Evaluation of pm10 exceedances at the Haren naval port

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TABLE DES MATIERES

1. INTRODUCTION

The Brussels Capital Region is one of the 3 Belgian Regions having complete competence over Environmental Matters. It has a surface of ~161 km^2 and a population of about 1.050.000 residents. The Brussels Region entirely corresponds to the air quality zone BEB10A.

1.1 Air quality network in Brussels Capital Region - Measuring sites

Corresponding to the annexes of the air quality directive 2008/50/EC, Brussels must have at least 4 measuring sites for each pollutant covered by this directive. The Region does report the air pollution data from 10 measuring sites (Table I.1) that form the telemetric air quality network, covering a variety of distinct urban environments.

Table I.1 : Typology of the Measuring sites in the Brussels Telemetric Network

Local Code	EOI Code	Location	Type of Activities
41R001	BETR001	Molenbeek Canal Lock	Dense traffic – habitation – industrial activities
41R002	BETR002	Ixelles Avenue de la Couronne	Dense traffic – canyon street – habitation
41B004	BETB004	Brussels Subway station Ste-Catherine	Commercial activities – habitation - traffic
41B005	BETB005	Eastman-Belliard Building	European district situated in a Park
41B006	BETB006	European Parliament Spinelli Building	European district Pedestrian zone
41B011	BETB011	Berchem Drèves des Maricolles	Urban background Residential
41R012	BETR012	Uccle Royal Meteorological Institute	Urban Background Residential
41N043	BETN043	Brussels Haren Naval Port	Industrial activities – traffic
41MEU1	BETMEU1	Brussels Meudon Park	Residential – near industrial zone
41WOL1	BETWOL1	Woluwé-St-Lambert Brussels Institute for the Management of the Environment	Dense traffic – highway Open surrounding

The stations 41R001 (Molenbeek), 41N043 (Haren naval port) and 41MEU1 (Meudon Park) are situated along the commercial and economic axis of the Brussels Capital Region. The Molenbeek site is situated near the canal, at the lock, in an area with dense

traffic and dense population and it is relatively close to the urban centre. The Haren site at the naval port is near the entrance of the industrial site in the northern part of Brussels, an area with dense and mainly heavy traffic, but with practically no habitation nearby. The Meudon station is situated in a Park, close to a residential area nearby the industrial sites in the northern part.

The stations 41R002 (Ixelles) and 41WOL1 (Woluwe) are traffic stations. The first is situated in a narrow canyon street with dense habitation and the Woluwe station is situated along a highway leading the traffic coming from the East towards the centre of Brussels, its immediate surrounding having a relatively open structure. The stations 41R012 (Uccle) and 41B011 (Berchem) are typical urban background stations, situated in residential areas with lean traffic density. The stations 41B005 and 41B006 are situated in the European district. The station 41B004 is an typical urban station, nearby the centre, in an area that combines commercial activities with dense population and local traffic.

1.2 Air quality network in Brussels Capital Region - Measuring techniques

Nitrogen oxides (nitrogen monoxide and dioxide) are measured in all ten measuring sites, the PM10 particle mass concentration in six measuring sites and the PM2.5 mass concentration in five of these six PM10 measuring sites. All PM mass concentration analyzers are continuous Tapered Element Oscillating Microbalances, TEOM model 1400Ab, equipped with FDMS 8500 modules (*Filter Dynamics Measurement System*). Other measurements of the telemetric network concern ozone, carbon monoxide, sulfur dioxide, carbon dioxide, benzene and mercury vapor. Additional instruments provide the sampling for the analysis of volatile organic components (VOC), polyaromatic hydrocarbons (PAH) and heavy metals such as lead, arsenic, nickel and cadmium.

Table I.2 : Pollution parameters measured in the Brussels Telemetric Network
Situation December 2010

	SO_2	NO_X $NO\text{-}NO_2$	O_3	CO	PM_{10}	$PM_{2,5}$	PNC	BC	CO_2	BTX	Hg
41R001	X	X	X	X	X	X	X	X			
41R002	X	1. X		X					X		
41B004		X	X	X							
41B005	X	X	X	X							
41B006		X		X						X	
41B011		X	X		X	X					
41R012	X	X	X		X	X			X		
41N043	X	X	X	X	X	X					
41MEU1	X	X			X	X					X
41WOL1	X	X	X	X	X		X	X	X	X	

Since 2008 the particle number concentration is measured along with the particle mass concentration in two traffic oriented sites. The particle number concentration (PNC) is registered for 31 different size classes, with diameters ranging from 0.25 µm up to 32 µm, by means of Grimm laser light scattering spectrometers, model 365. At these same two measuring sites monitoring Black Carbon (BC) was started, in July 2009 and July 2010 respectively, using and aethalometer, model AE22-ER from Magee Scientific.

Figure 1.1 represents the location of the measuring sites on a map of the Brussels Capital Region. The pollution parameters measured in each station are given in Table I.2.

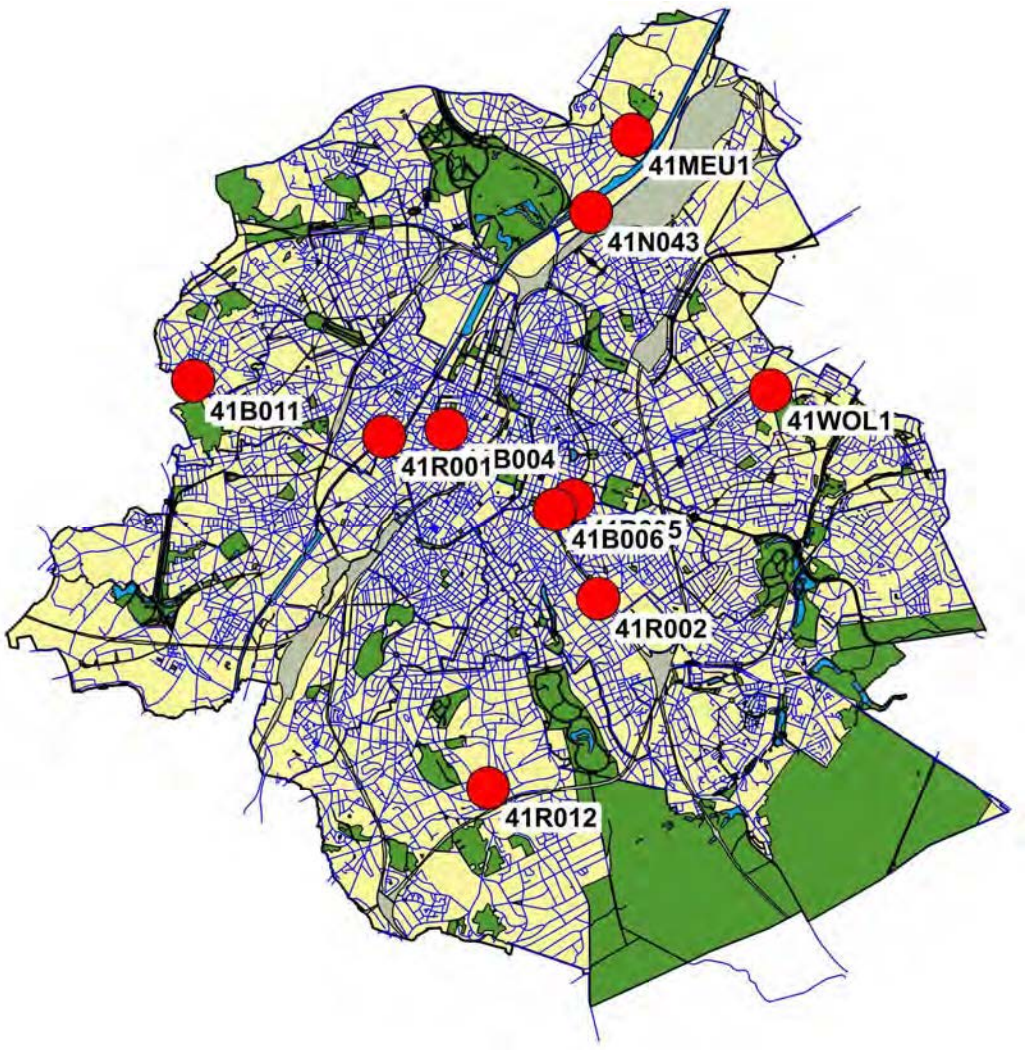


Figure 1.1 : Brussels Air Pollution Telemetric Network - Location of the Measuring Sites
This map has been realized using Brussels UrbIS®© - Distribution & Copyright CIRB.

1.3 Non Compliance with PM10 Daily Limit Value

The air quality directive 2008/50/CE foresees two limit values for PM10 in ambient air:

- The 40 $\mu g/m^3$ limit value for the annual average concentration is respected in all six measuring sites.
- **The Brussels Capital Region fails to meet the second limit value: 50 $\mu g/m^3$ as daily average PM10 concentration may not be exceeded on more than 35 days per year**. Since the year 2005 this second limit value has been systematically violated in two of the six PM10 measuring sites (Haren naval port and Molenbeek) and occasionally in some of the other sites. Postponing of the attainment of the deadline to the year 2011 was not granted by the EU commission. The proposed emission reduction measures were judged as insufficient to enable compliance, in due time, with the limit value. In its refusal the Commission mentioned especially the lack of low emission zones and measures such as road pricing.

In fact road traffic represents 70 to 75% of the local PM emissions as registered by the Brussels emission inventory. However, a comparison of PM mass concentration levels inside and outside Brussels seems to indicate that, depending on site location, **particles emitted directly by the local traffic represent on average only about 10 to 20% of the total measured PM10 mass concentration. The PM10 background level represents about 65% of the inner city concentration. Therefore drastic emission reductions will be needed if compliance has to be assured solely by local emission reductions**. In urban sites such as Molenbeek, a thorough analysis of the observed data shows that a drastic emission reduction (70 to 80%) will be needed if compliance is to be assured solely by local measures [*Particulate Matter and Nitrogen Dioxide in the Brussels Capital Region. Vanderstraeten et al. Geographical Forum and Environmental Protection Journal. Vol. 9, 2010, pp. 75-86* and *Particulates and Nitrogen Dioxide in the Brussels Ambient Air need Drastic Emission Reduction. Vanderstraeten et al., WSEAS Conference, Athens, September 2009, ISSN:1790-5095, ISBN 978-960-474-125-0*].

Furthermore the dimensionless normalized average weekly concentration pattern (Figure 1.2) shows a decrease, during the weekend, of only about 10 to 15 % for the PM10 and PM2.5 concentration, compared to a concentration loss of 40 to 60% for NO and 20 to 30% for NO_2, both traffic related pollutants. Background concentration for NO is generally very low and the presence of elevated levels of NO is practically entirely of local traffic origin. Since the background concentration is very low, the concentration decrease during the weekend is reflective of the decrease of local traffic density. At this stage, **even a permanent weekend emission regime would not permit to guarantee compliance with the PM10 daily limit value**.

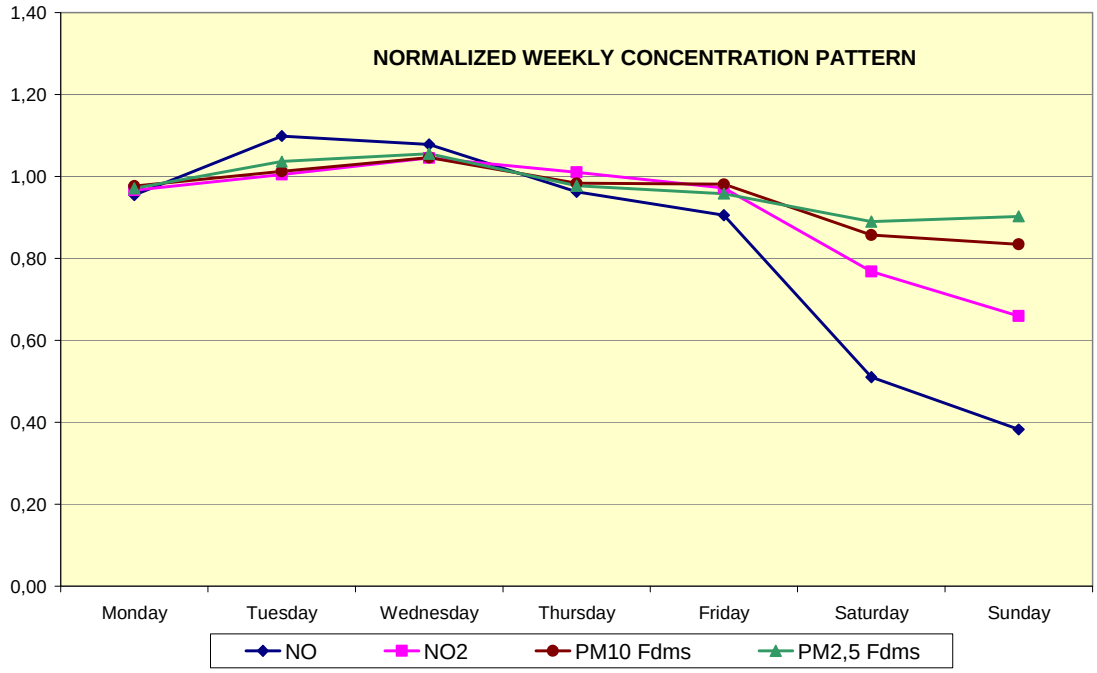


Figure 1.2: Normalized weekly concentration pattern for NO, NO_2, PM10 and PM2.5
Results averaged over 5 stations and 3 consecutive calendar years 2008-2010
Normalization at 1 by dividing the average concentration for each day of the week
by the average concentration for all working days

1.4 Most relevant processes influencing PM10 concentrations

In the Brussels Capital Region at least 3 different phenomena may lead, separately or by combination, to elevated PM10 concentrations and to an increased risk of exceeding the 50 µg/m^3 daily limit value.

1.4.1 Adverse meteorological conditions

Adverse meteorological conditions, due to a combination of temperature inversion and low wind speed resulting in poor dispersion, are a common factor leading to high concentration levels. Under these conditions, mainly occurring during winter time, between late November and early March, high concentration levels are detected at all sites, inducing simultaneous PM10 exceeding values at several locations. For instance, in February 2008 and January 2009, between 8 and 12 exceeding days were counted at the different measuring sites in Brussels.

1.4.2 Formation of secondary aerosols

A second phenomenon, very important and still underestimated is the formation of secondary aerosol, mainly occurring during the period March-April and to a lesser extent

during September-October. The spreading of manure on a large scale, in the surrounding regions, before and after the agricultural season, releases a massive source of ammonia. At conditions of moderate temperature and high relative humidity, together with the presence of NO_2, a stable secondary aerosol is formed with ammonium nitrate as a main component. Under these conditions elevated PM10 concentrations and simultaneous exceedances at different sites are observed over a much larger area than the Brussels Capital Region. During the month of April 2007 and again in April 2009 this formation caused between 8 and 16 exceeding days at the different measuring sites in Brussels.

Due to the same phenomenon the 2006 car free Sunday achieved the second highest daily value of that year [*Elevated PM10 concentrations and high PM2.5/PM10 in the Brussels Urban area during the 2006 Car Free Sunday. Vanderstraeten et al. International Journal for Environment and Waste Management. Vol. 6, No. 3/4, 2010, pp. 264-279*] and the car free Sunday of 2009 proved to be one of the other surprising exceeding days *[Observation of unusual high particulate mass and number concentration during traffic ban hours of the 2009 car free Sunday in the Brussels urban area. Vanderstraeten et al. Geographical Forum and Environmental Protection Journal, Vol. 10, Issue 1, 2011, pp.167-176. DOI:10.5775/fg.2067-4635.2011.035.i]*

1.4.3 Resuspension of the coarser fraction of PM10

The third phenomenon, (re)suspension of the coarser fraction (particles between 2.5 and 10 µm) is linked with the advection of dry air, mainly coming from the large eastern sector. Under these conditions and in the presence of a local source, particles of the coarser fraction (2.5 to 10 µm diameter) are suspended by the wind and/or by the turbulences created by the traffic. Due to the presence of local sources, this phenomenon is more frequently encountered at the two measuring sites (Haren and Molenbeek), where the limit value is systematically exceeded. This phenomenon is frequently observed at the Haren site.

2. MEASURING SITE AT THE HAREN NAVAL PORT

2.1 History of the network and of the Haren station

The Belgian Telemetric Network for air pollution was constructed in the period 1976-1980. Its main objective was the preservation of public health and therefore, in a first stage, the measuring sites were concentrated in and around the five biggest agglomerations of Belgium: Brussels, Antwerp, Gent, Liège and Charleroi. The aim was to measure the air quality at locations with a concentration of habitation and activities. These stations were called "regional stations" and had the character "R" in their codename: e.g. 41R001 (Molenbeek), 41R002 (Ixelles) and 41R012 (Uccle).

In a second phase the network had to be extended by measuring stations following a regular national grid of 20 km by 20 km. However due to budgetary problems this phase was not completed and only a few stations of this national grid were build. Some are located along the boarders with the Netherlands and France, along the coast and a few in the inner part of Belgium. These stations were called "national stations". They had the character "N" in their codename and they were named after the municipality of their location. In this way the station 41N043 was named after the municipality of Haren, at that time not yet integrated in the city of Brussels. The measuring site itself is not located in the centre of the village, but at the outskirts close to the canal and the naval port.

Since 1988 the competence over environmental matters (except radioactivity) in Belgium passed entirely to the Regions: Brussels, Flanders and the Walloon region. Due to a reorganization of the network just before that date, some of the measuring sites inside Brussels were skipped and only the stations at Molenbeek (R001), Ixelles (R002), Uccle (R012) and Haren (N043) continued. Long time series of data are only available at these original sites, especially for SO_2 (Molenbeek, Uccle and Haren), particles (Molenbeek and Haren) and NO and NO_2 (Molenbeek, Uccle and Ixelles). The data series for particles at Molenbeek and Haren form the longest data series available in Belgium.

During the period 1994-2002 supplementary analyzers were installed in the existing stations while measurements started also at some new locations inside the Brussels Capital Region, in order to obtain a good mix of stations representative for different types of urban environments (see Table I.1).

2.2 Description of the environment in the immediate surrounding of the Haren station

2.2.1 Location of the Haren station

The location of the Haren station is indicated in the aerial views in Figure 2.1. The pictures presented in Figure 2.2 show the environment close to the station.

The geographic coordinates of the Haren station are the following:

- Lambert : (x,y) = (151000, 174800)
- Geographic : 4° 23' 03.22" E, 50° 53' 03.78" N

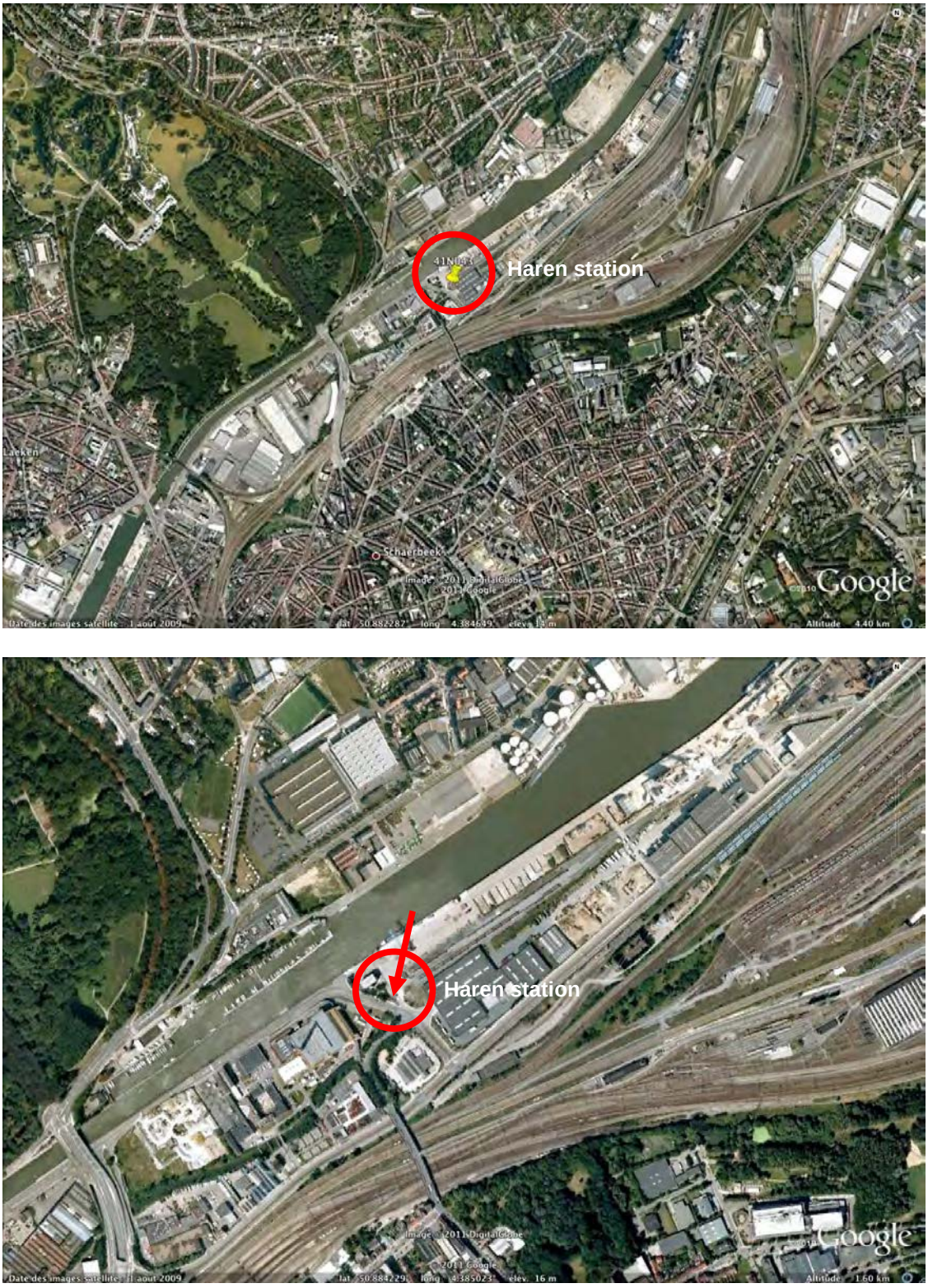


Figure 2.1: Aerial view of the Haren station. Source: Google Earth.

Figure 2.2: Haren station.

2.2.2 Industrial activities

The activities of the naval port play a significant role in the near environment of the Haren station. As shown in Figure 2.4, the naval port owns several sites along the Brussels canal “Canal de Willebroek”, parallel to the Senne Valley (North-South axis). In these sites, the construction industries stock outdoor materials, which can be easily transported by wind.

Considering more specifically the Haren site, it can be stated that local activities contribute to increase the presence of particulate matter in the ambient air. The main explaining factors are:

- The manipulation of granular materials by the construction industries close to the measurement station and by the transport of this dust by the wind (Figure 2.3) ;
- The truck traffic near the measurement station (distance of about 10 meters): the turbulence associated to the movement of vehicles induces indeed a significant resuspension of particles.

