Monitoring of Particles and other Pollutants under heavy transalpine Emission Burden

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The bilateral overland transport agreement between Switzerland and the European Community was supposed to lead to an increase of goods traffic in Switzerland and to raise air and noise pollution especially in the area of the alpine transit routes. To get basic data a special Monitoring Network was developed. The air related part of the system analyses the traditional pollutants as well as some particle characteristics related to heavy duty traffic. In this paper the monitoring system and first results are presented.

1. Introduction

Alpine regions are known as environmentally sensitive areas and therefore they need a relatively higher protection. The bilateral overland transport agreement between Switzerland and the European Community was supposed to lead to an increase of goods traffic and thus to raise air and noise pollution mainly in transit areas. To get basic data a special monitoring network along the alpine transit highways Gotthard and San Bernardino was developed, with emphasis to heavy duty traffic. Therefore in the air related part of the project some special particle characteristics have to be measured. The project is named "Monitoring of supporting measures, environment" (MSM-E).By the way it enforces the Position of Swiss federal authorities who states that from the view of public health also the concentration count and the surface area of ultrafine particles should be measured.

In connection with this project an investigation on air pollution burden in the alpine Reuss valley with the transit highway as the main source was elaborated. The question is, how strong the expected increasing of goods traffic affects the air quality in the valley and weather the health of inhabitants in the settlement area could be influenced adversely.

2. Previous studies

In the last few years several studies have been done in this area, mainly with NO2 and NOx as pollution indicators. They led to the conclusion that the air quality burden near highway in the Reuss valley is comparable to that found in Swiss Midlands with a three times greater traffic. This is due to a restricted atmospheric mixing based on the orography and frequent near ground temperature inversions at night und in the winter.

Valuable information about background pollution originates from temporarily closures of the Gotthard road tunnel. This was due to an avalanche on the highway and an accidental fire in the tunnel respectively. Knowledge about local NO2 burden in the valley originates from a local passive sampling network. With this network an information about the air quality in the valley before, during and after the tunnel closure could be attained (cp. figure "NO2 im Urner Reusstal). Comparing the situation before and during closure the dominant influence of the highway on the air pollution quality could be shown. Even in the village of Altdorf at a distance of one km from the highway the NO2 concentration dropped by 8 ug/m3. After reopening of the tunnel the HDV traffic had to be reduced by safety reasons by one third. Thus in the northern part of the highway a stretch for a controlled stops and releases of HDT traffic was installed. In this area NO2 concentration reached levels similar to the situation before closure whereas further south with free traffic an expected lower burden resulted. That shows that air quality in the whole valley is strongly influenced by the traffic emissions of the highway.

3. Methodology

The aim to be achieved was get knowledge about the concentration fields of various pollutants in the surroundings of the dominant line source and how they are influenced by meteorological effects.

The experimental setup consisted of two identical equipped ambient air monitoring stations placed near the flat Highway. One station (MSM-E) was placed at a distance of 8 m from the breakdown lane the other at 200 m. Both stations were equipped with monitors for gases and particulates (e.g. PM 10, soot and particle

number concentrations) and meteorology. (Cp. Table Ambient Air Monitoring Stations….). Additionally a temperature profile at the steep slope of the valley with 6 temperature sensors (height spacing 40 m) was used to detect temperature inversions.
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4. Results

The measurement period began in July 2002 und finished end of May 2003. Now a first overview on results is given.

At first mean values of concentration traces for a one week period in may 2003 are shown .The NOx Plot primarily shows the daily variations related to the frequencies of the goods traffic and consequently to the specific Swiss traffic regulations (Night ban and Sunday ban for HDV) e.g. low values at night time and over the weekend. Despite more or less constant HDV traffic during daytime at workdays high peak values are found in the early morning after the end of the night ban, strongly influenced by the unfavourable nocturnal dispersion conditions ending at about 9 o'clock. Afterwards there are moderate concentrations till about 20.00 h, when traffic begins to diminish. Over the whole week for the more distant station the NOx trace shows a similar time series but at a lower concentration. Highway traffic at a distance of 200 m remains the dominant NOx source.

How looks the situation for various particles? At first black carbon and particle number concentration are shown. Near the highway and during workdays the concentrations of black carbon and those of particle number show similar patterns. Over the weekend only black carbon drops remarkable but for particle number there is only a small reduction. At the more distant station the situation is less clear. The concentrations are strongly reduced and the patterns follow those at the highway only partly: morning peaks are found but black carbon shows additional peaks. At a distance of 200 m from Highway this traffic is still an important source for black carbon and Particle number concentration.

For PM10 one finds patterns which are more or less constant over the whole week and do not correlate with traffic relevant NOx , as the figure shows. The concentrations patterns are nearly the same for both stations. Nearly the same patterns were found for PM2.5. There is no distance dependence to see for both fractions. Other sources seem to be more important. It is known that at rural traffic exposed areas only about 38 % of the PM10 concentration can be attributed to traffic emission (BUWAL, SRU Nr.310, 1999).

After this view on daily variations over a period of one week in springtime seasonal variations are observed. For NOx and NO2 highest seasonal values are found in winter despite the fact that this is the season of lowest HDV traffic. From earlier investigation one knows that this is because of unfavourable dispersion conditions. Similar seasonal patterns are found for Particle number concentrations, whereas the situation for black carbon is not clear. A strong discrepancy between the two distances is obvious. For PM10 and PM2.5 the lack of the already mentioned distance dependence seems to be confirmed. At both distances the ratio for the concentrations of PM2.5/PM10 is 0.8 For Benzene the expected pattern with a highest value in winter is found at both sites.

From the above mentioned findings a first estimate for concentration profiles and the corresponding seasonal variations can be made. Concentration ratios at highway distances of 8 m and 200 m are calculated for different air pollutants (cp. Table Estimation of Concentration Profiles….*).* The ratios can be compared with tat of NOx (0.4 +/- 0.1), which serves as a kind of internal reference. A higher ratio is found for PM10 and PM2.5 (1.0 +/- 0.1), NO2 (.0.6 +/- 0.1), and black carbon (0.5 +/ -0.1). For the particle number concentration a ratio of only 0.3 +/- 0.1 is found. The ratios for Benzene and Toluene needs further investigation and will not be discussed further.

