Causes of high PM_{10} values measured in Denmark in 2006

Peter Wåhlin and Finn Palmgren
Department of Atmospheric Environment
National Environmental Research Institute
Århus University
Denmark

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Background

The limit value for 24-hour average concentration on 50 µg/m^3 not to be exceeded more than 35 times per year is exceeded more than 35 times in some busy urban streets in Denmark. In order to select efficient measures it is necessary to identify the most important causes of high 24-hour PM10 concentrations.

Analysis

The monitoring data from air quality monitoring stations from 2006 have been analysed in relation to annual variation and meteorology.

A detailed analysis for Copenhagen uses the concurrently measured PM_{10} values in 2006 (280 days) at the kerbside station HCAB and at the roof station HCOE. The average during the 280 days was 40.7 µg/m^3 at HCAB, and 26.5 µg/m^3 at HCOE. An analysis of PM_{10} measured with high time resolution (TEOM monitor) shows that the local traffic signal at HCOE in average is 16 % (0.16) of the signal at HCAB. The best estimate for the local traffic contribution PM_{10_TRAF} at HCAB is therefore $(PM_{10\_HCAB} – PM_{10\_HCOE})/(1-0.16)$. The non-traffic background is calculated as the rest of the PM_{10} at HCAB ($PM_{10\_HCAB} – PM_{10\_TRAF}$).

All available measurements are shown in figure 1. The full-drawn red line indicates the 50 µg/m^3 exceedance limit. The dotted red line is a 1:1 line, where the points below the line represent days with the highest background contributions and the points above the line represent highest local traffic contributions. The limit is exceeded in 24 % of the 280 days, corresponding to 88 days, if all 365 measurements were available. In 14 % of the 280 days it is mostly due to high background values, in 10 % it is mostly due to the local traffic. The data are grouped according to the seasons.

The exceedances related to traffic take mainly place in late winter, January-March, which indicate significant contributions from road salt for de-icing.

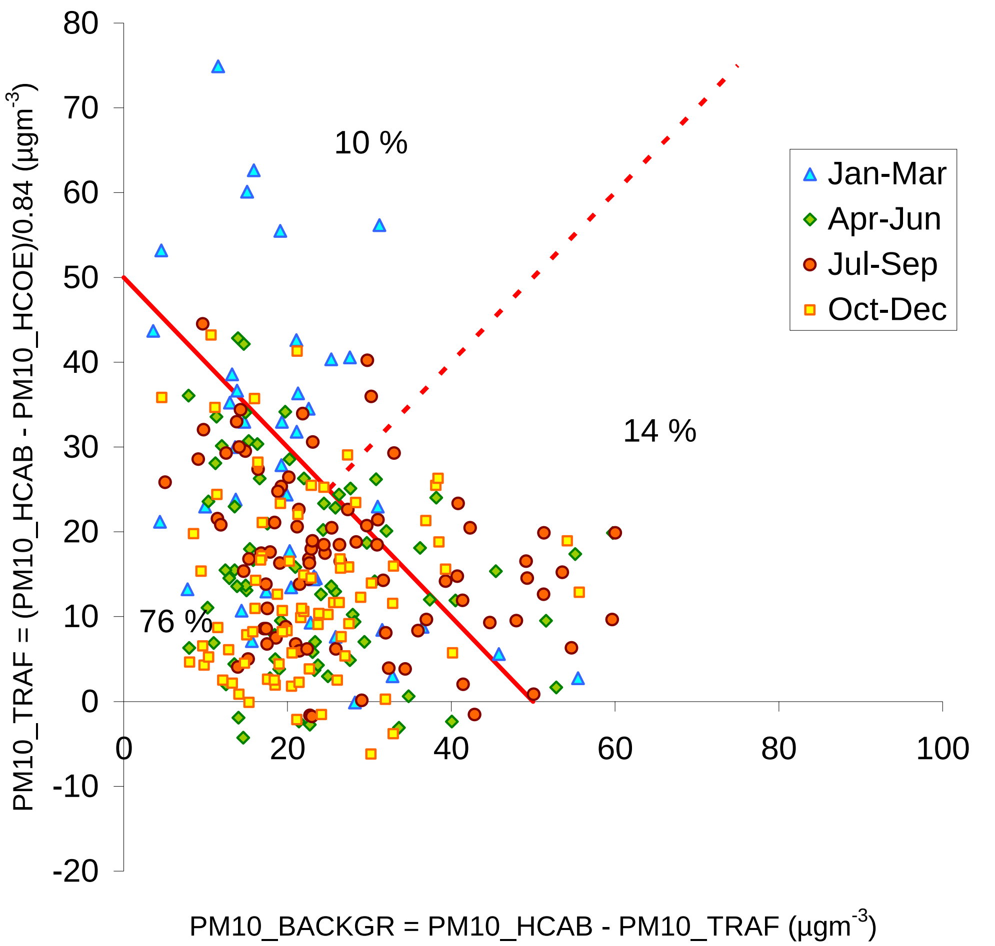


Figure 1. Local traffic contribution versus background contributions to PM_{10} at H.C. Andersen Boulevard in Copenhagen, 2006. The data are grouped in the seasons Jan.-Mar., Apr. Jun., Jul.-Sep. and Oct.-Dec.

The exceedances related to background take place during all seasons. In order to distinguish between local and regional background we have investigated the correlation between the PM_{10} concentrations at several street station (HCAB, JGTV, ODNS and AALB in Denmark and an urban background in Copenhagen (HCOE) and two regional background stations (LVBY and FOEL) in Denmark. The locations of the stations are shown in figure 2.

