Measuring Emissions from Heavy-Duty Vehicles Under Real World Conditions Using Advanced Portable Instruments and On-board Sensors

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11th Annual International PEMS Conference

The Joint Research Centre at glance

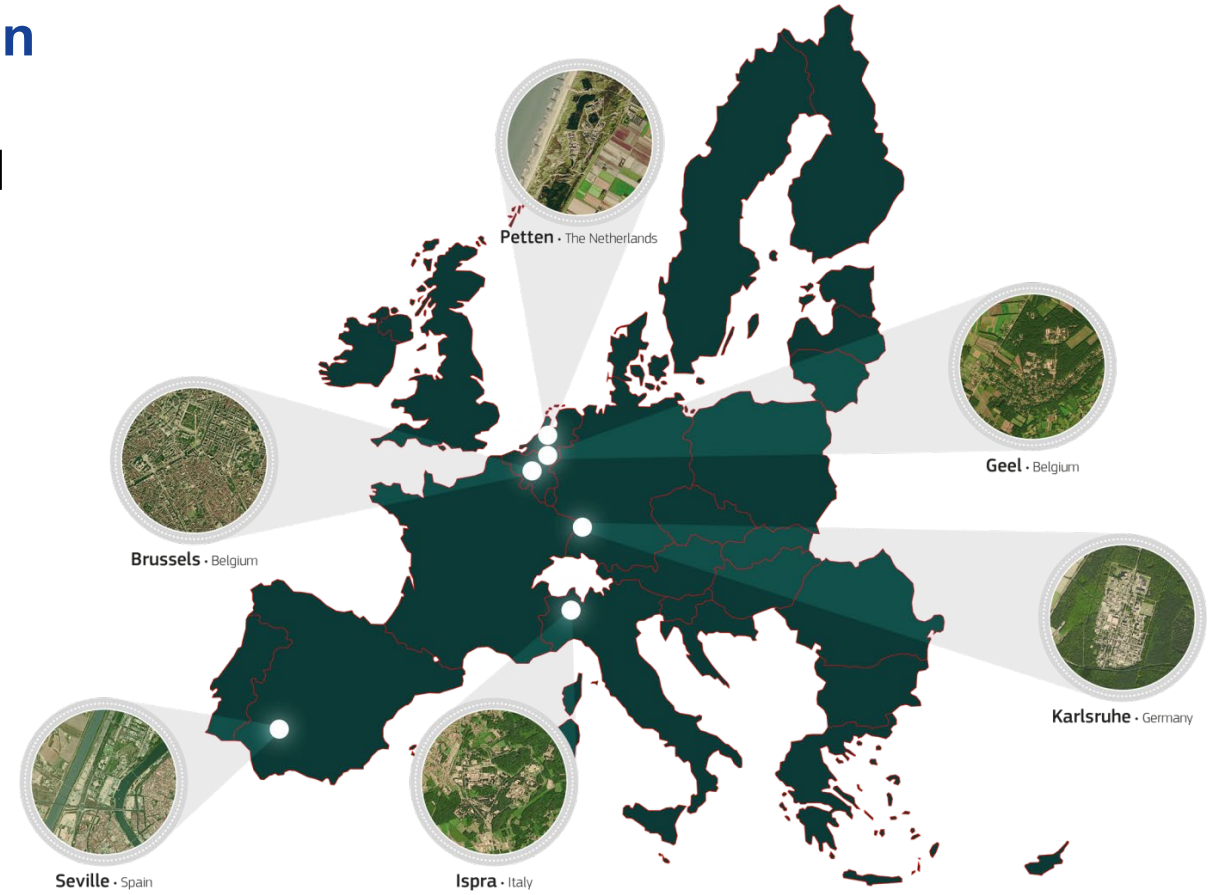
In-house science service of the European Commission

Independent, evidence-based scientific and technical support for many EU policies

2760 staff*

Almost 70% are scientists and researchers

Headquarters in Brussels and research facilities located in 5 Member States



Dir C: Energy, Transport & Climate

Sustainable Transport Unit: operates 8 vehicle test facilities (VELA labs), ~ 60 staff

* https://ec.europa.eu/jrc/en/publication/annual-reports/jrc-annual-report-2019

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Portable Emissions Measurement Systems on HDV

HD PEMS in EU include:

- CO_2
- NOx, CO, HC, CH_4,
- PN included with Euro VI-E

Emissions of NH_3 and N_2O

Emissions of NH_3 and N_2O are regulated in different regions:

- NH_3 (EU, South Korea)
  - QCL-IR, FTIR, LDS
- N_2O (USA, China)
  - QCL-IR, FTIR, NDIR, CG-ECD

