Air Quality Annual Report 2014

Report on Ambient Air Quality Monitoring at Frankfurt Airport

In addition to the regularly published air-pollution monitoring figures, this edition of the Air Quality Annual Report provides further analysis on two different subjects.

The first section is titled “Tracking Aircraft-Related Ambient Air Concentrations”. By means of a specific evaluation, we show how aircraft operations are affecting our monitoring results. In general, such influence can scarcely be distinguished from other effects. Neither special HLUG monitoring campaigns (Frankfurt-Lerchesberg, Flörsheim) nor our own on-site measurement were able to explicitly identify any portions of concentration due to air traffic. However, there is no doubt about aircraft contributing considerably to the measured ambient air concentrations, particularly in the airport vicinity as is known from model calculations.

The very special effect presented at this point is small both with respect to the applied standards and the measuring accuracy. Addressing it is purely technically motivated. Beyond that, no quantitative conclusions can be drawn as to the impact of the airport onto its surrounding area.

Model calculations are not only suitable for the assignment of pollutant concentrations, but also facilitate extrapolation of known relations into a spatial distribution or a temporal projection.

The second section, “Theory and Practice of Odor Impact”, exemplifies this. In this section we review the results of the odor monitoring program in the airport vicinity published in the previous year and correlate it to a corresponding current model calculation.

Sites of Ambient Air Quality Monitoring Stations in 2014 (S1a see page 7)

Annual Mean Values Compared to Air Quality Standards			
		Measured Value	*Air Quality Standard**
NO	*S1*	*42*	*200* [1]
	S2	*23*	
	S5	*16*	
NO_2	*S1*	*46*	*40* [2]
	S2	*37*	
	S5	*33*	
SO_2	*S1*	*2*	*50* [3]
	S2	*3*	
CO	*S1*	*0.3*	*-* [4]
	S2	*0.3*	
O_3	*S1*	*34*	*-* [4]
	S2	*40*	
PM10	*S1*	*19*	*40* [2]
	S2	*18*	
	S5	*19*	
Benzene	*S1*	*0.7*	*5* [2]
	S2	*(1.1)*	
Toluene	*S1*	*1.9*	*30* [5]
	S2	*(2.1)*	
m/p-Xylene	*S1*	*0.9*	*30* [5]
	S2	*(1.1)*	
Ethylbenzene	*S1*	*0.3*	*20* [1]
	S2	*(0.4)*	
Benzopyrene	*S1*	*0.2*	*1* [2]
	S2	*0.2*	
Arsenic	*S1*	*0.4*	*6* [2]
Lead	*S1*	*4.7*	*500* [2]
Cadmium	*S1*	*0.1*	*5* [2]
Nickel	*S1*	*1.9*	*20* [2]
( ) Major data gaps			

Measuring unit: µg/m³, CO: mg/m³, benzopyrene, 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

** Reference values used:*

[1] Reference value according to HLUG (Hessisches Landesamt für Umwelt und Geologie, Hessian State Agency for the Environment and Geology)
[2] Limit value 39. BImSchV (German ordinance transposing Air Quality Directive 2008/50/EC into national law); arsenic, cadmium, nickel and benzopyrene: target value
[3] Limit value TA Luft 2002 (German Technicral 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 S4 site was abandoned in early 2014. It had been introduced for the purpose of monitoring particle concentration while the Runway Northwest was being under construction. After the runway had been put into operation, the additional information gained with respect to S5 was only small.

Temporarily, there was a considerable loss of filter material of the BTEX samplers which was probably pecked up by birds. Thus, since the months of July, September and October are missing, the data capture on that site was only 75%. For all other components it exceeded 95%.

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	7	18
	S2			0	
	S5			0	
SO_2	S1	350	1 Hour	0	24
	S2			0	
CO	S1	10 [1]	8 Hours	0	0
	S2			0	
O_3	S1	180 [2]	1 Hour	4	0
	S2			19	
	S1	240 [3]	1 Hour	0	0
	S2			0	
	S1	120 [1]	8 Hours	15 [4]	25 [4]
	S2			19 [4]	
PM10	S1	50	24 Hours	7	35
	S2			1	
	S5			6	

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 floating mean of the day derived from hourly means (ozone: target value)
[2] Threshold for the information of the public by responsible authorities in case of exceedance within their network
[3] Threshold for setting off alert in case of exceedance within the public network
[4] Three-year average (2012, 2013, 2014)

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

In 2014, the mean temperature was markedly above the climatological average[1] and also above the mean temperature of 10°C to 11°C of preceding years. Only in March, however, the weather was also particularly dry and sunny. While over the year the precipitation sum of 650mm was not exceptional, 35% of the precipitation fell during July and August.

