S C I E N C E ▪ P A S S I O N ▪ T E C H N O L O G Y

Analysis of HDV remote sensing measurement data

Konstantin Weller

Institute of Thermodynamics and sustainable Propulsion Systems

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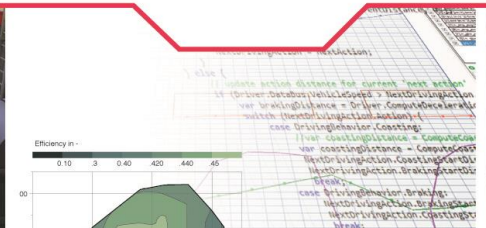


Content

- Analysis of remote sensing test database for HDV
- Elaboration of deterioration functions for HBEFA
- Comparison of HBEFA and remote sensing emission levels

Data sources

- Test data from different studies in Europe
  - Belgium (measurement device: HEAT)

Hooftman N., Ligterink N., Bhoraskar, A., (2020) Analysis of the 2019 Flemish remote sensing campaign. Commissioned by the Flemish Government - Flanders Environment Agency - Team Air quality policy

  - Germany (measurement device: Opus)

W. Schmidt, I. Düring: Ermittlung der Emissionen von Kraftfahrzeugen im fließenden Verkehr mit Remote Sensing Detection (EMI-RSD), Schlussbericht, Dresden, 2021

  - Sweden (measurement device: Opus)

Å. Sjödin et al.: Real Driving Diesel Vehicle Emissions as Measured by Novel Remote Sensing (RSD) Technology, Stockholm, 2021

  - United Kingdom (measurement device: Opus)

S. K. Grange et al.: Strong Temperature Dependence for Light-Duty Diesel Vehicle NOx Emissions, University of York, 2021

  - Switzerland (measurement device: Opus)

J. Sintermann, G.-M. Alt, M. Götsch, F. Baum, V. Delb: Langjährige Abgasmessungen im realen Fahrbetrieb mittels Remote Sensing, Zürich, 2020

Available data

- Data distribution according to
  - Driving situation: urban (Ger, Swe, UK, CH) and motorway driving (Bel)
  - Emission standard: focus on Euro V and Euro VI
  - HGV category: rigid trucks and long haul trucks
  - Vehicle age respectively mileage
- Number of valid data sets

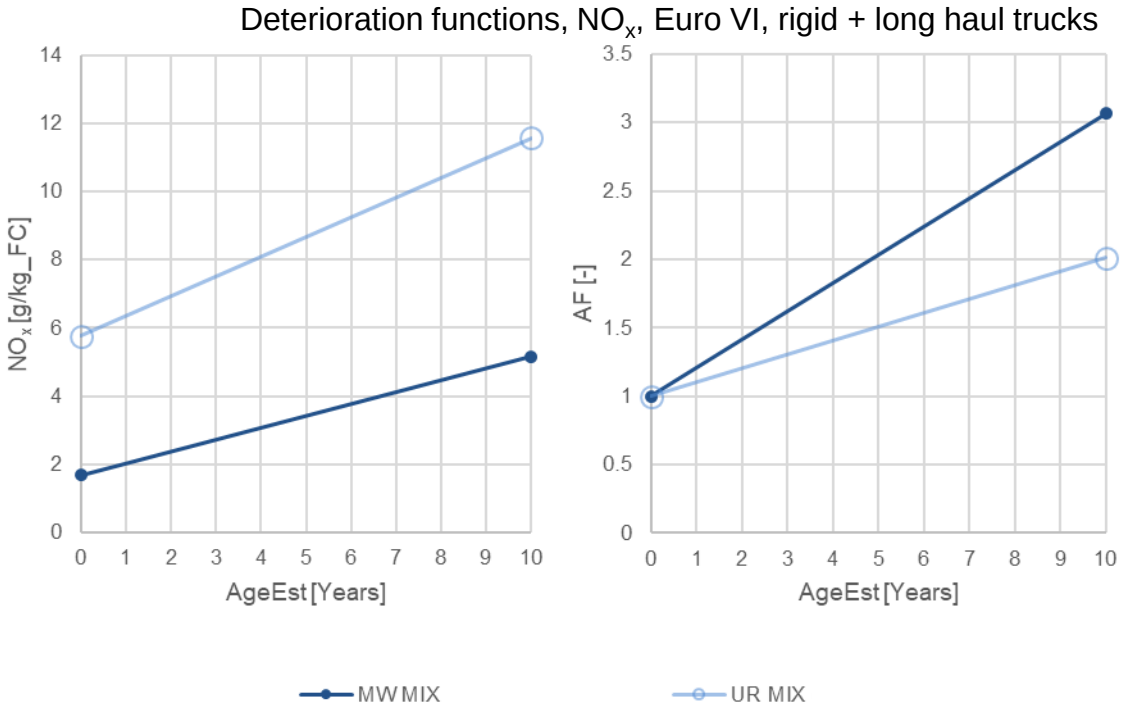
Traffic situation	RT - Euro V	RT – Euro VI	LH – Euro V	LH – Euro VI
Urban driving	1 104	1 574	2 246	5 026
Motorway driving	1 002	1 518	3 760	11 595

