NILU: F 8/2006

NILU: F 8/2006
REFERENCE: Q-303
DATE: JUNE 2006

Impact of long range transported air pollution on exposure in Norwegian cities

Steinar Larssen, Leiv Håvard Slørdal, Herdis Laupsa, Harold McInnes and Wenche Aas

Presented at:
Nordic Air Pollution Workshop 2006
March 6, 2006,
Centre of Health and Society
University of Copenhagen,
Copenhagen

Impact of long range transported air pollution on exposure in Norwegian cities

Steinar Larssen, Leiv Håvard Slørdal, Herdis Laupsa, Harold McInnes and Wenche Aas, Norwegian Institute for Air Research, NILU

Data from air pollution measurements all over Europe (source: AirBase http://air-climate.eionet.eu.int/databases/airbase/) show that the general situation in Europe is that the regional contribution to PM dominates the PM10 and PM2.5 concentrations in urban areas, while this regional contribution to NO2 is much less dominant. The regional scale concentrations are of course highest in the parts of central and eastern Europe, and diminishes towards the Northern parts of Europe. In central parts of Europe the regional scale concentrations are partly due to the country's own contribution and the contribution from 'long range transported' air pollution (LRTAP), while in Northern parts of Europe, the regional scale concentrations are to a large extent caused by LRTAP.

The regional/LRT contribution to cities in Norway has been studied, mainly for Oslo, using measurements and modelling, a combination of the EMEP Unified Model and NILU's urban scale model EPISODE, run within the AirQUIS AQMS software system. The main local sources to PM in air in Norwegian cities, for PM2.5: small scale wood burning and vehicle exhaust; to PM10: here the resuspension of road dust, caused by studded tyres, comes in as a large additional source. For both PM fractions, the LRT contribution comes in addition.

The results of these modelling efforts show that for NO2, the regional contribution to the population exposure in Oslo is small, about 10% to annual average exposure and negligible to the exposure to high-level short-term concentrations above limit values. For PM the LRT contribution is much more important: 40% of the PM10 exposure on an annual basis, and 50% to annual PM2.5 exposure. Looking at the high end of the exposure, only about 12% of the exposure situations above the PM10 short-term limit value (50ug/m3 as daily average) can be attributed to the LRTAP. These figures relate to the 2003 situation. Population exposure is calculated based upon a static population (at residents), and a population weighted average exposure concentration.

The regional contribution to PM concentrations in urban areas in more central regions of Europe would in general be higher both in absolute and relative terms.

Appendix A

Powerpoint Presentation

IMPACT OF LONG RANGE TRANSPORTED AIR POLLUTION ON EXPOSURE IN NORWEGIAN CITIES

Steinar Larssen, Leiv Håvard Slørdal, Herdis Laupsa, Harold McInnes and Wenche Aas

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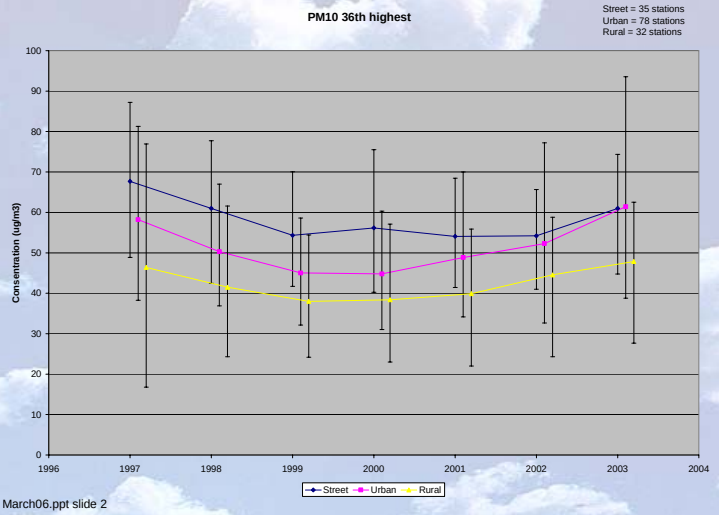
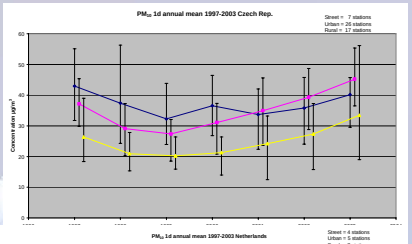
The European picture: The rural contribution dominate the urban PM_{10} concentrations



