



# Real-world vehicles emissions in the light of dieselgate and RDE legislation

TFEIP/EIONET12th May 2017 in Krakow

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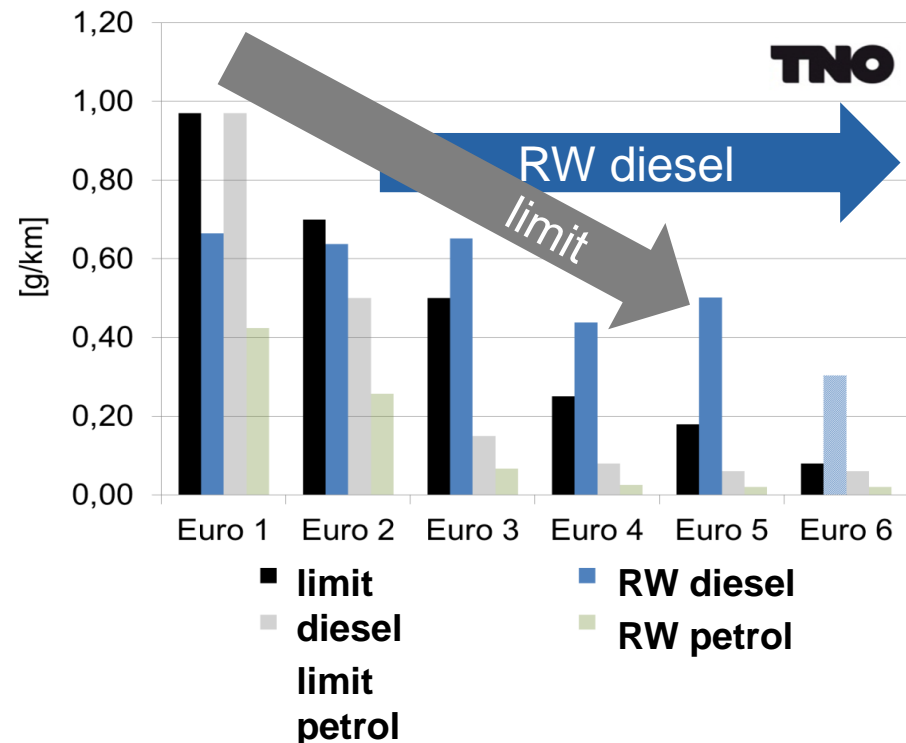
**2012 → 2017**



## Emission factors = real world emissions

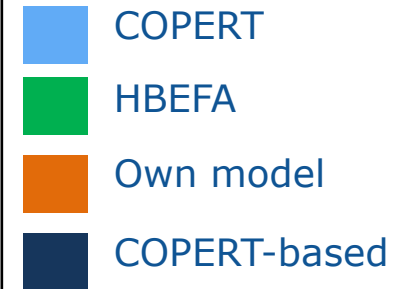
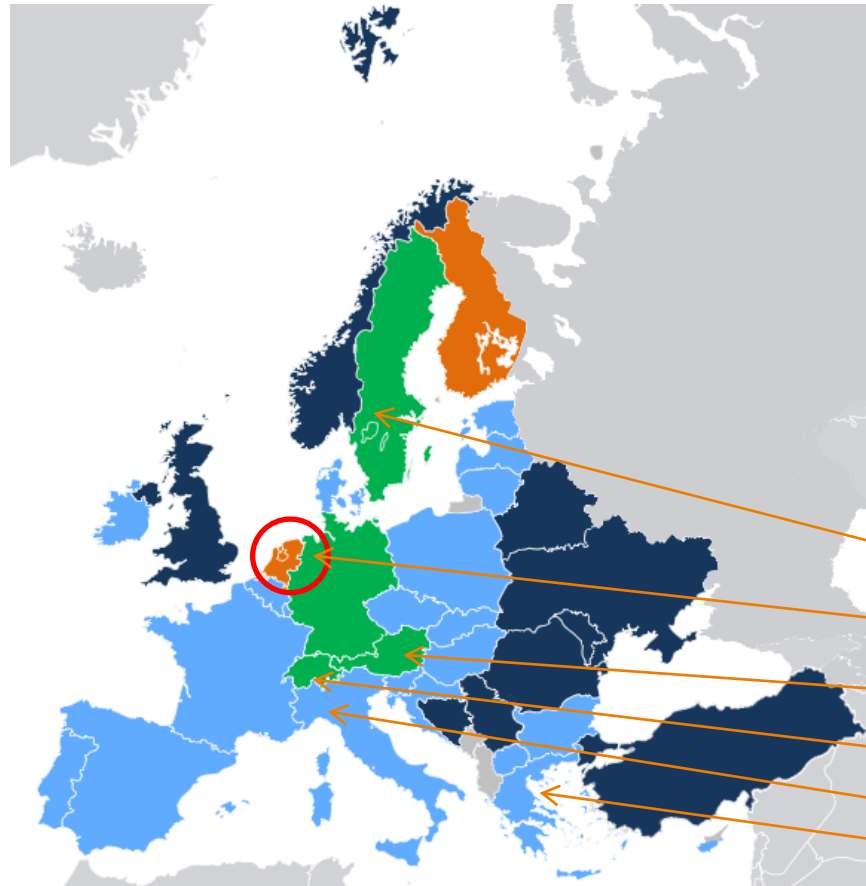
- › Typically higher than type-approval limits (but not always; all components)
- › reproducing as much as possible the real world conditions in the vehicle emission tests