These emissions are not verified or regulated during real-world operation

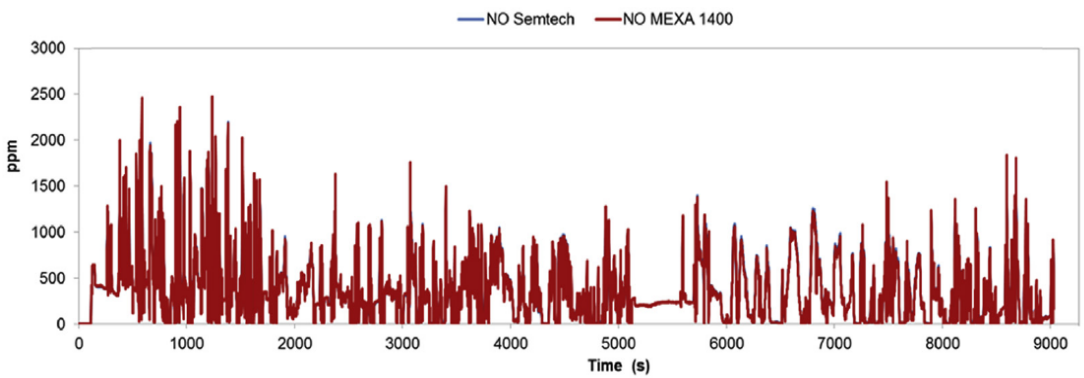
Where did it start?

Suarez-Bertoa et al., 2016, On-road measurement of NH_3 and N_2O emissions from a Euro V heavy-duty vehicle. Atmospheric Environment, 139, 167-175.

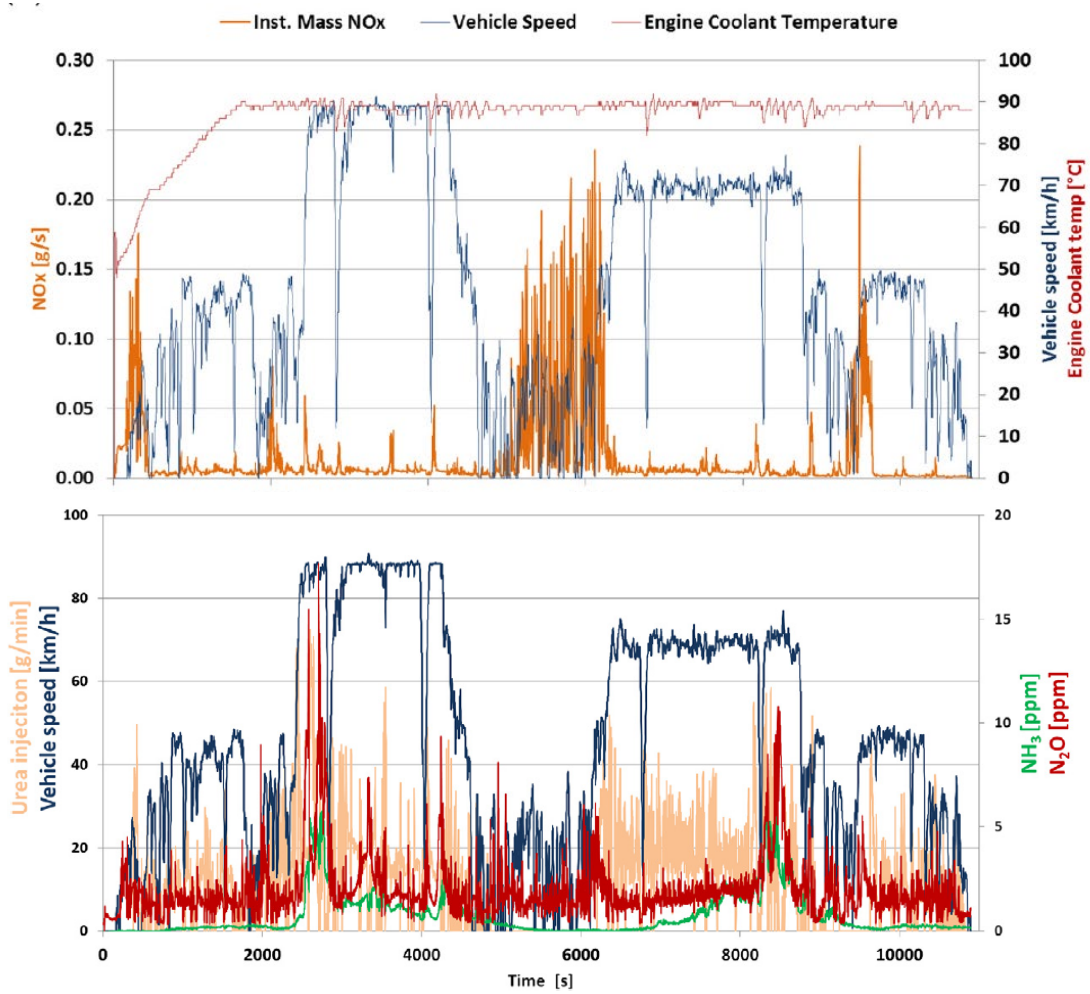
Mendoza-Villafuerte et al. 2017, NOx, NH_3, N_2O and PN real driving emissions from a Euro VI heavy-duty vehicle. Impact of regulatory on-road test conditions on emissions. Science of the Total Environment, 609, 546–555.

