Air Quality
Annual Report 2017

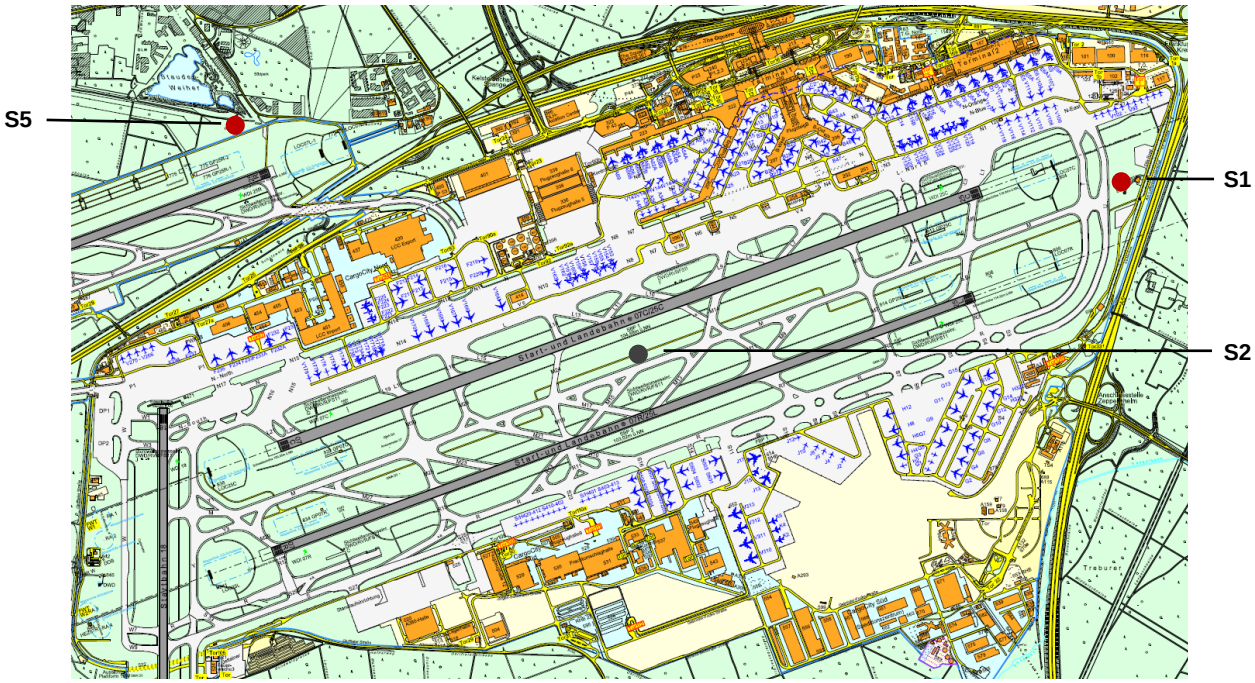
Report on Ambient Air Quality Monitoring at Frankfurt Airport

In 2017 there have been several changes concerning air quality monitoring at Frankfurt Airport. After the initial research targets had largely been achieved as described in the preceding year's report, it was a basic question of whether monitoring should be continued. It had been possible to determine the status quo of air quality at the airport and the limited effect the expansion had on it and also the degree of reality of the simulation models in use. However, continuing the monitoring series was desirable from a scientific point of view. The site is an addition to the regulatory network and facilitates the observation of future development, also regarding a further increase of air traffic. Such activities are already being performed by the Hessian State Agency for Nature Conservation, Environment and Geology (Hessisches Landesamt für Naturschutz, Umwelt und Geologie, HLNUG), partly in cooperation with another institution of the Hessian state called UNH, (Umwelt- und Nachbarschaftshaus) at Kelsterbach, which is particularly concerned with local airport impacts. It was thus agreed that the monitoring equipment would be transferred into the ownership of UNH and would be operated by HLNUG in future. Fraport will be provided with the results, so we can continue to present them in our Air Quality Annual Report.

Due to technical and logistic reasons, the station S2, located in the center runway system, had to be closed down at the beginning of the year. The new operator intends to put it into service again at another position within the airport premises.

As to the special topic for the present edition of the annual report, we chose "ultrafine particles". Though it is still a subject of research, this topic is being publicly discussed, also in relation to the air quality in the vicinity of airports.

Ambient Air Quality Monitoring Stations in 2017



S2: out of service since the beginning of 2017

Annual Mean Values Compared to Air Quality Standards

		Measured Value	Air Quality Standard*
NO	*S1*	*31*	*200 [1]*
	S2		
	S5	*13*	
NO_2	*S1*	*42*	*40 [2]*
	S2		
	S5	*30*	
SO_2	*S1*	*2*	*50 [3]*
	S2		
CO	*S1*	*0.3*	*- [4]*
	S2		
O_3	*S1*	*34*	*- [4]*
	S2		
PM10	*S1*	*17*	*40 [2]*
	S2		
	S5	*16*	
PM2.5	*S2*		*25 [2]*
Benzene	*S1*	*0.5*	*5 [2]*
	S2		
Toluene	*S1*	*1.1*	*30 [5]*
	S2		
m/p-Xylene	*S1*	*0.7*	*30 [5]*
	S2		
Ethylbenzene	*S1*	*0.3*	*20 [1]*
	S2		
Benzo(a)pyrene	*S1*	*0.2*	*1 [2]*
	S2		
Arsenic	*S1*	*0.3*	*6 [2]*
Lead	*S1*	*3.5*	*500 [2]*
Cadmium	*S1*	*0.1*	*5 [2]*
Nickel	*S1*	*1.4*	*20 [2]*

Measuring unit: µg/m³, CO: mg/m³, benzo(a)pyrene, arsenic, lead, cadmium and nickel: ng/m³

PM10 = particles passing a size selective airflow inlet with separation efficiency of 50% at aerodynamic diameter of 10 µm, PM2.5 definition corresponding

** Reference values used:*

[1] Reference value according to HLNUG (Hessisches Landesamt für Naturschutz, Umwelt und Geologie, Hessian State Agency for Nature Conservation, Environment and Geology)
[2] Limit value 39. BImSchV (German ordinance transposing Air Quality Directive 2008/50/EC into national law); arsenic, cadmium, nickel and benzo(a)pyrene: target value
[3] Limit value TA Luft 2002 (German Technical Instructions on Air Quality Control, for plants requiring licensing)
[4] No annual mean defined for assessment by respective regulations
[5] LAI recommendation (LAI = Länderausschuss für Immissionsschutz, Ambient Pollution Control Committee of German States)

The layout of tables and diagrams has been maintained in this report, although no results are available for the S2 station which is currently out of service. As soon as the station is in operation again, the data will be presented as usual.

In 2017, continuous monitoring was available during more than 99% of the time, except for a PM10 data capture of 98.5% at S5. Likewise, there was no loss of passive sampling of hydrocarbons and particle constituents.

