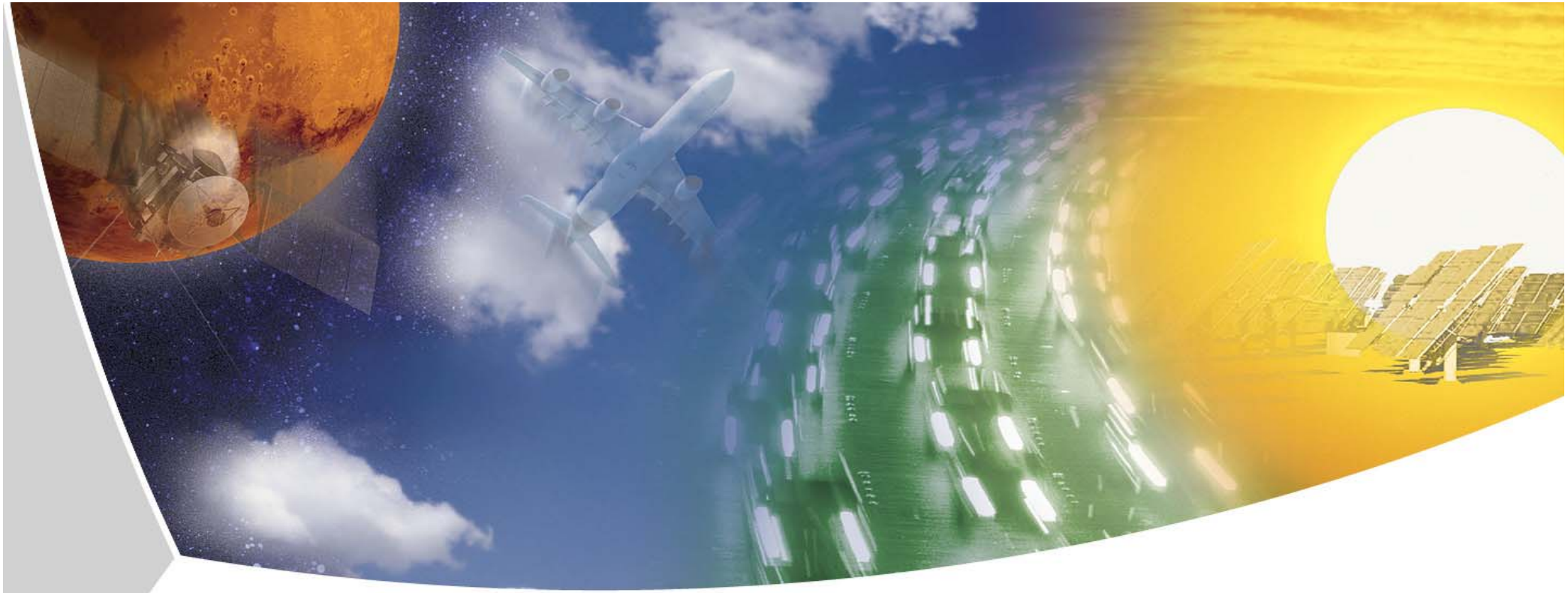

Global and country emission inventory of road transportation in the year 2000

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Filip Vanhove TML – Transport & Mobility Leuven/BE
with contributions of **S. Baidya** and **S. Martin** (DLR)

with financial support from the EU FP6 within the IP QUANTIFY (www.pa.op.dlr.de/quantify)

Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

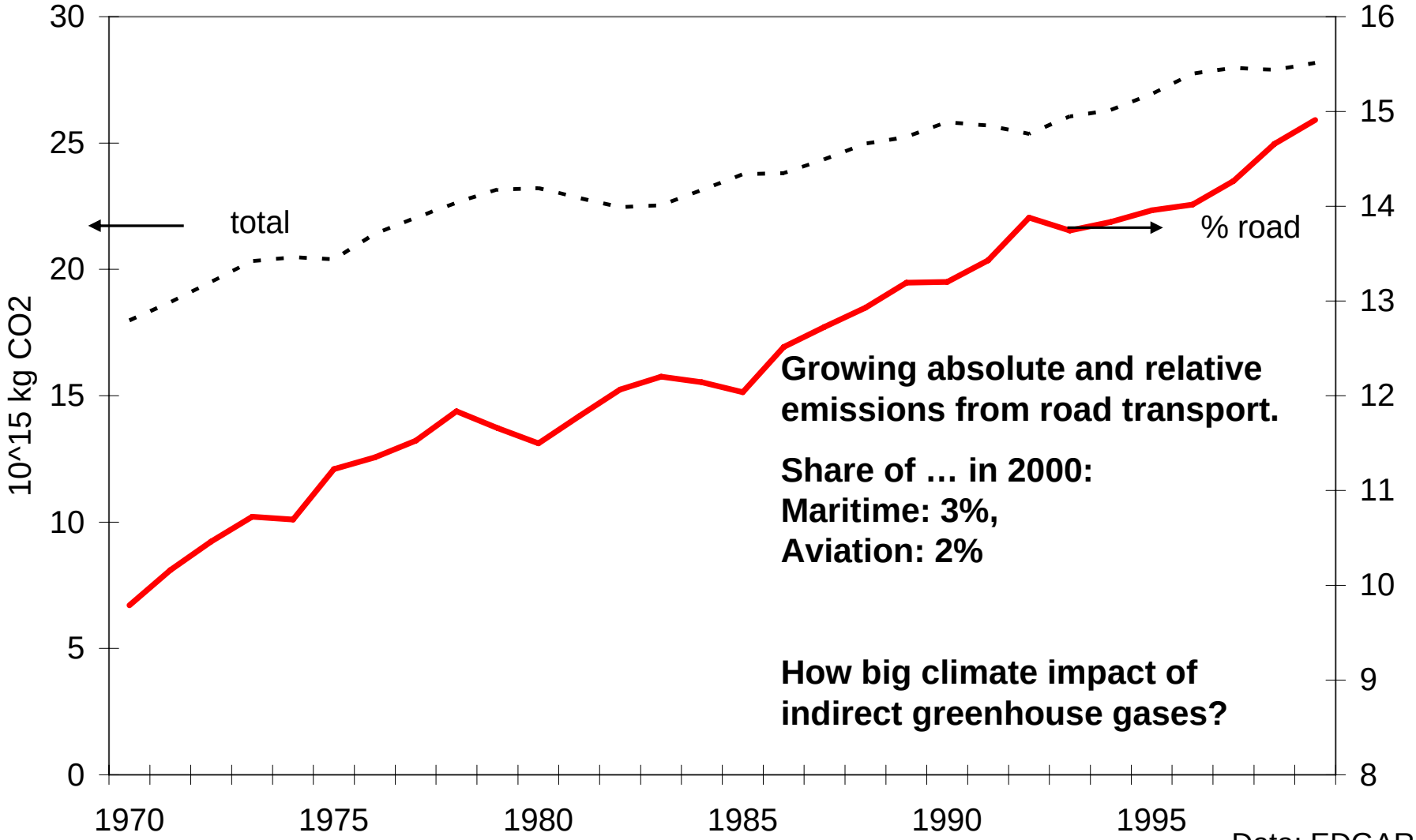
Global inventory of road transport's exhaust emissions

