

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

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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

Identification of malfunctioning

PTI

Real time monitoring

Euro7/VII

- Fast approach to select potential interesting vehicles to be tested in MaSu/ISC programmes
- Tool to identify malfunctioning or intentional tampering?
- 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

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

## Instruments

- CVS flow – dilution air flow (flowrate)
- HORIBA MEXA (NO<sub>x</sub>) – engine out
- HORIBA MEXA (NO<sub>x</sub>) – tailpipe out
- AVL MOVE (NO<sub>x</sub>, flowrate) – tailpipe out
- Custom CAN / OBD signal acquisition

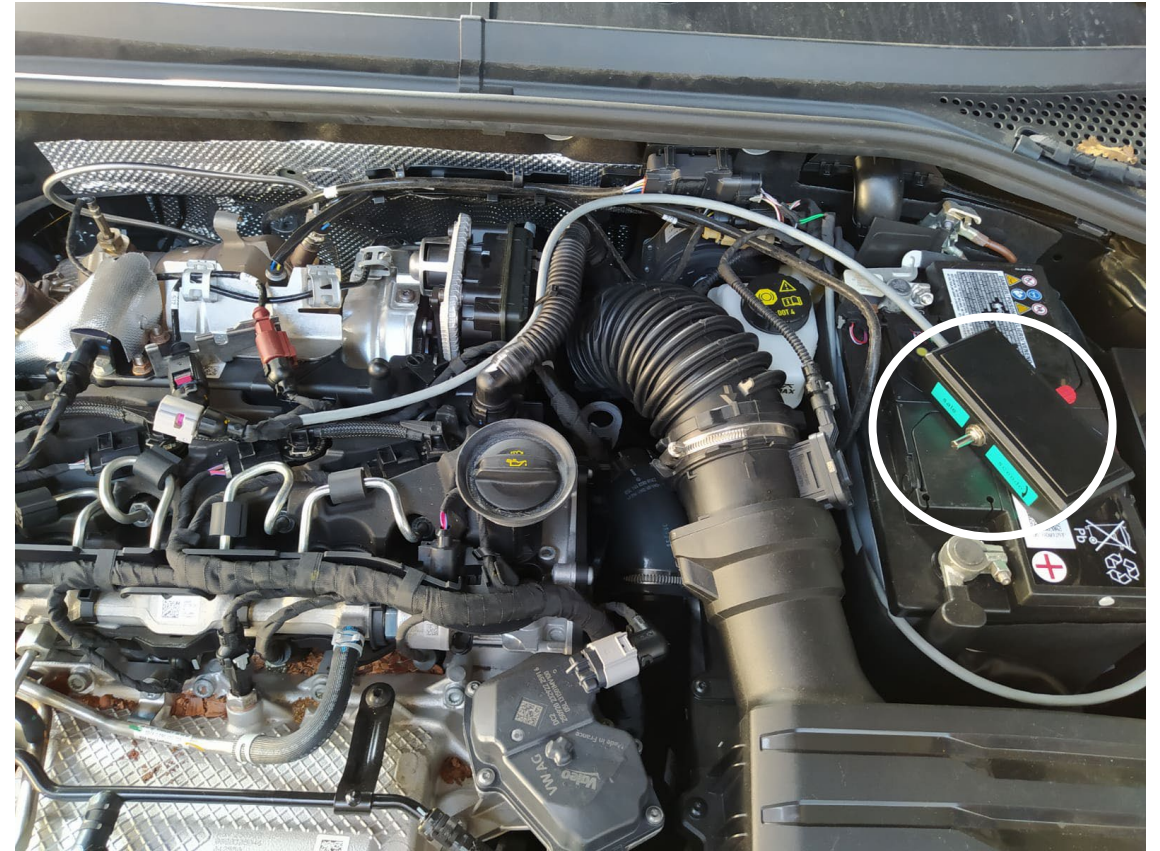
## Tests performed

- 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

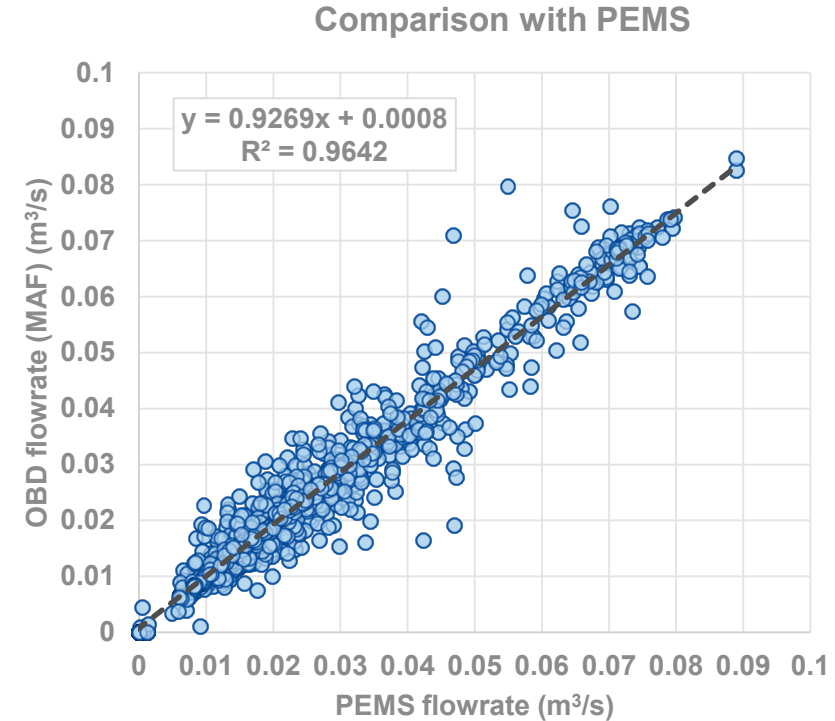
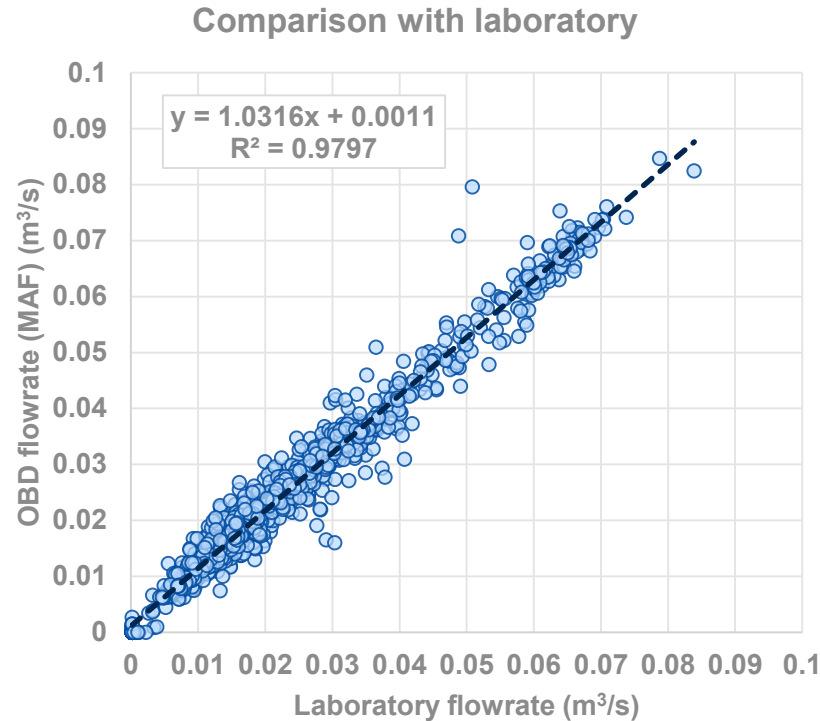


