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science for global insight

Do Remote Sensing campaigns across Europe give consistent results?

The case of Light Commercial Vehicles

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Acknowledgements:

Coauthors: Y. Chen & R. Sun (U South Carolina), and **Data:** AWEL Zürich, OPUS RSD, D. Carslaw (U York), A.Sjodin (IVL), J.Tate (U Leeds)

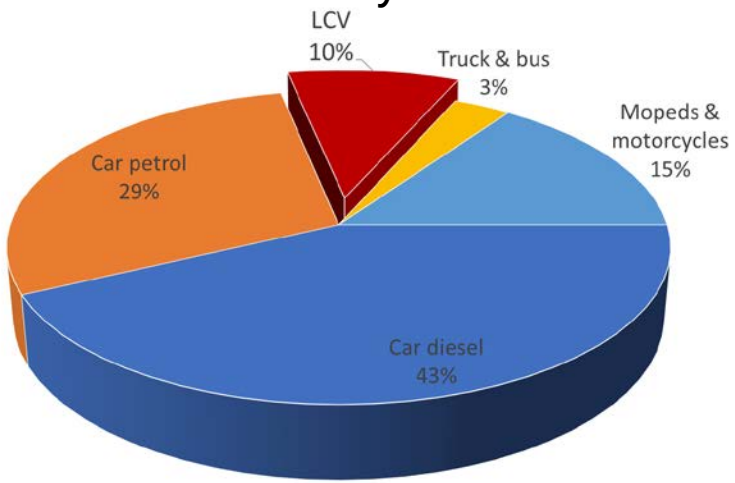
The issue

Emissions from passenger cars well measured,

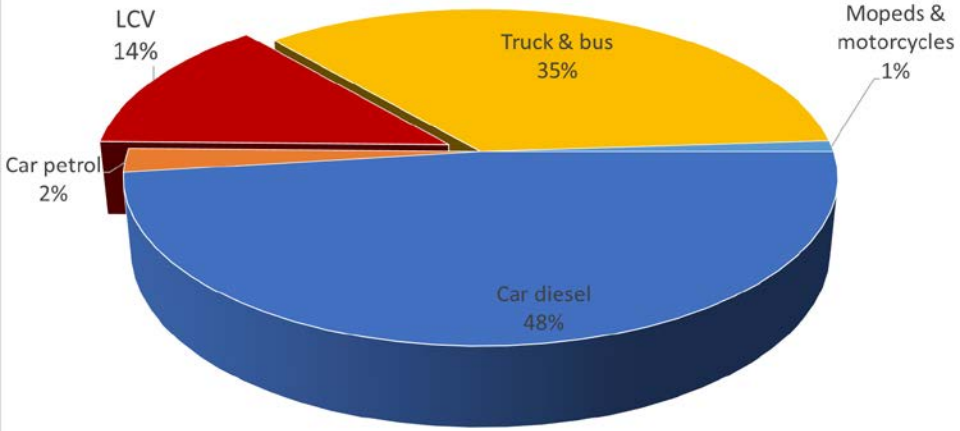
- Ease to recruit and measure…
- >90% of records in European RS data (chassis & PEMS

but other 30% vehicles ~50% total NOx and PM

EU27 in 2020: Share by vehicle numbers



EU27 in 2020: Share by NOx emissions



IIASA GAINS for EC Clean Air Outlook 2020

On-road measurements less abundant

Pool on-road data from different measurement campaigns:

For LCVs ~86,000 Remote Sensing records in CONOx db

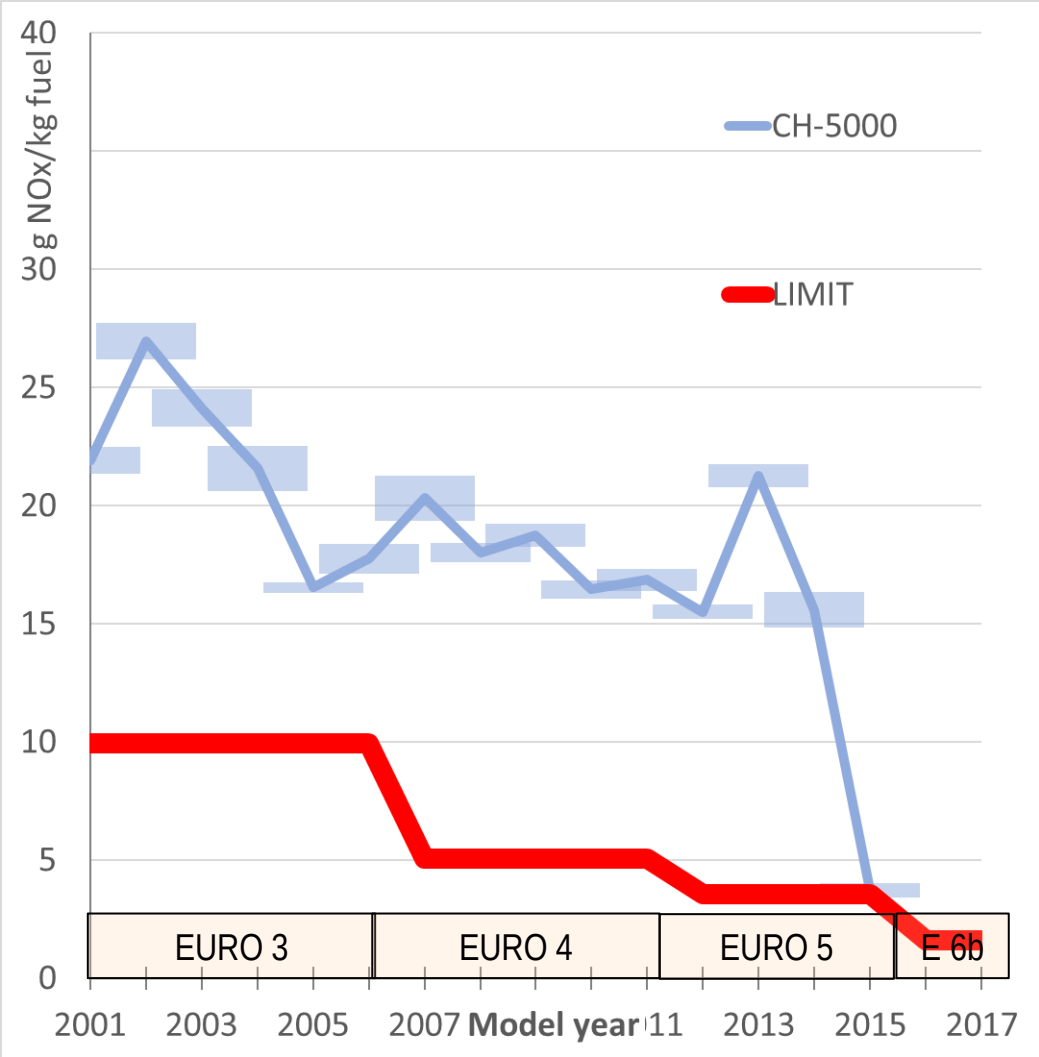
- range from 2011 to 2018;
- 4 countries: CH, ES, SE, UK;
- 18 locations

⇔

- Diverse operating teams and procedures
- Diverse RS instruments (FEAT, OPUS 4600 & 5000),
- Diverse fleets, ambient and driving conditions.