Average NO<sub>x</sub> emissions of petrol and diesel passenger cars





# Emission Models in EU



## ERMES Board Institutes:

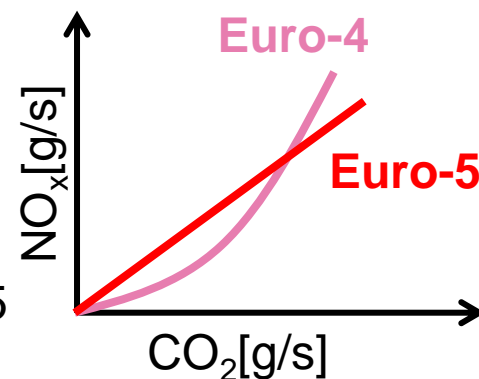
- IVL
- TNO (VERSIT)
- TUG
- INFRAS } (HBEFA)
- JRC (chair)
- LAT (COPERT)



slide from presentation at  
ERMES meeting in 2012

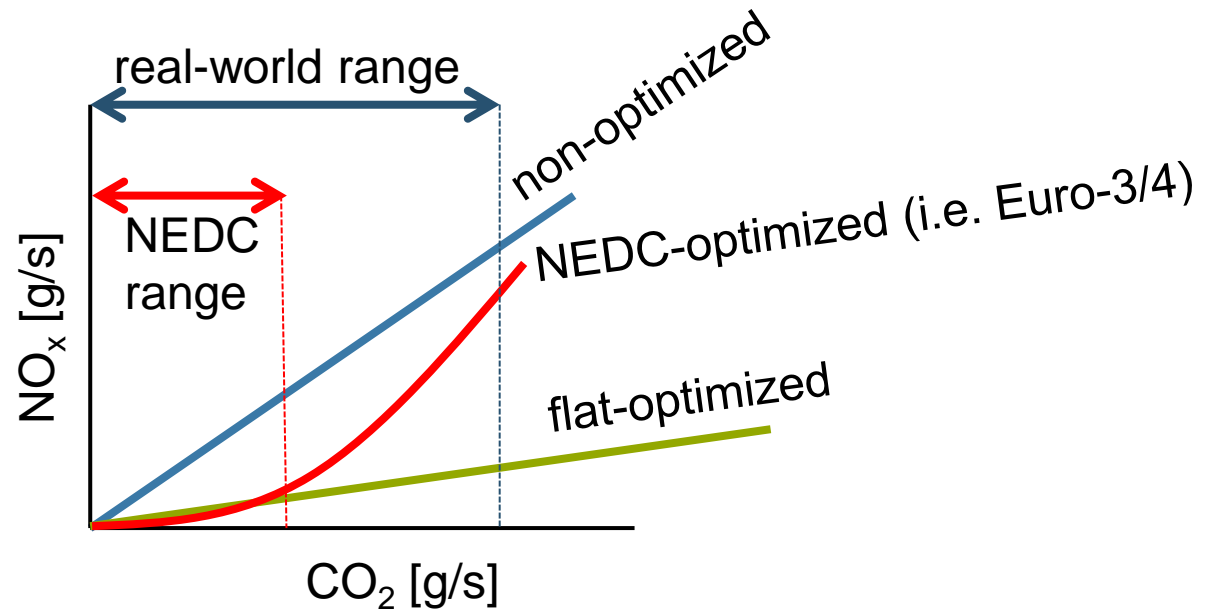
## Euro-5 NO<sub>x</sub> and NO<sub>2</sub> emissions (preliminary) *(market sales rather than early adapters)*

- › 11 vehicles measured at Horiba (2011-2012):
  - › ~50% of the engines (OEM-group/cc/kW)
  - › ~20% of the make/models
- › No longer positive effects for low load (TA test)
- › Less emission “incidents” at high load with Euro-5
- › Higher NO<sub>x</sub> for Euro-5 emission than Euro-4
  - › Euro-5: 4 gram NO<sub>x</sub> per kg CO<sub>2</sub> across the board
  - › Euro-4: 2.8 (low load) - 4 (high load) gram NO<sub>x</sub> per kg CO<sub>2</sub>
- › NO<sub>2</sub> fraction lower 30% (~28% cold engine, Euro-4: 55%)
- › No trends with vehicle sizes and engine sizes visible
- › Cold-start effects by adding CADC urban after cold start CADC
- › CADC maximal engine demand often < 70% of rated power





## specific NO<sub>x</sub> emissions: NO<sub>x</sub> per CO<sub>2</sub>



**NEDC optimized:** higher real-world, with low NEDC, NO<sub>x</sub> emission

CO<sub>2</sub> rate related to power consumption:  
1 CO<sub>2</sub> [g/s] ~ 5 kW

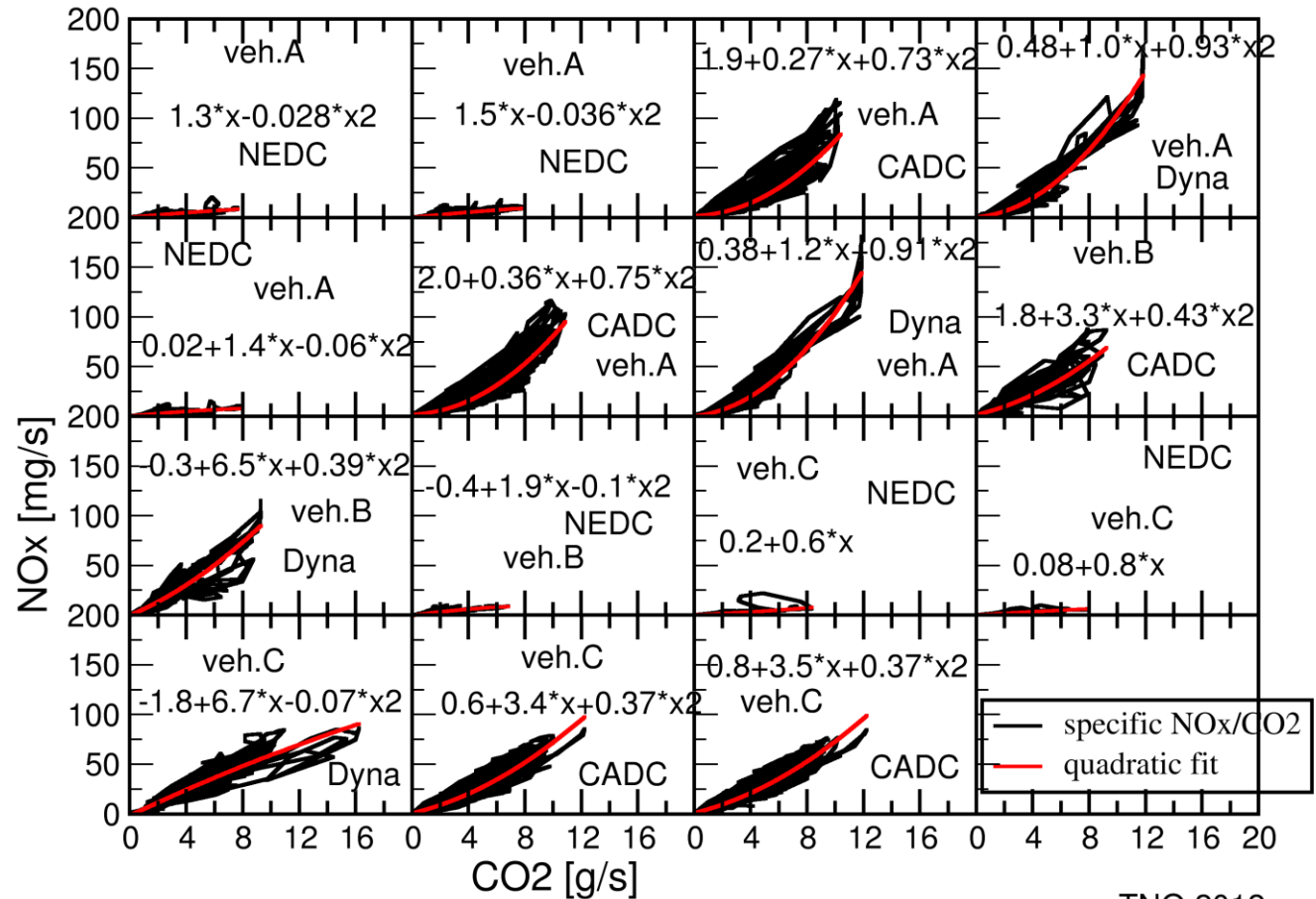
NEDC range: 0 – 7 g/s  
real-world range: 0 – 12 g/s