Figure 2. The position of the sites HCAB, JGTV, ODNS, AALB, HCOE, LVBY and FOEL . The map is generated using MapSource (Garmin Ltd.)

The figures 3a-3f show the measured values of PM_{10} at the four kerbside stations HCAB, JGTV, ODNS, and AALB, where the limit values were exceeded in 2006 (reddish colours). Also shown (bluish colours) are the PM_{10} at the three background sites HCOE, LVBY and FOEL. The LR label indicates days with high PM_{10} values at the kerbside stations when the background level in Denmark was increased due to transboundary transport of PM. The transport was mostly from continental Europe (especially the eastern part), which can be seen by the air mass trajectories (figures 5a and 5b) calculated for one of the days (at noon) in each of the different episodes. The S label indicates a frost period in March when road salting was probably the main reason for high PM_{10} values. Road salting is usual in Denmark in the winter, also in periods with temperatures around the freezing point. The air temperature in Copenhagen (HCOE) during 2006 is shown in figure 4. A longer frost period occurred in March in the period when we had many exceedances, which was traffic related probably due to de-icing of the roads.

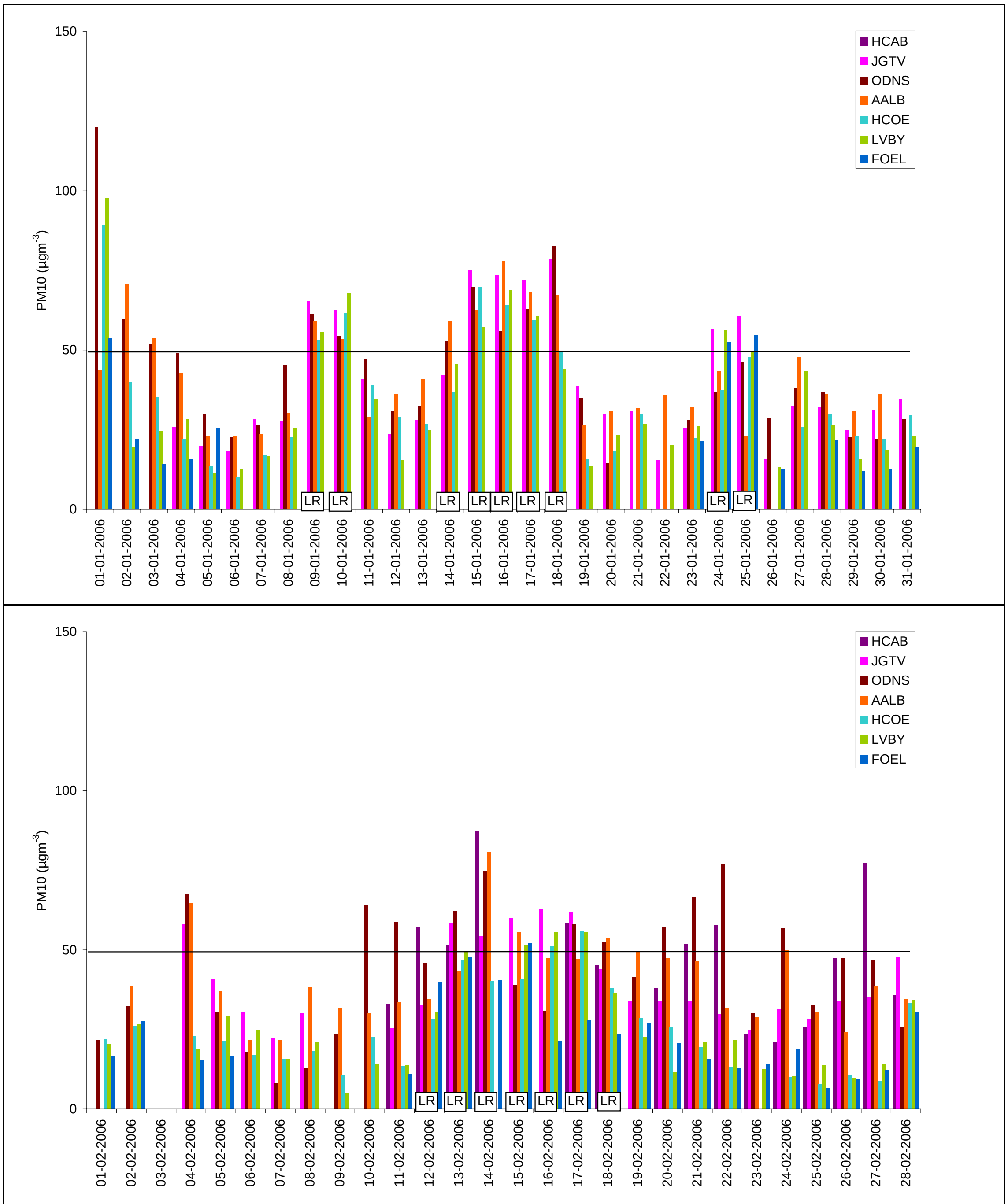


Figure 3a. PM_{10} January and February 2006.