Summary of the different data sources enables reasonable data analysis

Elaboration of deterioration functions

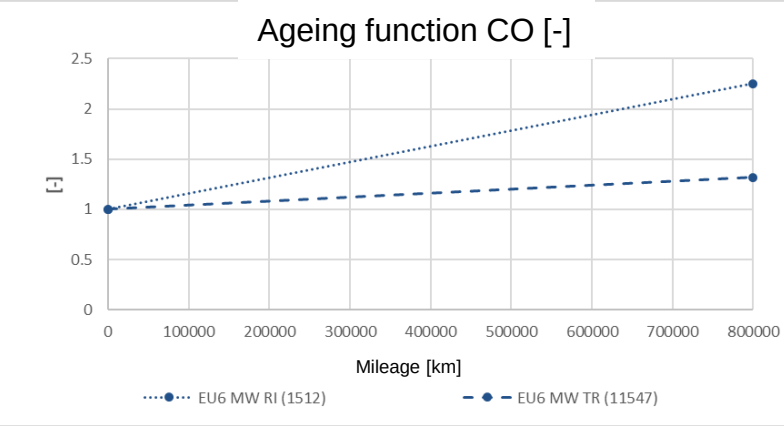
- Impact on absolute emission levels of each measurement campaign by
  - Various fleet composition per country
  - Different ambient conditions
  - Variety of the traffic situations

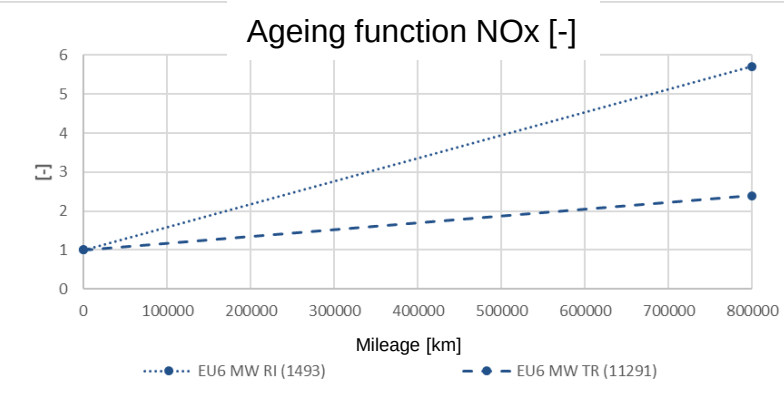
  → Elaboration of deterioration functions per measurement campaign
- Final deterioration functions by weighting of single functions based on number of data sets



HBEFA deterioration functions

- Results for motorway driving → similar trends for urban traffic
- CO: increase of emissions with higher mileage
  - Ageing of DOC
- NO_x: ageing effects clearly visible
  - Ageing of DOC and SCR
- NO_2/NO_x ratio decreases
  - Ageing of DOC (and SCR)
- HC: low emission level, no deterioration visible
- PN: emission level independent of mileage