# Distinct difference between NEDC and real-world

## 3 Euro-5 diesel vehicles specific NOx emissions

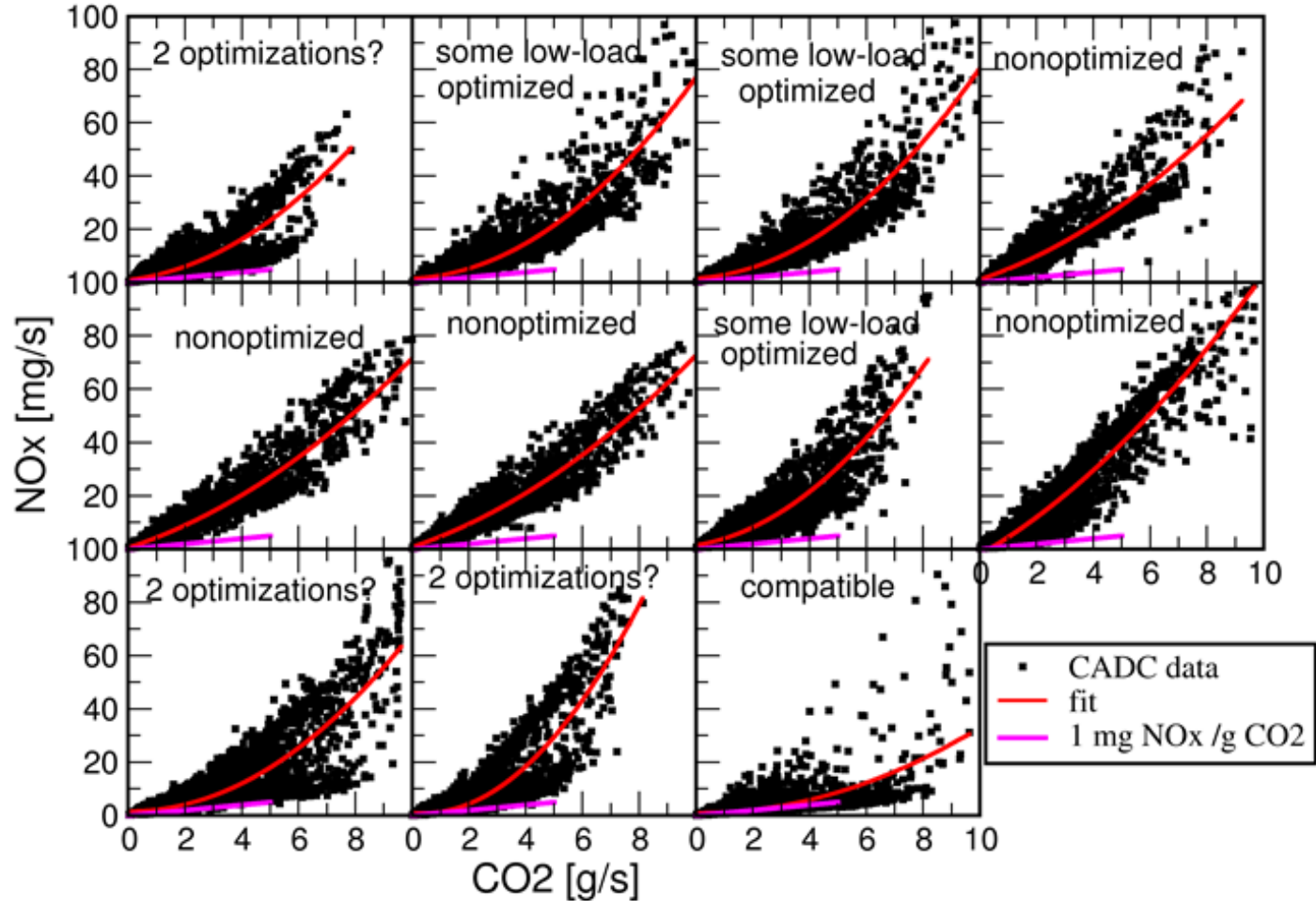
NEDC, CADC, TNO-Dynacycle





## specific NO<sub>x</sub> emissions (mg/kg CO<sub>2</sub>)

11 Euro-5 diesel vehicles on the CADC test

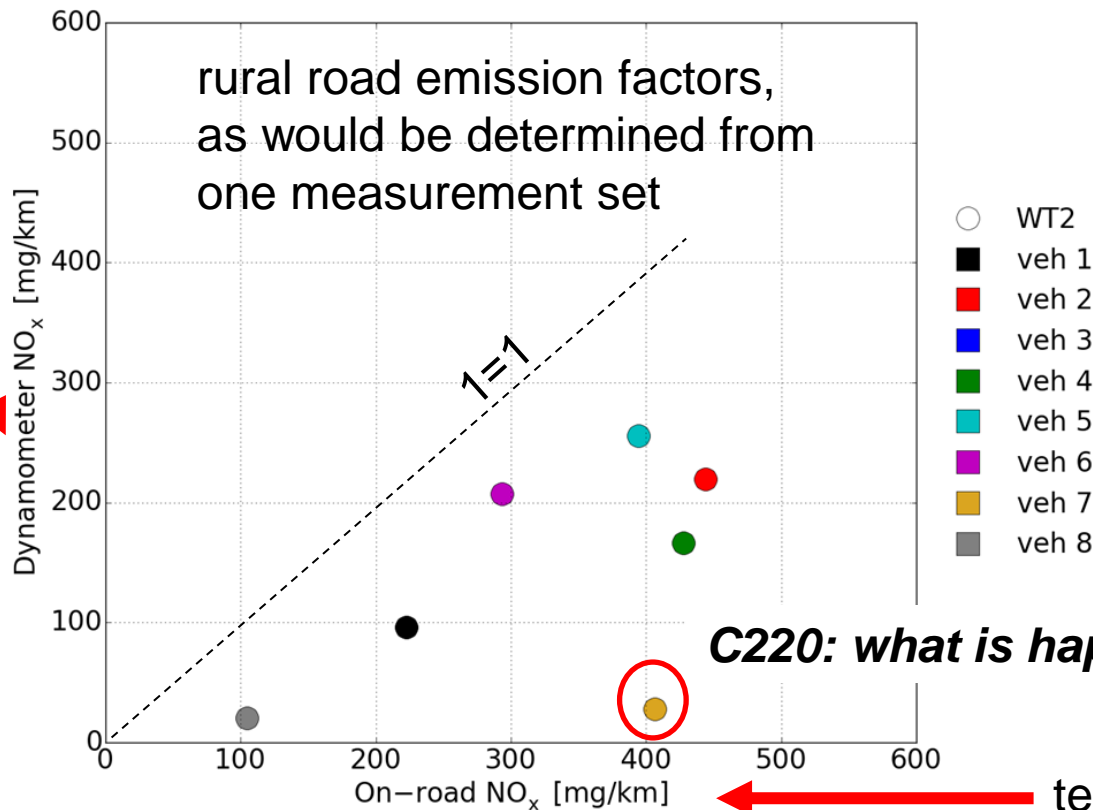




# where were you when dieselgate started? (19/9/2015)

Answer: *looking at a Euro-6 diesel Mercedes-Benz C220*

Dynamometer vs on-road NO<sub>x</sub>



real world cycle in the laboratory