# Methods

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

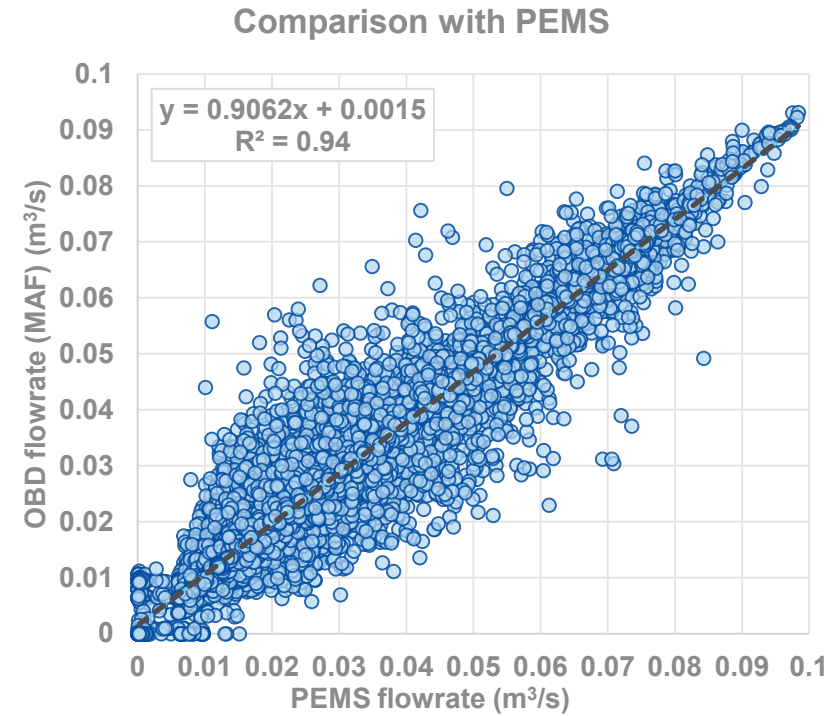
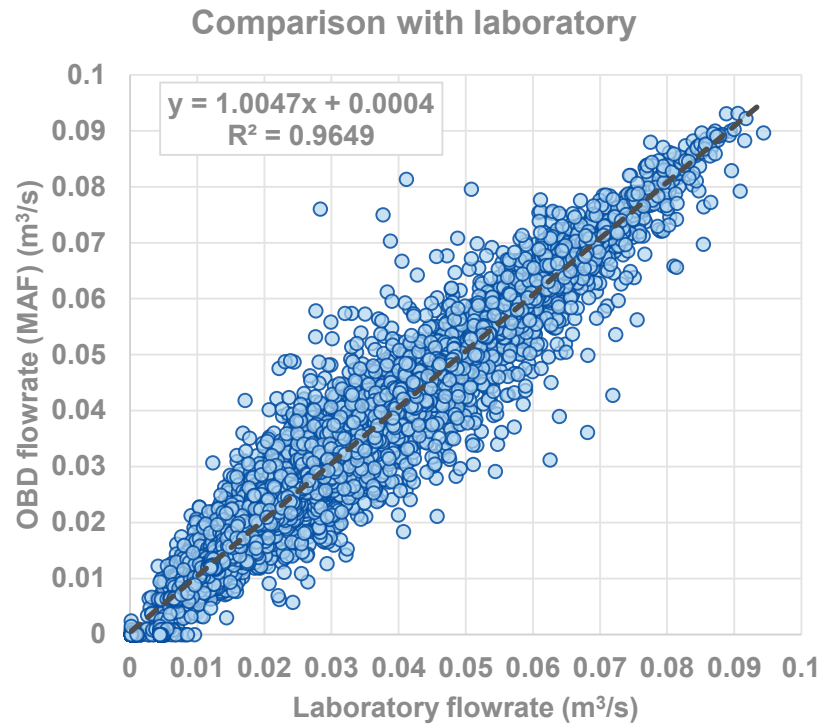


# Results – flow rate



- 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

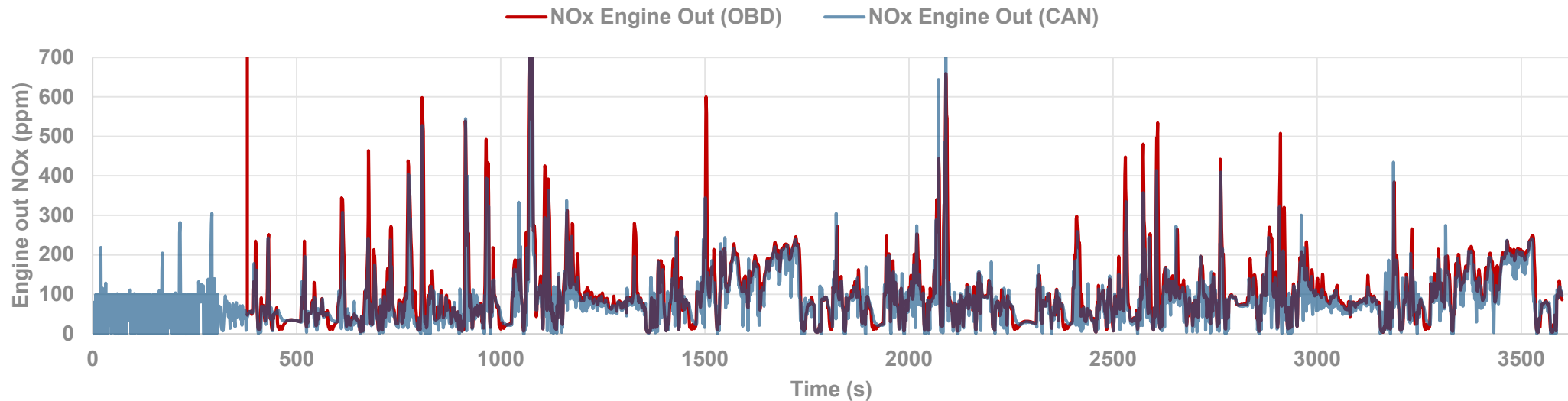
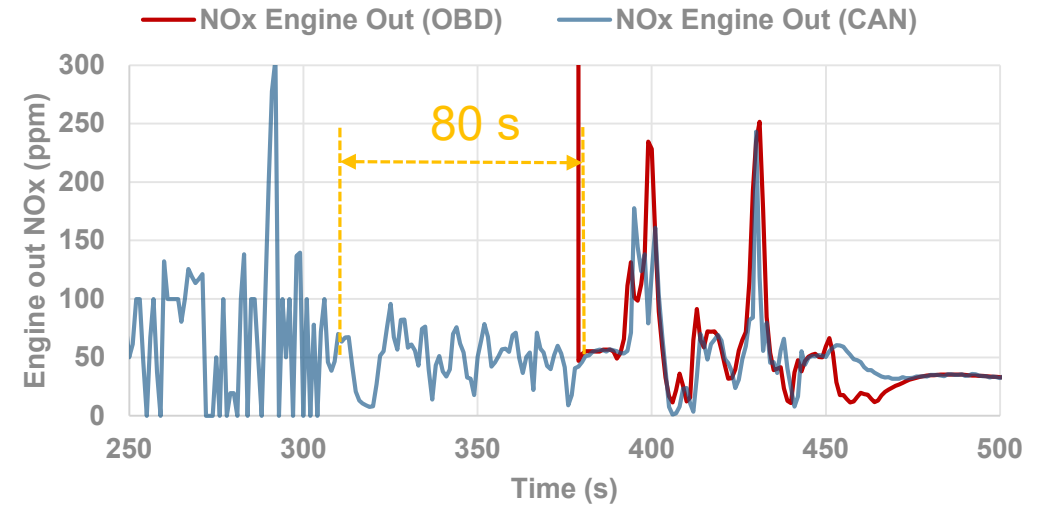
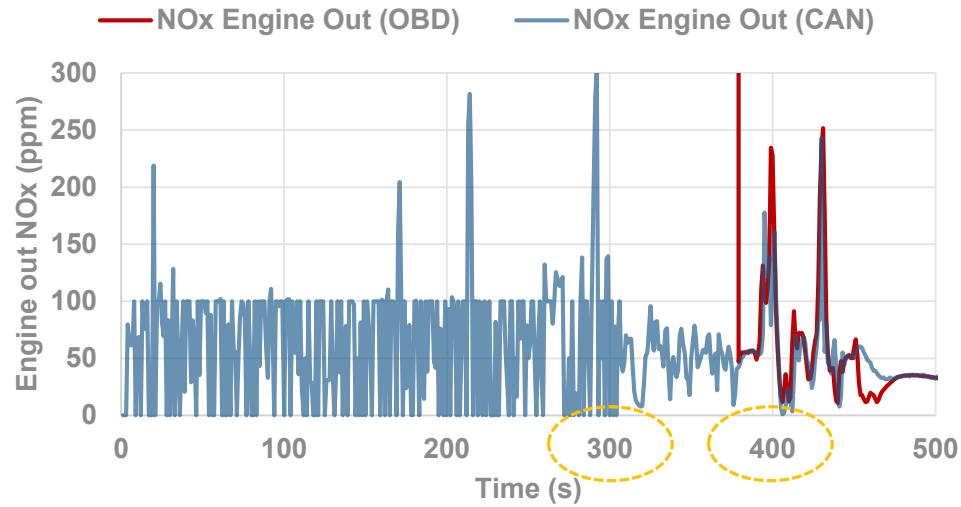
# Results – flow rate