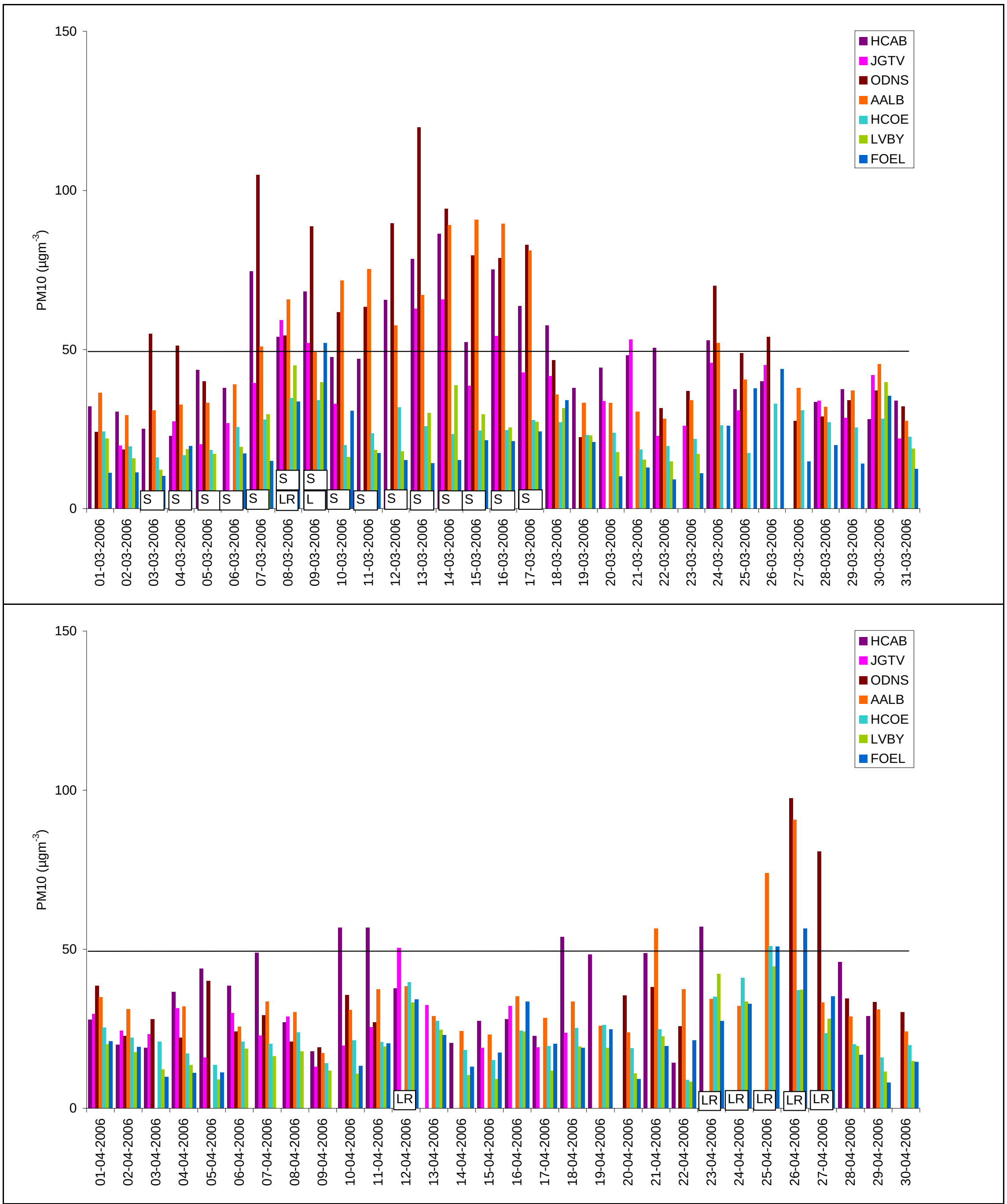


Figure 3b. PM_{10} March and April 2006