Exceedance Frequency of Short-Term Standards

		Short-Term Standard	*Reference Interval*	*Recorded Exceedance Number per Year*	*Permissible* Exceedance Number per Year*
NO_2	*S1*	*200*	*1 Hour*	*0*	*18*
	S2				
	S5			*0*	
SO_2	*S1*	*350*	*1 Hour*	*0*	*24*
	S2				
CO	*S1*	*10 [1]*	*8 Hours*	*0*	*0*
	S2				
O_3	*S1*	*180 [2]*	*1 Hour*	*5*	*0*
	S2				
	S1	*240 [3]*	*1 Hour*	*0*	*0*
	S2				
	S1	*120 [1]*	*8 Hours*	*18 [4]*	*25 [4]*
	S2				
PM10	*S1*	*50*	*24 Hours*	*5*	*35*
	S2				
	S5			*4*	

Measuring Unit: µg/m³, CO: mg/m³
** Short-term standards according to 39. BImSchV (for explanation on 'permissible' refer to air quality report 'Lufthygienischer Jahresbericht 2004', available in German only):*

[1] Maximum permissible eight-hour running mean of the day derived from hourly means (ozone: target value)
[2] Threshold for the responsible authorities to inform the public in case of exceedance within their network
[3] Threshold for triggering the alert in case of exceedance within the public network
[4] Three-year average (2015, 2016, 2017)

Corresponding short-term values for the assessment of PM2.5, particle constituents, NO, benzene, toluene, m/p-xylene, and ethylbenzene are not available.

Along with average sunshine duration in 2017, the temperature of 11.3°C was about 1° above the long-term mean[1] again, as in the preceding years. More sunshine than usual occurred only in August and September. The overall precipitation sum of 665 mm was slightly elevated. Except for May, the first half of the year was too dry. The second half was too wet except the month of October.

Regarding the concentration values, changes were small compared to the preceding year. The ozone alert threshold was not exceeded and the information threshold was exceeded only in the course of five hours. Although running eight-hour means above 120 µg/m^3 appeared on 13 days only, the key figure for this long-term target value decreases just slowly, because it still includes the large number of 29 days in 2015.

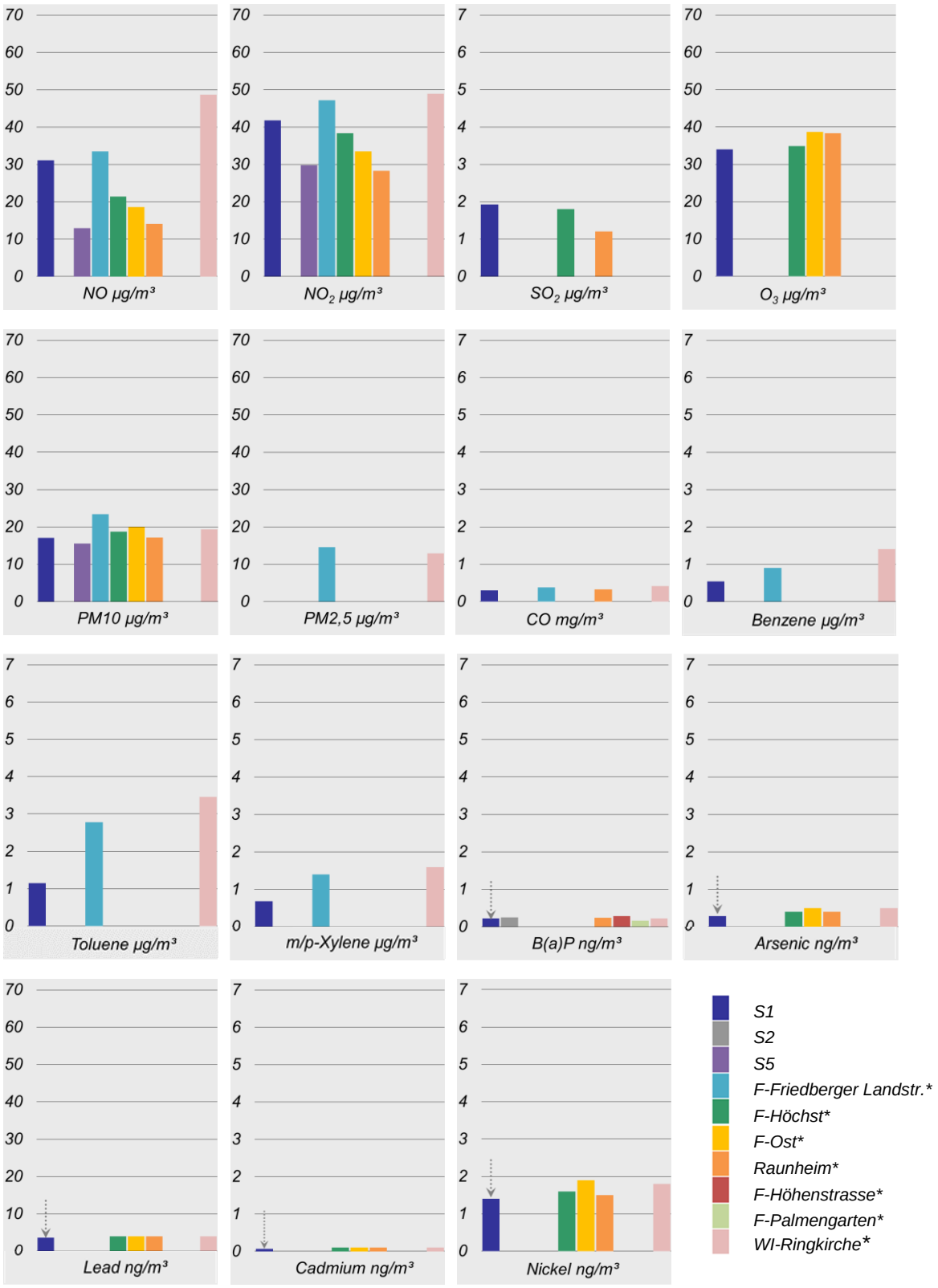
In the reporting period, the threshold for PM10 daily means was exceeded on five days atS1 and on four days at S5. This would have been permissible up to 35 days a year, even in the inhabited surroundings.

Only the annual mean of the NO_2 concentration at S1 remained above the reference value, at a level of 42 µg/m^3, however, less markedly than in the preceding year (45 µg/m^3). Concentrations exceeding the short-term threshold did not occur in the reporting period.

The key figures of the reporting period would again largely comply with human health protection standards, if they were applicable to airports. Once more, the only exception is the slightly elevated annual NO_2 mean at S1 being increased by vehicle emissions. It is similar to the concentration level at those urban sites that are also exposed to road traffic and does not represent a particular feature related to the airport.

[1] 1981-2010 at the airport station of the German Meteorological Service (DWD)

Annual Means at Airport Sites Compared to Values from Nearby Sites of Public Network (HLNUG)*



No bar = species not available at site, F = Frankfurt/Main, WI = Wiesbaden, particle constituents: bars = preceding year's data, arrows = current FRA data

** Reference: Lufthygienischer Monatsbericht Dezember 2017 (running annual means), HLNUG and Lufthygienischer Jahresbericht 2016 (Teil 2: Staub und Staubinhaltsstoffe), HLNUG.*
Part 2 ("Teil 2") for particles and particle constituents for 2017 not available by editorial deadline of this report.