TNO aimed to based all emission factors on on-road tests from 2015 onwards

**target set out in 2012**

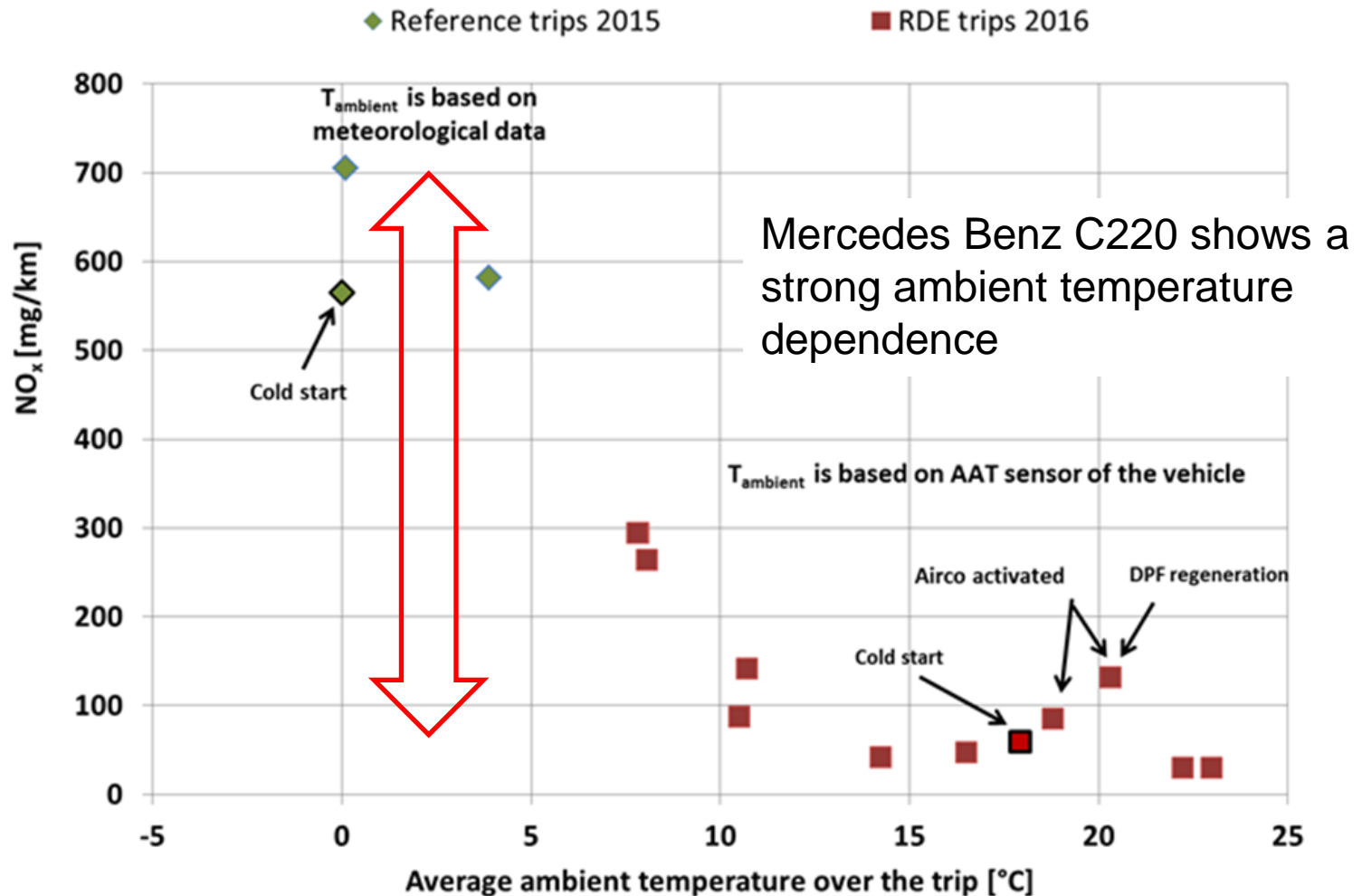
***C220: what is happening?***

testing on the road





## On road testing at different ambient temperatures





**Jump to ... 1 September 2017**

## **European RDE (Real Driving Emissions) legislation**

→ On road testing compulsory for new vehicle models type approval

→ from 1 September 2019 for all vehicle models (*real relevant date*)