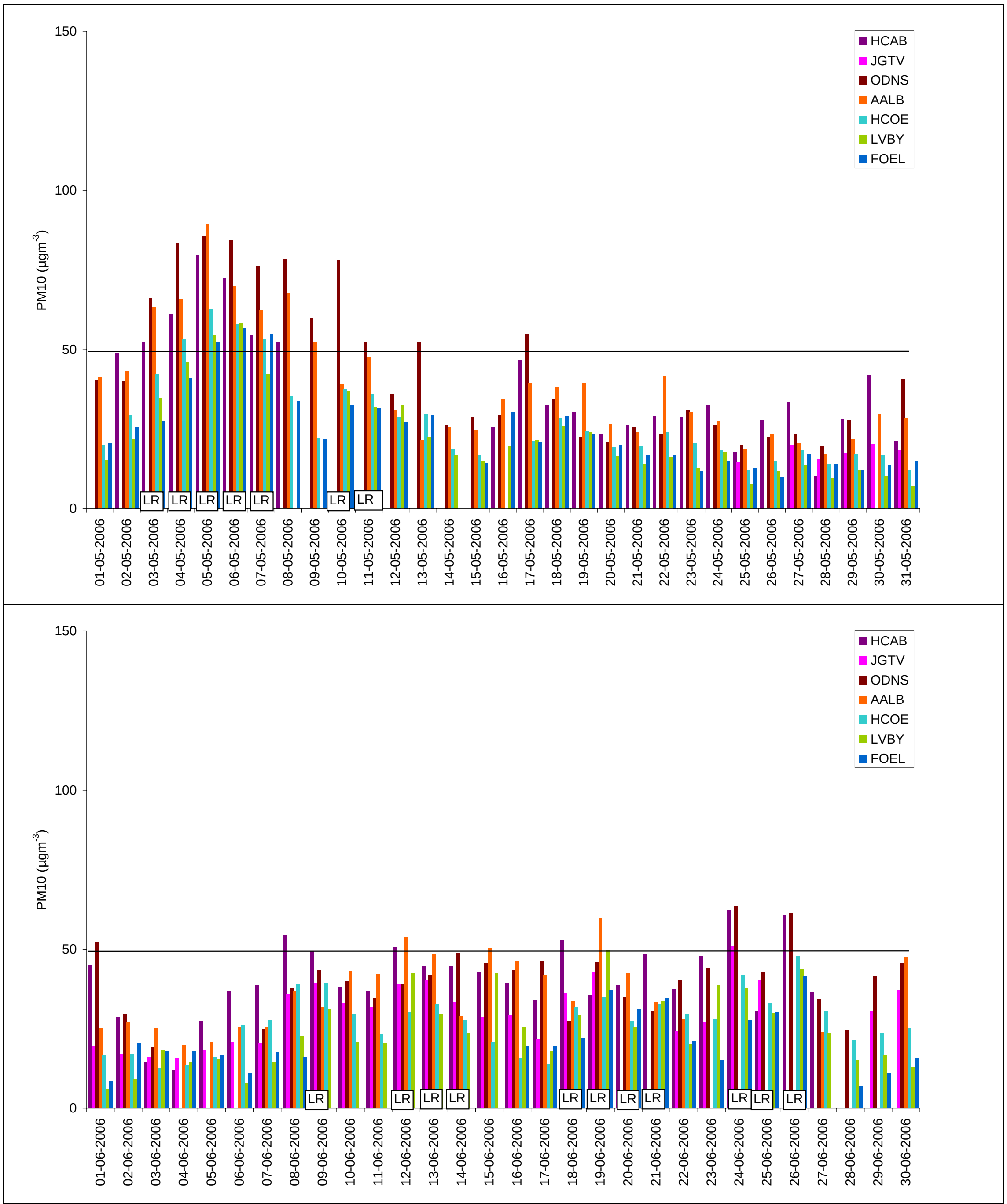
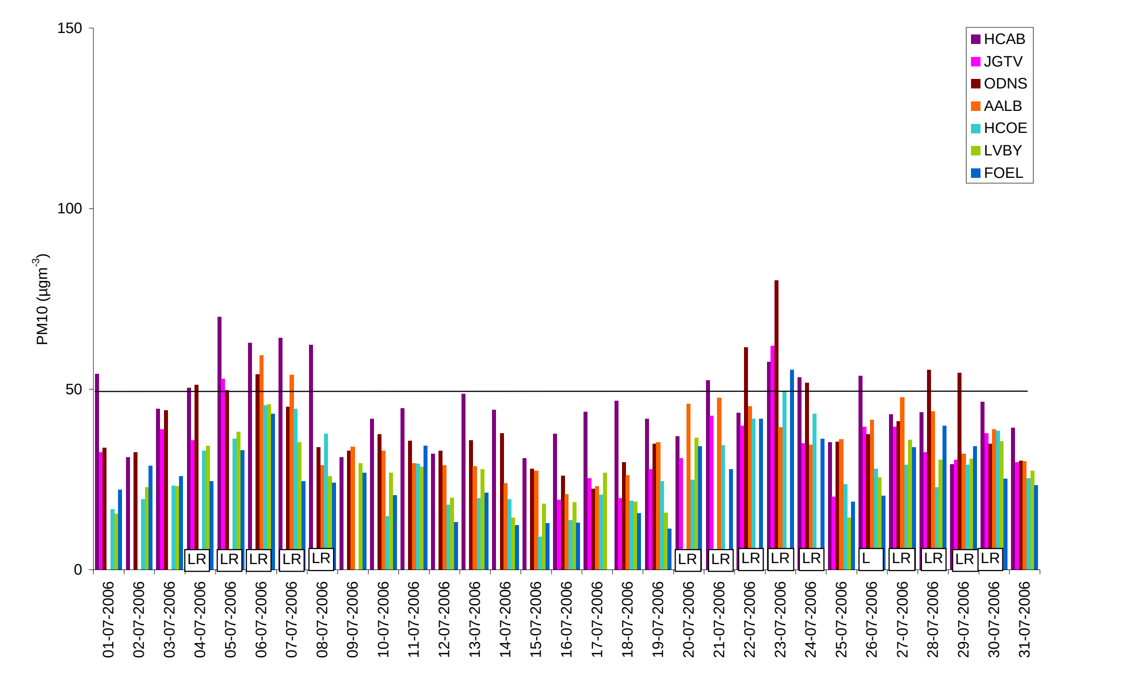


Figure 3c. PM_{10} May and June 2006.