- Road transportation
  - i.e. all movements of motorised vehicles on public roads;
  - Differentiated by 5 vehicle categories and 5 fuel types.

- Tail-pipe exhaust emissions:
  CO_2, SO_2, CO, VOC, NMVOC, CH_4, NO_x, prPM.
  Not included:
  - Evaporative emissions (VOC);
  - Brake, clutch + tyre wear, resuspension (PM);
  - Discharges from accidents, maintenance, end-of-life (HFCs)

- Consistent treatment of all countries in the world!

Importance of road transport‘s emissions for climate change



Data: EDGAR 3.2

Approach: Transport volume x emission factors

- Transport activity for 5 vehicle categories x 4 fuel types, on country level:

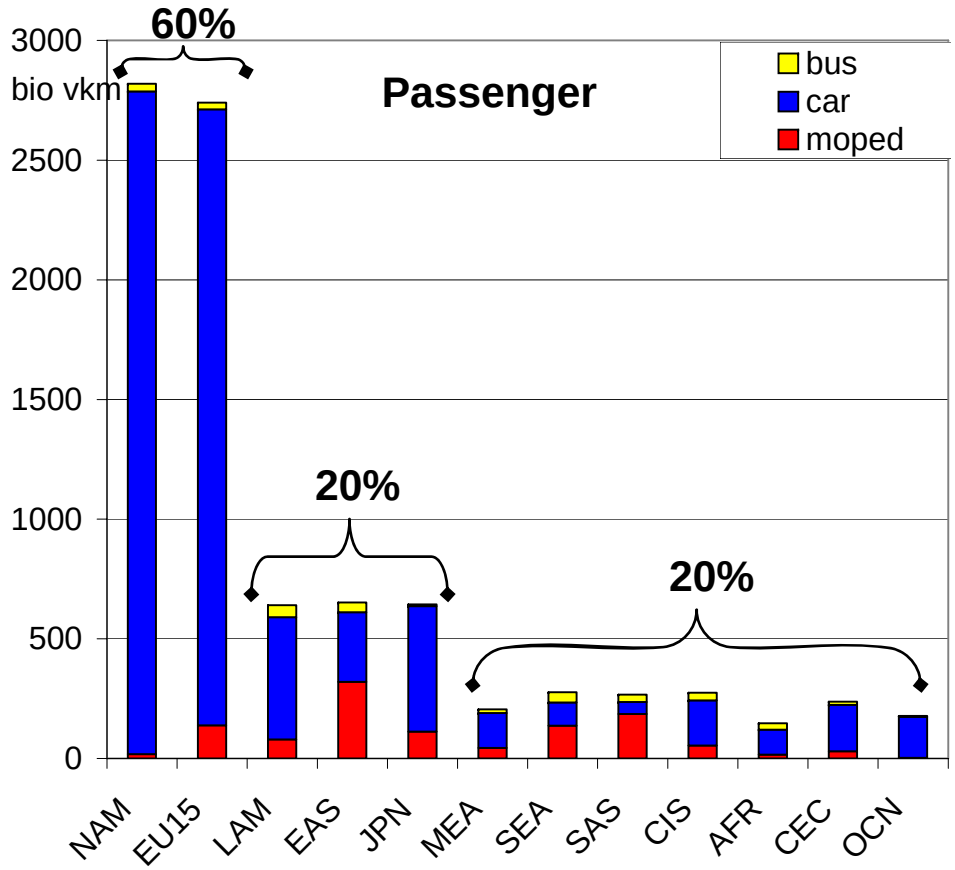
Passenger tr.	Freight transport	Fuels
Cars	Light duty trucks	Gasoline - LPG/CNG - (m)ethanol
Bus	Heavy duty trucks	Diesel - biodiesel
2 wheelers		

