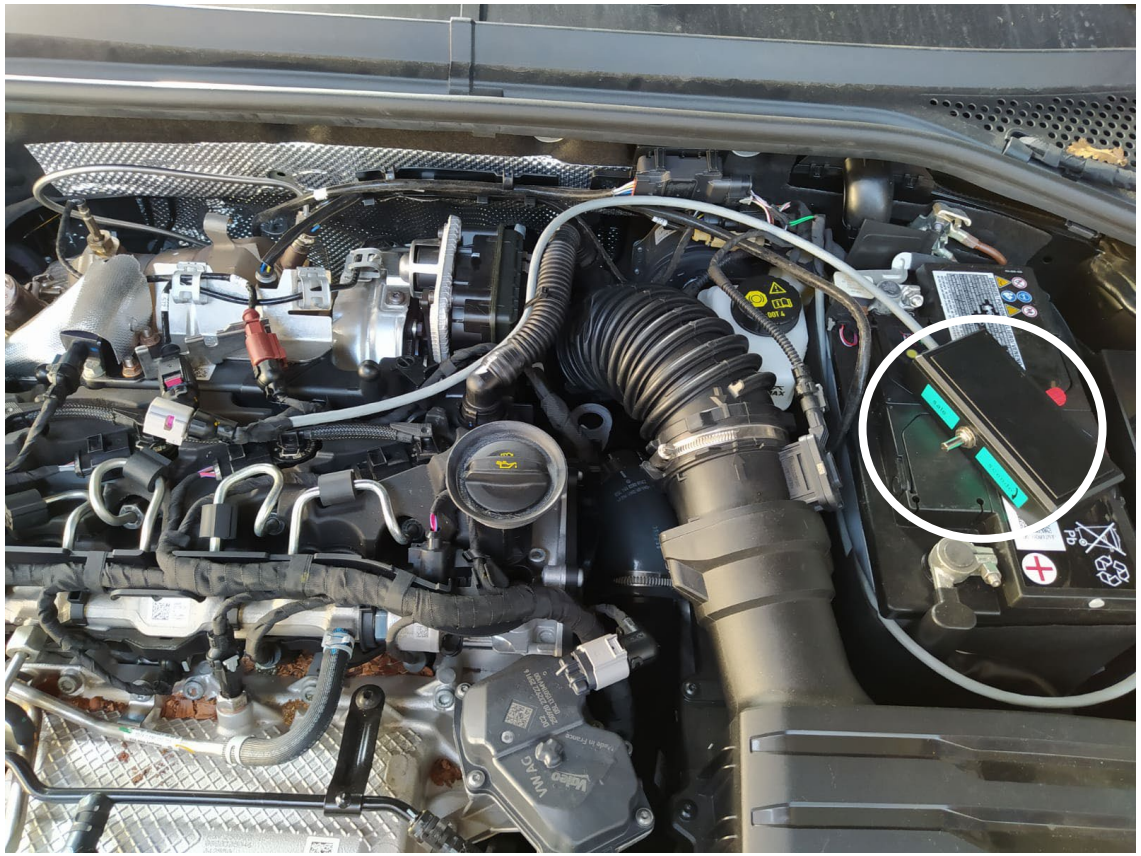
Tests performed

- WLTC cold + hot @ 23˚C
- WLTC cold + hot @ 0˚C
- Steady state tests @ 23˚C
- WLTC cold + hot @ 23˚C (with simulated SCR malfunctioning)
- Urban cycle on road

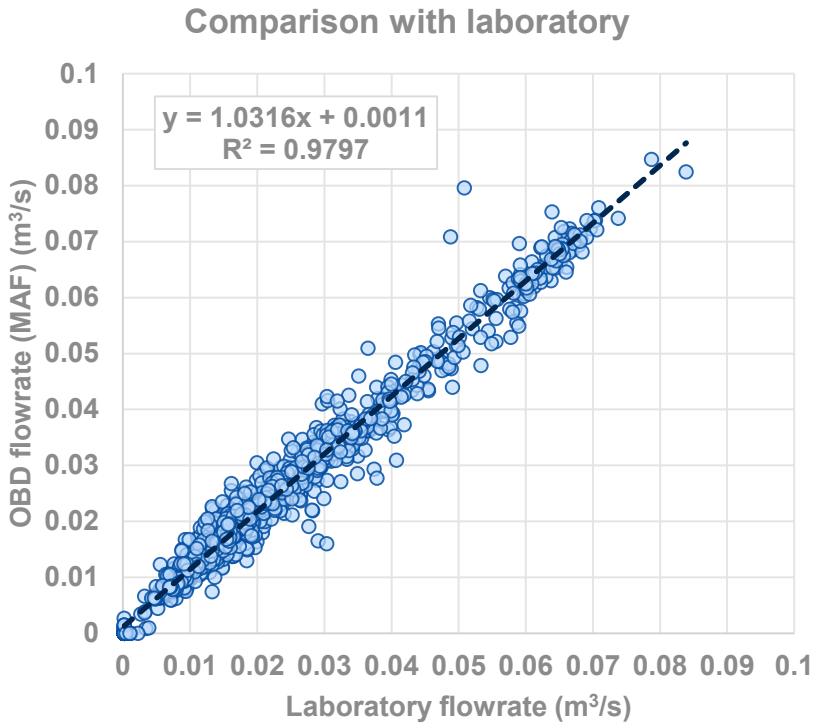
Methods

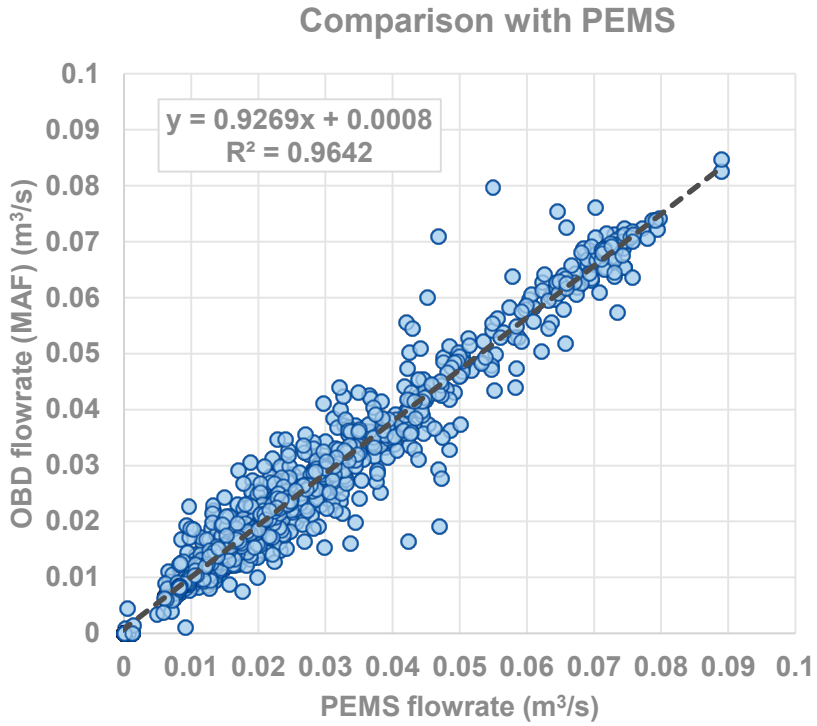
- Example of experimental installation for engine out direct sampling and T simulation