Where did it start?

Euro V



Euro VI



Portable measurement systems

	PEMSLAB	OBS-ONE-XL	LAS-NH_3/N_2O
Measuring principle	FTIR*	QCL	LAS
Compounds measured	N_2O, NH_3, CO, NOx,…	N_2O, NH_3	N_2O, NH_3
Cell temperature	180 °C	113 °C	190 °C
Sampling rate	1 Hz	10 Hz	10 Hz

*Spectral resolution 8 cm^{-1}

More information at: https://doi.org/10.3390/app112110055 and https://doi.org/10.3390/catal12020184

Emissions of NH_3 and N_2O - HD CNG

Tested vehicle

Fuel	CNG
Category	M3 Class I (interurban bus)
ATS	TWC
Standard	Euro VI-D
ICE size (cm^3)	8710
Production	2019

Instruments

Lab-grade:

- AVL-AMA
- AVL-SESAM (FTIR)
- MEXA-ONE-QL-NX (QCL)

Portable:

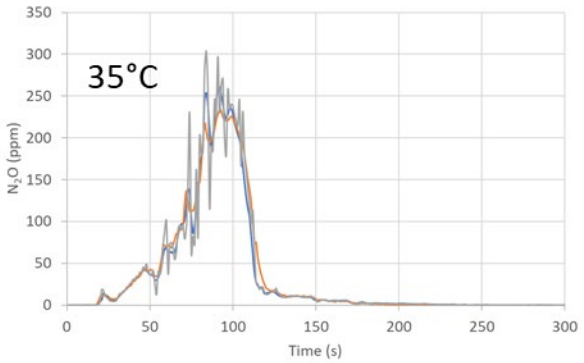
- HORIBA OBS-ONE-XL (pQCL)
- PEMSLAB (pFTIR)

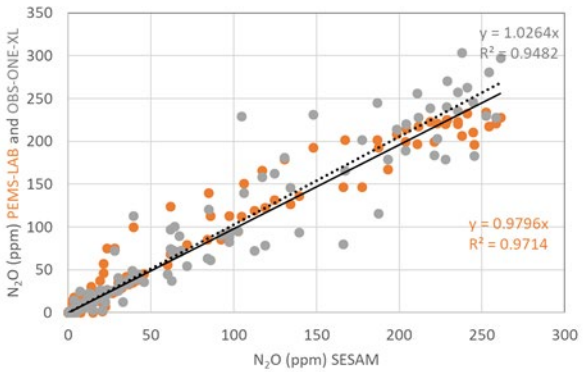
Tests performed

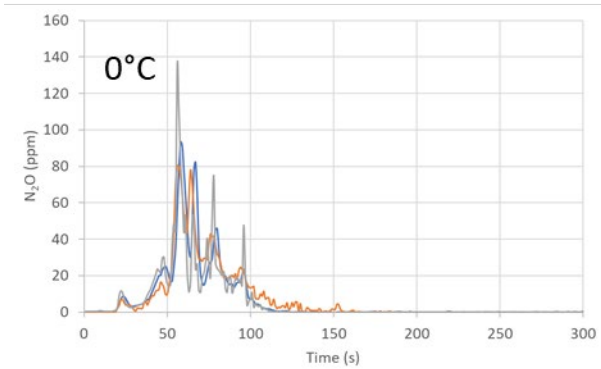
- WHVC cold + hot @ 35˚C
- WHVC cold + hot @ 23˚C
- WHVC cold + hot @ 0˚C
- WHVC cold + hot @ -7˚C
- On-Road tests

