ZURICH AIRPORT

Airport Local Air Quality

Zurich Airport Regional Air Quality Study 2013

Contents

1. Introduction

Zurich Airport is continuously monitoring the air quality at the airport and in its surrounding area. Legislative standards and recommendations as well as our own effort to keep adverse impacts of the airport as low as possible, lead to a comprehensive modeling and measuring of the airport air quality. Complementary to the regular measuring and the annual modeling of the airport's contribution to local air pollution, this study provides a complete assessment of the regional air quality situation in 2012. We provided an almost identical study of the regional air quality in 2005, using data from the year 2004 [1]. This means, eight years after the last overall picture, we provide, in co-operation with the cantonal authorities of the WWEA (Office of Waste, Water, Energy and Air), an up-to-date version of the study. Due to substantial changes in 2007 in the methodology to compile the emission inventory, which is the basis of the modeling, it is not appropriate to directly compare the results of the concentration modeling from the different years.

The work is divided in five distinctive tasks:

- Develop the airport emission inventory using the existing tool LASPORT (Version 2.0) and the actual Zurich Airport air traffic, handling activities and infrastructure operations;
- Perform a dispersion calculation of Zurich airport induced emissions, using the same tool and considering actual meteorological conditions for 2012;
- Combine the results with a regional emission inventory and calculate the total ambient regional pollution concentrations;
- Perform actual air quality measurements at and around the airport at a number of locations;
- Compare the measured values with the modeled values at given receptor locations.

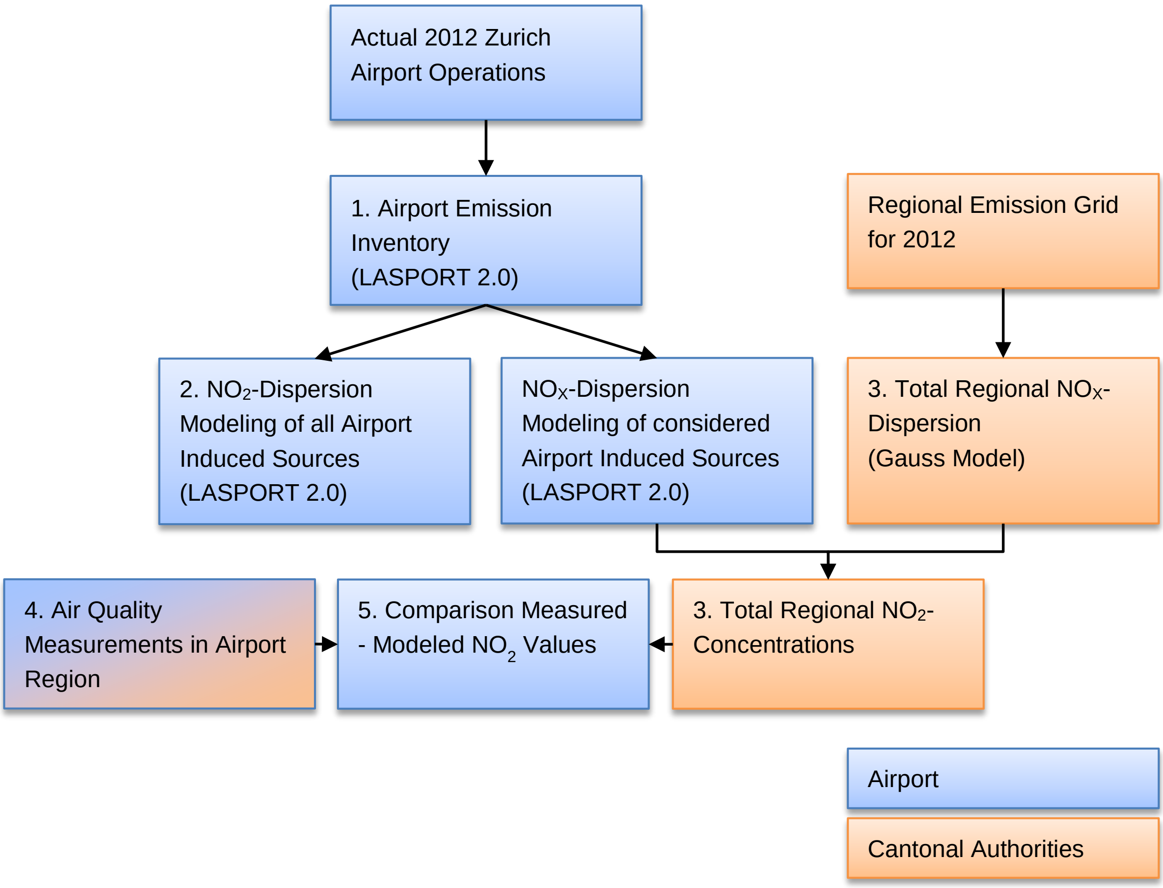

Figure 1 Flowchart of tasks.

