Modelling the source contribution of particulate matter in Oslo: comparison between models and observations

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Summary

Results of air quality modelling for the city of Oslo are reported. Source specific dispersion model calculations are carried out for PM_{10}, $PM_{2.5}$, elemental carbon (EC), Benzo(a)pyrene (BaP) and particle number concentrations (PNC) and validated against available monitoring data. Model calculations for PM_{10} and $PM_{2.5}$ are compared to observations at 9 fixed monitoring sites in Oslo (hourly means) and at 20 ESCAPE monitoring sites (fortnightly means). Modelled source contributions for $PM_{2.5}$ are also compared to receptor model calculations made using chemical analysis of ESCAPE monitoring site data.

The dispersion model performs very well for $PM_{2.5}$ and elemental carbon, reasonably well for PM_{10} and acceptably for both BaP and PNC (validation not shown). The receptor modelling at ESCAPE sites is non-conclusive due to the non-suitability of the data from these sites for receptor modelling calculations.

The population exposure to these different compounds is assessed within the city of Oslo, with focus on the transport sector source contributions. The results indicate significantly different source contributions, dependent on the compound addressed. For PM_{10}, $PM_{2.5}$ the largest contribution is from the regional background, followed by traffic. For EC and PNC the largest contribution is from traffic. For BaP the largest contribution is from domestic wood burning.

Emissions

Existing PM emissions inventories for Oslo have been enhanced to include elemental carbon (EC), Benzo(a)pyrene (BaP) and particle numbers (PN). In addition, non-exhaust traffic emissions have been modelled using the NORTRIP road dust emission model *(Denby et al., 2013a, 2013b)* and shipping emissions have been provided using STEAM2 data (*Jalkanen et al., 2012*).

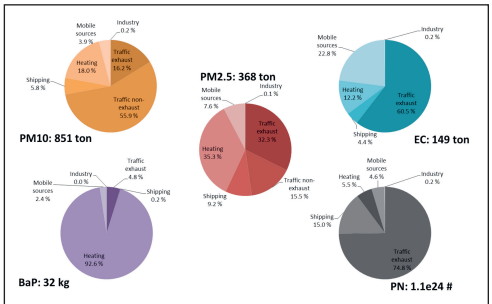

Figure 1: Total emissions, and their source apportionment, for the various PM compounds modelled in Oslo for the year 2009.

Source contributions at fixed monitoring sites

Source contributions are modelled using the EPISODE dispersion model (*Slørdal, 2003*) at 9 fixed monitoring sites measuring PM_{10} and $PM_{2.5}$ in Oslo. These are mostly traffic stations with the exception of 'Sofienbergparken', which is an urban background station. $PM_{2.5}$ is both under and overestimated whilst PM_{10} is generally underestimated by the model. The underestimation of PM_{10} can be seen all year round.

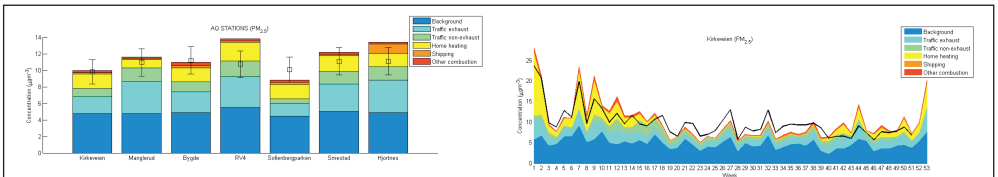

Figure 2: Calculated source contributions at fixed monitoring sites in Oslo for $PM_{2.5}$. Weekly average time series for the centrally located station (Kirkeveien) is also shown.

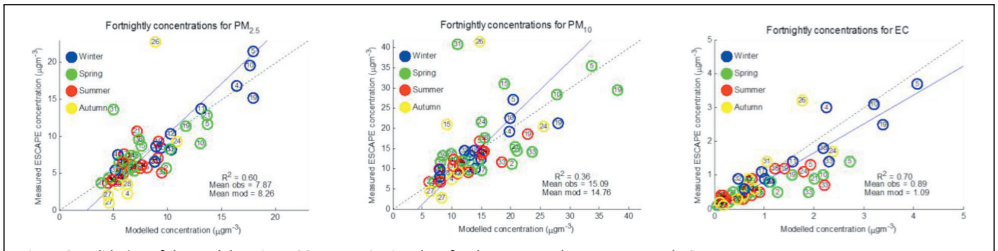

Figure 3: Validation of the model against ESCAPE monitoring data for the compounds PM_{10}, $PM_{2.5}$ and EC.