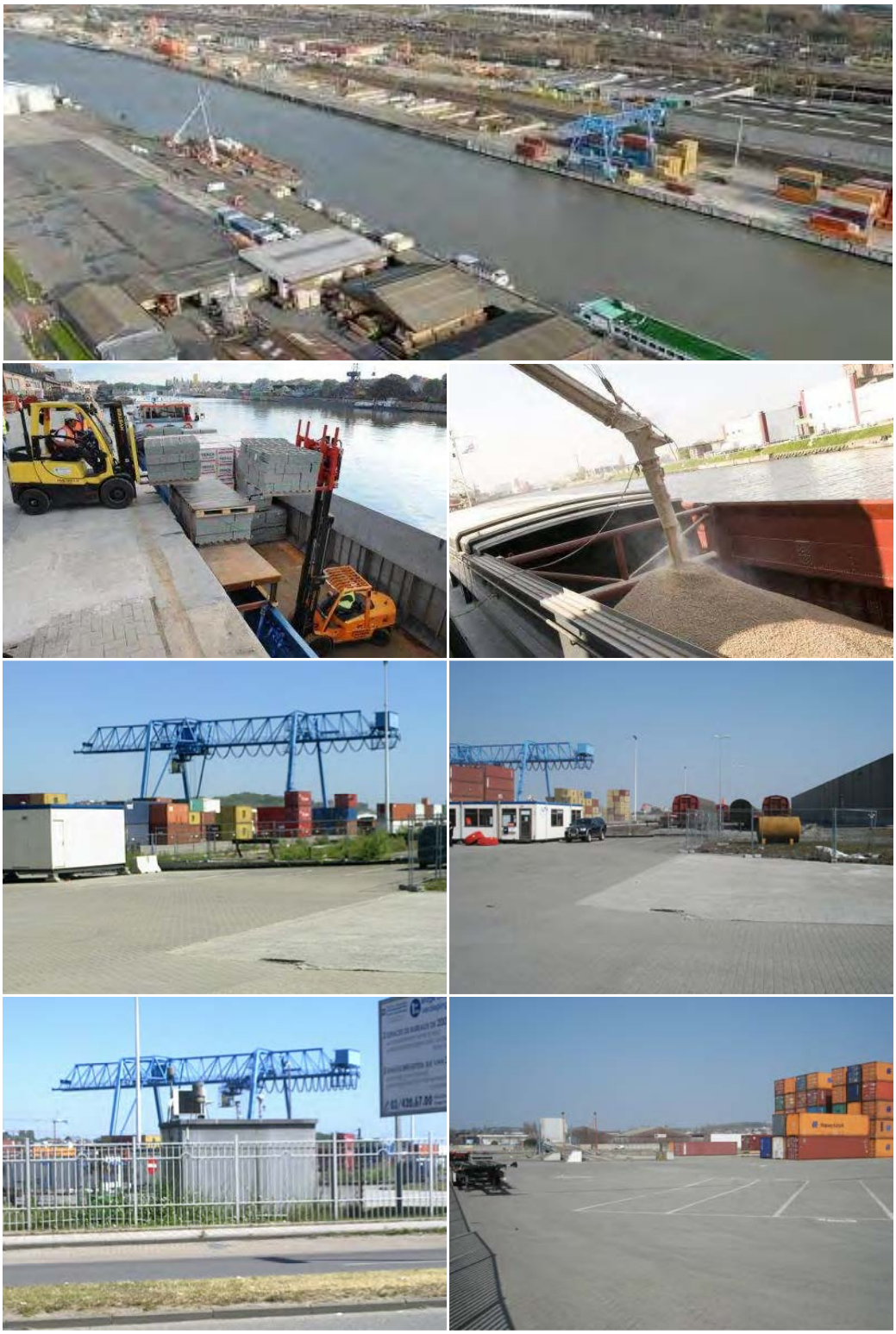


Figure 2.3: Activities in the naval port of Brussels, in the site of Haren.
Source: http://www.portdebruxelles.be.

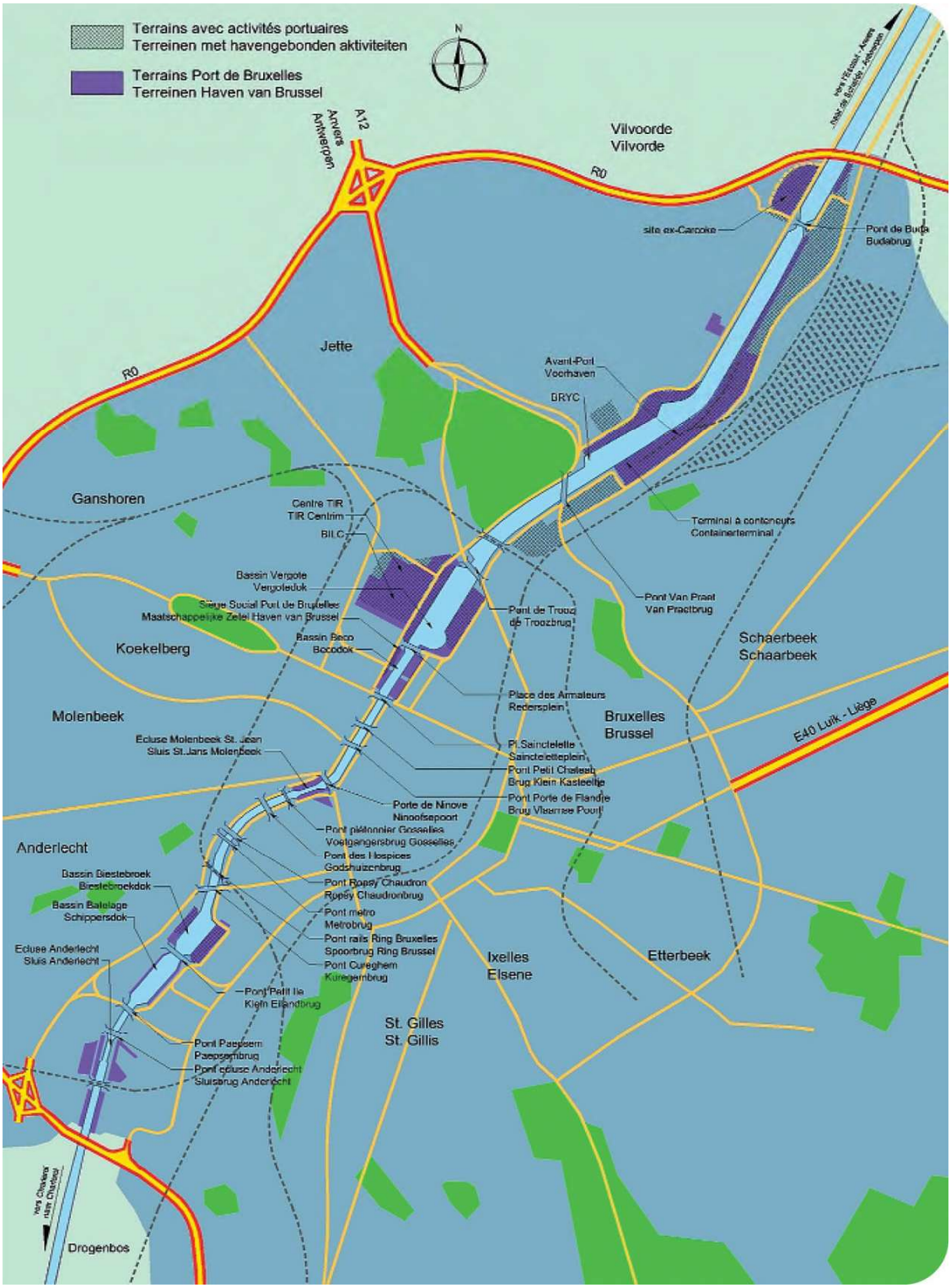


Figure 2.4: Sites occupied by the naval port of Brussels.
Source: http://ffue.org/PDF/PlanActionPortBruxelles_SecretEtat_BGrouwels.pdf

2.2.3 Population density in the surrounding of the Haren station

In 1998, the AATL (Brussels-Capital Ministry's Administration of Housing and Regional Planning) has established an inventory – the SITEX database – of the buildings and their occupancy. The Figure 2.5 presents the land occupancy in the surrounding of the Haren station. Habitations are identified by mauve circles, offices by orange circles, small enterprises by blue circles, and industries by fuchsia squares.

Figure 2.5: Land occupancy in the surrounding of the Haren station (41N043) from the Brussels SITEX database (1998). Habitations are identified by mauve circles, offices by orange circles, small enterprises by blue circles, and industries by fuchsia squares. This map has been realized using Brussels UrbIS®© - Distribution & Copyright CIRB.

It appears clearly that the Haren station is representative for the air quality in an industrial environment. No inhabitant is present within a radius of 400 m around the station (figure 2.5). The closest habitations are located on the South of the station.

The following table indicates the amount of habitations, offices, small enterprises and industries in function of the distance to the measurement station:

Distance to the Haren station	Habitations	Offices	Enterprises	Industries
250 m	0	1	0	2
500 m	30	3	6	3
750 m	389	26	20	7
1000 m	1877	44	57	9
1500 m	6272	67	180	16
2000 m	12736	108	317	28

2.2.4 Conclusions

The station of the Haren naval port is typical for industrial activities, combined with dense and heavy traffic and with practically no habitation in the immediate surrounding.

3. AVERAGE WEEKLY CONCENTRATION PATTERN

The PM10 mass concentration is measured in six stations of the Brussels Air Pollution network: Molenbeek (R001), Berchem (B011), Uccle (R012), Haren naval port (N043), Meudon Park (MEU1) and at the Brussels Environmental Institute (WOL1). With the exception of the Woluwe site, the PM2.5 mass concentration is measured simultaneously with the PM10 mass concentration in five of the six PM10 measuring sites.

3.1 Weekly PM10 concentration pattern

The graph in Figure 3.1 represents the average weekly concentration pattern for PM10. It represents the average PM10 mass concentration for each of the considered sites and for each day of the week. The results are computed for an overall period corresponding to three consecutive calendar years: 2008, 2009 and 2010. In this way the contribution from one or a few special events with accidentally high concentrations are smoothed out.

The average concentration for all stations is lower than 40 µg/m^3, the limit value for the annual average concentration.

The average concentration computed *for the working days* (Monday to Friday) is systematically higher at Haren naval port (41N043) than at the other measuring sites. The average concentration on working days at Haren ranges between 37.0 and 40.0 µg/m^3, while at the other stations the values are ranging between 25.7 and 34.7 µg/m^3. The second highest set of values is obtained at the Molenbeek site (31.3 to 33,0 µg/m^3).

However, *during the weekend*, a much steeper decrease of the PM10 concentration is observed at Haren, with average daily concentrations of 27.3 and 25.0 µg/m^3 respectively for Saturday and Sunday. The weekend concentration values join these of the other stations (23 tot 26.7 µg/m^3). During the weekend a concentration decrease of about 30 to 35% is observed at the Haren station compared to only 10 to 20% at the other sites.

3.2 Weekly PM2.5 concentration pattern

The graph in Figure 3.2 represents the average weekly concentration pattern for PM2.5. It represents the average PM2,5 mass concentration for each site and each day of the week. As for PM10 the results are computed for an overall period of 3 consecutive calendar years: 2008, 2009 and 2010. The average weekly concentration at the Haren station is not higher than at the Molenbeek site. For both stations the average weekday concentrations are ranging between 22.3 and 25.3 µg/m^3 (Haren) and 22.4 and 26.0 µg/m^3 (Molenbeek) respectively. The average weekday concentration at the other sites is ranging between 16.7 and 25.0 µg/m^3. The concentration decrease during the weekend is slightly more pronounced at the Haren site compared to the other sites: 20 to 27% at Haren and 10 to 22% at the other sites.

3.3 Conclusion

The PM2.5 weekly concentration pattern observed at the Haren site is more or less comparable to those observed at the other measuring sites. The average weekday

concentrations for PM10 are systematically higher at the Haren site compared to the other sites. **This concludes to a non negligible contribution, in the order of 30%, for the coarse fraction, particles between 2.5 and 10 µm diameter, during the week (Monday to Friday) at the Haren site.**

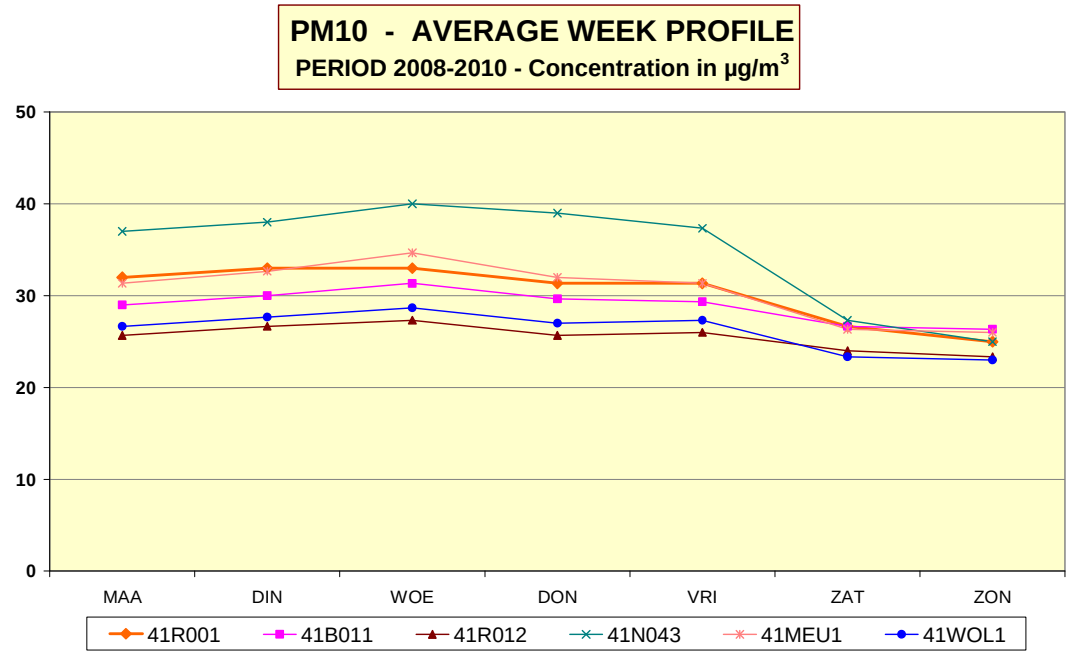


Figure 3.1 : PM10 – Average Weekly Concentration Pattern
Brussels Capital Region. Period 2008-2010

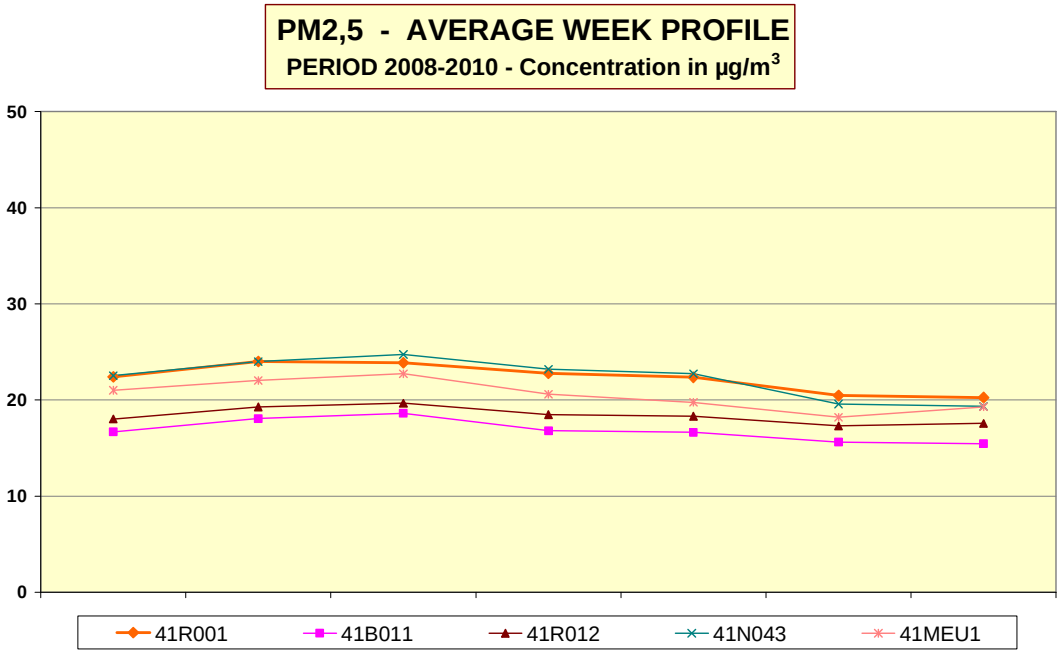


Figure 3.2 : PM2,5 – Average Weekly Concentration Pattern
Brussels Capital Region. Period 2008-2010

4. EXCEEDANCE TIME – WIND DIRECTION – HUMIDITY

4.1 Exceedance time in relation to Wind Direction

Observation of meteorological parameters for the days with PM10 exceedances caused by the presence of an important contribution of the coarse fraction (particles between 2.5 and 10 µm) made clear that these high PM10 values occurred more frequently when the wind was blowing from the large sector East (figure 4.3). The sector East is known for the advection of dryer continental air masses.

To objectify this impression we computed for each of the measuring sites and for each main wind direction (N, NE, E, SE, S, SW, W, NW), the percentage of the time corresponding to the exceedances days observed. Therefore we formed a frequency table, counting the number of half hourly periods corresponding to the occurrence of the 8 main wind directions. This was done first for all the days of the considered period, and secondly, site by site, for the exceeding days of the considered measuring site. The ratio between the two results, for exceeding days and for all the days, represents for each of the main wind directions the percentage of time corresponding to exceedances days. The results for the period 2005 – 2010 (6 consecutive calendar years) are represented in Figure 4.1.

The results for 3 of the sites are very similar: Berchem (B011), Uccle (R012) and Woluwe (WOL1). The results for the Meudon site (MEU1) are slightly higher, but the highest results are obtained for the Molenbeek (R001) and the Haren (N043) site. The difference between the measuring sites is clearly expressed for the large sector East (NE, E and SE). When the wind is blowing from the main sector East, the Haren site (N043) is for 35.5% of the time in exceedance, the Molenbeek site (R001) for 24,5% of the time, the Meudon site (MEU1) for 19,3% of the time, and the other sites for respectively 14,5% (B011), 13,7% (WOL1) and 11,6% (R012) of the time. The differences between stations are less important when the wind is blowing from the large sector West (SW, W and NW)

This exercise is repeated but slightly adapted. A frequency table is made counting the number of half hourly periods corresponding to the occurrence of the 8 main wind directions, first for all the days of the considered period, and secondly for the exceedance days of each measuring site, but for this second table exclusion was made for the days with solely an exceedance at the Haren (N043) or at the Molenbeek (R001) site. The computed results for this second exercise are represented in Figure 4.2 and it can be seen that the results for the Haren and Molenbeek site join the results for the other sites.

In conclusion, the supplementary exceeding days (surplus of exceeding days) at the sites of Haren and Molenbeek are strongly correlated with the large sector East.

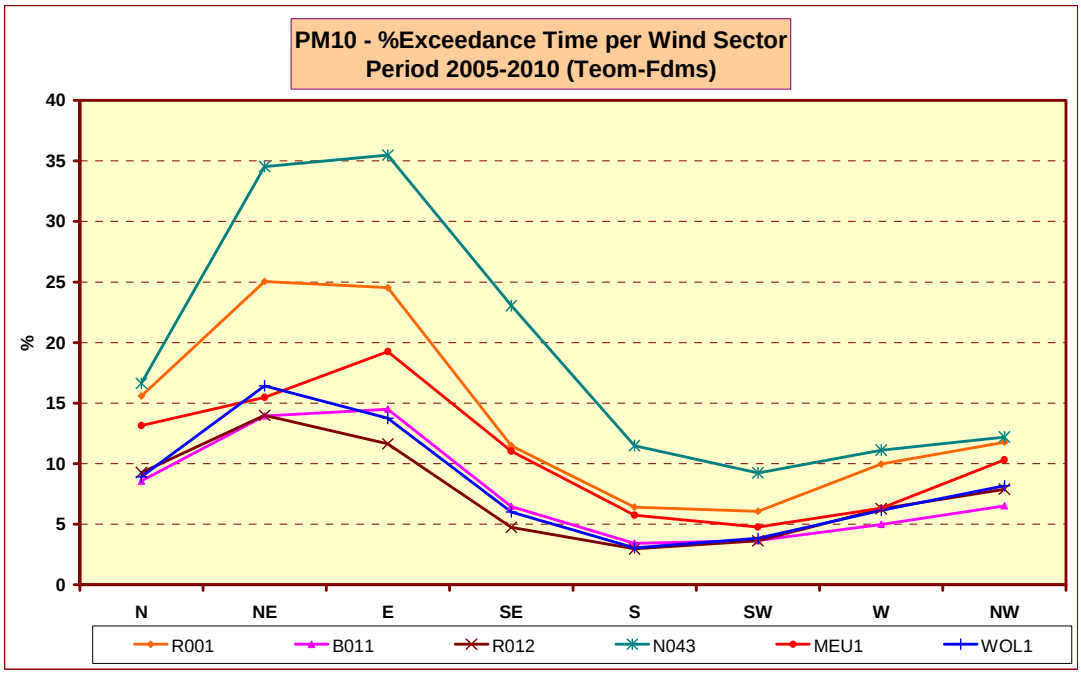


Figure 4.1 : Exceedance Time in relation to Wind Direction – All Days
Period 2005 – 2010

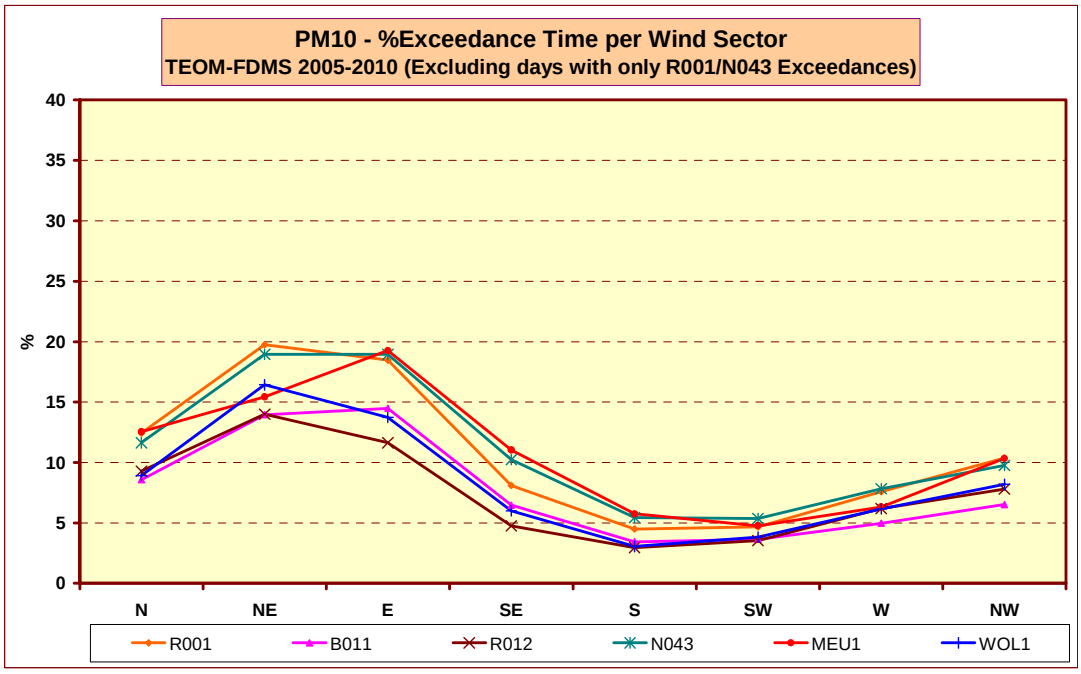


Figure 4.2 : Exceedance Time in relation to Wind Direction – Exclusion of days with solely exceedances at N043 or R001. Period 2005 – 2010

Figure 4.3 : Pollution rose at the Haren station. The PM10 measurements have been considered for the period from 1/7/2006 to 30/6/2011 (five years) and only for working days. Meteorological data are taken from the wind measurements at the Zwijndrecht station (source: IRCEL-VMM). Arithmetic mean, percentile 90 and percentile 98 on half-hourly PM10 concentrations are represented respectively by blue, red and yellow surfaces. See figure 2.5 for the explanation of the land use. This map has been realized using Brussels UrbIS®© - Distribution & Copyright CIRB.