2. Emission inventory

The emission inventory for Zurich Airport for 2012 has been developed using the LASPORT (version 2.0) program system in the monitor calculation mode. This mode uses a specified movement journal and all other source groups based on a detailed airport setup. The table below shows the standard emission inventory for Zurich Airport, including all emission sources. For this study, however, some of the sources were excluded, because they are already included in the cantonal emission inventory. This is the case for the emissions of the local energy power station (combined heat power plant) and landside vehicle traffic.

Source Group	CO (t/a)	VOC (t/a)	NO_X (t/a)
Air Traffic (performance based LTO cycle)	1,479	284	978
Other airport sources	139	73	120
Total	1,618	357	1,098

Table 1 Emission inventory for 2012 (LSZH)

The emission inventory data as displayed in table 1 only refers to this specific study set-up. Standard emission inventory reporting of Zurich airport includes all emission sources that are related to the activities at the airport. Specifically, aircraft emissions are calculated in the advanced mode which includes performance based modeling.

For the simplified characterization of air quality impacts, emission inventories from different contributors are often listed. Such contributors may include aviation, industry, traffic, agriculture and housing. However, the actual impacts on pollution concentrations only occur from emissions released between ground level and approximately 300 meter above ground (1,000ft). Above this threshold, emissions hardly contribute to the local concentrations anymore. If emission inventory data from airports are used as a surrogate for impact estimation or for source comparison reasons, then the upper emission loads from aircraft have to be subtracted.

3. Dispersion Calculation

3.1. Airport Induced Pollution Concentrations

3.1.1. General Settings

The dispersion calculation has been performed using the scenario module of LASPORT 2.0. The input data for the scenario is based on the actual aircraft by aircraft operations. This ensures that the same aircraft and operations data is being used while at the same time the calculation time for the dispersion is considerably reduced.

3.1.2. Source Dynamics

The source dynamics of the emissions from aircraft engines is accounted for by a power-dependent, directed exit velocity and turbulence characteristics. For other source groups, thermal plume rise is covered parametrically based on the German Guideline VDI 3782 Part 3 (APU, GPU) [2].

3.1.3. Meteorology

The necessary meteorological parameter is derived from an automated ultrasonic anemometer located at the airport, 10 meters above ground. One hour mean values are being used. The generation of boundary layer profiles is done with the meteorological pre-processor of LASAT.

3.1.4. Orography

The model uses the complex terrain function instead of the flat terrain. Basis is the Swisstopo digital terrain model that provides the altitude above mean sea level with an accuracy of ≤1 m on a 25 m grid. The buildings are not considered in the dispersion calculation.

3.1.5. Chemistry

The chemical conversion of NO to NO_2 is modeled by means of linear conversion rates dependent on the atmospheric stability according to the German Guideline VDI 3782 Part 1 [3]. The initial value is set to 0.15 NO_2 in NOx.