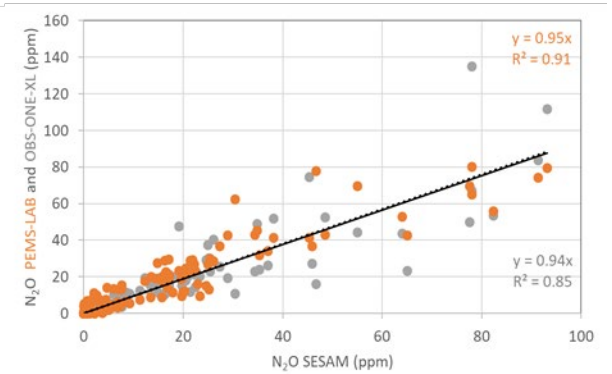
N_2O emissions measurements

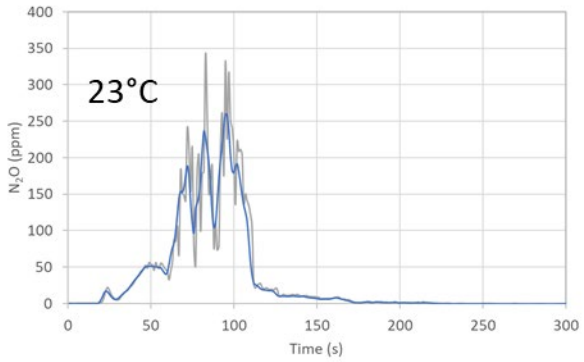
Lab-FTIR pQCL pFTIR

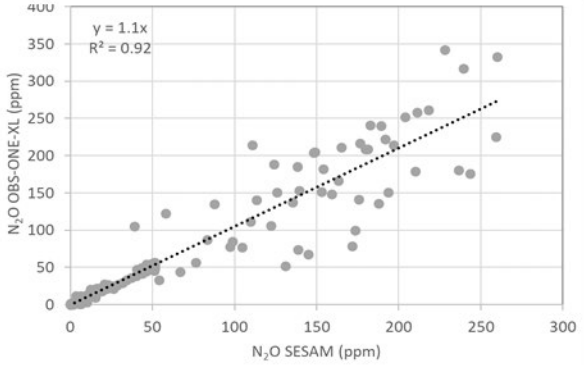


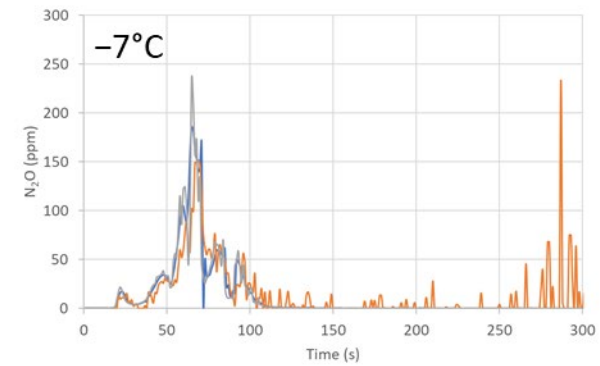


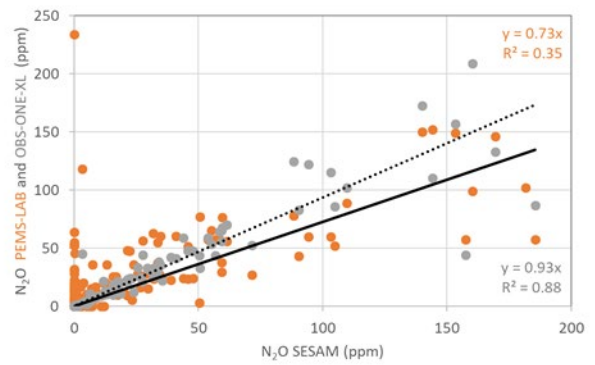