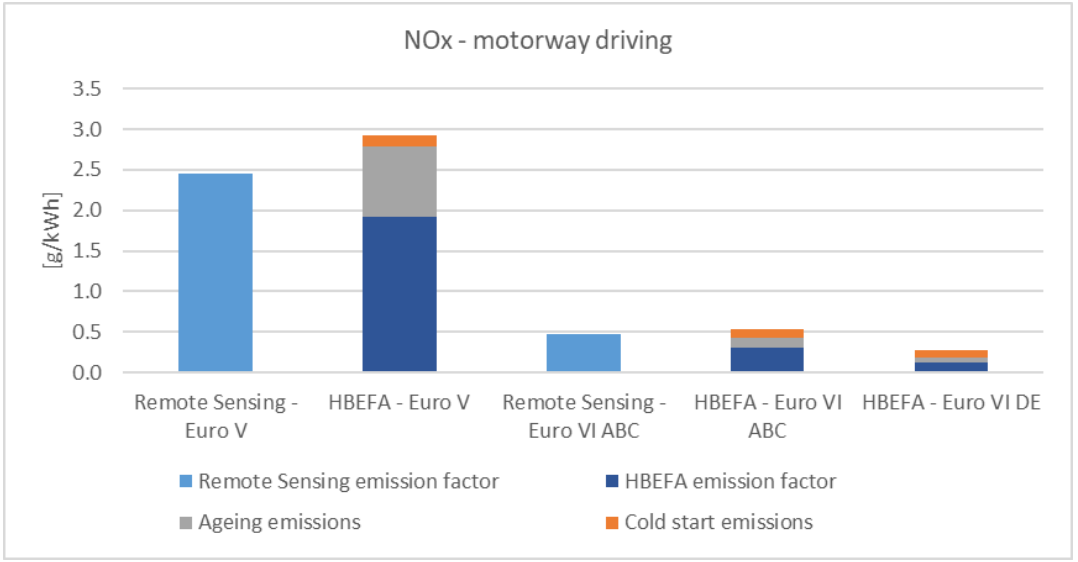


Comparison of emission factor of RS and HBEFA

- Emission factors can be divided in
  - Emissions in hot operating conditions
  - Cold start extra emissions
  - Increase of emissions because of deterioration effects due to higher mileage
- Remote sensing data
  - no information on start conditions → uncertainty regarding influence of cold start extra emissions
  - Deterioration effects are implicitly included
- HBEFA emission factors
  - Hot emission factors
  - Deterioration functions based on remote sensing data
  - Cold start extra emissions based on test data of more than 100 trucks [K. Weller, S. Hausberger, B. Hinterplattner: Cold start emissions EURO VI HDV results]
- Uncertainty based on traffic situation (average German traffic situations of HBEFA used)
- Uncertainty regarding vehicle mass → no information in remote sensing data, but effect lowered by use of g/kWh

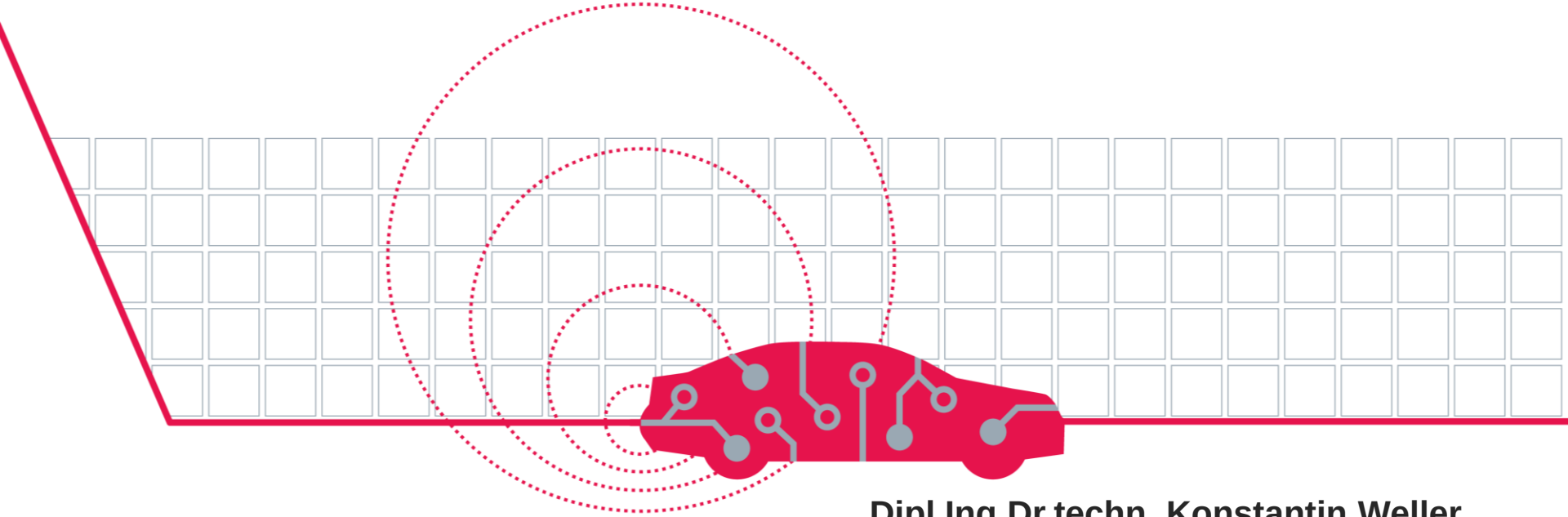
Emission levels of HBEFA and RS data: motorway driving