3.1.6. Dispersion Calculation Results

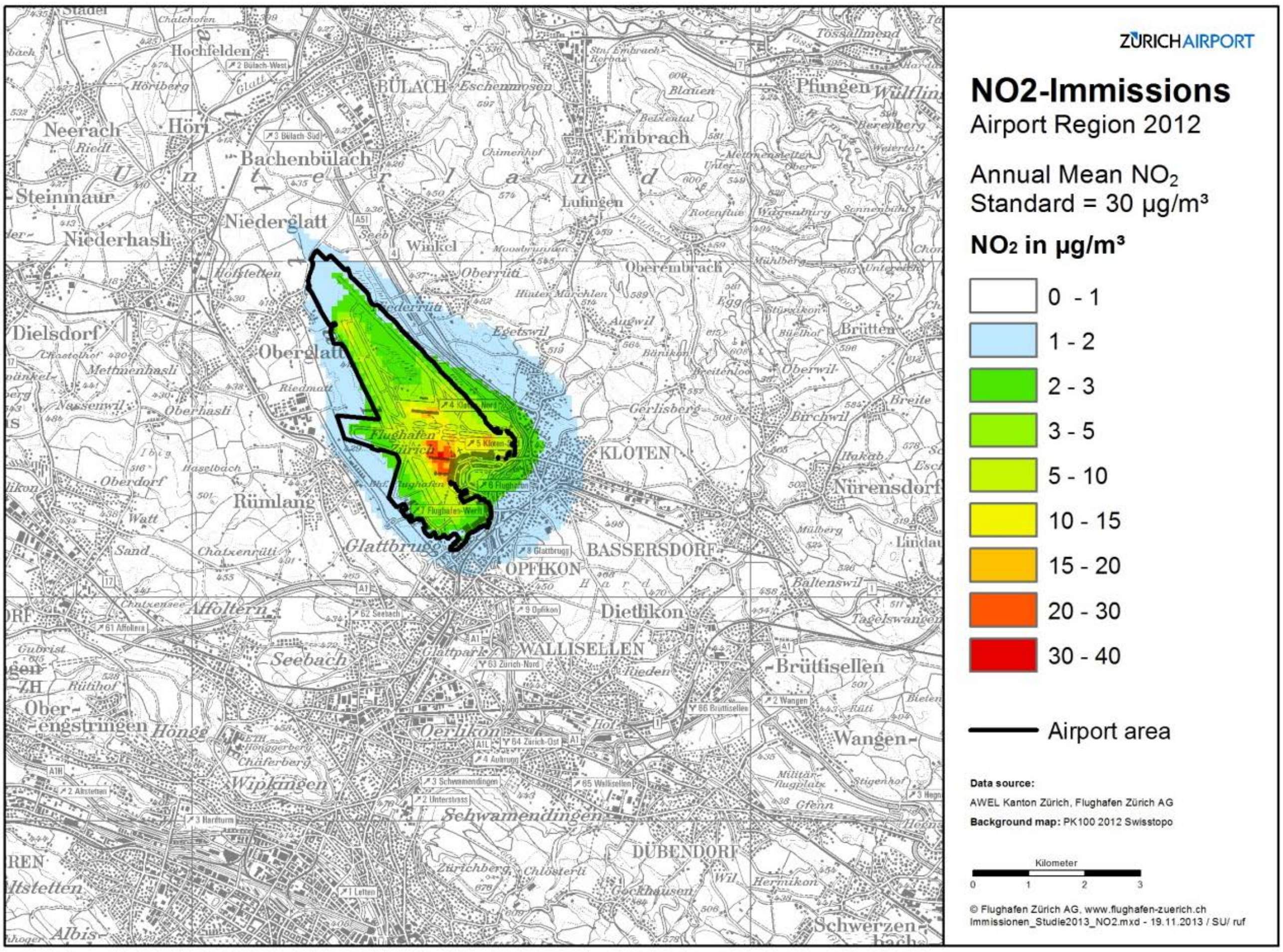

Figure 2 NO_2 pollution concentration induced by Zurich Airport 2012.

The results show concentrations contours that are to a large degree within the airport boundary (the 3 $\mu g/m^3$ contour is considered significant). The total influence of aircraft and airport end approximately 2km outside the airport boundary.

3.2. Total Ambient Concentrations Airport Region

3.2.1. Applied Methodology

On behalf of the regional and national authorities (in particular the Canton of Zurich), the companies INFRAS and METEOTEST have developed and operate a dispersion model for air pollutants. This model uses an emission inventory with emissions from all relevant sources (road, rail, ship traffic, heating in houses, trade and industries, construction and industrial machinery, forestry and off-road activities). Given that detailed analyses have been done for 2010 and 2015, the emissions of the year 2012 have been linearly scaled for this study. The NO_X concentration is calculated using a Gauss model with a meteorological pre-processor, resulting in annual mean values on a hectar-grid (100 x 100 m). Inventories and grid are implemented in a geographical information system (GIS).

A detailed description of the methodology is available here:
http://www.bafu.admin.ch/publikationen/publikation/01634/index.html?lang=en

The NO_X-concentration grid is combined with the NO_X-concentration grid of the airport induced emissions and transformed into the final NO_2 concentration map. Since the regional model already contains the landside access traffic to the airport as well as the heating, this part is subtracted from the airport's model in order to avoid double counting.

In addition to the NO_X emission sources in the area, also background NO_X emissions are accounted for in the model. The concentration is a function of reference and the actual terrain elevation, regional NO_X production and import from further away. The resulting NO_X has been calculated into NO_2 by means of an empirical conversion. This yields good values for annual mean values, while for short term considerations of very high NO_X exposures a different approach would have to be applied.

3.2.2. Results

Figure 3 shows the airport region of approximately 16 x 16 km. The areas of increased annual mean NO_2 pollution concentrations can be identified as being the roads (mostly major highways) and the airport apron. This reflects the rather detailed emission modeling for both of these sources (availability of operational data and emission factors). Large parts of residential areas in the vicinity of the airport show NO_2 concentrations below the Swiss standard of 30µg /m^3 annual mean.