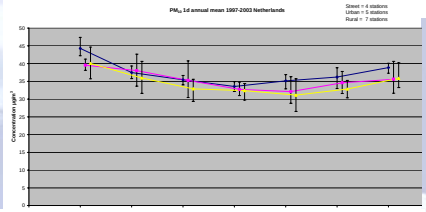
Source: ETC/ACC - AirBase

The rural contribution varies between countries/ regions

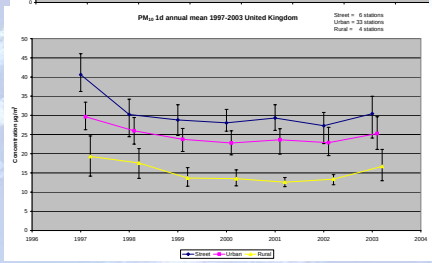
CZ



NL



UK



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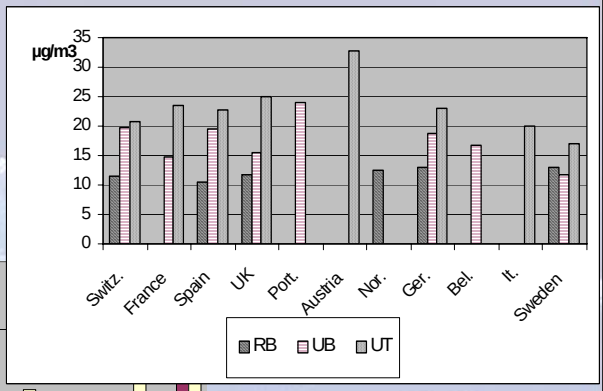
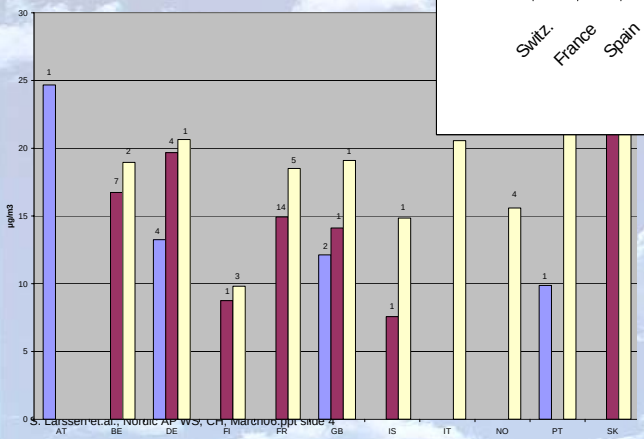
The rural contribution is large also for $PM_{2.5}$





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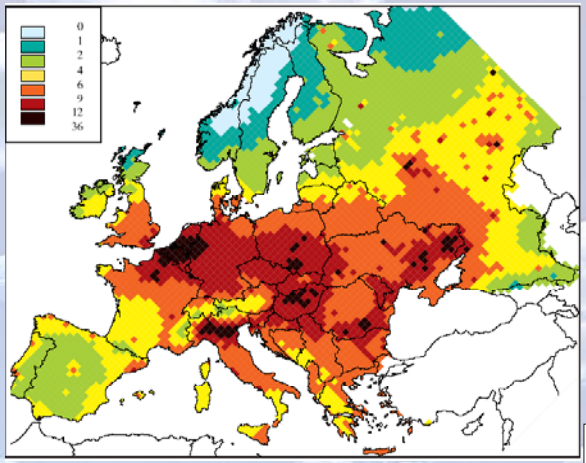
Health effects of PM in Europe, as assessed under the CAFE program, calculated from EMEP emissions in 50x50 km^2 grids.

Where is the increased exposure in cities?

Reduction in life expectancy, 2000 (months)



Source: DGEnv - CAFE

http://europa.eu.int/comm/environment/air/cafe/pdf/ia_report_en050921_final.pdf

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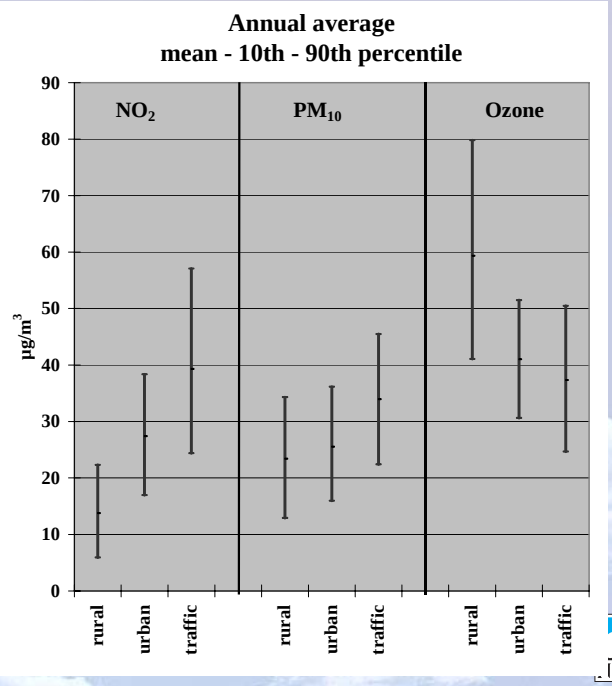
The rural contribution is small for NO_2, large for PM_{10}