Do data really fit together? *Here: LCVs*

NOx: N1-III across Europe



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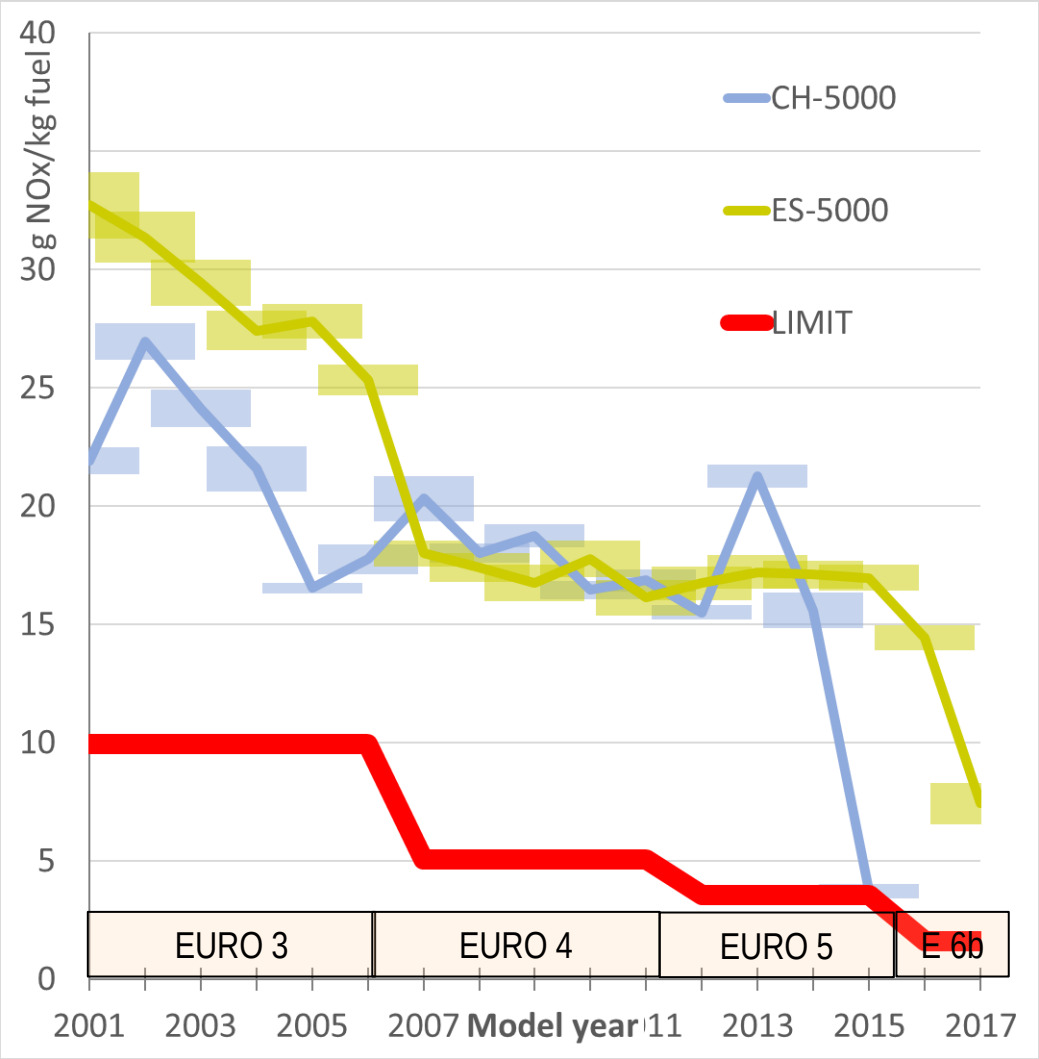

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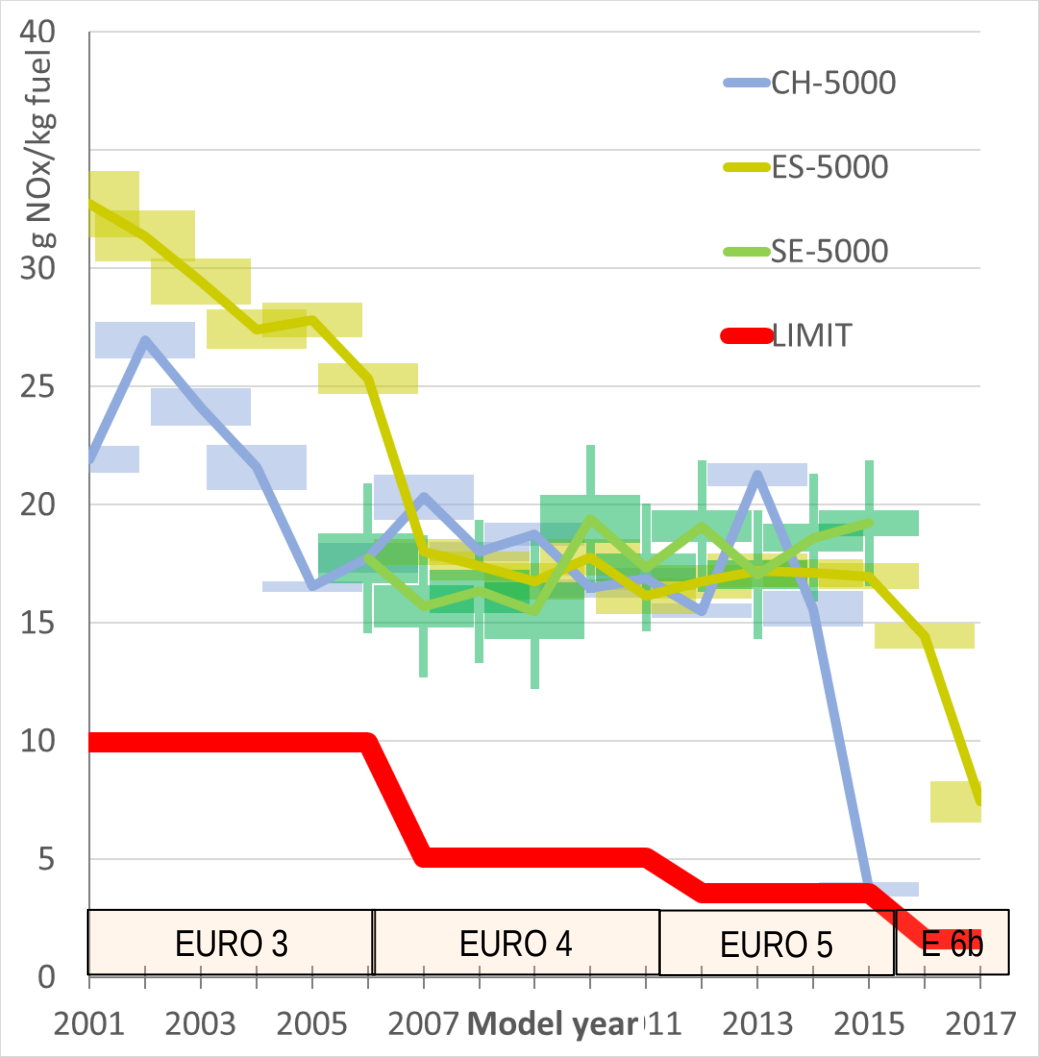
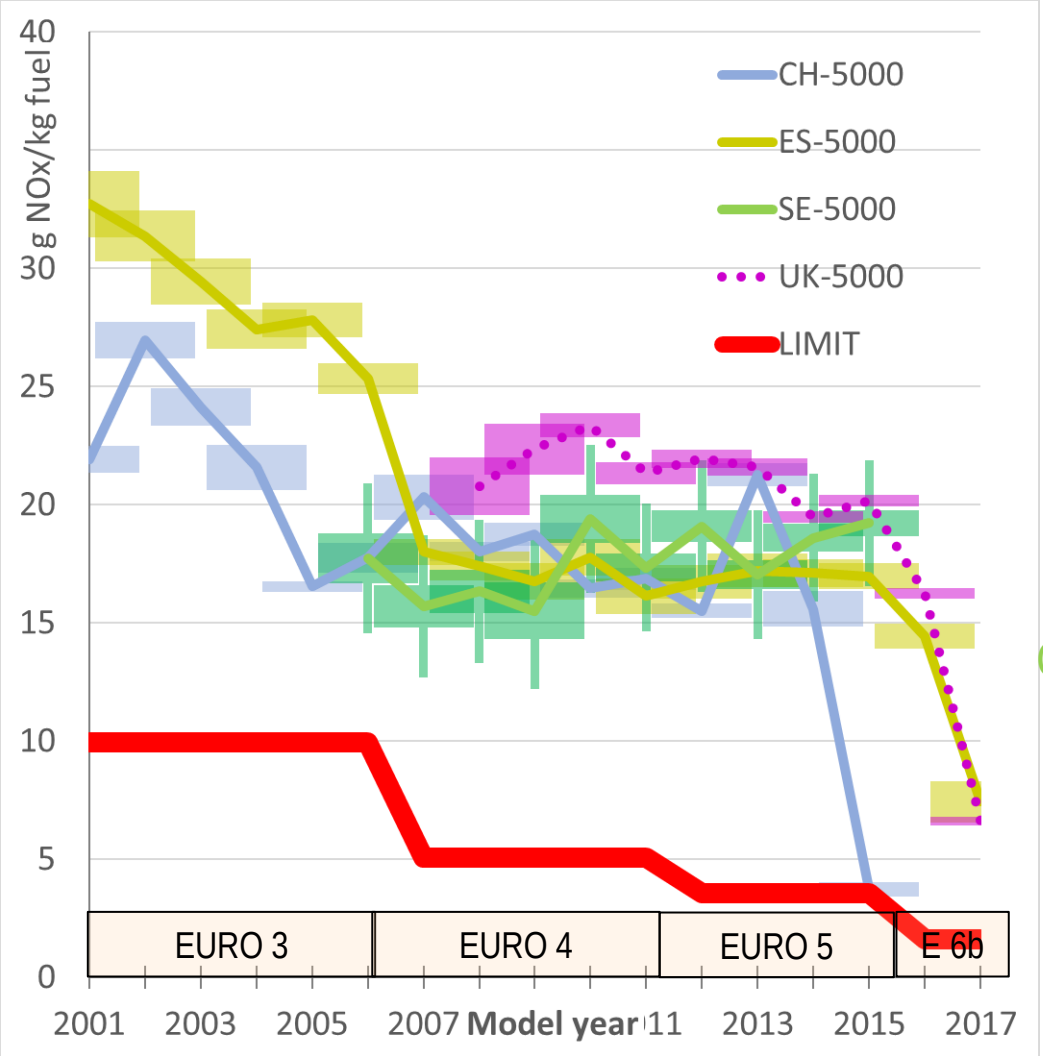