5. Conclusion

The measurement of the concentration gradient near a Highway in an alpine valley gives beside near highway values an estimate how concentrations develop over a distance of 200 m and additionally it allows extrapolation of highway related burden to more distant settlement areas. The extension of chemical analyzers to nonregulated substances was useful with regard to source identification and to possible health impact. Useful traffic indicators are beside NOx black carbon and particle number but not PM10 and PM2.5.The high correlation between concentrations of NOx with black carbon and particle numbers allows estimates of concentration fields of these compounds from NOx measurements. The recording of diesel

relevant parameters could also help to detect the influence on air quality of increasing car traffic driven by diesel engines.

Other pollution sources in the valley have to be considered and reviewed for PM10/PM2.5 relevance e.g. large construction sites and wood burning. The analyses of the data have to proceed. To get more detailed information about the size distribution of ultra fine particles the measuring system should be extended with a particle sizer suitable for monitoring networks.

In future this method can be useful for investigations at highways with a different emission pattern that means with motors under high load or under idle conditions e.g. at highway stretches with a strong gradient or with a controlled stop/release of HDV. It further could be useful for other European transit axes and could lead to comparable facts about the development of air pollution with emphasis to goods transport.

Acknowledgement

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Altdorf , 03/10/2003 Franz Akermann

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7th ETH Conference on Combustion Generated Nanoparticles

Introduction

- Alpine regions are sensitive regions!
- The Reuss valley belongs to the alpine valleys crossed by a transit Highway.
- The Highway (A2) is the main source of air pollution in this valley
- How strong is the Air Quality in the settlement area of the valley influenced by A2? (e.g. by Particles)
- First Results of a new study are presented.

Contents

- Previous studies
- Project Lubetrax X
- Methodology
- Results
- Conclusion

Previous Studies

- LUBETRAX:
  - the near highway atmospheric pollution in the Reuss valley is comparable to Swiss Midlands due to a 3 times greater traffic:
  - Orography and frequent near ground temperature inversion (winter and night time) yield a restricted atmospheric mixing.

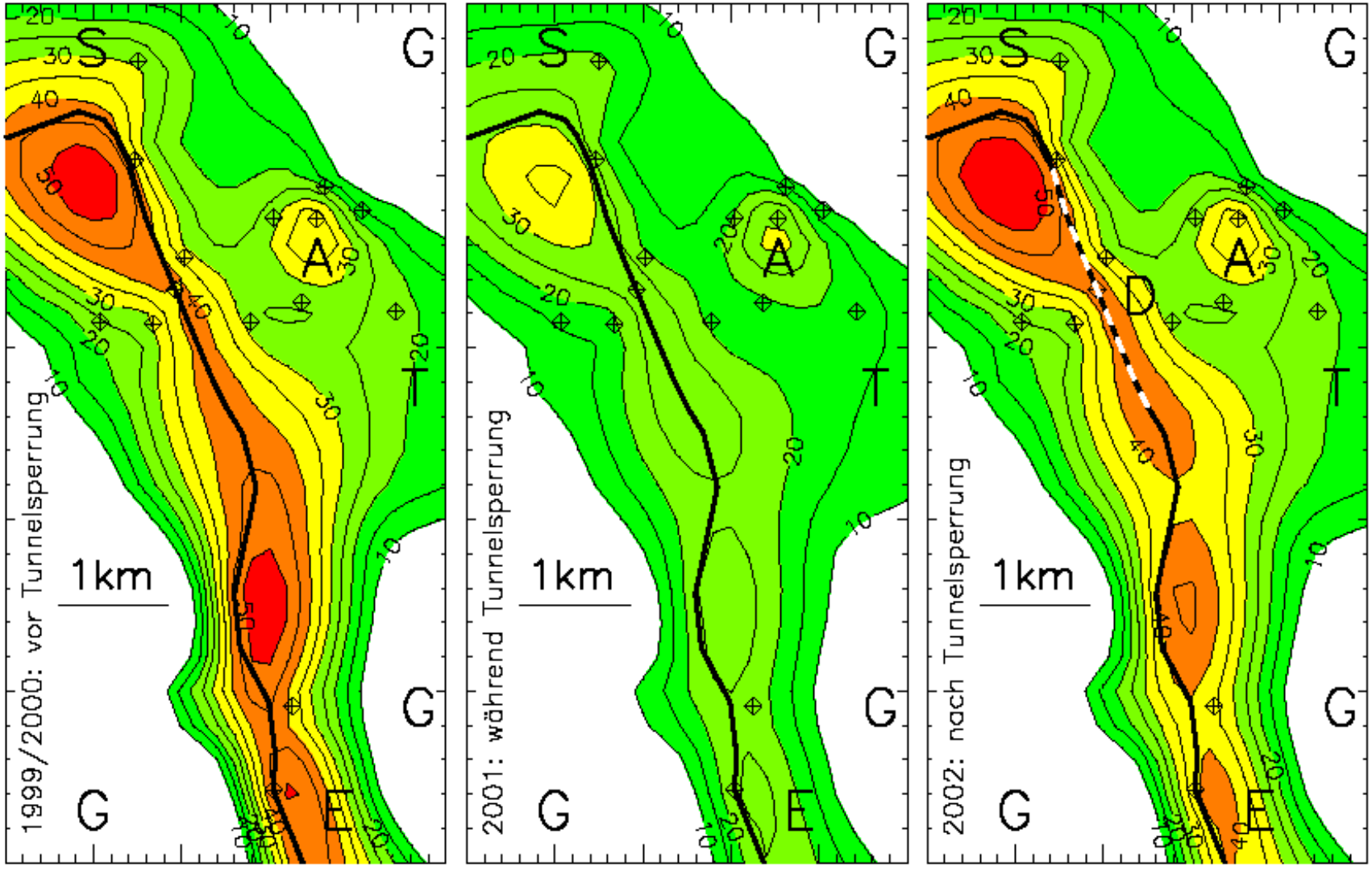
Previous Studies

- Gotthard road tunnel closures:
  - Valuable information about the background pollution originate from temporarily closures of the highway due to an avalanche and due an accidental fire in the tunnel
  - Concentration field of NO2 in the Urner Reuss valley