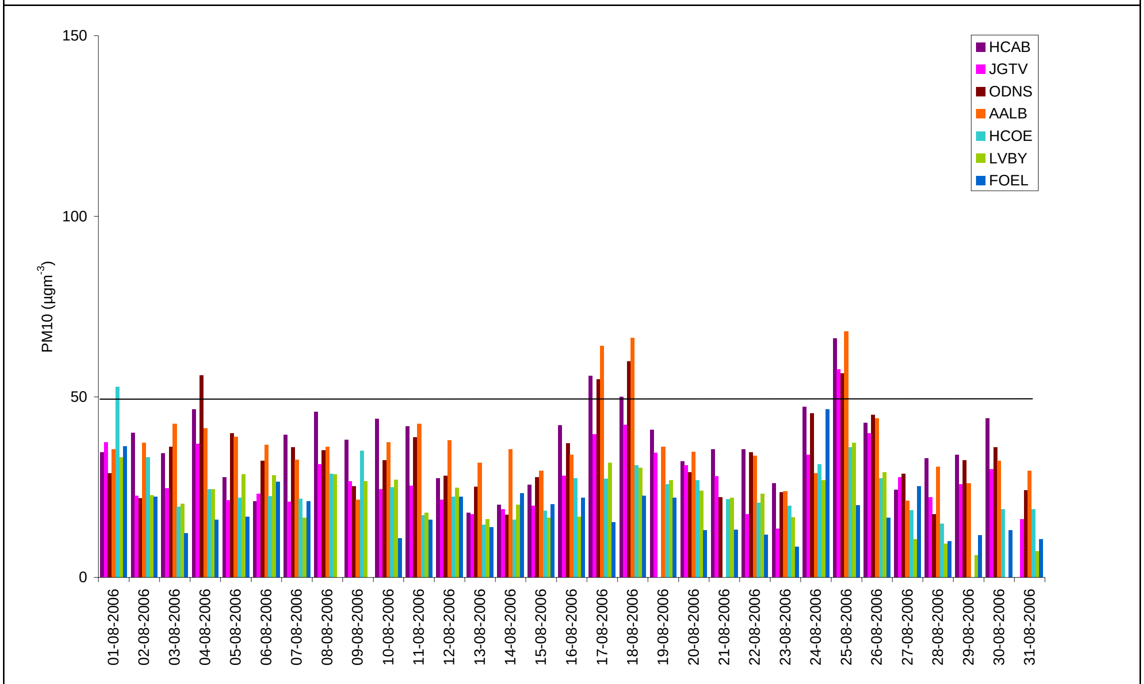


Figure 3d. PM_{10} July and August 2006

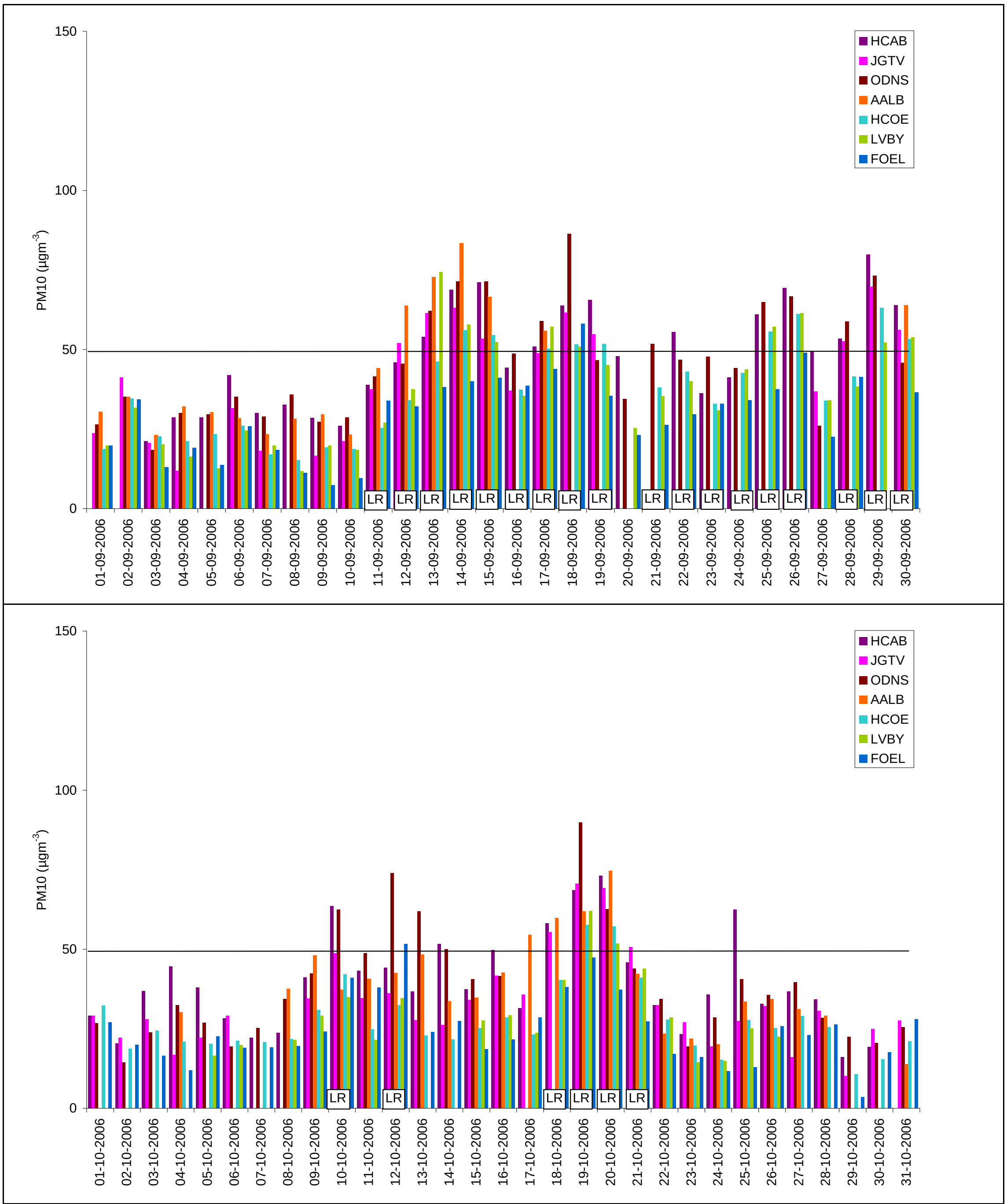
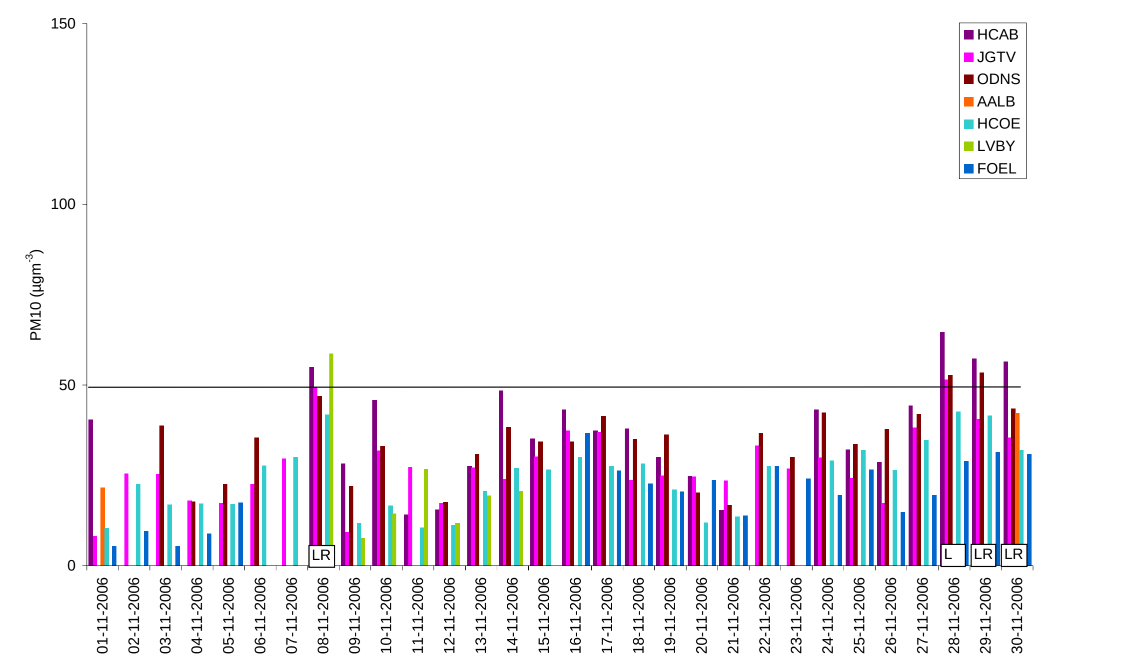


