Real vehicle emissions – Measuring and interpreting

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London smog 1962

You don't manage what you don't measure

Mandatory techniques to measure emissions

- Recruit vehicle(s)   - Which???
- Laboratory test or on-the road   - Reproducible/reliable?
- Which test drive?   - Representative for...!?
- Thousands of seconds for this vehicle

1…10…100 tests needed for traffic emissions?
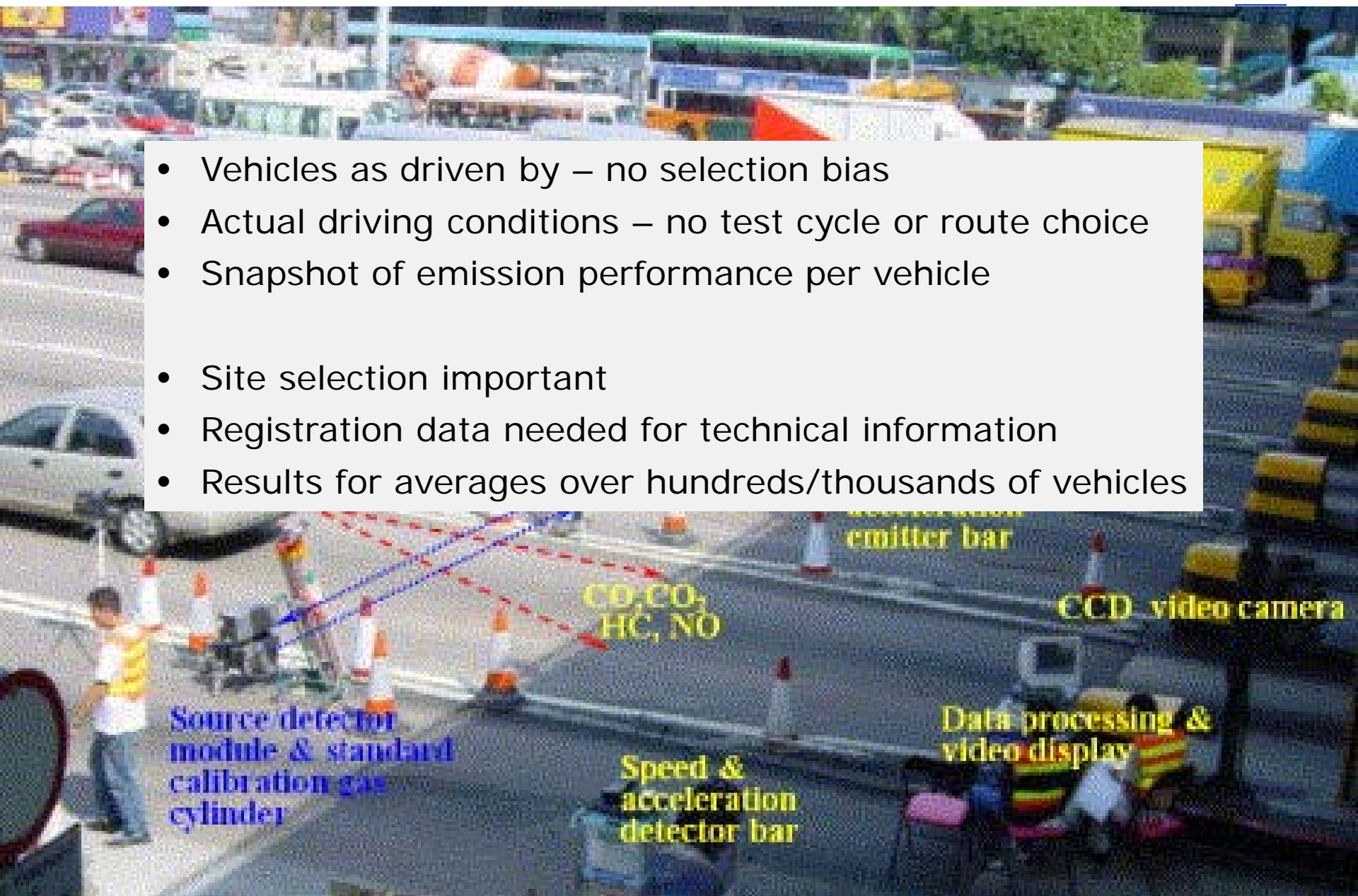
Mobile laboratory in the vehicle