Source: ETC/ACC AirBase



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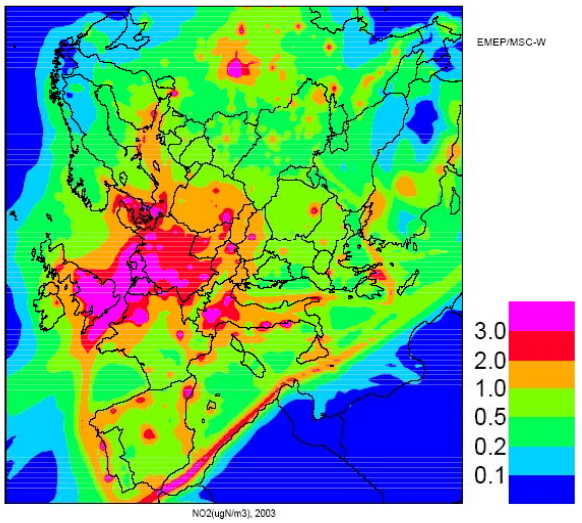
Regional scale concentrations in Europe (and in Norway)

NO_2,
annual average,
2003,
from EMEP model,

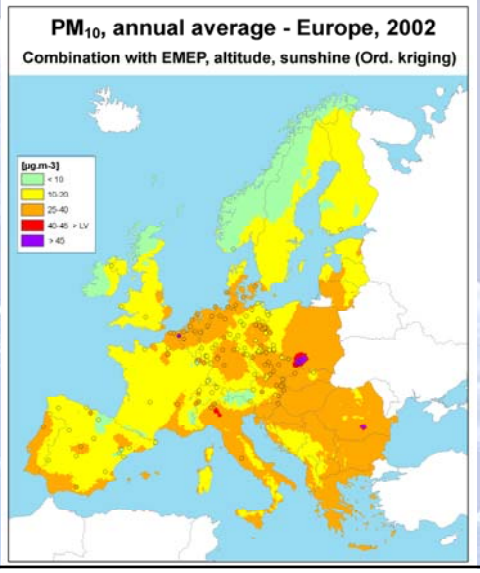
Source:
EMEP/MSC-W



Regional scale concentrations in Europe (and in Norway)

PM_{10},
annual average,
2002,
EMEP model with
kriged observations

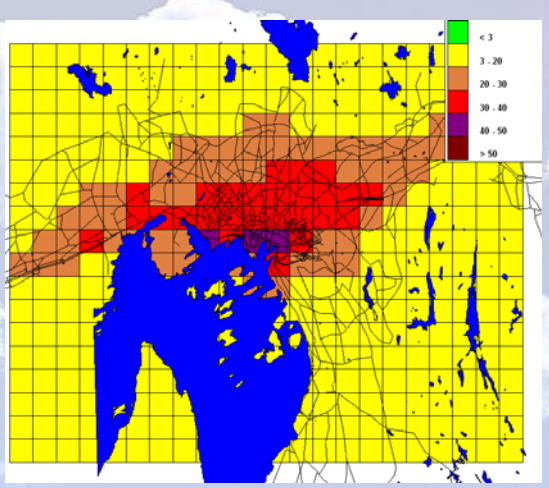
Source:
ETC/ACC:
Technical Paper 2005/8



LOCAL AND REGIONAL CONTRIBUTIONS TO NO_2 CONCENTRATIONS IN OSLO

NO_2 concentrations, Oslo, 2003, annual average modelled by AirQUIS / EPISODE

Background Concentration	**2.35 µg/m³**
Population Weighted Average	**22.9 µg/m³**
Population Weighted Average Exceedances	**45.4 µg/m³**
Total Number of People with Exceedances	21 135
Threshold Value	40 µg/m³



Regional background contributes ~10% to the population exposure

Source contributions to exposure to NO_2 in Oslo, above short-term limit value, 2003

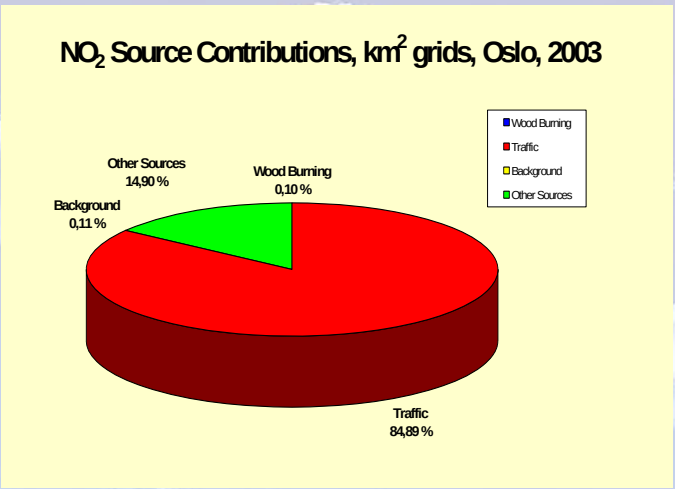
Limit value:

150 µg/m³ as

9th highest hourly value

(Ntl. Goal for Norway)