Figure 3e. PM_{10} September and October 2006



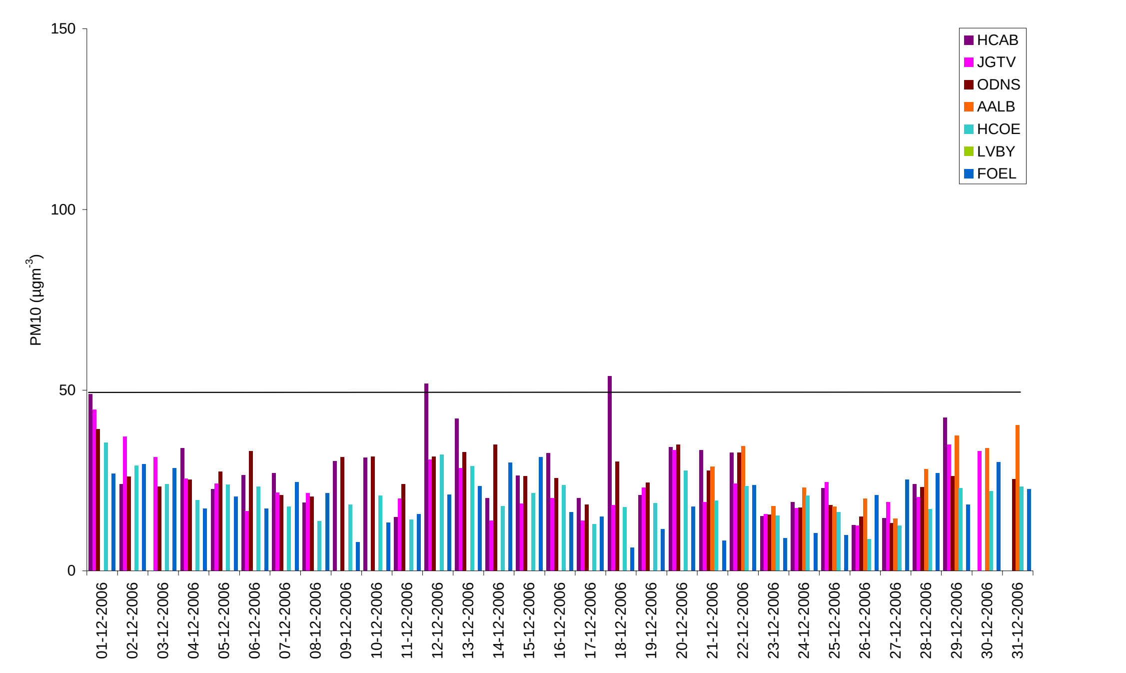


Figure 3f. PM_{10} November and December 2006.