Besch et al., WVU 2014 – PEMS testing leading to dieselgate revelation
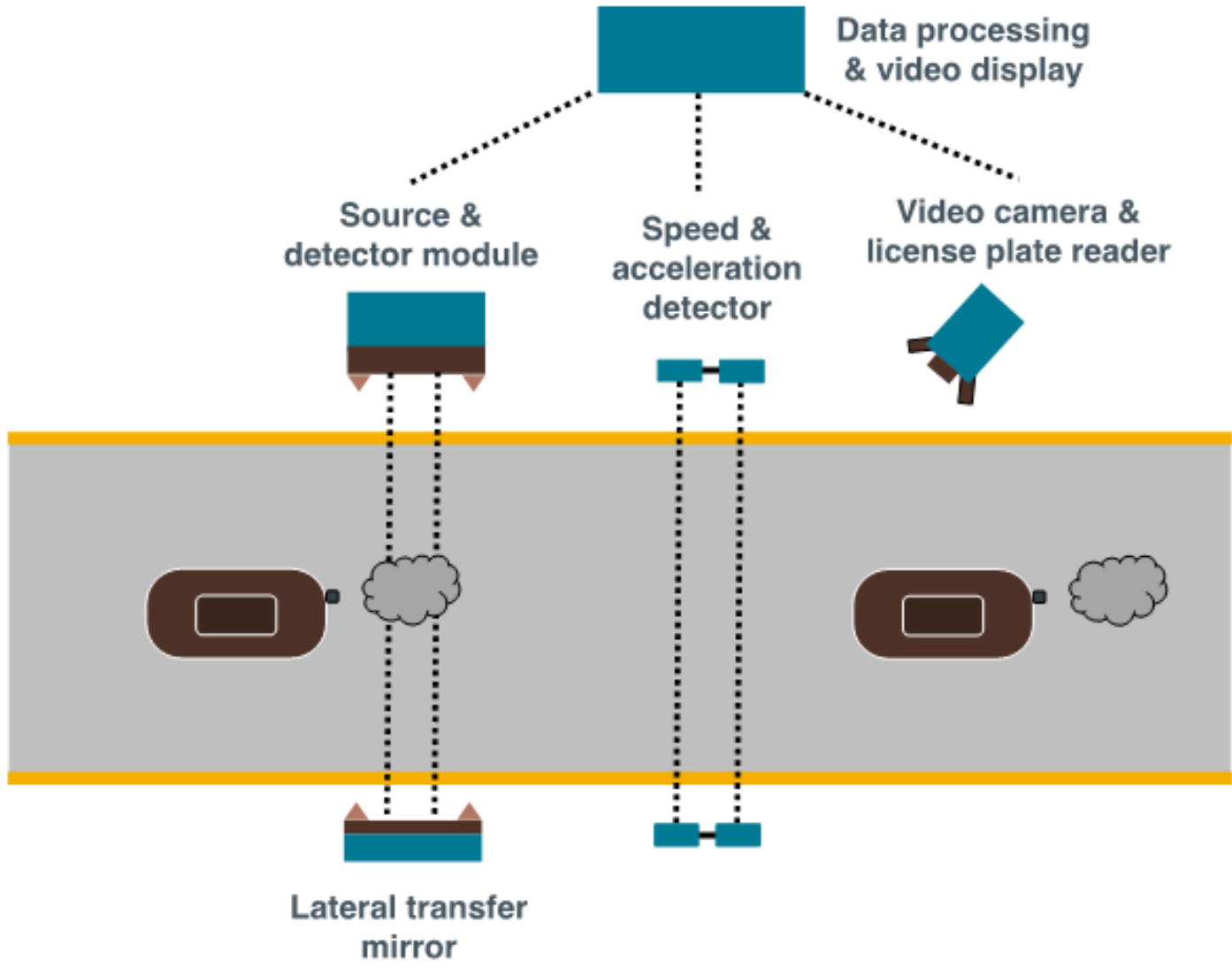
On-road remote sensing in Hong Kong
Chan et al., AtmEnv 38, 2004

- Vehicles as driven by – no selection bias
- Actual driving conditions – no test cycle or route choice
- Snapshot of emission performance per vehicle

- Site selection important
- Registration data needed for technical information
- Results for averages over hundreds/thousands of vehicles

emitter bar

CCD video camera

CO, CO₂
HC, NO

Source detector
module & standard
calibration gas
cylinder

Speed &
acceleration
detector bar

Data processing &
video display

Remote sensing scheme (cross-road)

Data processing & video display

Source & detector module

Speed & acceleration detector

Video camera & license plate reader

Lateral transfer mirror

You don't manage what you don't measure

Conventional & mandatory techniques to measure emissions

- Recruit vehicle(s)   - Which???
- Laboratory test or on-the road   - Reproducible?
- Which test drive?   - Representative for...!?
- Thousands of seconds per vehicle
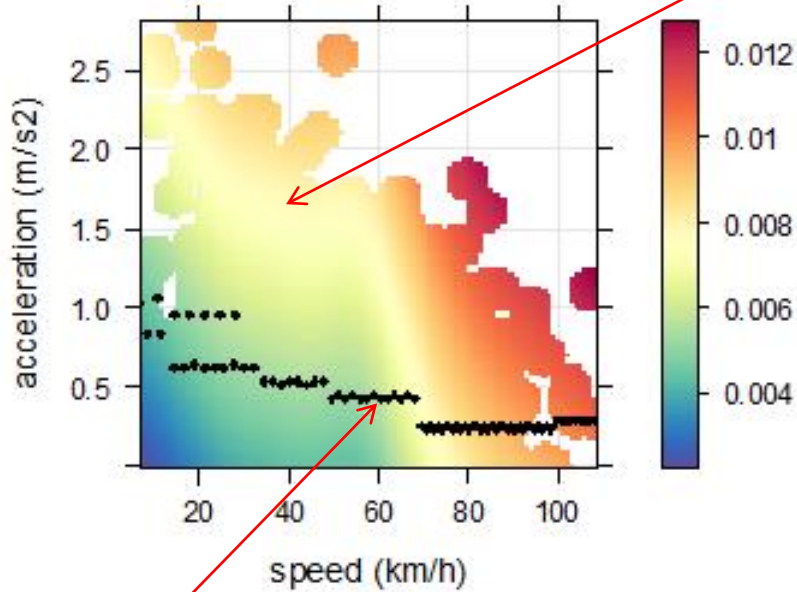
What tell 1…10…100 tests about traffic emissions?