Results – flow rate





- Example of WLTC in the laboratory at 23°C, similar results at 0°C
- Flow rate in laboratory: CVS flow – dilution air flow
- Reference EFM from AVL PEMS system used
- MAF from OBD, no signal for exhaust flow available (mandatory from 2021)
- Better correlation on steady state tests

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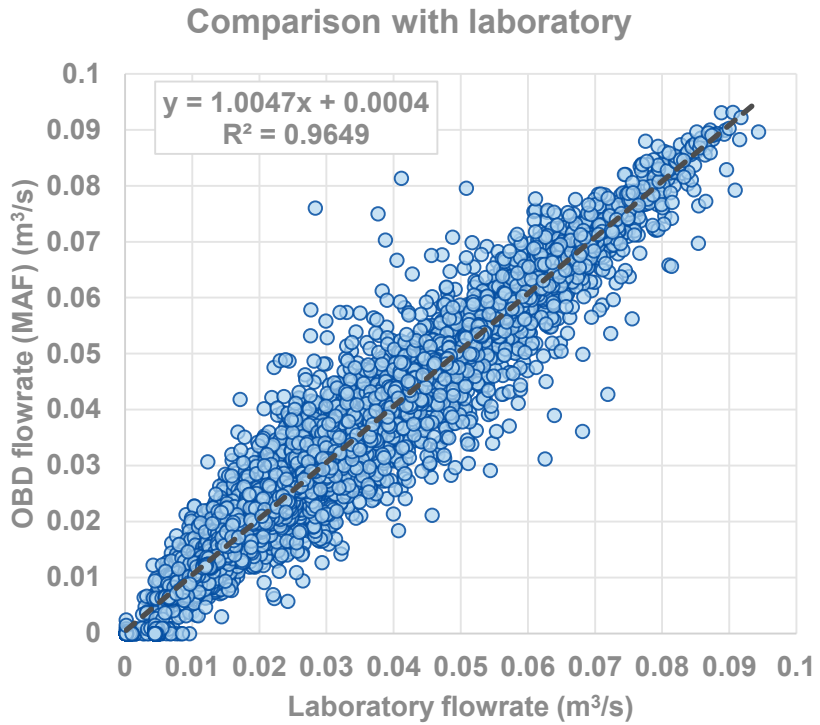
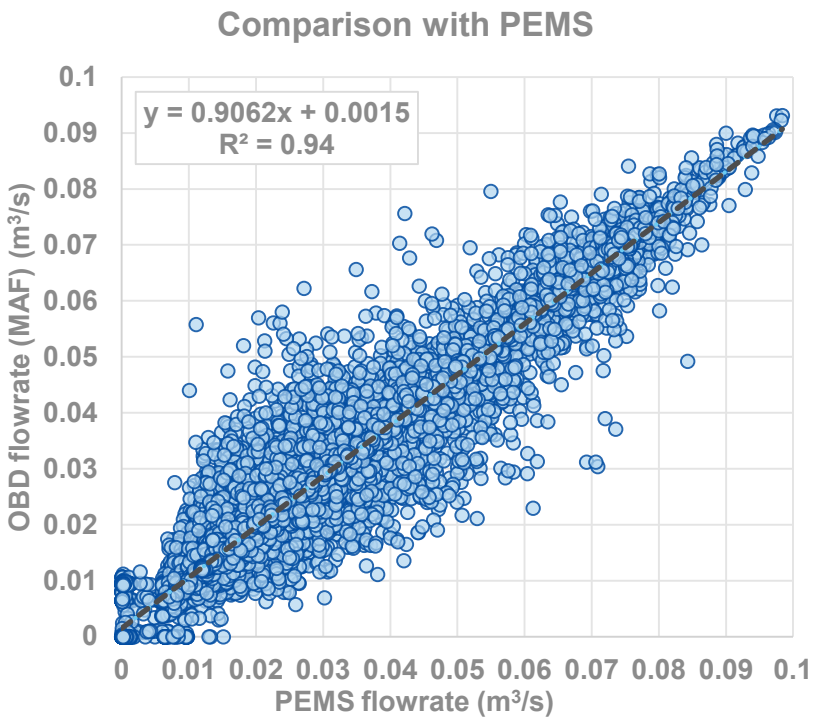
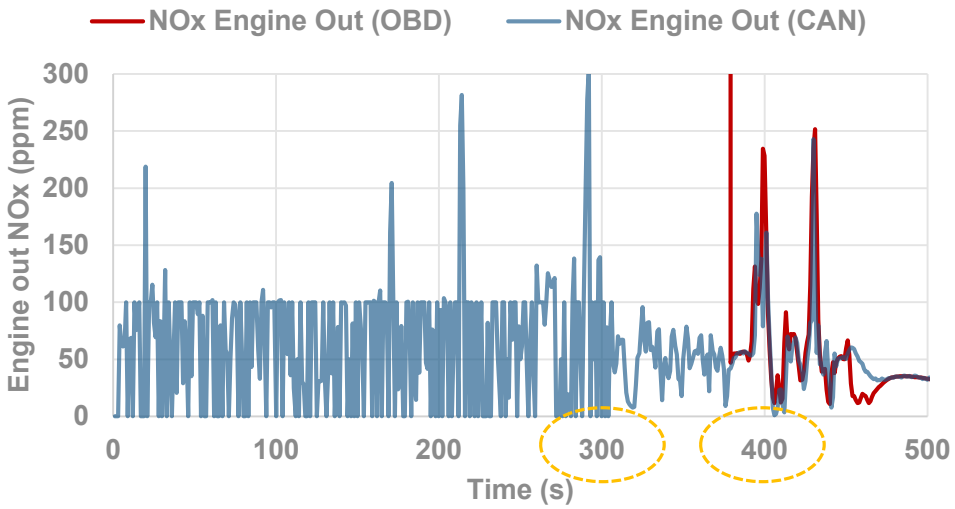
Results – flow rate