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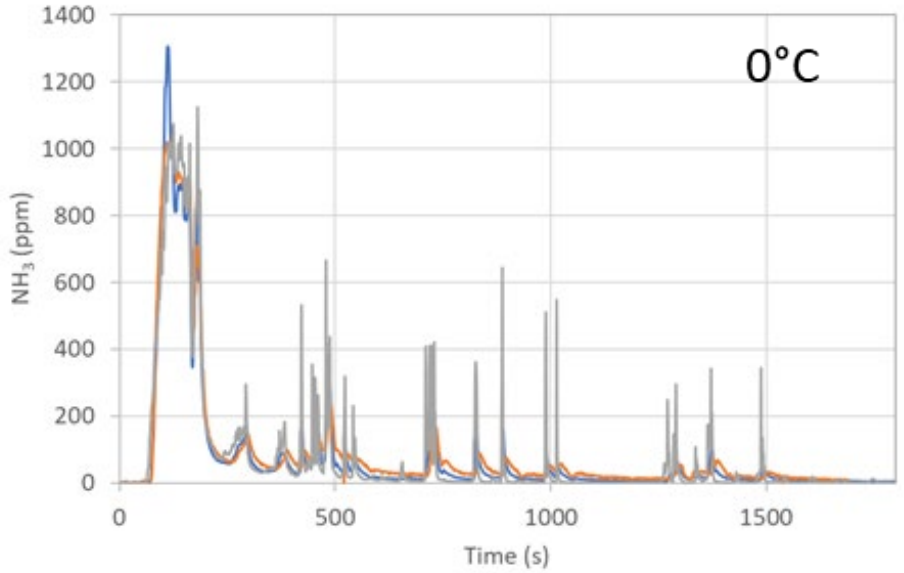
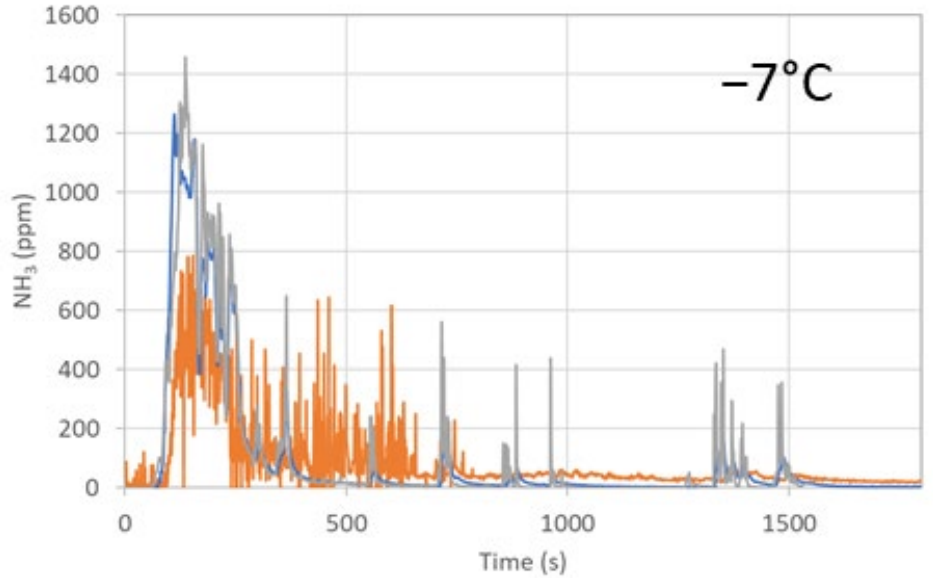
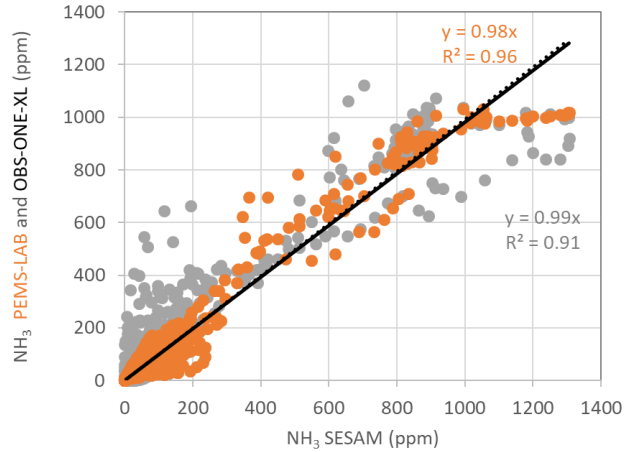
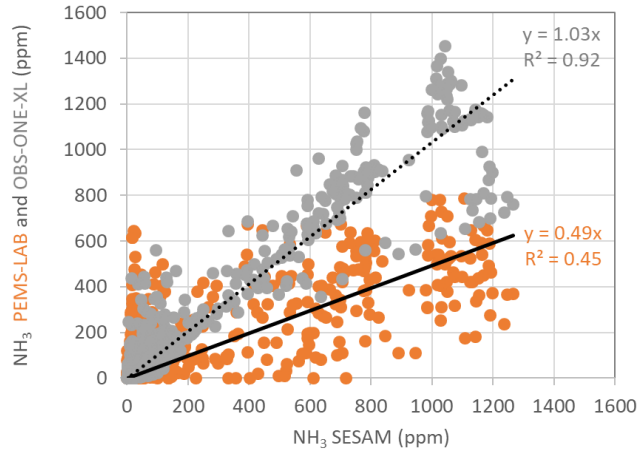
NH_3 emissions measurements