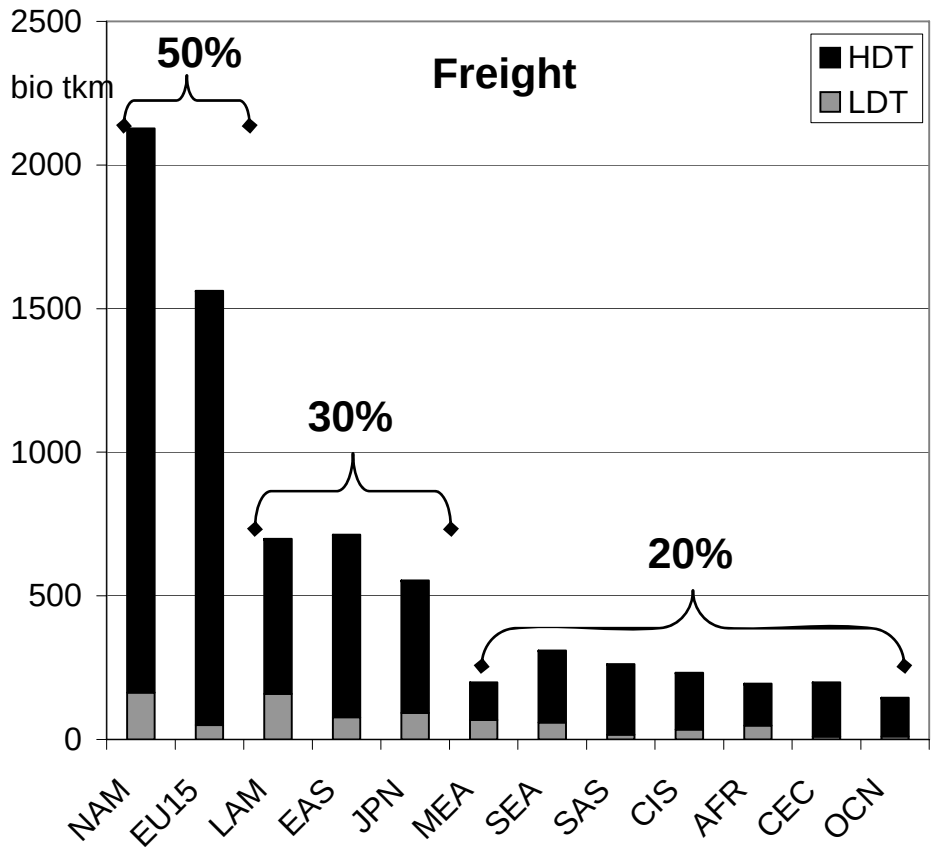
  - activity data per country by TML Leuven (Vanhove et al.)
  - emission factors per region by KTI Budapest (Meretei et al.)
    - relative to test cycle; regular maintenance assumed: Probably lower estimate

- Essential **validation**: Fuel sales statistics per country/region! (IEA with modifications)

- This is first calculation for many countries at this differentiation.

Global transport volumes in the year 2000



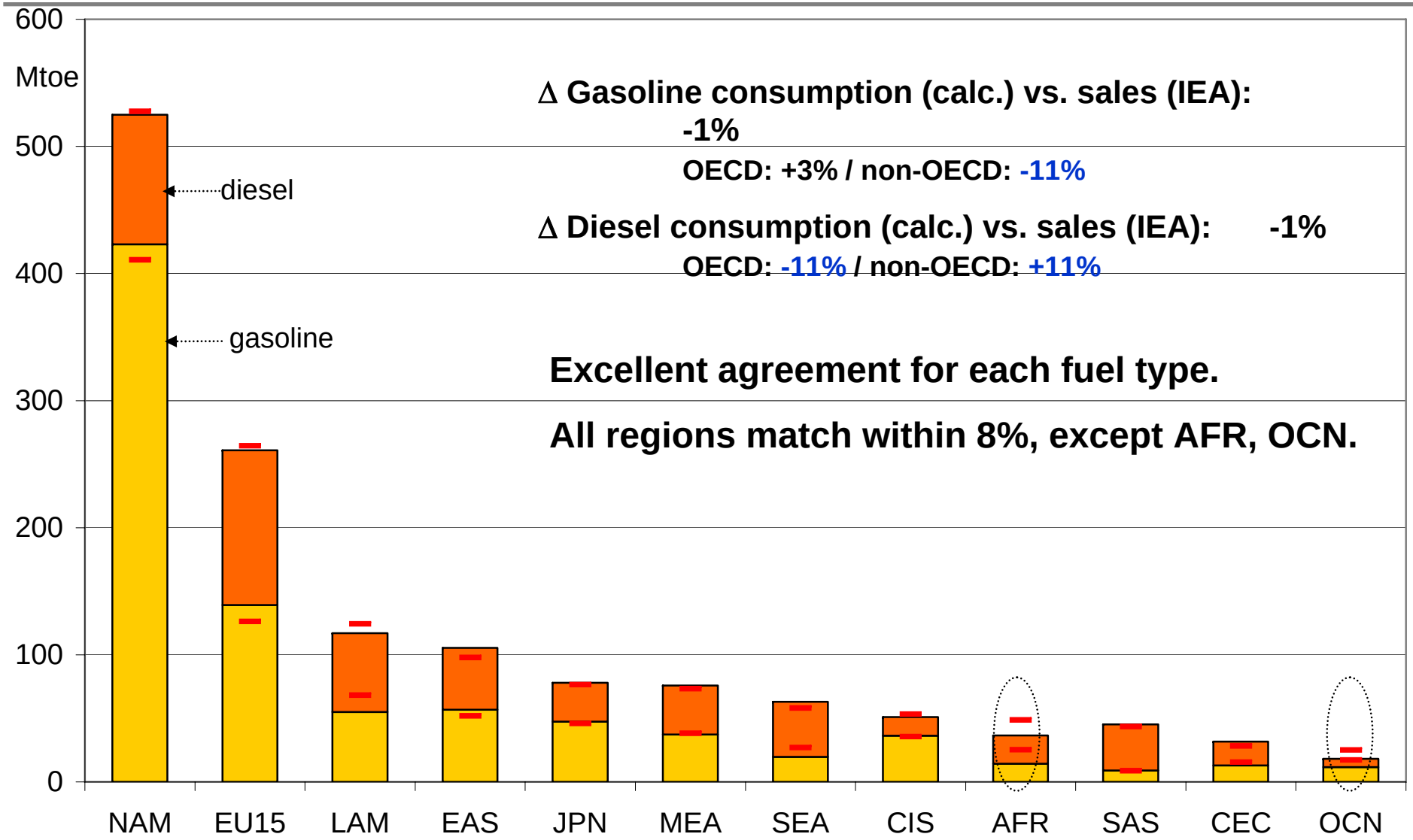


- **OECD regions dominate road transport volumes**
- **Asia & Latin America follow**