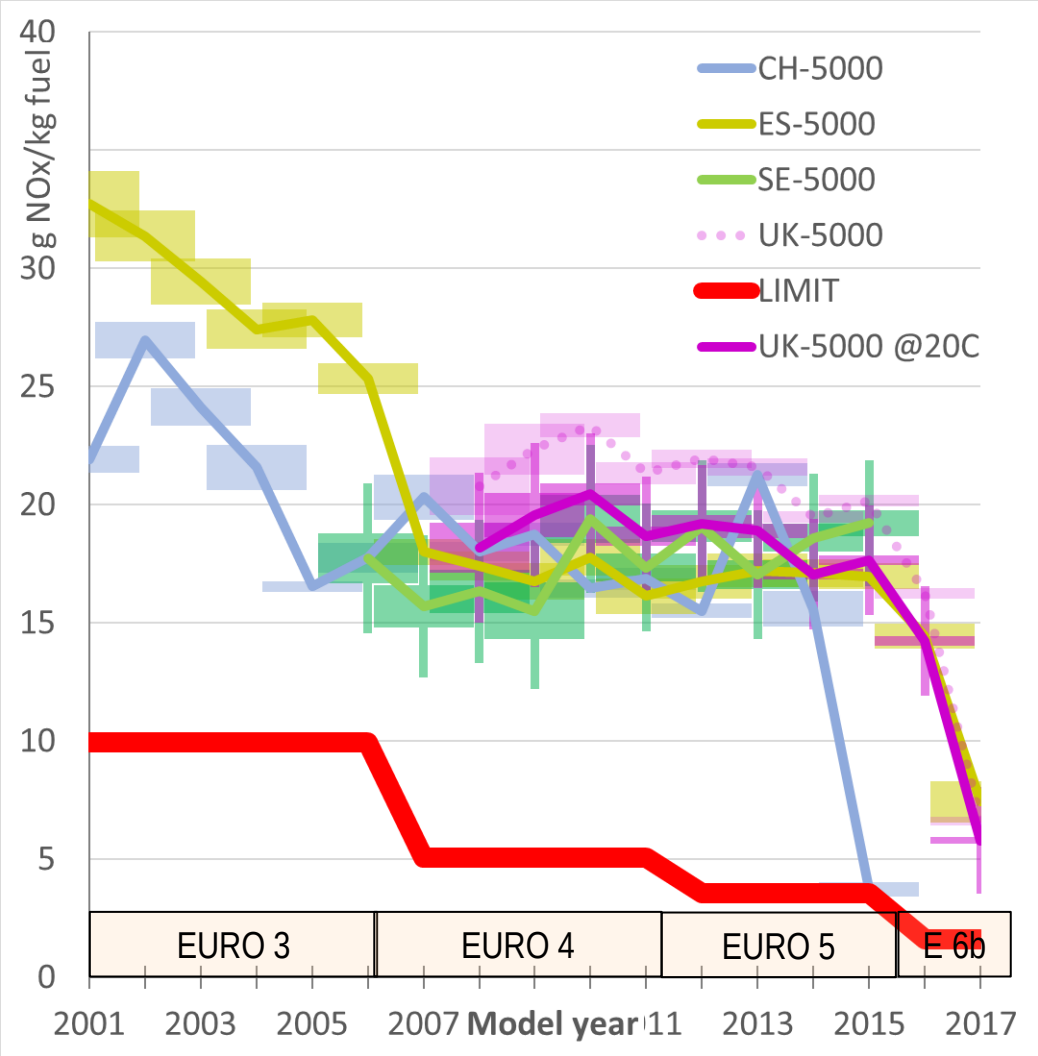
NOx: N1-III across Europe



London: ~10° C

CH, ES, SE: ~20° C

NOx: N1-III across Europe



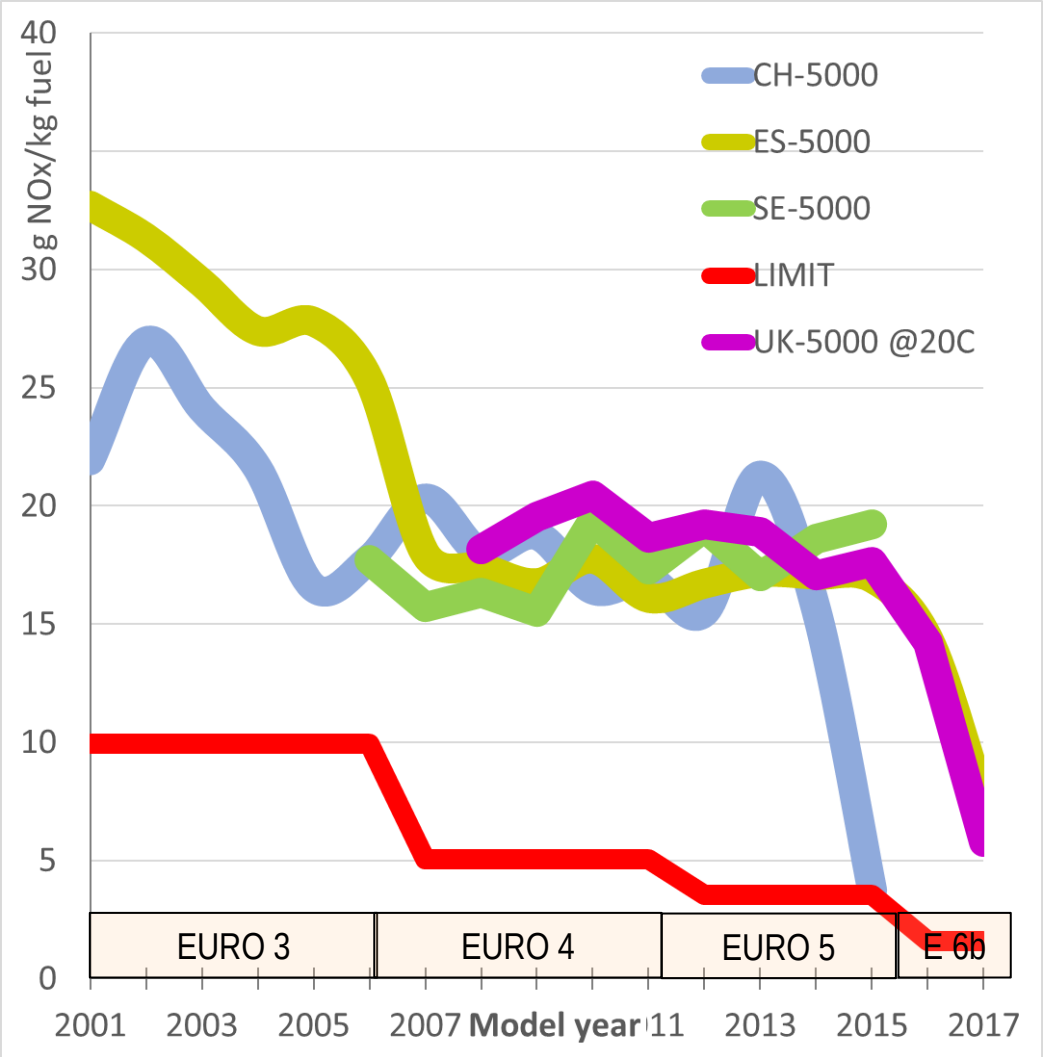
On-road NOx emissions of LCVs (N1-III) very consistent

Temperature dependence/ anomaly very important