Lab-FTIR
pQCL
pFTIR



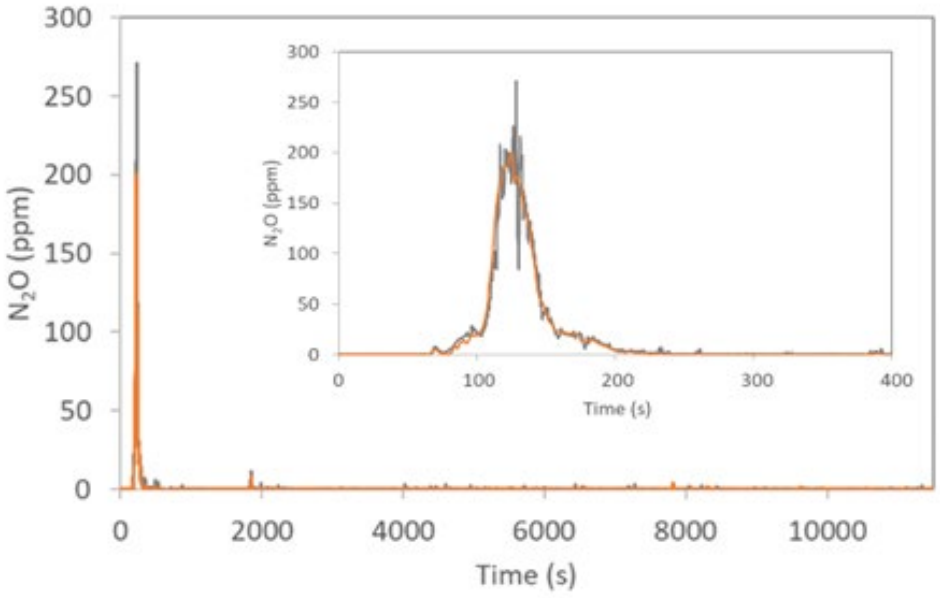


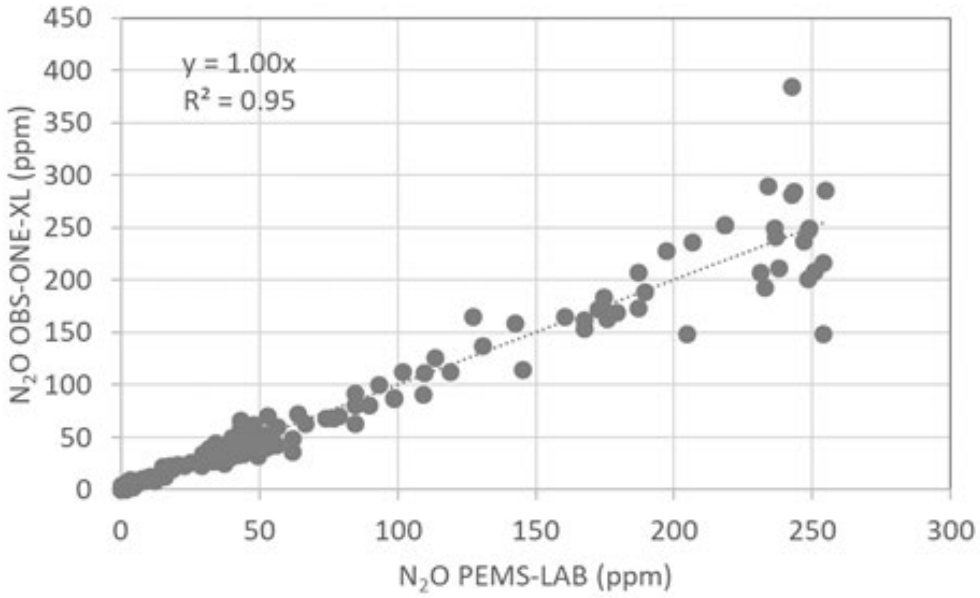




N_2O emissions measurements on-road

pQCL pFTIR





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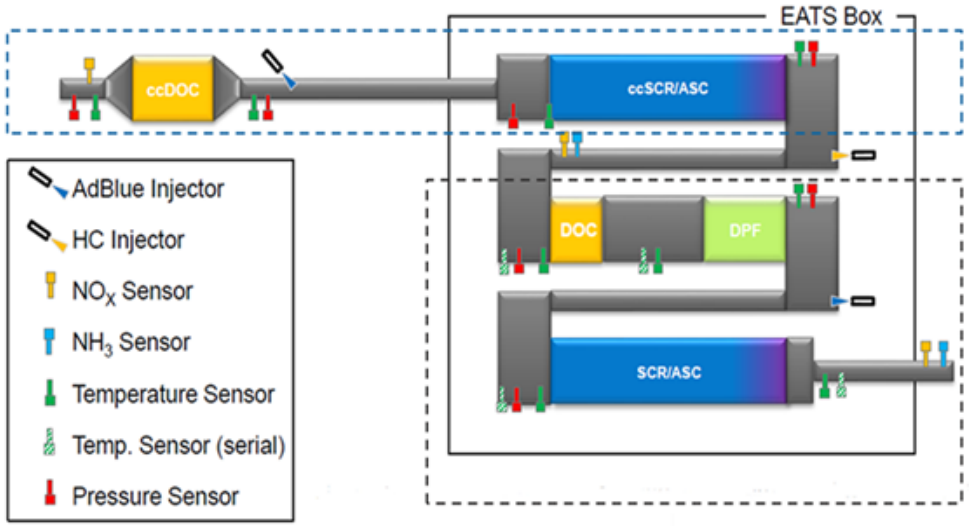
Emissions from a HD Diesel Demonstrator