Vanhove et al. 2006

Vanhove et al. 2006 Data: v20061215

Validation: Fuel consumption (calc.) vs. fuel sales (IEA) y2000



Δ Gasoline consumption (calc.) vs. sales (IEA): -1%

OECD: +3% / non-OECD: -11%

Δ Diesel consumption (calc.) vs. sales (IEA): -1%

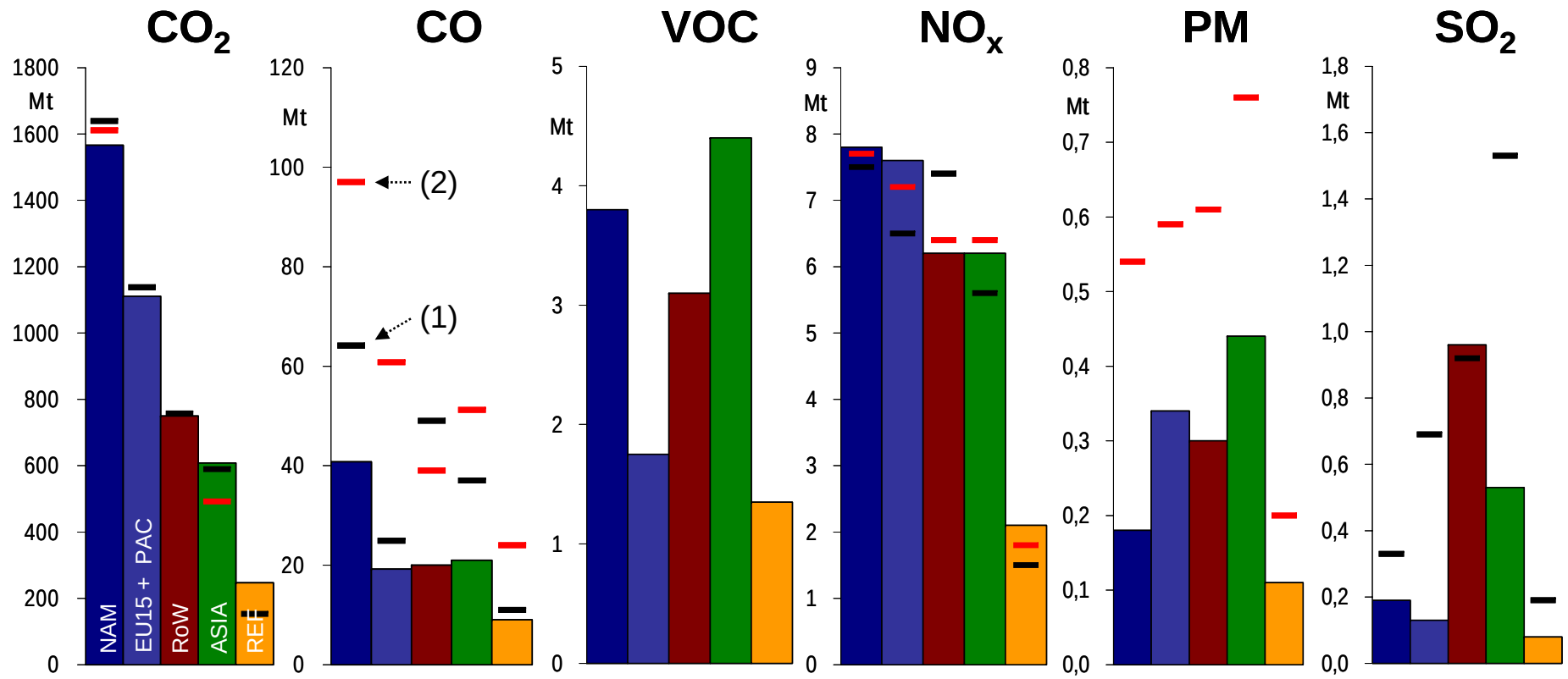
OECD: -11% / non-OECD: +11%

Excellent agreement for each fuel type.

All regions match within 8%, except AFR, OCN.