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

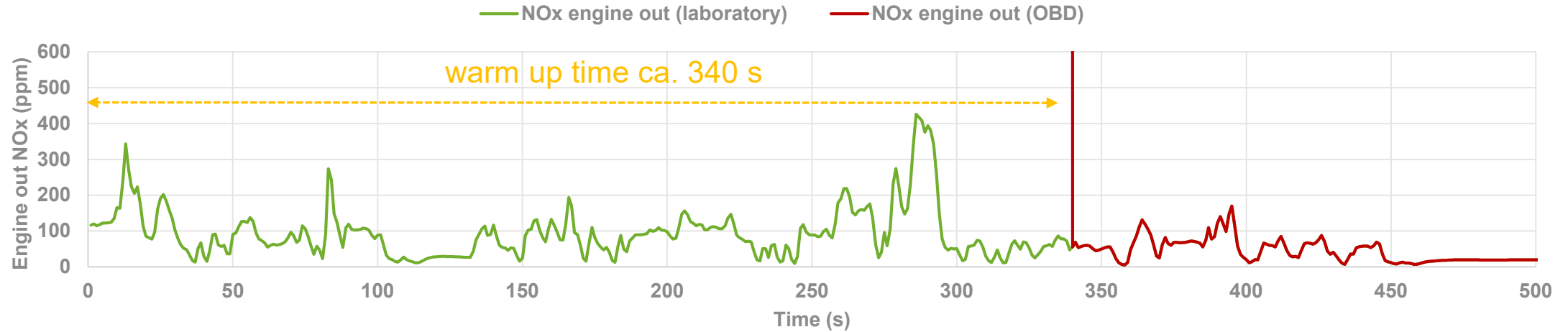


# Results – NO<sub>x</sub> concentration (CAN vs OBD)

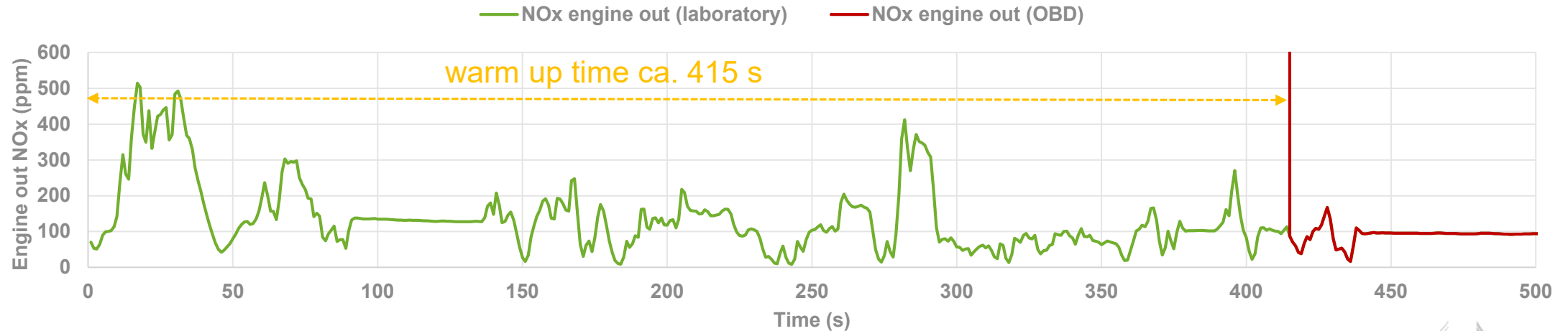


# Results – NOx concentration (OBD vs LAB)

NOx engine out @ 23°C: laboratory vs OBD

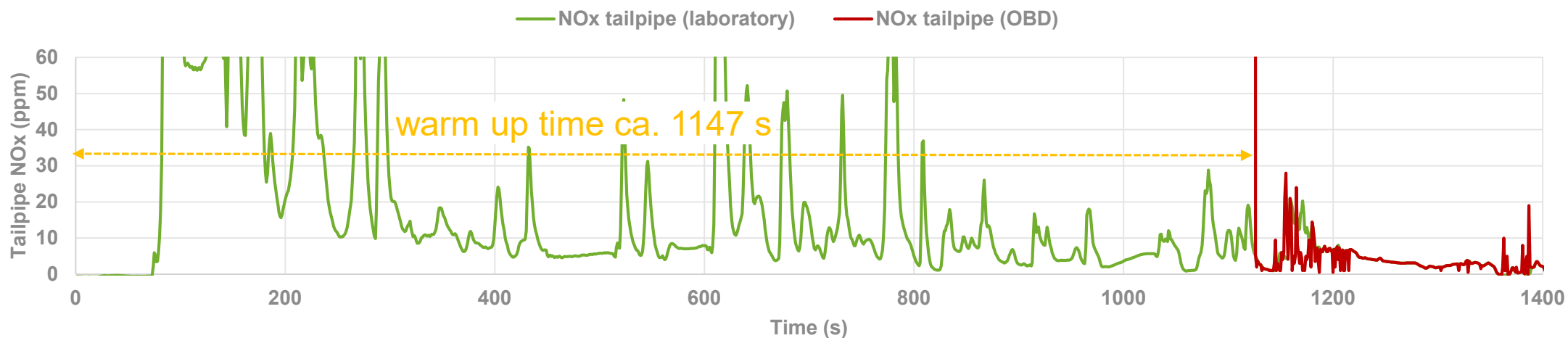