Regional background gives negligible contribution



LOCAL AND REGIONAL CONTRIBUTIONS TO AMBIENT PARTICULATE MATTER IN OSLO, NORWAY

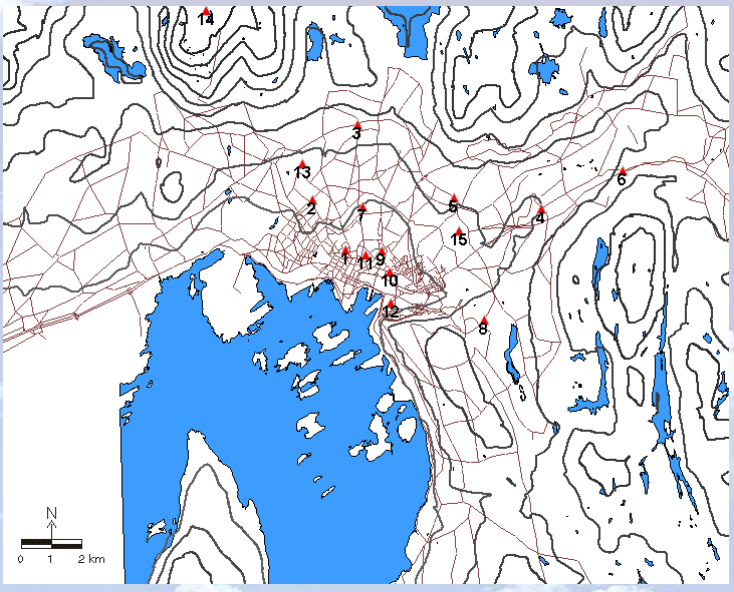
(Based on a two month simulation period: Nov – Dec 2003)

Leiv Håvard Slørdal[1] and Peter Wind[2]

[1]Norwegian Institute for Air Research (NILU), Kjeller, Norway

[2]Norwegian Meteorological Institute (met.no), Oslo, Norway

Oslo; urban model domain



The applied models

Regional scale: **The EMEP Unified model**

Urban scale: **AirQUIS**

Principal features of the EMEP model

- **Regional Eulerian model for the description of transport and chemical transportation of air pollutants in Europe**
- **Includes O_3, SO_x, NO_x, NH_x, PM, Aerosols, wet and dry deposition**
- **HIRLAM meteorology, 50 km resolution**
- **Extensively used for policy purposes (UNECE, EU)**
- **More details: http://www.emep.int**

Principal features of AirQUIS

- **Urban Eulerian model (~1 km grid resolution) with embedded subgrid line- and point- source models for near source description**
- **Includes O_3, NO_2, NO_x, PM_{10}, $PM_{2,5}$, wet and dry deposition**
- **MM5 meteorology, 1 km resolution.**
- **Extensively used for urban AQ and policy purposes**
- **More details: http://www.airquis.com**

OSLO: Main Sources of Particulate Matter

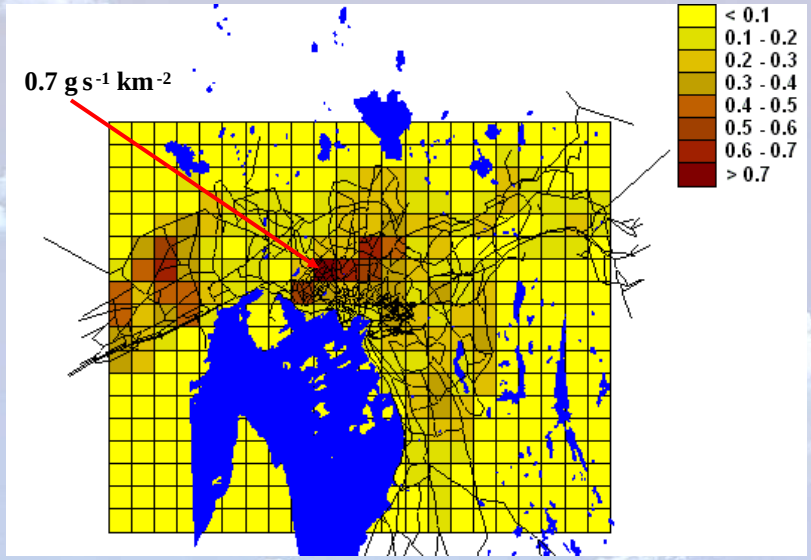
Fine fraction: $PM_{2.5}$

Sources:
- Domestic wood burning
- Vehicle exhaust
- Long range transport

Coarse fraction: $PM_{10} - PM_{2.5}$

Sources:
- Re-suspended dust (vehicle-induced and wind-blown)
- Long range transport

Average emission intensity of $PM_{2.5}$ in ($g\,s^{-1}\,km^{-2}$) for November – December 2003