Borken et al. 2006 Data: v20061215

Exhaust emissions per region in the year 2000



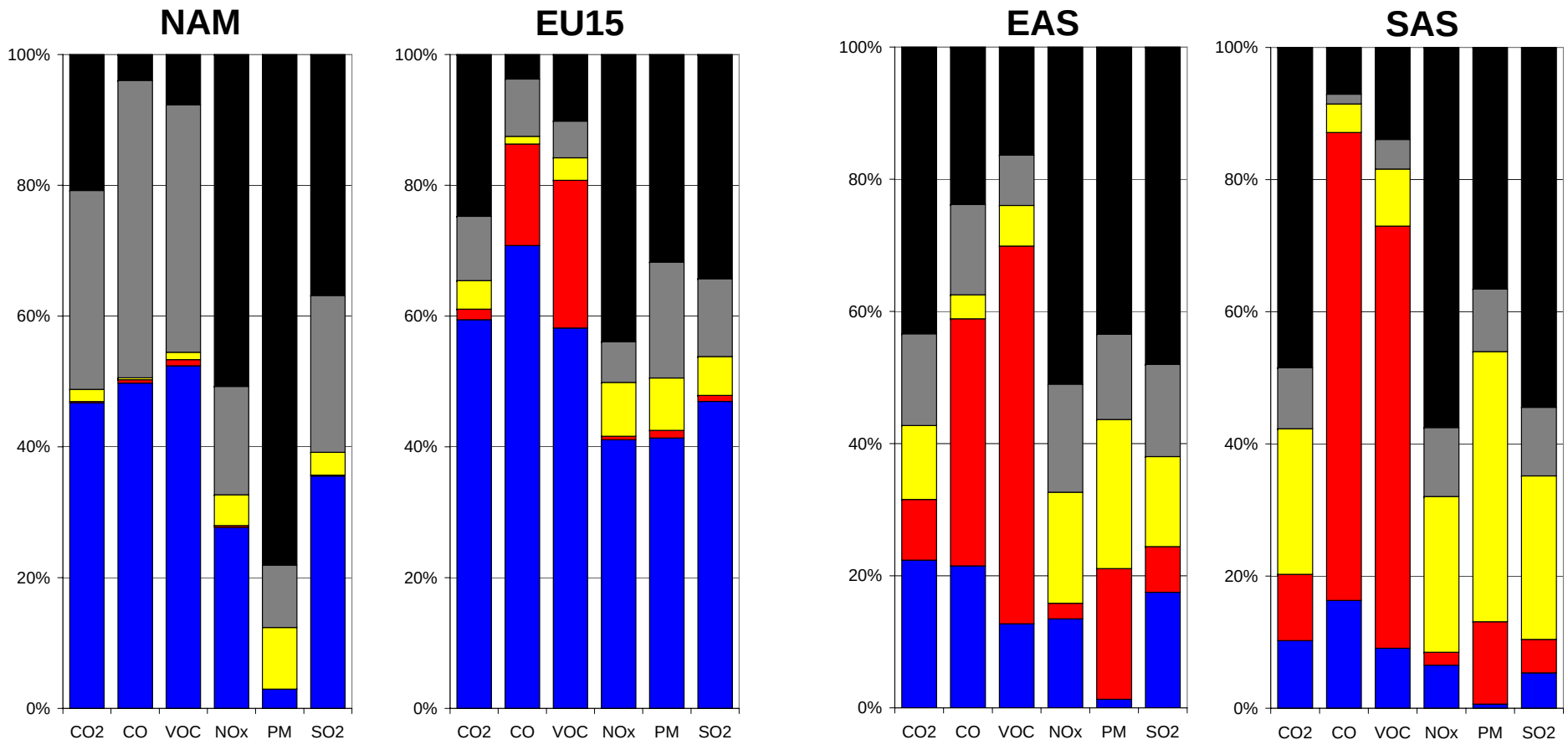
Borken et al. 2006 Data: v20061215

- Concurrence for CO2 and NOx
- Large uncertainties for all other compounds

(1) Aardenne et al. 2005

(2) Fulton & Eads 2004

Distinct vehicle emission pattern for each region

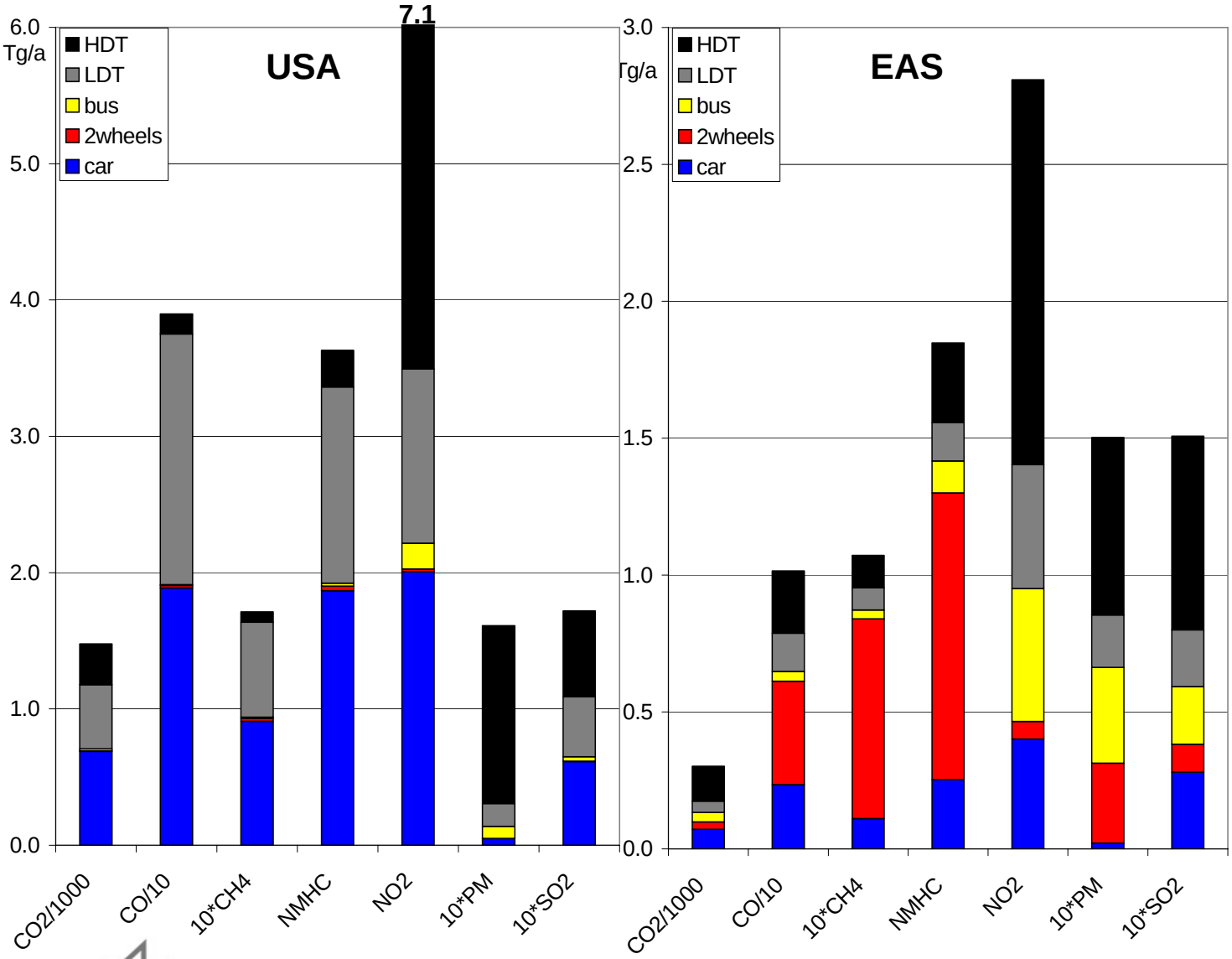


Typical for OECD:
High use (indicator: CO2) and emission share of passenger cars and light duty vehicles.