Remote sensing of vehicles passing by

- ~~Recruit~~ vehicle(s) as given   - **Whole fleet at once!!!**
- ~~Laboratory test or~~ on-the road   - Reliable!
- ~~Which test drive?~~   - Representative street(s)
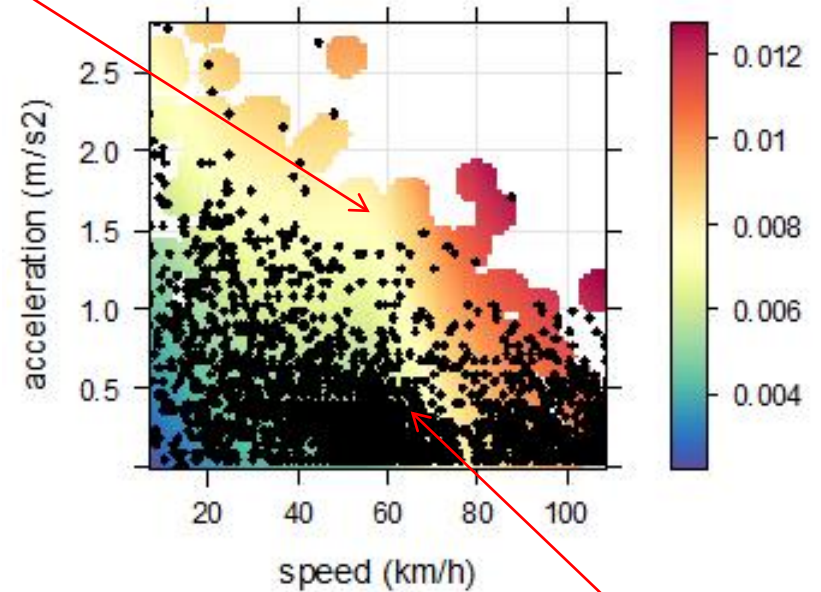- Snapshots for thousands of vehicles