Comparison at ESCAPE monitoring sites

A comparison with ESCAPE monitoring data, measured in 2009 in Oslo, is made. 20 different sites measured PM and NO_x compounds for three fortnightly averaging periods. The PM samples were chemically analysed for elements and organics. Receptor modelling was carried out using PMF-3 (*Norris et al., 2008*) to determine source contributions. Receptor modelling in Oslo using the ESCAPE data did not provide well defined source contributions.

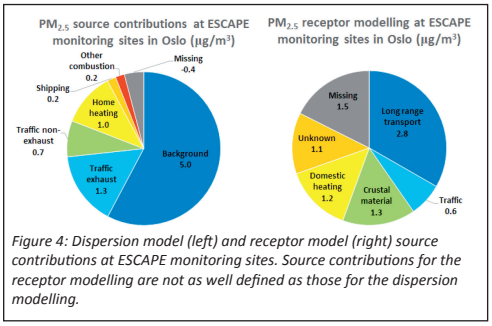

Figure 4: Dispersion model (left) and receptor model (right) source contributions at ESCAPE monitoring sites. Source contributions for the receptor modelling are not as well defined as those for the dispersion modelling.

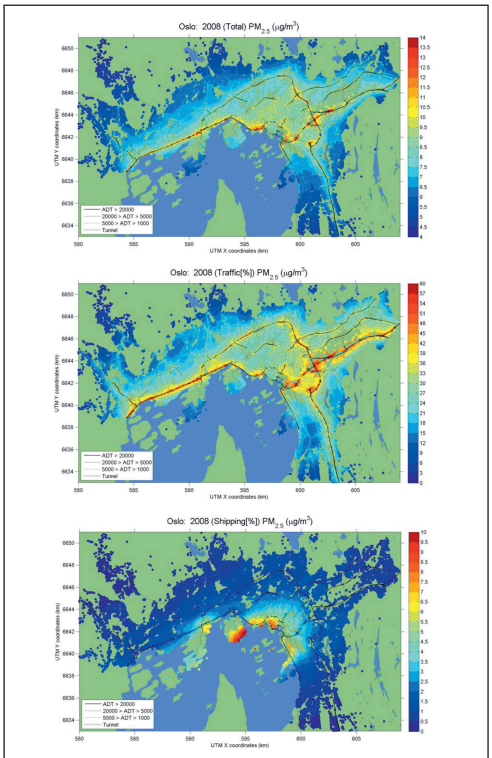

Figure 5: $PM_{2.5}$ concentrations calculated using the EPISODE model at home addresses in Oslo (top). Source contribution (%) from traffic (middle) and shipping (bottom).

Source contributions to exposure

Source contributions were calculated using the dispersion model at home addresses in Oslo. Maps showing the total concentrations for $PM_{2.5}$ and the relative contribution from the two transport sources of traffic and shipping are shown in Figure 5.

The source contributions for all five PM compounds studied show (Figure 6) that for PM_{10} and $PM_{2.5}$ the major contribution to exposure is from the regional background, followed by traffic (exhaust and non-exhaust). The major contributor to EC and PNC is traffic whilst the major contributor to BaP are non-transport sources, in this case wood burning emissions from domestic heating. Shipping makes a minor contribution in all cases and is largest for PNC.

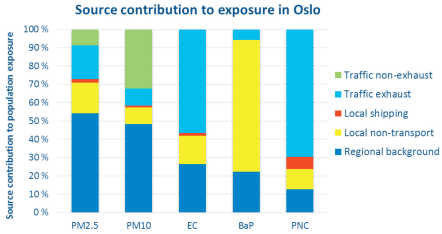

Figure 6: Modelled contribution of traffic, shipping and non-transport (mostly domestic heating) sources to population exposure (home address concentrations) in Oslo for the year 2009. Shown are the PM related compounds of PM_{10}, $PM_{2.5}$, EC, BaP and PNC.

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References

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