NOx engine out @ 0°C: laboratory vs OBD

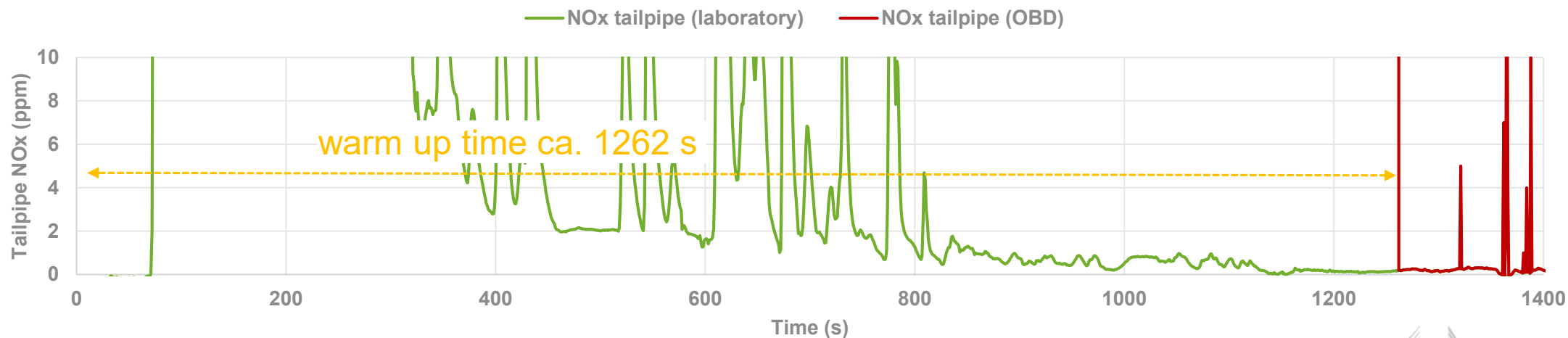


# Results – NOx concentration (OBD vs LAB)

NOx tailpipe out @ 23°C: laboratory vs OBD

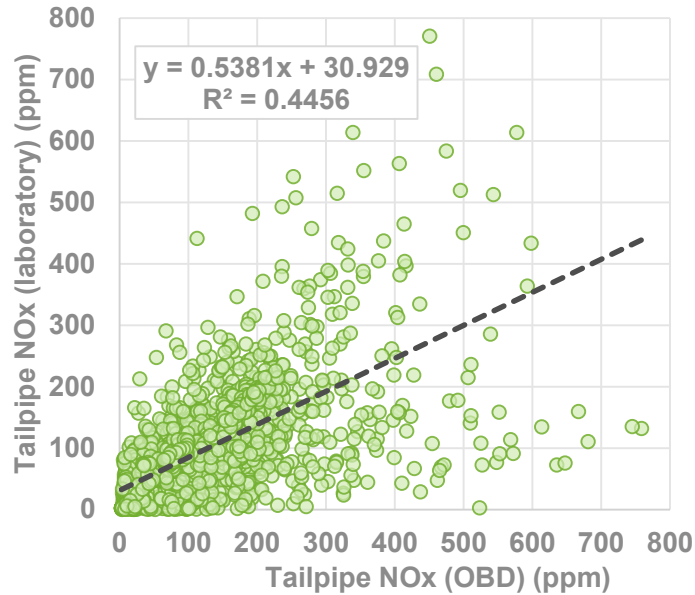


NOx tailpipe out @ 0°C: laboratory vs OBD

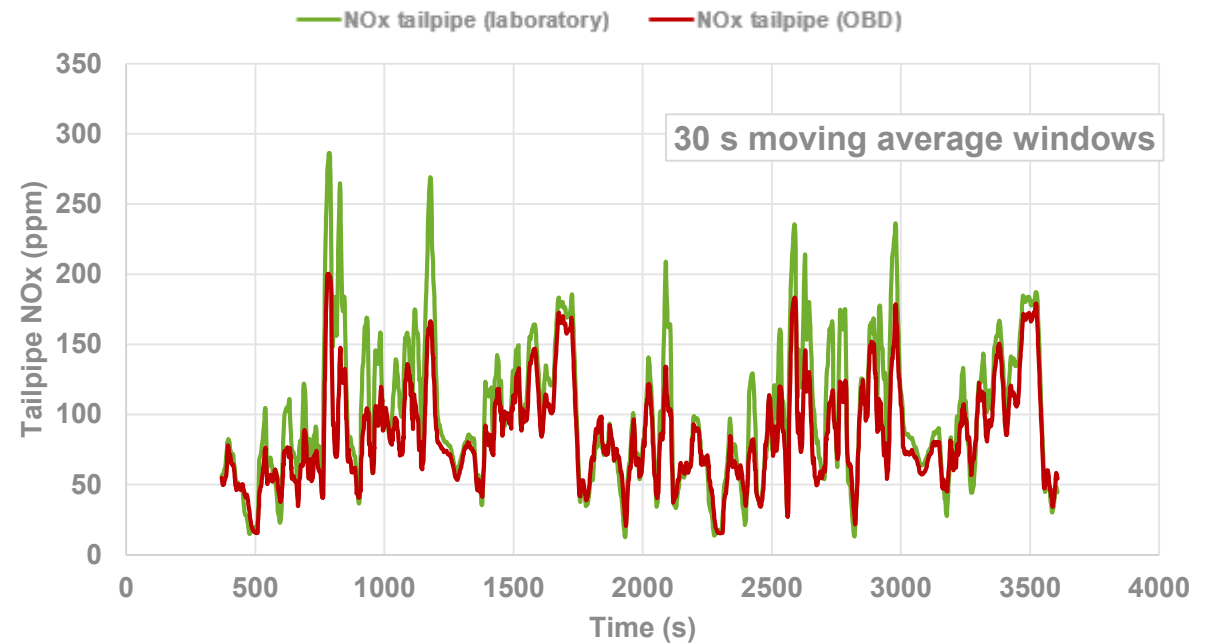
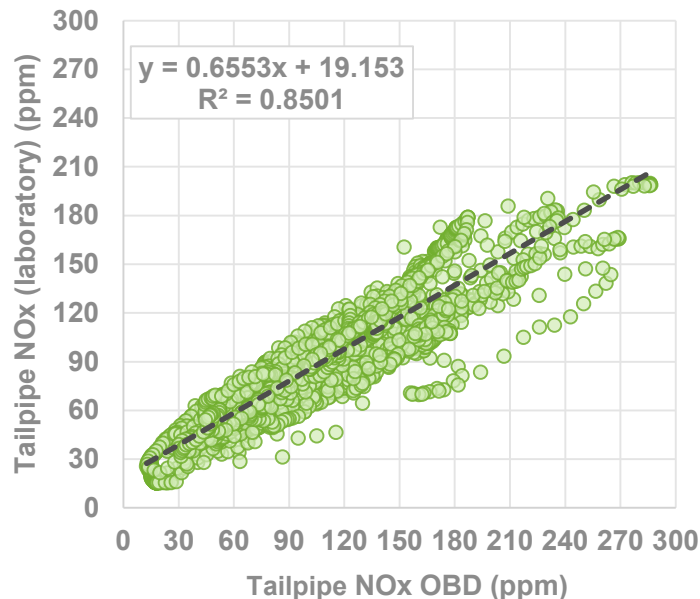