London: ~10° C

London': ~20° C
CH, ES, SE: ~20° C

NOx: N1-III on-road & HBEFA?



On-road NOx emissions of LCVs (N1-III) very consistent

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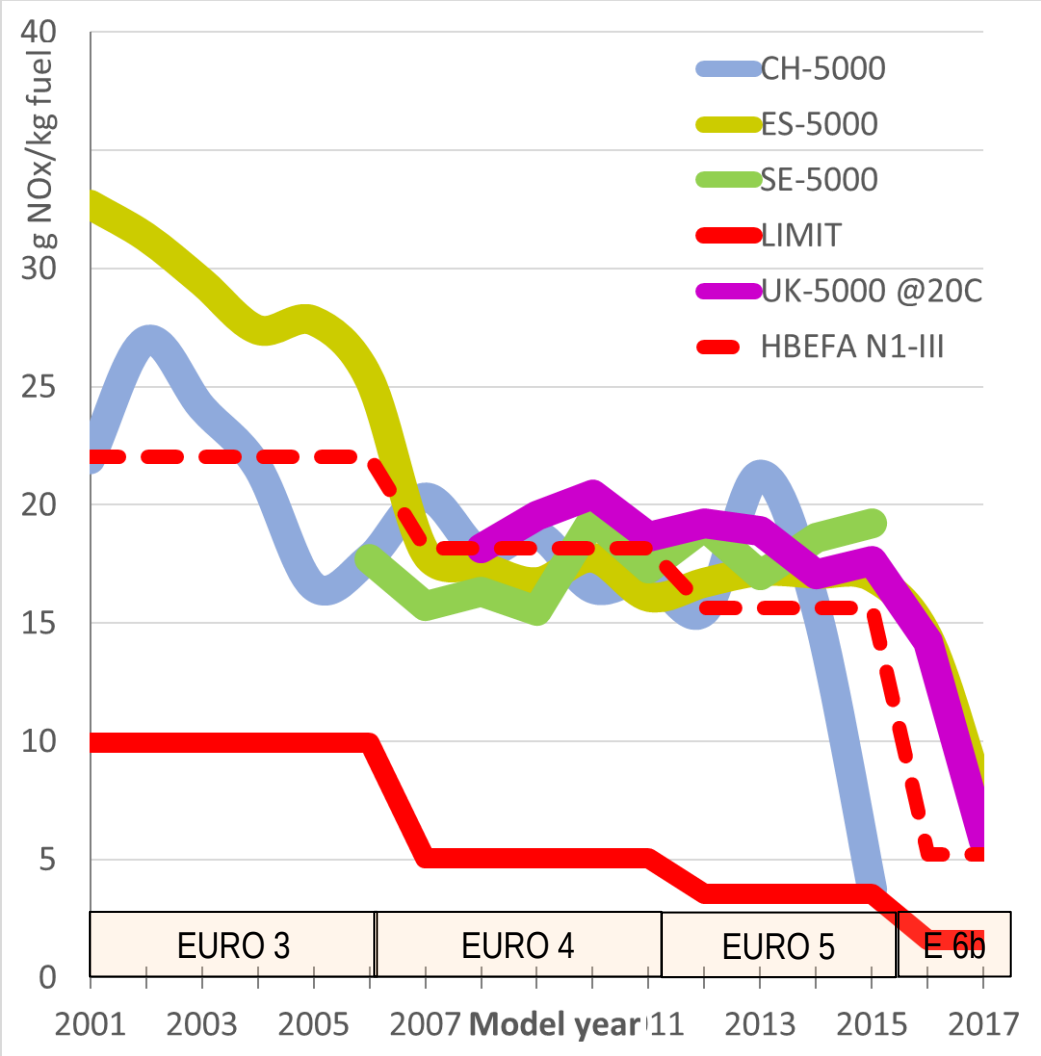
NOx: N1-III on-road & HBEFA!!!

