Real vehicle emissions – Measuring and interpreting

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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
Remote sensing scheme (cross-road)
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 sensing
- NEDC
- PEMS

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RS monitoring of performance in fleet

On-road NO\textsubscript{x} emissions of gasoline cars (Zürich/CH)

![Graph showing on-road NO\textsubscript{x} emissions over model years for various Euro standards.]
RS monitoring of performance in fleet

On-road NO$_x$ emissions of diesel cars (Zürich/CH)

Chen & Borken-Kleefeld, AtmEnv. 88 (2014)
NOx emissions by brand: Euro 5 (64,000 records)

Distinct pattern by manufacturer (not brand) though relatively uniform

Worst manufacturer ~2 times higher than best.

Remote sensing can tell...
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!
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

No PEMS
High number of NO$_2$ exceedances across Europe – here year 2009 ($\approx$ current situation)

In 2009

~17% of stations above AQ limit value of 40 $\mu$g/m$^3$;

$\Leftrightarrow$

~10-20% of population affected by excess NO$_2$ mostly along busy roads
At traffic stations, 
~75% of ambient NO₂ from road vehicles

|= Influence of diesel vehicles much higher than their share in national emissions

Contributions to ambient NO₂:
~40% Diesel cars + LCV
~25% Trucks & bus
~6% Gasoline cars
~25% all other sources on average