Institute for Atmospheric and Climate Science
IACETH

NO_2 im Urner Reusstal

KANTON URI
AMT FÜR UMWELTSCHUTZ



Legende: A=Altdorf; E=Erstfeld; T=Schächental; S=Urner See; G=Gebirge D=Dosierstelle (2002)
Zahlenwerte geben die NO_2-Konzentrationen in $\mu g/m^3$
Mittelung über jeweils November und Dezember

M. Semmler (IACETH) & F. Akermann (AfU, Abt. Immissionsschutz); 2003

The Project Lubetrax X

- Question:
  - How strong does the increasing goods traffic affect the air quality and the health in the settlement area near the A2?

- Methodology:
  - Two measuring stations: one at the highway and another one 200m off. For a time period of one year.
  - Sensitive air quality measurement of HDV and cars, included are non regulated species (cancerogenics**).**

- Equipment:
  - The chemical monitors are extended mainly to Particulates!

- This project is also part of the activities based on the Swiss traffic shift act.(shift of goods traffic from road to railway).
- With MSM-E six Air/Noise Monitoring Station are active along Gotthard an San Bernardino Highway. The Instrumentations are equal to Lubetrax .
- One Station in Uri is part of MSM-E network.

Ambient Air Measurement Station in Swiss Alpine Valleys

	Components	Apparatus	Manufacturer	Principle
Gases	NO2/Nox	ML9841A	MonitorLabs	Chemoluminescence
	CO	ML9830	MonitorLabs	IR-absorption (gasfiltercorrelation)
	O3	ML9810	MonitorLabs	UV-absorption
	BTX	GC-855	Syntech	Gaschromatographie PID
Particles	PM10 (Ref.)	High Vol. Sampler DHA-80	Digitel	Gravimetrie
	PM10	TEOM 1400AB	Rupprecht & Patashnik	Microbalance
	PM2.5	TEOM 1400AB	Rupprecht & Patashnik	Microbalance
	Partikel	CPC 3022A	TSI	Condensation particle counter
	Russ	AethalometerAE10 or Carusso	Magee Scientific or TSI	Absorption or Multi Angle Absorption
	PAH	PAS	Ecochem	Photoionisation
	Oberfläche	NanoMet	Matter Engineering	Diffusion Charger for $r < 0.5\ \mu m$
Meteo:	Meteo	Meteo light	Meteolabor	diverse