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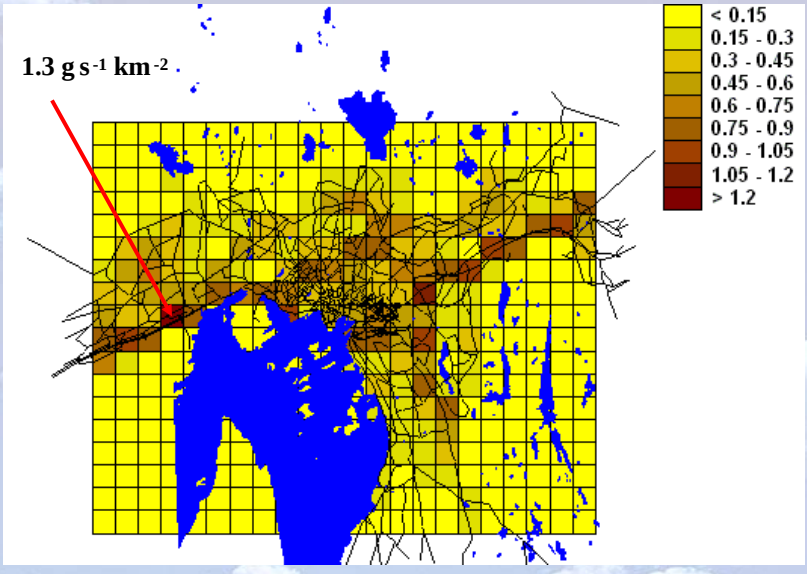
Average emission intensity of PM_{10} in ($g\,s^{-1}\,km^{-2}$) for November – December 2003



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COMPARISON OF MODEL RESULTS WITH OBSERVATIONS

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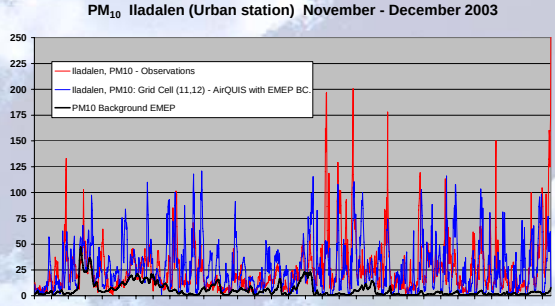
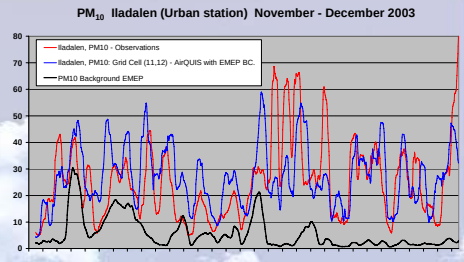
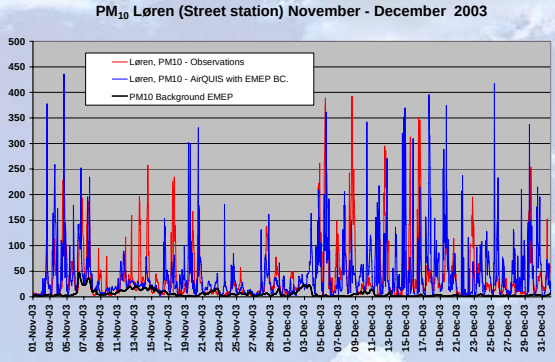
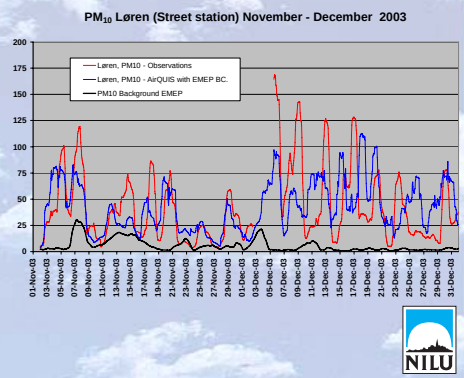
PM10 Urban and Street st.









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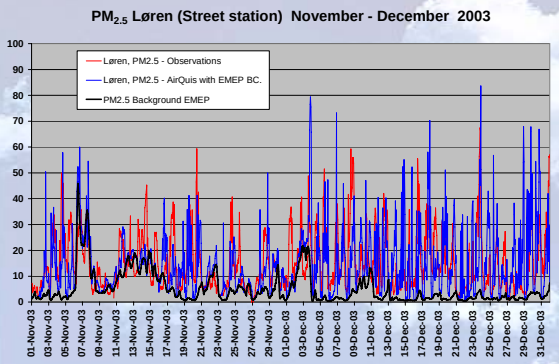
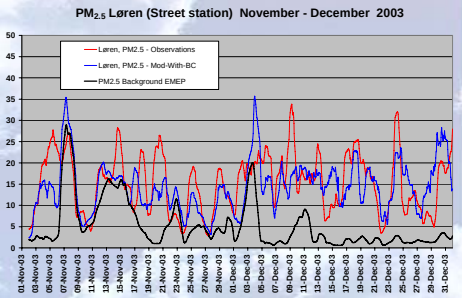
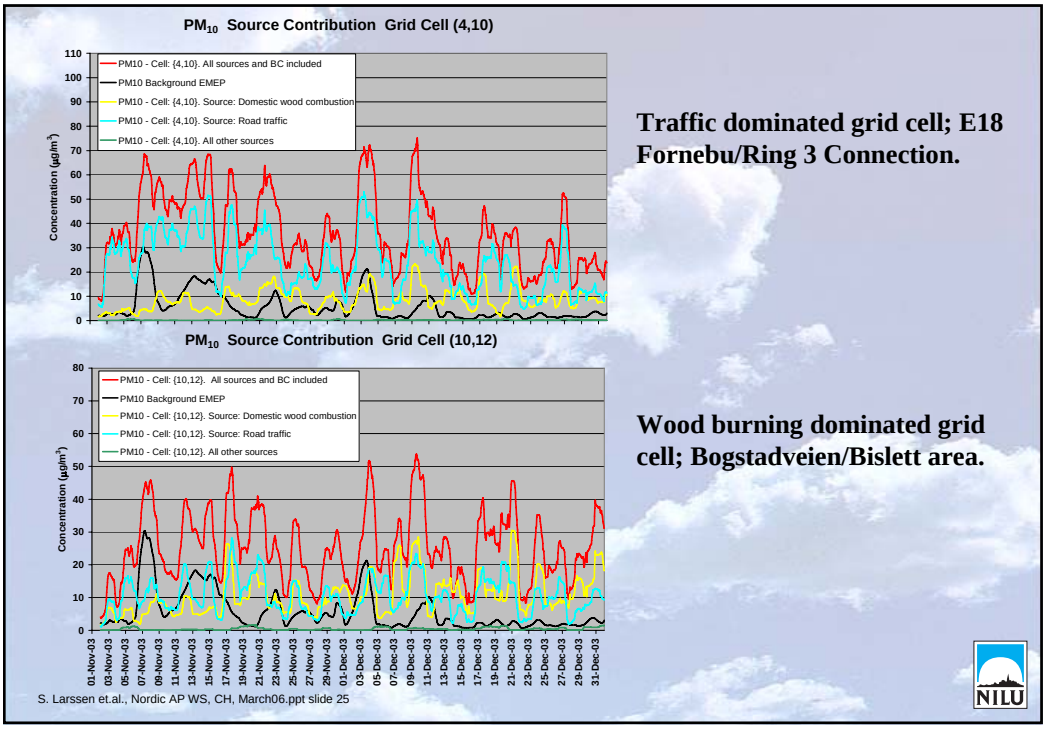
$PM_{2.5}$ Street station