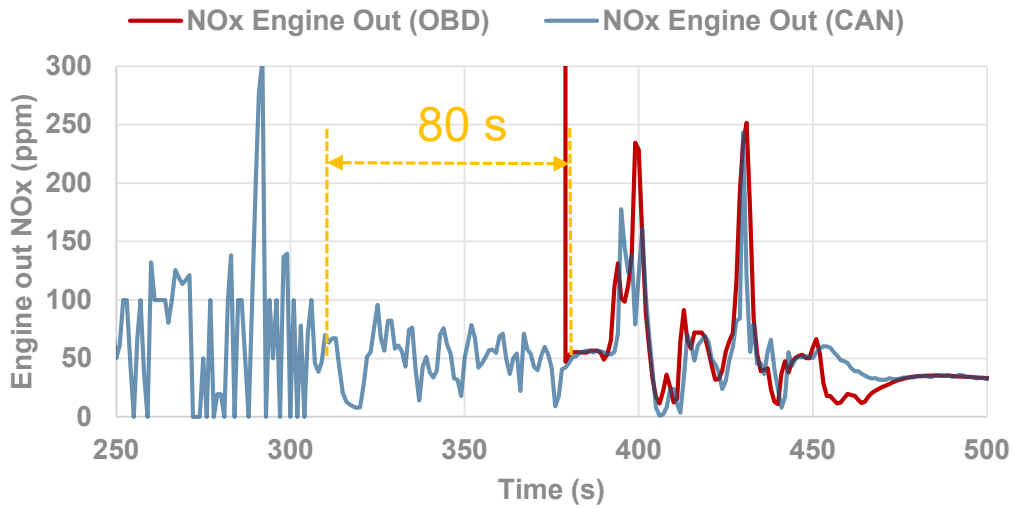


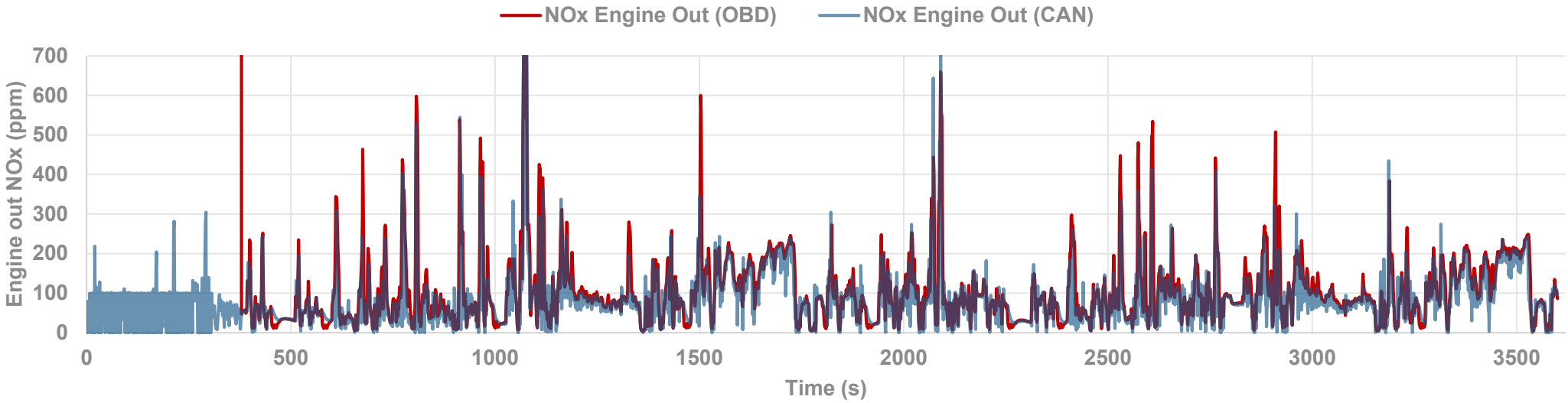


- Correlation on the whole data set (varying temperature and type of cycle)
- MAF from OBD, no signal for exhaust flow available

Results – NOx concentration (CAN vs OBD)







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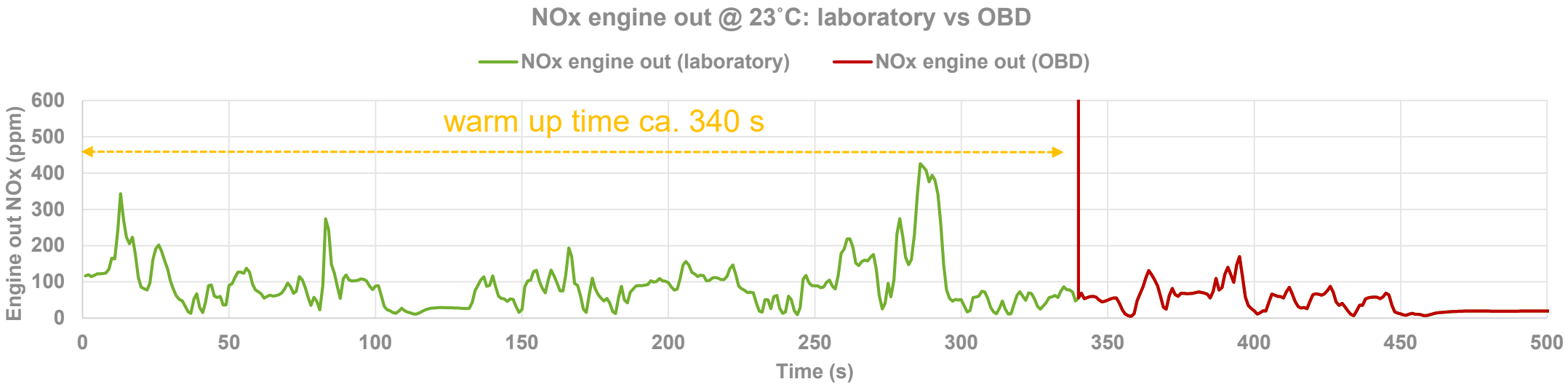
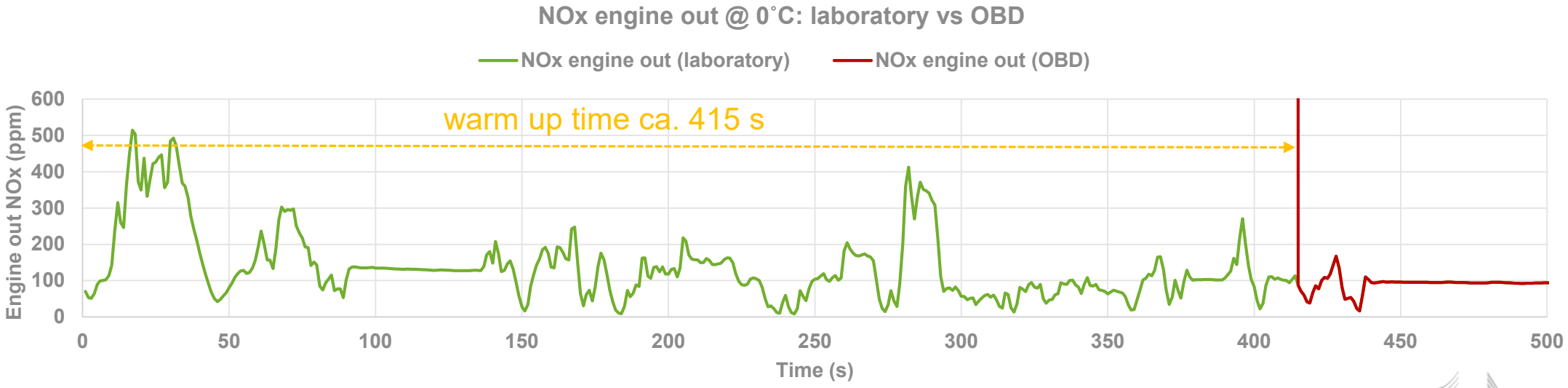
Results – NOx concentration (OBD vs LAB)