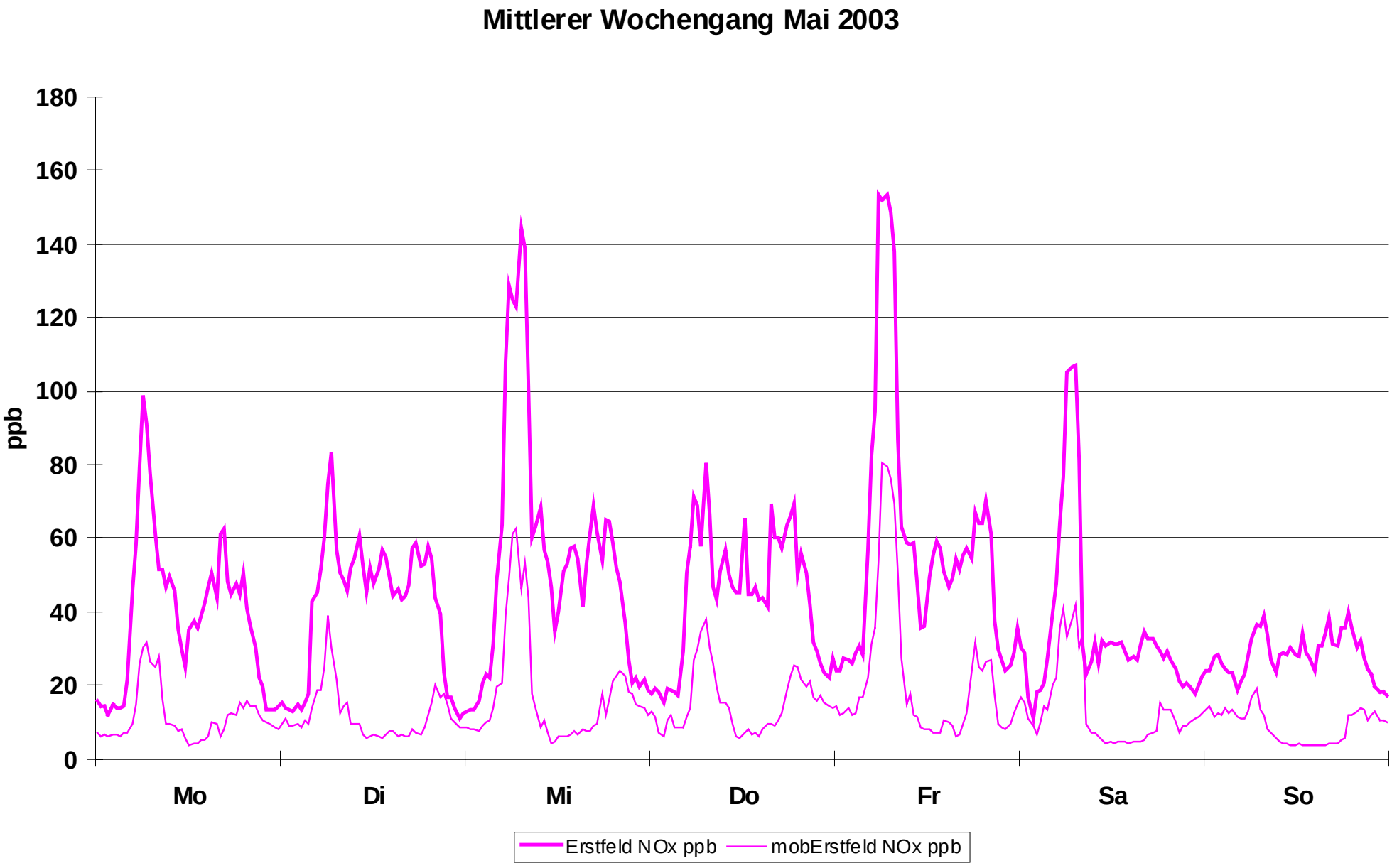
Results

- Overview over the air quality of one year and distance dependence relative to A2.
- Correlations between concentrations of pollutants.

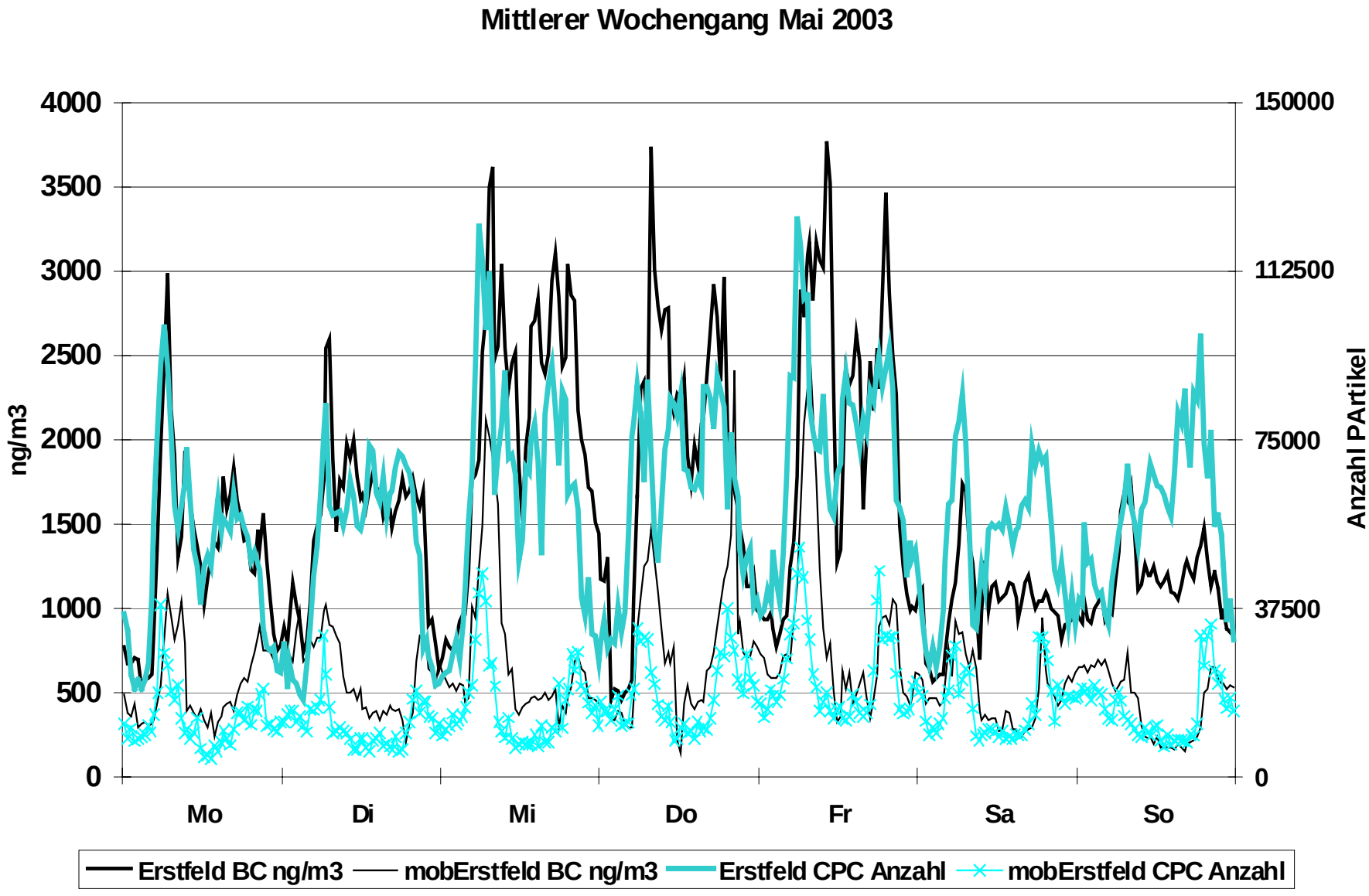
Concentration traces over a one week period

- Remarks to A2-traffic
  - In Switzerland, heavy goods traffic is limited by a night ban (22.00- 05.00) and a Sunday ban.
  - Maximum frequencies of HDV are in springtime and autumn.
  - Maximum frequencies of cars are in Summer
  - Lowest traffic emissions are in winter!