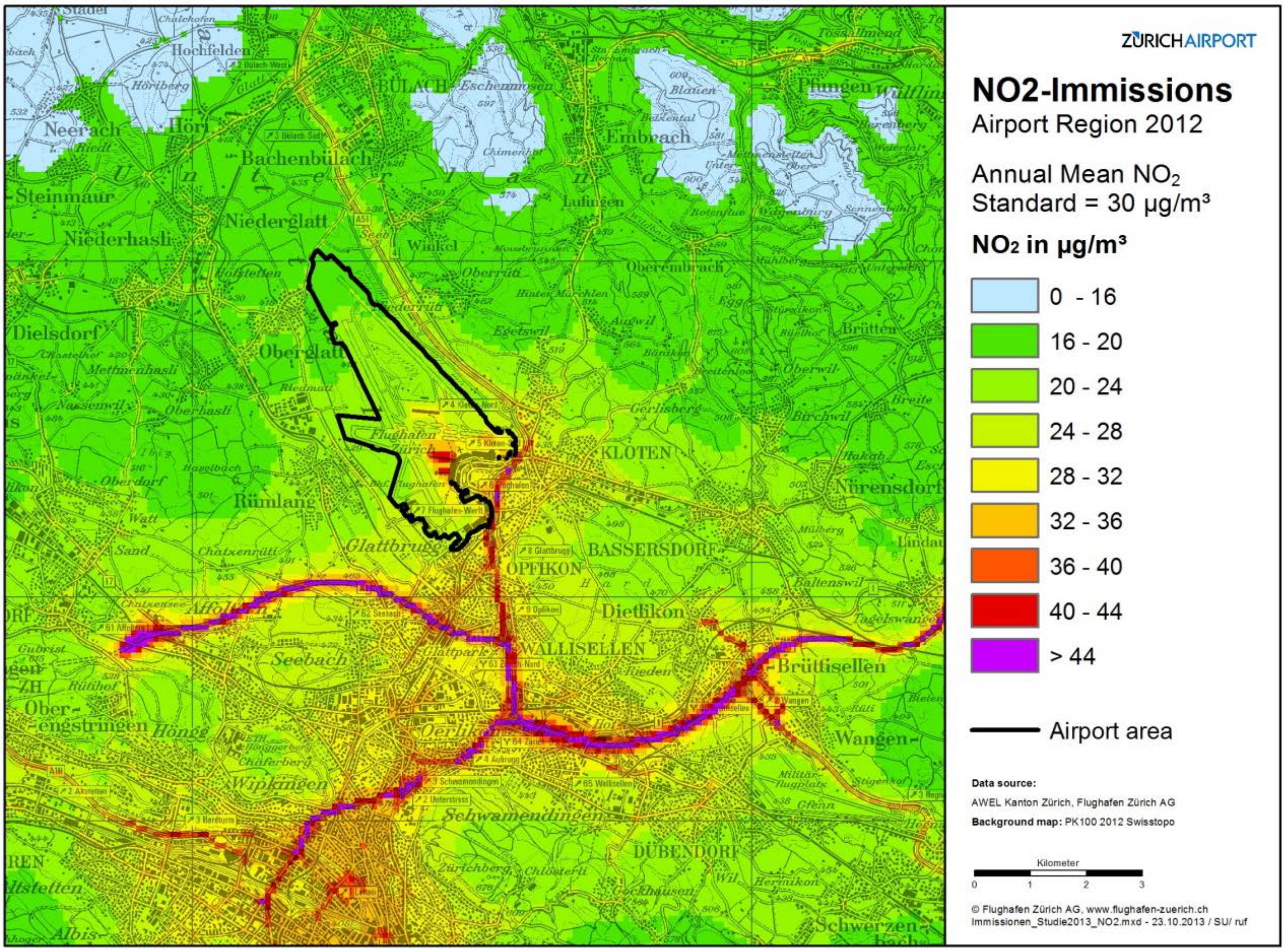

Figure 3 Total NO_2 pollution concentration in the larger Zurich airport area in 2012.[1]

4. Measured Concentrations

Zurich Airport has monitored the local air quality in the vicinity of the airport for many years. The monitoring sites have been selected following a monitoring concept that has been developed with the cantonal authorities and was last updated in 2011. It reflects average annual wind situations, expected main source contributors, and expected development of pollution concentrations in the future. The monitoring devices in the region are passive NO_2 sampling tubes that are changed and analyzed every two weeks. The stations at the airport site are, apart from two passive sampling tubes, automated continuous monitoring stations, using the DOAS methodology (differential optical absorption spectroscopy) and a standard NOx/NO/NO_2 analyzer (Table 2).

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[1] The significant stop in pollution from one of the motorways West of the airport is due to the road leading into a tunnel (“Gubrist”-tunnel).

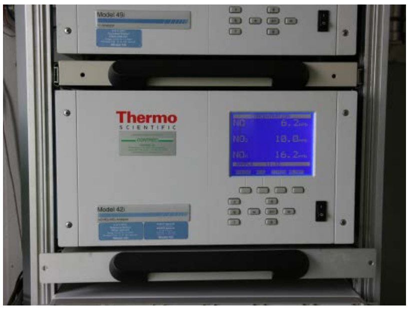
Passive NO_2 Sampling Tubes	DOAS Measurement Path	Analyzer in Container
		

Table 2 Air Quality Monitoring Devices Zurich Airport and Region

Figure 4 shows the measured concentrations of NO_2 in relation to the Swiss legal standard of 30 µg/m^3 annual mean. The values show the total concentrations from all sources, while the modeled values in Figure 2 are from airport induced sources only. This does not allow yet for a direct comparison between the model and the measurements, but gives indications about the relevance of potential sources (e.g. road traffic south of the airport).