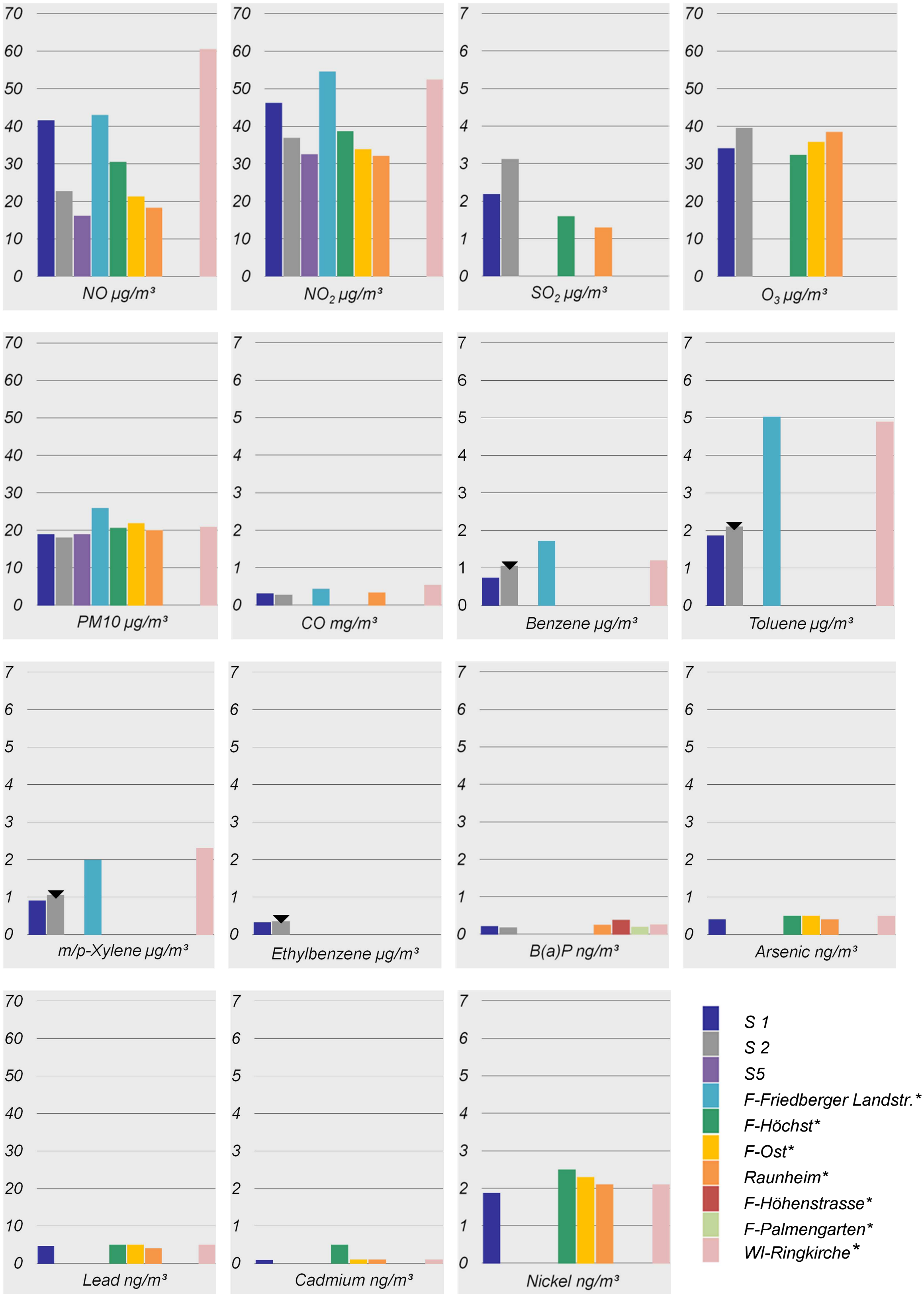
Owing to the rainy summer months, the ozone information threshold was less frequently exceeded than in the previous year, as is the case with the PM10 daily average threshold.