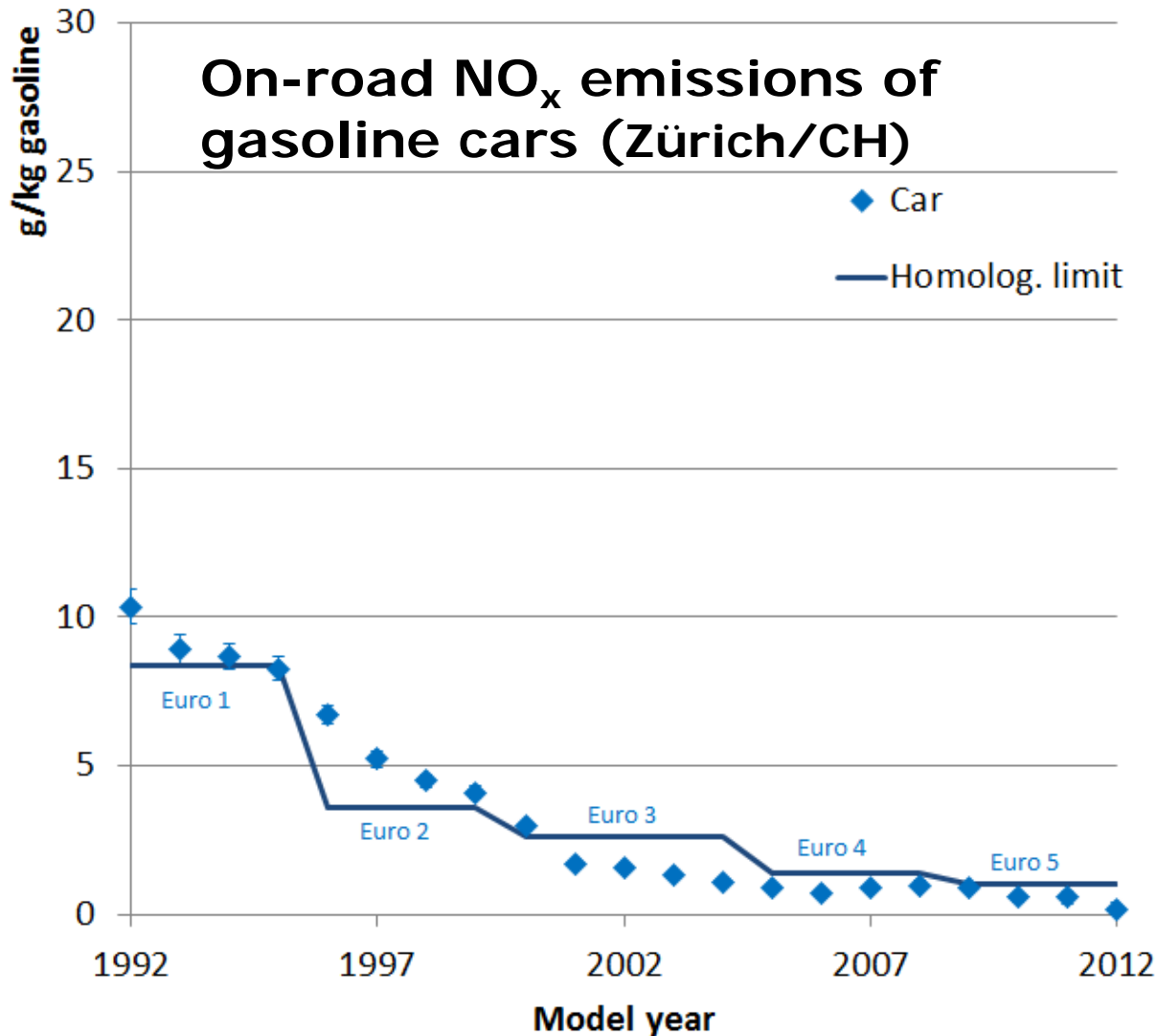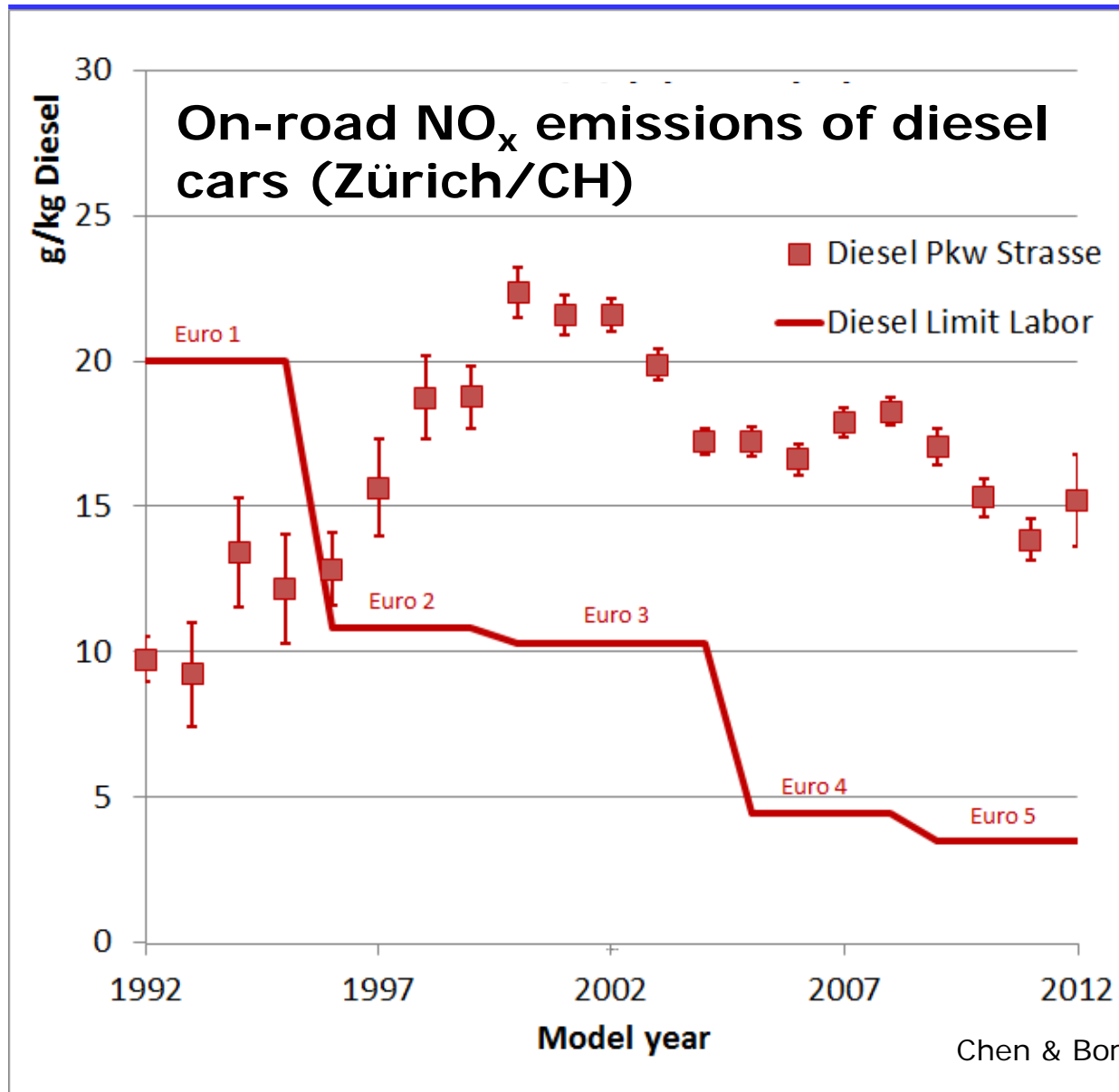# Wide range of driving conditions

London remote

NEDC

PEMS

CONOX

RS monitoring of performance in fleet

On-road NOₓ emissions of gasoline cars (Zürich/CH)

Chen & Borken-Kleefeld, AtmEnv. 88 (2014)

RS monitoring of performance in fleet

On-road NOx emissions of diesel cars (Zürich/CH)

Chen & Borken-Kleefeld, AtmEnv. 88 (2014)