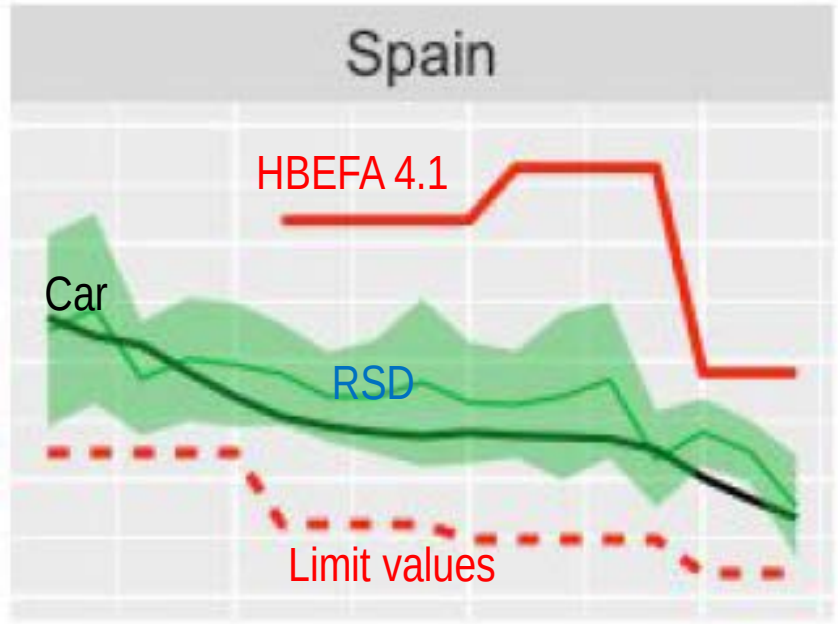


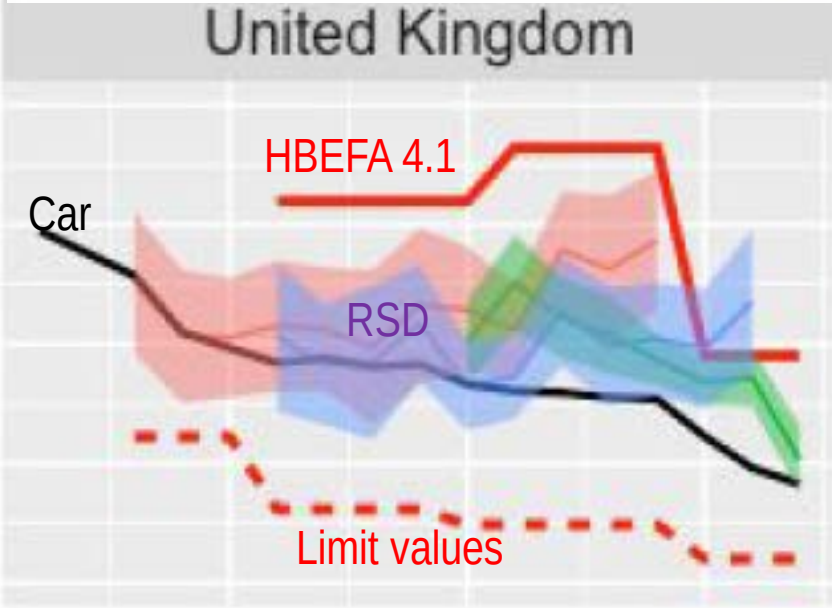
On-road NOx emissions of LCVs (N1-III) very consistent

Temperature dependence/ anomaly very important (as for passenger cars)

HBEFA 4.1 fitting for urban driving !!!

NOx: N1-I on-road & HBEFA



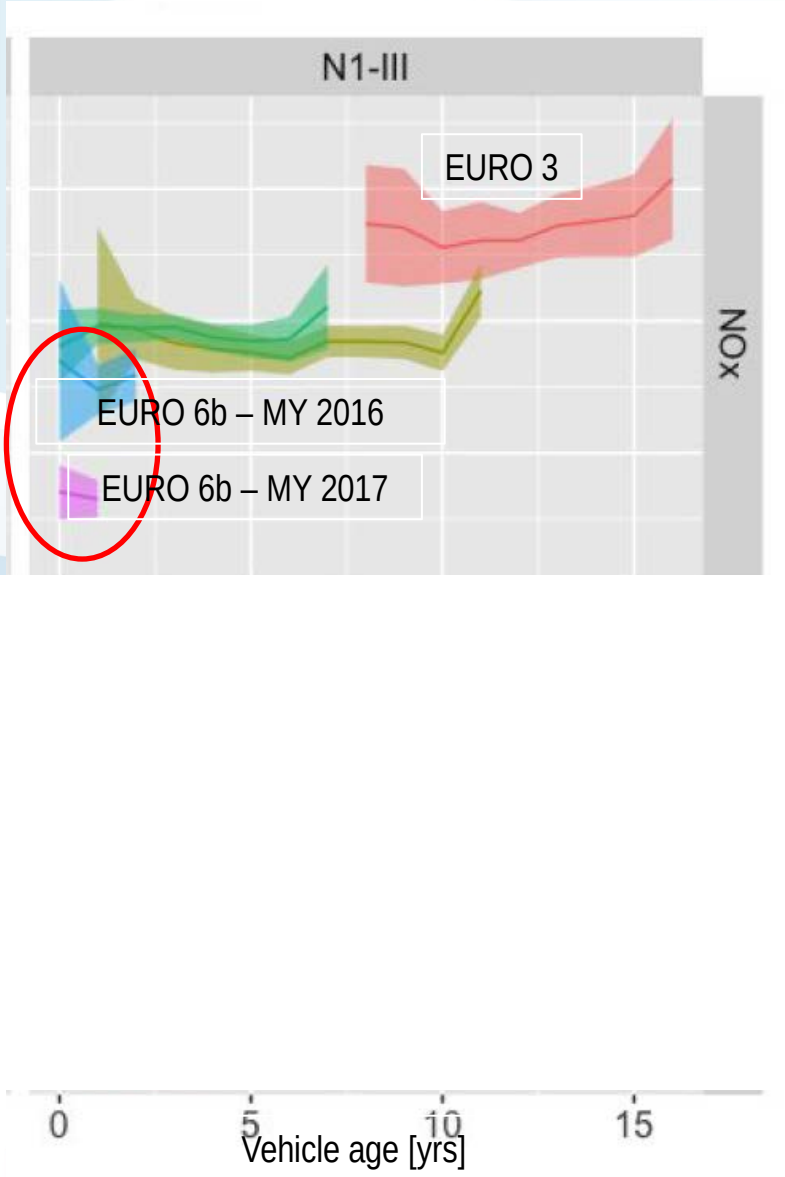


On-road NOx emissions of LCVs (N1-I) very consistent, similar to passenger cars

Always far higher than TA limits

HBEFA 4.1 should be revised for N1-I and N1-II (no big deal)

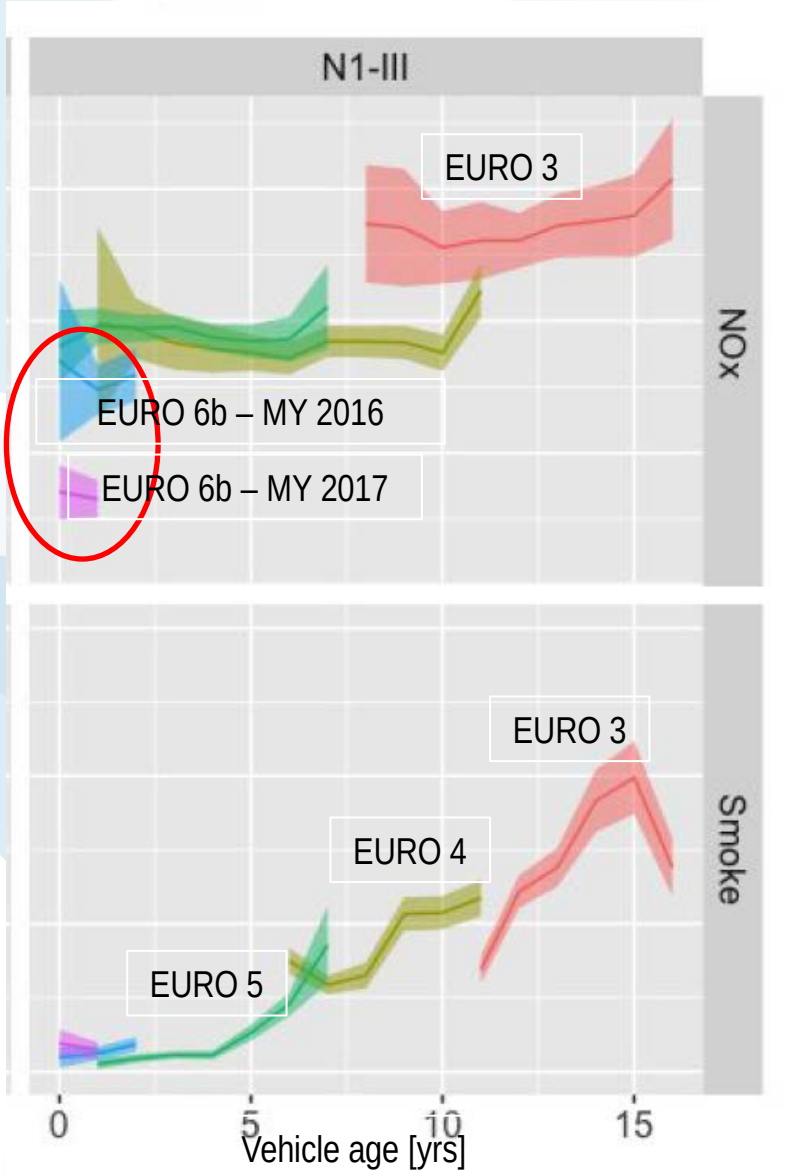
NOx and smoke with vehicle age – avg. over countries & instruments