The NO_2-concentration level also slightly declined but continues to be higher than the annual reference value at S1. The number of hours with average concentrations exceeding the short-term threshold at this site decreased from eight to seven. Again, these occasions were confined to situations with north-northeasterly wind direction (from outside the airport) at low speed during evening rush hours.

Since the ozone information threshold is no limit value as such and the remaining observed short-term exceedance frequencies are within the permissible range, nearly all key figures derived at the airport would comply with human health protection standards, if they were applicable at airports. The only exception is the annual NO_2-mean at S1. It is broadly similar to the concentration level at those urban sites that are also exposed to road traffic.

[1] *1981-2010 at the airport station of the German weather service*

Annual Means at Airport Sites Compared to Values from Near Sites of Public Network (HLUG*)



No bar = species not available at site, F = Frankfurt/Main, WI = Wiesbaden, ▼ = major data gaps

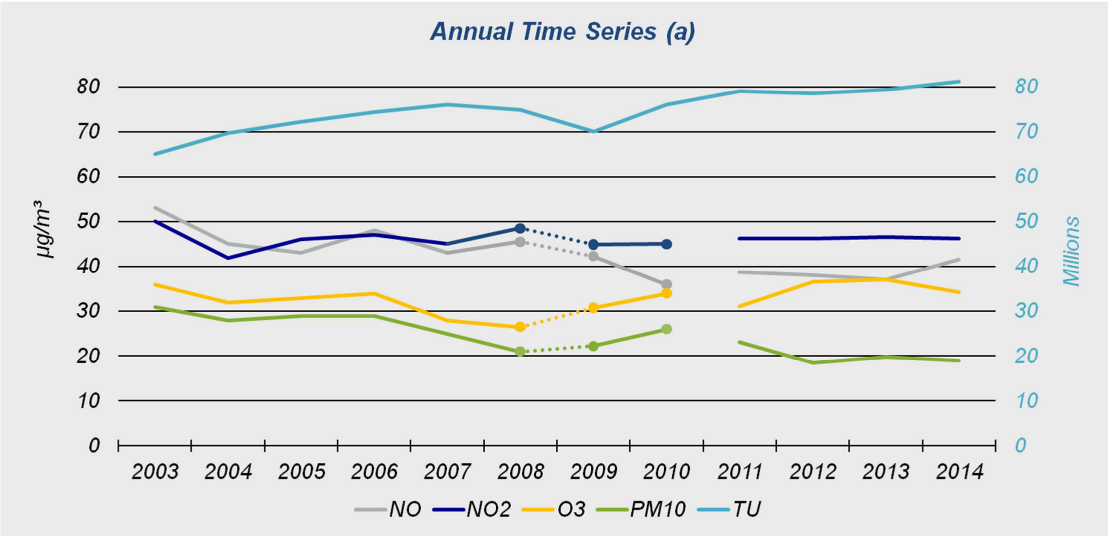
* Reference: Lufthygienischer Monatsbericht Dezember 2014 (floating annual means), HLUG and
Lufthygienischer Jahresbericht 2013 (Teil 2: Staub und Staubinhaltsstoffe), HLUG.
Part 2 (“Teil 2”) for particles and particle constituents for 2014 not available by copy deadline of this report.