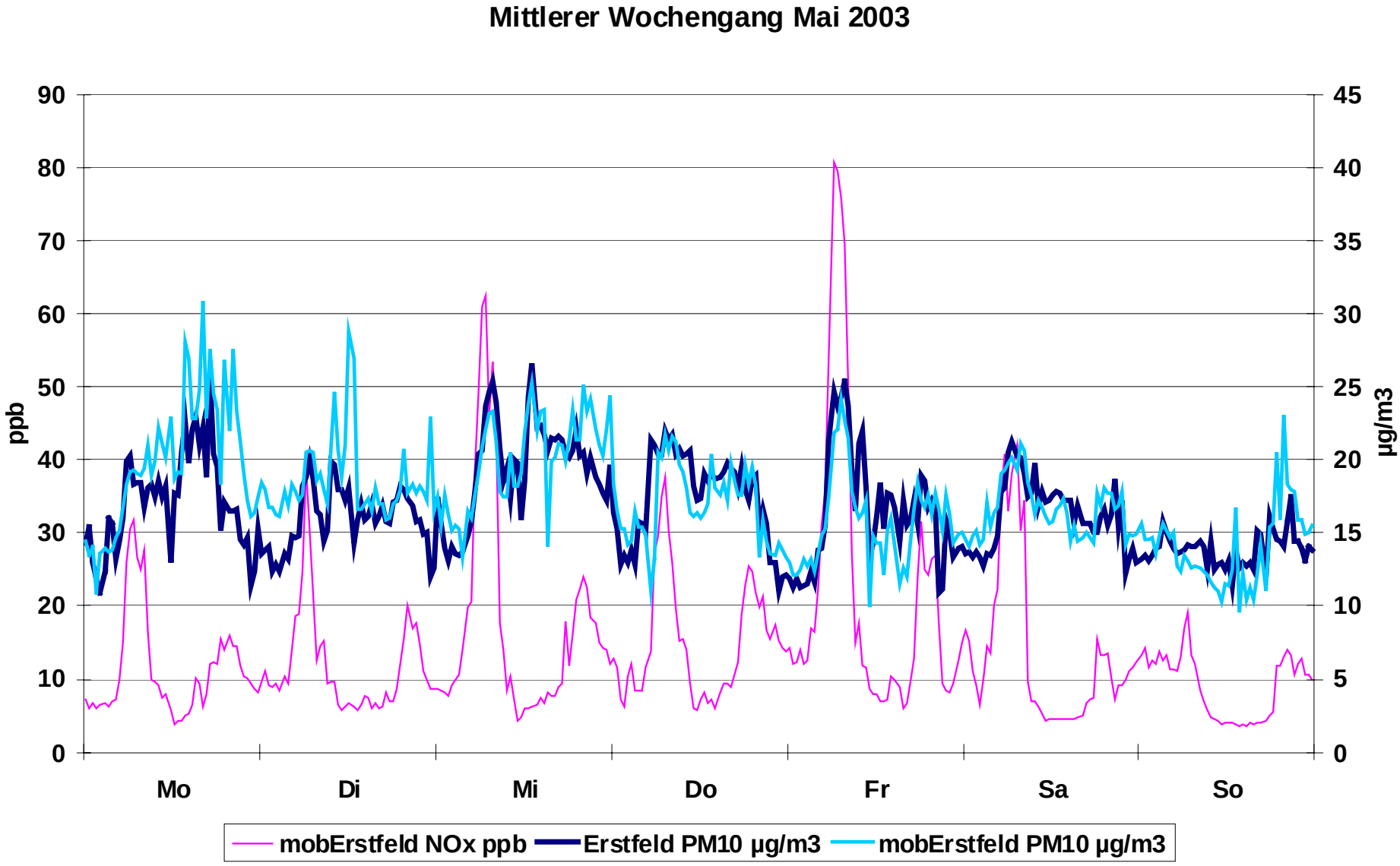
NOx


Mittlerer Wochengang Mai 2003
ppb
180
160
140
120
100
80
60
40
20
0
Mo
Di
Mi
Do
Fr
Sa
So
Erstfeld NOx ppb
mobErstfeld NOx ppb

