Eindrapport

UFP- en BC-metingen rondom de luchthaven van Zaventem

English Summary

J. Peters, P. Berghmans, J. Van Laer, E. Frijns

Met medewerking van
BIM, ECN, ISSeP en VMM

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VITO NV
Boeretang 200 - 2400 MOL - BELGIE
Tel. + 32 14 33 55 11 - Fax + 32 14 33 55 99
vito@vito.be - www.vito.be

BTW BE-0244.195.916 RPR (Turnhout)
Bank 375-1117354-90 ING
BE34 3751 1173 5490 - BBRUBEBB

SUMMARY

Introduction and objective of the study

Utrafine particle (UFP) emissions from aircraft engines have been associated with increased UFP concentrations in areas surrounding airports. Measurement campaigns by the US EPA indicated that UFP emissions from aircraft engines are in the range of 10^{15} to 10^{17} particles per kg fuel, with variations depending on the engine type, fuel type, engine load and the environmental conditions. The smaller UFP fraction is the dominant fraction in terms of particle number counts (PNC).

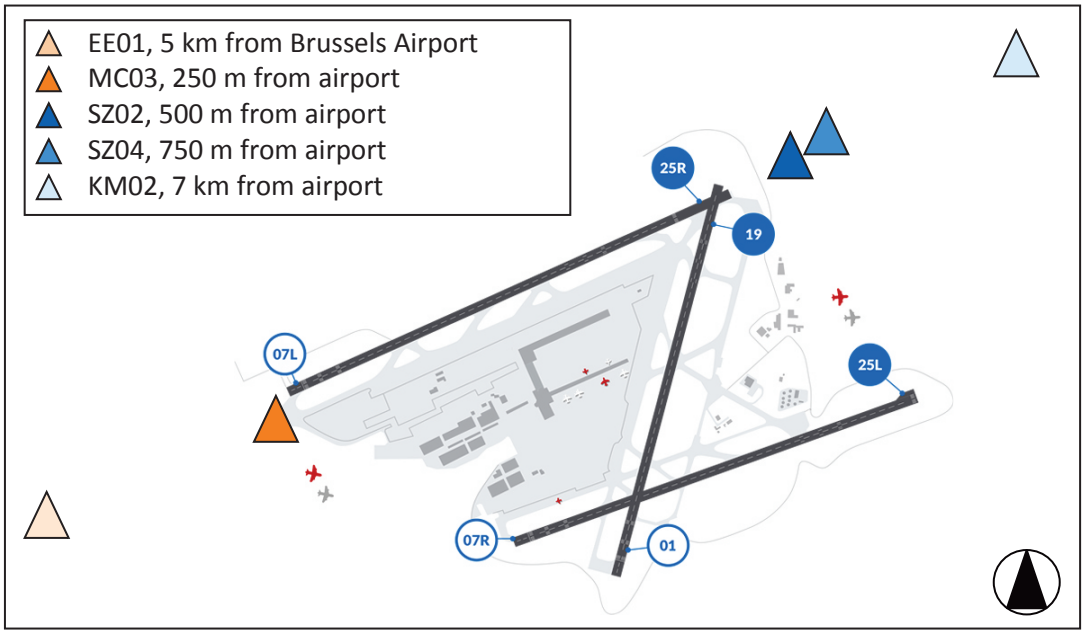
A number of studies investigated the UFP concentration in the vicinity of airports worldwide (mainly in Europe and the US). The UFP number concentration pattern shows a high temporal and spatial variation. The highest UFP concentrations are associated with landing and take-off (LTO) operations. UFP concentrations near the runway decrease drastically after aircraft take-off. The high number of LTO operations at airports results in a highly dynamic UFP concentration pattern through time.

Results from environmental monitoring studies in areas surrounding airports indicate a decreasing trend in UFP concentration with distance to the airport. Wind direction and wind velocity are other important parameters determining the spatial UFP pattern around airports. In particular, elevated UFP concentrations are observed in downwind areas. Effects of aircraft UFP emissions have been observed at a distance of over 15 km from the airport.

A monitoring study was performed in an area around Brussels Airport, Belgium. **The objective of the study was to investigate the potential contribution of operations at Brussels Airport on the local air quality at surrounding residential areas.** Therefore the concentration of UFP, black carbon (BC) and nitrogen oxides (NO_x) were measured at different locations near the airport and measurements were compared to literature results.

Monitoring plan

Five locations were selected as monitoring locations, including one existing air quality monitoring station from the Flanders Environment Agency (VMM). The monitoring stations were located on a transect aligned with a busy runway (25R/07L) at varying distance from the runways. Four of the measurement locations (EE01, MC03, SZ02 and SZ04) are characterized as urban background stations, whereas one location (KM02) is a rural station.