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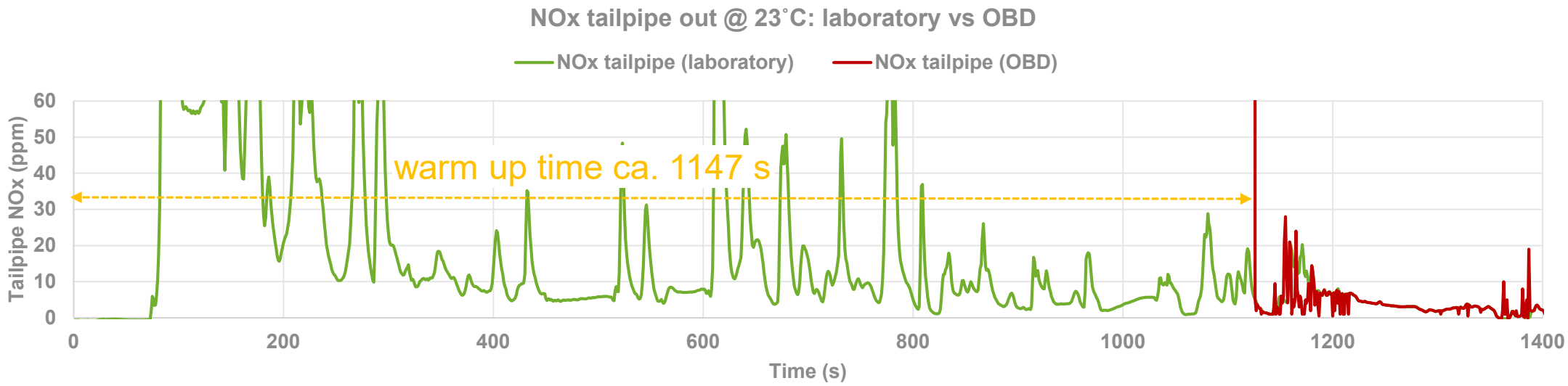
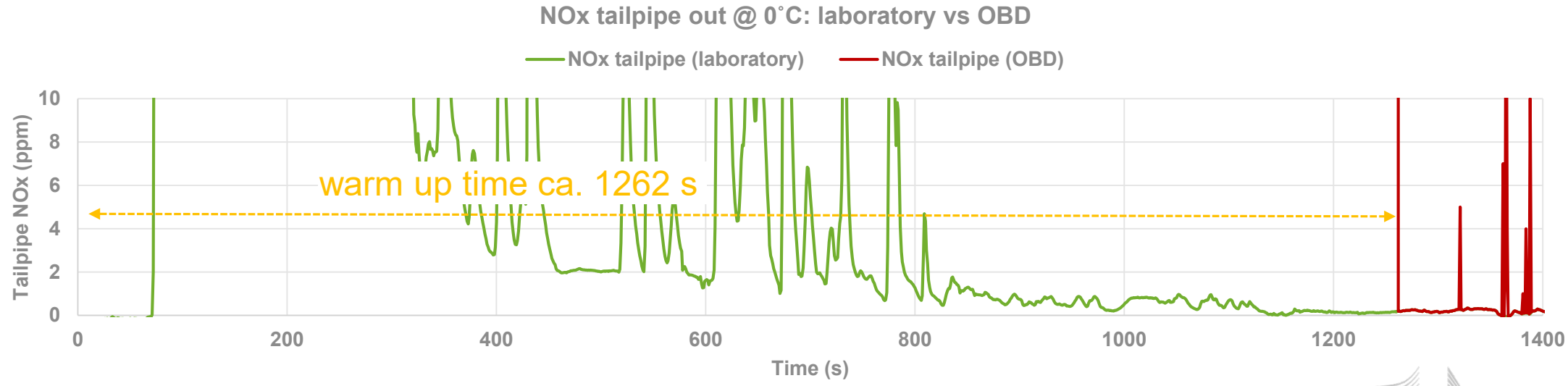
Results – NOx concentration (OBD vs LAB)





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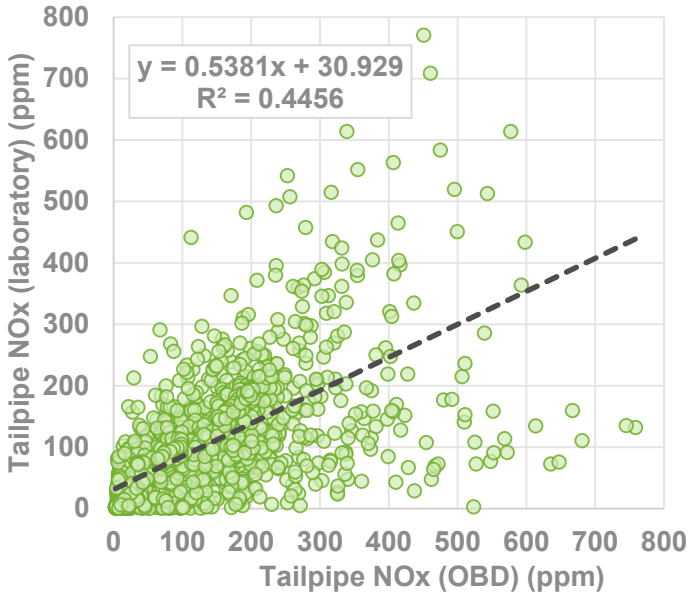
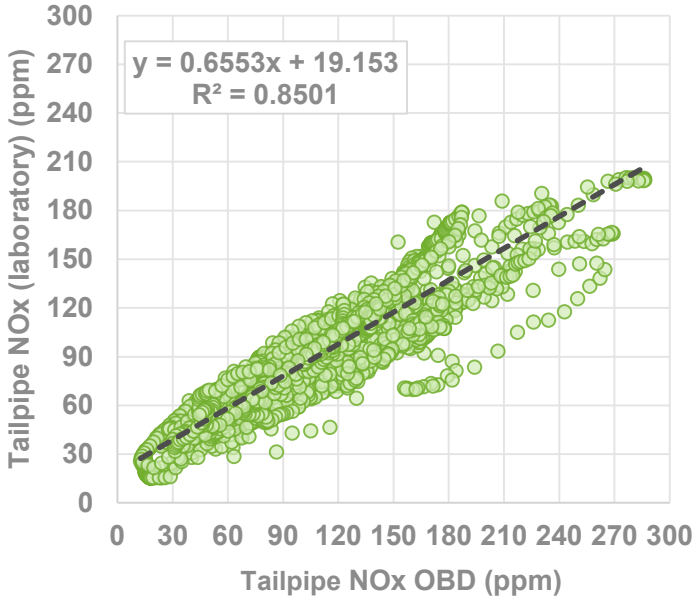
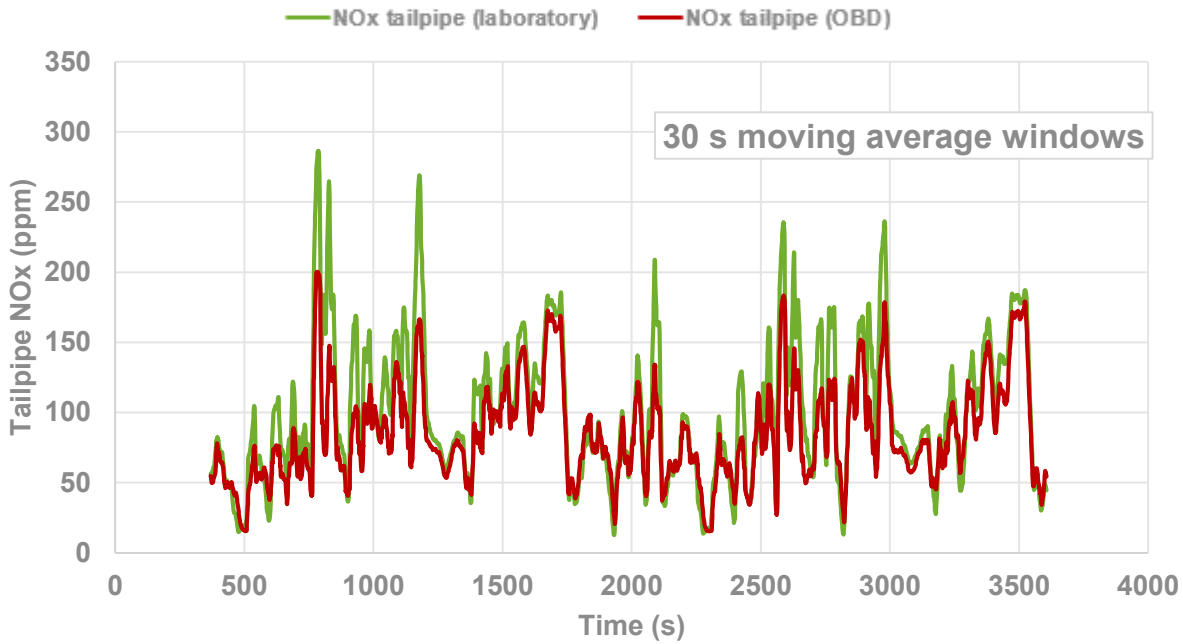
Results – NOx concentration (MAW)