Black Carbon and Particle Count



PM10 and NOx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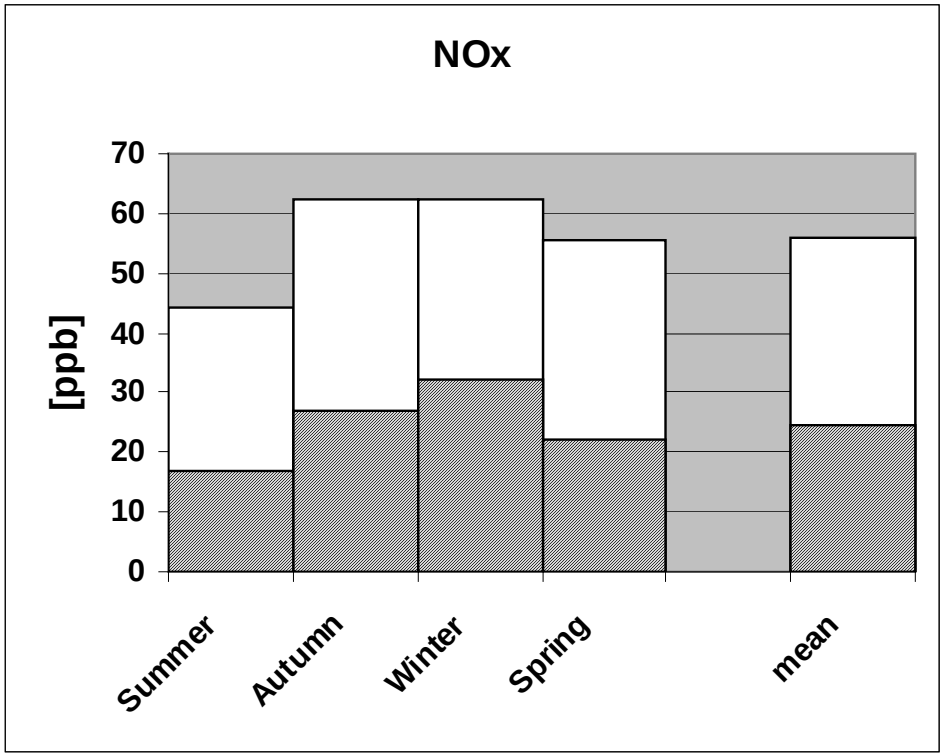
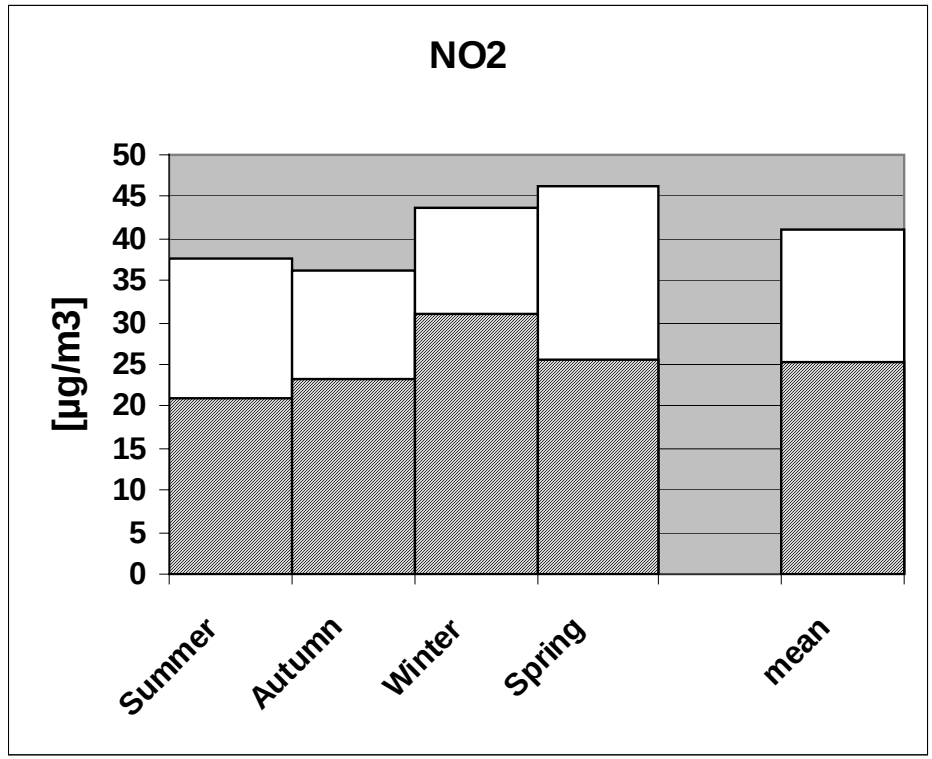
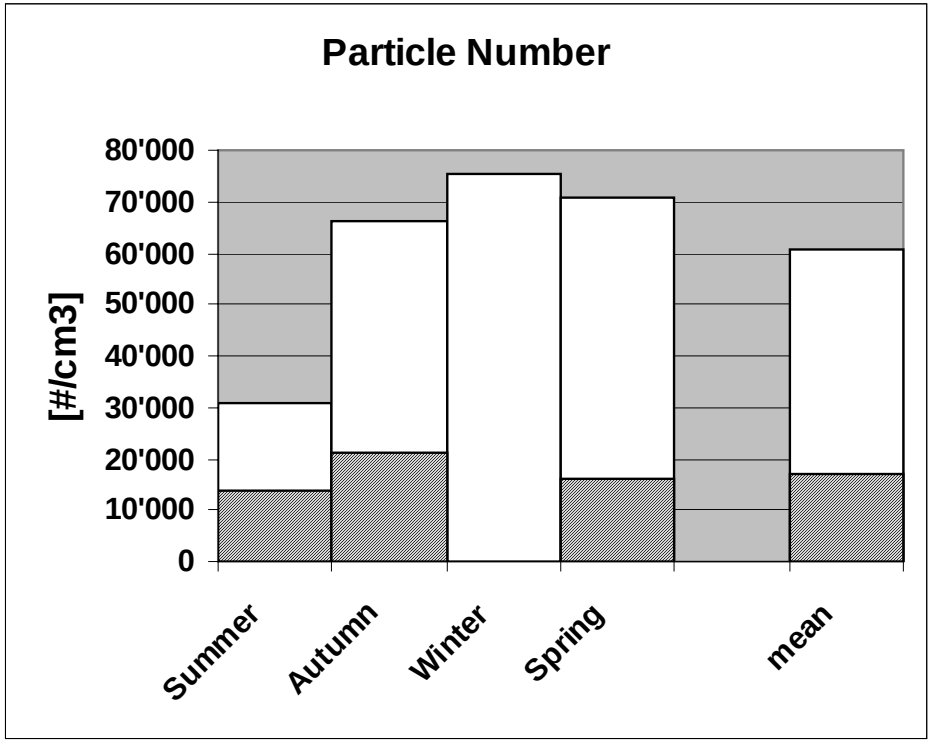
ppb
µg/m3
90
80
70
60
50
40
30
20
10
0
45
40
35
30
25
20
15
10
5
0
Mo
Di
Mi
Do
Fr
Sa
So
mobErstfeld NOx ppb
Erstfeld PM10 µg/m3
mobErstfeld PM10 µg/m3