The monitoring was performed for UFP, BC, NO_x and PM_{10}. The UFP number concentration was continuously monitored at locations EE01, KM02, MC03 and SZ04 with a scanning mobility particle sizer (SMPS) within different particle size classes of 10-20, 20-30, 30-50, 50-70, 70-100, 100-200 and 200-294 nm. The UFP measurement resolution was five minutes. The BC and NO_x concentration was measured at EE01, KM02, MC03 en SZ02 at a resolution of 30 minutes. The PM_{10} concentration was determined on a daily basis. The monitoring was done during a two month period, i.e. October and November 2015. An overview of the instruments that were used at the different monitoring stations is given in this Table:

Location	Parameter	Monitor
Steenokkerzeel SZ04	UFP	TSI SMPS 3936L76
	PM_{10}	Leckel SEQ47/50
Steenokkerzeel SZ02	BC	MAAP 5012
	NO_x	NO_x TS42i
Diegem MC03	UFP	IfT custom classifier and CPC3772
	BC	Magee AE22
	NO_x	NO_x 42C
	PM_{10}	Leckel SEQ47/50
Evere EE01	UFP	IfT custom classifier and CPC3772
	BC	Magee AE22
	NO_x	NO_x TS42C
	PM_{10}	Leckel SEQ47/50
Kampenhout KM02	UFP	TSI SMPS 3936L76
	BC	MAAP 5012
	NO_x	NO_x TS42C
	PM_{10}	Leckel SEQ47/50

Meteorological data from a nearby meteorological station (Melsbroek) were provided by BIM. Information about LTO operations at Brussels Airport during the two month monitoring period was provided by LNE and is based on flight information and radar measurements of Belgocontrol and Brussels Airport Company.

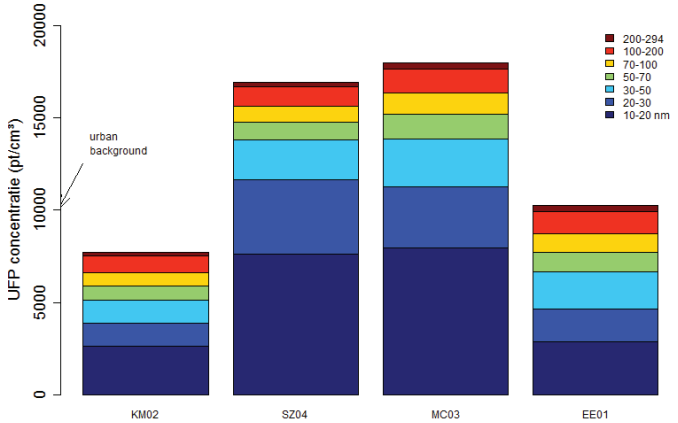
Before the two months monitoring period, a two week period (14-28/09/2015) of simultaneous measurements at one of the sites (SZ04) was performed to compare the instruments. Based on these simultaneous measurements, the UFP monitoring systems were adjusted and rescaling models were parameterized to increase comparability between the measurements from different instruments. The correspondence of the rescaled simultaneous measurements was excellent, with a difference of less than 3% between most instuments for the majority of UFP size classes.

Results

The results presented are mainly focused on the smallest UFP fraction of this study, i.e. 10-20 nm, which is the fraction with the largest contribution to aircraft emissions. Based on the entire measurement period, the average and 99th percentile (P99) number concentrations of UFP of size class 10-20 nm are largely increased at the nearby monitoring stations SZ04 and MC03 compared to KM02 and EE01 stations which are situated further away from the airport.

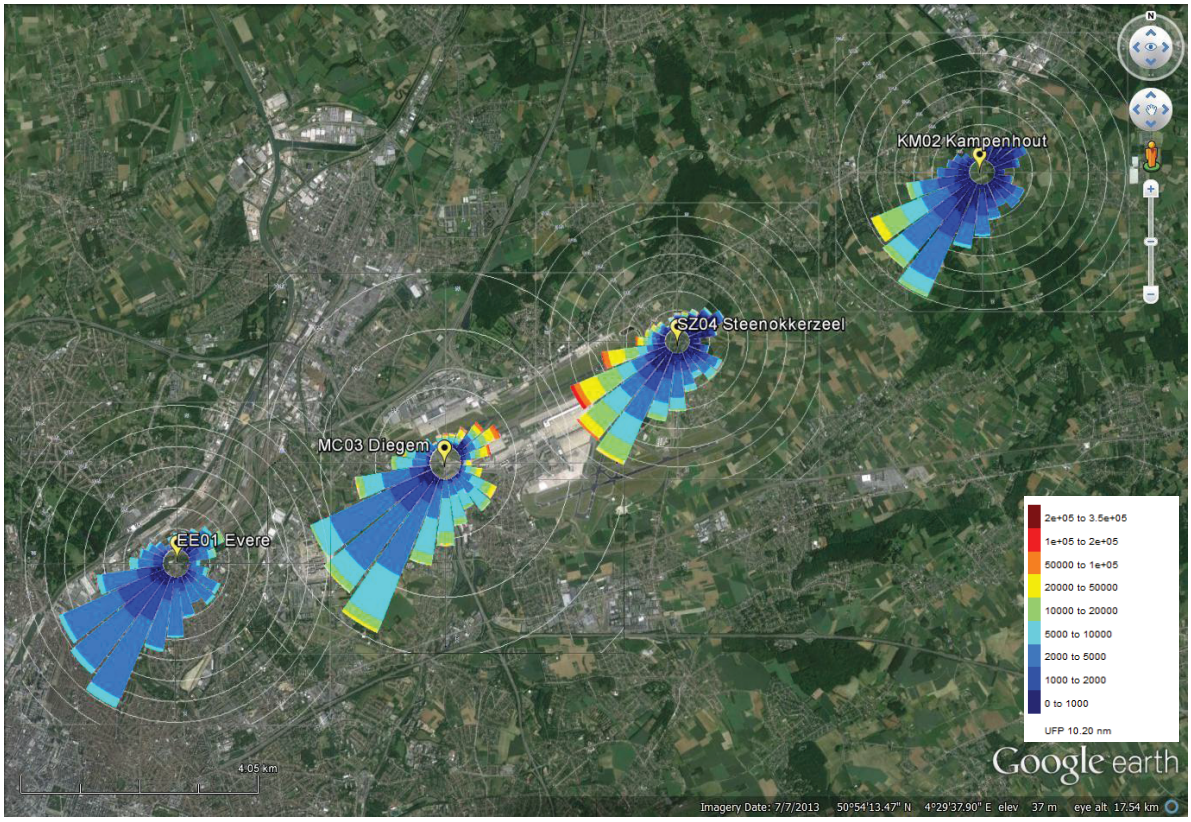
Location	Average 10-20 nm		P99 10-20 nm	
	pt/cm³	ratio	pt/cm³	ratio
Evere (EE01)	2 891	1,1	10 063	0,5
Diegem (MC03)	8 119	3,1	68 992	3,5
Steenokkerzeel (SZ04)	7 776	3,0	74 370	3,7
Kampenhout (KM02)	2 615	1	19 660	1
* ratio [location]/[KM02] KM02 is a rural background site				