- RS vs. HBEFA
  - Euro V: RS lower by 12 to 16 %
  - Euro VI: fit in uncertainty of cold start emissions
- Development of emission factors
  - Euro V → Euro VI: reduction of 82 %
  - Euro VI ABC → Euro VI DE: reduction of 48 %
- MW in average 40 % lower NOx emissions than urban driving



Summary

- Remote sensing data of HDV can be used when combining different data sources
- Elaboration of ageing functions based on RS data
  - Deterioration effects for CO, NO_x and NO_2
  - No mileage effects for HC and PN
- Comparison of HBEFA and remote sensing underlies different uncertainties
- Remote sensing confirms HBEFA → Euro VI comes along with noticeable reductions of real world emissions



Dipl.Ing Dr.techn. Konstantin Weller

weller@ivt.tugraz.at

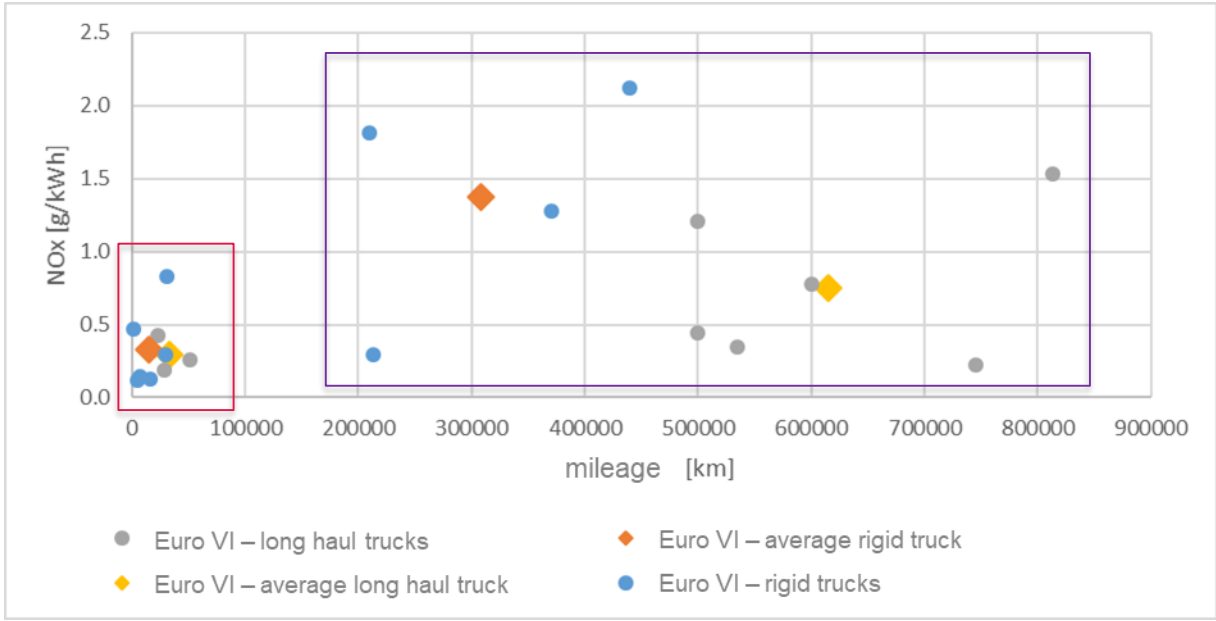
Inffeldgasse 19

8010 Graz

itna.tugraz.at

Deterioration effects based on PEMS data

- NO_x:
  - Comparable emission increases
  - Rigid truck with higher deterioration effects than long haul trucks
- Deterioration functions based on PEMS results for CO, HC and PN similar to remote sensing data



Deterioration functions, NO_x, Euro VI, rigid + long haul trucks based on PEMS data

Emission levels of HBEFA and RS data: urban driving

- RS overestimates HBEFA
  - Euro V: by 16 to 25 % (cold start uncertainty)
  - Euro VI: 46 to 84 %
- Development of emission factors
  - Euro V → Euro VI: reduction of 80 %
  - Euro VI ABC → Euro VI DE: reduction of 57 % (high SCR efficiency even in urban driving conditions)