# Results – NOx concentration (MAW)

Raw data



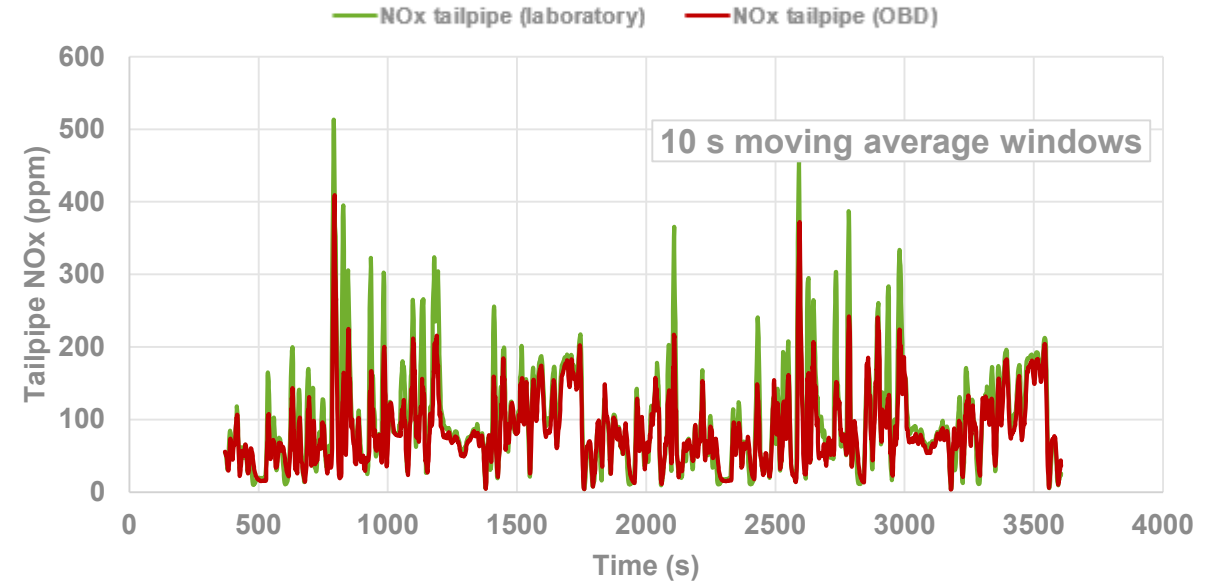
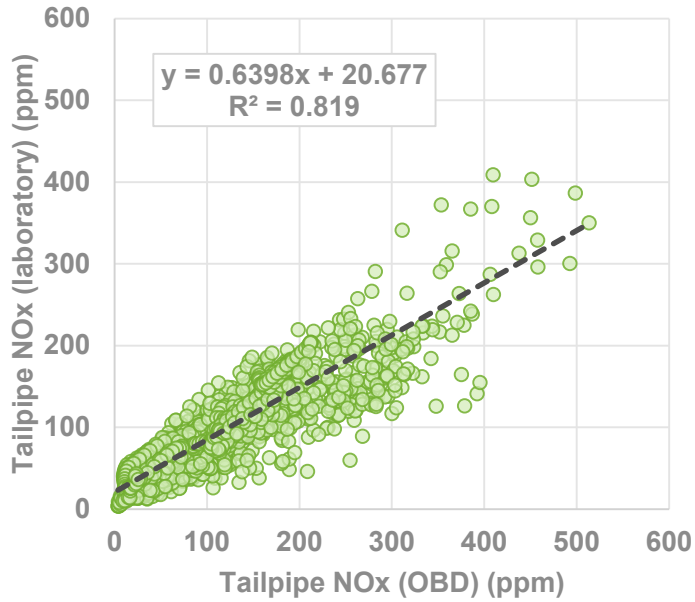
30 s MAW applied



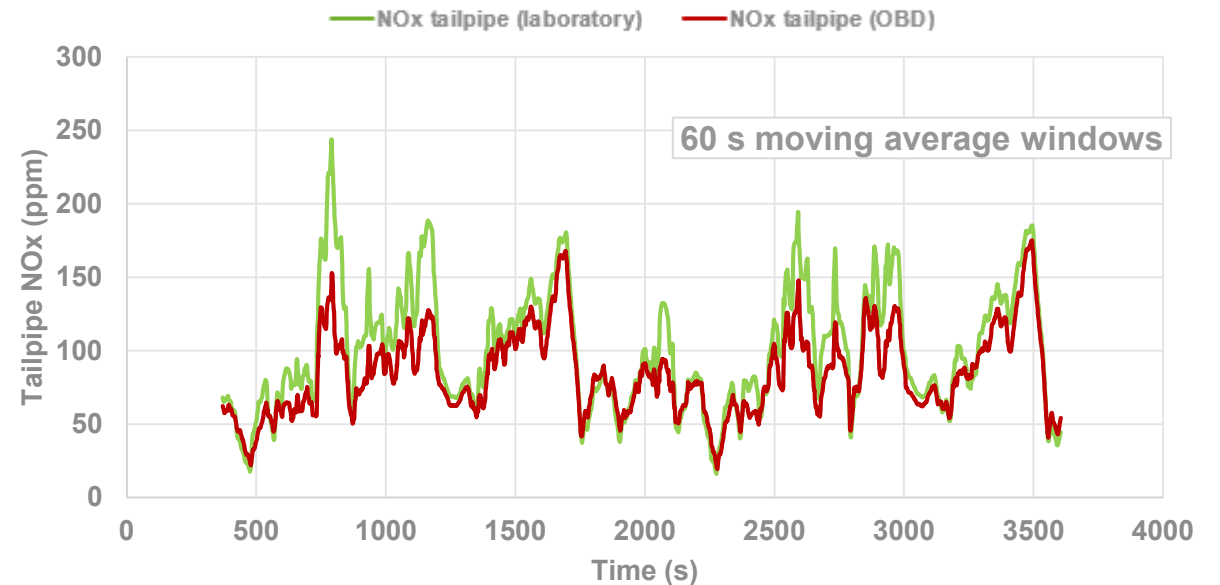
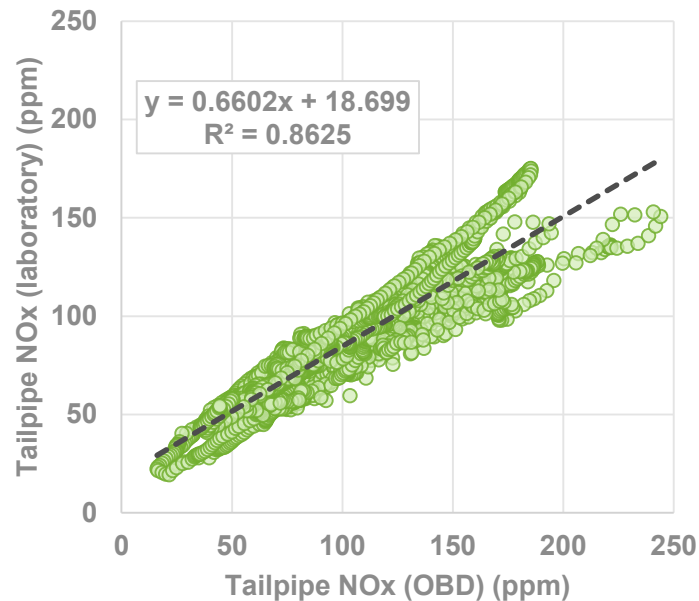
- Correlation of OBD vs references (laboratory, PEMS) generally not good due to different signal dynamics
- MAW significantly improve correlation