4.2 Exceedance time in relation to Relative Humidity

A similar exercise is made by relating the exceedances and the relative humidity. A frequency table is made, counting the occurrence of half hourly periods corresponding to nine different classes of relative humidity: <36% RH, 36-44%, 44-52%, 52-60%, 60-68%, 68-76%, 76-84%, 84-92% and 92-100% RH. Also in this case the frequency table is computed first for all days of the considered period and secondly, for the exceeding days at each of the PM10 measuring sites. The ratio between these two data sets are represented in Figure 4.4, giving for each measuring site the percentage of the time, corresponding to a humidity class, that the limit value is exceeded at a measuring site.

The results are represented in Figure 4.3. As it was the case for the exercise with the wind direction, the results for 3 sites are very similar: Berchem (B011), Uccle (R012) and Woluwe (WOL1). The results are higher for the Meudon (MEU1) and Molenbeek site (R001) and much higher for the Haren (N043) site, especially for the lower classes of relative humidity. When the relative humidity has values between 36 and 44% RH, the Haren site (N043) is in exceedance for 33,0% of the time, the Molenbeek site (R001) for 19,2% of the time, the Meudon site (MEU1) for 15,4% and the other sites for respectively 8,6% (WOL1), 8,4% (B011), and 5,3% (R012) of the time.

A similar exercise, but with the exclusion of the days with solely exceedances at the Haren or the Molenbeek site leads to the results represented in Figure 4.4. The results for these two sites now become comparable with the results for the other sites, meaning that the supplementary exceedance time at these two sites is strongly correlated with the presence of dry air masses.

Taking into account the results obtained in section 4.1, it can be concluded that **the supplementary exceeding days at the Haren and the Molenbeek site, corresponding mainly to the presence of an important amount of the coarse fraction, are strongly correlated with the importation of dryer air masses from the large sector East.**

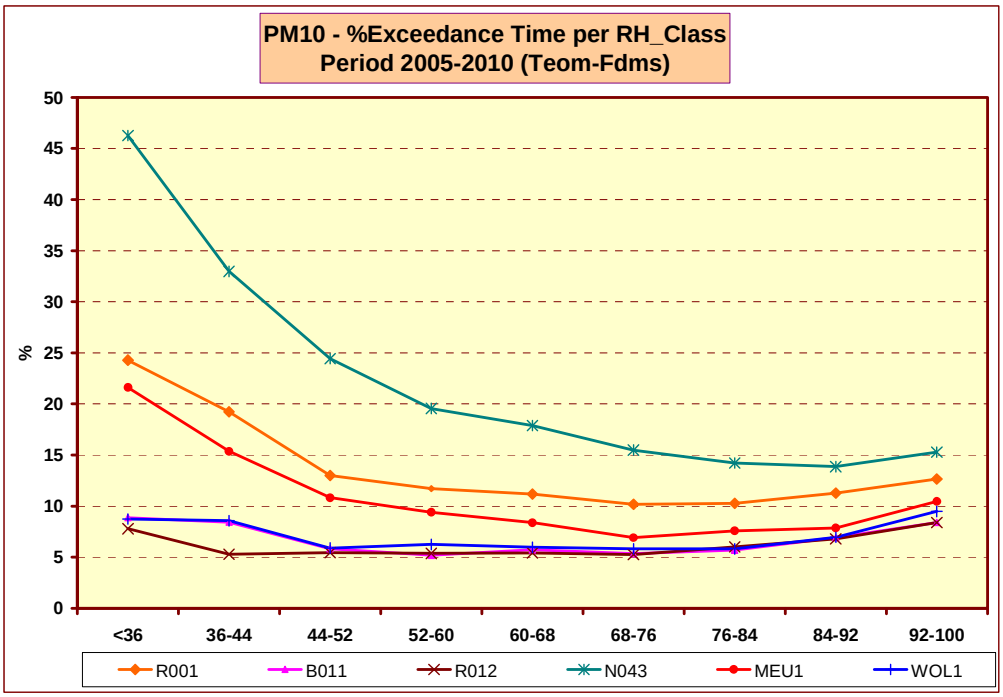


Figure 4.3 : Exceedance Time in relation to Relative Humidity – All Days
Period 2005 – 2010

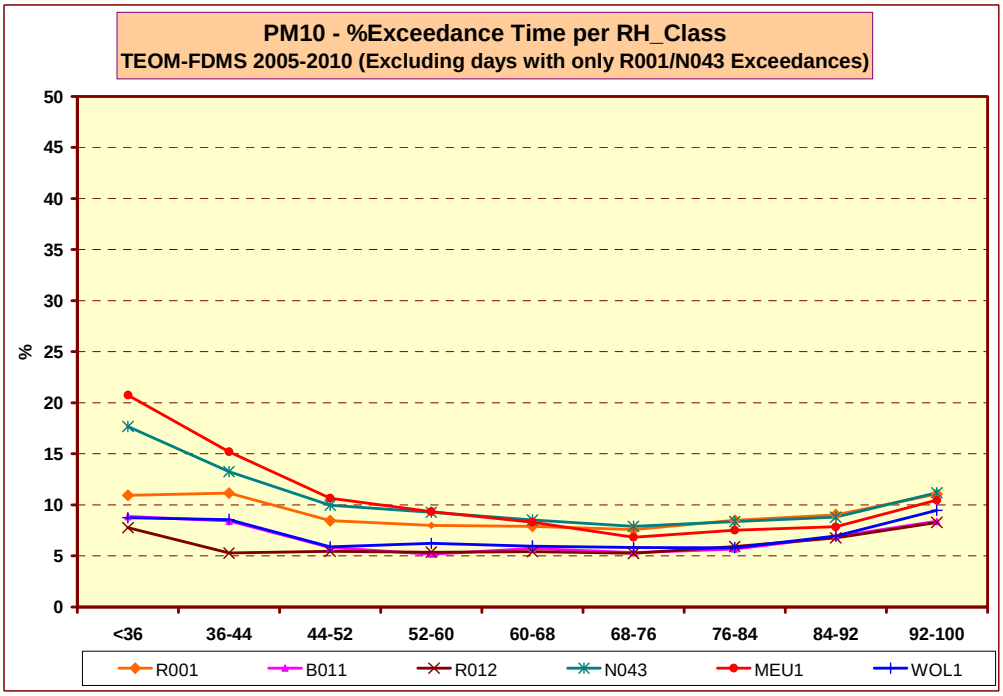


Figure 4.4 : Exceedance Time in relation to Relative Humidity – Exclusion of days with solely exceedances at N043 or R001. Period 2005 – 2010

5. PRESENCE OF THE COARSER FRACTION - SPECIFIC CASES

In this chapter the presence of the coarser fraction, leading to daily PM10 exceeding values, is illustrated by a limited selection of specific cases. In some of the cases the presence of the coarse fraction is observed only at the Haren site (N043), in others the coarse fraction is simultaneously present at the Haren, Molenbeek (R001) and Meudon (MEU1) site, but with a different intensity. In still some other examples the presence of the coarse fraction is superposed upon high PM levels present everywhere, e.g. PM10 and PM2.5 values close or above the 50 µg/m^3 value and caused by the formation of secondary aerosol. In such cases the coarse fraction cannot be held responsible for the exceedances. Examples are given for the following periods:

Period	Number of exceedance days explained by:	
	Coarser fraction	Abundant formation of secondary particles
Sunday 04 – Saturday 10 May 2008	5	-
Monday 15 – Sunday 21 September 2008	4	-
Sunday 29 March – Saturday 05 April 2009	1 or 2	4
Monday 22 – Saturday 27 June 2009	2 or 3	-
Monday 14 – Saturday 19 June 2010	2	-
Sunday 06 – Friday 11 March 2011	2 or 3	-
Sunday 17 – Saturday 23 April 2011	5	1

For each of the cases four different graphs are presented. The graph "**a**" represents the evolution of the hourly PM10 and PM2.5 concentration data (continuous line) measured at the Haren site (N043), together with the computed daily average values (histogram). The PM10 data are given in blue color and PM2.5 in magenta color. This graph permits to see to what extent the PM10 values at the Haren site are higher than the PM2.5 values. The horizontal line across the graph represents the 50 µg/m^3 limit value.

The graph "**b**" represents the evolution of the relative humidity measured at the Uccle site, and the wind direction measured at Zwijndrecht (at 153-m height) or at Uccle (at 30-m height). When they are available, the wind measurements at Zwijndrecht are preferred to those of Uccle, because they are much less influenced by site effects. This graph characterizes the most significant meteorological variables.

The graph "**c**" represents the evolution of the PM10 concentration measured at the different PM10 sites. In this graph the PM10 values at the Haren site can be compared with the PM10 values measured at the other sites.

Finally the graph "**d**" represents the evolution of the PM2.5 concentration measured at the different measuring sites. The combination of graphs "**c**" and "**d**" allows to see if increased PM10 concentrations at Haren are followed by increased PM2.5 concentrations or not.

5.1 Period “Sunday 04 – Saturday 10 May 2008”

The graph in Figure 5.1.a reveals very high PM10 values compared to PM2.5 during the working days, Monday 05 till Friday 09 May 2008. The PM10 daily limit value of 50 µg/m^3 is exceeded at the Haren site during 5 consecutive working days.

The meteorological conditions were the following:

Temperature	Temperatures in the afternoon raised from about 22°C on Sunday 04 May till 28°C on Saturday 10 May 2008
Wind direction	South-East to East
Relative humidity	Very low values for the relative humidity (~30% RH) in the afternoon and during the whole week (Figure 5.1.b)
Precipitation	Last precipitation on 2 May 2008

Under these conditions the soil and road surfaces could become very dry. The graph in Figure 5.1.c reveals that the PM10 values increased simultaneously in some other sites, but with a lower amplitude than at the Haren site. However there were no PM10 exceeding values at the other sites. The average PM10 value computed over the different sites ranged between 29 and 34 µg/m^3 and the average of the PM2.5 concentration over the different sites ranged between 16 and 20 µg/m^3.

The graph in Figure 5.1.d shows no important increase of the PM2.5 concentration values and the results are very similar over the different measuring sites.

It can be stated that the following exceedances at the Haren site (N043) are mainly caused by the presence of the coarse fraction:

Date	Day of the week	PM10_N043	PM2.5_N043
05/05/2008	Monday	58 µg/m^3	20.0 µg/m^3
06/05/2008	Tuesday	67 µg/m^3	23.6 µg/m^3
07/05/2008	Wednesday	66 µg/m^3	24.3 µg/m^3
08/05/2008	Thursday	62 µg/m^3	20.1 µg/m^3
09/05/2008	Friday	53 µg/m^3	18.5 µg/m^3

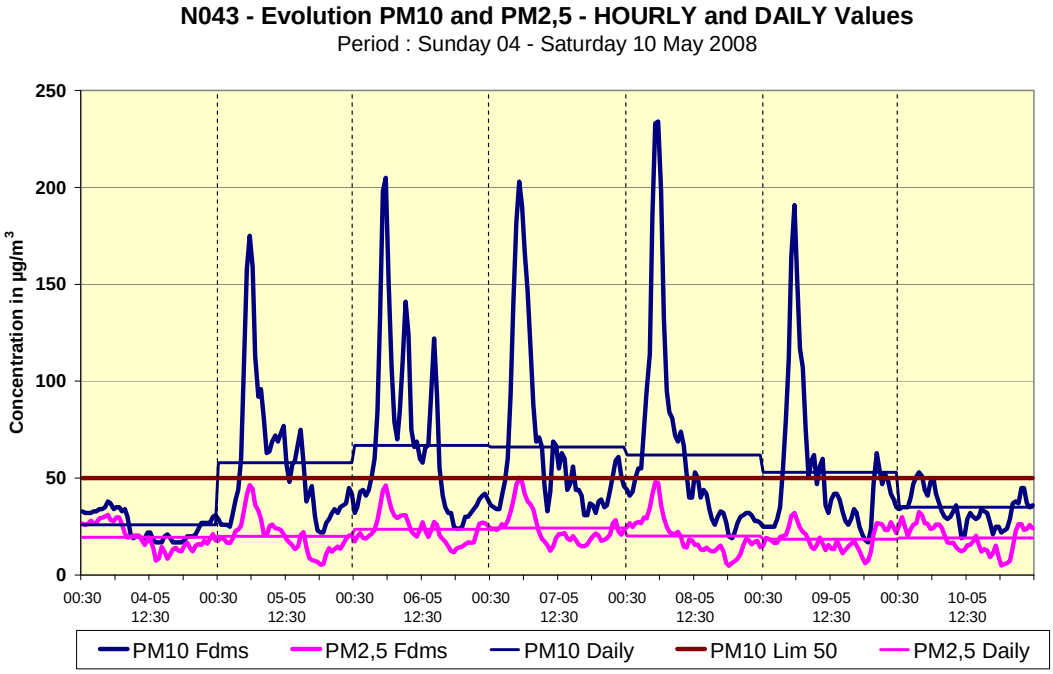


Figure 5.1.a : PM10 and PM2.5 concentration at the Haren site
Sunday 04 – Saturday 10 May 2008

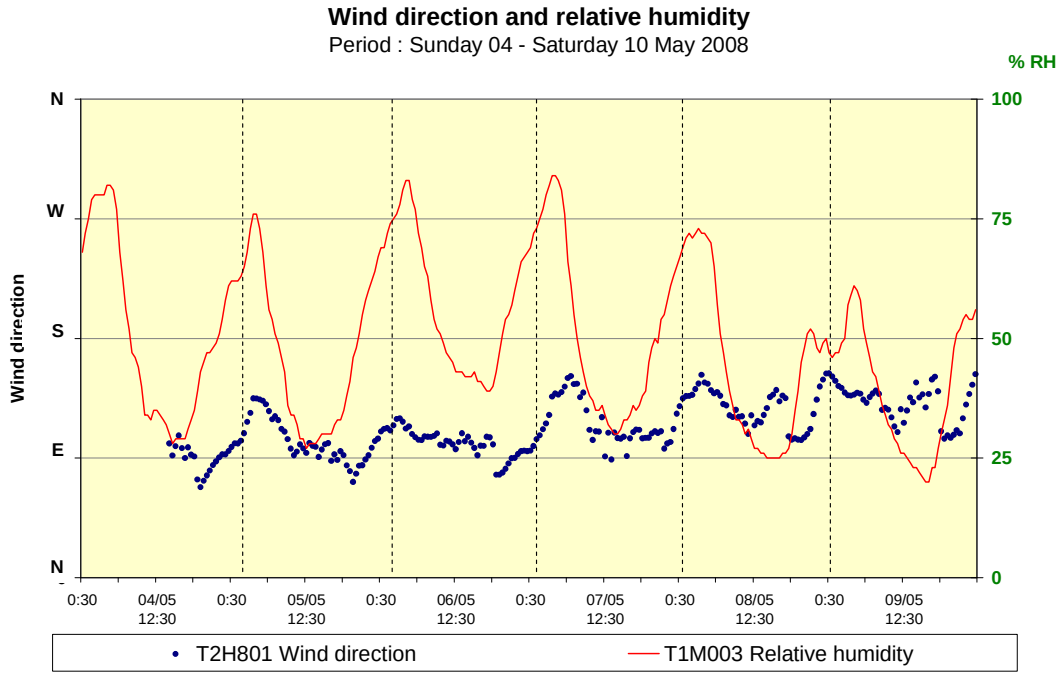


Figure 5.1.b : Wind direction at Zwijndrecht – Relative Humidity at Uccle
Sunday 04 – Saturday 10 May 2008

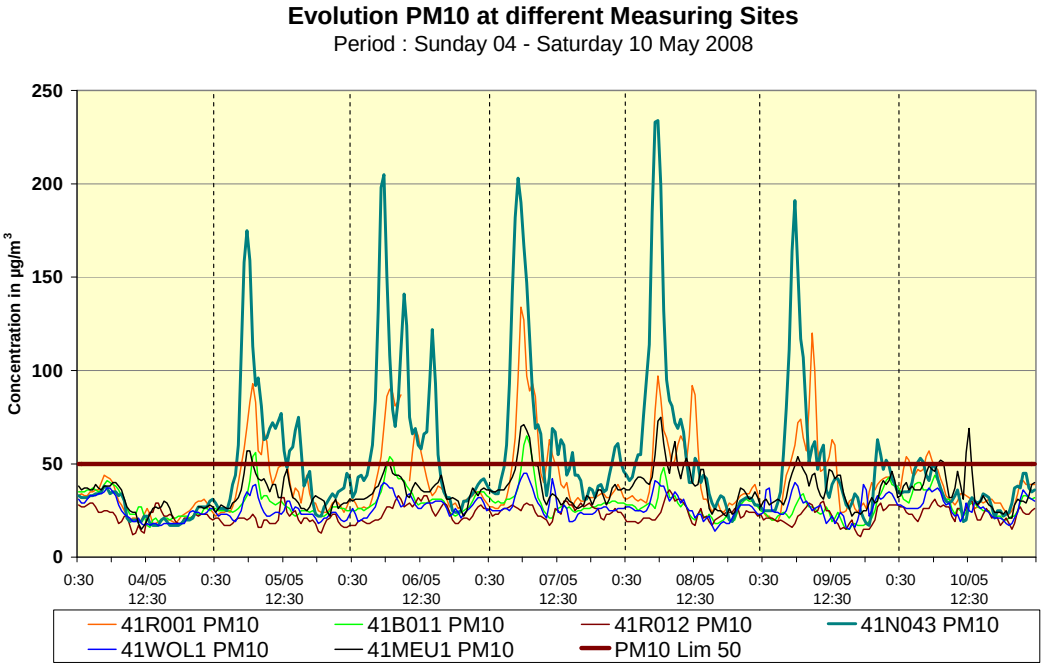


Figure 5.1.c : PM10 concentration at the different measuring sites
Sunday 04 – Saturday 10 May 2008

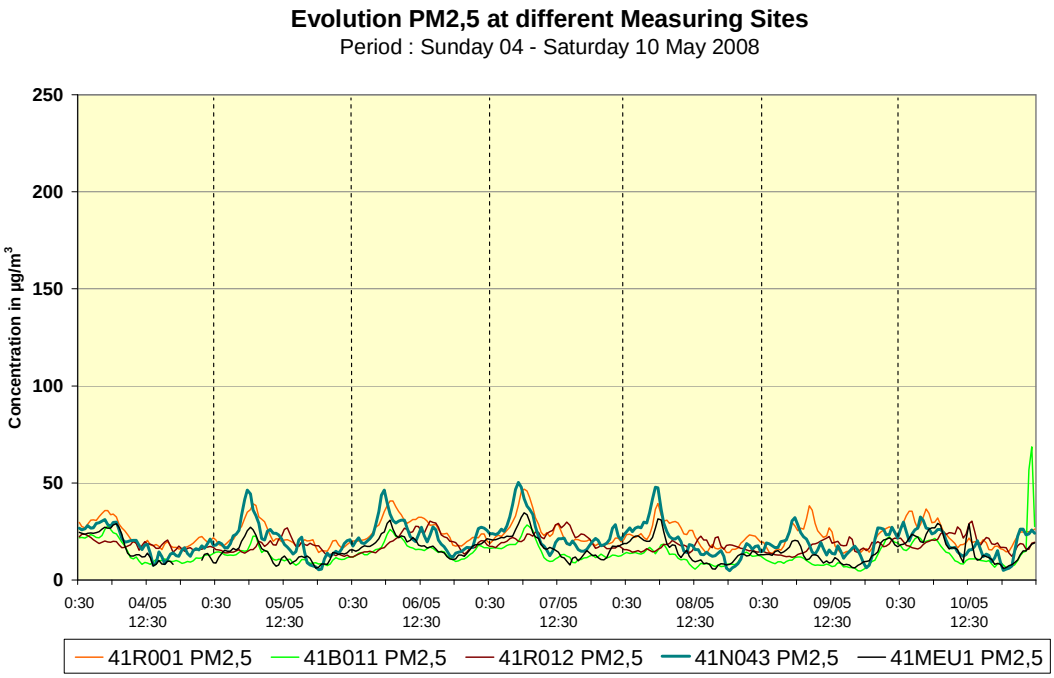


Figure 5.1.d : PM2.5 concentration at the different measuring sites
Sunday 04 – Saturday 10 May 2008

5.2 Period "Monday 15 – Sunday 21 September 2008"

The graph in Figure 5.2.a reveals very high PM10 values compared to PM2.5 during the working days, from Tuesday 16 till Friday 19 September 2008. The PM10 daily limit value of 50 µg/m^3 is exceeded at the Haren site during 4 consecutive working days.

The meteorological conditions were the following:

Temperature	Temperatures in the afternoon were between 16 and 18°C
Wind direction	East to North-East
Relative humidity	Low values for the relative humidity (~40 to 50% RH) in the afternoon and during the whole week (Figure 5.2.b)
Precipitation	Last precipitation on 12 September 2008

Under these conditions the soil and road surfaces could become dry. The graph in Figure 5.2.c reveals that the PM10 values increased, practically only at the Haren site, on Wednesday 17 and Thursday 18 September 2008. On Tuesday 16 and Friday 19 September a small increase of the PM10 concentration could also be observed at some of the other measuring sites. However no PM10 exceeding values were observed at the other sites. The average of the PM10 daily values computed over the different sites ranged between 29 and 39 µg/m^3 and the average of the PM2.5 concentration over the different sites ranged between 20 and 28 µg/m^3.