→ Focus on diesel NO<sub>x</sub> and direct injection petrol particulates emissions

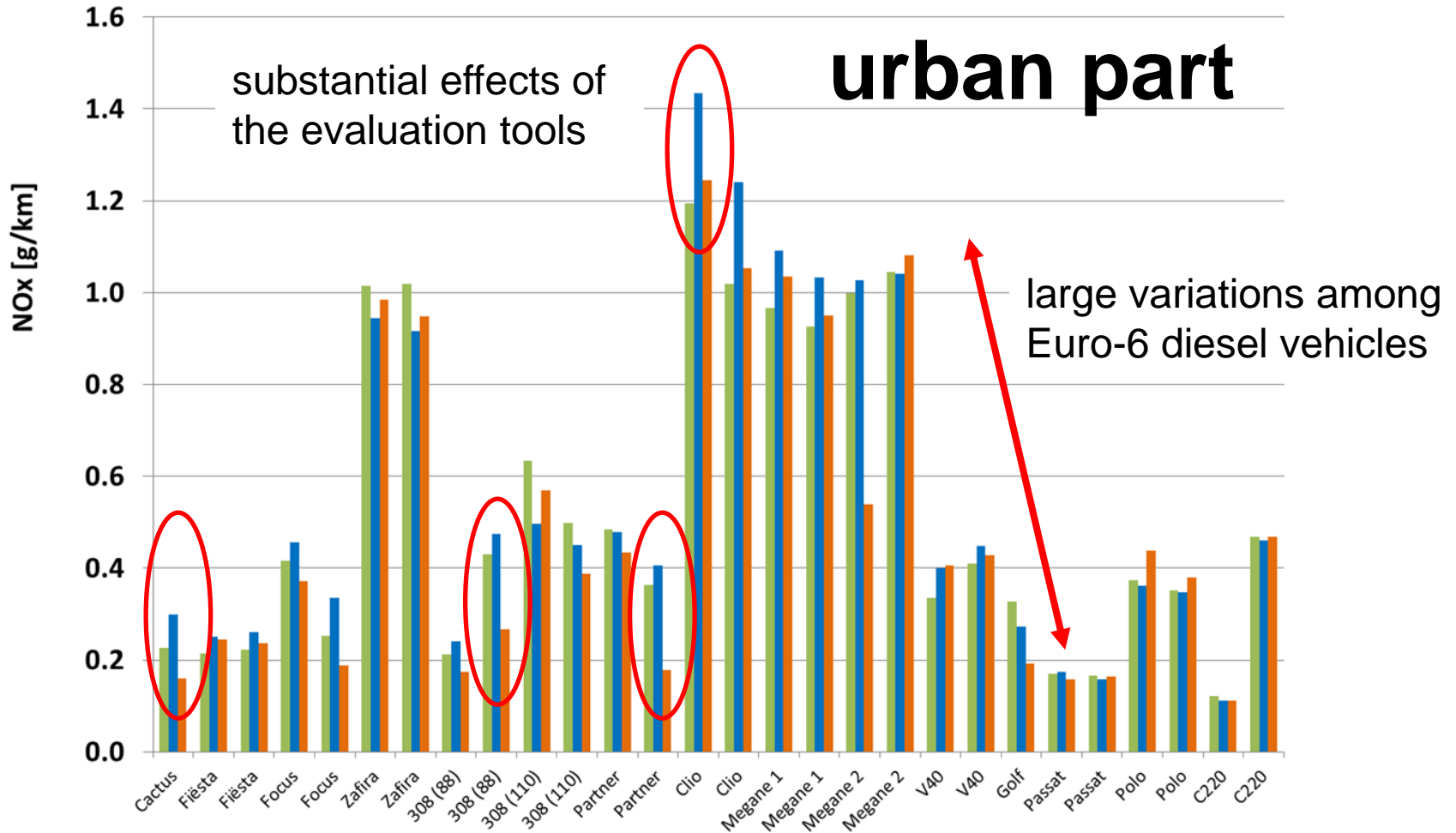
*High hopes, big opposition, long process (started in 2011)*