Hardly evidence for NOx deterioration with vehicle age

Step changes across EURO 6 generations

NOx and smoke with vehicle age – avg. over countries & instruments



Hardly evidence for NOx deterioration with vehicle age

Step changes across EURO 6 generations

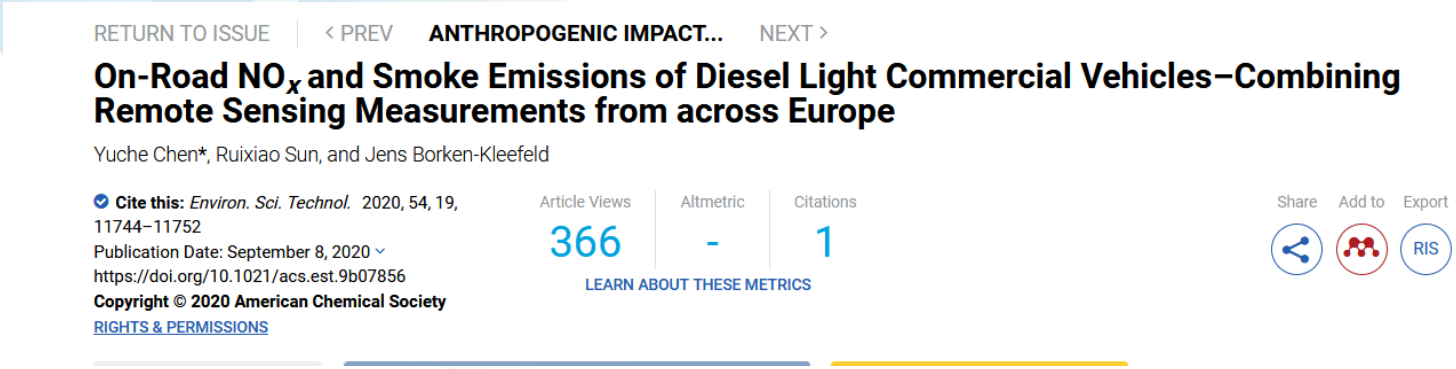
Smoke measurements indicate

- Successively lower emission levels for more modern LCVs
- significant deterioration.

Conclusions

On-road measurements needed for trucks and highways

- Data pooling possible and crucial to address less abundant vehicles or driving conditions
  - Care needed between RSD instrument generations/types
- Deterioration of NOx rather small, but significant for smoke emissions (hence for PM!?)
- HBEFA 4.1 NOx emission factor confirmed for N1-III, but should be revised for N1-I and N1-II



Environmental Science & Technology

Further reading

- **AWEL Zurich:** “Langjährige Abgasmessungen mittels Remote Sensing” https://awel.zh.ch/internet/baudirektion/awel/de/luft_klima_elektrosmog/verkehr/rsd.html

- **ICCT / TRUE:** Remote sensing campaigns in London (2017/18) and Paris (2018) https://www.theicct.org/publications/vehicle-emission-remote-sensing

- **CONOx: Pan-European RS data** published by the Swiss BAFU https://www.bafu.admin.ch/ -> studies.html

- **CARES – City Air Remote Emission Sensing** H2020 project https://cares-project.eu/