The graph in Figure 5.2.d shows no important increase of the PM2.5 concentration values and the results are very similar over the different measuring sites.

It can be stated that the following exceedances at the Haren site (N043) were caused by the presence of the coarse fraction:

	Date	**Day of the week**	**PM10_N043**	**PM2.5_N043**
	16/09/2008	Tuesday	69 µg/m^3	27.4 µg/m^3
17/09/2008	Wednesday	68 µg/m^3	27.7 µg/m^3	
	18/09/2008	Thursday	92 µg/m^3	24.1 µg/m^3
	19/09/2008	Friday	92 µg/m^3	33.0 µg/m^3

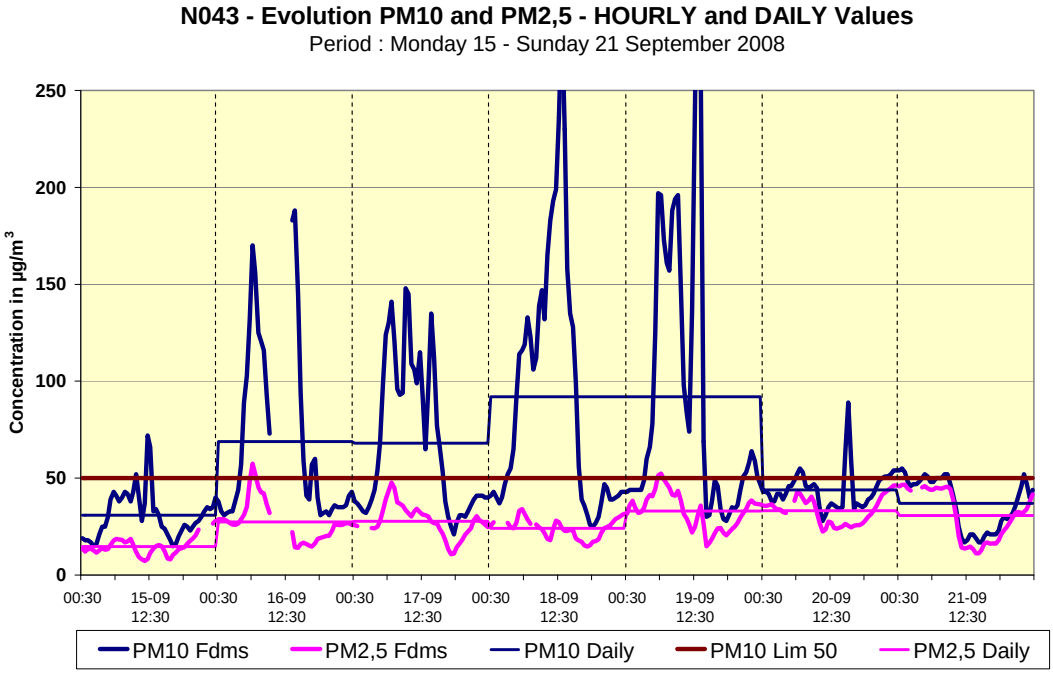


Figure 5.2.a : PM10 and PM2.5 concentration at the Haren site
Monday 15 – Sunday 21 September 2008

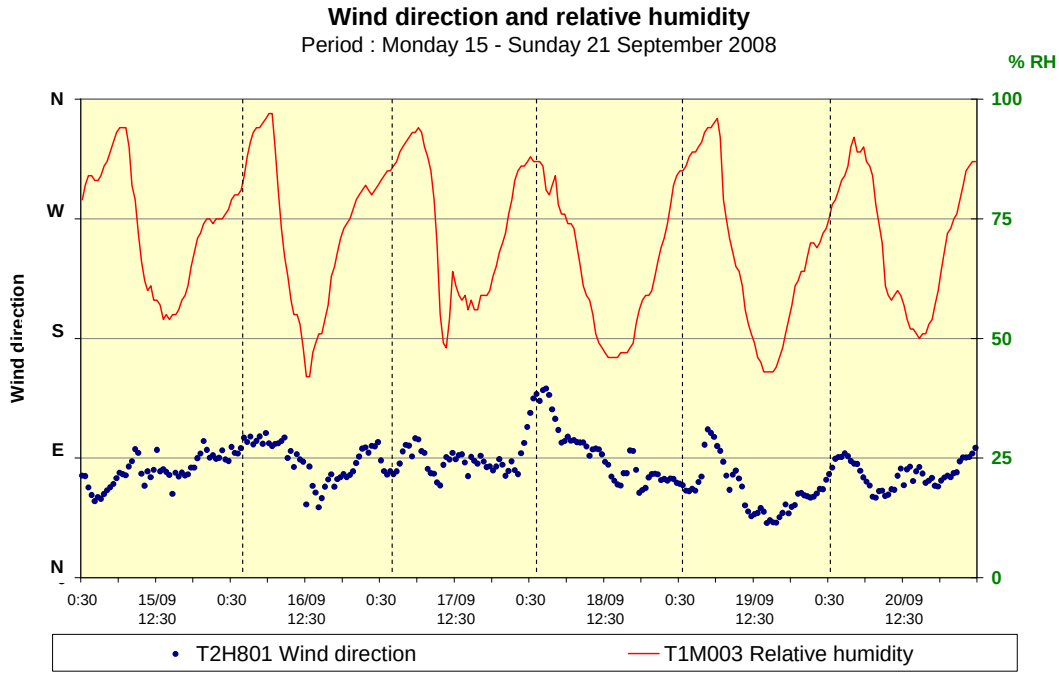


Figure 5.2.b : Wind direction at Zwijndrecht – Relative Humidity at Uccle
Monday 15 – Sunday 21 September 2008

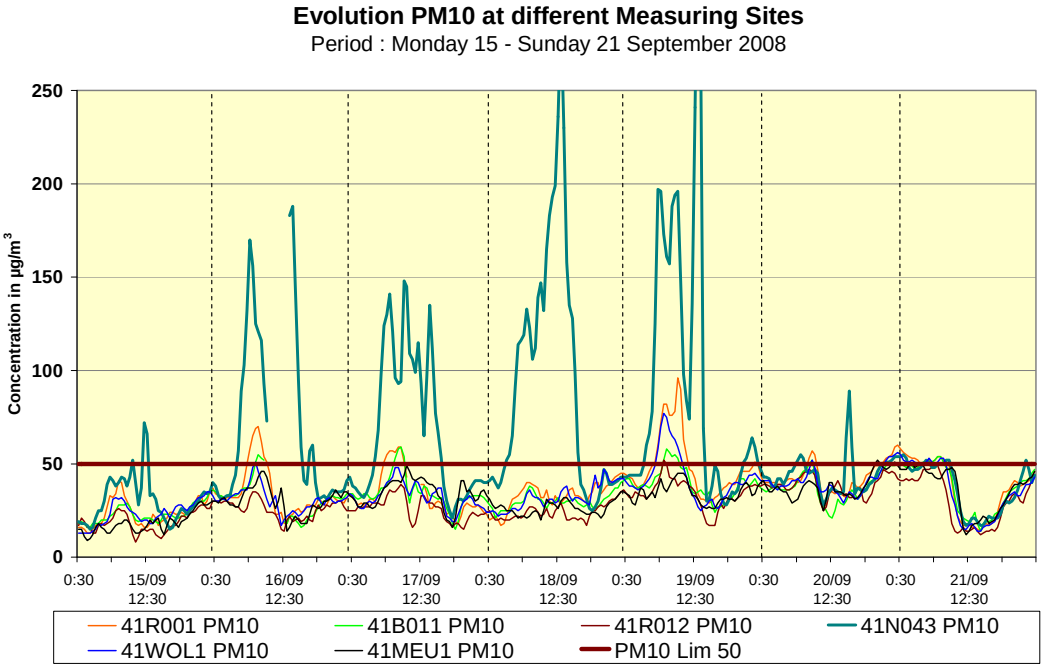


Figure 5.2.c : PM10 concentration at the different measuring sites
Monday 15 – Sunday 21 September 2008

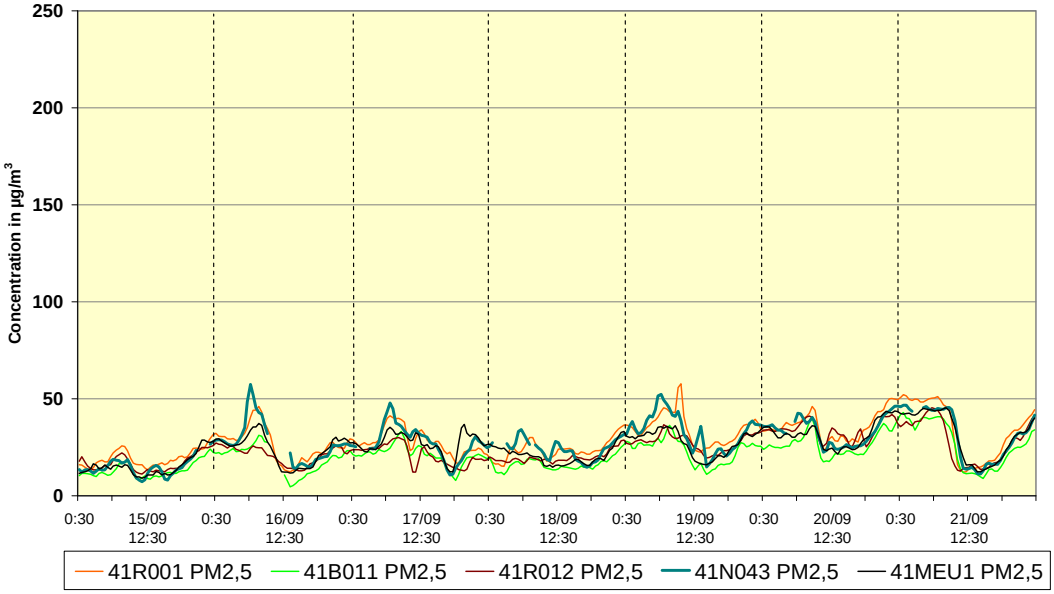


Figure 5.2.d : PM2.5 concentration at the different measuring sites
Monday 15 – Sunday 21 September 2008

5.3 Period "Sunday 29 March – Sunday 05 April 2009"

The graph in Figure 5.3.a reveals very high PM10 values during some of the working days: Tuesday 31 March, Wednesday 01 and Friday 03 April 2009. The PM10 values are relatively higher than the PM2.5 values on Monday 30 March and Thursday 02 April. The PM2.5 concentration is very high on Friday 03 and Saturday 04 April and relatively high on Sunday 05 April 2009. The daily PM2.5 concentration at the Haren site reaches respectively 87.0 µg/m^3 on Friday, 94.4 µg/m^3 on Saturday and 42.1 µg/m^3 on Sunday.

At the Haren site, the PM10 daily limit value is exceeded during 6 consecutive working days, from Monday 30 March till Saturday 04 April 2009. Only on Wednesday 01 April the presence of the coarse fraction is clearly necessary for exceeding the PM10 daily limit value. Monday 30 March seems to be a doubtful case. On Tuesday 31 March and Friday 03 April 2009 the PM2.5 concentration was that high, respectively 48.6 and 87.0 µg/m^3, that the PM10 exceedance could not be identified as caused by the coarse fraction. On Saturday 04 April the PM2.5 concentration reached 94.4 µg/m^3, or about 92% of the PM10 concentration, clearly an example of the presence of secondary aerosol.

The meteorological conditions were the following:

Temperature	Temperatures in the afternoon were between 9 and 11°C on 29 and 30 March, and between 14 and 21°C from 31 March till 5 April.
Wind direction	29 & 30 March: North-West 31 March, 1 & 2 April: North-East 3 & 4 April: North-West to South-West
Relative humidity	Low values for the relative humidity (~40 to 50% RH) in the afternoon, from Sunday 29 March till Thursday 02 April (Figure 5.3.b). At the end of the week the humidity stays higher.
Precipitation	Last precipitation on 28 March 2009

The graph in Figure 5.3.c reveals that the PM10 values increased, at the Haren site and also at some of the other sites, on Tuesday 31 March, Wednesday 01 April and Friday 03 April 2009. On Tuesday 31 March and from Thursday 02 till Sunday 05 April the PM10 concentration was relatively high in the other sites leading to PM10 exceedances in several of the other sites.

The graph in Figure 5.3.d shows a continuous increase of the PM2.5 concentration during the week, leading to average PM2.5 daily concentrations above 50 µg/m^3 on Friday 03 and Saturday 04 April 2009. Therefore the PM10 exceedances on these days cannot be identified as caused by the presence of the coarse fraction.

It can be stated that the following exceedance at the Haren site (N043) was most likely caused by the presence of the coarse fraction:

	Date	Day of the week	PM10_N043	PM2.5_N043
01/04/2009	Wednesday	128 µg/m^3	39,4 µg/m^3	

The exceedance on Monday 30 March could eventually be identified as caused by the coarse fraction:

Date	Day of the week	PM10_N043	PM2.5_N043
30/03/2009	Monday	52 µg/m^3	34.8 µg/m^3

The following exceedances could **not** be identified as caused by the coarse fraction:

Date	Day of the week	PM10_N043	PM2.5_N043
31/03/2009	Tuesday	88 µg/m^3	48.6 µg/m^3
02/04/2009	Thursday	76 µg/m^3	42.4 µg/m^3
03/04/2009	Friday	140 µg/m^3	87.0 µg/m^3
04/04/2009	Saturday	103 µg/m^3	94.4 µg/m^3

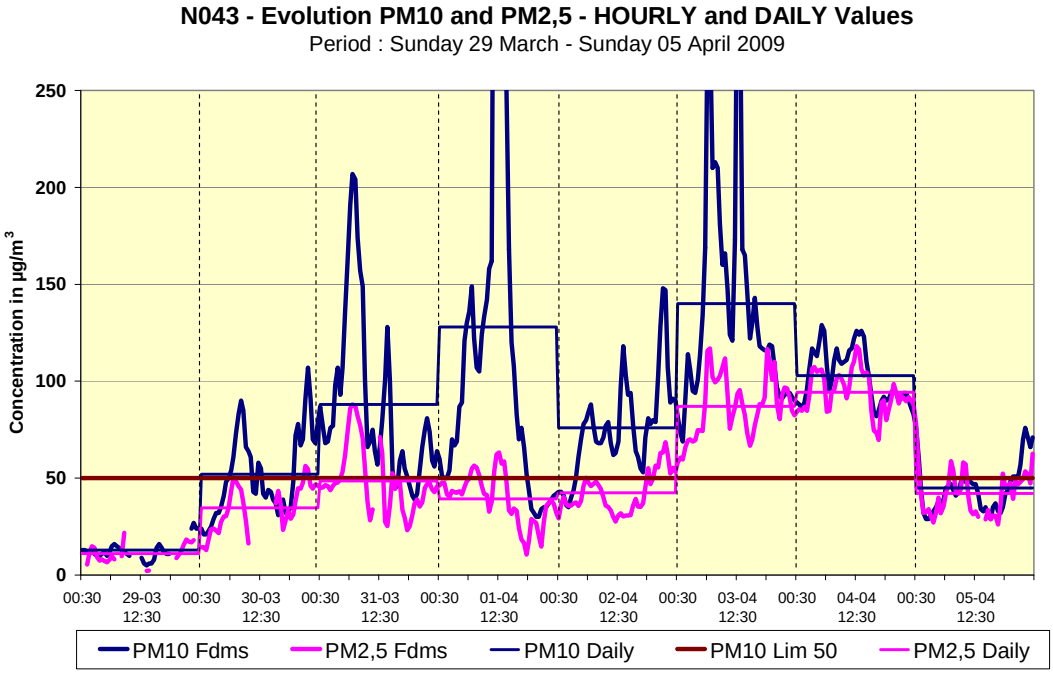


Figure 5.3.a : PM10 and PM2.5 concentration at the Haren site
Sunday 29 March – Sunday 05 April 2009

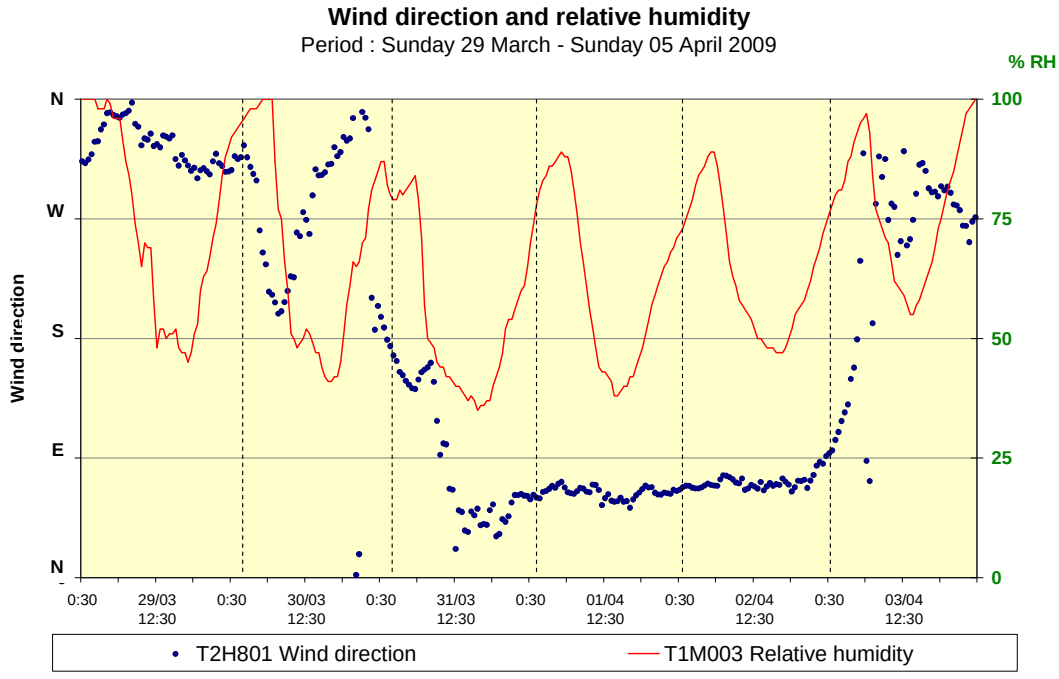


Figure 5.3.b : PM10 at the Haren site – Relative Humidity at Uccle
Sunday 29 March – Sunday 05 April 2009

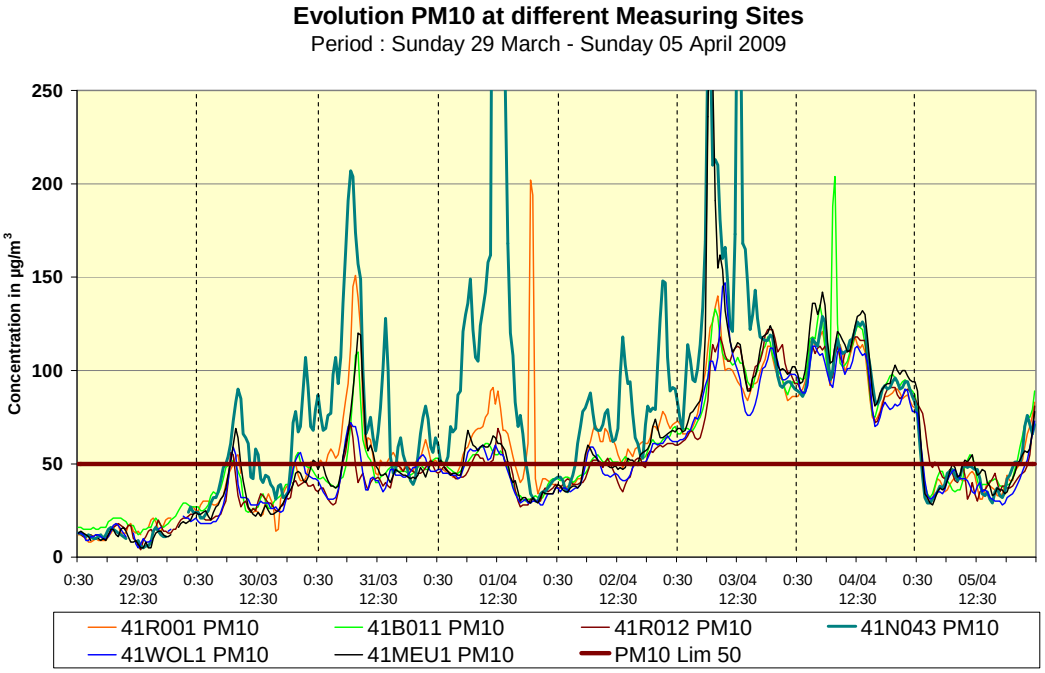


Figure 5.3.c : PM10 concentration at the different measuring sites
Sunday 29 March – Sunday 05 April 2009

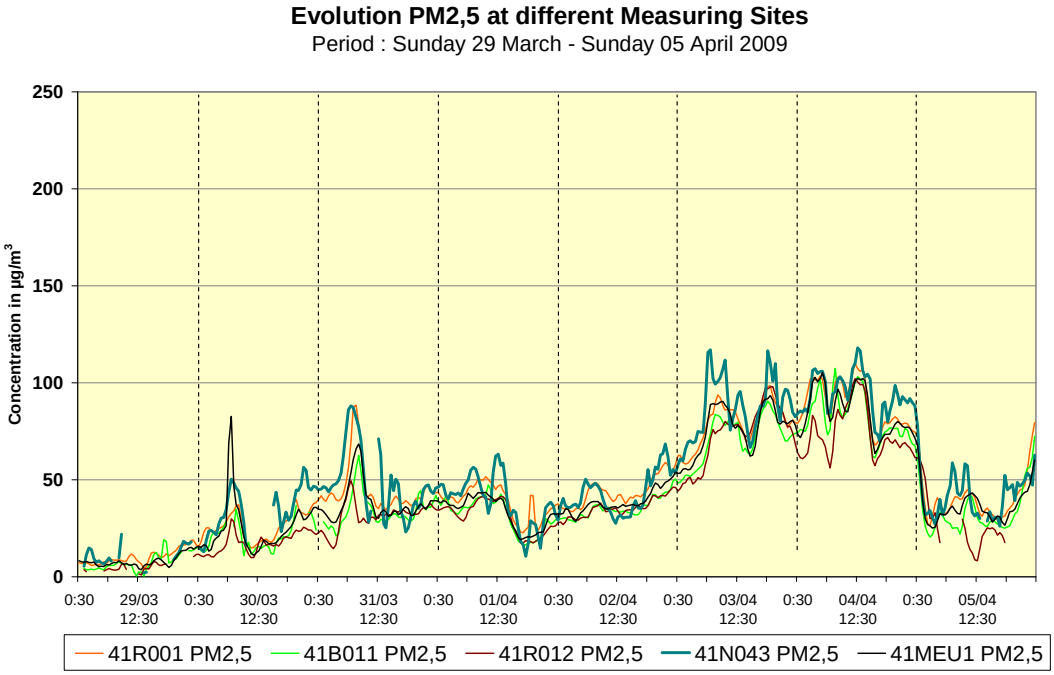


Figure 5.3.d : PM2.5 concentration at the different measuring sites
Sunday 29 March – Sunday 05 April 2009

5.4 Period "Monday 22 – Saturday 27 June 2009"

The graph in Figure 5.4.a reveals very high PM10 values compared to PM2.5 on Wednesday 24 June 2009 and relative high PM10 values on Thursday 25 June. Also on Monday 23 and Friday 26 June peak values for PM10 were observed. The PM10 daily limit value of 50 µg/m^3 is exceeded at the Haren site during 3 consecutive working days, from Wednesday 24 till Friday 26 June 2009.