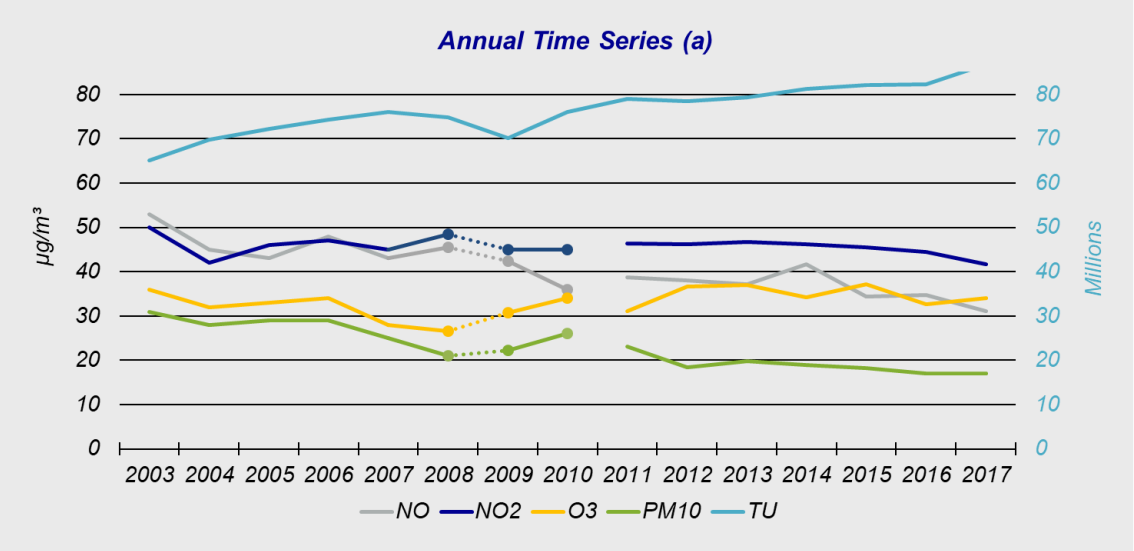
Comparison between Fraport Sites and Nearby HLNUG Sites

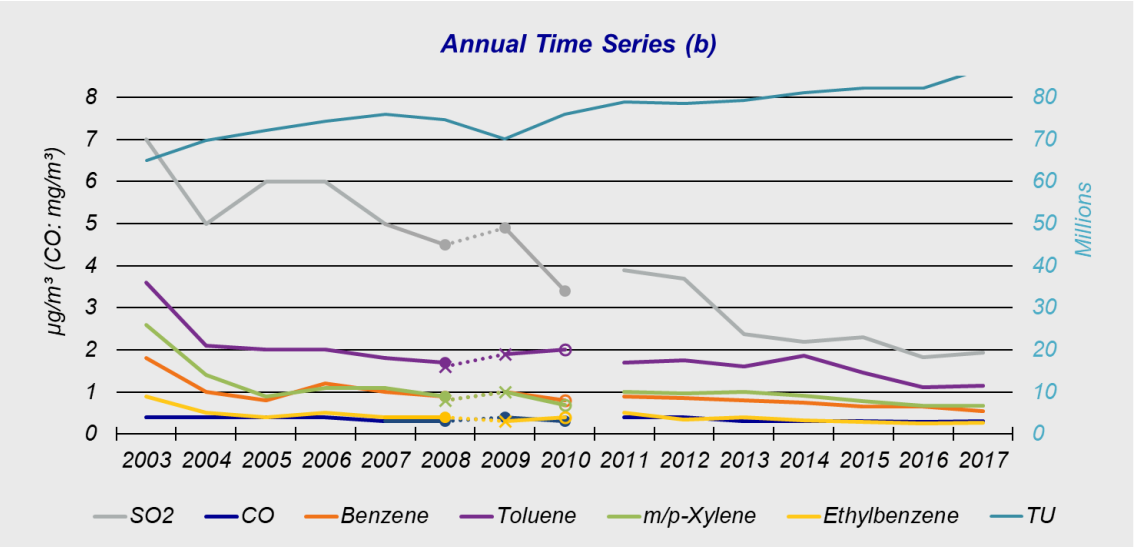
Compared to the preceding year, concentrations of nitrous oxides and BTX aromatic compounds at the comparative HLNUG sites exposed to road traffic have decreased slightly but noticeably, as is the case at the airport sites as well. Averaged throughout the year, NO_2 values above 50 µg/m³ did no longer occur, NO values above 40 µg/m³ only at the site of Wiesbaden-Ringkirche. At the urban background sites, this is less discernable. Thus, differences of concentration levels between the site types have decreased, where the airport station S1 continues to be in the range between them.

At all sites, the concentrations of hydrocarbons and particle constituents, benzo(a)pyrene, arsenic, lead, cadmium and nickel, were very small in relation to the corresponding standards as they have been before.

Time Series of Annual Means (Station S1) and Traffic Units (TU)

The decreasing concentration trend of nitrous oxides and hydrocarbons, as well as the unchanged particle concentration, is independent of the development of traffic units having notably increased in 2017. The updated time series shows the reverse behavior of NO and ozone again, even along with relatively small changes.





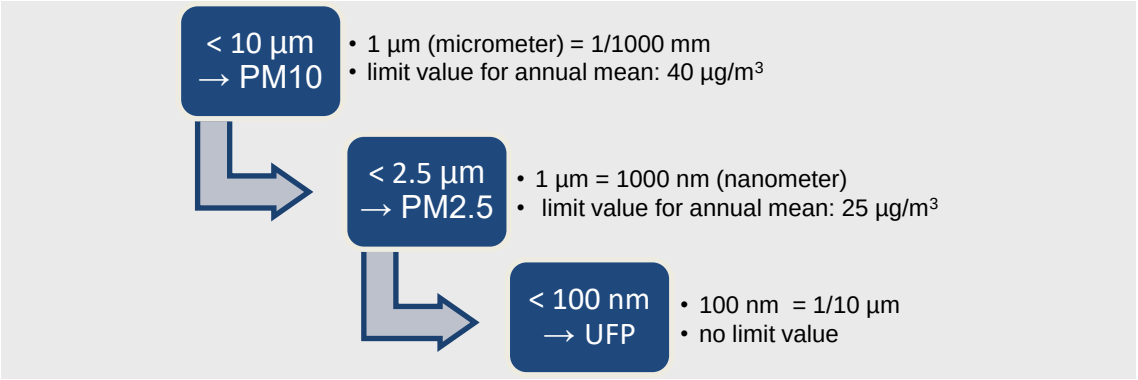
1 TU = 1 passenger including luggage or 100 kg of airfreight or airmail respectively
Solid lines: measurement results at site, dotted lines: minor change of site 2008 / 2009, 2010 relocation approx. 1000m to the north-northeast
Large dots: correction for gaps of data at site, crosses: low data volume at site without correction,
Circles: data derived from two sites without possibility for correction

Special Topic "Ultrafine Particles" (UFP)

This year's special topic covers a group of particles still under research and therefore not assessable by means of routine air quality control. Ultrafine particles may directly be emitted by various mechanisms or may secondarily be formed from gaseous components. In particular, they originate from combustion processes. Indoors, UFP are emitted while frying, baking or using candles, for instance. In ambient air, primarily combustion engines come into consideration as sources, besides natural events. Some selected features referring to aircraft emissions are covered below.