Raw data



30 s MAW applied





- Correlation of OBD vs references (laboratory, PEMS) generally not good due to different signal dynamics
- MAW significantly improve correlation

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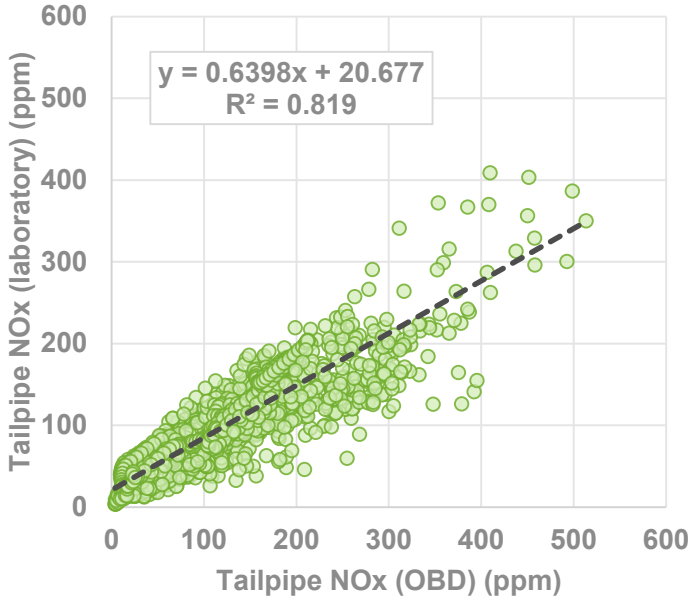
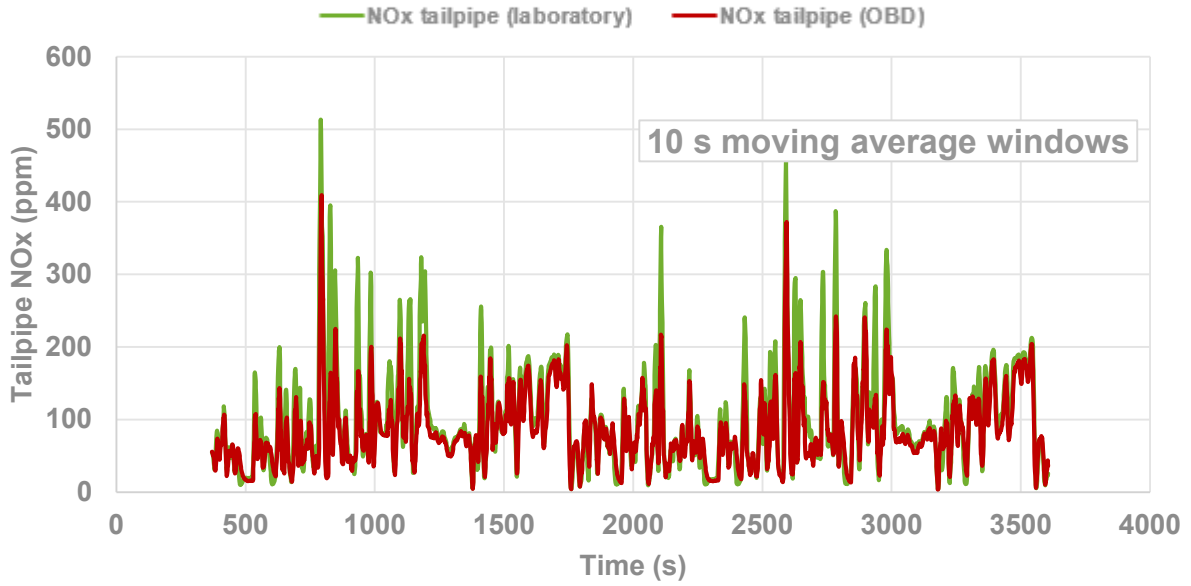
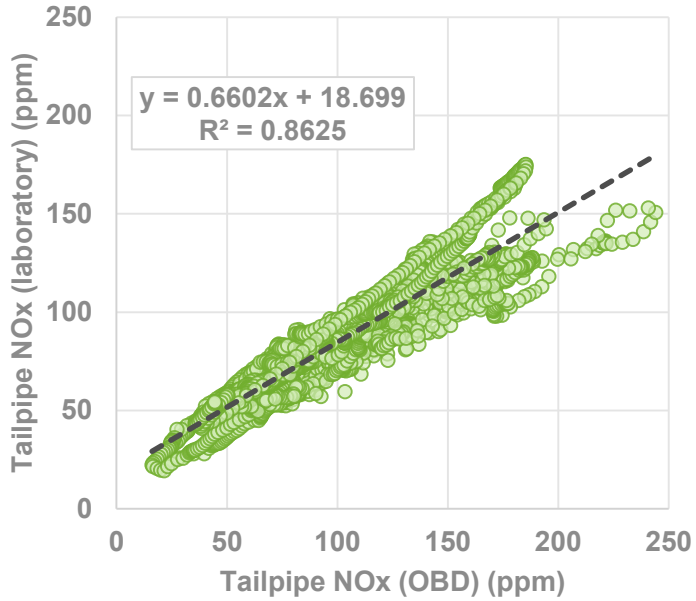
Results – NOx concentration (MAW)