The meteorological conditions were the following:

Temperature	From Wednesday 24 till Friday 26 the temperatures in the afternoon were between 25 and 28℃
Wind direction	East to North-East from 22 till 26 June North-West on 27 June
Relative humidity	Low values for the relative humidity (~40 to 50% RH) in the afternoon from Monday 22 till Friday 27 June 2009 (Figure 5.4.b)
Precipitation	Last precipitation on 21 June 2009

Under these conditions the soil and road surfaces could become dry. The graph in Figure 5.4.c reveals that the PM10 values increased, practically only at the Haren site, on Tuesday 23, Thursday 25 and Friday 26 June 2009. On Wednesday 24 June a small increase of the PM10 concentration could be observed at some of the other measuring sites. However no PM10 exceeding values were observed at the other sites. The average of the PM10 daily values computed over the different sites ranged between 23 and 38 µg/m^3 and the average of the PM2.5 concentration over the different sites ranged between 14 and 27 µg/m^3.

The graph in Figure 5.4.d shows no important increase of the PM2.5 concentration values and the results are very similar over the different measuring sites. During the night from Friday 26 till Saturday 27 June there is an increase of both PM10 and PM2.5 concentrations at all measuring sites. This is probably another case related to the formation of secondary aerosol.

It can be stated that the following exceedances at the Haren site (N043) were caused by the presence of the coarse fraction:

	Date	**Day of the week**	**PM10_N043**	**PM2.5_N043**
	24/06/2009	Wednesday	62 µg/m^3	18.6 µg/m^3
25/06/2009	Thursday	55 µg/m^3	27.8 µg/m^3	

The following exceedance case could eventually be linked to the presence of the coarser fraction:

	Date	**Day of the week**	**PM10_N043**	**PM2.5_N043**
26/06/2009	Friday	51 µg/m^3	33.2 µg/m^3	

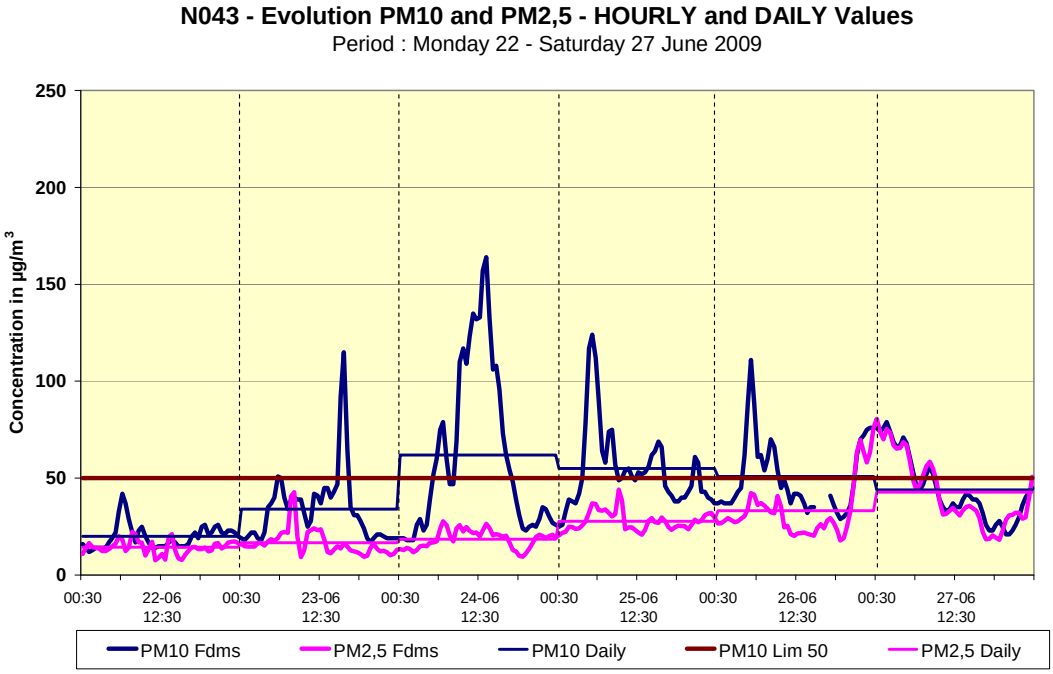


Figure 5.4.a : PM10 and PM2.5 concentration at the Haren site
Monday 22 – Saturday 27 June 2009

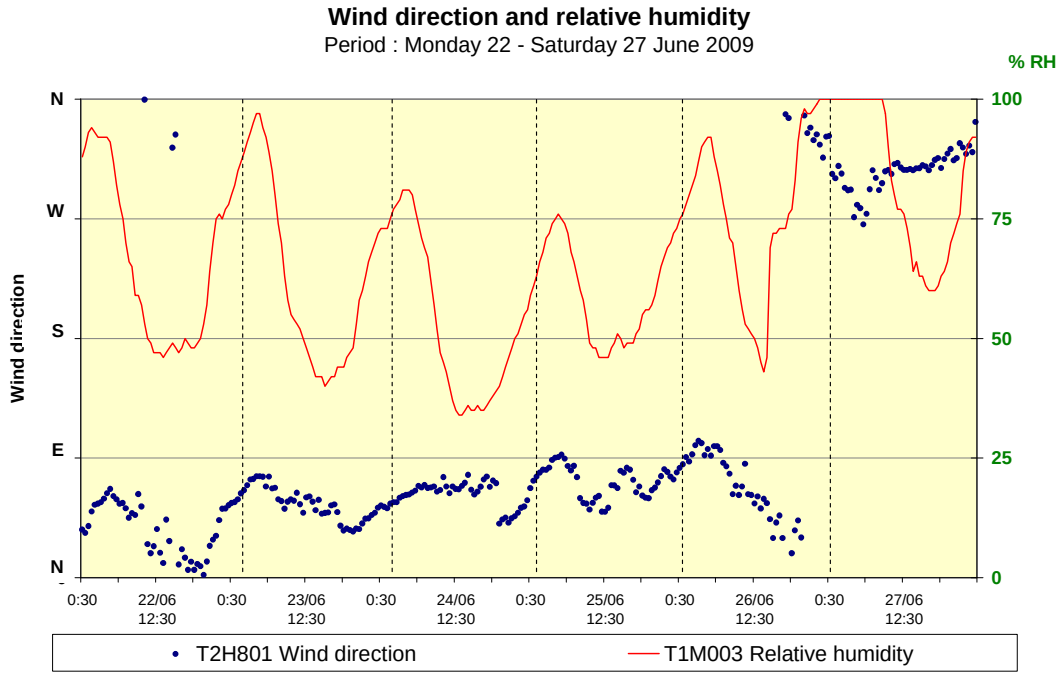


Figure 5.4.b : Wind direction at Zwijndrecht – Relative Humidity at Uccle
Monday 22 – Saturday 27 June 2009

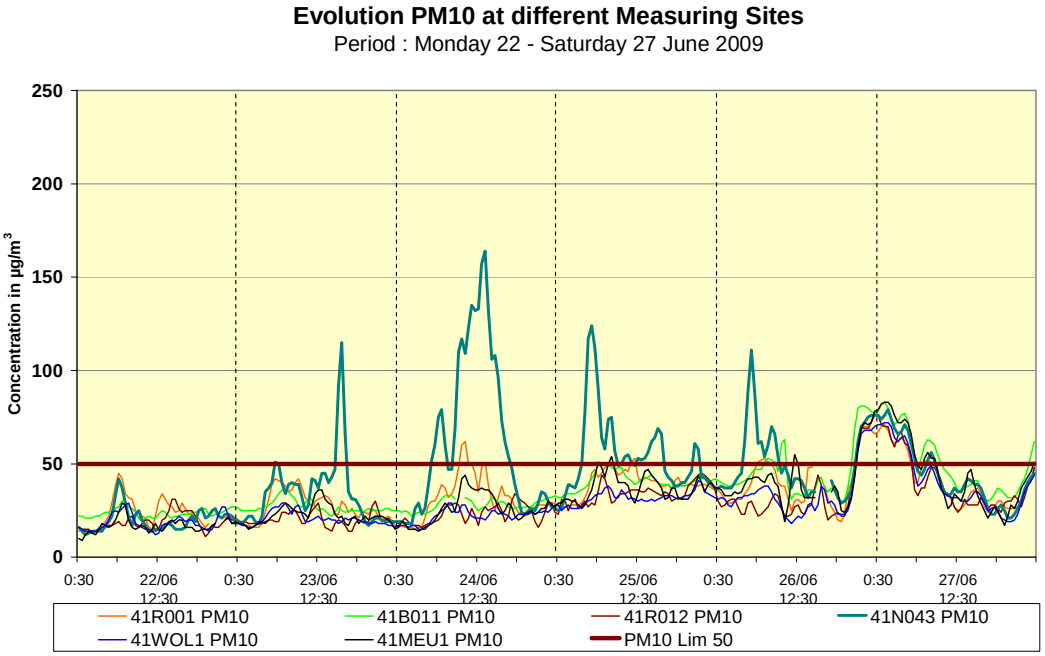


Figure 5.4.c : PM10 concentration at the different measuring sites
Monday 22 – Saturday 27 June 2009

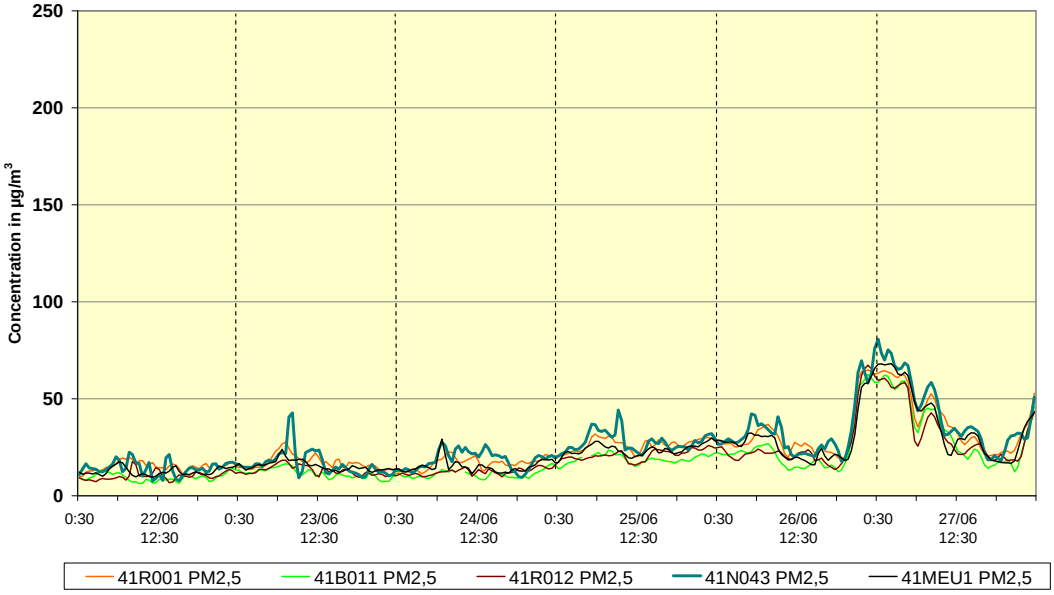


Figure 5.4.d : PM2.5 concentration at the different measuring sites
Monday 22 – Saturday 27 June 2009

5.5 Period “Monday 14 – Saturday 19 June 2010”

The graph in Figure 5.5.a reveals very high PM10 values compared to PM2.5, from Monday 14 till Thursday 17 June 2010. This is especially the case on Wednesday 16 and Thursday 17 June, when the PM10 daily limit value of 50 µg/m^3 is exceeded at the Haren site during 2 consecutive working days.

The meteorological conditions were the following:

Temperature	The temperatures in the afternoon were between 20 and 23°C
Wind direction	North-East to North
Relative humidity	Low values for the relative humidity (~40% RH) in the afternoon from Monday 14 till Thursday 17 June 2010 (Figure 5.5.b)
Precipitation	Last precipitation on 10 June 2010

Under these conditions the soil and road surfaces could become dry. The graph in Figure 5.5.c reveals that the PM10 values increased not only at the Haren site but also at the Meudon site, at a distance of about 1.5 km from the Haren site. However no PM10 exceeding values were observed at the other sites. The average of the PM10 daily values computed over the different sites on Wednesday 16 and Thursday 17 June was respectively 26.8 and 25.5 µg/m3. The average of the PM2.5 concentration over the different sites at these days was 9.1 and 11.6 µg/m^3 respectively.

The graph in Figure 5.5.d shows no important increase of the PM2.5 concentration values and the results are very similar over the different measuring sites.

It can be stated that the following exceedances at the Haren site (N043) were caused by the presence of the coarse fraction:

Date	**Day of the week**	**PM10_N043**	**PM2.5_N043**
16/06/2010	Wednesday	79 µg/m^3	10.3 µg/m^3
17/06/2010	Thursday	57 µg/m^3	11.8 µg/m^3

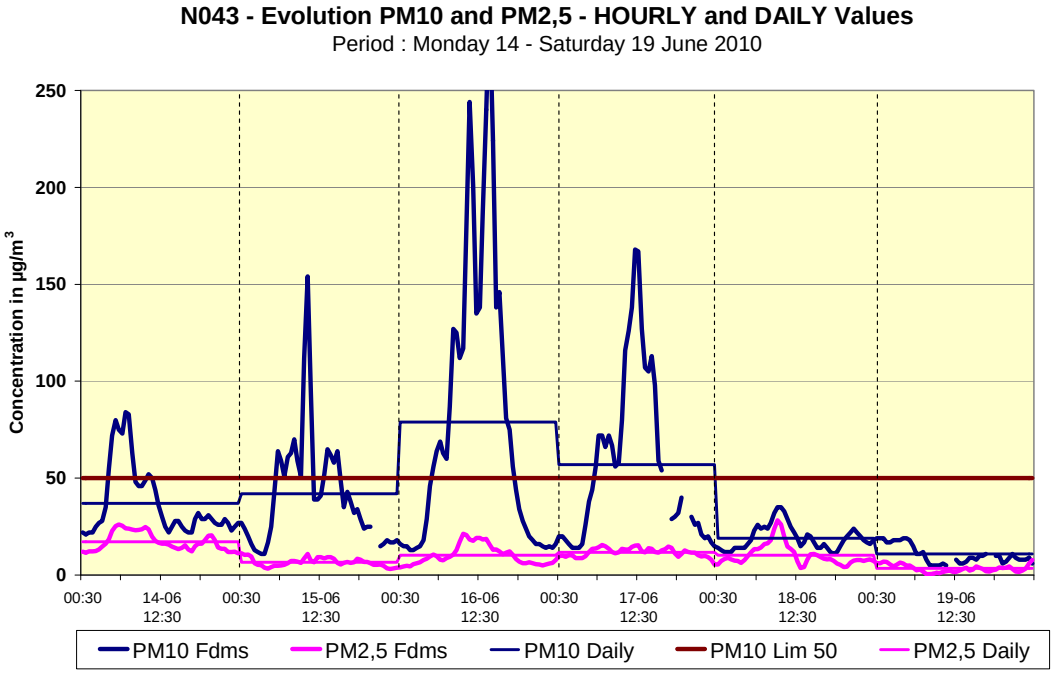


Figure 5.5.a : PM10 and PM2.5 concentration at the Haren site
Monday 14 – Saturday 19 June 2010

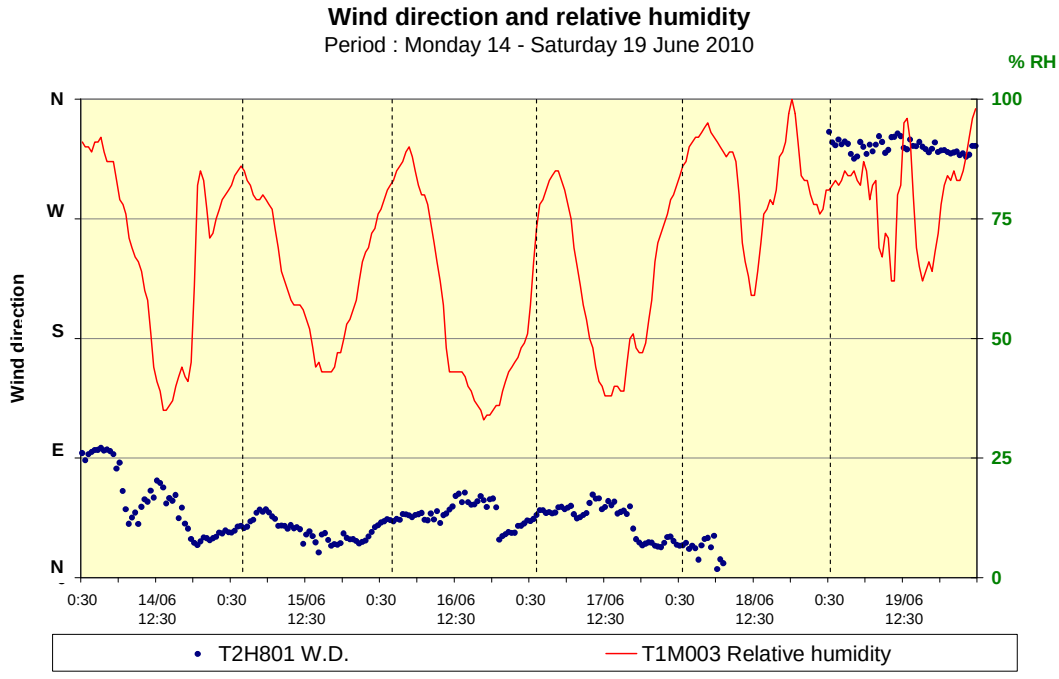


Figure 5.5.b : Wind direction at Zwijndrecht – Relative Humidity at Uccle
Monday 14 – Saturday 19 June 2010

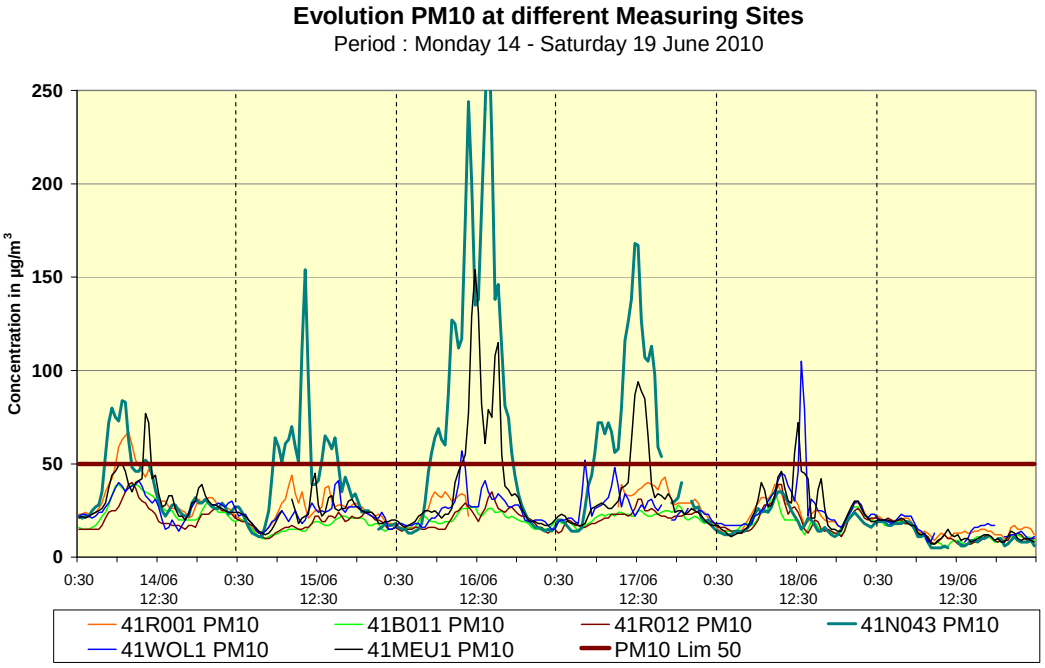


Figure 5.5.c : PM10 concentration at the different measuring sites
Monday 14 – Saturday 19 June 2010

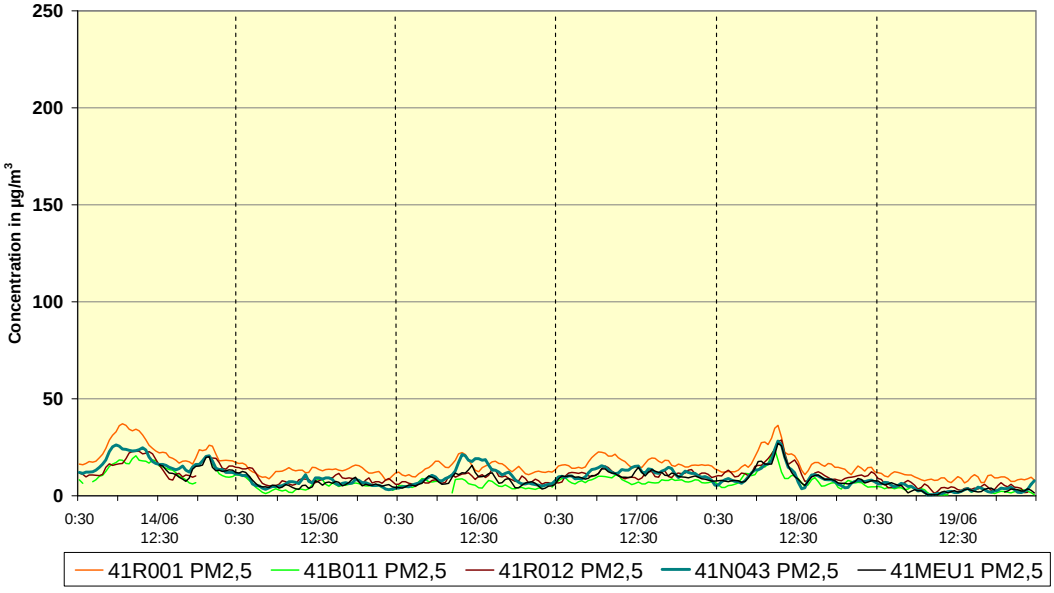


Figure 5.5.d : PM2.5 concentration at the different measuring sites
Monday 14 – Saturday 19 June 2010

5.6 Period "Sunday 06 – Friday 11 March 2011"

The graph in Figure 5.6.a reveals very high PM10 values compared to PM2.5, on Monday 07 and Tuesday 08 March 2011. Also on Wednesday 09 March an increase of the PM10 concentration was observed compared to the PM2.5 concentration. The PM10 daily limit value of 50 µg/m^3 is exceeded at the Haren site during 3 consecutive working days, from Monday 07 till Wednesday 09 March 2011.