Typical for Asia:
High emission share of mopdes and busses. Little car travel.

Borken et al. 2006 Data: v20061215

Emissions by vehicle category in most important regions



For comparison:

Level factor 2-4 lower, exc. sulfur (!),

Very different vehicle shares,

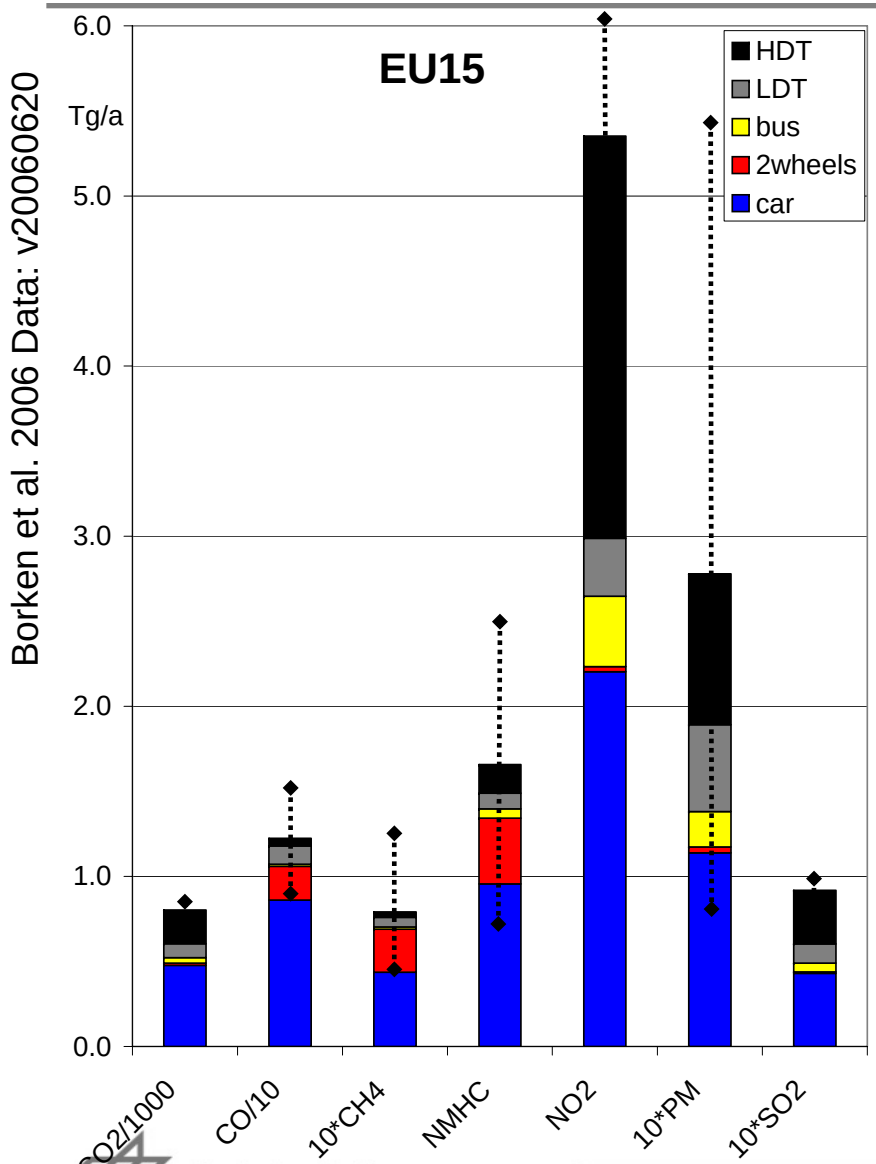
Each compound dominated by different vehicle types – different per region,