# Results – NO<sub>x</sub> concentration (MAW)

10 s MAW  
applied

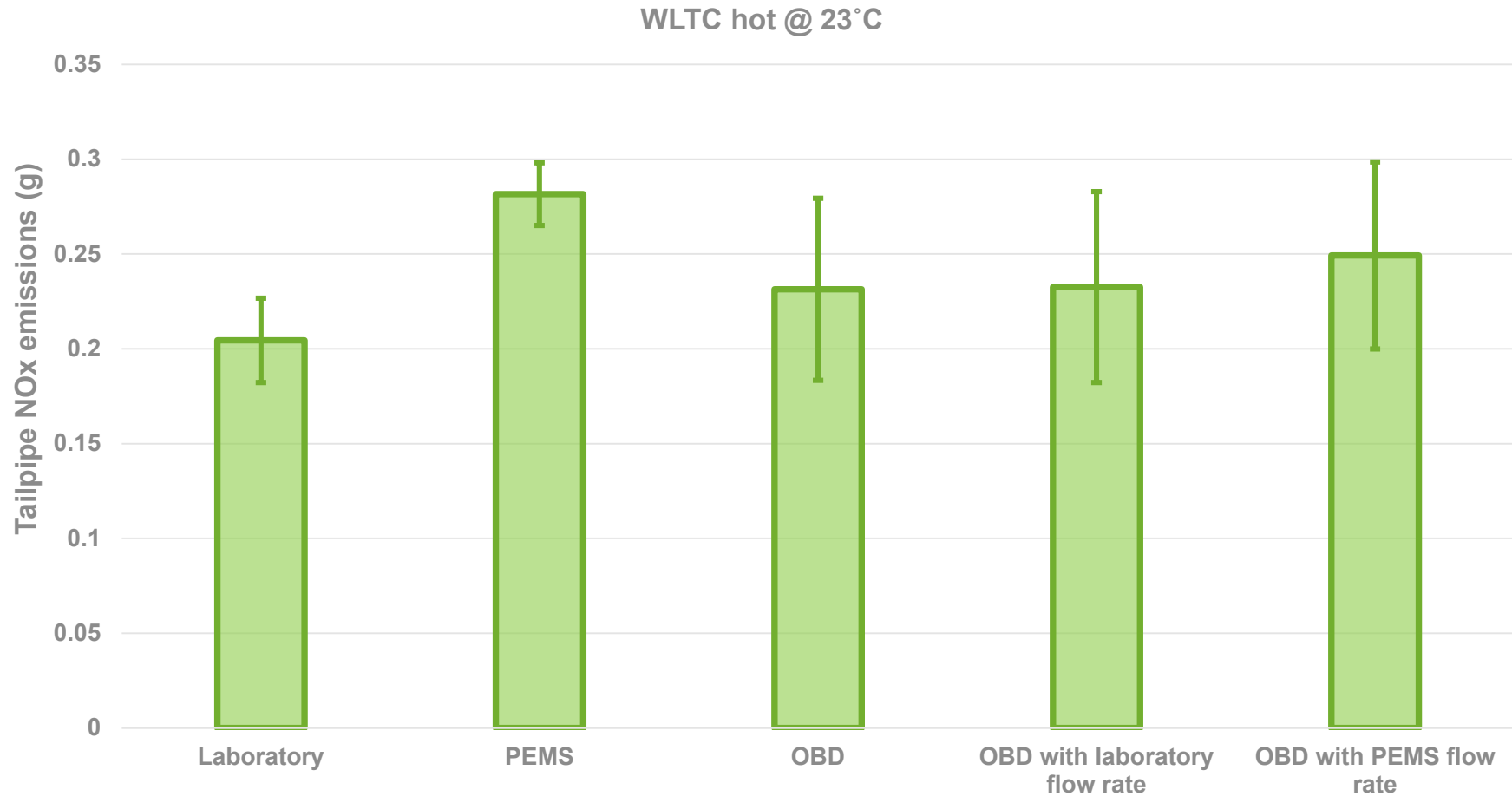


60 s MAW  
applied



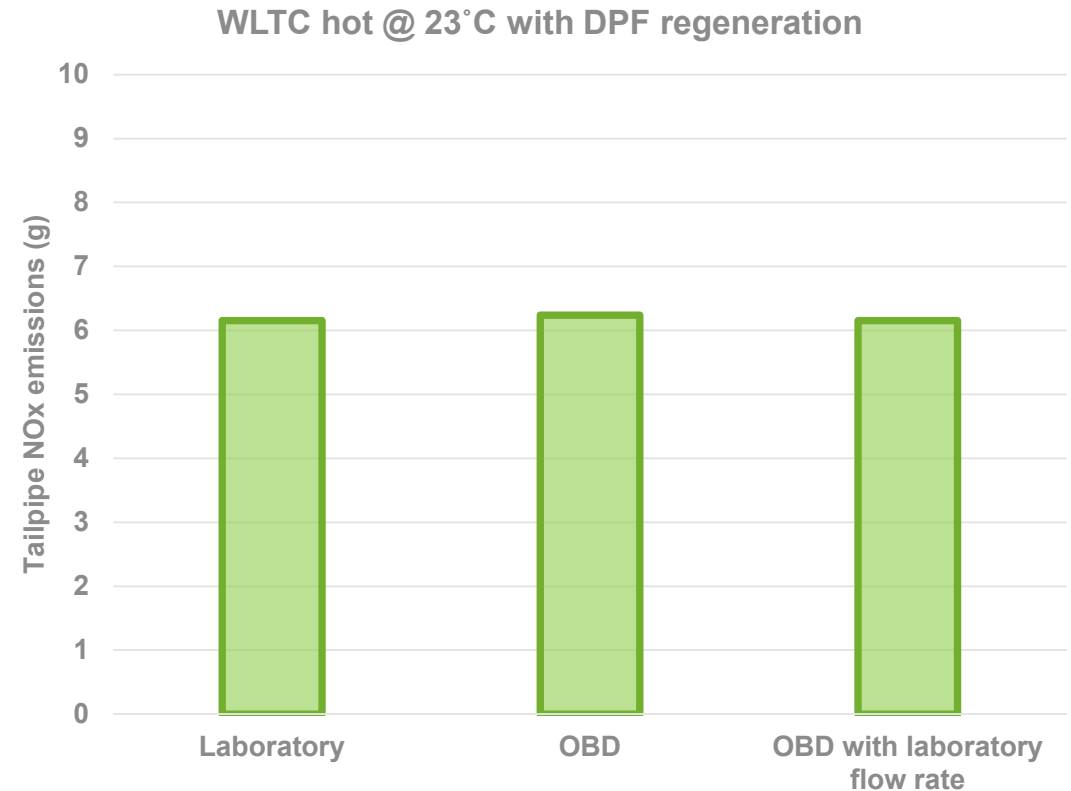
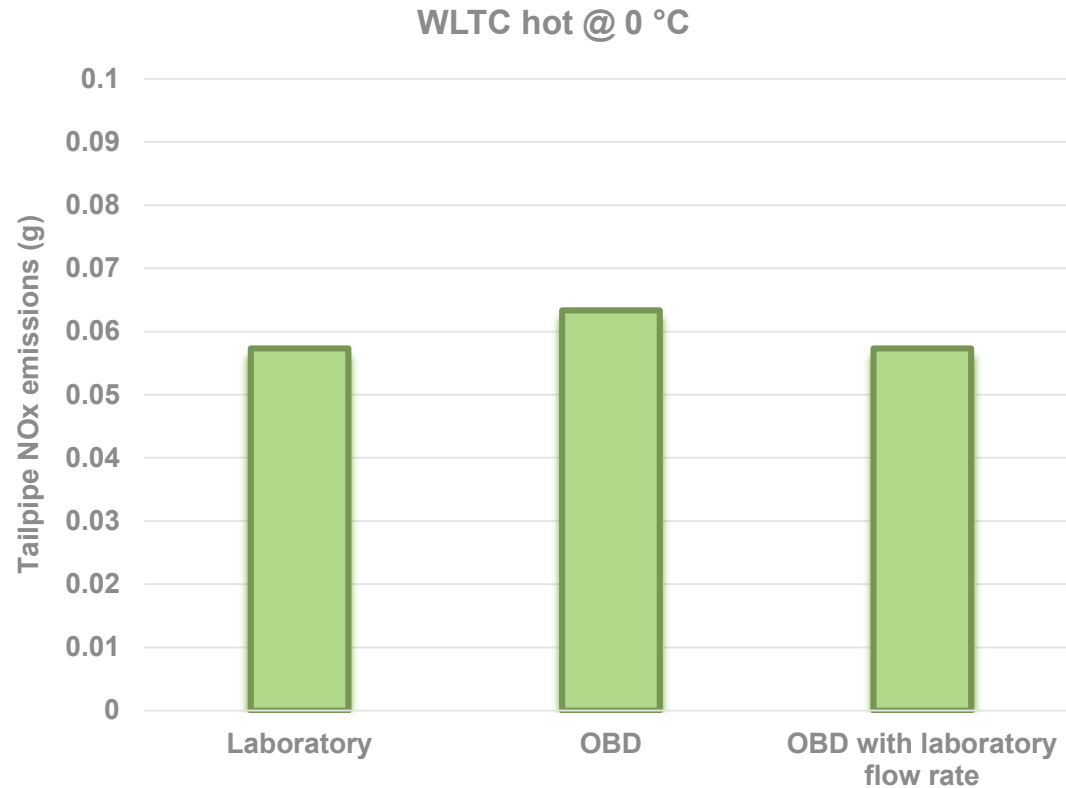