The share of the 10-20 nm fraction in the total 10-294 nm UFP number concentration is much larger near the airport (SZ04 45% and MCO3 45%) in comparison to the more distant locations (KM02 35% and EE01 28%). The UFP concentrations vary between the hours of the day, with the highest concentrations during the morning rush (6 – 10 am local time) and evening rush (4 – 8 pm local time). The number of LTO operations at Brussels Airport shows a similar bimodal pattern.



The analysis of UFP concentration measurements in relation to wind direction showed increased UFP concentrations of the 10-20 nm size class at all the monitoring locations when they were situated downwind of the airport. At the nearby stations, the UFP number concentrations of the

10-20 nm size class exceed 50 000 pt/cm³ during 6-11% of the time for SZ04 and MC03, respectively. For larger UFP classes (> 70 nm) the UFP pollution roses did not show the directionality toward the airport which was observed for the smaller UFP classes.



An additive model was used to account for the contribution of airport operations to the UFP concentration at nearby downwind locations. An overcompensation by this model was inevitable, so the values reported here are probably rather conservative estimates. Under downwind conditions, for 25% of the time an airport contribution to the 10-20 nm UFP particle numbers of 20 000 to 28 000 pt/cm³ was estimated. For 10% of the time a contribution of more than 44 000 to 58 000 pt/cm³ was found, and for 5% of the time of 66 000 to 82 000 pt/cm³. The maximal contribution ranged between 255 000 and 276 000 pt/cm³.

Flight information was used to further investigate the variability in UFP concentration. A visual inspection of 3D plots of the hourly mean UFP concentration of the 10-20 nm size class, the hourly prevailing wind direction and the hourly number of LTO operations showed a clear gradient of increasing UFP concentration with increasing numbers of LTO operations during downwind conditions, especially at SZ04 which is downwind under the dominant southwesterly wind direction. At MC03 the gradient is less clear due to a much lower number of measurements under downwind conditions .

The variability of the hourly 10-20 nm UFP concentration in function of meteorology and LTO operations was further analysed using a multiple linear regression model. For the two locations NE of the airport the models explained 60% (SZ04) and 51% (KM02) of the measured variation. The model identified the number of LTO operations at the nearest runway 25R during downwind conditions as the most important independent variable in explaining the variation in UFP

concentration at both sites. The analysis revealed a correlation between the UFP concentration in the surrounding area of the airport and aircraft LTO operations.

The contribution of airport activities to the other measured air pollutants, BC, NO_x and PM_{10}, is much less evident. The analysis of BC and NO_x concentration profiles in function of wind direction did not reveal higher contributions from the airport than from other (probably mainly traffic) sources. The daily average PM_{10} concentration was similar at all measurement sites.

Conclusion

In urban environments, road traffic is generally the dominant source of primary UFP (10-100 nm). In the area surrounding Brussels Airport, a significant contribution of airport activity to the UFP 10-20 nm number concentration is observed. The contribution decreases with increasing distances, but effects are measurable at a distance of 7 km from the airport. There is a clear relationship between LTO operations, wind direction and distance to the airport and the UFP concentration that is observed at a monitoring site in the area around the airport. In contrast, the airport activity does not have a higher contribution to the BC, NO_x and PM_{10} concentration at the monitoring sites compared to the contributions from traffic at nearby roads and motorways.

Full report available at:
https://www.vmm.be/publicaties/ufp-en-bc-metingen-rondom-de-luchthaven-van-zaventem