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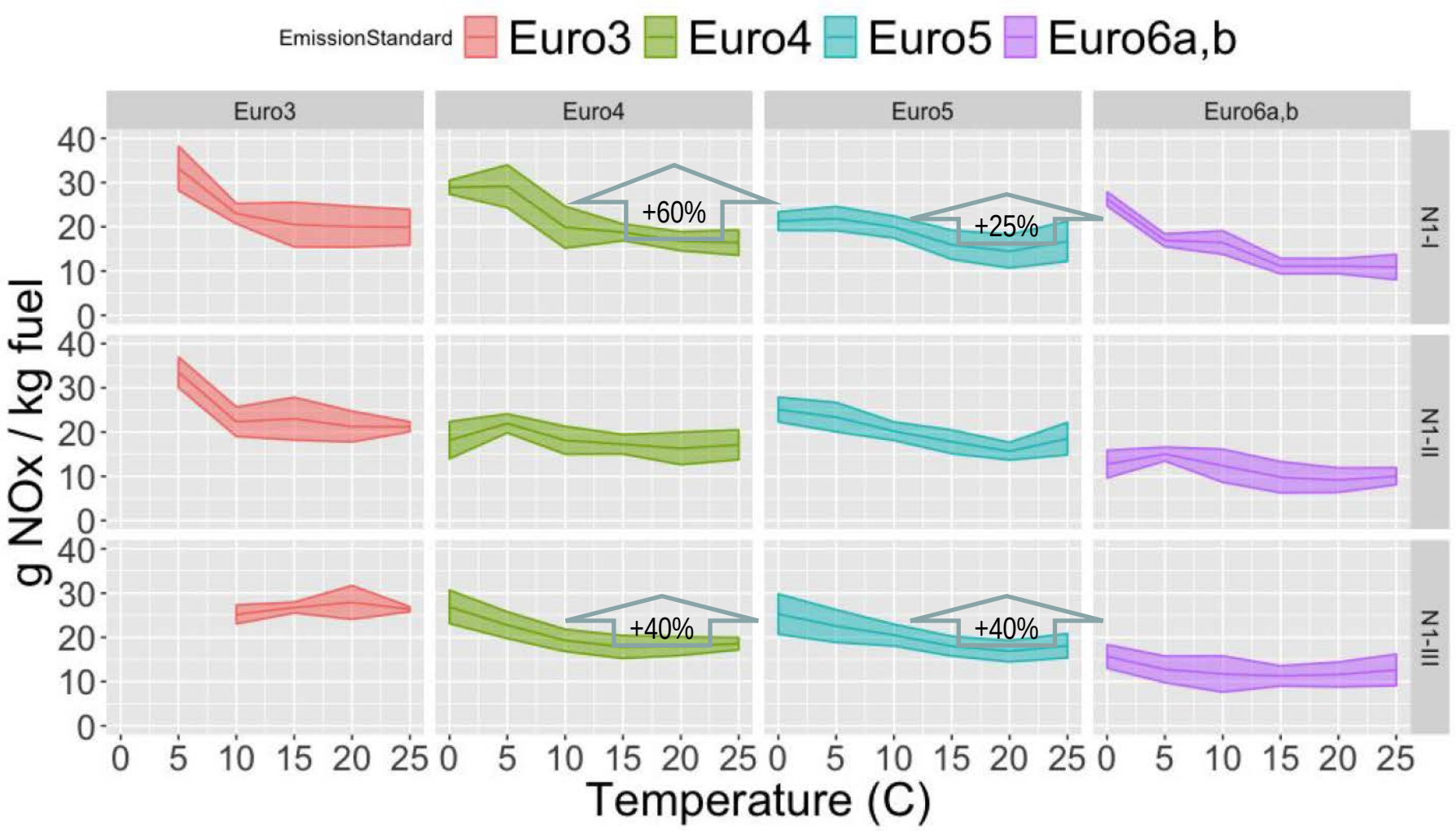
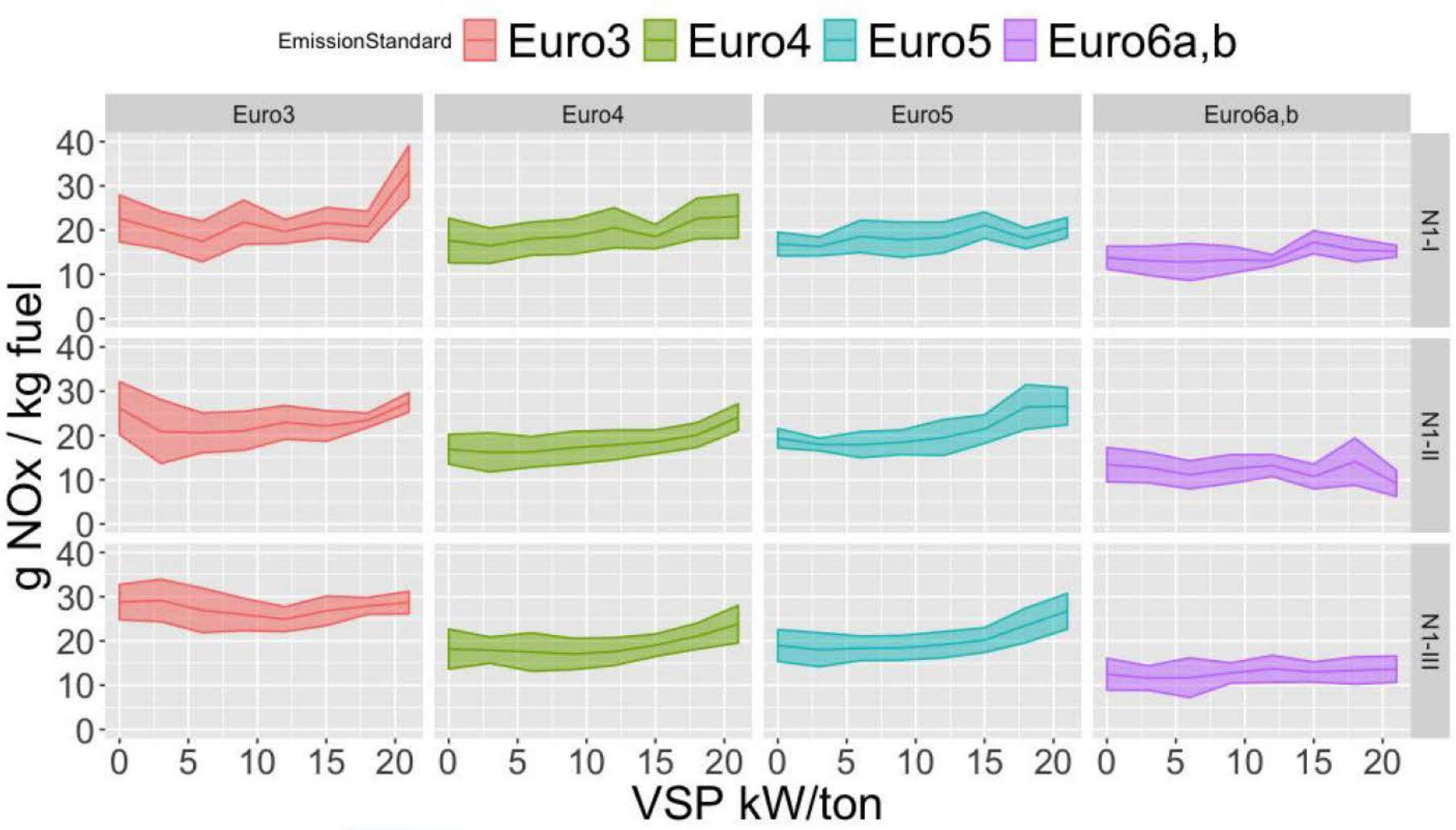
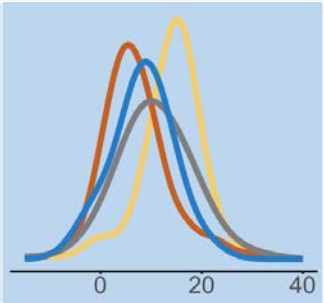
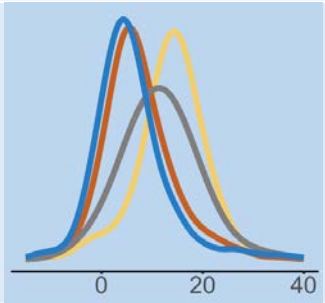
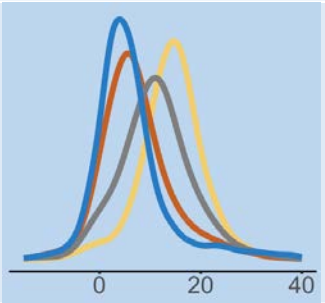
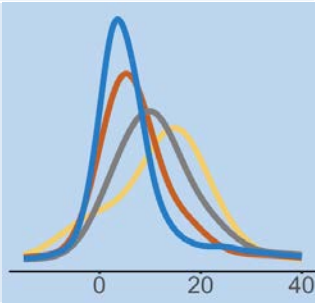
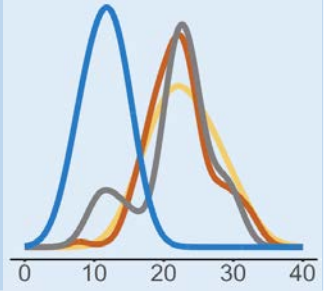
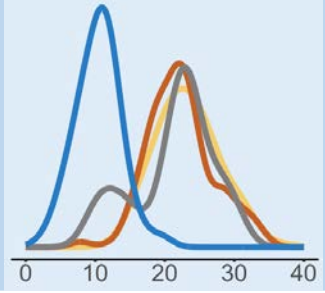
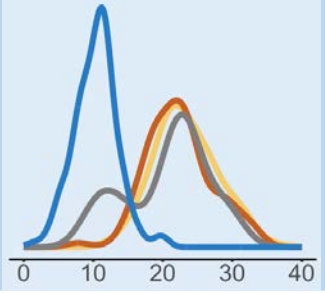
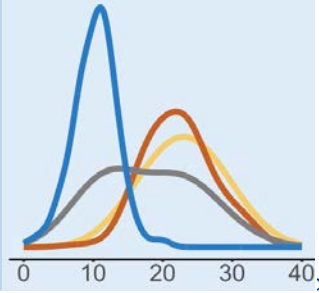
NOx emission rate by temperature