SOURCE CONTRIBUTIONS TO THE ESTIMATED DAILY RUNNING AVERAGES OF PM_{10}



Traffic dominated grid cell; E18 Fornebu/Ring 3 Connection.

Wood burning dominated grid cell; Bogstadveien/Bislett area.

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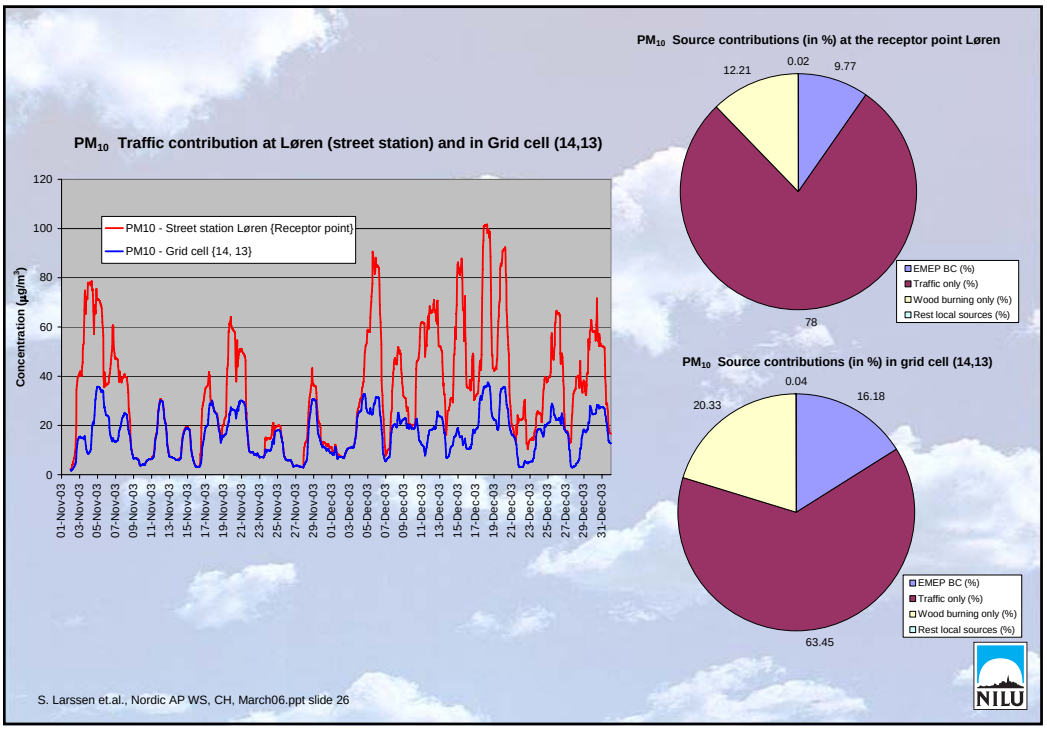