What are Ultrafine Particles?

Particles of less than 100 nm diameter are called "ultrafine", independently of their physical or chemical properties.



Usual particle size classification

They barely contribute to particle mass or mass concentration but mainly represent the number of particles. Therefore, mass concentration is not a suitable measure for describing the occurrence ultrafine particles. Instead, concentration is usually given as number of particles per cubic centimeter (1/ccm, #/ccm or #/cm^3).

How Are UFP to Be Assessed?

The occurrence of UFP is quite diverse and it is not yet clear which variable is appropriate as a target figure for assessment. Moreover, the essential properties and figures are closely related to the measurement concept:

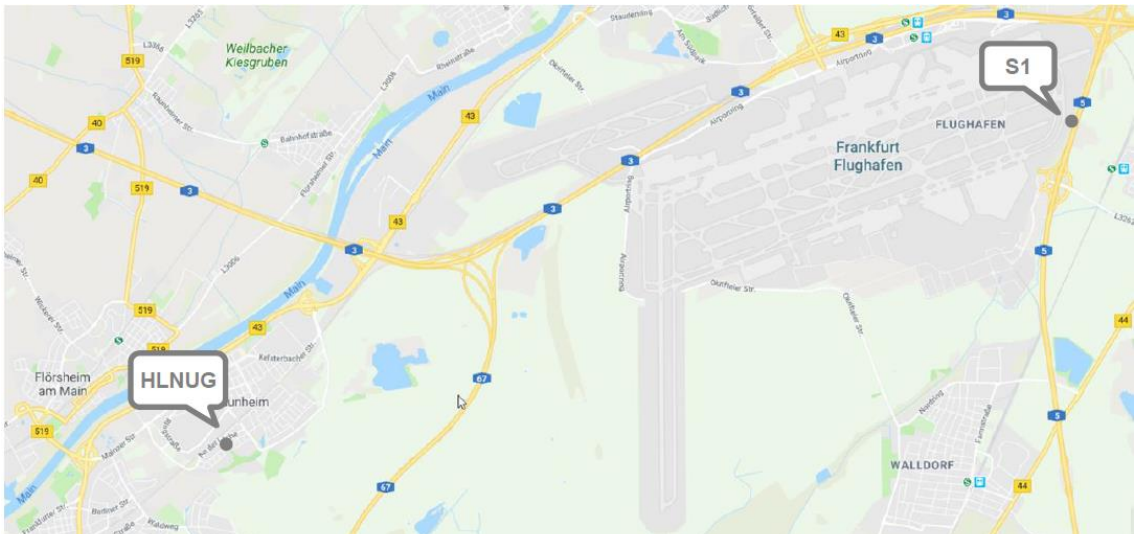
- chemical composition (soot, metals, …)
- total number concentration (particles per ccm)
- number concentration within a certain size range, particle size distribution
- surface
- volatility (formation and decay of non-stable constituents strongly depends on ambient conditions)

According to the model concept, at least insoluble particles can get into the human body via the respiratory system; the smaller the particles are, the deeper they can get, thus potentially causing various harmful reactions even in remote organs. However, there is not as yet sufficiently reliable information on specific UFP impacts in ambient air that would be distinguishable from other well-known pollutants. On the occasion of the review of the EU limit values in 2013, the World Health Organization (WHO) saw "increasing, though as yet limited, evidence" with respect to potential specific health risks by UFP. Hence there was no reason to recommend a limit value. Thus, regarding the complexity of the subject and the findings of the research on impacts still being inadequate, a definition of such a necessarily tangible recommendation is currently not foreseen.

Are There Any Available Insights in Regard to Airports?

As early as 2012, the Airports Council International (ACI) published documentation on the subject of airports and ultrafine particles. Meanwhile a number of additional studies have been performed at and around airports that will be described in an updated version of the report. The publication is envisaged for the first half year 2018. Accordingly, particles emitted by aircraft engines are mainly in a size range below 30 nm. Elevated concentrations are observed near airports, as is the case with traffic-exposed sites. With increasing distance, the UFP concentration decreases as well.

A particular UFP monitoring program with respect to Frankfurt Airport has been initiated by HLNUG in co-operation with the German Environment Agency (Umweltbundesamt, UBA, Langen office) at the site of Raunheim[2] in 2015. The monitoring results, particle number concentration in the range of 3 – 1000 nm), are provided as half-hour-values via internet[3]. The following description refers to information already published by HLNUG and Fraport's own analysis of original data from the 2017 reporting period. Additionally, data from the airport station S1 are used for comparison.



HLNUG UFP monitoring site at Raunheim and airport site S1 for reference. Map background: google maps

What Is the UFP Concentration Level?

Concentration data do not only depend on the site but to a large extent also on the temporal resolution. According to the detection frequency and the interval of averaging, extreme values level up more or less. Even supposed all other conditions being equal, different monitoring periods, e.g., seasons, may lead to different results. As mentioned before, in case of UFP, the measured variable itself strongly depends on the measurement concept and vice versa. On these grounds, UFP monitoring results are often difficult to compare or can be compared to a limited extent only.

The data in the following table, retrieved from a publication by the HLNUG, have to be regarded under these considerations.

Site	*Character-istics*	*Range (nm)*	*Mean (1/cm³)*	*Median (1/cm³)*	*Max. 1h-Value (1/cm³)*	*Interval of Avara-ging*
Raunheim	Urban BG	3 – 1000	16,100	12,300	142,000	09/2015– 03/2016
Langen	Urban BG	3 – 1000	12,200	10,500	67,000	2010 – 2013
Berlin	Urban BG	4.5 – 1000	8,700	7,700	49,000	05/2014 – 08/2014
Dresden	Traffic	5 – 800	14,923	-	-	2010 – 2013
Leipzig	Traffic	5 – 800	16,321	-	-	2010 – 2013
Melpitz	Rural BG	5 – 800	5,651	-	-	2010 – 2013
	BG = Background					

Comparison of UFP concentrations according to Jacobi et al. 2016

[2] Results from another HLNUG-station at Frankfurt Schwanheim, north of the airport, operating since October 2017, were not yet available by the deadline of this report.
[3] https://www.hlnug.de/?id=9231&station=601

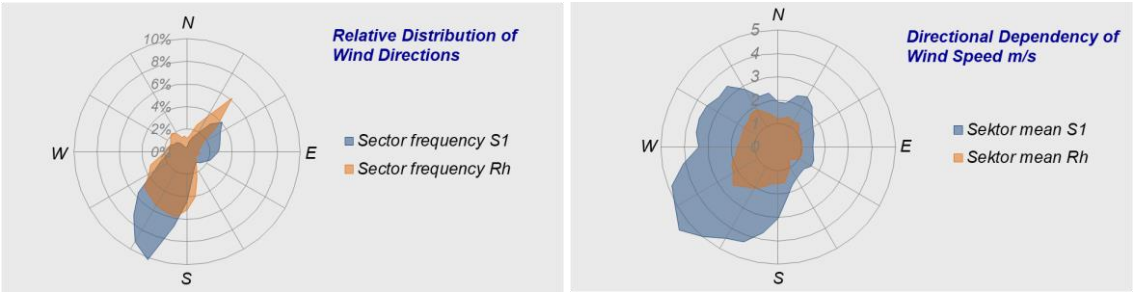
How Can an Airport Influence Be Recognized by Monitoring Results?