The meteorological conditions were the following:

Temperature	The temperatures in the afternoon were between 8 and 12℃
Wind direction	06 March: North-East 07 March: East 08 March: South-East to South-West 09 till 11 March: South-West to West
Relative humidity	Low values for the relative humidity (~40% RH) in the afternoon from Sunday 06 till Tuesday 08 March 2011 (Figure 5.6.b). From 09 till 11 March the relative humidity was around 80%.
Precipitation	Last precipitation on 5 March 2011

The graph in Figure 5.6.c reveals that the PM10 values increased practically only at the Haren site. Only on Monday 07 March there was some light increase of the PM10 concentration at some of the other sites. However no PM10 exceeding values were observed at the other sites. The average of the PM10 daily values computed over the different sites ranged between 24.5 and 40.5 µg/m^3 and the average of the PM2.5 concentration over the different sites between 16.1 and 31.1 µg/m^3.

The graph in Figure 5.6.d shows a slight increase of the PM2.5 concentration at the Haren site, compared to the other sites, on Tuesday 07 March 2011.

It can be stated that the following exceedances at the Haren site (N043) were caused by the presence of the coarse fraction:

	Date	**Day of the week**	**PM10_N043**	**PM2.5_N043**
07/03/2011	Monday		75 µg/m^3	20.3 µg/m^3
08/03/2011	Tuesday		105 µg/m^3	39.2 µg/m^3

The following exceedance value could probably be identified as caused by presence of the coarse fraction:

	Date	**Day of the week**	**PM10_N043**	**PM2.5_N043**
09/03/2011	Wednesday		57 µg/m^3	32.3 µg/m^3

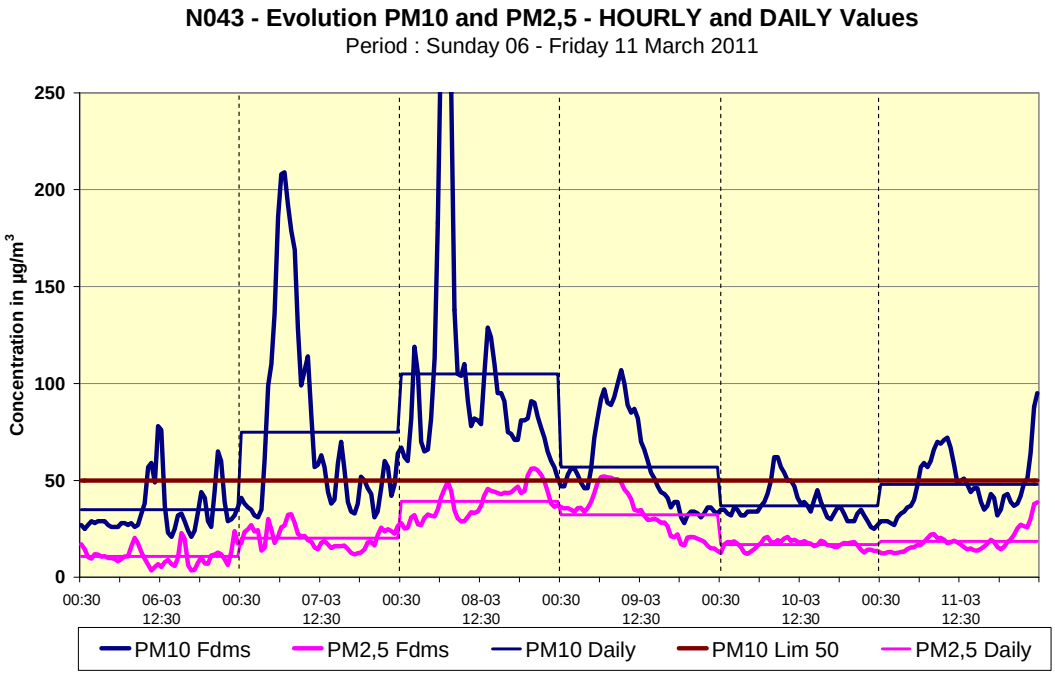


Figure 5.6.a : PM10 and PM2.5 concentration at the Haren site
Sunday 06 – Friday 11 March June 2011

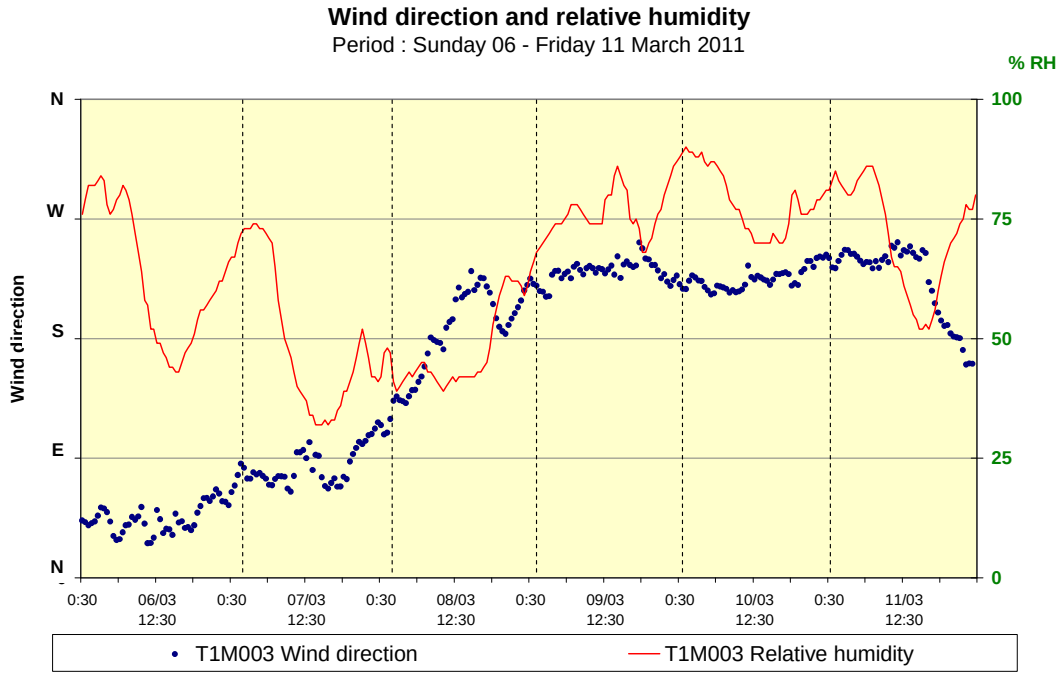


Figure 5.6.b : Wind direction and Relative Humidity at Uccle
Sunday 06 – Friday 11 March June 2011

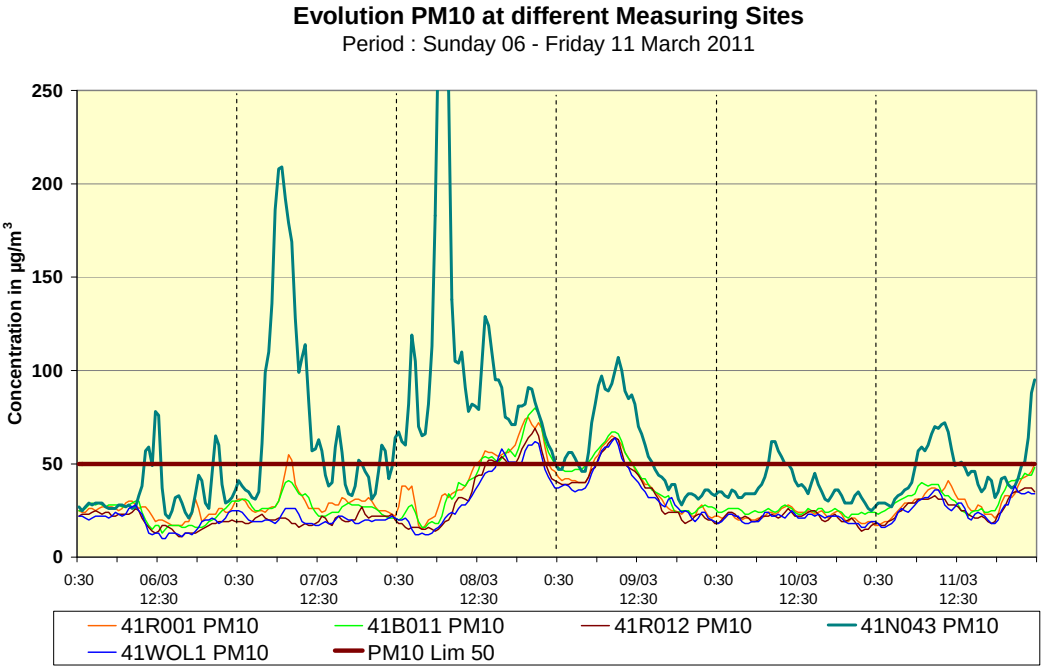


Figure 5.6.c : PM10 concentration at the different measuring sites
Sunday 06 – Friday 11 March June 2011

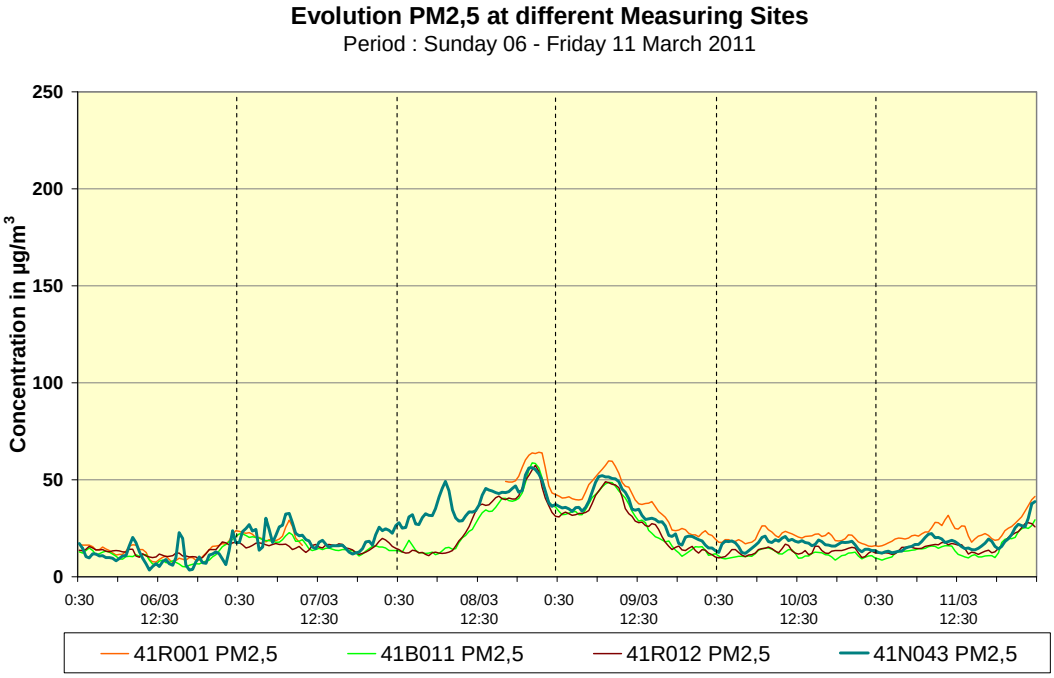


Figure 5.6.d : PM2.5 concentration at the different measuring sites
Sunday 06 – Friday 11 March June 2011

5.7 Period "Sunday 17 – Saturday 23 April 2011"

The graph in Figure 5.7.a reveals very high PM10 values compared to PM2.5, on the working days from Monday 18 till Friday 22 April 2011. On Sunday 17 April a more moderate increase of the PM10 concentration was observed. The PM10 daily limit value of 50 µg/m^3 is exceeded at the Haren site during 6 consecutive working days, from Sunday 17 till Friday 22 April 2011.

The meteorological conditions were the following:

Temperature	The temperatures in the afternoon, from Monday till Friday, were between 22 and 26°C.
Wind direction	17 till 19 April: North-East to South-East 20 till 22 April: South-East 23 April: East
Relative humidity	Low values for the relative humidity (~30 to 40% RH) in the afternoon from Sunday 17 till Friday 22 April 2011 (Figure 5.7.b)
Precipitation	April 2011 was abnormally dry and characterized by a limited number of precipitation events

Under these conditions the soil and the road surfaces can become very dry. The graph in Figure 5.7.c reveals that the PM10 increase from Monday till Friday was also observed at the other sites, but with a much lower intensity. On Sunday 17 April the PM10 concentration was nearly identical in all measuring sites. The average of the PM10 daily values computed over the different sites reached 59.3 µg/m^3 on Sunday 17 April and ranged between 33.5 and 45.0 µg/m^3 from Monday 18 till Friday 22 April. The average of the PM2.5 concentration over the different sites was 51.8 µg/m^3 on Sunday 17 April and ranged between 22.2 and 30.9 µg/m^3 during the rest of the week.

The graph in Figure 5.7.d shows a slight increase of the PM2.5 concentration at the Haren and the Molenbeek site, compared to the other sites, on the working days from Monday 18 till Friday 22 April.

It can be stated that the following exceedances at the Haren site (N043) were caused by the presence of the coarse fraction:

	Date	**Day of the week**	**PM10_N043**	**PM2.5_N043**
18/04/2011	Monday		81 µg/m^3	32.8 µg/m^3
19/04/2011	Tuesday	79 µg/m^3	27.8 µg/m^3	
20/04/2011	Wednesday	102 µg/m^3	34.1 µg/m^3	
21/04/2011	Thursday	91 µg/m^3	37.2 µg/m^3	
22/04/2011	Friday	90 µg/m^3	32.8 µg/m^3	

The following exceedance at the Haren site could **not** be identified as caused by the presence of the coarse fraction:

	Date	**Day of the week**	**PM10_N043**	**PM2.5_N043**
17/04/2011	Sunday	70 µg/m^3	52.5 µg/m^3	

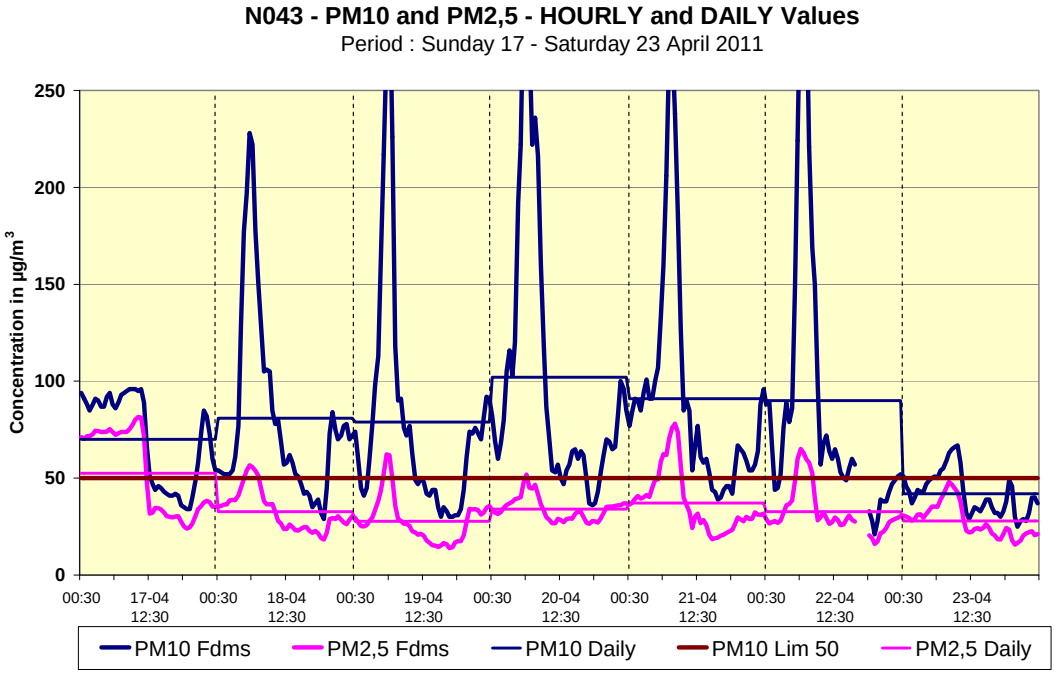


Figure 5.7.a : PM10 and PM2.5 concentration at the Haren site
Sunday 17 – Saturday 23 April 2011

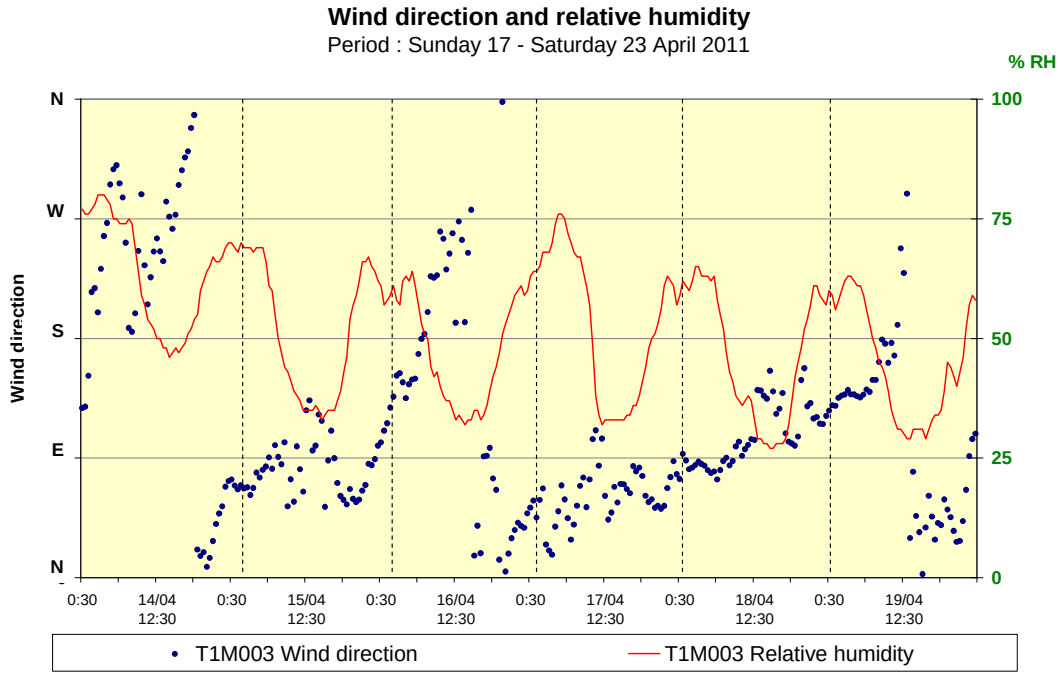


Figure 5.7.b : Wind direction and Relative Humidity at Uccle
Sunday 17 – Saturday 23 April 2011

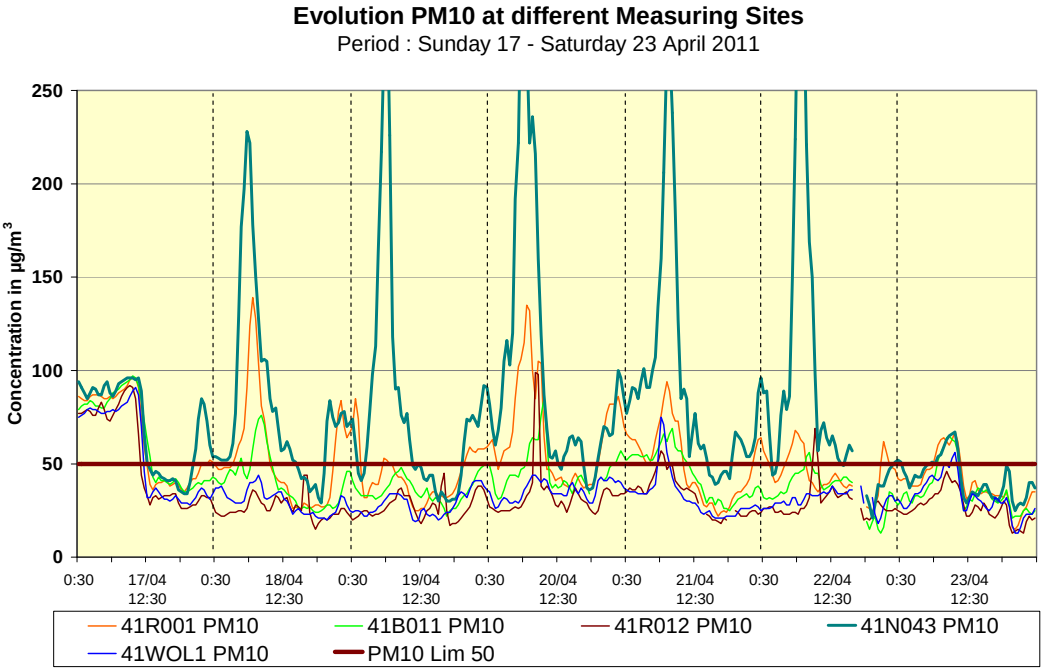


Figure 5.7.c : PM10 concentration at the different measuring sites
Sunday 17 – Saturday 23 April 2011

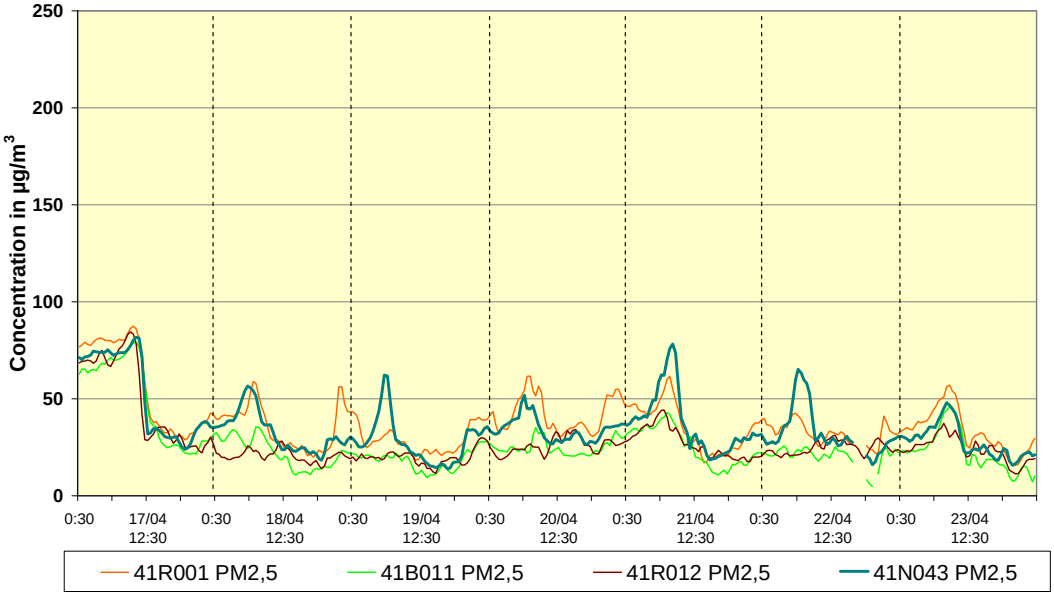


Figure 5.7.d : PM2.5 concentration at the different measuring sites
Sunday 17 – Saturday 23 April 2011

6. ESTIMATION EXCEEDANCES CAUSED BY THE COARSE FRACTION

A detailed analysis of the PM10 exceedances at the Haren site (N043) leads to the conclusion that PM10 exceedances caused by the coarser fraction occur regularly but exclusively on working days. This explains to a great extent the sharper decrease of the concentration level during the weekend as can be seen in the average weekly concentration profile for the Haren site (see Figure 3.1 in chapter 3. Weekly concentration pattern). Based on the observations of all PM10 exceedances, as illustrated by some typical examples in chapter 5, a tentative is made to objectify the estimate of the number of exceedances that are being caused by the presence of an important amount of the coarse fraction. A first approach is based on the measured concentrations, by applying experimental criteria. A second approach is based on the simulation of the PM10 daily concentrations.