# Results – Emissions calculation



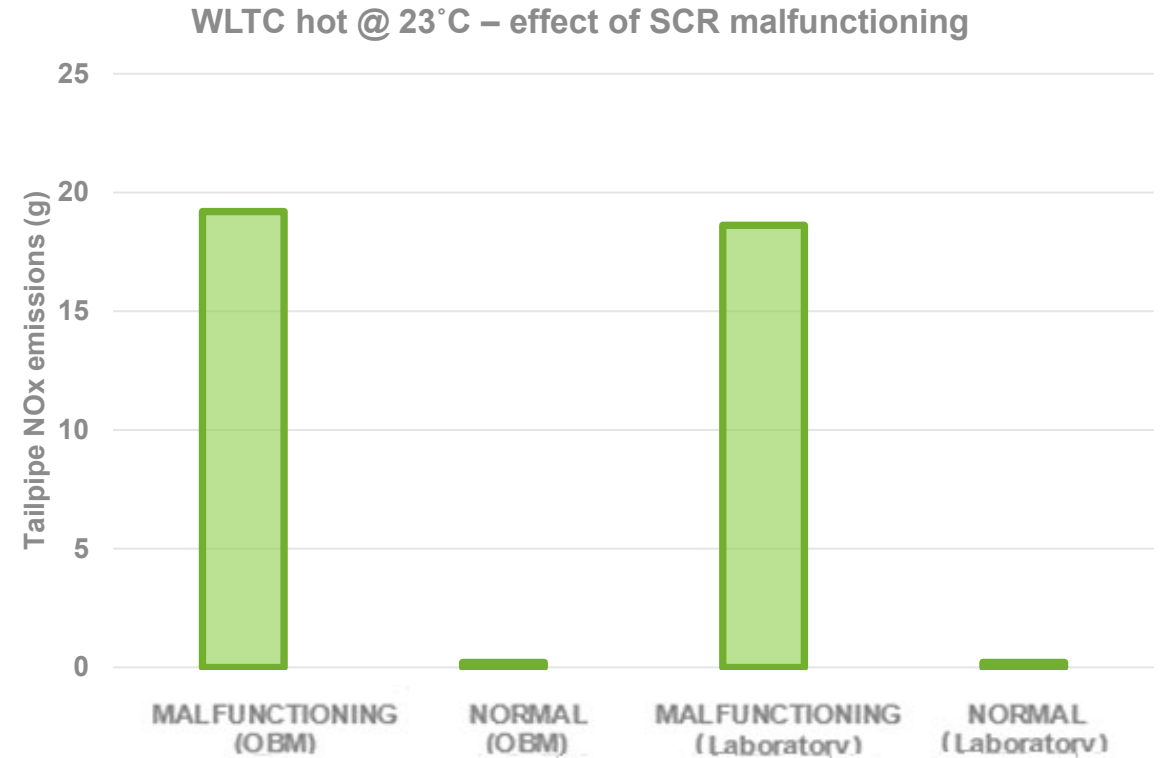
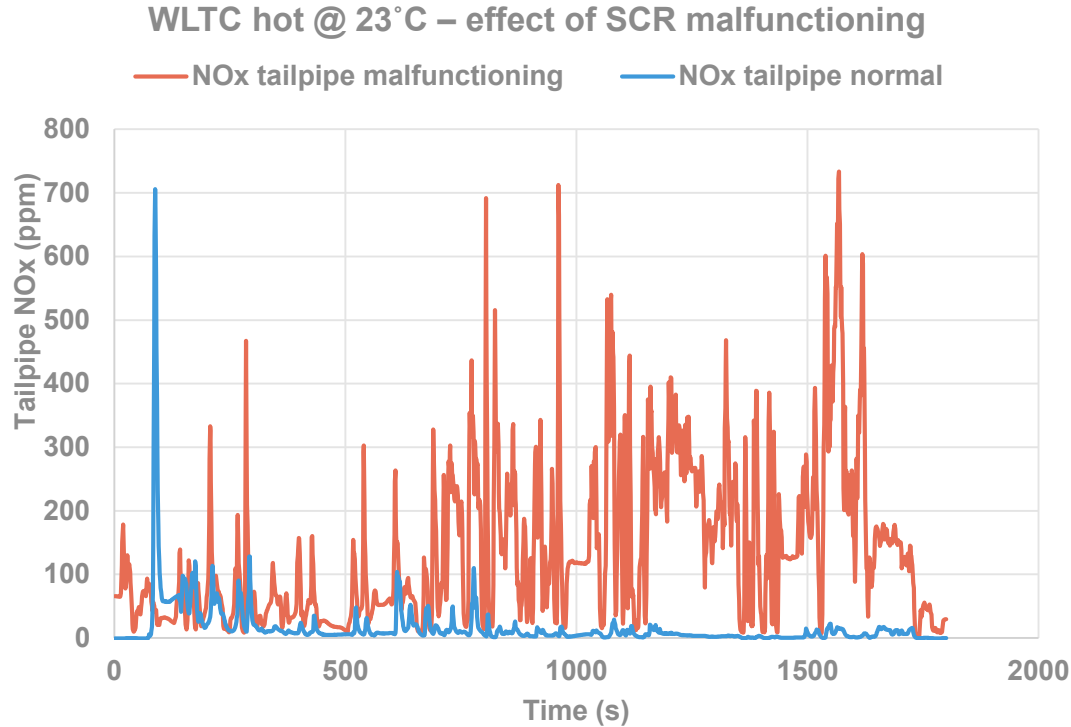
- Good agreement between the different methods
- PEMS difference mostly due to EFM

