FIELD MEASUREMENTS WITHIN A QUARTER OF A CITY INCLUDING A STREET CANYON TO PRODUCE A VALIDATION DATA SE

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Concept of measurements

Quality assurance / quality control activities

Interpretation of measurement results

Harmonisation 09, 02 June 2004

For the execution of the European Air Quality Framework Directive 96/62/EC and its daughter directives 12-monthly air pollution maps with a spatial resolution of 200 m^2 are required

Tools for this task with the necessary quality are not available up to now and were developed on the basis of numerical models (meso-/micro-scale model system M-SYS) in frame of the project VALIUM (AFO 2000 program)

Validation of this model system is necessary

Continuous measurements of air pollutants inside a street canyon and in the surrounding area of 1 km x 1 km (Göttinger Straße in Hannover) were performed in addition to the routine NLÖ monitoring from beginning 2001 until end of 2003

Investigations were combined with wind tunnel experiments at UHH

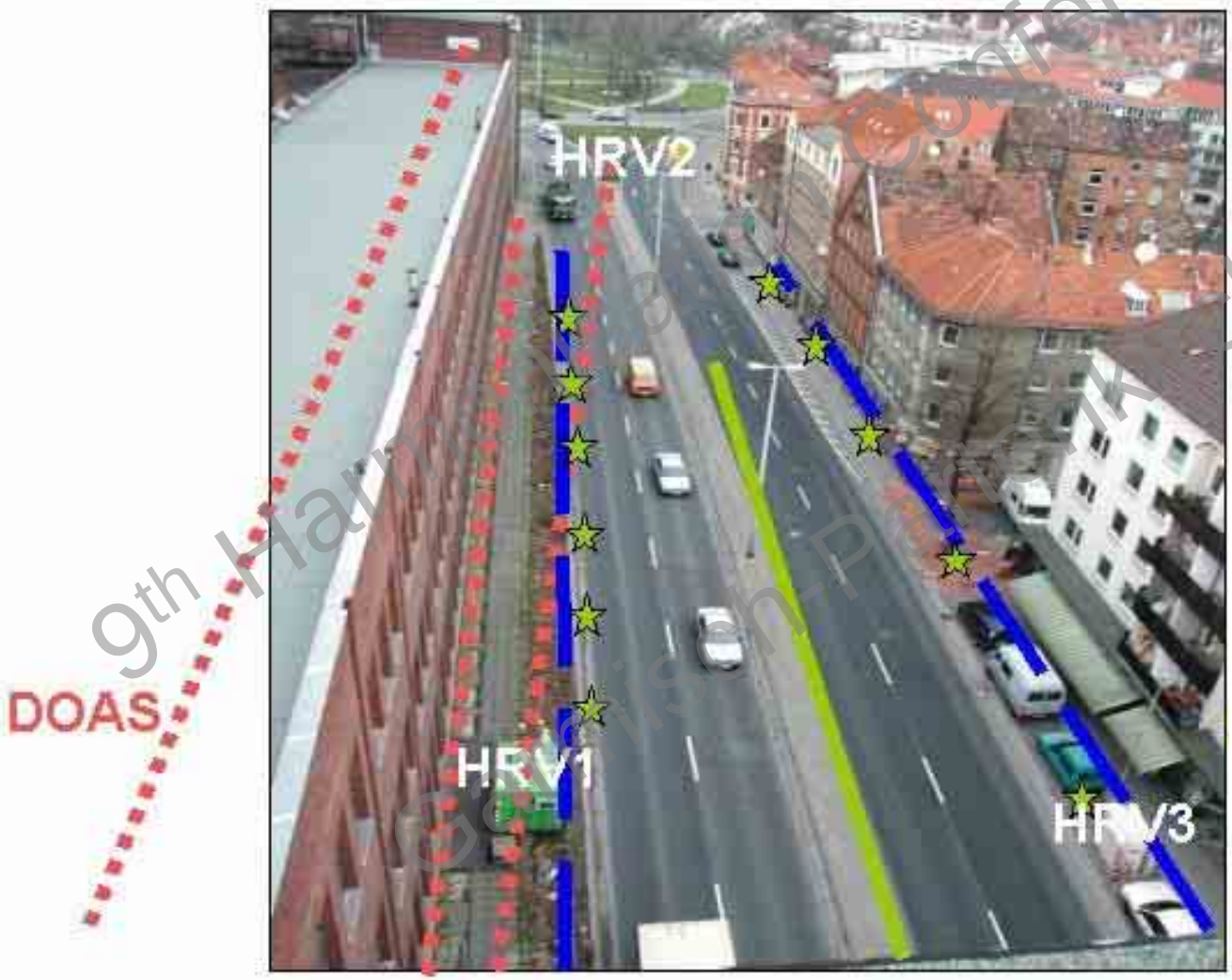
Concept of measurements

Both air pollutants and meteorological parameters were measured by in situ instruments at four sites inside the street canyon (HRVS, HRV1, 2, 3) and at three sites in the surroundings (HRSW, HRV4, HRV5)