NOx emissions by brand: Euro 5 (64'000 records)
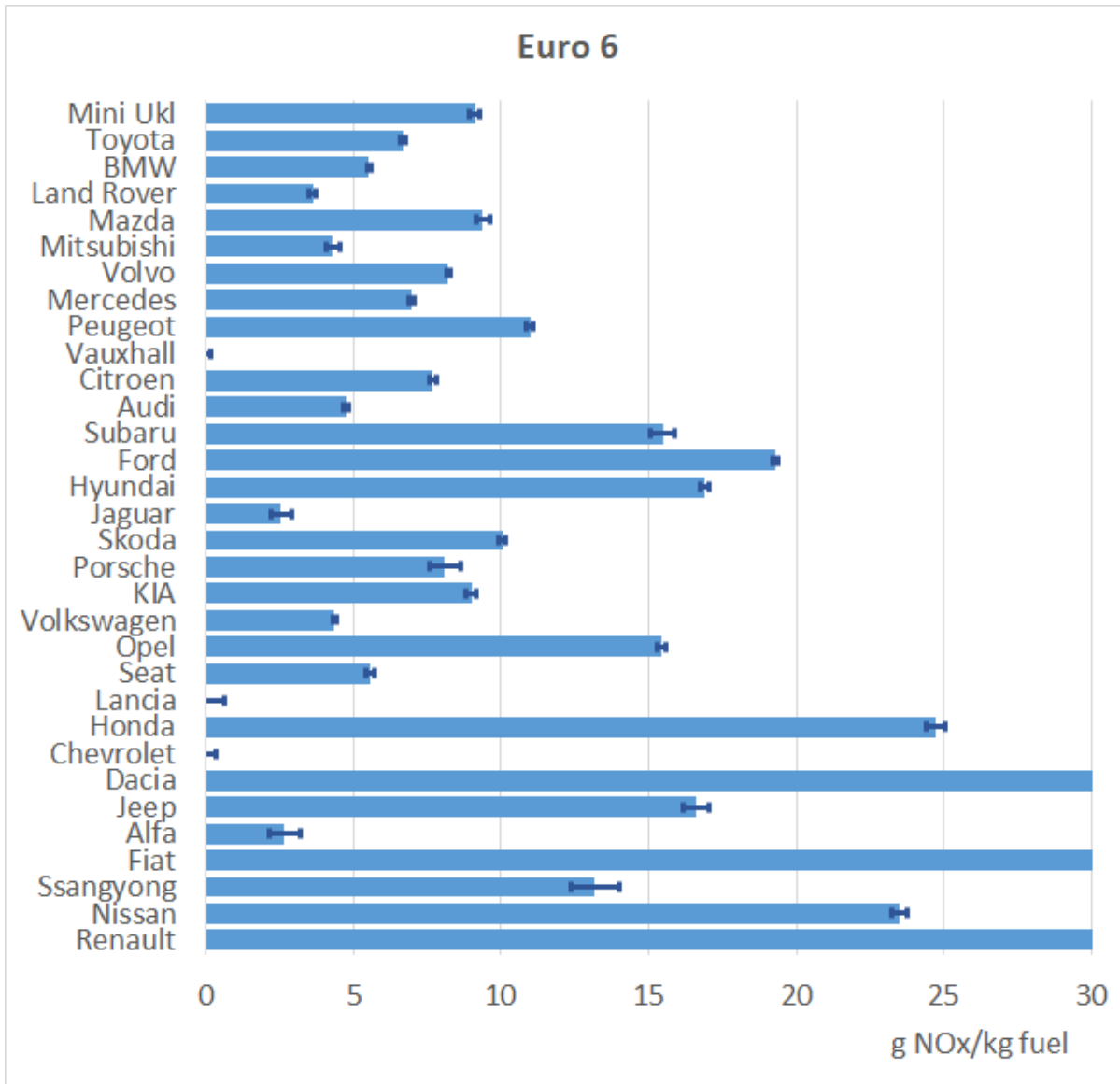
Euro5

g NOx/kg fuel
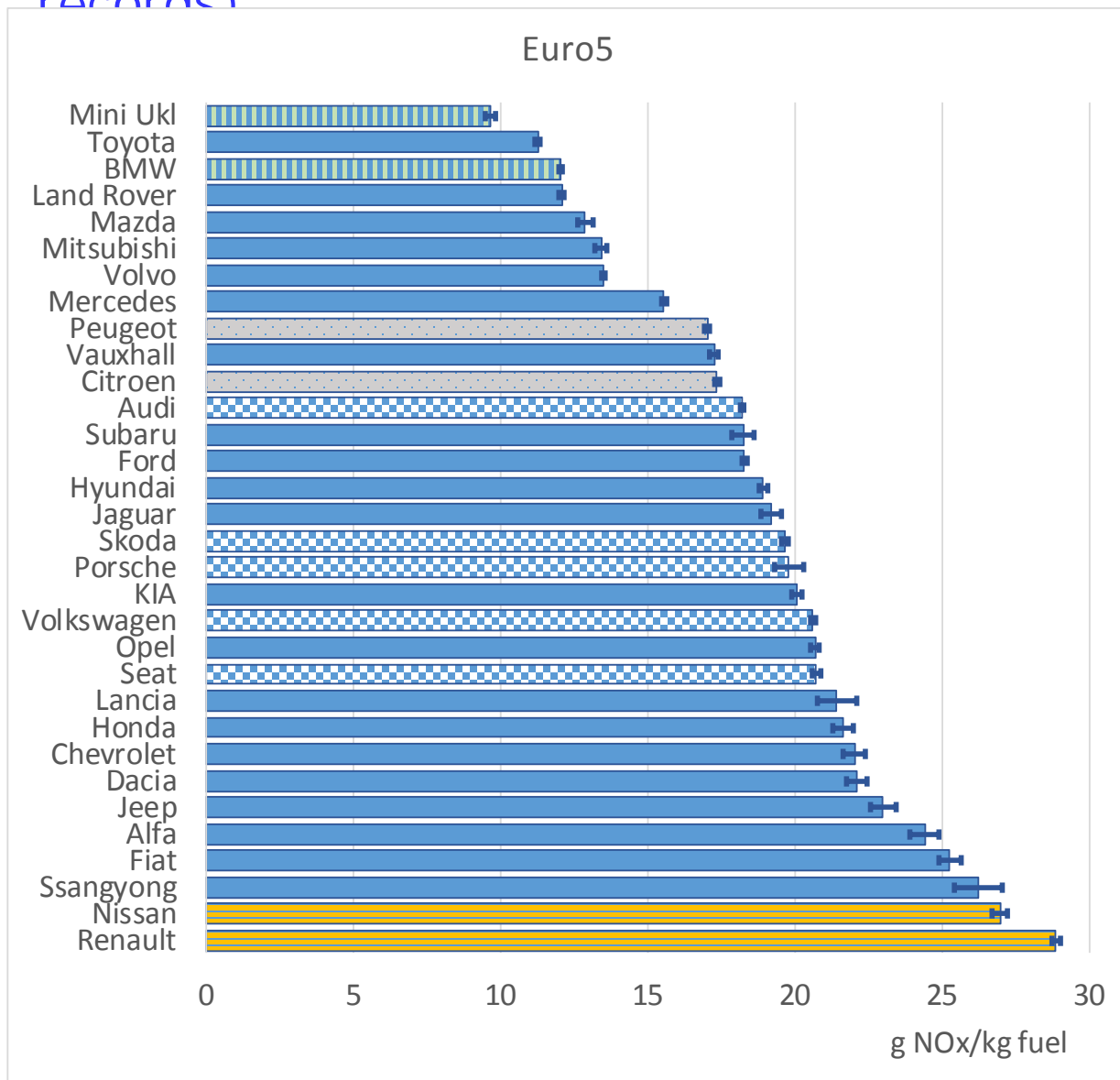
Distinct pattern by manufacturer (not brand) though relatively uniform