Tested vehicle

Fuel	Diesel
Category	N3
Standard	Euro VI-C modified
ICE size (cm^3)	12 800



Instruments

Lab-grade:
- AVL-AMA
- AVL-SESAM (FTIR)
- MEXA-ONE-QL-NX

Portable:
- HORIBA OBS-ONE-XL
- AIP LAS-N_2O/NH_3

Sensors:
- NOx and NH_3

Tests performed

Test	T (˚C)
WHVC **COLD** & **HOT**	-7, 23, 35
RWT **COLD**	-7, 23, 35
Urban cycle **COLD**	-7, 23
JRC drive **COLD**	-7
“worst case” cycle **COLD**	-7

17 Different tests

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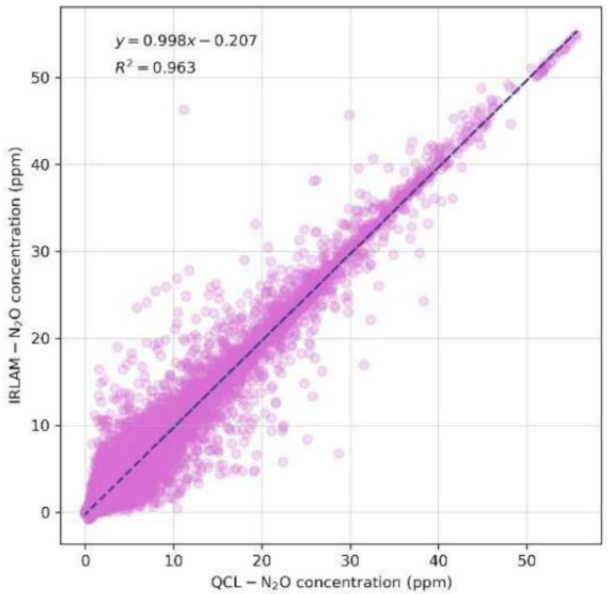
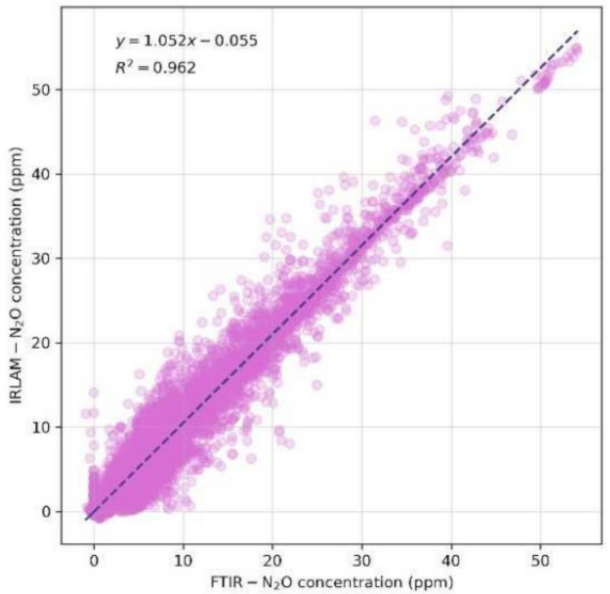
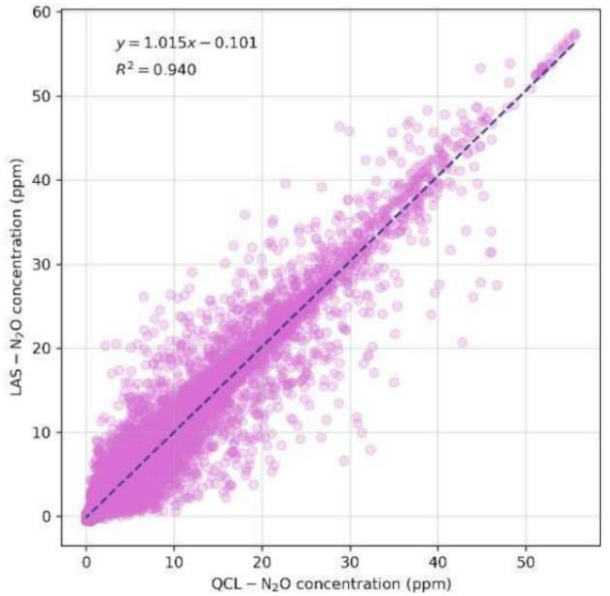
N_2O emissions measurements