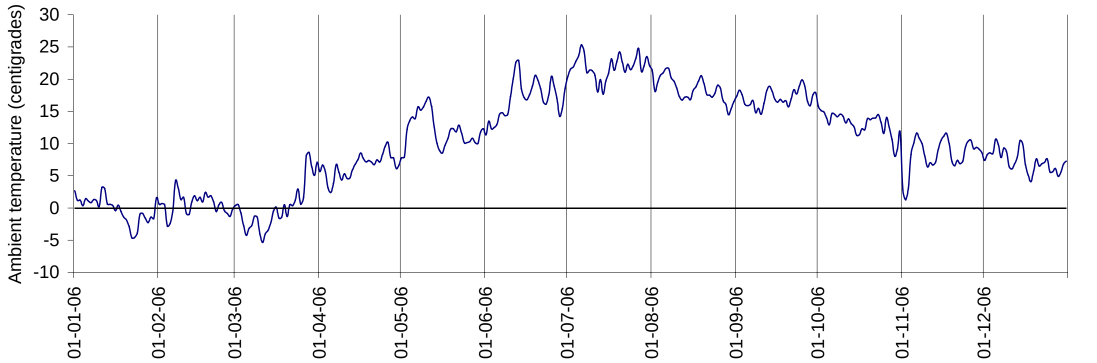


Figure 4. Daily average temperature in Copenhagen (HCOE) during 2006.

The air mass trajectories are calculated using the Flextra model developed by Andreas Stohl (NILU) in cooperation with Gerhard Wotawa og Petra Seibert (Institute of Meteorology and Geophysics, Wienna) and using meteorological data provided from ECMWF (European Centre for Medium Range Weather Forcast).

Selected trajectories are shown in Figure 5a-5b. There are 3 trajectories in each plot with three different heights at arrival in Copenhagen (small triangle indicates arrival close to the ground). Height along the trajectories is indicated by colour (red: low, blue: high). Each 3-hour interval along the trajectory path is indicated by a small legend, each 24-hour interval by a big legend.

All selected trajectories show possible transport from the southern directions between east and southwest, most pronounced in January and May when transport took place from Poland, the Baltic countries and Germany.

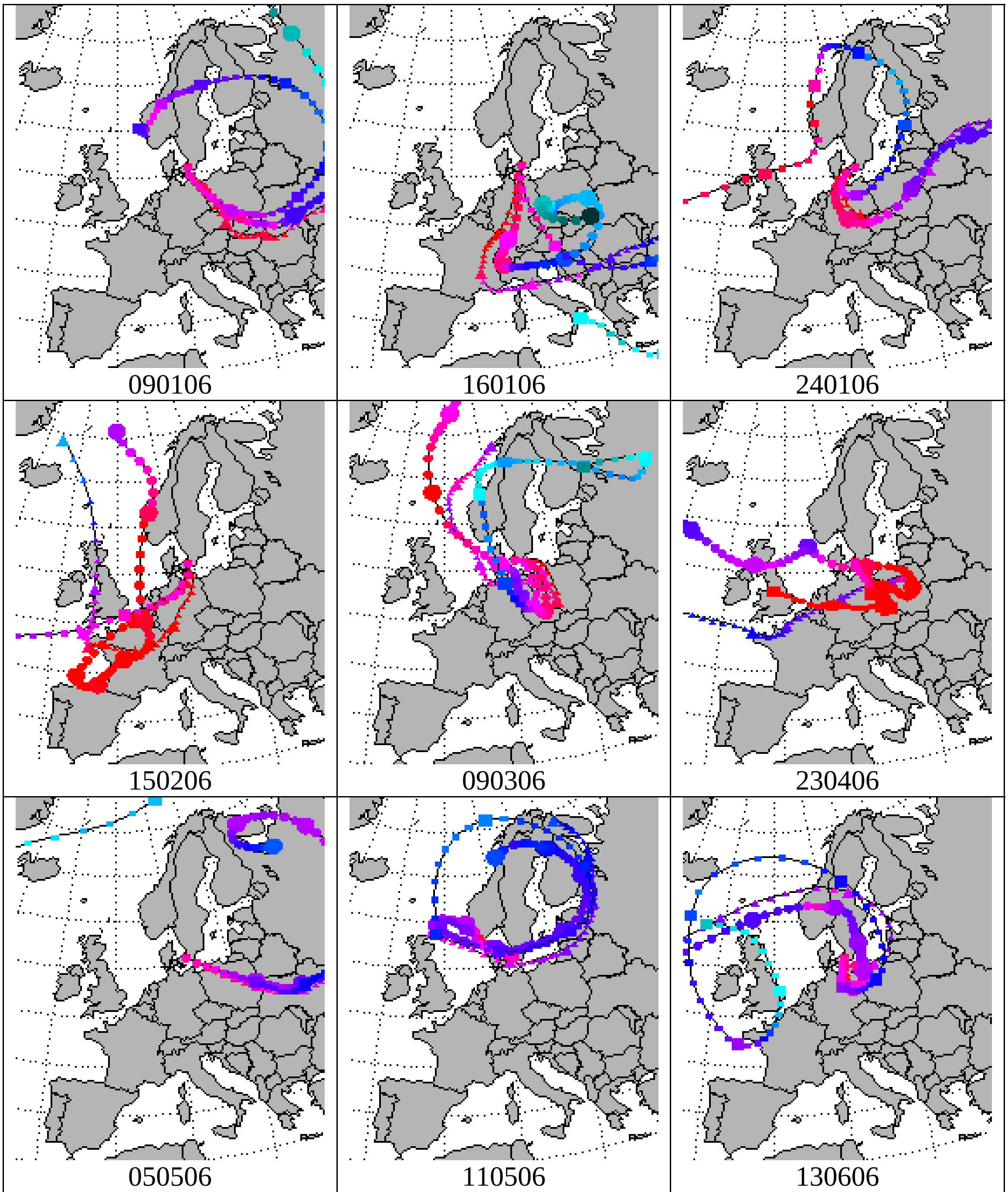

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Figure 5a.