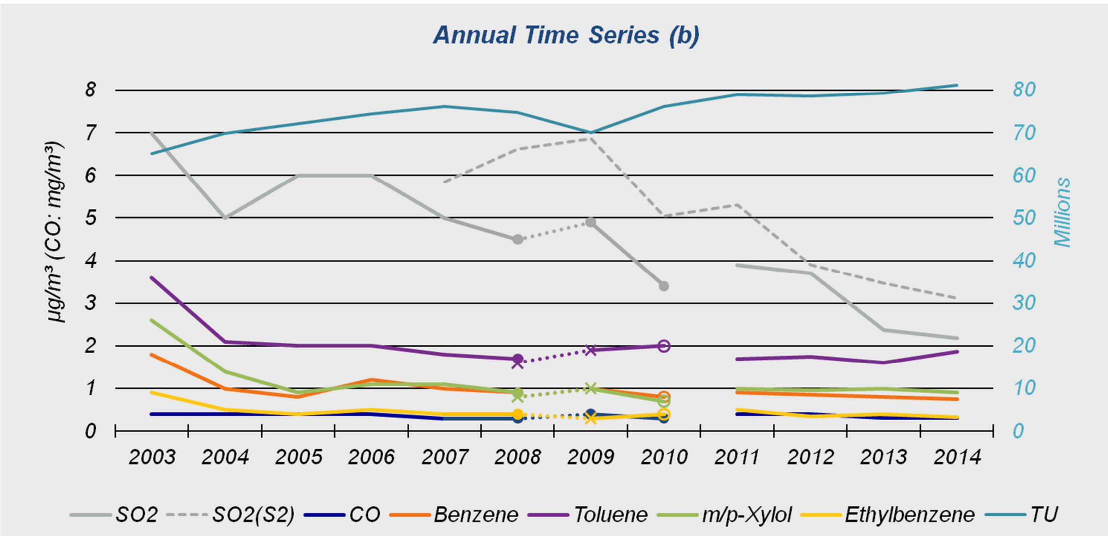
Comparison between Fraport Sites and Nearby HLUG Sites

In 2014 again, the annual means at the airport sites were within the medium and lower range of those at the comparative HLUG sites, like in the preceding years except for SO_2. The 2008 and 2009 annual reports already addressed aircraft emissions as a potential reason for the higher values at S2, without being able to prove this in detail. Nowadays, this component is no longer considerably important with respect to air quality and therefore it is no longer included comprehensively in the public monitoring network. Special HLUG monitoring campaigns at Frankfurt-Lerchesberg (2012/2013) and Flörsheim (2013/2014) yielded only 1.3 µg/m^3 averaged over a one-year period in each case and thus did not indicate any potential airport influence. This question will be discussed further on the following pages.

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

Most of the components continue to reveal minor changes. NO and ozone values are running reversely, regarding the year-to-year variation and also regarding dependency on the location. A tendency towards a decline of PM10-concentration and a marked decline of SO_2–concentration can be observed. This year's time series diagram additionally includes the SO_2-values at the current site of S2 in the central airfield. In the previous years, the concentration there has declined to a very low level as well, but it was still above the S1-values east of the airfield.





1 TU = 1 passenger including luggage or 100 kg of air freight 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

Tracking Aircraft-Related Ambient Air Concentrations

In case of superposing air pollution contributions from various emission sources sharing the same species of pollutants the fractions from distinct pollutants cannot simply be assigned by measurement alone. The strong and highly variable influence of meteorology on the spatial and temporal distribution of pollutants exacerbates this even more. Only if single emission sources are very dominant a relation to the pollutants can be found by elaborate evaluation.