# Results – Emissions calculation



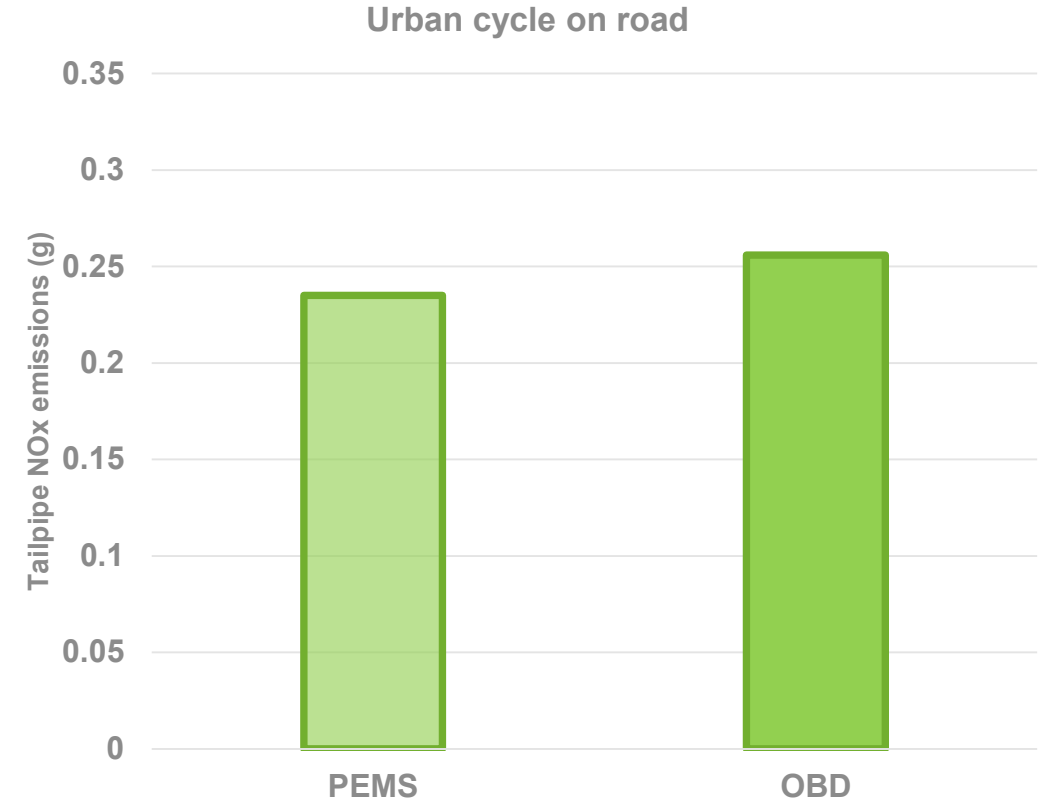
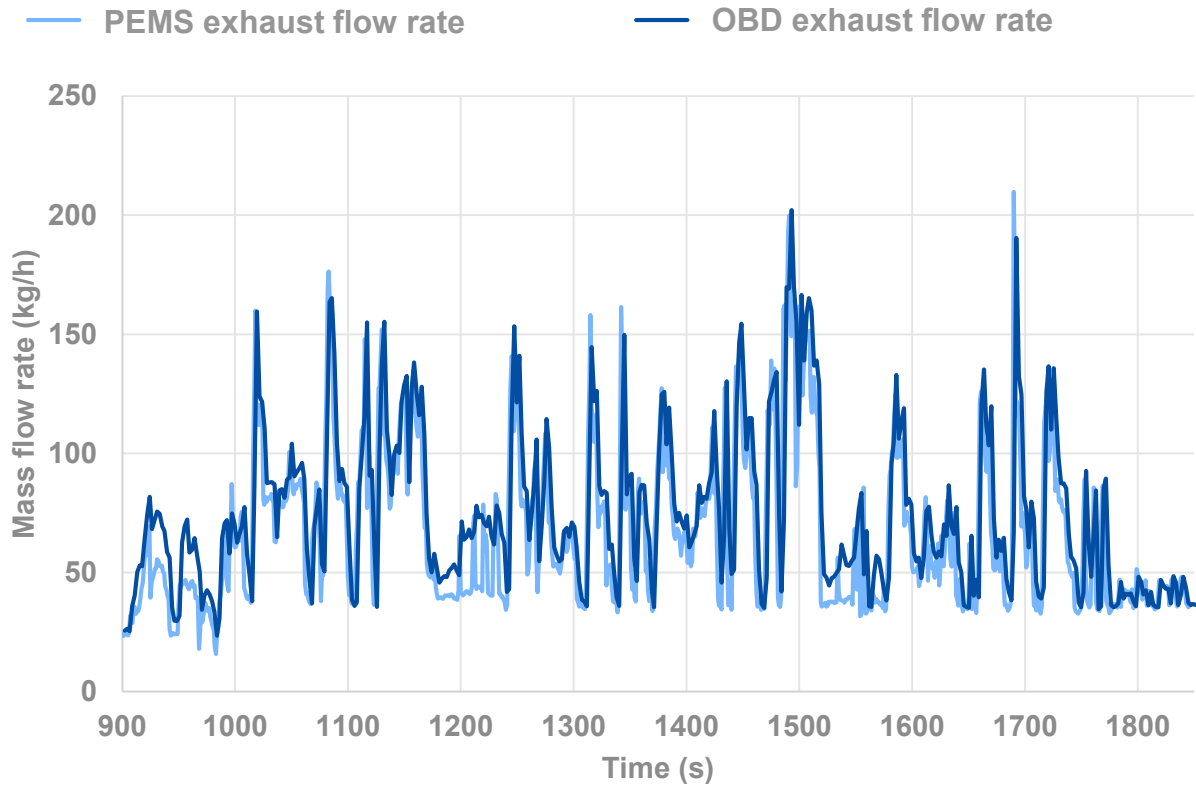
- Good agreement between the different methods even under different conditions

# Results – SCR malfunctioning



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

# Results – On road emissions



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

# 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 NO<sub>x</sub> emitters.
- Tests will continue on various types of vehicles to create a database.





# Thank you



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