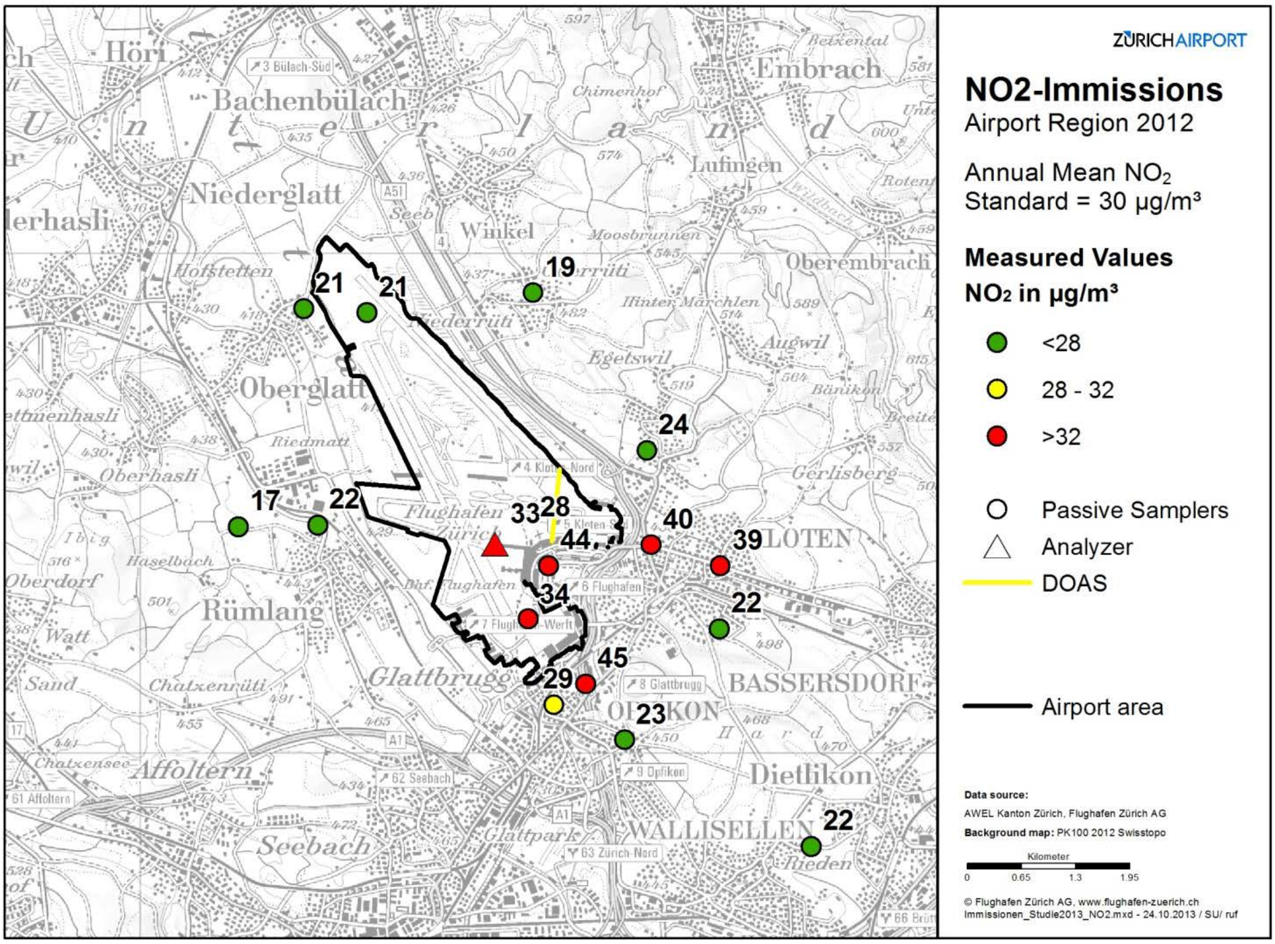


Figure 4 Measured NO_2 pollution concentration in 2012 (values are in µg NO_2/m^3);

5. Comparison Measured - Modeled Concentrations

The measured and the modeled total NO_2 concentrations have been compared and evaluated (Figure 5 and Figure 6). The locations were grouped according to their anticipated main contributor specified in the airport's ambient air quality monitoring concept (May 2013):

- Monitoring stations most likely to be dominated by **road traffic**;
- Monitoring stations most likely to be dominated by **airport activities**;
- Monitoring stations most likely to dominated by **other sources**;
- **Background** monitoring stations.