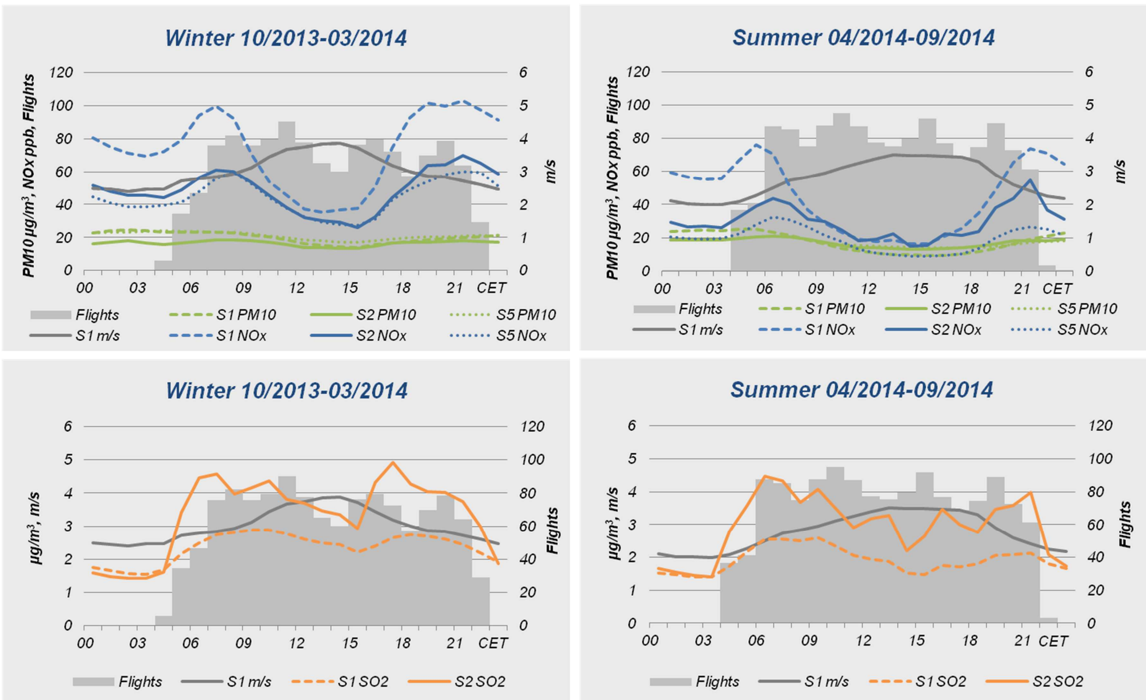
Special HLUG monitoring campaigns at Frankfurt-Lerchesberg and Flörsheim did not reveal any indication of particular aviation influence. Pollutant concentrations there have decreased by dilution to such an extent that they could not be distinguished by measurement from contributions due to other sources, e.g. road traffic. Likewise, the usual statistical figures of our own monitoring series did not allow any definite conclusions on aviation shares. First of all, this means that contributions by aviation cannot be of any major relevance with respect to air quality, particularly outside the airport. Thus the following attempt to identify specific pollutant contributions is purely technically motivated.

In order to eliminate as many interfering influences as possible, evaluation is performed considering the following principals:

- Examination of the close range, where the effects searched for are supposed to be largest
- Considering different exposition at various sites
- Establishing a temporal relation to the “air traffic” pollutant
- Comparison between components of different importance for the influence searched for

Accordingly, the following graphs display the mean diurnal variation of nitric oxides (NOx = NO + NO_2), particles (PM10) and sulfur dioxide (SO_2) in parallel to the course of aircraft movements and wind speed, during winter 2013/2014 and summer 2014 respectively. The time axis refers to CET as is usual in terms of monitoring. Thus, aircraft movements begin and end one hour earlier during Central European summertime. In consequence, during the winter period a superposition of CET and summertime occurs on the time axis.

Influence of other local sources is assumed to be least at site S2 in the central airfield. There, the effect searched is expected to be most obvious. The results are therefore highlighted by a solid line. In comparison the S1 data near the A5 motorway are displayed as a dashed line, while the S5 data near Runway Northwest are shown as a dotted line.



Latest mean diurnal variation of air traffic, wind speed and measured concentration data
Same color = same component