Worst manufacturer ~2 times higher than best.

Remote sensing can tell...

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NOx emissions by brand: Euro 6
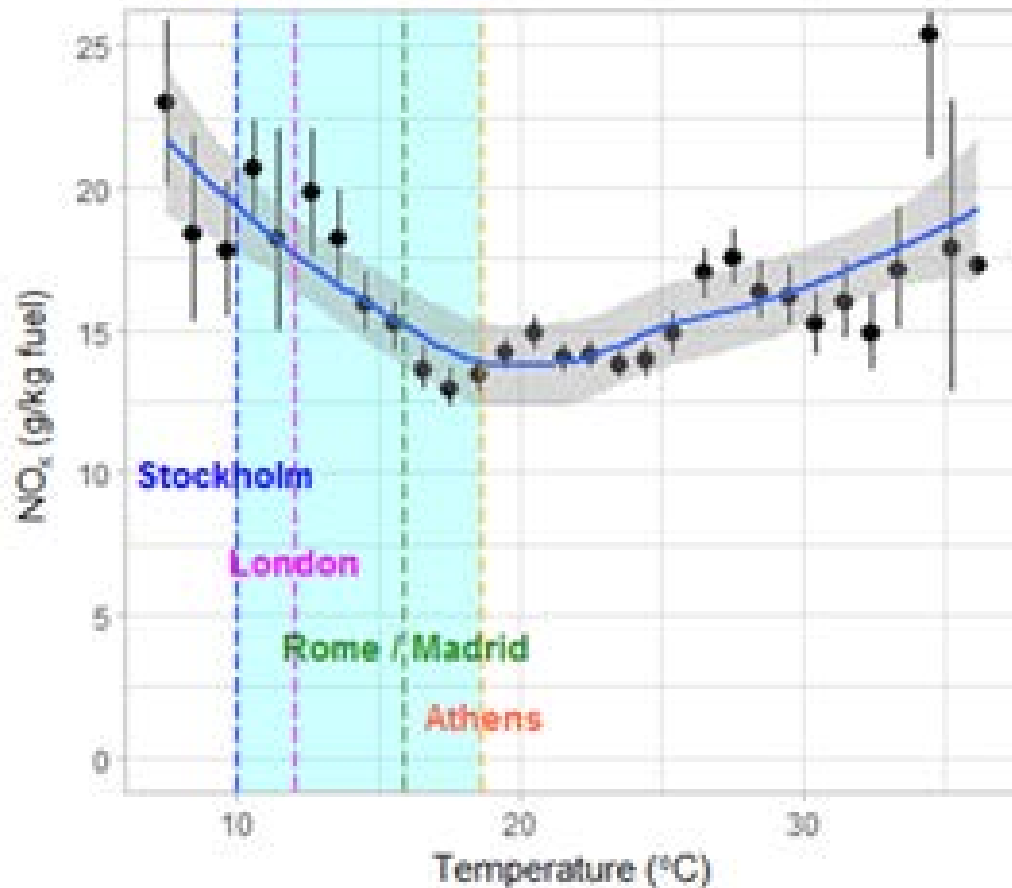## (~10,000 records)

Big diversity with Euro 6

Important which manufacturer & model is chosen.

Worst manufacturer ~10 times higher than best.

Remote sensing can tell...

Temperature dependence PC-D5

- Clear dependence of NO emission rate from ambient temperature
- Below and above 20C!