The first HLNUG analysis revealed elevated UFP-concentrations at Raunheim. As Raunheim is also located within the range of influence of traffic sources (A67, A3, B43), this alone is scarcely a clear indication of the airport as a UFP source. The mean diurnal variation of the UFP concentration displayed a similar pattern as the one of other components. In general, maximum values are found during the morning and evening road traffic peaks and lower concentrations throughout the afternoon, when vertical mixing of the atmosphere is better and pollutants are correspondingly diluted.

As already described in previous annual reports, an airport influence on the pollutant concentration in the vicinity can be made detectable only by detailed analysis. To this end, site comparisons, comparisons between various components and model calculations are used.

Site Comparison Wind Direction and Speed

For further analysis, firstly the frequency distribution of wind direction and speed at the two sites, Raunheim and airport, are compared. The directional frequencies and mean values are divided into 10°-sectors each. The 90°-sector value (East = E) for instance is valid for directions from 86° to 95°. It is assigned to the center of the sector at 90°.



Frequency distribution of wind directions (left) and directional dependency of wind speed (right) 2017, Raunheim (orange) and airport S1 (blue) respectively

The distribution of directions is characterized by a maximum from south-southwest and a second smaller one from northeast for each of the two sites. The south-southwesterly directions are more frequent at the airport than at Raunheim. Regarding the airport, this is a characteristic distribution as it is prevailing in most years. Due to less disturbed flow conditions, wind speed is markedly higher at the airport than it is at Raunheim, generally speaking. According to the related large-scale weather situations, the mean wind speed from southwesterly directions is higher than from all easterly directions.

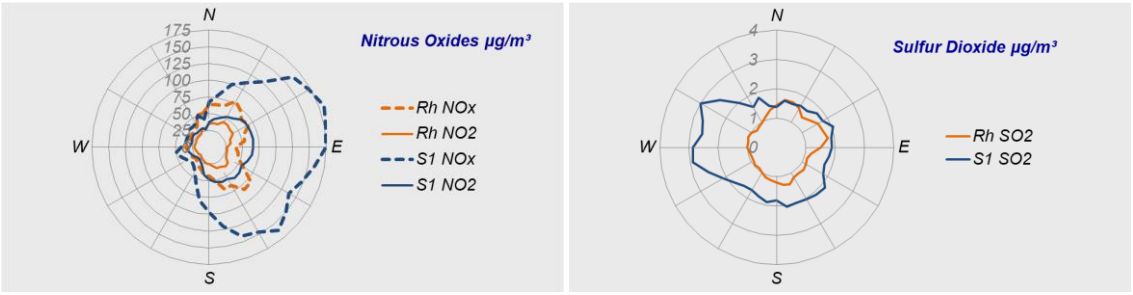
During weather conditions associated with easterly wind and low wind speed, also the vertical mixing of air is limited. Thus, pollutants can accumulate in the surface layer. Additional to the location of emission sources, this can influence the directional distribution of pollutants. Therefore the concentration levels in easterly sectors are frequently elevated.

Dependency of Nitrous Oxides and Sulfur Dioxide on Wind Direction

Likewise, markedly elevated concentrations of nitrous oxides are to be found with easterly wind directions at Raunheim and at the airport. However, the directional concentration distributions being more pronounced to the northeast and to the southeast also indicate an influence of the near motorways: A67 and the Mönchhofdreieck junction at Raunheim as well as A3/A5 and the Frankfurter Kreuz junction in close proximity to the airport. Such influence on station S1 has already been recognized in previous analysis.

Here, the stronger influence of motorways at the monitoring site S1 is discernable by generally higher values and by the larger ratio of NOx [4] to NO_2. Large shares of NO reflect primary emissions close to the source. With increasing source distance, NO oxidizes to NO_2, so NOx- and NO_2-values level up to each other.

[4] Nitrous oxides (NOx) are given as NO_2-equivalents. To this end NO is converted by the mass proportion 46:30 of NO_2:NO.



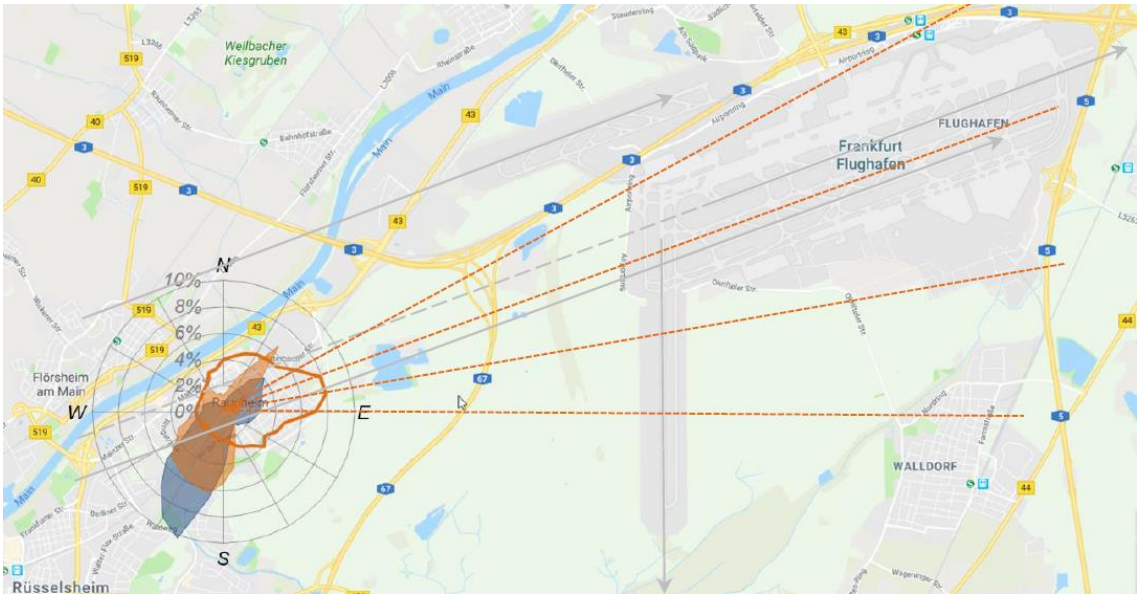
Dependency of nitrous oxides (left) and sulfur dioxide (right) on wind direction 2017, Raunheim (orange) and airport S1 (blue) respectively

A different pattern appears with the dependency of SO_2 on wind direction. Most of the fuels currently in use contain only a small amount of sulfur, so road traffic in particular is not deemed to be an essential source. Due to the higher sulfur content of the aircraft fuel kerosene, the influence of air traffic can be reflected in its proximity here. Although the concentration values are within the lower detectable range, both data series display a more or less distinct maximum from the direction of the airport. At the airport site, accordingly, it is located in the westerly sectors, deviating from the findings with respect to other components described above. At Raunheim, slightly higher concentrations occur – except in the case of easterly direction (airport) – also with northeasterly direction, which might be caused by other local sources. Even ship traffic on the Main River could play a certain role in this respect. For all three of the sectors, the corresponding frequencies are small. Therefore, the reliability of a source apportionment is additionally limited.