*will NO<sub>x</sub> emission limits finally meet real-world emissions?*



# RDE Euro-6 urban results 2016

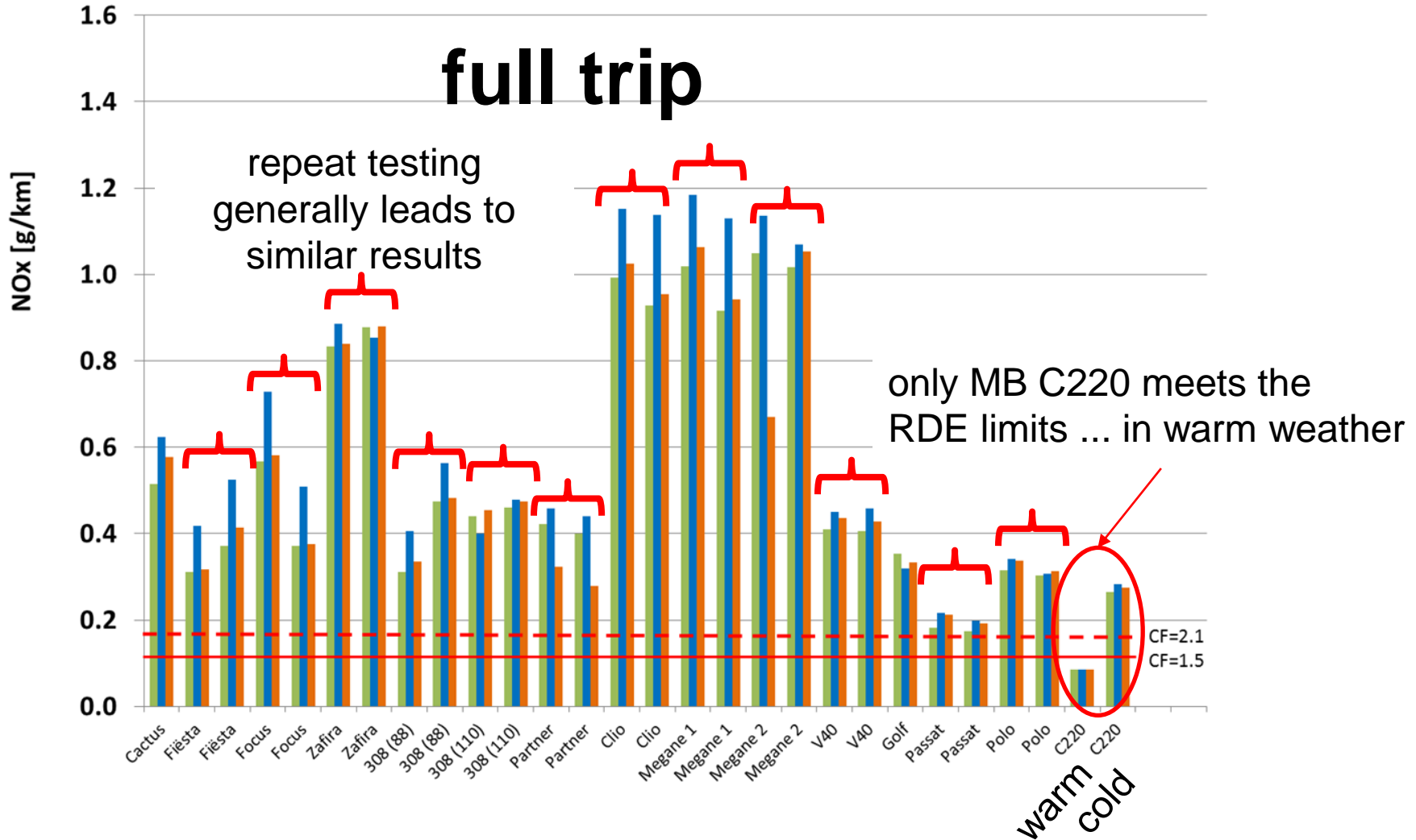
TNO Raw CLEAR Weighted EMROAD MAW





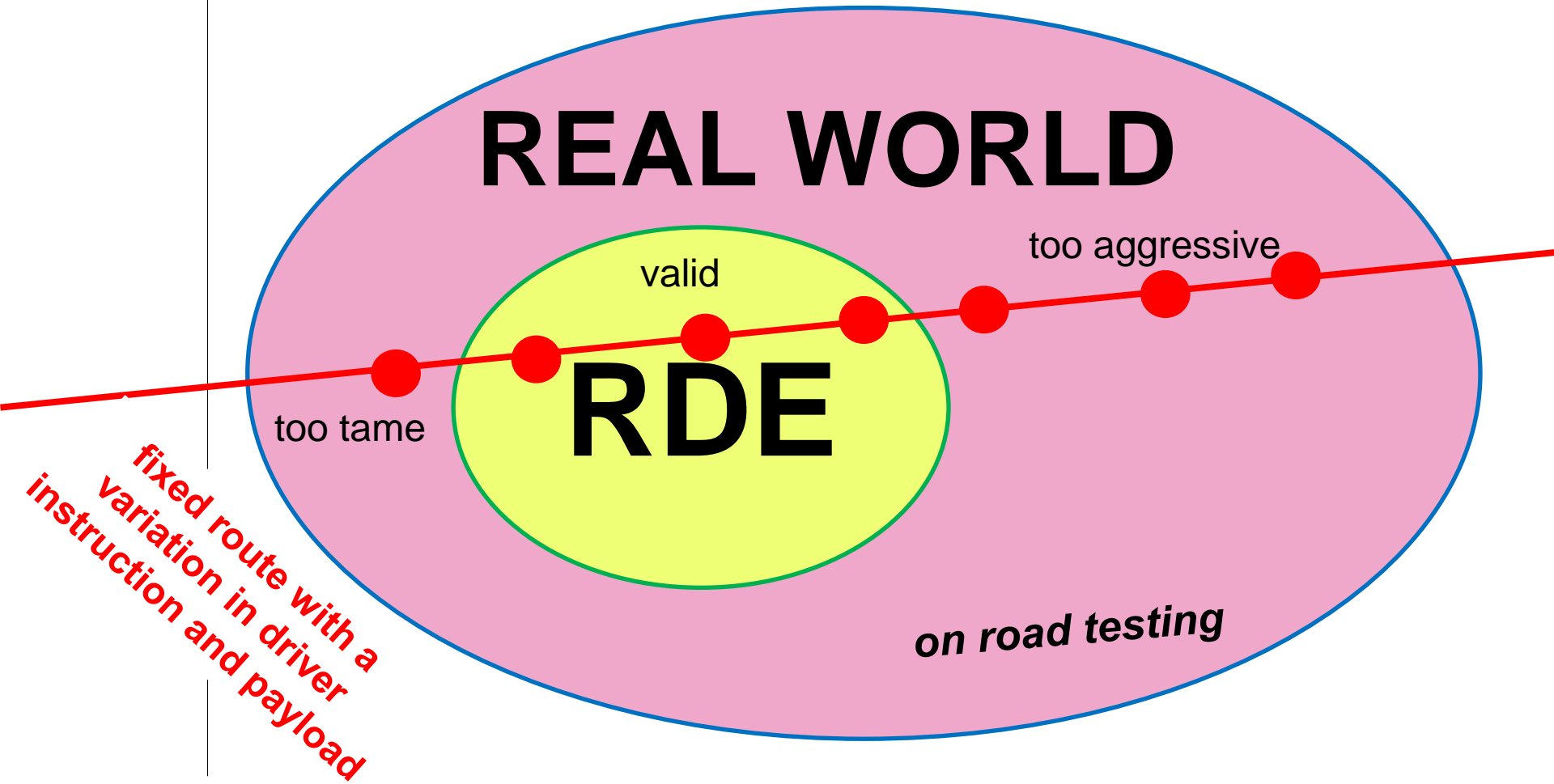
# RDE Euro-6 results 2016

TNO Raw CLEAR Weighted EMROAD MAW