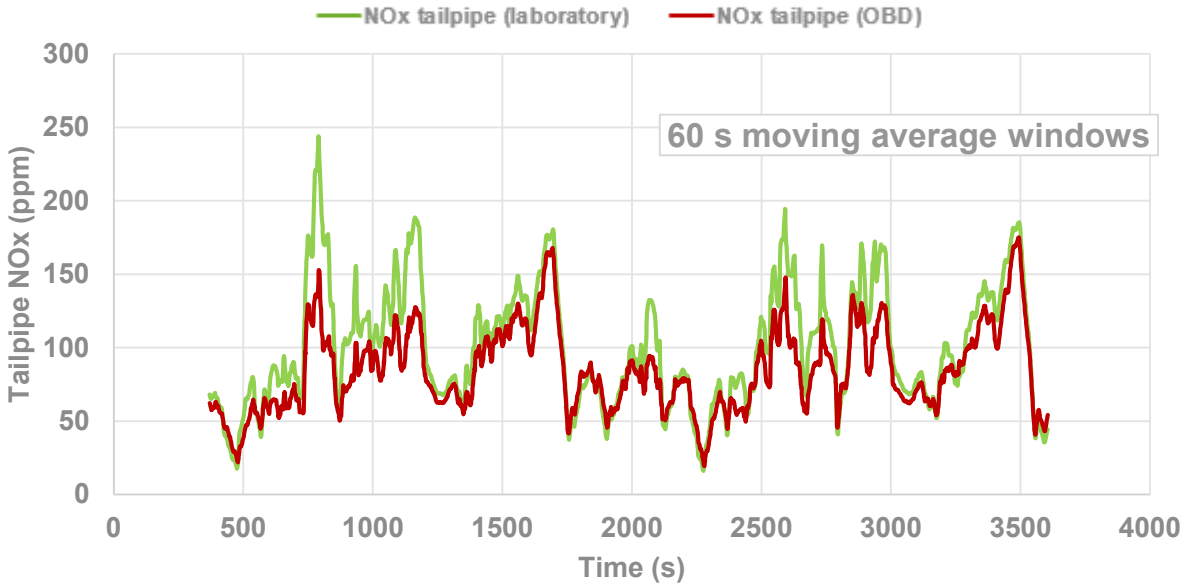
10 s MAW applied



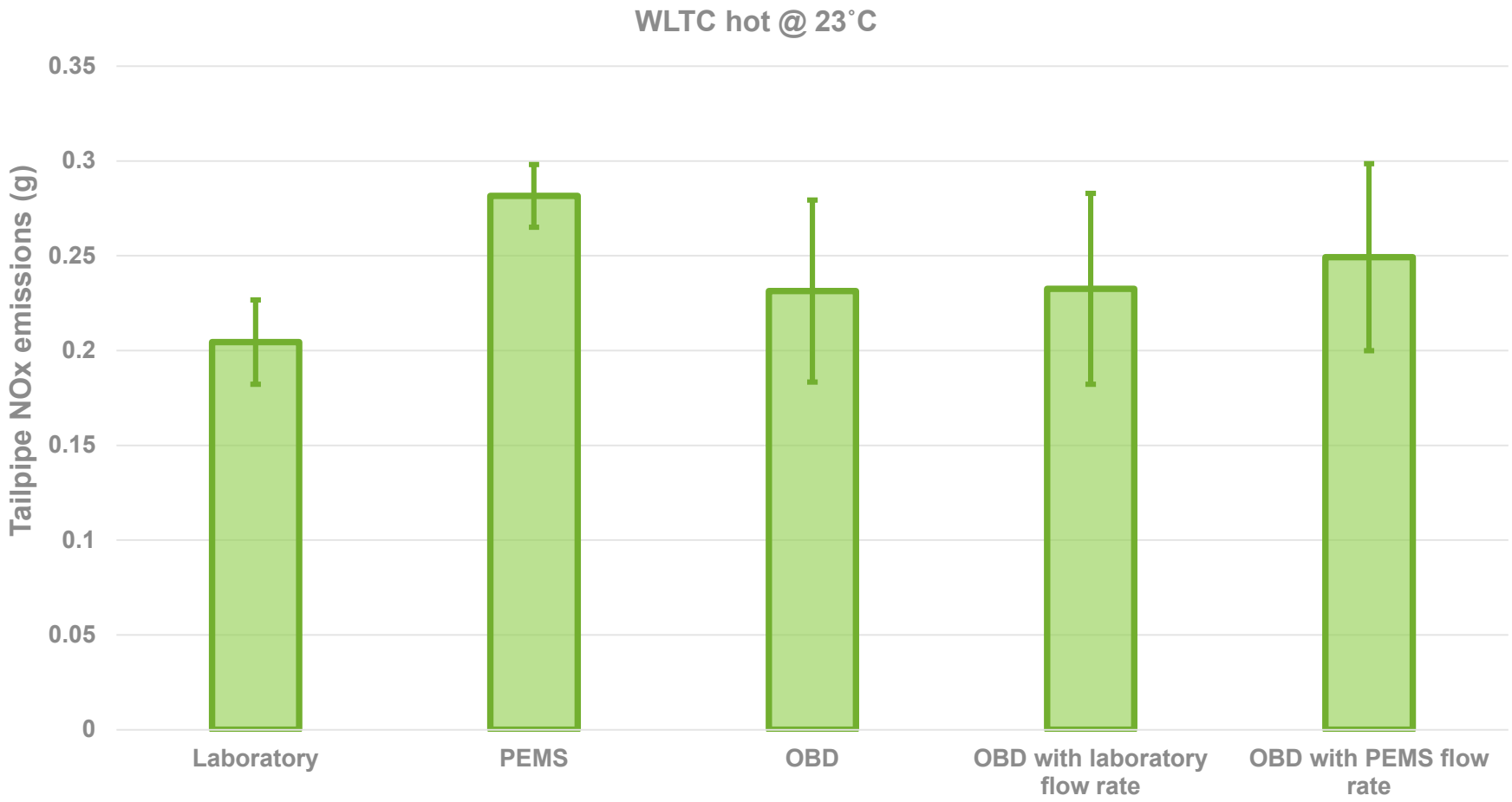


60 s MAW applied



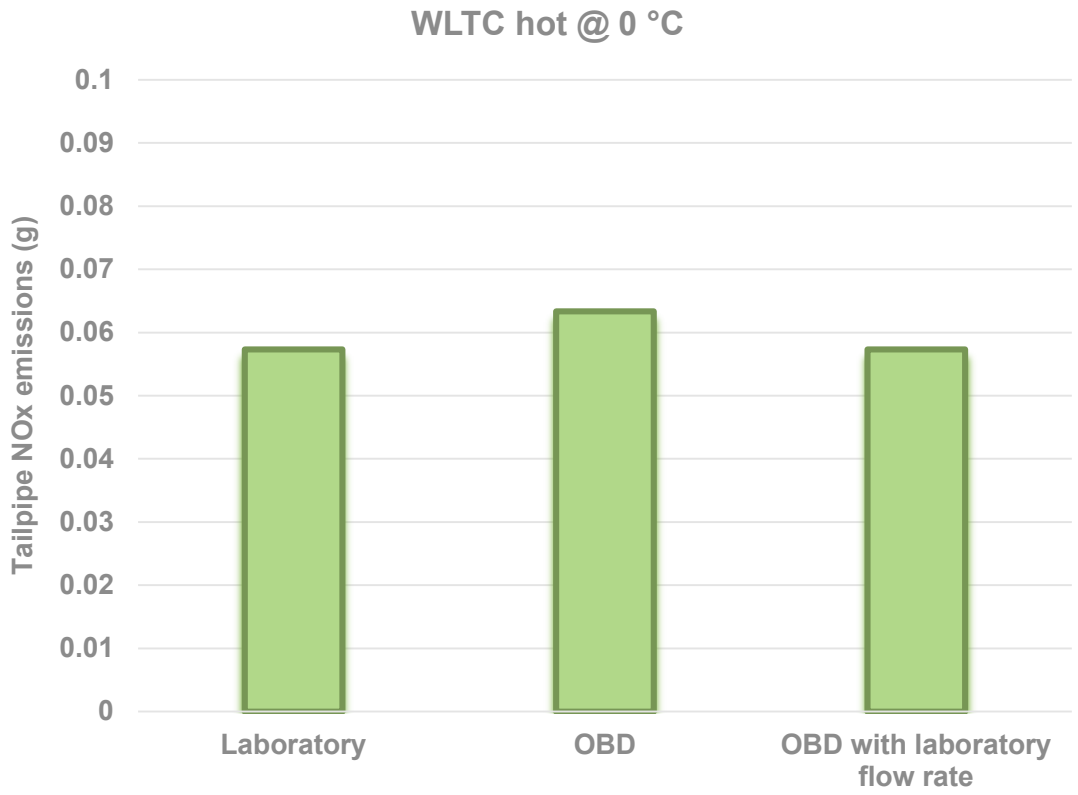


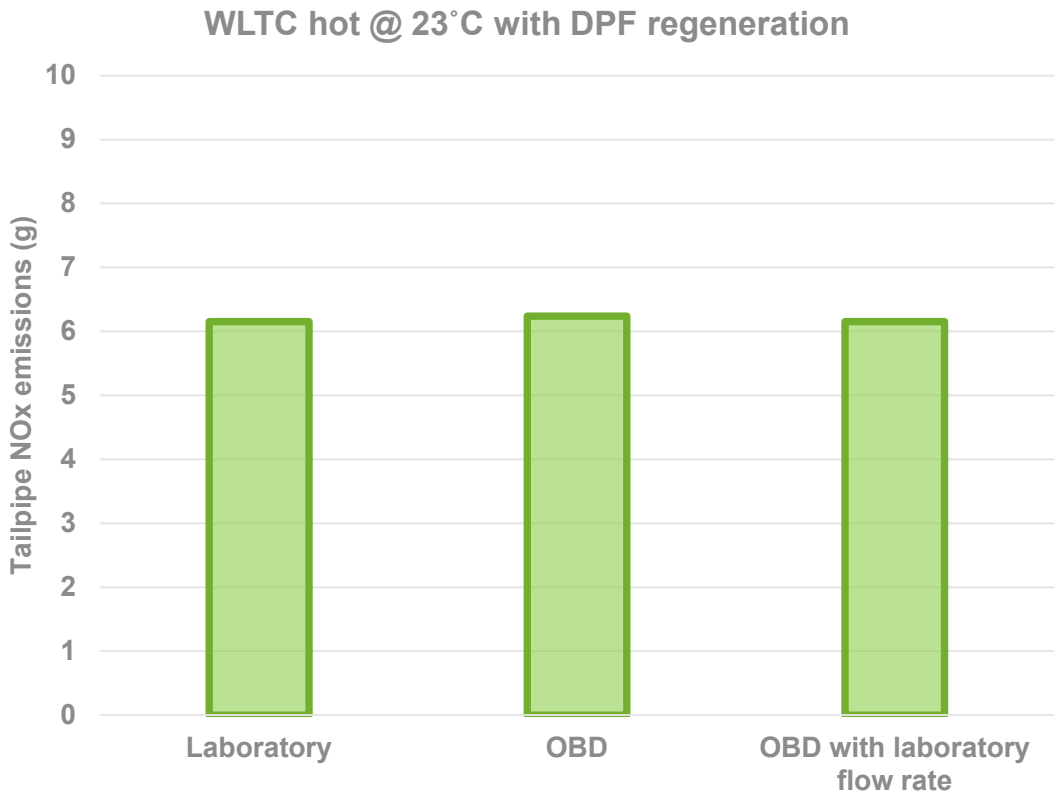
Results – Emissions calculation



- Good agreement between the different methods