According to model calculations, admittedly, an airport's contribution is expectable directly at the airport and still at Raunheim as well, which nevertheless is not discernable from the results in the case of nitrous oxides due to the predominating influence of road traffic. Likewise, the airport contribution to the sulfur dioxide concentration is hardly important with respect to air quality because of the low concentration level.

UFP Dependency on Wind Direction

Expectedly, the UFP concentration at Raunheim is higher with wind directions including easterly components from North and East to Southeast than with westerly wind directions. However, a particular feature is the strongly pronounced maximum from an easterly direction, slightly shifted to the East-Northeast, which is not found with other pollutants, e.g., those which are characteristic for road traffic.



Frequency distribution of wind directions at Raunheim (orange colored area) and at the airport (blue area) together with wind direction dependent distribution of the UFP concentration at Raunheim (orange colored line) 2017. Aircraft movements during operational direction 07 (east wind) are indicated by grey arrows. The orange colored, dashed lines indicate the central axes of the 10° wind direction sectors associated with particularly high UFP concentrations. The UFP concentration is scaled in % of 500,000 particles per ccm, i.e. the outer 10%-circle refers to 50,000 per ccm and the maximum occurring sector mean at the 8%-circle refers to 40,000 per ccm. Background map: google maps

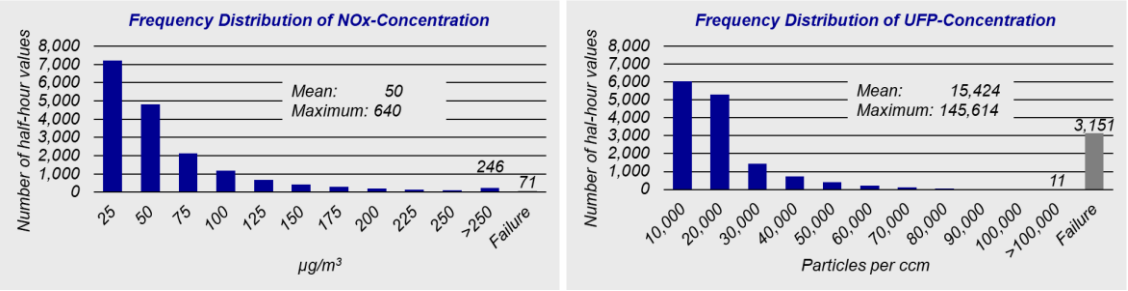
The two 10° sectors concerned, which include stronger northern components, comprise the airport apron area and the first section of Runway 18W (for aircraft takeoffs), where model calculations have also yielded the highest nitrous oxide concentrations from aircraft engines. The other two sectors point to an area already located south of the airport. In this direction, barely a part of Runway 18W is located, but the motorway A67 passes there as well. From a purely geometrical point of view, parts of the approach path to the South Runway in close proximity of Raunheim also come into consideration. The flight altitude, however, is more than 300 m there, so such a contribution should be small. This follows from the remarks on vertical mixing as described below as well.

Wind directions with markedly elevated UFP concentrations at Raunheim are also rare and associated with low wind speeds where wind directions may be more fluctuating. Therefore, a fluctuation margin must be presupposed with respect to the directional dependency described. However, the deviation compared to pollutant distributions depending on road traffic suggests an airport influence on the UFP concentration at Raunheim in the case of corresponding wind direction.

Influence of Vertical Mixing on the UFP Concentration

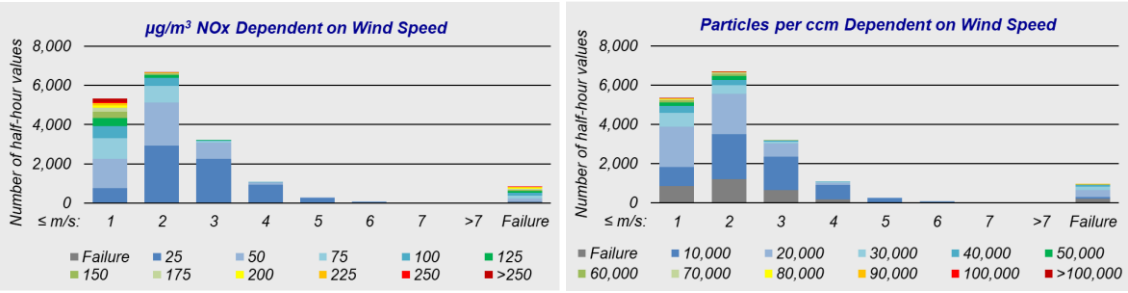
Occasionally, the assumption is expressed that aircraft contribute considerably to the pollution in the surface layer even while overflying or passing at higher altitude. As an indication, elevated concentrations with higher wind speeds are pointed out which due to stronger turbulence also enable enhanced downward mixing from above. Within the scope of this report, it is only indirectly possible to consider whether or not the present monitoring results give hints to such an impact. To this end, concentration frequency distributions are used as a function of wind speed and stability class. A comparison between the NOx and the UFP distributions is supposed to reveal respective features with UFP which are not detectable with NOx being dominated by road traffic.

At that, the classification of both of the components should be approximately comparable, i.e., it should consist of an equal number of classes and comprise the whole range except for a few extreme values. In addition, the range around the mean value and the most frequent values respectively should not be too highly aggregated. As expected, because of the technically much more challenging monitoring method, the UFP series includes notably more gaps than the NOx series. Failures need to be considered as well in order not to bias the results.



Frequency distribution of half-hour values of NOx (left) and UFP (right) at Raunheim 2017

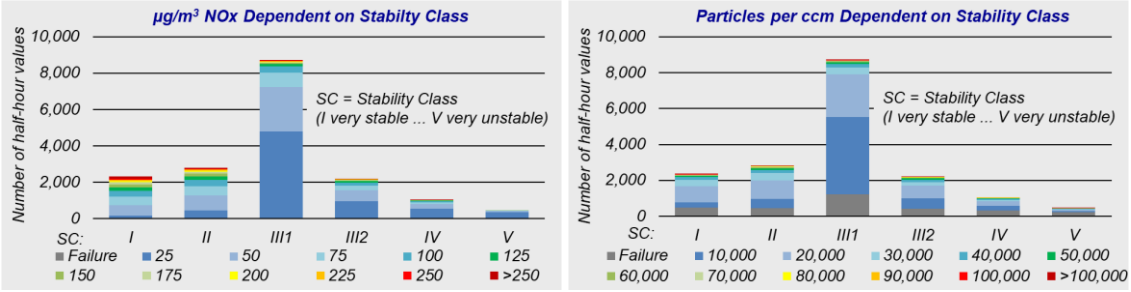
The selected classification represents a compromise which is not suitable to meet all of the requirements. One difference between the two distributions is that very high values above the maximum class resolved occur markedly more frequently with NOx than with UFP. This is also obvious from the following distributions distinguished on the basis of wind speed and stability class.