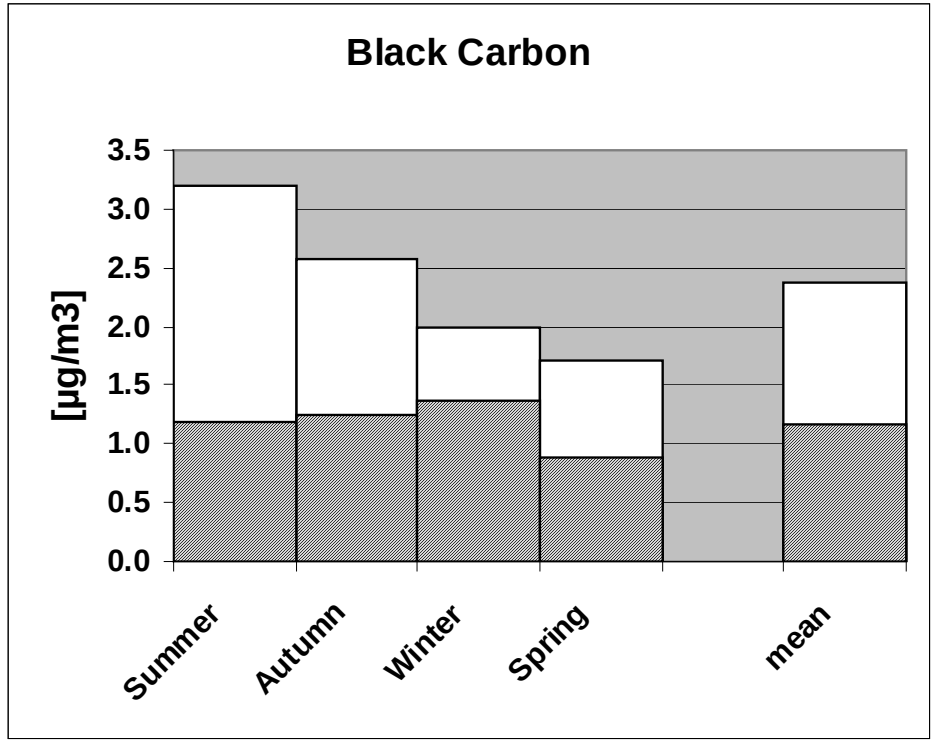
NOx and NO2, seasonal values



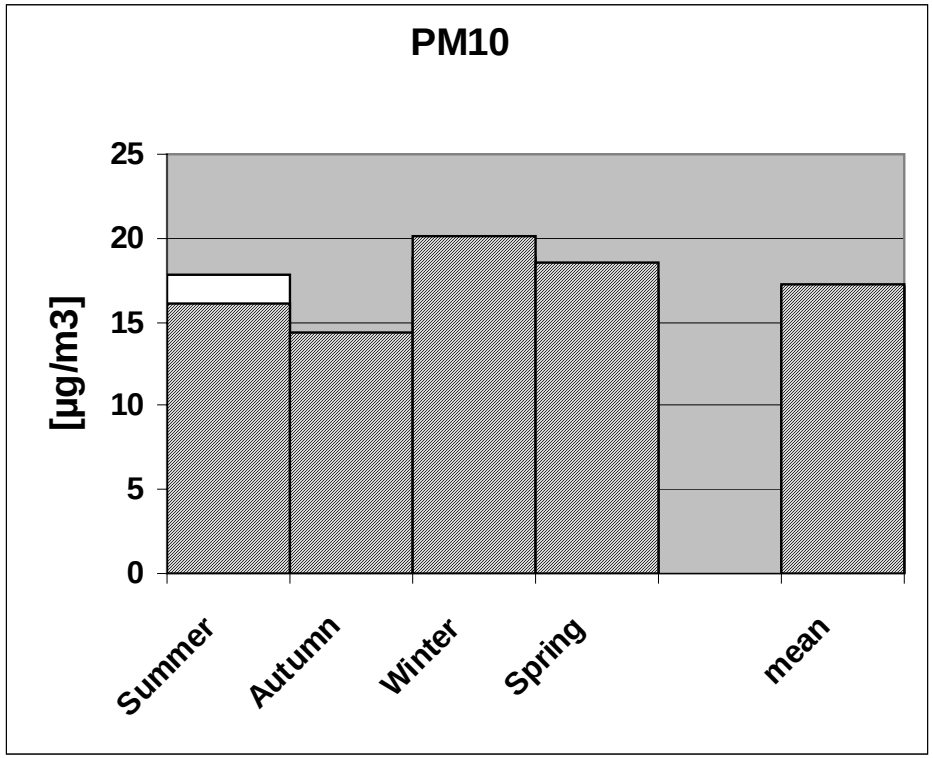


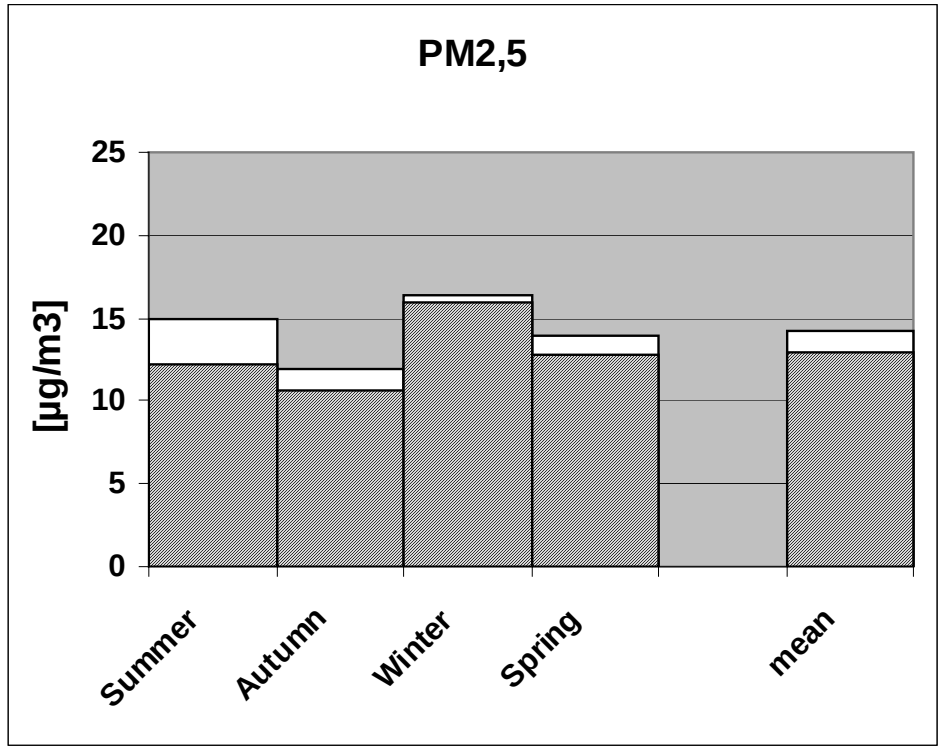
Particle Count and Black Carbon, seasonal values