typical pattern,

=> Differentiation needed

Borken et al. 2006 Data: v20061113

Variation of emission estimates – the case of OECD countries



Uncertainty mostly due to

- **distribution between vehicle types,**
- **uncertainty of emission factors.**

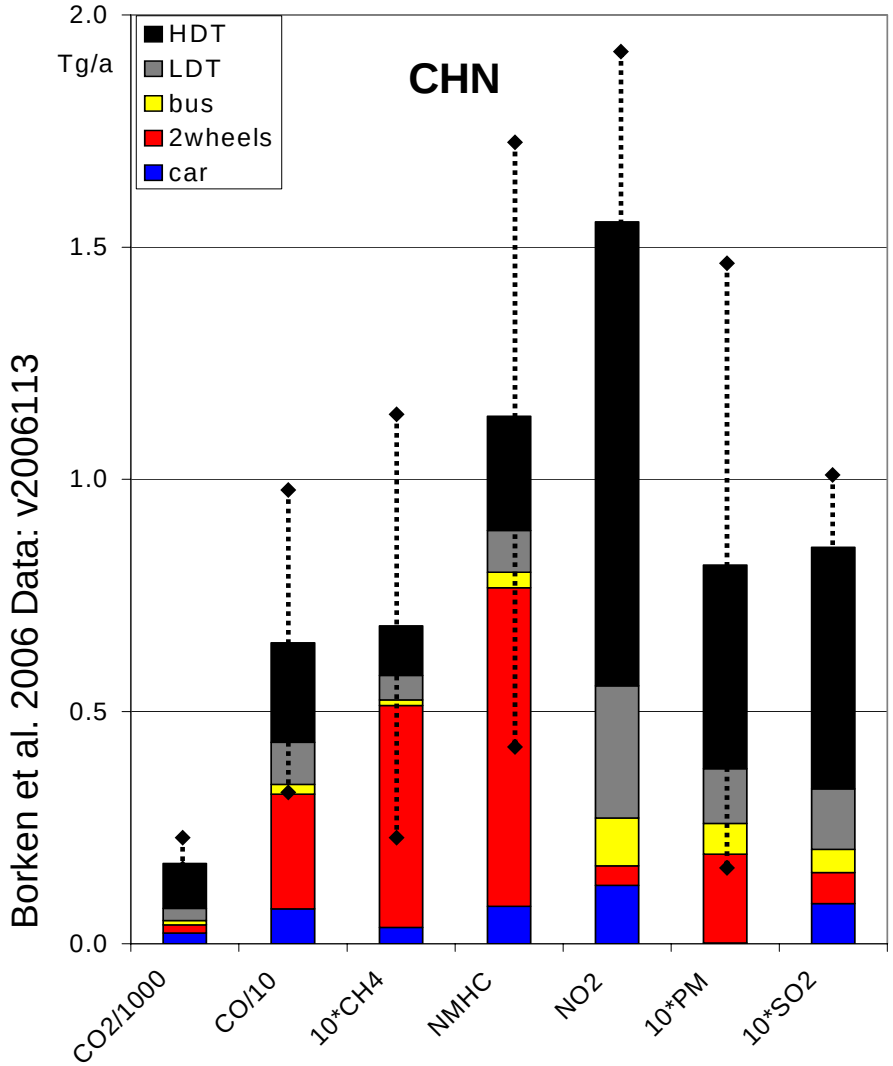
Compared to sales data:

- **ΔCO2: gasoline <2%, diesel <5%;**
- **ΔSO2: gasoline <5%, diesel <10%**

Compared to other regional inventories, variation in emission factors:

- **ΔNO2 ~15%**
- **ΔCO ~30%**
- **ΔHC ~50%**
- **ΔPM ~80%**

Variation of emission estimates – the case of non-OECD countries



Emissions estimates more uncertain, as

- **irregular driving conditions (overloading),**
- **irregular maintenance (-> super-emitters),**
- **higher diversity of fleet with very old, old, and new vehicles,**
- **high dynamics,**
- **less reliable data gathering.**

Compared to sales data:

- **ΔCO2: gasoline ~5-10%, diesel ~10-15%;**
- **ΔSO2: gasoline ~10-20%, diesel ~20-30%**

Compared to other regional inventories variation in emission factors:

- **ΔNO2 ~25%** **ΔCO ~50%**
- **ΔHC ~75%** **ΔPM ~100%**

Further reading

- Borken, Steller, Vanhove, Meretei:
  Global and Country Inventory of Road Passenger and Freight Transportation, their Fuel Consumption and their Emissions of Air Pollutants in the Year 2000.
  Transportation Research Record/86th Annual Meeting of the Transportation Research Board, Washington/USA (submitted)
  www.trb.org

- Steller & Borken:
  Global road transport's emission inventory for the year 2000.
  Proceedings of the TAC-Conference, June 26 to 29, 2006, Oxford/UK (in print)
  www.pa.op.dlr.de/tac

- Borken & Steller:
  Road transport's emission inventory for the year 2000 – grid- and countrywise.
  Meteorologische Zeitschrift (submitted)

Summary: Validated, consistent, comprehensive and differentiated global emission inventory for road transport

Globally **relevant countries** for emission control:

- **G7:** USA, Japan, Germany, France, UK, Italy, Canada, **Asia:** China, India, **Russia**, **Latin America:** Brazil, Mexico,
  secondary: Iran, Saudi-Arabia, Indonesia, Malaysia, Thailand

account for 60-80% of global pollutant emissions from road.

Relevant vehicle categories:

- **Cars & LDT** in **OECD regions**;
- **Mopeds & busses**, notably in **Asia**.