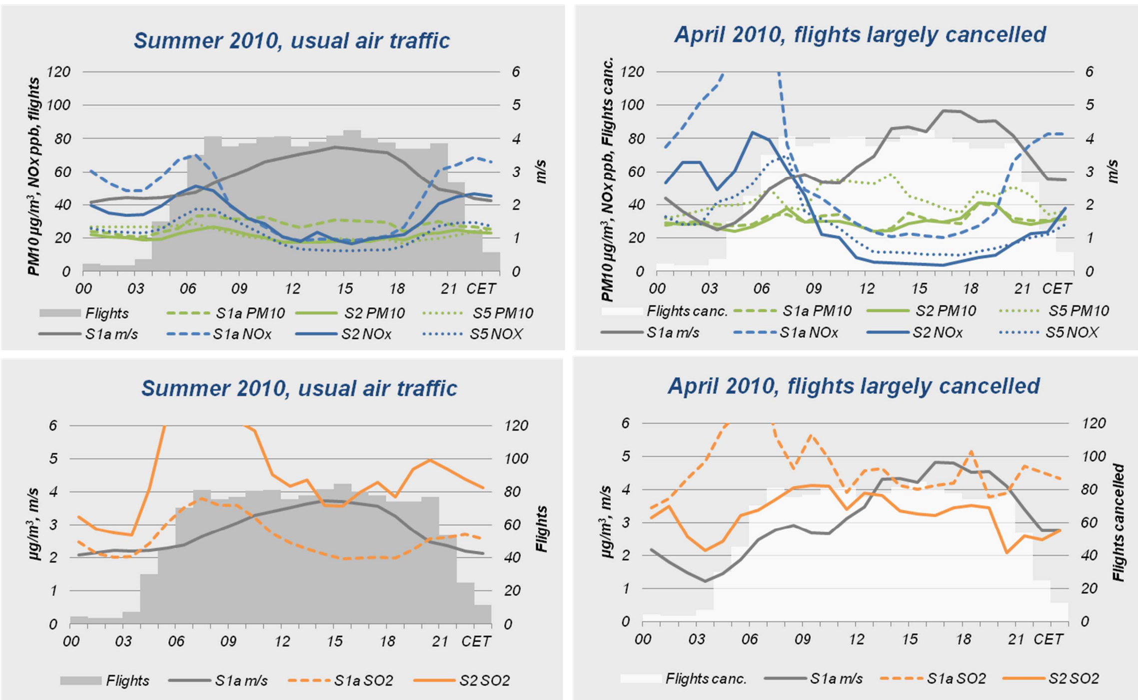
In general, concentrations are higher in winter than in summer, largely due to limited atmospheric mixing during winter, which is also reflected in the course of wind speed. The corresponding concentration graphs behave inversely displaying a narrow minimum during daytime in winter and a considerably wider one in summer. Thus, the morning and evening peaks from road traffic emissions are superposed.

While particle concentration is running nearly constantly because of the well-known high regional background share, thus maintaining a common level at all sites, there are large differences regarding the other components. Maximum values of nitrous oxides are found at S1 near the motorway, followed by S2 and S5. During daytime, when atmospheric mixing is enhanced, the concentration values largely assimilate to each other at the three sites. In the evening and at night, concentration values continue to be widely apart.

The SO_2-graphs at S1 and S2 behave quite differently. The higher and somewhat more regular shape of the winter values at both sites is partly due to domestic heating. At night, concentrations are practically the same, but during the time of air traffic the S2 values in the central airfield are above those of S1. The excess SO_2 at S2 can only be explained by air traffic. Large-scale influence from distant sources should have a similar impact on both sites. Likewise additional local influences within the range of S2 cannot serve as an explanation. While many emission sources have widely reduced their SO_2-emissions already, kerosene still contains a clearly higher amount of sulfur than, for instance, diesel fuel or the commonly used sulfur reduced domestic fuel oil.

This evaluation does not allow to absolutely quantify the SO_2-contribution from aircraft because the background fraction is unknown as is a certain SO_2-contribution from aircraft that should likewise be assumed at the location of S1. Furthermore, it should be considered that the measured SO_2-values in the range of few $\mu g/m^3$ are on a very low level regarding the reference values and the measurement accuracy as well.

The observed reverse proportion S2:S1 of the SO_2-concentration compared to nitrous oxides is also found during other years. At this point a period will be presented which reveals the relationship to air traffic in a particular way. As covered by our Annual Air Quality Report 2010, during April that year nearly all flights had been cancelled for several days following an Icelandic volcano eruption and the danger to air traffic due to its ash plume. Back then, impact analysis focused on the component NO_2 being relevant with respect to air quality. Regarding other variable influences, particularly meteorology, no impacts could be identified. The diagrams of the mean diurnal variation below verify that the data measured during summer days with usual air traffic were well comparable to those in the summer of 2014.



Mean diurnal variation of air traffic, wind speed and concentration data measured in summer 2010
Same color = same component

It should be noticed that the site properties of S1a correspond only approximately to those of S1 (see cover page). Differences of the concentration levels are obvious particularly for SO_2. They may partly be due to a declining emission trend. But regarding the low concentration level, instrument effects cannot be excluded either.

The results for April days, when practically no air traffic took place, should not be over-interpreted considering the smaller data basis and the corresponding large fluctuations. Due to weather conditions the concentrations are partly higher than on average days with usual air traffic. The elevated PM10-concentrations at the S5 site are assumed to be related to activities during the construction of Runway Northwest.