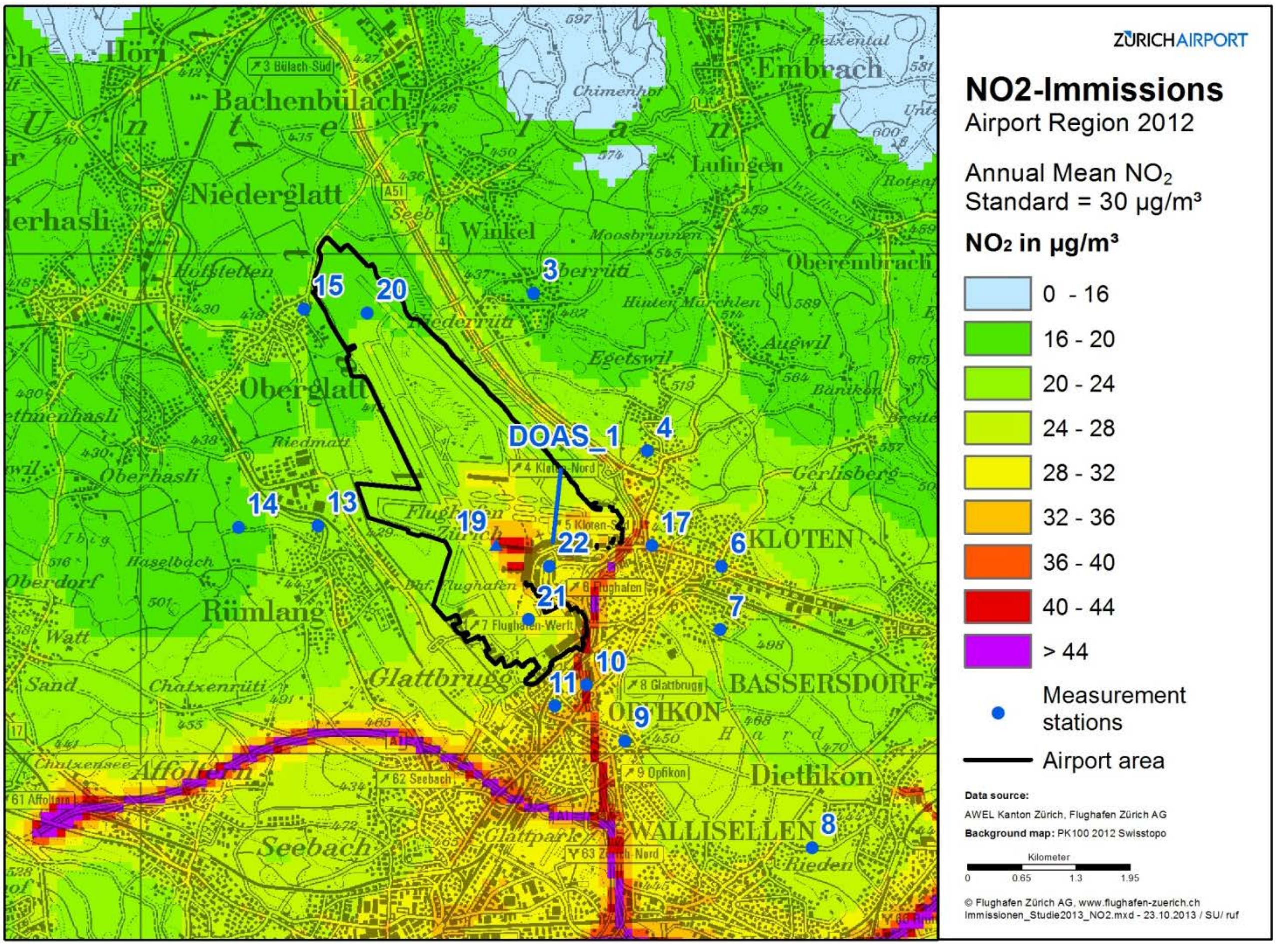


Figure 5 Modeled total NO_2 concentrations and measurement stations in 2012 (numbers = station numbers)