# getting experience with RDE testing



# factor 100 differences: small variations can “double” the emissions

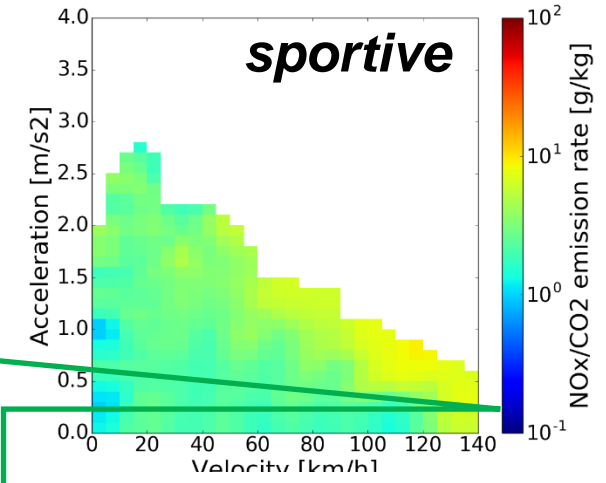
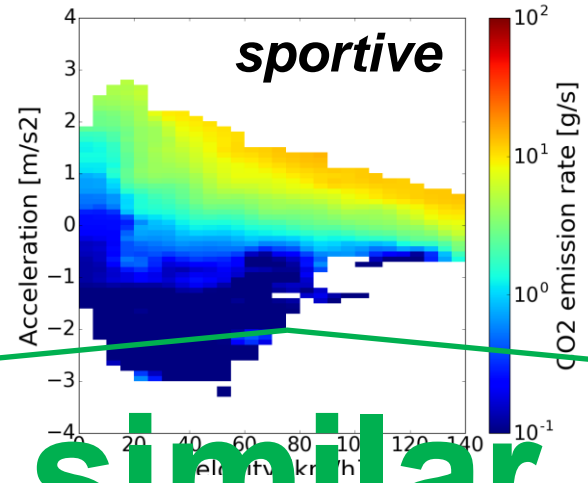
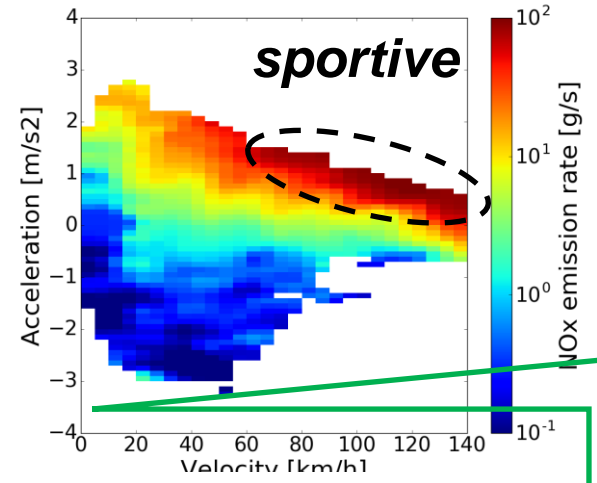
independent RDE testing



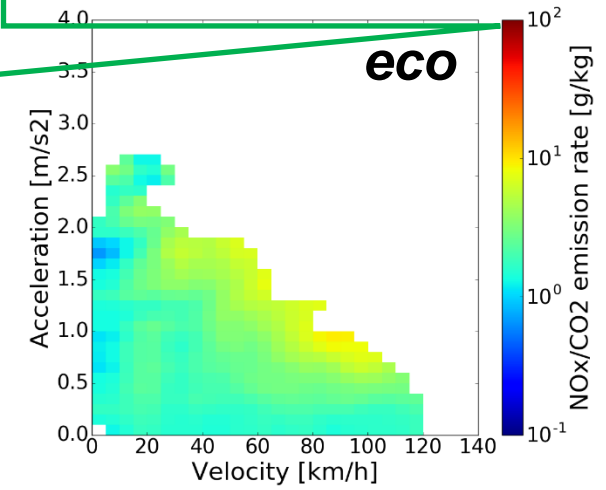
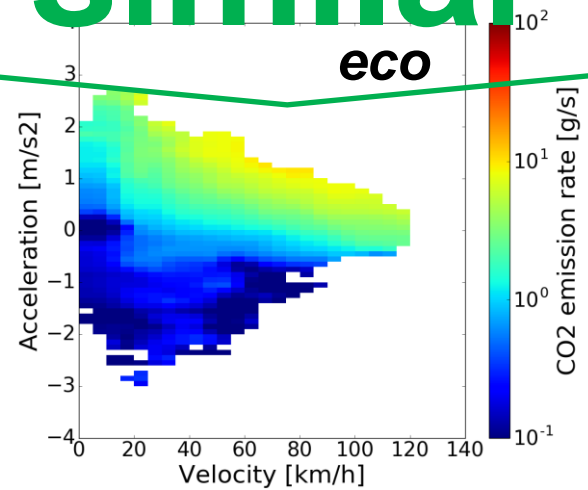
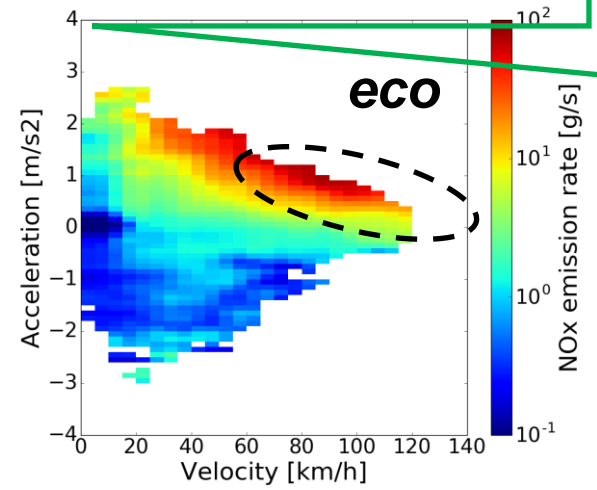
## NOx [mg/s]

