Road transport’s emission inventory for the year 2000

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Emission inventory for road transport

- Emission inventory from road transportation, **here** for the year 2000.
  - i.e. all movements of motorised vehicles on public roads;
  - Differentiated by 5 vehicle categories and 4 fuel types.

- Tail-pipe exhaust emissions: CO2, SO2, CO, VOC, NMVOC, CH4, NOx, prPM
  - not included (in this version):
    - Evaporative emissions (VOC);
    - Brake, clutch + tyre wear, resuspension (PM);
    - Discharges from accidents, maintenance, end-of-life (HFCs)

- All countries on the world &
  on 1°x1° grid
  - ~ to population density with modifications for each region and vehicle category, e.g.:
    - Heavy duty trucks: ~90% in rural areas;
    - mopeds: ~90% in urban areas.
Importance of road transport’s emissions for climate change

Growing absolute and relative emissions from road transport.

Share of ... in 2000:
Maritime: 3%, Aviation: 2%

How big climate impact of indirect greenhouse gases?

Data: EDGAR 3.2
Activity based approach scaled to fuel consumption

- Bottom-up (Tier 2), starting from transport activity for 2*5 vehicle categories, on country level:

<table>
<thead>
<tr>
<th>Passenger tr.</th>
<th>Freight transport</th>
<th>Fuels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
<td>Light duty vehicles</td>
<td>Gasoline- LPG/CNG - (m)ethanol</td>
</tr>
<tr>
<td>Bus</td>
<td>Heavy duty vehicles</td>
<td>Diesel - biodiesel</td>
</tr>
<tr>
<td>2 wheelers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 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)

- For many countries this is the first calculation for several exhaust gases at this differentiation.
Global transport volumes in y2000

Passenger

Freight

rest: 40%

rest: 40%

Vanhove et al. 2006
Global consumption (calc.): 1.370 Mtoe
Global fuel sales (IEA with corrections for CHN, IND): 1.403 Mtoe \( \Delta: -2\% \)

We modelled the biggest consumers individually:
USA, EU15, JP, KOR, CHN, HKG, TWN, IND, RUS, BRA, MEX, ARG, VEN
\( \Leftrightarrow 85\% \) of global road fuel consumption!
Road fuel consumption (calc.) vs. road fuel sales (IEA)

\[ \Delta \text{Gasoline consumption (calc.) vs. sales (IEA): -3\%} \]
OECD: -3\% / non-OECD: -21\%

\[ \Delta \text{Diesel consumption (calc.) vs. sales (IEA): -1\%} \]
OECD: +12\% / non-OECD: +10\%

Almost perfect agreement for each fuel type.
All regions match within 5\%, except MEA, AFR, OCN.

We recalculate IRN, SAU, TUR, ISR.
Comparison with global road transport’s emissions: EDGAR

Using EDGAR’s transport data:
Hemispheric distribution of road transport emissions

Emissions distributed ~ to population density with modifications:
2wheels ~90% urban, HDVs ~ 90% rural.

CO2 and NOx equal, for CO and NMVOC different level and distribution.

Of total road transport’s emissions
~60-75% in Northern mid-latitudes,
~33% in tropics,
<10% Southern hemisph.
(exc. SO2: 22%)
Road transport's NOx emissions in the year 2000

>30°N: 67%
>0°N: 23%
<0°S: 7%
<30°S: 2%

kg NO₂ per km²
NOx: Highest emission densities in OECD + IND + CHN

>30°N: 67%
>0°N: 23%
<0°S: 7%
<30°S: 2%

<500 10⁷ 2*10⁷ 2*10⁸ kg NO₂ per km²
Road transport’s NMVOC emissions in the year 2000

>30°N: 61%
>0°N: 29%
<0°S: 7%
<30°S: 2%

kg NMHC per km²
NMVOC: Highest emission densities in OECD + IND + CHN

>30°N: 61%
>0°N: 29%
≤0°S: 7%
<30°S: 2%

kg NMHC per km²
## Summary: Road transport emissions in 2000

<table>
<thead>
<tr>
<th></th>
<th>SO2</th>
<th>NMHC</th>
<th>NOx</th>
<th>prPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total:</td>
<td>111 Tg</td>
<td>15 Tg</td>
<td>29 Tg</td>
<td>1,33 Tg</td>
</tr>
</tbody>
</table>

**Data:** v2006113

[Borken et al. 2006]
Bulk (~75%) of road transport emissions in few countries only

- SO2: Total: 111 Tg
- NMHC: Total: 15 Tg
- NOx: Total: 29 Tg
- prPM: Total: 1,33 Tg

Borken et al. 2006 Data: v2006113

Deutsches Zentrum für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft
Emissions by vehicle category in most important regions

High shares from passenger cars and light trucks – typical for OECD countries.

Gasoline powered vehicles dominate CO, VOC; diesel powered vehicles dominate NOx, PM, SO2.
High shares from mopeds, bus and truck; very little travel with passenger cars (in 2000).

Development of both growth in transport volumes, shift to passenger cars, and reduction in emission limits is very dynamic!
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.
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:
- $\Delta CO_2$: gasoline <2%, diesel <5%;
- $\Delta SO_2$: gasoline <5%, diesel <10%

Compared to other regional inventories, variation in emission factors:
- $\Delta NO_2 \sim 15\%$
- $\Delta CO \sim 30\%$
- $\Delta HC \sim 50\%$
- $\Delta PM \sim 80\%$
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:

- $\Delta CO_2$: gasoline ~5-10%, diesel ~10-15%;
- $\Delta SO_2$: gasoline ~10-20%, diesel ~20-30%

Compared to other regional inventories variation in emission factors:

- $\Delta NO_2$ ~25%  $\Delta CO$ ~50%
- $\Delta HC$ ~75%  $\Delta PM$ ~100%
Summary and outlook

- Validated, consistent, comprehensive and differentiated emission inventory for road transport on country by country and 1° longitude by 1° latitude for the year 2000.
  - New: prPM from gasoline powered vehicles.

- ~2/3 of total emissions & highest emission densities in Northern mid-latitudes.
- Only ~10-15 countries are responsible for the bulk of global pollutant emissions:
  - USA, DE, FR, GB, I, JP, CHN, IND, RUS, BRA, (MEX, THA, IDN)

- Vehicles in OECD: Abundant transportation, notably by passenger cars + trucks;
- Vehicles in non-OECD: High emissions from mopeds, busses, trucks, but emission from passenger cars are rising.

In progress:
- Sensitivity of emissions wrt different shares of vehicles and super-emitters;
- Determine BC/OC & PM1 fractions;
- Develop transport stories compatible with SRES scenarios for 2025 – 2050 - 2100.
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:
Global road transport’s emission inventory for the year 2000.
Meteorologische Zeitschrift (in preparation)