6.1 Estimation based on experimental criteria

The identification of a PM10 exceedance at the Haren site as being caused mainly by the presence of the coarse fraction is based on the following principles:

- the PM10 daily concentration level at the Haren site should be significantly higher than the PM2.5 concentration;
- the PM10 daily concentration level at the Haren site should be sufficiently higher than the PM10 concentration at the other sites;
- the average PM10 or PM2.5 concentration, computed for the other sites, should be sufficiently lower than the 50 µg/m^3 limit value.

In some cases, an increase of the PM2.5 concentration goes along with a very high PM10 concentration at the Haren site. This can be explained by the findings made at the Woluwe site. A study about the particle number concentration (0.25 tot 32 µm) at that traffic site has shown that the particle number concentration in the range ~0.7 to ~2.5 µm diameter consist of at least two different populations. Part of the particles correlate very well with the classes below 0.7 µm and another part with the particles above 2.5 µm *[Black Carbon, PM10 Mass Concentration, Nitrogen Monoxide, Nitrogen Oxides and Particulate Number concentration at the Woluwe traffic sites. IBGE-BIM Report 2010, documentation centre at www.ibgebim.be]*. Most of the time however the PM2.5 concentrations at the different sites are quite comparable. To distinguish a PM10 concentration at the Haren site as significantly higher than the PM2.5 concentration, it should rather be compared to the average PM2.5 value computed for the other sites than to the PM2.5 concentration at the Haren site.

The criteria are build based upon the measured or the computed daily average PM10 and PM2.5 concentrations. Let us define the following variables:

- **PM10_N043** = the average daily PM10 concentration at the Haren site
- **PM10_AVG** = the computed average of the PM10 daily concentrations measured at the other sites – AVERAGE_PM10 (R001, B011, R012, MEU1, WOL1) (*)
- **PM2.5_AVG** = the computed average of the PM2.5 daily concentrations measured at the other sites – AVERAGE_PM2.5 (R001, B011, R012, MEU1) (*)

*(*) Data for respectively **4** PM10 sites and **3** PM2.5 sites should be available for the validation of the computed PM10_AVG and PM2.5_AVG values*

SET_1 – First set of six (6) experimental criteria:

PM10 daily values at the Haren site are identified as being caused by the presence of an important amount of the coarse fraction if at least 5 of the following 6 criteria are met:

Criterion 1.1	PM10_AVG < 40 µg/m^3
Criterion 1.2	PM2.5_AVG < 35 µg/m^3
Criterion 1.3	PM10_N043 > (1.5 * PM10_AVG)
Criterion 1.4	(PM10_N043 - PM10_AVG) > 17 µg/m^3
Criterion 1.5	PM10_N043 > (2 * PM2.5_AVG)
Criterion 1.6	(PM10_N043 - PM2.5_AVG) > 23 µg/m^3

The fixation of PM2.5 criteria relatively close to the PM10 criteria is based on the fact that the PM2.5 mass concentration may represent frequently 80 tot 90% of the PM10 mass concentration as it is the case in the presence of secondary aerosol.

SET_2 – Second set of four (4) experimental criteria:

The first two criteria of SET_1 stay unchanged, but the third and fourth criterion are a recombination (OR) of the criteria 3 and 4, respectively 5 and 6 from SET_1.

PM10 daily values at the Haren site will be identified as being caused by the presence of an important amount of the coarse fraction if at least 3 of the following 4 criteria are met:

Criterion 2.1	PM10_AVG < 40 µg/m^3
Criterion 2.2	PM2.5_AVG < 35 µg/m^3
Criterion 2.3	PM10_N043 > (1.5 * PM10_AVG) **OR** (PM10_N043 - PM10_AVG) > 17 µg/m^3
Criterion 2.4	PM10_N043 > (2 * PM2.5_AVG) **OR** (PM10_N043 - PM2.5_AVG) > 23 µg/m^3

The tables in the following pages illustrate the application of the two criteria SETS on the examples presented in chapter 5.

Example Period "Sunday 04 – Saturday 10 May 2008" – PM mass concentration values expressed in µg/m^3

Date	PM10 daily concentration						PM2.5 daily concentration					AVERAGE		Result Criteria Set_1							Result Criteria Set_2					PM10 N043	
	PM10_R001	PM10_B011	PM10_R012	PM10_N043	PM10_MEU1	PM10_WOL1	PM2.5_R001	PM2.5_B011	PM2.5_R012	PM2.5_N043	PM2.5_MEU1	PM10_AVG	PM2.5_AVG	Criterion 1.1	Criterion 1.2	Criterion 1.3	Criterion 1.4	Criterion 1.5	Criterion 1.6	Result SET_1	Criterion 2.1	Criterion 2.2	Criterion 2.3	Criterion 2.4	Result SET_2	Apply Criteria SET_1	Apply Criteria SET_2
04/05/08	27	27	22	26	30	24	23.1	14.8	18.3	19.6	17.1	26.0	18.3	1	1	0	0	0	0	2	1	1	0	0	2	26	26
05/05/08	40	28	20	**58**	34	24	22.1	12.0	16.7	20.0	13.5	29.2	16.1	1	1	1	1	1	1	**6**	1	1	1	1	**4**	**58**	**58**
06/05/08	43	32	24	**67**	36	28	26.4	15.8	20.1	23.6	18.1	32.6	20.1	1	1	1	1	1	1	**6**	1	1	1	1	**4**	**67**	**67**
07/05/08	47	31	25	**66**	38	28	24.9	14.9	21.3	24.3	18.0	33.8	19.8	1	1	1	1	1	1	**6**	1	1	1	1	**4**	**66**	**66**
08/05/08	44	27	23	**62**	40	26	22.5	11.5	17.1	20.1	14.9	32.0	16.5	1	1	1	1	1	1	**6**	1	1	1	1	**4**	**62**	**62**
09/05/08	43	25	21	**53**	36	27	21.4	10.2	16.9	18.5	13.1	30.4	15.4	1	1	1	1	1	1	**6**	1	1	1	1	**4**	**53**	**53**
10/05/08	37	29	24	35	36	27	23.5	15.6	20.0	19.2	16.5	30.6	18.9	1	1	0	0	0	0	2	1	1	0	0	2	35	35

The five exceedances, from Monday 05 till Friday 09 May 2008 are identified as being caused by the presence of an important amount of particle mass belonging to the coarse fraction. This is confirmed by applying the criteria SET_1 as well as the criteria SET_2.

Example Period "Monday 15 – Sunday 21 September 2008" – PM mass concentration values expressed in µg/m^3

Date	PM10 daily concentration						PM2.5 daily concentration					AVERAGE		Result Criteria Set_1							Result Criteria Set_2					PM10 N043	
	PM10_R001	PM10_B011	PM10_R012	PM10_N043	PM10_MEU1	PM10_WOL1	PM2.5_R001	PM2.5_B011	PM2.5_R012	PM2.5_N043	PM2.5_MEU1	PM10_AVG	PM2.5_AVG	Criterion 1.1	Criterion 1.2	Criterion 1.3	Criterion 1.4	Criterion 1.5	Criterion 1.6	Result SET_1	Criterion 2.1	Criterion 2.2	Criterion 2.3	Criterion 2.4	Result SET_2	Apply Criteria SET_1	Apply Criteria SET_2
15/09/08	24	23	19	31	18	24	19.5	13.3	16.9	14.7	15.5	21.6	16.3	1	1	0	0	0	0	2	1	1	0	0	2	31	31
16/09/08	34	31	26	**69**	30	31	26.4	19.0	21.1	27.4	23.8	30.4	22.6	1	1	1	1	1	1	**6**	1	1	1	1	**4**	**69**	**69**
17/09/08	34	34	26	**68**	34	32	27.9	21.1	21.0	27.7	27.1	32.0	24.3	1	1	1	1	1	1	**6**	1	1	1	1	**4**	**68**	**68**
18/09/08	33	30	24	**92**	26	32	23.8	16.4	19.8	24.1	20.6	29.0	20.2	1	1	1	1	1	1	**6**	1	1	1	1	**4**	**92**	**92**
19/09/08	49	39	34	**92**	34	42	34.4	23.2	27.6	33.0	27.6	39.6	28.2	1	1	1	1	1	1	**6**	1	1	1	1	**4**	**92**	**92**
20/09/08	43	38	38	44	38	40	36.2	26.9	33.8	33.2	31.8	39.4	32.2	1	1	0	0	0	0	2	1	1	0	0	2	44	44
21/09/08	37	37	30	37	36	35	34.0	26.5	28.0	30.8	31.3	35.0	30.0	1	1	0	0	0	0	2	1	1	0	0	2	37	37

The four PM10 exceedances at the Haren site, from Tuesday 16 till Friday 19 September 2008 are identified as being caused by the presence of an important amount of particle mass belonging to the coarse fraction. This is confirmed by applying the criteria SET_1 as well as the criteria SET_2.

Example Period "Sunday 29 March – Sunday 05 April September 2009" – PM mass concentration values expressed in µg/m^3

Date	PM10 daily concentration						PM2.5 daily concentration					AVERAGE		Result Criteria Set_1							Result Criteria Set_2					PM10 N043	
	PM10_R001	PM10_B011	PM10_R012	PM10_N043	PM10_MEU1	PM10_WOL1	PM2.5_R001	PM2.5_B011	PM2.5_R012	PM2.5_N043	PM2.5_MEU1	PM10_AVG	PM2.5_AVG	Criterion 1.1	Criterion 1.2	Criterion 1.3	Criterion 1.4	Criterion 1.5	Criterion 1.6	Result SET_1	Criterion 2.1	Criterion 2.2	Criterion 2.3	Criterion 2.4	Result SET_2	Apply Criteria SET_1	Apply Criteria SET_2
29/03/09	15	19	15	13	12	13	10.2	7.3			8.1	14.8	8.5	1	1	0	0	0	0	2	1	1	0	0	2	13	13
30/03/09	36	37	31	52	34	33	26.3	20.6	17.7	34.8	25.1	34.2	22.4	1	1	1	1	1	1	6	1	1	1	1	4	52	52
31/03/09	64	51	44	88	54	46	44.9	34.2	31.3	48.6	38.0	51.8	37.1	0	0	1	1	1	1	4	0	0	1	1	2	88	88
01/04/09	62	46	44	128	47	44	38.8	31.9	30.7	39.4	33.4	48.6	33.7	0	1	1	1	1	1	5	0	1	1	1	3	128	128
02/04/09	58	52	48	76	52	49	43.8	35.4	35.3	42.4	38.6	51.8	38.3	0	0	0	1	0	1	2	0	0	1	1	2	76	76
03/04/09	95	96	96	140	116	94	79.1	71.0	72.9	87.0	75.9	99.4	74.7	0	0	0	1	0	1	2	0	0	1	1	2	140	140
04/04/09	98	106	98	103	109	94	89.0	82.0	74.1	94.4	84.9	101.0	82.5	0	0	0	0	0	0	0	0	0	0	0	0	103	103
05/04/09	44	47	46	45	46	41	40.8	33.7		42.1	36.7	44.8	37.1	0	0	0	0	0	0	0	0	0	0	0	0	45	45

The PM10 exceedances at the Haren site, on Monday 30 March and Wednesday 01 April 2009 are identified as being caused by the presence of an important amount of particle mass belonging to the coarse fraction. This is confirmed by applying the criteria SET_1 as well as the criteria SET_2.

The PM10 exceedances on Tuesday 31 March, and from Thursday 02 till Saturday 04 April 2009 are **not** identified as being caused by the presence of particles belonging to the coarser fraction. In fact the PM10_AVG values are higher than 50 µg/m^3 and even close to 100 µg/m^3 on Friday 03 and Saturday 04 April. The PM2.5_AVG values are higher than 35 µg/m^3 on Tuesday and Thursday and higher than 70 µg/m^3 on Friday and Saturday.

Example Period "Monday 22 – Saturday 27 June 2009" – PM mass concentration values expressed in µg/m^3

Date	PM10 daily concentration						PM2.5 daily concentration					AVERAGE		Result Criteria Set_1							Result Criteria Set_2					PM10 N043	
	PM10_R001	PM10_B011	PM10_R012	PM10_N043	PM10_MEU1	PM10_WOL1	PM2.5_R001	PM2.5_B011	PM2.5_R012	PM2.5_N043	PM2.5_MEU1	PM10_AVG	PM2.5_AVG	Criterion 1.1	Criterion 1.2	Criterion 1.3	Criterion 1.4	Criterion 1.5	Criterion 1.6	Result SET_1	Criterion 2.1	Criterion 2.2	Criterion 2.3	Criterion 2.4	Result SET_2	Apply Criteria SET_1	Apply Criteria SET_2
22/06/09	23	24	19	20	17	19	15.2	9.5	10.3	14.3	12.5	20.4	11.9	1	1	0	0	0	0	2	1	1	0	0	2	20	20
23/06/09	27	27	20	34	23	21	17.2	11.5	13.0	16.6	15.4	23.6	14.3	1	1	0	0	1	0	3	1	1	0	1	3	34	34
24/06/09	31	28	23	62	26	22	17.0	11.1	12.5	18.6	15.2	26.0	14.0	1	1	1	1	1	1	6	1	1	1	1	4	62	62
25/06/09	39	41	34	55	37	32	26.5	19.0	21.1	27.8	23.8	36.6	22.6	1	1	1	1	1	1	6	1	1	1	1	4	55	55
26/06/09	40	46	33	51	41	34	31.8	24.9	26.2	33.2	28.3	38.8	27.8	1	1	0	0	0	1	3	1	1	0	1	3	51	51
27/06/09	41	50	40	44	45	40	39.5	34.0	33.6	42.8	38.2	43.2	36.3	0	0	0	0	0	0	0	0	0	0	0	0	44	44

Two PM10 exceedances at the Haren site, on Wednesday 24 and Thursday 25 June 2009 are identified as being caused by the presence of an important amount of particle mass belonging to the coarse fraction. This is confirmed by applying the criteria SET_1 as well as the criteria SET_2.

The PM10 exceedance on Friday 26 June 2009 is most likely also caused by the presence of the coarse fraction, as confirmed by the application of the criteria SET_2. In fact this is a limit case with respect to the criteria SET_1. Although there is an important amount of the coarse fraction present, the PM10_N043 value is not greater than 1.5 times the PM10_AVG value (51 against 38.8 µg/m^3), the PM10_N043 is not greater than the PM10_AVG value by at least 17 µg/m^3 and the PM10_N043 value fails to be higher than 2 times the PM2.5_AVG value by only a few µg/m^3 (51 versus 27.8 µg/m^3).

The criteria SET_2 enables to identify more clearly some of the exceedances caused by the presence of the coarse fraction, especially those whit PM10_N043 values less then ~60 µg/m^3, corresponding to PM10_AVG and PM2.5_AVG values that are relatively close to respectively 40 and 35 µg/m^3.

Example Period "Monday 14 – Saturday 19 June 2010" – PM mass concentration values expressed in µg/m^3

Date	PM10 daily concentration						PM2.5 daily concentration					AVERAGE		Result Criteria Set_1							Result Criteria Set_2					PM10 N043	
	PM10_R001	PM10_B011	PM10_R012	PM10_N043	PM10_MEU1	PM10_WOL1	PM2.5_R001	PM2.5_B011	PM2.5_R012	PM2.5_N043	PM2.5_MEU1	PM10_AVG	PM2.5_AVG	Criterion 1.1	Criterion 1.2	Criterion 1.3	Criterion 1.4	Criterion 1.5	Criterion 1.6	Result SET_1	Criterion 2.1	Criterion 2.2	Criterion 2.3	Criterion 2.4	Result SET_2	Apply Criteria SET_1	Apply Criteria SET_2
14/06/10	34	26	23	37	33	27	23.4	13.2	15.0	17.2		28.6	17.2	1	1	0	0	1	0	3	1	1	0	1	3	37	37
15/06/10	25	17	18	42	23	23	12.8	5.0	8.5	6.7	6.2	21.2	8.1	1	1	1	1	1	1	6	1	1	1	1	4	42	42
16/06/10		20	20	79	42	25	14.4	5.7	8.5	10.3	7.7	26.8	9.1	1	1	1	1	1	1	6	1	1	1	1	4	79	79
17/06/10		21	21	57	33	27	17.0	7.8	11.0	11.8	10.5	25.5	11.6	1	1	1	1	1	1	6	1	1	1	1	4	57	57
18/06/10	23	19	20	19	27	28	17.5	8.7	13.0	10.3	10.6	23.4	12.5	1	1	0	0	0	0	2	1	1	0	0	2	19	19
19/06/10	15	12	12	11	13	15	9.3	2.5	4.6	3.4	3.1	13.4	4.9	1	1	0	0	1	0	3	1	1	0	1	3	11	11

Both PM10 exceedances at the Haren site, on Wednesday 16 and Thursday 17 June 2010 are identified as being caused by the presence of an important amount of particle mass belonging to the coarse fraction. This is confirmed by applying the criteria SET_1 as well as the criteria SET_2.

Example Period "Sunday 06 – Friday 11 March 2011" – PM mass concentration values expressed in µg/m^3

Date	PM10 daily concentration						PM2.5 daily concentration					AVERAGE		Result Criteria Set_1							Result Criteria Set_2					PM10 N043	
	PM10_R001	PM10_B011	PM10_R012	PM10_N043	PM10_MEU1	PM10_WOL1	PM2.5_R001	PM2.5_B011	PM2.5_R012	PM2.5_N043	PM2.5_MEU1	PM10_AVG	PM2.5_AVG	Criterion 1.1	Criterion 1.2	Criterion 1.3	Criterion 1.4	Criterion 1.5	Criterion 1.6	Result SET_1	Criterion 2.1	Criterion 2.2	Criterion 2.3	Criterion 2.4	Result SET_2	Apply Criteria SET_1	Apply Criteria SET_2
06/03/11	24	23	19	35		19	13.1	10.6	12.8	10.7		21.3	12.2	1	1	1	0	1	0	4	1	1	1	1	4	35	35
07/03/11	30	28	20	75		20		16.5	15.7	20.3		24.5	16.1	1	1	1	1	1	1	6	1	1	1	1	4	75	75
08/03/11	46	44	37	105		35		28.9	29.1	39.2		40.5	29.0	0	1	1	1	1	1	5	0	1	1	1	3	105	105
09/03/11	40	42	37	57		37	37.6	28.0	27.8	32.3		39.0	31.1	1	1	0	1	0	1	4	1	1	1	1	4	57	57
10/03/11	22	25	21	37		21	20.2	11.5	13.0	16.9		22.3	14.9	1	1	1	0	1	0	4	1	1	1	1	4	37	37
11/03/11	31	33	27	48		27	24.0	14.9	16.4	18.5		29.5	18.4	1	1	1	1	1	1	6	1	1	1	1	4	48	48

Two PM10 exceedances at the Haren site, on Monday 07 and Tuesday 08 March 2011 are identified as being caused by the presence of an important amount of particle mass belonging to the coarse fraction. This is confirmed by applying the criteria SET_1 as well as the criteria SET_2.
The PM10 exceedance on Wednesday 09 March is most likely caused by the presence of the coarse fraction. This exceedance is a limit case with respect to the criteria SET_1. In fact the PM10_N043 value of 57 µg/m^3 fails to be greater than 1.5 times the PM10_AVG value (39.0 µg/m^3) by only 1 µg/m^3 and the PM10_N043 value is not greater than 2 times the PM2.5_AVG value (31.1 µg/m^3) by only a few µg/m^3. Also in this case the application of criteria SET_2 enables to identify more clearly some of the exceedances caused by the coarse fraction, especially those with PM10_N043 values less then ~60 µg/m^3, corresponding to PM10_AVG or PM2.5_AVG values that are relatively close to respectively 40 and 35 µg/m^3.

Data for the Meudon site are not available for the considered period. Therefore the validation of the PM10_AVG and PM2.5_AVG values is based on the availability of data for at least 3 and 2 measuring sites respectively. For PM10, data are available for 4 stations, and for PM2.5, with the exception for 7 and 8 March, data are available for 3 stations.

Example Period "Sunday 17 – Saturday 23 April 2011" – PM mass concentration values expressed in µg/m^3

Date	PM10 daily concentration						PM2.5 daily concentration					AVERAGE		Result Criteria Set_1							Result Criteria Set_2					PM10 N043	
	PM10_R001	PM10_B011	PM10_R012	PM10_N043	PM10_MEU1	PM10_WOL1	PM2.5_R001	PM2.5_B011	PM2.5_R012	PM2.5_N043	PM2.5_MEU1	PM10_AVG	PM2.5_AVG	Criterion 1.1	Criterion 1.2	Criterion 1.3	Criterion 1.4	Criterion 1.5	Criterion 1.6	Result SET_1	Criterion 2.1	Criterion 2.2	Criterion 2.3	Criterion 2.4	Result SET_2	Apply Criteria SET_1	Apply Criteria SET_2
17/04/11	64	64	54	70		55	57.4	48.6	49.4	52.5		59.3	51.8	0	0	0	0	0	0	0	0	0	0	0	0	70	70
18/04/11	54	40	26	81		30	35.5	22.3	20.6	32.8		37.5	26.1	1	1	1	1	1	1	6	1	1	1	1	4	81	81
19/04/11	43	36	27	79		28	28.6	18.3	19.8	27.8		33.5	22.2	1	1	1	1	1	1	6	1	1	1	1	4	79	79
20/04/11	65	46	33	102		36	42.0	25.0	25.8	34.1		45.0	30.9	0	1	1	1	1	1	5	0	1	1	1	3	102	102
21/04/11	49	44	33	91		32	35.3	25.5	27.2	37.2		39.5	29.3	1	1	1	1	1	1	6	1	1	1	1	4	91	91
22/04/11	45	35	29	90		31	32.4	20.7	24.5	32.8		35.0	25.9	1	1	1	1	1	1	6	1	1	1	1	4	90	90
23/04/11	40	36	27	42		32	33.4	22.5	23.9	28.0		33.8	26.6	1	1	0	0	0	0	2	1	1	0	0	2	42	42

The five PM10 exceedances at the Haren site, from Monday 18 till Friday 22 April 2011 are identified as being caused by the presence of an important amount of particle mass belonging to the coarse fraction. This is confirmed by applying the criteria SET_1 as well as the criteria SET_2.