CONOX WP2 report: Sjodin, Borken-Kleefeld, Carslaw et al. Dec 2017

High emitter detection

- Distr

Perspective

- Network of (semi-)mobile RS monitoring over Europe
  - Unknown emission performance of fleet in CEE
    - High share of old, used vehicles ⇔ deteriorated!?
    - Widespread (?) tampering (particle filter, SCR)
    - Low (?) maintenance & repair
    - Bigger air pollution problems in general

- Coordinated & with data exchange:
  - Gaining leverage,
  - Quickly covering the market,
  - Sharing analytical skills,
  - Comprehensive & complementary

- Similarly: Measure in Africa, India, Indonesia, Russia, ...
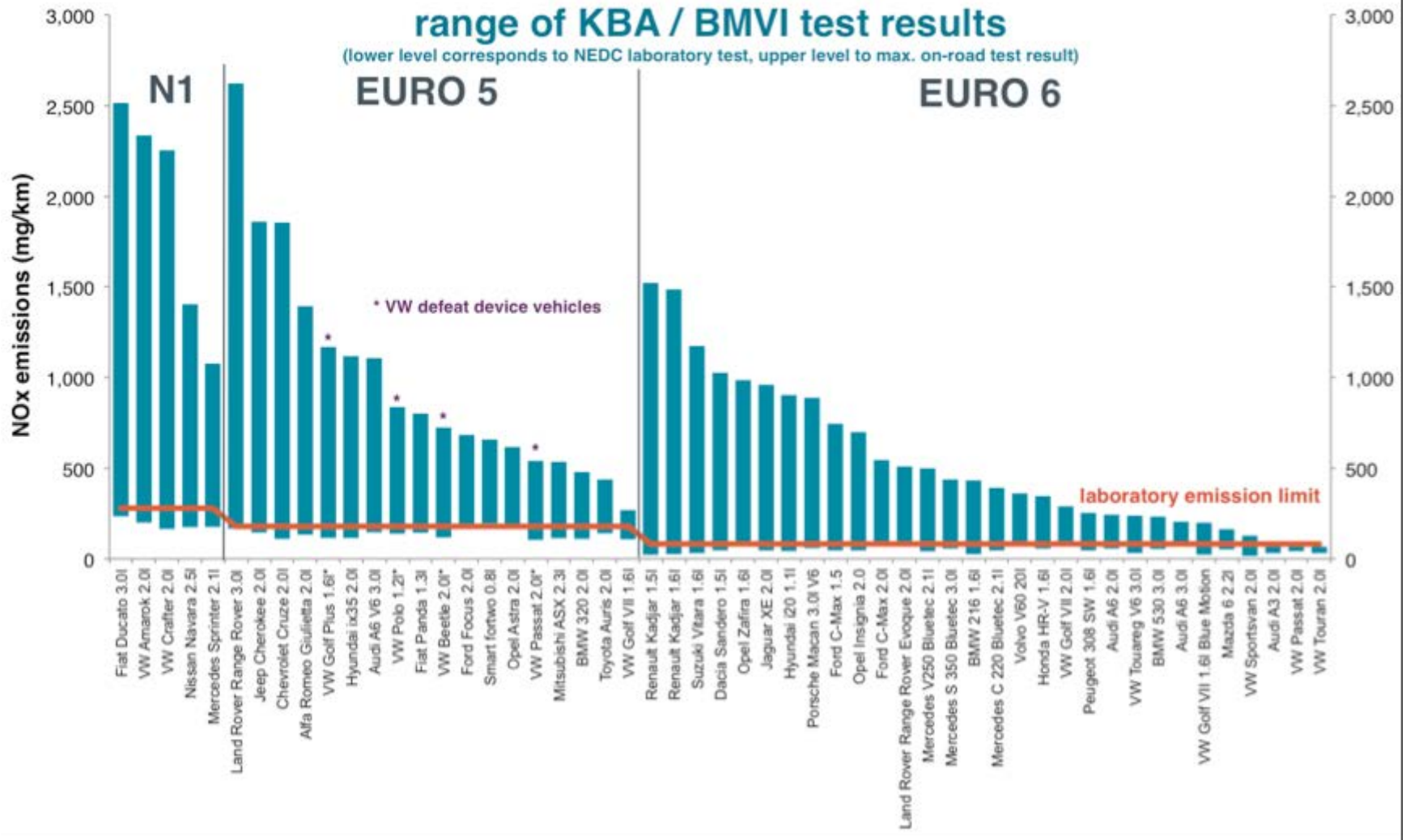
References – further reading