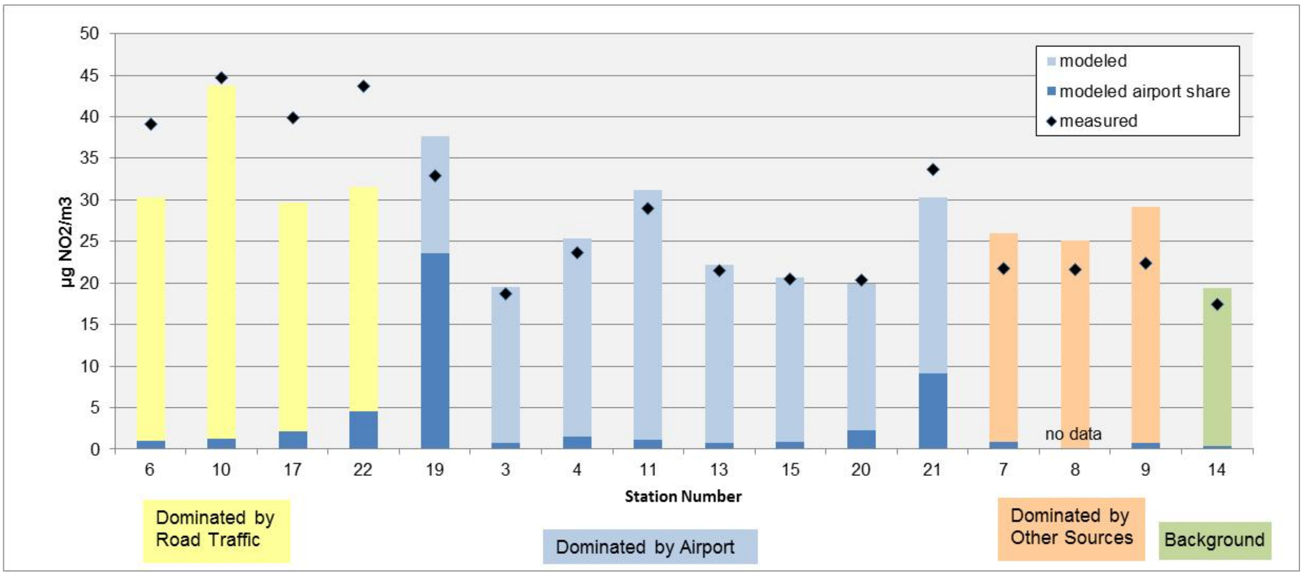


Figure 6 Modeled vs. measured NO_2 concentration values (2012).

Locations that are mostly road emission dominated show higher measured concentrations than modeled values (Nr. 6, 10, 17, 22). In the particular case for Zurich, this is known to the authorities. The model calculates spatial averages within 100 m and may therefore not reflect maximum values as they occur next to streets.

Measurement stations at the airport show a much better accordance to modeled values. Some of them correspond exactly with the modeled values (Nr. 3, 13, 15, 20), others show lower values (Nr. 19, 4, 11) and one is higher (Nr. 21). Stations dominated by other sources are all of them overestimated when modeled. Overall, modeled values at the airport correspond well with the measured values.

As the calculation method changed in the year 2007, it is not feasible to compare the modeled values from 2012 to those from 2004 in the preceding study. However, it is possible to compare the measured values. Figure 7 shows the development at the stations dominated by the airport. Overall tendency is to slightly lower values for most of the stations. At the same time, traffic capacity increased by almost 40%. That means, the airport's growth was not at the expense of regional air quality. Continuously improving infrastructure, modernized ground equipment and ever more efficient flight operations (bigger airplanes with better passenger-load-factors) allow pollution to stay at the same level or even improving a little bit. It is important to see that there is no correlation between the number of aircraft movements and regional air quality. The latter seems rather mostly influenced by meteorological conditions during the year.

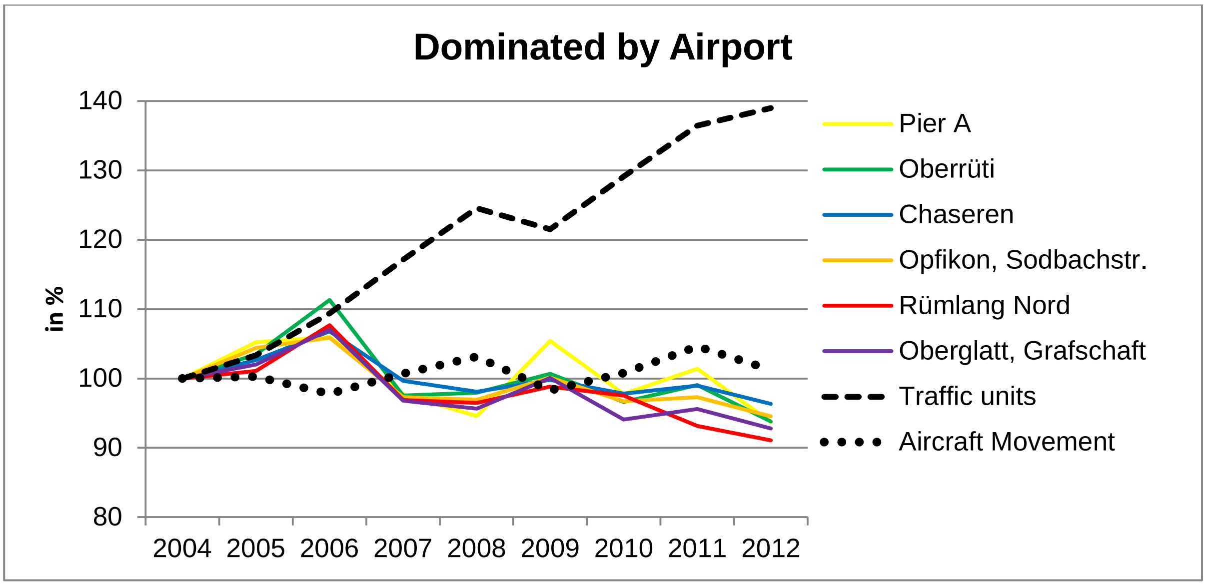


Figure 7 Development in percent of measured values of stations dominated by airport.