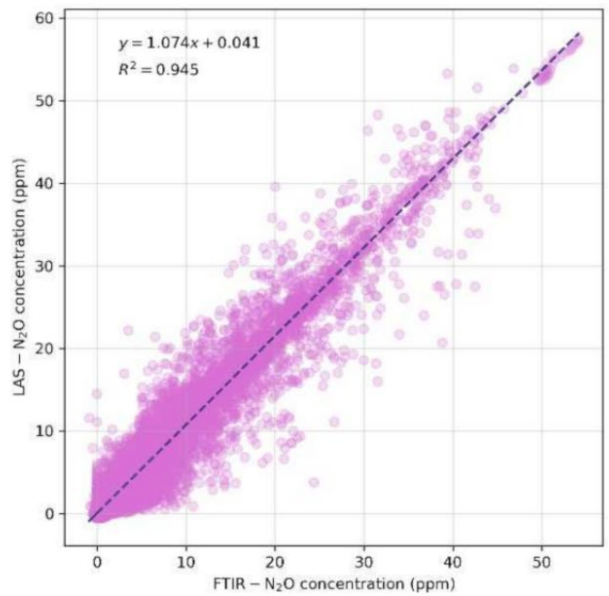
pQCL (IRLAM) vs Lab-QCL and Lab-FTIR





LAS vs Lab-QCL and Lab-FTIR





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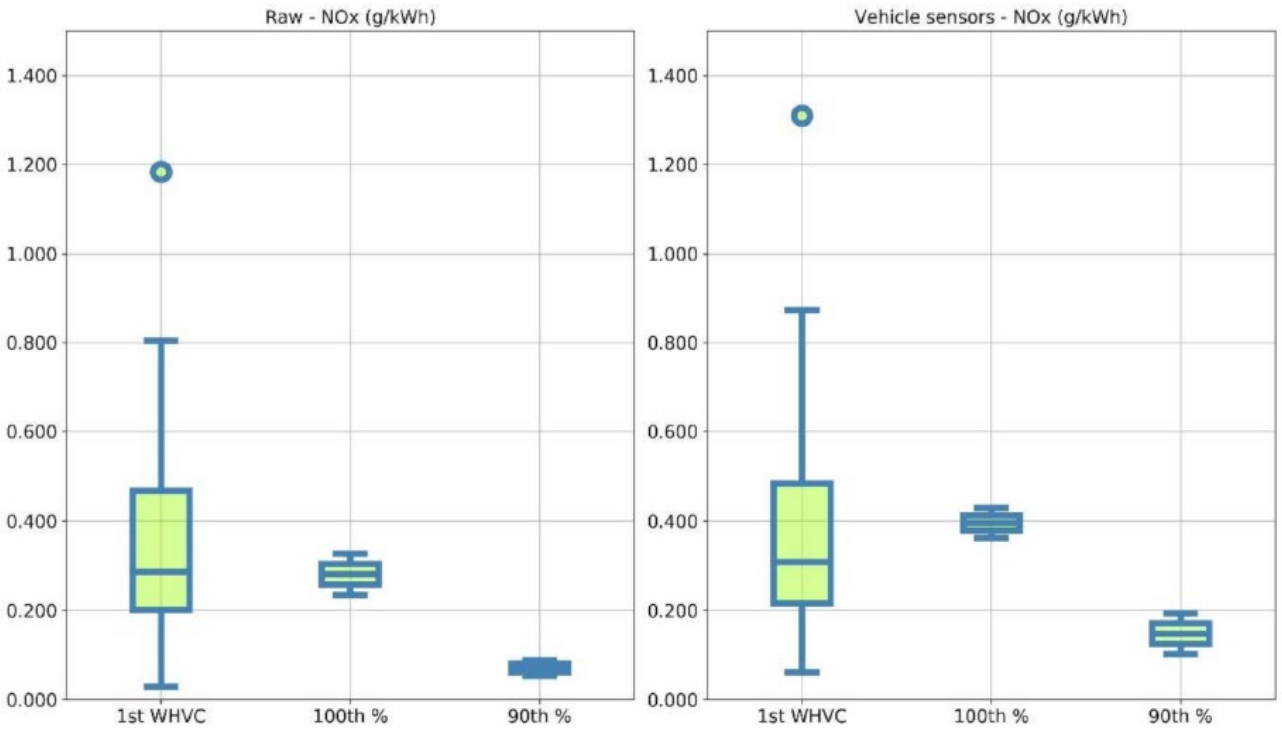
NOx emissions using on-vehicle sensors



- Commercial sensors present in the vehicle
- Emissions calculated using laboratory exhaust flow
- Sensors slightly overestimate emissions:
  - 15% short tests and 50% for 100th %
  - Larger at 90th % possibly due to the very low concentrations of the emissions.

Closing remarks

- There are portable measurement systems for NH_3 and N_2O that provide comparable results to laboratory grade instruments

- The specifications of the instruments needed for some applications must be carefully considered

- NOx measurements using commercially available on-vehicle sensors are very promising

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Thank you

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