- ICCT White Paper on Remote sensing

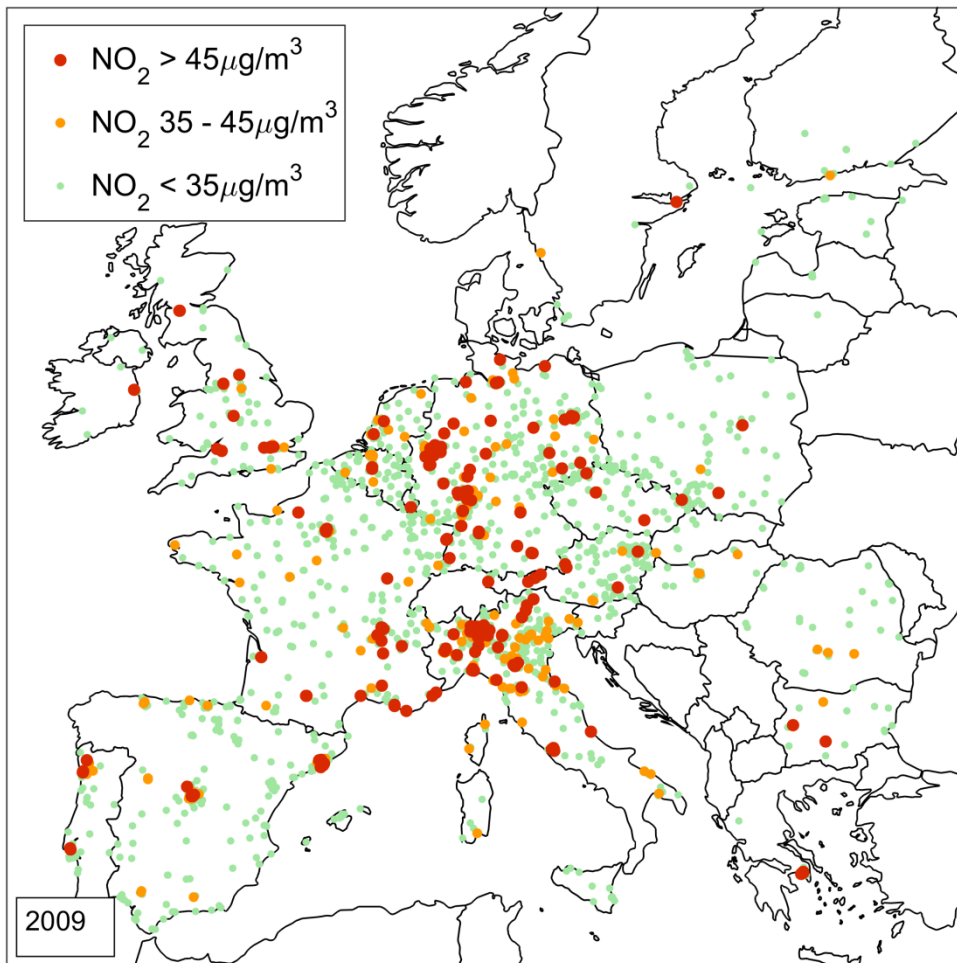- CONOx reports with methodological advances

- Backup slides

EU inquiries 2016: Defeat strategies in whole fleet

Official tests do not cover top selling models

High number of NO$_2$ exceedances across Europe — here year 2009 (≈ current situation)
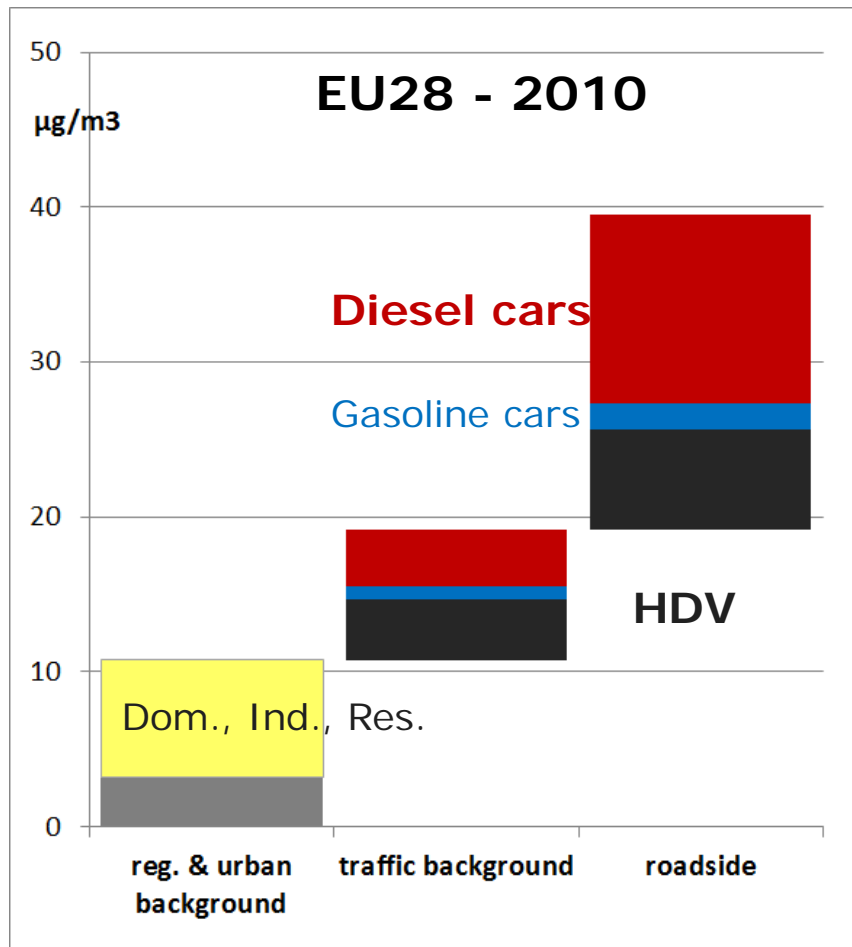

In 2009
~17% of stations above AQ limit value of 40 µg/m^3; ⇔

~10-20% of population affected by excess NO$_2$ mostly along busy roads

Sources for ambient NO$_2$ at traffic site - EU28

EU28 - 2010

Diesel cars

Gasoline cars

Dom., Ind., Res.

HDV

reg. & urban background

traffic background

roadside

All traffic stations

At traffic stations,
~75% of ambient NO$_2$
from road vehicles

⇔ Influence of **diesel** vehicles
much higher than their share in
national emissions

Contributions to ambient NO$_2$:
~40% Diesel cars + LCV
~25% Trucks & bus
~6%   Gasoline cars
~25% all other sources
                    on average