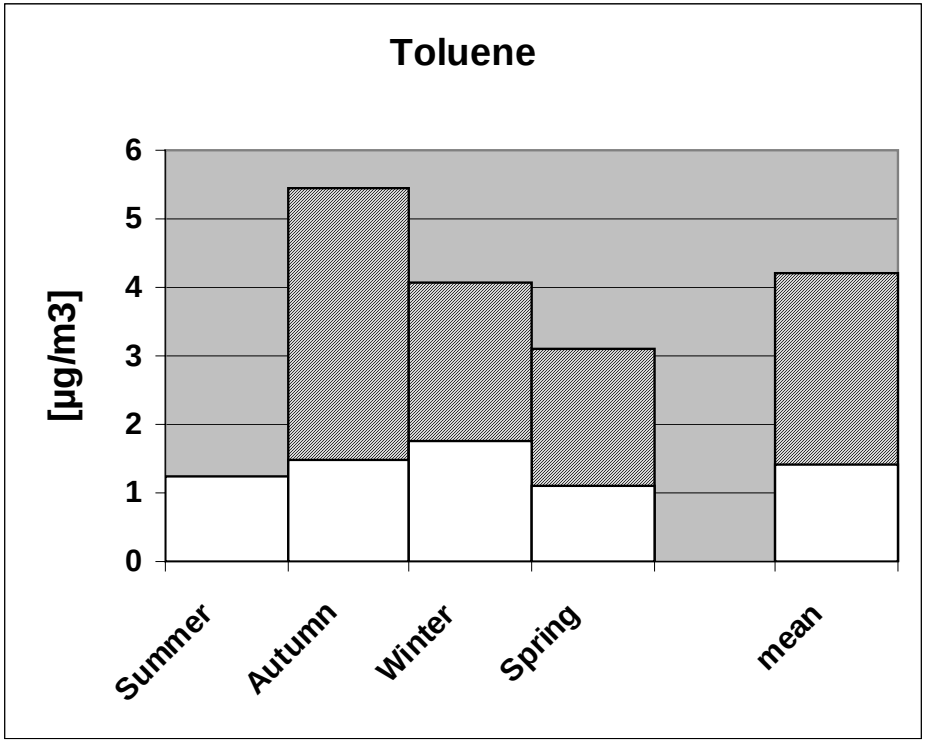


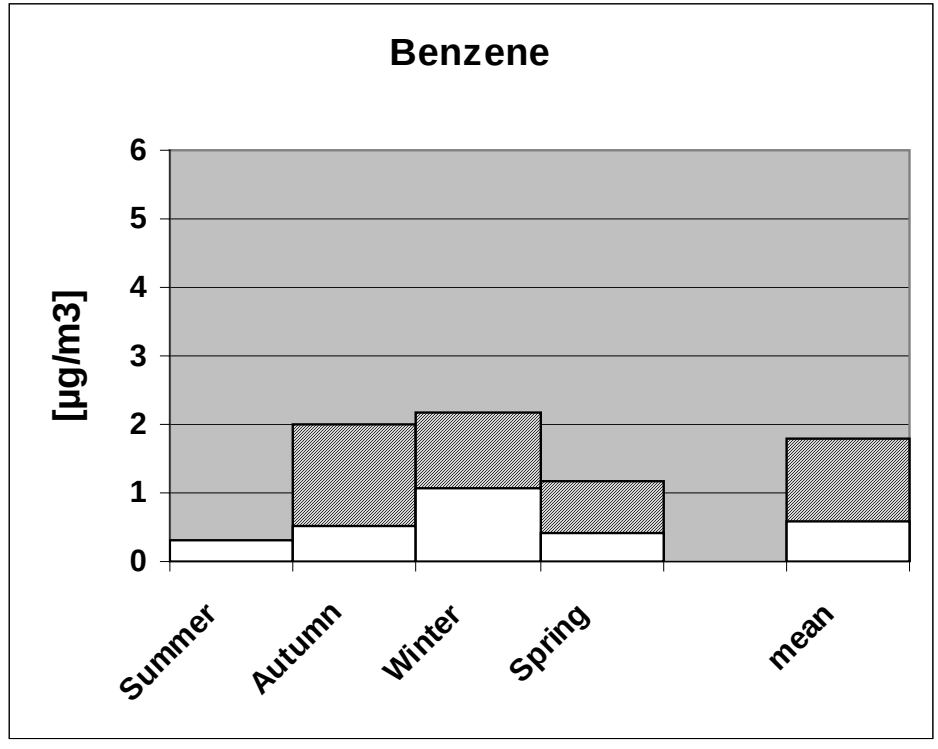
PM10 and PM2.5, seasonal values





Benzene and Toluene, seasonal values





Estimate on a Concentration Profile (with seasonal variation) at the Gotthard Highway (8 to 200 m)

Species	c(8) [ug/m3]	c(200)/ c(8)	Remarks
PM10	17	1.0 +/- 0.1	no decrease
PM2.5	14	0.9 +/- 0.1	very small decrease
NO2	41	0.6 +/- 0.1	smaller decrease than NOx
black carbon	2.4	0.5 +/- 0.15	
NOx	56 ppb	0.4 +/- 0.1	reference for "nearly inert gas"
CPC	60800 #/cm3	0.3 +/- 0.1	strong decrease: koagulation?
benzene	0.6	3.0 +/- 1.0	strong increase: other sources?
toluene	1.4	2.9 +/- 0.6	strong increase: other sources?

Conclusion

- The gradient measurements showed substance depending concentration decreases near a highway, and allow estimates the highway related burden in settlement areas.
- The extension of the chemical Analyzers to nonregulated substances is useful (source and health)
- useful traffic indicators are black carbon and CPC, but not PM10 and PM2.5
- Other pollution sources have to be considered (Benzene)
- The analyses and Interpretation of the data have to proceed.
- This method could be useful for other transit axes too!

This work

- is a result of a collaboration with:
  - In-Luft Team of Central Switzerland
  - BUWAL (Air, MSM-E)
  - ETH/IAC

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  - Canton of Uri
  - BUWAL
  - ASTRA

- Thanks to all partners !