However, according to the reverse proportion S2:S1 of the SO_2-concentration compared to days with air traffic, the relationship to aircraft emissions seems to be obvious. Such relation is not to be established applying usual standards that focus on the relevance of the detected pollution. Only by performing a comparative analysis of the rather irrelevant SO_2-concentration with respect to further components at various sites – near the source but not yet quite independent, in parallel to air traffic and at a suitable aggregation level- a connection can be revealed. This knowledge alone is not sufficient in order to assess the importance of the airport with respect to air quality in its vicinity. To this end detailed model calculations are still necessary.

Theory and Practice of Odor Impact

In the previous year's report we presented the results of the odor field inspection performed in compliance with a corresponding provision by the zoning decision for Runway Northwest. For comparison, results of the odor projection model 2020 provided for the approval procedure were also shown. Now we have performed a model calculation for this current edition of the annual report that enables us to theoretically reproduce the odor frequencies which had practically been detected.

The LASPORT model applied for this purpose is not a specific odor model but is commonly in use at German airports in order to simulate material airport-related emissions and, in particular, aircraft-related emissions, as well as their dispersion. The application to odor issues needs some adjustments and simplifications, thus it represents a more or less rough estimate. Initially the results are provided as frequency values of hourly averaged substance concentration. This substance concentration is scaled by an adjustment factor which on one hand allows for the relation between substance and odor and on the other hand for the relation between hourly mean and short-term odor perception to be detected.

The estimate is based on the findings of the expansion approval expert study G20 (Odor Projection) regarding the relationship between odor and the concentration of hydrocarbons (HC). Aircraft HC-emissions are simulated by LASPORT specific methods. In order to approximately consider HC-emissions due to aircraft fuelling the approach from G13.2 (Road Traffic and Stationary Sources at the Airport) is transferred to current traffic data.

Details of Model Calculation

Approval procedure study G20 original:

- *Partly burnt HC: 31 OU/mg*
- *Unburnt HC: 16 OU/mg*
- *Scaling factor for hourly means: 1.3*
- ➔ *1 OU from 0.025 mg/m^3 HC on as hourly mean*

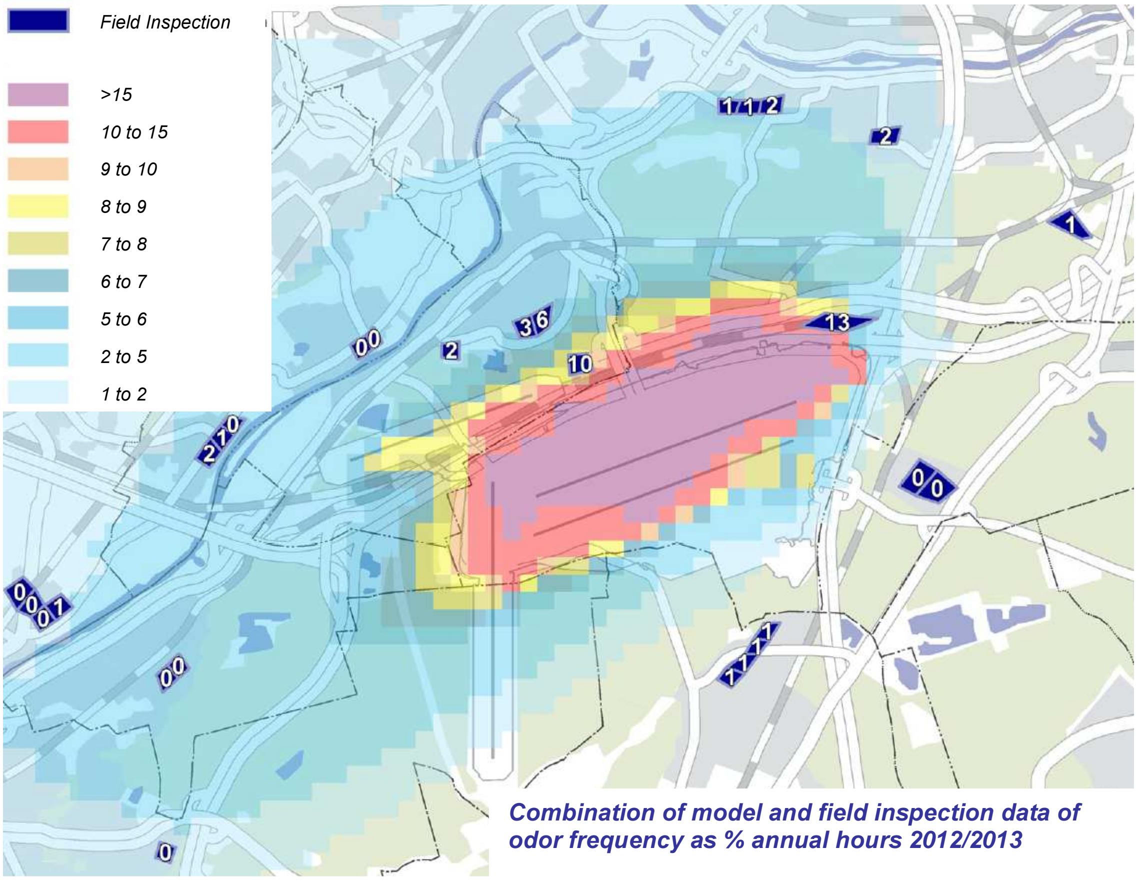
Current adjustment:

- *Summarizing HC weighting unburnt HC by 16/31*
- *Scaling factor: 1.5 considering current knowledge on emissions during engine ignition phase*
- ➔ *1 OU from 0.021 mg/m^3 HC on as hourly mean*

1 OU corresponds to the amount of a substance being the lower limit for odor perception.

For comparison the modeled one-year period corresponds to the period of the latest field inspection by Odournet GmbH between 2012-09-06 and 2013-09-05. The corresponding meteorological data were retrieved from the WebWerdis data base of the DWD German Weather Service and transformed into the required structure of an hourly time series.

The following map shows the results of the field inspection inserted into the model grids. The number values and the color scaling represent the frequency of odor hours during the 2012/2013 inspection campaign. According to the "Guideline on Odour in Ambient Air – GOAA" (Geruchsimmissionsrichtlinie – GIRL), 10% would be permissible for residential areas and 15% for commercial and industrial areas. Odor frequencies below 2% are deemed irrelevant.



Combination of model and field inspection data of odor frequency as % annual hours 2012/2013

In summary, it can be stated that the G20 modeling methodology is transferable to currently available operational and meteorological data if slightly adjusted. The calculated odor frequencies are largely distributed in the pattern determined by field inspection and can serve as indicative information for areas or scenarios where field inspection data are not available.

Deviations were to be expected particularly with very small frequencies. These may as well be caused by rare (modeled) events not having occurred or not having been detected during the inspection (see "0"-values at Raunheim, Kriftel). The information of 2%, as an example, refers to two odor hours per year registered by inspection. As even short-term perception is accounted for odor hours, it may possibly be only six minutes twice a year, meaning real single events. With higher relevant exposure in the vicinity, beginning with odor frequencies as low as about 5%, the coincidence is considerable.

Further Information:

Fraport AG
www.fraport.de

HLUG (Hessisches Landesamt für Umwelt und Geologie)
Hessian State Agency for the Environment and Geology
www.hlug.de

HLUG Special Monitoring Campaign Frankfurt-Lerchesberg
http://www.hlug.de/start/luft/sonstige-berichte.html
Erhebung der Luftqualität im Einzugsbereich der neuen NW-Landebahn des Flughafen Frankfurt Station „Frankfurt-Lerchesberg“

HLUG Special Monitoring Campaign Flörsheim
http://www.hlug.de/start/luft/sonstige-berichte.html
Erhebung der Luftqualität (Station „Flörsheim“) und des Staubniederschlags im Einzugsbereich der neuen NW-Landebahn des Flughafens Frankfurt

ACI Study on Air Quality during the Period of Cancelled Flights due to Volcanic Ash Plume
„Effects of Air Traffic on Air Quality in the Vicinity of European Airports“
www.fraport.de/aciluftqualitätsstudie2010

Geruchsimmissionsrichtlinie
www.lanuv.nrw.de/luft/gerueche/bewertung.htm

Guideline on Odour in Ambient Air – GOAA
http://www.lanuv.nrw.de/luft/gerueche/infos.htm

Information on LASPORT
http://www.janicke.de

Odor Field Monitoring, Odournet GmbH
http://www.odournet.com

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