## CO2 [g/s]

## NOx/CO2 [g/kg]



# similar





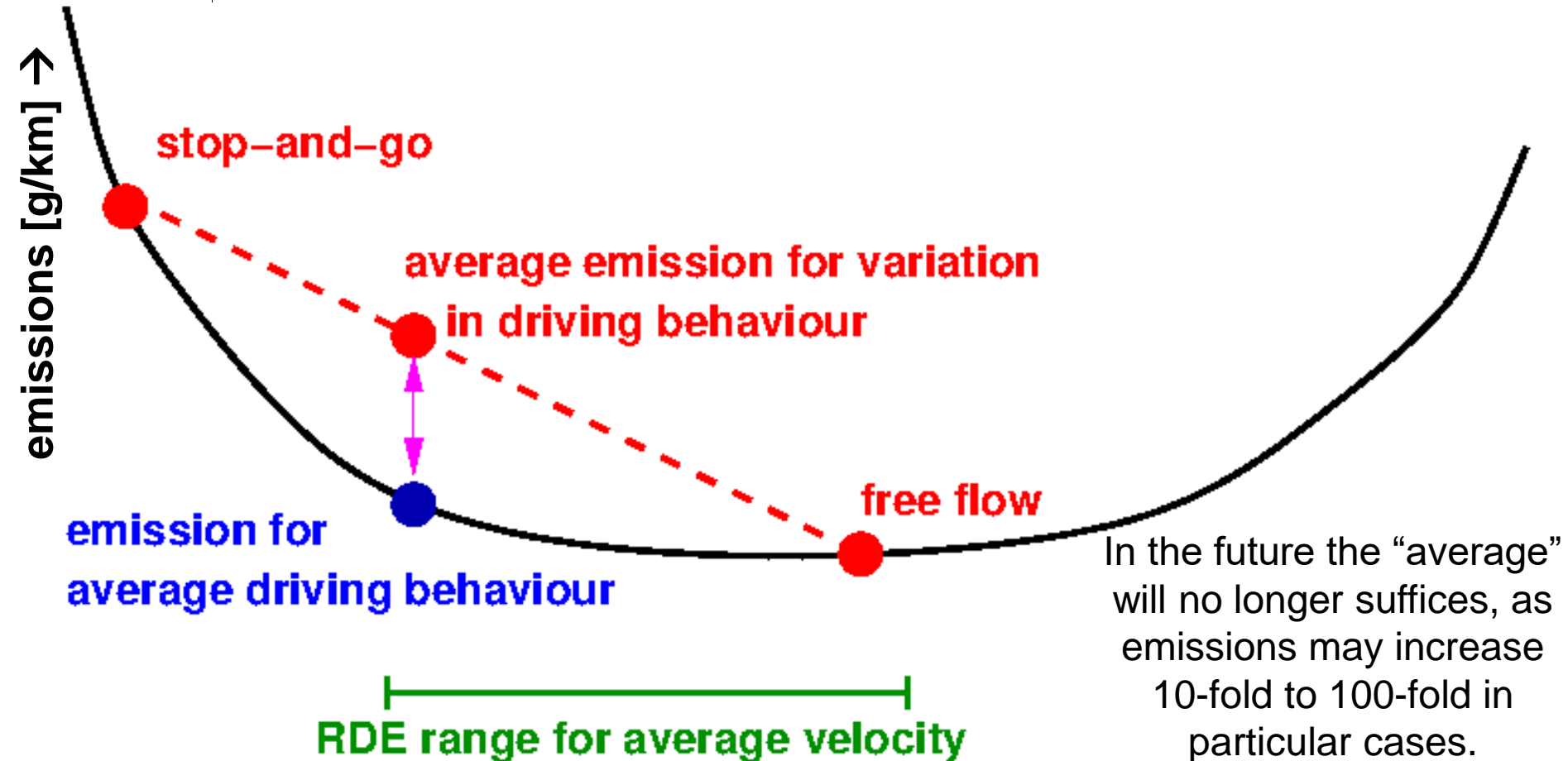
RDE compliant? (N1 Class II)	ok		Urban part too aggressive			ok	skewed road type fractions	Urban part too aggressive	1% to much stop time in urban part	ok			Not sufficient dynamics on highway
	1	2	3	4	5	6	7	8	9	10	11	12	13
Trip	1	2	3	4	5	6	7	8	9	10	11	12	13
Style	normal	normal	sport	sport	sport	normal	eco	sport	sport	sport	normal	eco	eco
Weight [kg]	1482	1482	1940	1940	1960	1820	1660	1940	1940	1960	1820	1680	1700
Average velocity [km/h]	47.3	45.4	38.5	38.5	39.6	49.6	46.5	44.2	44.0	48.8	49.4	44.9	46.3
Average velocity (v>0) [km/h]	52.8	54.3	52.1	55.9	56.5	57.9	53.1	57.5	56.1	58.4	57.6	53.2	52.3
CO2 [g/km]	140	157	175	179	194	142	122	180	175	166	140	127	116
EMROAD CO2	159	178				159				199	152	145	
NOx [mg/km]	280	392	579	623	908	452	281	734	557	513	367	291	172
EMROAD NOx	174	240				291				329	235	187	
NOx/CO2 [g/kg] per second	1.8	2.3	3.2	3.0	4.7	3.1	2.2	3.5	2.8	2.7	2.3	2.3	2.4
NOx/CO2 [g/kg] from EMROAD total	2.0	2.5				3.1				3.0	2.6	2.3	
Urb CO2 [g/km]	159	173	six valid EMROAD trips			160	only two valid CLEAR trips			183	151	137	
Urb EMROAD CO2	154	170				159				185	151	138	
Urb NOx [mg/km]	302	462				504				425	345	311	
Urb EMROAD NOx	162	269				346				304	235	203	
Urb NOx/CO2 [g/kg] from EMROAD total	2.0	2.7				3.3				2.5	2.6	2.3	



factor 5 in all driving, but only a factor 2 within RDE boundaries



# CONVEXITY



In the future the “average” will no longer suffice, as emissions may increase 10-fold to 100-fold in particular cases. New measurement techniques are needed





## Conclusions

- › Hopefully, NO<sub>x</sub> emissions of diesel passenger cars will reduce from 2020, but with fleet-renewal rates full effect will take until 2030
- › Real world emission factors are a factor 3 to 5 higher than the emission limits: there has been a clear sign from ~2005 the type-approval legislation was ineffective, but details changed.
- › On road testing is necessary from ~2012 because of sensors in modern cars. Real world cycles in laboratory tests were already needed from the 1980's, because of limited load on the NEDC test.