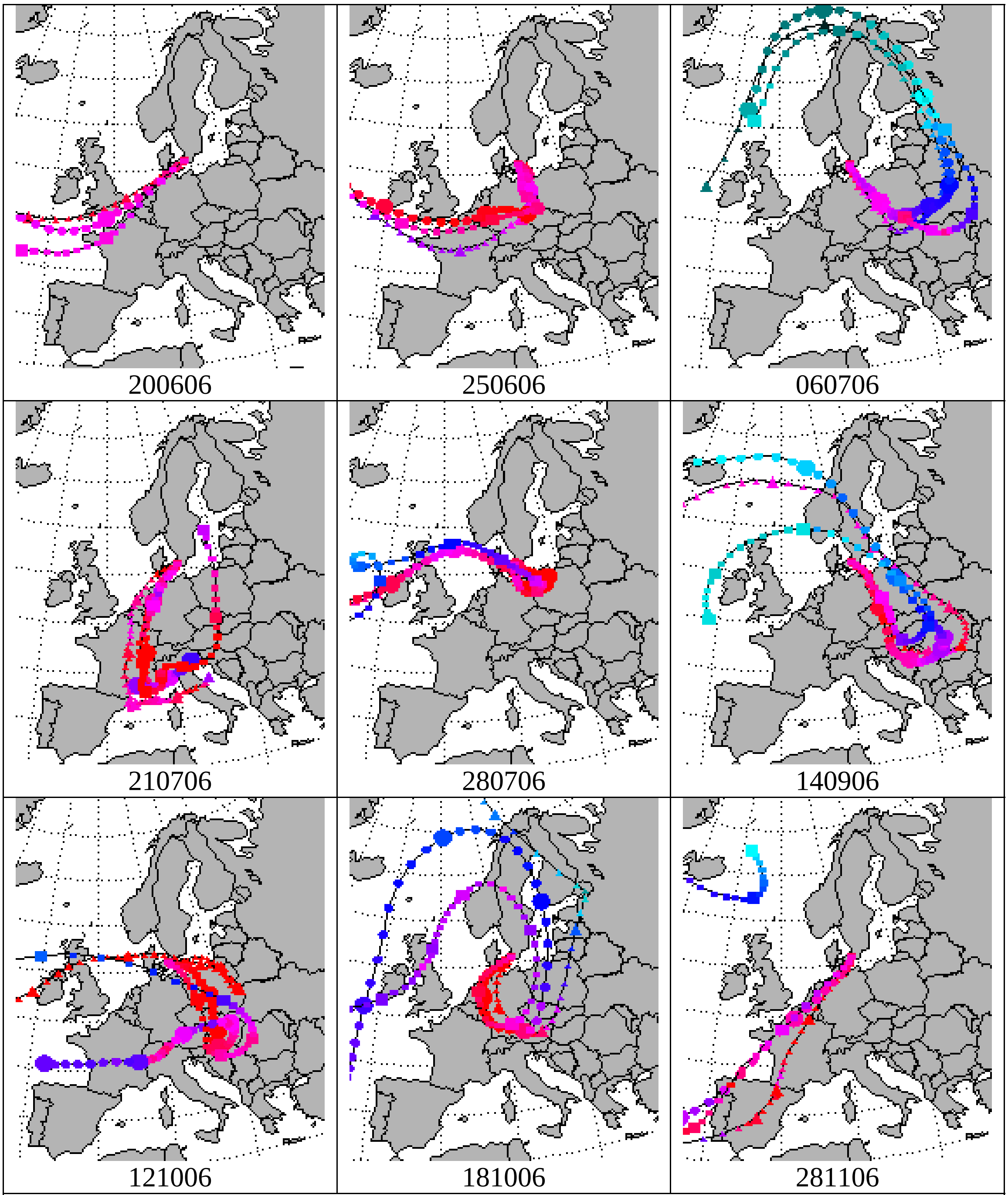

Figure 5b.

Discussion and conclusions

The analysis showed that in 2006 two types of exceedance situations in relation to the 24-hour limit value were especially pronounced, one related to local traffic and one related to background pollution.

Many traffic related situations took place in winter, when de-icing of the roads are necessary. We observed these exceedance situations in all investigated cities.

The background related situations took place when long-range (transboundary) transport was likely. We found especially high concentration at street stations as well as at background stations. Trajectories confirmed that transport was from continental

European sectors between east and southwest. The background part of PM_{10} during these situations was typically between 70 % and 90 % and in many cases above 100 % of the 24-hour limit value 50 $\mu g/m^3$. When the air came from the northern sectors (Sweden and Norway) the background values were much lower (around 10 μgm^{-3}). This means that the background level is highly influenced by long-range transport, and that it is not possible by local measures to remove this type of exceedances.

A few exceedance situations could not clearly be related to these types. They could be special local episodes or combinations of regional and local pollution. A few episodes with contribution from re-suspension of dust from the roads occurred probably in dry periods, e.g. in August, where we observed high traffic contributions in all cities. Pollen and other material from the vegetation that has deposited on the roadway have probably also contributed to re-suspended dust in the period May-October. In the early winter (November-December), after the pollen season and before the road salting season, there were very few exceedances that can be related to traffic.