6. Conclusions

This study analyzes the local air quality in the wider region of Zurich Airport. Therefore, the result of a detailed calculation of the airport's contribution to concentrations was integrated in the comprehensive model of the cantonal authorities. The resulting map shows the total NO_2 concentration in a 100x100m grid. At first sight it gets clear that highest values appear along the motorways and slightly lower ones on the airport apron directly around the piers A and B. Further on, we can find high values of NO_2 along other highly frequented roads in the suburban areas. At the same time, concentrations around the airport remain relatively low. As showed in other studies and in annual concentration calculations, the pollution originating at the airport does not spread very widely. On the contrary, it is mainly restricted to the airport apron and regular starting points on the runways. Outside the airport fence, already after a short distance the contribution of the airport cannot be determined any more.

Modeled concentrations were verified by actual measurements at various stations. The results show a good degree of correlation between modeled and measured values at the discrete receptor points. Especially the stations that are categorized as to be dominantly affected by the airport show a high correlation. That means that both the cantonal and the airport's model used to calculate concentration are quite accurate.

Annexes

A.1. Short Description of LASPORT

LASPORT is a program package for dispersion calculations in the context of air pollutant emissions from airports. In particular, emissions of aircrafts (complete LTO cycles), auxiliary power units (APU), ground power units (GPU), and airside and landside car traffic as well as any stationary source are accounted for.

The dispersion calculation is carried out with an integrated version of LASAT. It is based on a meteorological time series in which all meteorological parameters are specified as hourly means for the time period of interest (usually a complete year). The necessary input data are created with the help of an emission data base, an interactive graphical user interface and transformation programs. Data input, program execution, and result visualisation can be handled within the graphical user surface. For the definition of aircraft movements, two different methods are provided: With monitor calculations, individual aircrafts are tracked with a high spatial and temporal resolution. Monitor calculations are particularly suited to study situations in the past for which detailed information about aircraft movements and emissions are available. With scenario calculations, more general information about aircraft movements (like e.g. the total number of aircrafts of a given type together with the annual distribution of departures and approaches over the runways and parking positions) are used to create hourly means of aircraft movements which are distributed among the runways, taxiways and parking positions. Scenario calculations demand less input data and computation time and can be used e.g. to study prognosis scenarios.

LASAT (Lagrangian simulation of aerosol transport) is a program package for atmospheric dispersion simulations. It is based on a Lagrangian dispersion model which calculates the turbulent transport of trace elements in the lower atmosphere (up to a height of about 1000 m) by a stochastic simulation of the motion of a representative sample of particles on a computer. Effects of dry and wet deposition, sedimentation, linear chemical conversion and plume rise are accounted for.

The program package includes a meteorological pre-processor which provides the vertical profiles of the mean wind velocity and direction and the turbulence parameters. For complex terrain (orographically structured terrain, buildings), a diagnostic wind field model is used to calculate the three-dimensional wind and turbulence fields.

An arbitrary number of emission sources can be defined in form of point, line, and area sources. Among other parameters, source strength, source geometry and meteorological data can be specified as time series. The result of a dispersion calculation is the time series of the three-dimensional concentration distribution for each trace element. Here, a concentration value is the spatial mean over a cell of the pre-defined spatial grid and the temporal mean with respect to a pre-defined time interval. For each concentration value, the statistical uncertainty inherent to stochastic simulation methods is calculated and written out automatically during the simulation.

LASAT is a tool for the expert who has to assess special dispersion situations. LASAT has its origin in a model which was developed in 1980 and which has been tested in various research projects. Since 1990 it is generally available as a software package and it is now applied by state agencies, experts, industrial companies, fire-brigades, and airports. LASAT is verified according to the German guideline VDI 3945 Part 3 and served as the base for the dispersion model AUSTAL2000 of the revised German administrative regulation TA Luft.

Figures

Tables

Sources

No.	Document Name
[1]	Airport Local Air Quality Studies, ALAQS Case Study: Zurich Airport 2004, a comparison of modeled and measured air quality. EEC/SEE/2005/017. Eurocontrol Experimental Centre. Brétigny-sur-Orge, 2005.
[2]	VDI 3782 Part 3: Environmental Meteorology; Dispersion of air pollutants in the atmosphere; Calculation of Plume Rise. Beuth, Berlin, 1985.
[3]	VDI 3782 Part 1: Environmental Meteorology; Gaussian plume model for air quality management. Beuth, Berlin, 2001.

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Version	Date	Name	Modifications
1.0	3.12.2013	Ruf, Maraini, Fleuti	

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