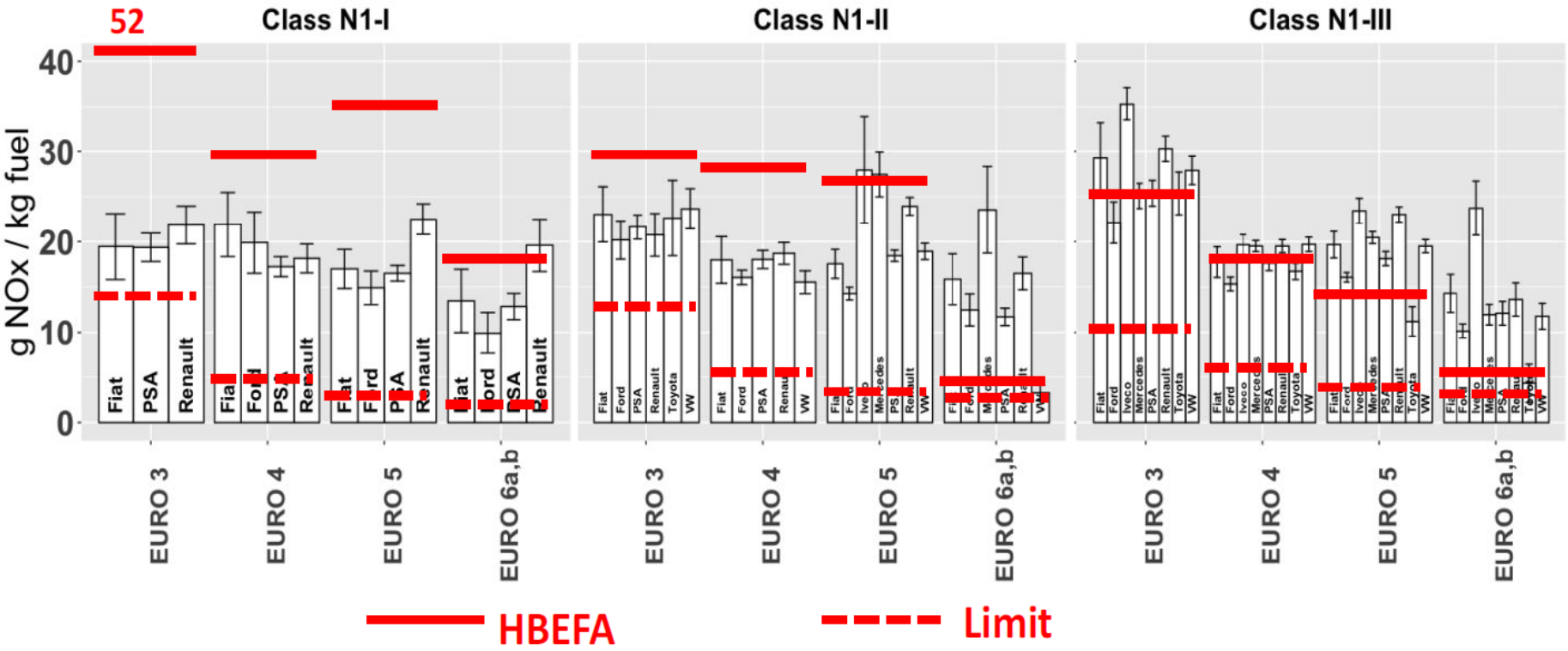
NOx emission rate = f(VSP)



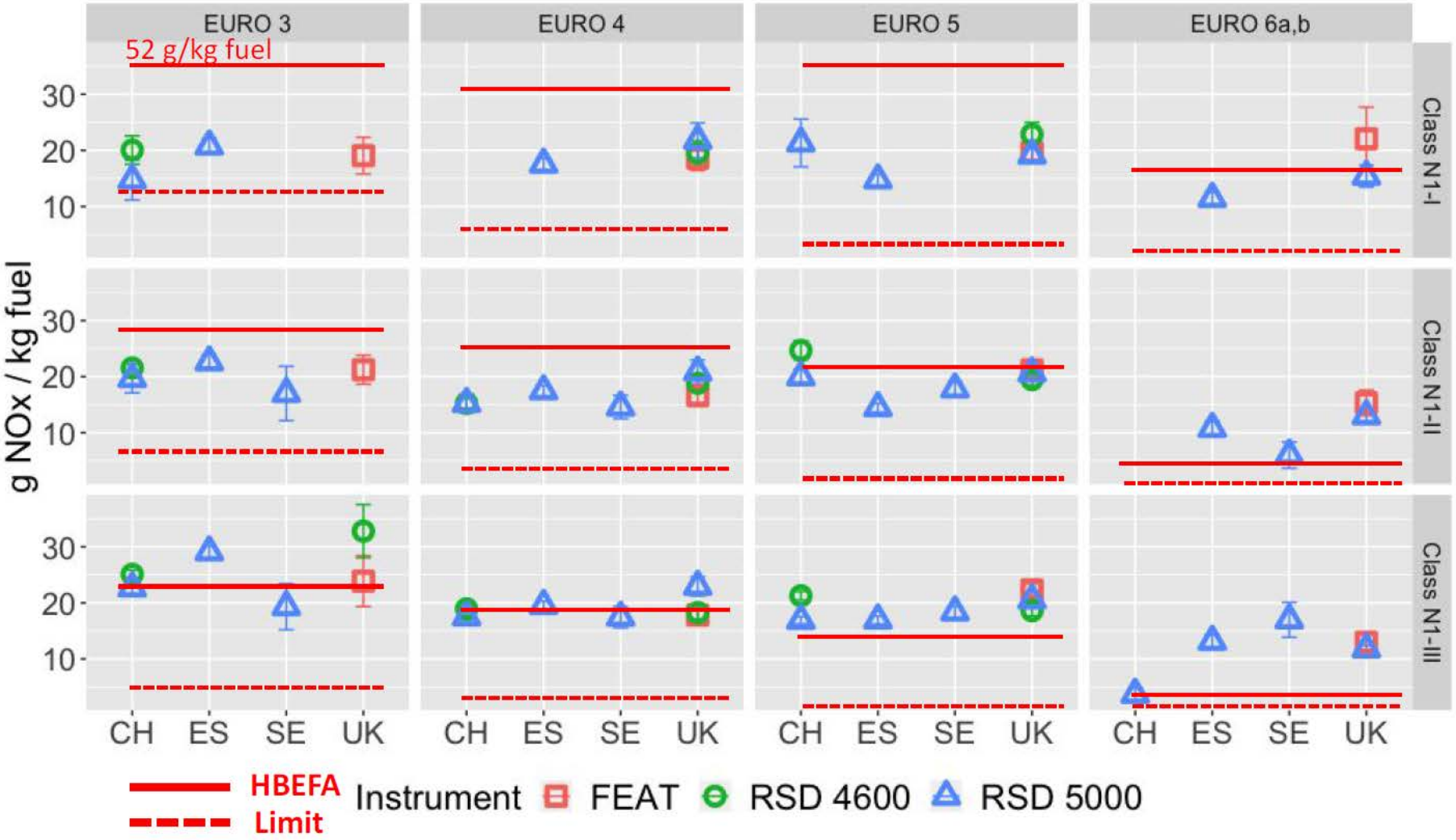
RS records for LCVs in Europe ('til 2018)

		Euro 3 N1-III	Euro 4 N1-III	Euro 5 N1-III	Euro 6a,b N1-III
# of records	UK	329	2567	11248	2680
	SE	257	625	2245	182
	ES	2955	4192	4575	719
	CH	2613	6224	6842	105
Measurement year and instrument	UK	FEAT: 2012, 2013, 2017, 2018; RSD 4600: 2013, 2015; RSD 5000: 2017, 2018			
	SE	RSD 5000: 2016			
	ES	RSD 5000: 2017			
	CH	RSD 4600: 2011, 2012, 2013, 2014, 2015; RSD 5000: 2016, 2017			
Average age (years)	UK	9.4	6.5	3.1	0.9
	SE	11.8	6.6	2.7	0.5
	ES	13.5	9.3	3.0	0.6
	CH	14.4	9.5	4.5	0.9
VSP (kW/ton)	UK SE ES CH				
Ambient Temperature (C)	UK SE ES CH				

NOx by size, country, EURO norm by manufacturer



NOx by size, country, instrument by EURO norm



HBEFA 4.1 for average traffic (not urban) @50k, 0 grade, avg. temp in DE 2015.

EURO 6 = average over 6a to 6d

RSD: Grouped by size/country/instrument but not adjusted for age/mileage, temperature or traffic.

PM/opacity: N1-III on-road