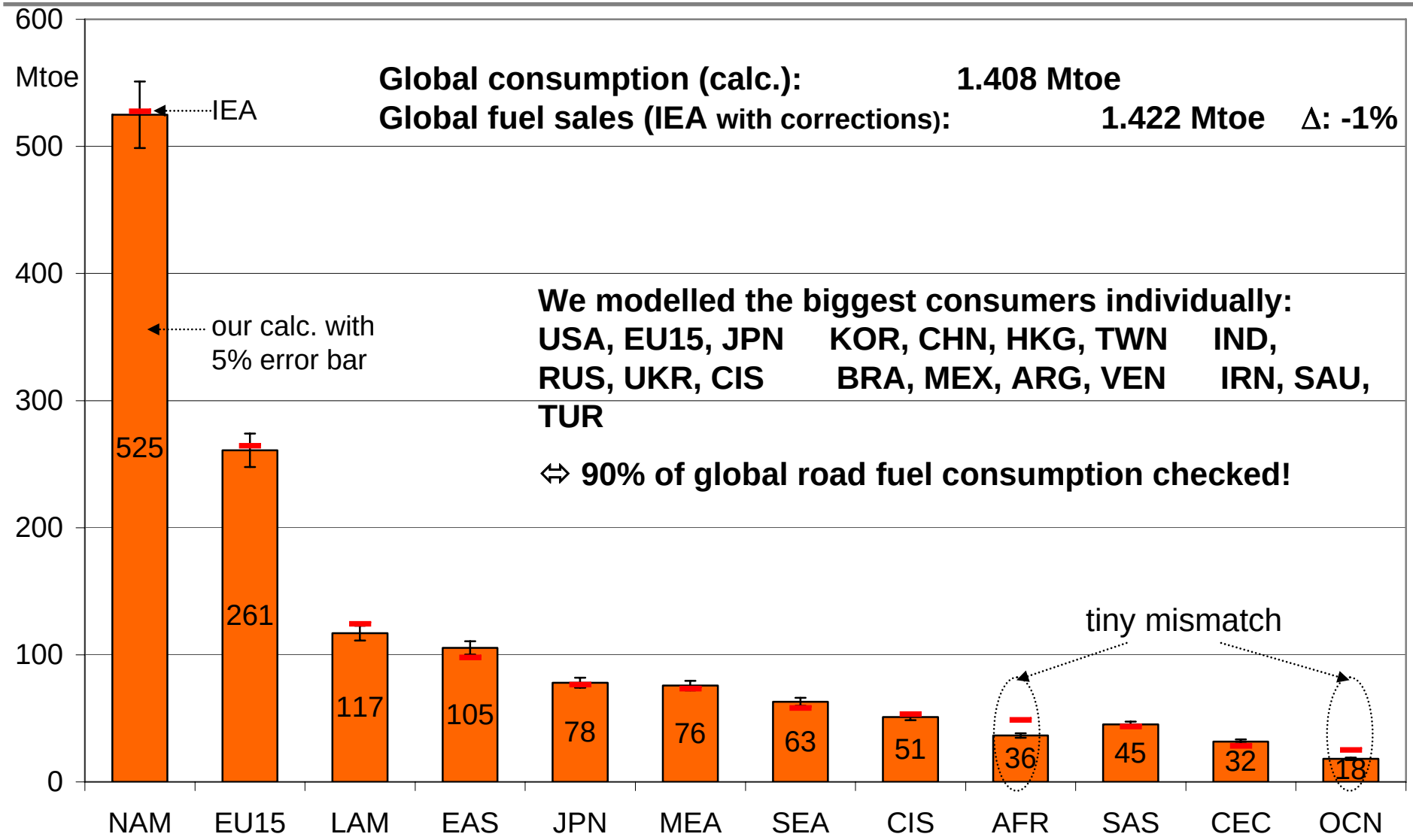
Outlook:

- Transport stories for 2025 – 2050 – 2100, regionally differentiated.
- Sensitivity analysis wrt super-emitters.

Emission factors for y2000 aggregated by regions

	Fuel con.	CO	HC	NOx	PM	Fuel con.	CO	HC	NOx	PM
	g/veh-km	g/veh-km	g/veh-km	g/veh-km	g/veh-km	g/veh-km	g/veh-km	g/veh-km	g/veh-km	g/veh-km
	Passenger car - gasoline fueled					Passenger car - diesel fueled				
OECD	52-86	2.5-7.5	0.17-0.78	0.38-0.95	0.001	51-79	0.3-0.88	0.09-0.39	0.62-1.12	0.11-0.15
ASIA	81-89	8.6-15.4	0.96-2.1	1.4-2.5	0.002-0.003	60-76	0.58-1.45	0.17-1.18	0.98-1.45	0.20-0.26
REF	61-81	5.7-11.5	0.65-1.9	0.98-1.7	0.001-0.003	52-68	0.56-1.16	0.15-0.99	0.90-1.45	0.18-0.22
RoW	88-104	5.7-11.5	0.65-1.9	0.98-1.9	0.001-0.003	68-89	0.56-1.16	0.15-0.99	0.70-1.45	0.16-0.22
	Light duty truck – gasoline fueled					Bus & coach - diesel fueled				
OECD	83-103	12-18	0.6-1.4	0.9-2.3	0.002	281-326	0.4-1.1	0.16-0.50	0.9-1.1	0.17-0.22
ASIA	113-138	22-28	1.7-2.4	2.7-3.2	0.003-0.006	286-348	1.0-2.0	0.65-1.41	1.8-4.8	0.28-0.63
REF	101-103	21-28	1.2-2.4	2.3-3.0	0.002-0.006	318-340	0.9-1.5	0.20-1.28	1.3-4.8	0.26-0.29
RoW	89-156	21-28	1.2-2.4	2.3-3.0	0.002-0.006	340-374	0.9-1.5	0.20-1.28	1.2-4.8	0.26-0.37
	Moped & motorcycle - gasoline fueled					Heavy duty truck - diesel fueled				
OECD	29-56	10.1-15.6	2.1-3.5	0.21-1.23	0.002-0.1	221-266	1.5-2.6	0.51-1.00	8.5-11.5	0.25-0.47
ASIA	24-30	12.9-15.9	3.8-4.6	0.15-0.22	0.1	272-273	2.6-3.6	1.25-2.20	11.7-13.6	0.62-0.68
REF	29	15.1-15.4	3.8-3.9	0.22-0.24	0.002-0.1	253-272	2.3-3.3	0.93-2.00	10.4-12.0	0.43-0.62
RoW	29-30	13.2-15.4	3.8-4.1	0.16-0.24	0.1	238-306	2.3-3.3	0.93-2.00	10.4-12.0	0.43-0.62
Region proxies: OECD := EU15+JPN+NAM+OCN; ASIA := EAS+SAS+SEA; REF := CEC+CIS; RoW := AFR+LAM+MEA										

Validation: Fuel consumption (calc.) vs. fuel sales (IEA)



Global consumption (calc.): 1.408 Mtoe
Global fuel sales (IEA with corrections): 1.422 Mtoe Δ: -1%

We modelled the biggest consumers individually:
USA, EU15, JPN KOR, CHN, HKG, TWN IND, RUS, UKR, CIS BRA, MEX, ARG, VEN IRN, SAU, TUR

⇔ 90% of global road fuel consumption checked!

Borken et al. 2006 Data: v20061215