The PM10 exceedance on Sunday 17 April 2011 could **not** be identified as caused by the presence of the coarse fraction. The PM10_AVG and PM2.5_AVG values, respectively 59.3 and 51.8 µg/m^3, are already higher than 50 µg/m^3.

Data for the Meudon site are not available for the considered period. Therefore the validation of the PM10_AVG and PM2.5_AVG values is based on the availability of data for at least 3 and 2 measuring sites respectively. In this case, data are available respectively for 4 PM10 measuring sites and for 3 PM2.5 measuring sites.

The number of PM10 exceedances at the Haren site (N043) caused by the presence of an important amount of the coarse fraction is estimated by applying the experimental criteria from SET_1 and SET_2 systematically on all exceedances observed during the calendar years 2008, 2009 and 2010 and during the six month during period "January – June 2011". The results are represented in Table VI.1.

Table VI.1 : Haren site – Estimation of the number of PM10 exceedances caused by the presence of the coarse fraction

Period	N043 – Observed Exceedance Days	Due to Coarse SET_1	Due to Coarse SET_2
2008	**66**	29	32
2009	**66**	15	18
2010	**47**	17	23
Jan-June 2011	***58***	*24*	*28*

The number of PM10 exceedances **not** caused by the local (re)suspension of the coarse fraction are obtained by subtracting the exceedances identified as being caused by the presence of the coarse fraction from the total number of observed exceedances. The results are given in Table VI.2.

Table VI.2 : Haren site – Estimation of the number of PM10 exceedances **not** caused by the local (re)suspension of the coarse fraction

Period	N043 – Observed Exceedance Days	N043 – Estimation Exceedance Days NO SUSPENSION Applying SET_1	N043 – Estimation Exceedance Days NO SUSPENSION Applying SET_2
2008	**66**	37	34
2009	**66**	51	48
2010	**47**	30	24
Jan-June 2011	***58***	*34*	*30*

The results presented in Tables VI.1 and VI.2 shows that at least one third of exceedance days in Haren can be attributed to the presence of the coarse fraction of particles. Without this supplement of PM10 measurements, the daily limit value would be surely respected in 2010, and possibly in 2008. Nevertheless, the number of exceedance days in 2009 would remain greater than 35.

6.2 Estimate of PM10 daily values at Haren without local resuspension of coarse particles

In the previous sections, it has been shown that PM2.5 concentrations measured at the different sites in Brussels are quite comparable, even during events influenced by significant amount of dust transported by wind and/or resuspension of particles. This is explained by the diameter of the transported and/or resuspended particles which is generally greater than 2.5 µm.

The difference in the temporal evolution of PM10 and PM2.5 allows to estimate the PM10 concentrations that would be measured in Haren without the local activities of the naval port. In particular, a new time series of PM10 concentrations at the Haren station has been computed (i) using the PM2.5 concentrations measured at this station, and (ii) applying a ratio PM10/PM2.5 deduced from the other measurement stations that are not influenced by the activities of the Haren naval port.

Concretely, the ratio PM10/PM2.5 has been obtained from the measurements at the following stations: B011 (Berchem), R001 (Molenbeek) and R012 (Uccle). The most realistic estimate of the ratio PM10/PM2.5 in the air quality zone is given by:

$$\text{ratio\_mean} = \text{AVERAGE}\left(\left.\frac{\text{PM10}}{\text{PM2.5}}\right|_{\text{B011}}, \left.\frac{\text{PM10}}{\text{PM2.5}}\right|_{\text{R001}}, \left.\frac{\text{PM10}}{\text{PM2.5}}\right|_{\text{R012}} \right)$$

Then the time series of PM10 at the Haren station without the local activities of the naval port is estimated as :

$$\text{PM10\_noactivities}|_{\text{NO43}} = \text{PM2.5}|_{\text{NO43}} * \text{ratio\_mean}$$

where $\text{PM2.5}|_{\text{NO43}}$ are the PM2.5 measured at the Haren station.

Since the averaged ratio “ratio_mean” is only an estimate, it is also important to characterize the impact of its uncertainty on the time series of computed PM10. With this aim in view, it can be assumed that “ratio_mean” is bounded by the following ratios:

$$\text{ratio\_min} = \text{MIN}\left(\left.\frac{\text{PM10}}{\text{PM2.5}}\right|_{\text{B011}}, \left.\frac{\text{PM10}}{\text{PM2.5}}\right|_{\text{R001}}, \left.\frac{\text{PM10}}{\text{PM2.5}}\right|_{\text{R012}} \right)$$

$$\text{ratio\_max} = \text{MAX}\left(\left.\frac{\text{PM10}}{\text{PM2.5}}\right|_{\text{B011}}, \left.\frac{\text{PM10}}{\text{PM2.5}}\right|_{\text{R001}}, \left.\frac{\text{PM10}}{\text{PM2.5}}\right|_{\text{R012}} \right)$$

Therefore, the estimated PM10 concentrations should fluctuate within the interval $\left(\text{PM10\_min}|_{\text{NO43}}, \text{PM10\_max}|_{\text{NO43}}\right)$

$$\text{where} \quad \text{PM10\_min}|_{\text{NO43}} = \text{PM2.5}|_{\text{NO43}} * \text{ratio\_min}$$
$$\text{PM10\_max}|_{\text{NO43}} = \text{PM2.5}|_{\text{NO43}} * \text{ratio\_max}$$

The estimated contribution of the supplementary coarse fraction related to the activities of the naval port is given by:

$$PM10\_local\_coarse\big|_{NO43} = PM10\_observed\big|_{NO43} - PM10\_noactivities\big|_{NO43}$$

with $PM10\_observed\big|_{NO43}$ are the observed concentrations at the Haren station.

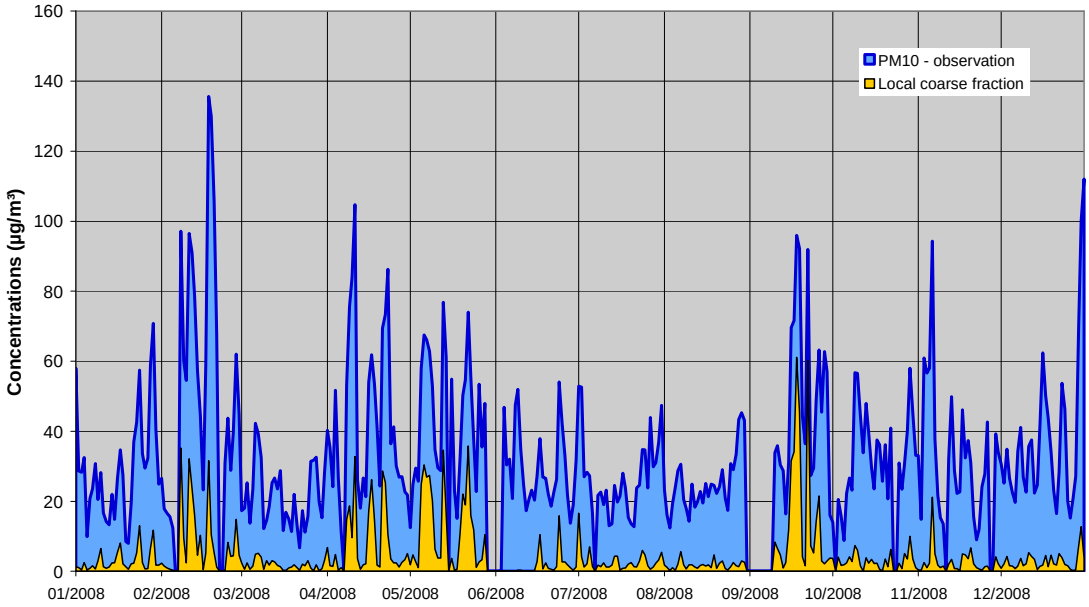
These formulas have been applied for the period from 1 January 2008 to 30 June 2011. The corresponding results are presented in Figure 6.1. The observed PM10 concentrations $PM10\_observed\big|_{NO43}$ are represented with the blue curve, while the estimated contribution of the supplementary coarse fraction related to the activities of the naval port $PM10\_local\_coarse\big|_{NO43}$ is represented by the yellow surface. This latest contribution is generally weak, since the annual average of the supplementary coarse fraction is about 6 $\mu g/m^3$. However, during dry periods, this contribution on daily concentrations is not negligible and often larger than 20 $\mu g/m^3$.

The time series $PM10\_noactivities\big|_{NO43}$ can be used to assess the impact of the supplementary coarse fraction on the exceedances of the daily limit value on PM10. The results presented in Table VI.3 shows that **about 20 to 30 exceedance days observed in Haren can be attributed to these phenomena. Without the supplementary coarse fraction, the daily limit value would be surely respected in 2010, and probably in 2008. Nevertheless, the number of exceedance days in 2009 would remain greater than 35.**

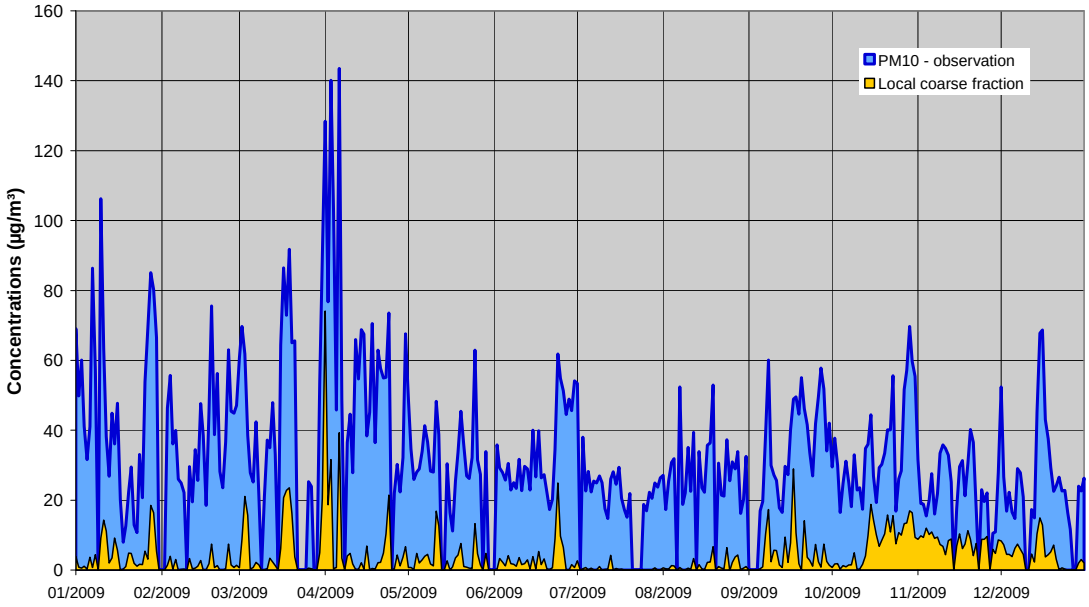
Table VI.3 : Exceedances of the PM10 daily limit value at the Haren station for the years 2008, 2009, 2010 and 2011. The second column of the table corresponds to the observed exceedances, the third column includes the estimation of the number of PM10 exceedances without the presence of the coarse fraction. The two last columns gives idea of the uncertainty on the above-mentioned estimate, expressed as a range of the number of exceedances.

Year	Measurements	Estimate without the coarse fraction	Range of the estimate	
			Min.	Max.
2008	**66**	**33**	23	45
2009	**66**	**42**	35	51
2010	**47**	**21**	19	26
2011 (6 months)	***58***	***27***	*19*	*39*

Daily PM10 concentration at the Haren station - Period: 2008



Daily PM10 concentration at the Haren station - Period: 2009



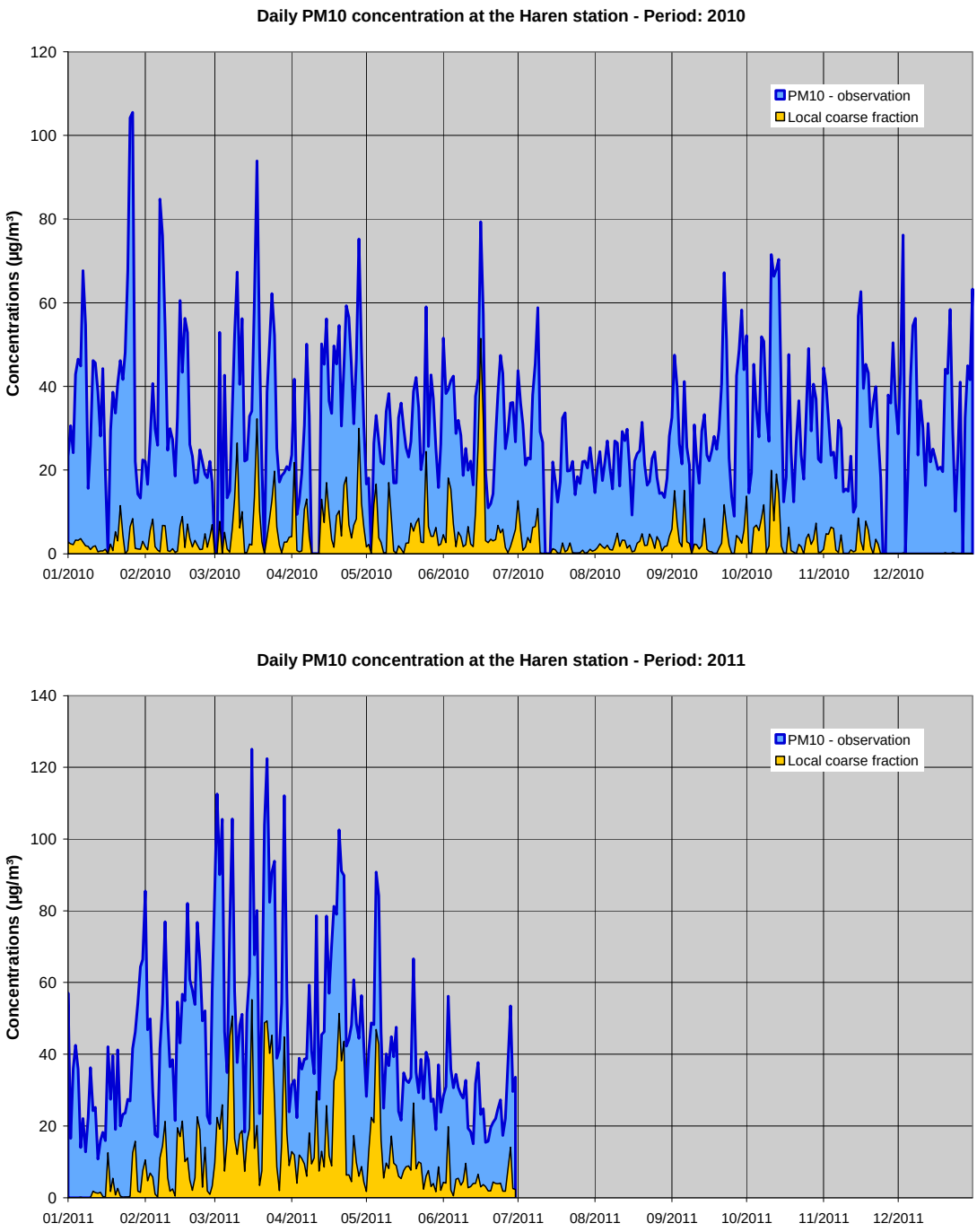


Figure 6.1 : Daily PM10 concentrations at the Haren station for the years 2008 (a), 2009 (b), 2010 (c), and 2011 (d). The concentrations are expressed in microgram/m3 (Y-axis). The blue curve represents PM10 concentrations effectively measured at Haren, and the yellow surface shows the estimated contribution of the supplementary coarse fraction due to the activities of the naval port.

7. MEASURE TO DECREASE THE EMISSION OF COARSER PM10

The Plan Air-Climat – adopted in November 2002 – included a specific measure to reduce the emission of the coarse fraction of PM10. During dry periods, the construction industries have to humidify or cover their fine particles piles. The effective application of the legislation is controlled by the "Permit Inspection" of Brussels Environment.

The impact of this measure appears clearly on the time series of PM10 measurements at the Haren station. As shown in Figure 7.1, PM10 concentrations have significantly decreased in 2005: the average over the period 2000-2004 was 43 µg/m^3, while the average over the period 2006-2011 is 35 µg/m^3. Therefore, this measure has probably reduced the PM10 exposure by about 8 µg/m^3.

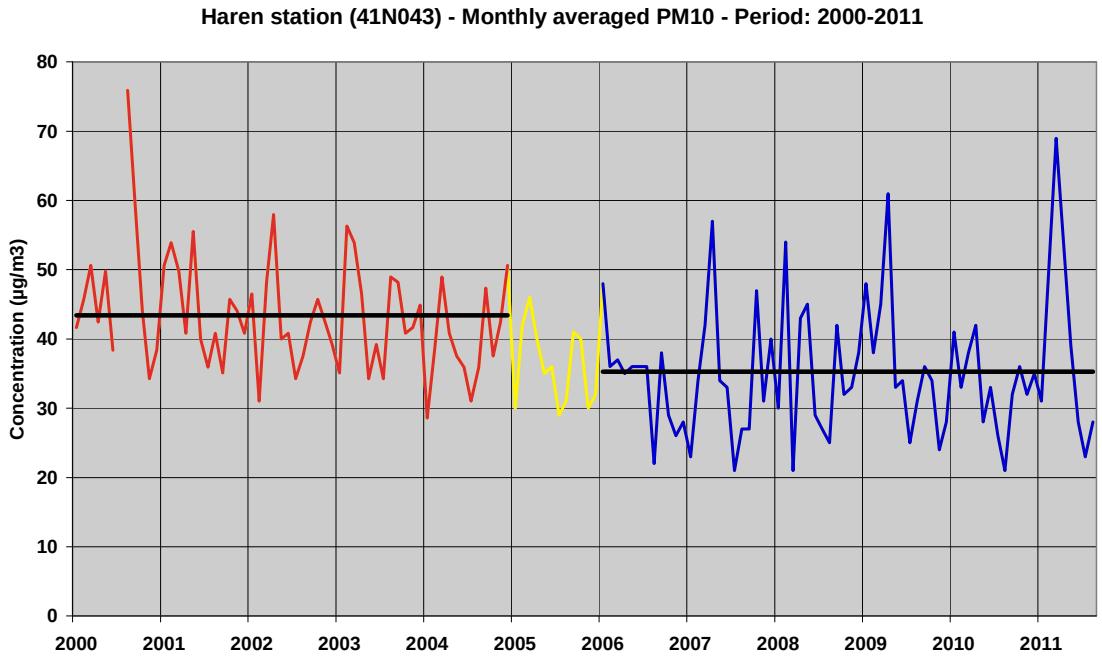


Figure 7.1: Monthly PM10 concentrations at the Haren station for the period 2000-2011. The red curve identifies the period from 2000 to 2004, the yellow curve corresponds to the year 2005, and the blue curve shows the measurements since 2006. The data series have been homogenized in order to take into account the transition from TEOM to TEOM-FDMS monitors.

CONCLUSIONS

The Haren station is one of the first station of the Belgian Telemetric Network for air pollution constructed in the period 1976-1980. The data series for particles at Molenbeek and Haren form the longest data series available in Belgium.

The Brussels Capital Region fails to meet the daily limit value fixed on PM10 in several measurement stations. The role of local emission sources in the observed exceedances of this limit value is complex. If road traffic represents 70 to 75% of the local PM emissions as registered by the Brussels emission inventory, a comparison of PM mass concentration levels inside and outside Brussels seems to indicate that, depending on site location, particles emitted directly by the local traffic represent on average only about 10 to 20% of the total measured PM10 mass concentration. The PM10 background level represents about 65% of the inner city concentration. Therefore drastic emission reductions will be needed if compliance has to be assured solely by local emission reductions. It has also been shown that even a permanent weekend emission regime would not permit to guarantee compliance with the PM10 daily limit value.

The Haren station is one of the Brussels stations that fails to respect the daily limit value on PM10. This station is typical for industrial activities, combined with dense and heavy traffic and with no habitation within a radius of 400 m around the station. The naval port owns several sites along the Brussels canal "Canal de Willebroek", parallel to the Senne Valley (North-South axis). In these sites, the construction industries stock outdoor materials, which can be easily transported by wind.

A comparison with the PM10 measurements from the other stations in the Region reveals that a non negligible fraction of PM10 measured at Haren can be attributed to the resuspension of the coarser fraction of particles (diameter between 2.5 and 10 µm) in relation with the local activities of the naval port. The analysis of the average weekly PM10 concentration pattern concludes to a **local contribution in the order of 30%, for the coarse fraction of particles (diameter between 2.5 and 10 µm), during the week (Monday to Friday) at the Haren site**.

Resuspension is highly dependant on meteorological conditions. It is linked with the advection of dry air, mainly coming from the large eastern sector. Under these conditions and in the presence of a local source, particles of the coarser fraction are suspended by the wind and/or by the turbulences created by the traffic. Due to the presence of local sources, this phenomenon is more frequently encountered at the two measuring sites (Haren and Molenbeek), where the limit value is systematically exceeded.

A limited selection of specific cases has been analyzed in order to illustrate the presence of the coarser fraction, leading to daily PM10 exceeding values. In some of the cases the presence of the coarse fraction is observed only at the Haren site (N043), in others the coarse fraction is simultaneously present at the Haren, Molenbeek (R001) and Meudon (MEU1) site, but with a different intensity. In still some other examples the presence of the coarse fraction is superposed upon high PM levels present everywhere, e.g. PM10 and PM2.5 values close or above the 50 $\mu g/m^3$ value and caused by the formation of secondary aerosol. In such cases the coarse fraction cannot be held responsible for the exceedances.

Two approaches have been proposed to assess the impact of the local resuspension of the coarser fraction on the exceedances of the PM10 daily limit value at Haren. The first approach relies upon experimental criteria on PM2.5 and PM10 measurements. The second approach is based on the PM10/PM2.5 ratio to estimate the contribution of local resuspension on PM10 measurements. Both approaches lead to the same conclusions:

- **At least one third of the exceedances (i.e. 20 to 30 days) observed at Haren can be attributed to the local resuspension of the coarser fraction.**
- **Without the supplementary coarse fraction, the daily limit value would be surely respected in 2010, and probably in 2008. Nevertheless, the number of exceedance days in 2009 would remain greater than 35.**

Finally, it should also be noted that the measure decided in the Plan Air-Climat 2002 – which consists of humidifying or covering the fine particles piles in the construction industries – was efficient and has probably allowed to reduce the PM10 annual mean by about 8 $\mu g/m^3$ since 2005.