Distribution of half-hour values of NOx (left) and UFP (right) at Raunheim 2017 dependent on wind speed

The highest values for both components are to be found within the two lowest wind speed classes. If, unexpectedly, failure is not systematically more frequent with certain size categories, then an essential difference between the two distributions does not exist.

The same is valid for the figure distinguished by stability class. Stable stratification impedes vertical mixing, so pollutants can accumulate in the surface layer. Therefore, the higher values are to be found with the more stable classes, as is more obvious with NOx due to more frequent very high values. Apart from this and from the larger number of failure values with UFP, the two distributions are very similar.



Distribution of half-hour values of NOx (left) and UFP (right) at Raunheim in 2017 dependent on stability class. Determination of stability class based on VDI 3782 (2017) using DWD data WebWerdis

The analysis presented here can reflect only single features of the complex interaction of emission characteristics, geometry, wind direction, atmospheric stability, and the corresponding frequencies. In the process, no obvious indications of a considerable UFP contribution from higher altitudes have emerged. Otherwise, this would have been contradictory to the knowledge regarding the dispersion of aircraft emissions. The transport predominantly takes place horizontally, even though throughout a layer of relatively large thickness. The lower approach and departure segments contribute to this, but aircraft engine emissions due to all other movements at ground level do so as well, with larger exit momentum and thermal buoyancy causing stronger vertical initial mixing than in the case of, e.g., road traffic emissions, see Air Quality Annual Report 2011.

Comparison with Calculated Model Time Series of SO_2, PM10 and NOx

In order to simulate the particular source and dispersion behavior of aircraft emissions, the Lasport calculation model is used. It considers all individual aircraft movements together with an hourly resolved time series of meteorological data. By approximation, the influence of wing vortices is also included.

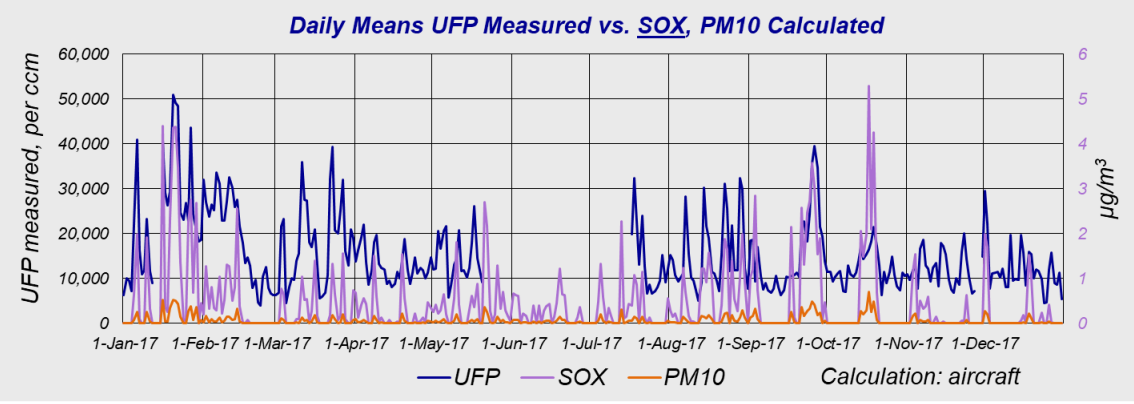
Currently, the model is not yet designed for ultrafine particles, partly because acknowledged emission factors for the particle number in aircraft exhaust are not yet available. If the measured UFP concentration is strongly determined by aircraft, a corresponding temporal pattern could turn up in the calculated time series of other aircraft emission components. This could be the case, e.g., for SO_2, being emitted proportionally to the fuel burnt. Likewise, a relation between the UFP number concentration and the calculated PM10 mass concentration is conceivable, but not necessarily to be presupposed.

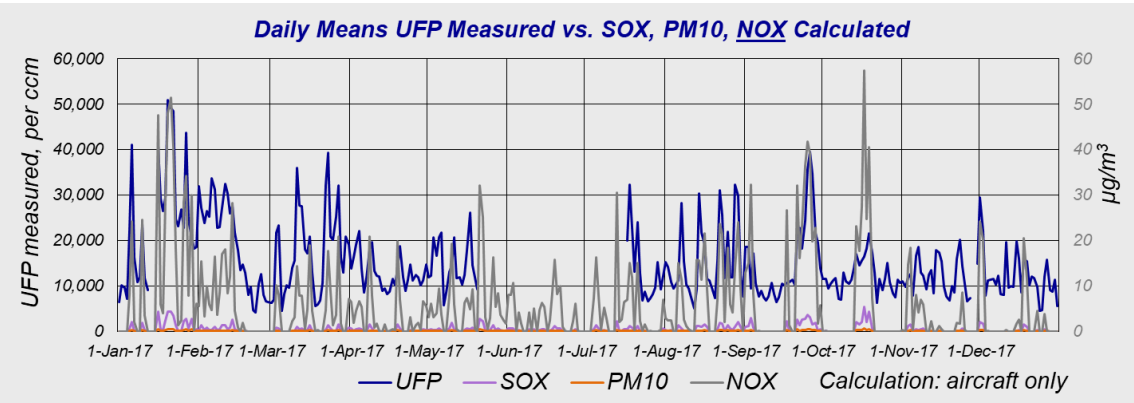
The following diagrams compare the daily means of measured UFP number concentrations (UFP) and calculated values due to these other aircraft emissions:

- sulfur oxides (SOX, mainly refers to sulfur dioxide)
- particle mass concentration (PM10)
- nitrous oxides (NOX)

As to the model data, the original denominations were maintained in order to better distinguish them from the measured values. Measurement and model data refer to the site of Raunheim, simultaneously.

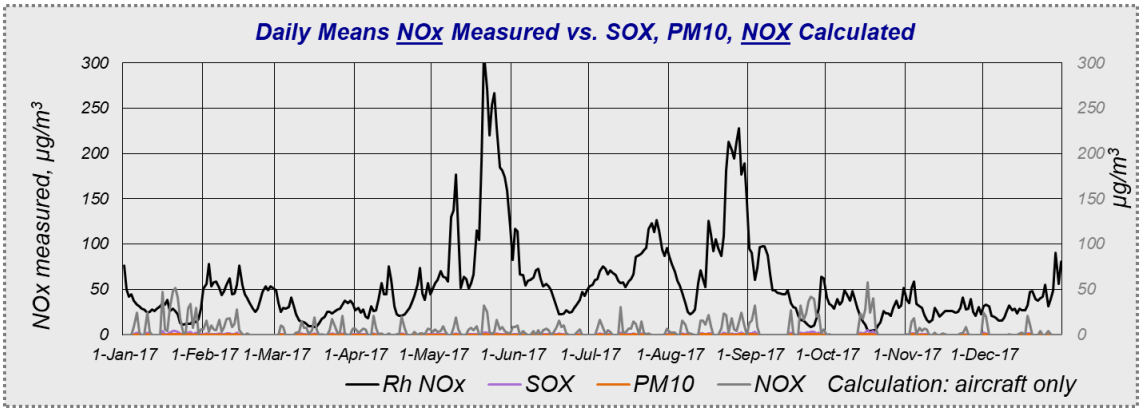
The UFP series includes a major gap of data in the summer of 2017. It is based on a level of about 10,000 per ccm, fluctuating by a temporal pattern in common with the calculated aircraft contributions of sulfur oxides, PM10, and nitrous oxides, at least temporarily. However, UFP peaks without corresponding elevated model values occur as well.