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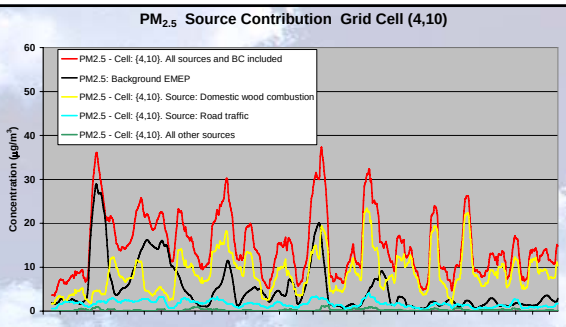
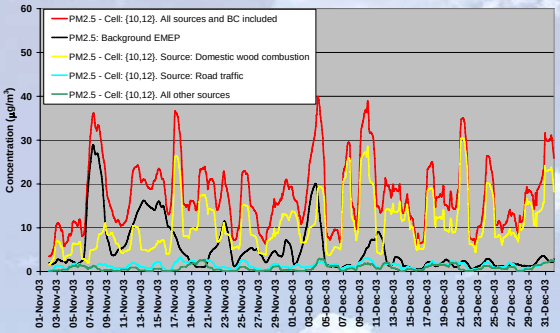
SOURCE CONTRIBUTIONS TO THE ESTIMATED DAILY RUNNING AVERAGES OF $PM_{2.5}$



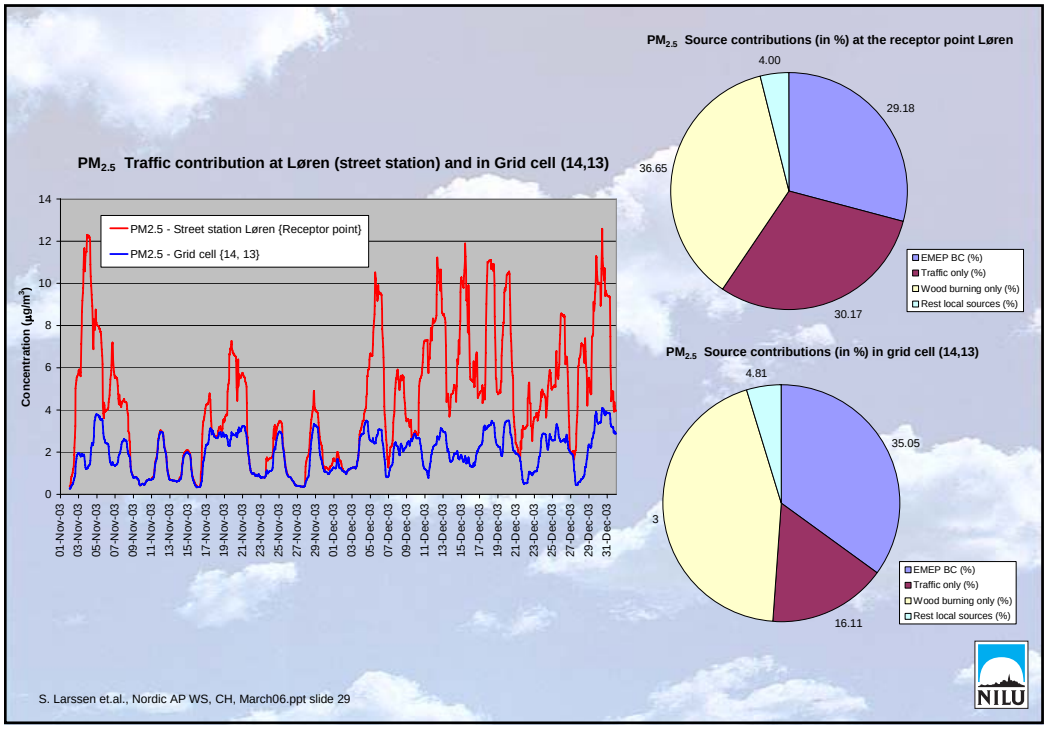
$PM_{2.5}$ Source Contribution Grid Cell (4,10)

Traffic dominated grid cell; E18 Fornebu/Ring 3 Connection.



$PM_{2.5}$ Source Contribution Grid Cell (10,12)

Wood burning dominated grid cell; Bogstadveien/Bislett area.



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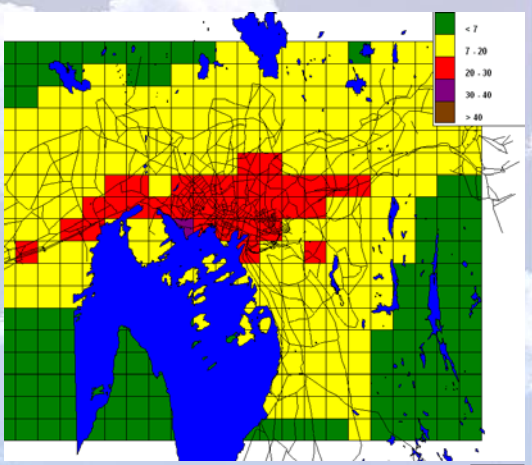
PM_{10} concentrations, Oslo, 2003, annual average modelled by AirQUIS / EPISODE

Background Concentration	**6.5 µg/m³**
Population Weighted Average	**15.9 µg/m³**
Population Weighted Average Exceedances	**23.7 µg/m³**
Total Number of People with Exceedance	178 490
Threshold Value	20 µg/m³