- PEMS difference mostly due to EFM

Results – Emissions calculation





- Good agreement between the different methods even under different conditions

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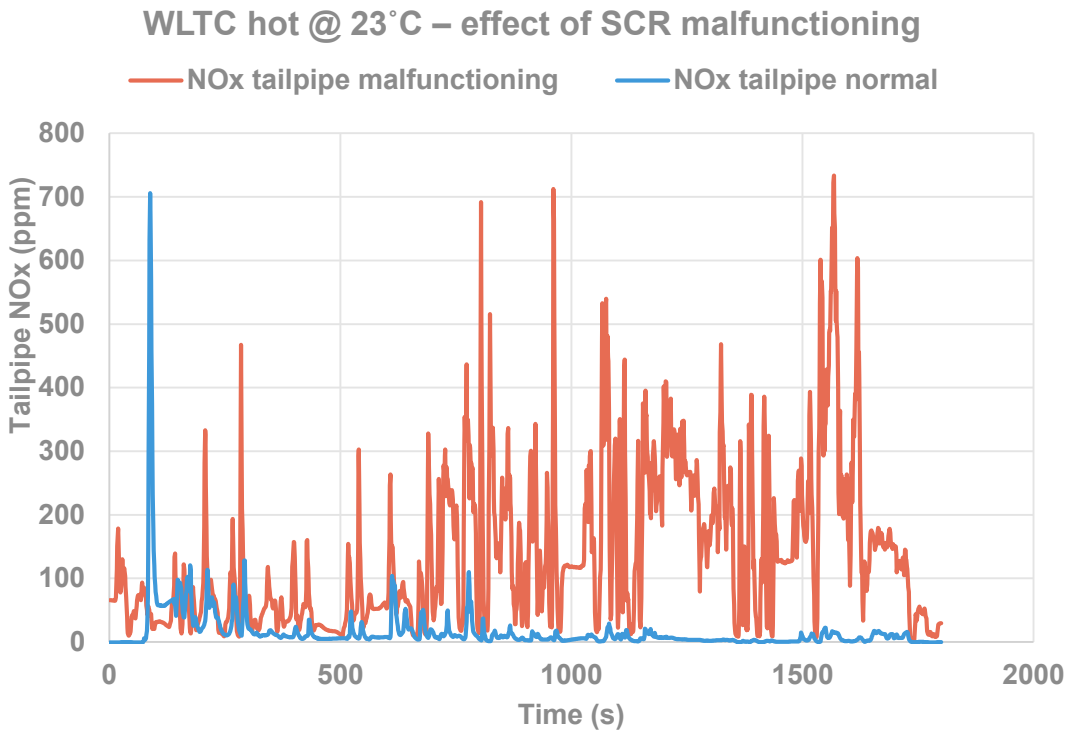
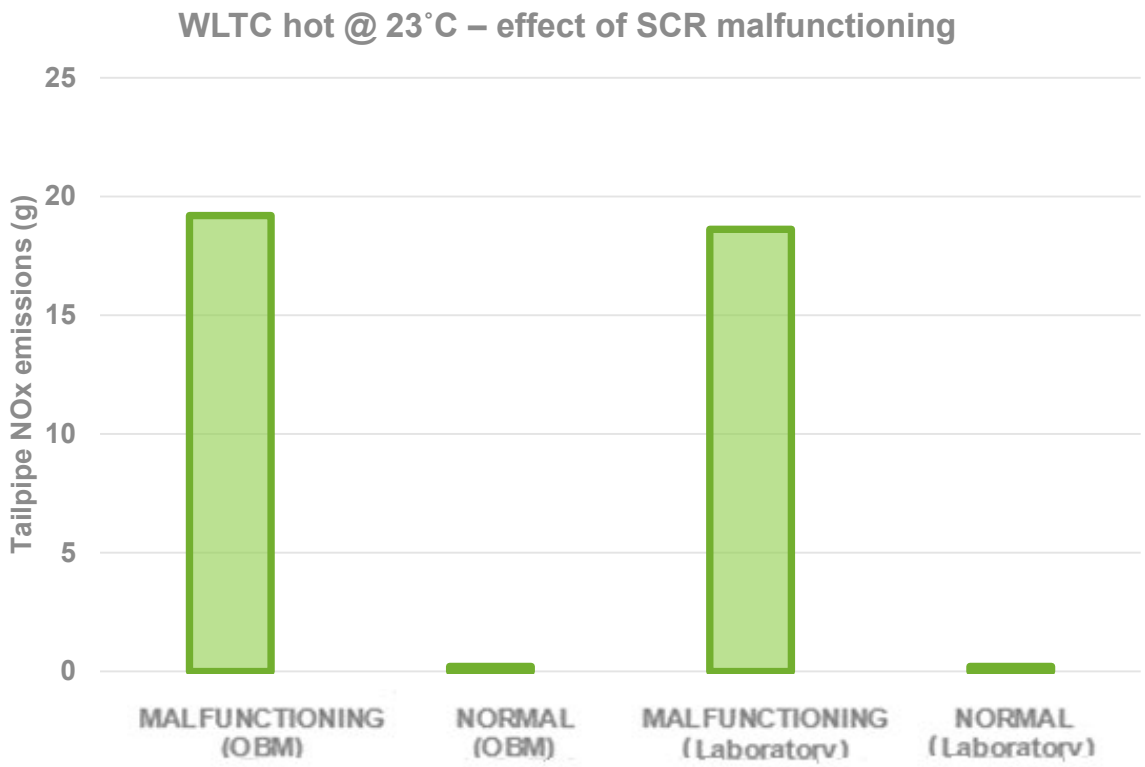
Results – SCR malfunctioning