Daily mean time series of measured UFP and model values for other components at Raunheim 2017. The right y-axis is valid for model values, optimized for the highlighted model component. Top: SOX (also valid for PM10, NOX being out of scale), bottom: NOX (also valid for SOX and PM10)

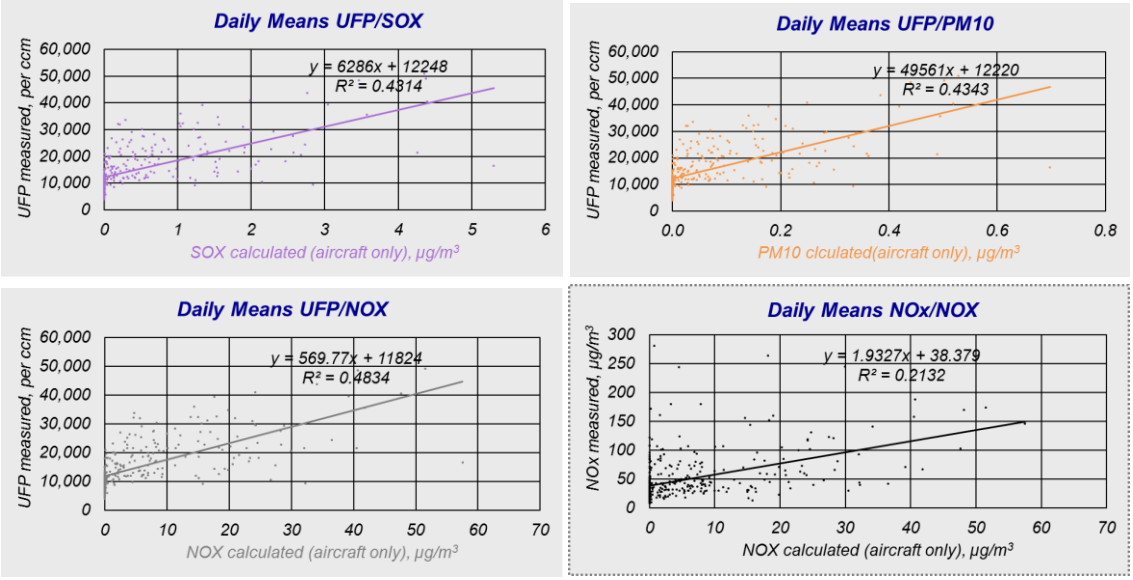
If not compared to the UFP concentration, but to the NOx concentration measured at Raunheim, the calculated aircraft NOX contribution does not reveal such a common pattern.



Time series of nitrous oxides daily means according to measurement (NOx) and to model calculation (NOX) respectively at Raunheim. Diagram highlighted in order to emphasize that it refers to measurement and modelling of the same component, in contrast to the preceding diagrams. However, the model values can only represent the aircraft-related part of the total concentration measured.

An influence of aircraft emissions on the UFP measurement results at Raunheim seems to be recognizable here as well, while the measured NOx values – as mentioned before – are determined by other local sources to a higher degree. However, a common temporal pattern of measured and calculated results does not necessarily mean a causal relation. Also, a common dependency, e.g., on atmospheric conditions or on a superior emission pattern (diurnal variation) can have such an effect. Conversely, a relation may be obscured, as the model dispersion situation can only be an approximation of the real conditions within the model area, possibly leading to a temporal shift, for instance. Such a biasing influence is reduced, although not completely eliminated, with the choice of daily means in contrast to higher resolved data.

The following “correlation” diagrams, however, do not represent real correlation analysis, the significance of which could be approached by statistical methods. This would presume some preconditions[5] which are not implicitly valid here.



“Correlation” of daily means between measurement and calculation results at Raunheim 2017. Top left and right, also bottom left: measured UFP versus another calculated component respectively. Bottom right: NOx measured versus calculated (NOX, aircraft)

Even with this indicative outline, a relation to the measured UFP concentration seems obvious, being approximately equal for all of the three model components, while slightly increasing from SOX and PM10 to NOX (see the first three of four partial diagrams above). The y-intercept of the regression line is at 12,000 particles per ccm for all three cases (y-value for x = 0). Thus, daily UFP means (y) of this amount are to be expected when, according to the model calculation, no contributions of aircraft emissions are present (x = 0, corresponding wind direction). It is approximately the concentration level which was also determined in urban background, although still a little higher.

Expectedly, the relation between the measured NOx concentration and its calculated proportion due to aircraft emissions is notably less pronounced (see fourth partial diagram above). The more or less distinct correlations of the UFP measurement and the model results for aircraft exhaust components being already calculable fit well into the frame of knowledge already gained by analysis of the monitoring results. Therefore, they also represent a confirmation of the model.

Conclusions and Prospect

The HLNUG/UBA monitoring indicates an influence of the airport on the UFP concentration at Raunheim, although it is not the only one. The corresponding wind directions are rather rare and usually related to low wind speed. Maximum UFP concentrations are also observed with low wind speed and stable atmospheric stratification when vertical mixing is constrained, as is the case for other pollutant components. Indications of a contribution from higher altitudes due to passing the site of Raunheim have not been found. A comparison to calculated time series for other components indicates that the temporal structure of an airport influence can be reflected by the model, at least approximately.

The UFP concentration at Raunheim corresponds to the level at other sites which are typically more exposed to road traffic. There will be no reliable basis for an assessment with respect to air quality relevance in the near future.

[5] Normal distribution and independence within the sample

In future, it will be possible to simulate the emission and dispersion of ultrafine particles from air traffic by using Lasport. An emission limit is currently being developed by ICAO (International Civil Aviation Organization). At first, this will be the case for the mass-related concentration of all particles, later for the number concentration of ultrafine particles as well.

The German Environment Agency (Umweltbundesamt, UBA) has initiated a project that aims at investigating the influence of Frankfurt Airport on the UFP concentration in its vicinity. To this end, model calculations as well as existing monitoring results are used. Fraport is supporting this project by means of the scientific advisory board. New knowledge on this topic will be published on the Fraport website.

Further Information:

Fraport AG
www.fraport.de

HLNUG Hessisches Landesamt für Naturschutz, Umwelt und Geologie
(Hessian State Agency for Nature Conservation, Environment and Geology)
http://www.hlnug.de

REVIHAAP
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of 21 May 2008
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http://ec.europa.eu/environment/air/quality/legislation/existing_leg.htm

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https://werdis.dwd.de/

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