Regional background contributes ~40% to the population exposure



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Source contributions to PM_{10} exposure at hot spot locations in Oslo, 2003,

above daily limit value

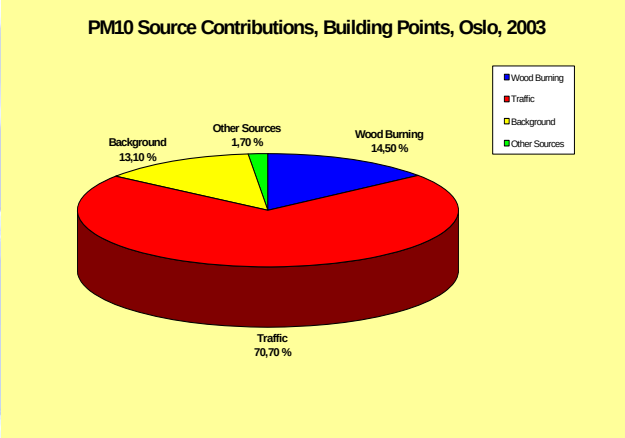
Limit value:

50 µg/m³

as 8th highest daily value

(Ntl. Goal for Norway)

Regional background contributes 13 %



Source contributions to PM_{10} exposure in km^2 grids in Oslo, 2003, above daily limit value

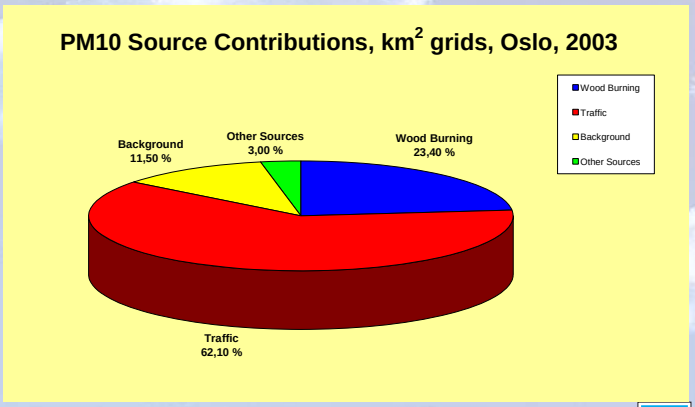
Limit value:

50 µg/m³

as 8th highest daily value

Regional background contributes

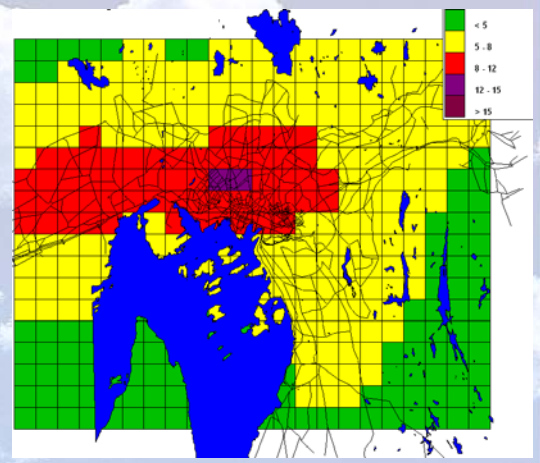
11.5 %



$PM_{2.5}$ concentrations, Oslo, 2003, annual average modelled by AirQUIS / EPISODE

Background Concentration	**4.1 µg/m³**
Population Weighted Average	**8 µg/m³**
Population Weighted Average Exceedances	**12.7 µg/m³**
Total Number of People with Exceedance	28 095
Threshold Value	12 µg/m³

Regional background contributes ~50% to the population exposure



CONCLUSIONS

- **In Europe, the regional contribution to PM concentrations in urban areas is large/dominating, while it is small for NO2**
- **Regional concentration level is not the same as LRT, although in Norway they are almost synonimous**
- **A regional scale model, coupled with an urban dispersion model with fine scale resolution (~1km), and with subgrid line source treatment is needed to produce realistic concentration levels and population exposure estimates within the urban area**

CONCLUSION

- **The annual average regional background $PM_{2.5}$ concentrations in Oslo was ~ 4 μg m^{-3} for 2003 (~ 50% of the population averaged concentration calculated for the entire Oslo city area)**
- **The regional concentration level of $PM_{2.5}$ can episodically go as high as 40 μg m^{-3}**
- **The regional background for PM10 was ~ 7 μg m^{-3} (annual average), which is about 40% of the population averaged concentration**
- **Regional background PM10 contributes only 12% on days with exceedances of the daily limit value**

CONCLUSION

- **The highest concentration peaks in Oslo are caused by local sources, reaching 73 μg m^{-3} for $PM_{2.5}$ and about 400 μg m^{-3} for PM_{10} at observations sites during the simulation period**
- **Domestic wood burning is the dominant source of $PM_{2.5}$ in the central and western city area, contributing to more than 60 % in some grid cells**
- **Traffic induced re-suspension of surface particles is the most important contributor to the coarse particle fraction (PM_{10}-$PM_{2.5}$), contributing to more than 70 % of the total PM_{10} concentrations in some grid cells**

Further information can be found on:

http://www.nilu.no

Thank you for your attention