- It would be possible to screen malfunctioning ATS by using properly functioning on-board sensors

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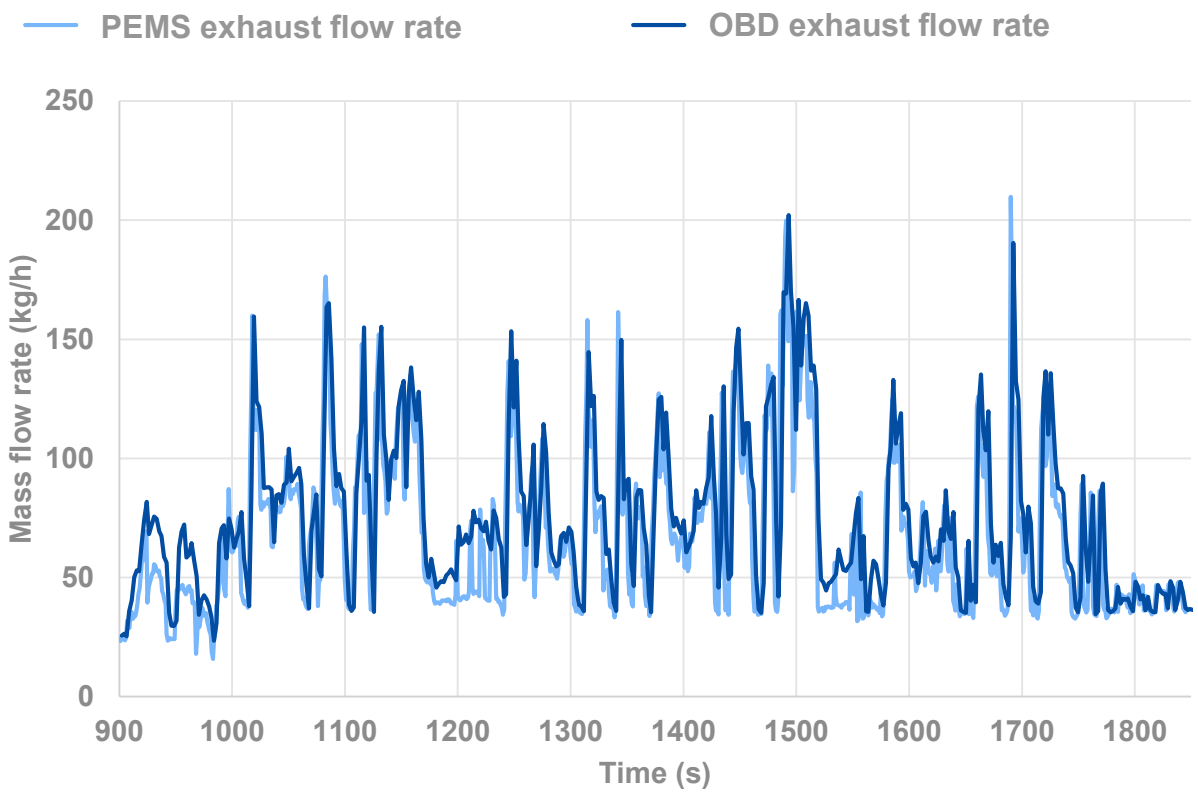
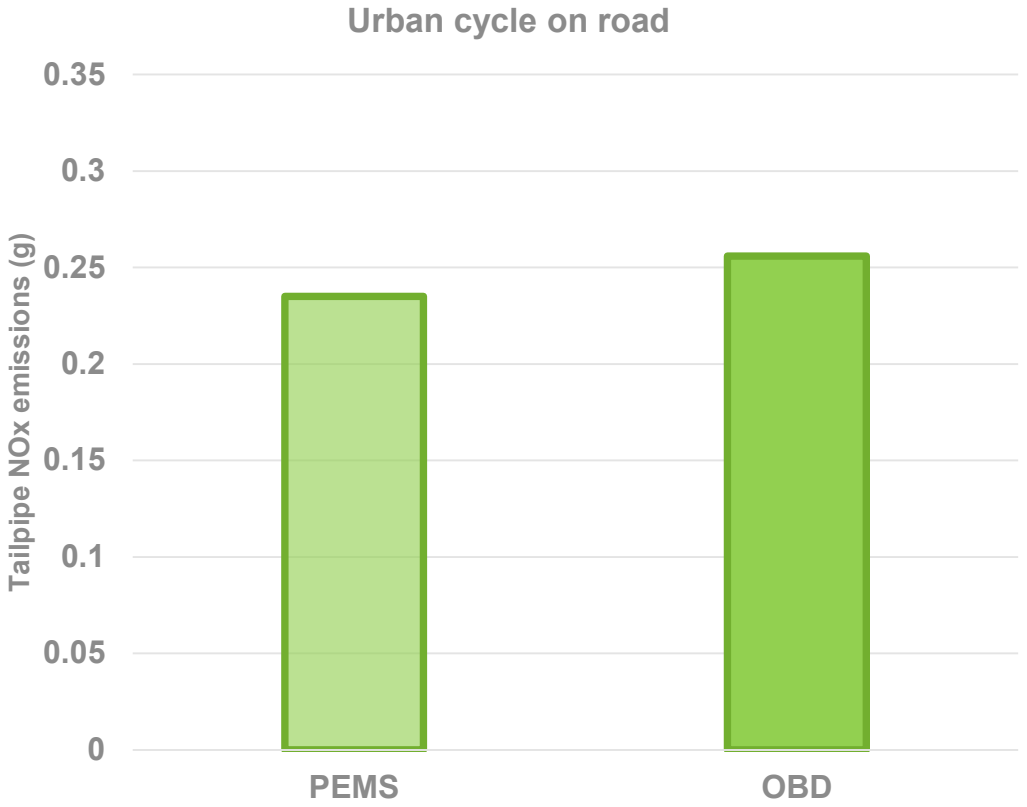
Results – On road emissions





- Good agreement also in urban driving conditions on road (warm up!)

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Closing remarks

- The good agreement with the Laboratory and PEMS suggests that OBD signals can be used to fast screen modern Diesel vehicle emissions.
- At present, due to the sensor's warm-up time, it would not be possible to estimate cold start emissions.
- It would be possible to recognize malfunctioning ATS by using OBD data. Hence, detecting high NOx emitters.
- Tests will continue on various types of vehicles to create a database.

Thank you

European Commission