Path-averaging optical measurement techniques (two, some times three DOAS systems) were used continuously on the ground and on the roof of a building at the street

Acoustic remote sensing of wind and turbulence profiles and mixing layer heights was performed by a SODAR south-west of Göttinger Straße in about 500 m distance, completed by a ceilometer and a Wind-Temperature-Radar

Three intensive operational phases in different seasons with tracer SF_6 experiments and investigation of vertical gradients (path-averaging FTIR measurements for CO, DOAS measurements for NO_2) were executed

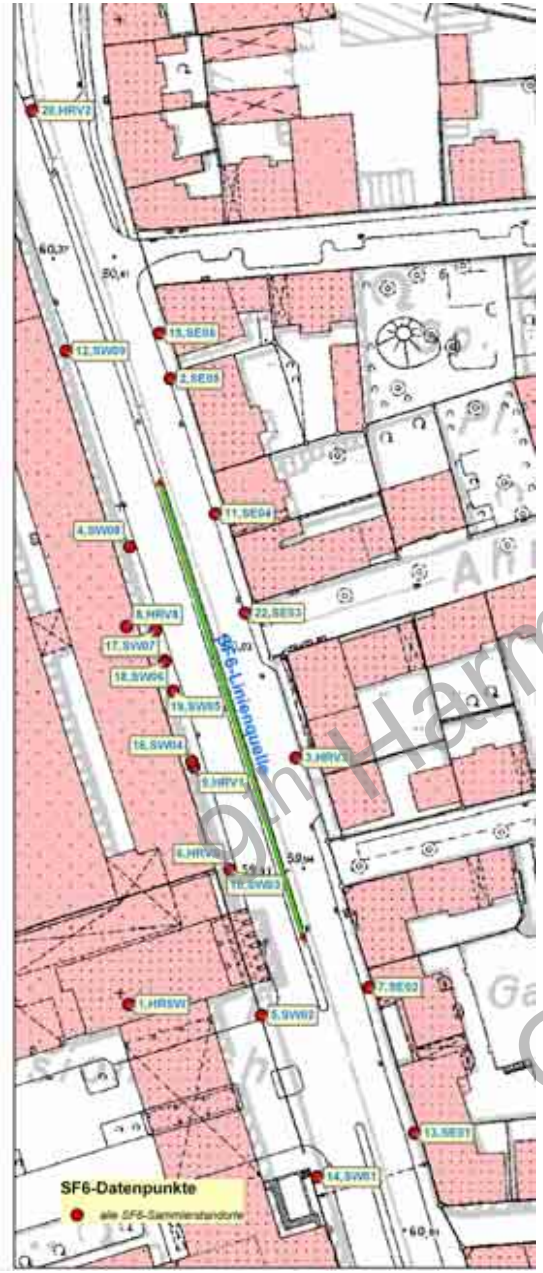


SF6 line source and sampling sites

FTIR

Annual mean of PM10 and NO_2 (year 2002) at all stations and number of days which exceed the boundary value 50 µg/m³ for PM10 and number of hours which exceed the boundary value 200 µg/m³ for NO_2 corresponding EC Daughter Directive 1999/30/EG

Station	PM10 Annual mean (µg/m³)	PM10 Number of days >50 µg/m³	NO_2 Annual mean (µg/m³)	NO_2 Number of hours >200 µg/m³
HRSW	29	42	25	0
HRV1	43	102	58	0
HRV2	41	104	61	4
HRV3	40	90	53	3
HRV4	28	34	27	0



Intensive operational phases

Tracer 07 August 2002, 09:00 – 16:00 CET
northerly winds (street parallel) up to 3 m/s
23 October 2002, 13:00 – 17:00 CET,
westerly winds around 6 m/s
24 October 2002, 09:00 – 17:00 CET,
westerly winds around 7 m/s
25 October 2002, 13:00 – 17:00 CET,
southerly winds (street parallel) around 6 m/s
26 October 2002, 11:00 – 17:00 CET,
westerly winds around 10 m/s
11 April 2003, 09:00 – 17:00 CET,
westerly winds around 3 m/s
23 April 2003, 09:00 – 17:00 CET,
easterly winds around 3 m/s,
probe sampling without tracer release also
canister sampling analyses for about 50 VOC
2 USA in 3 m altitude in the street canyon

Quality assurance / quality control activities

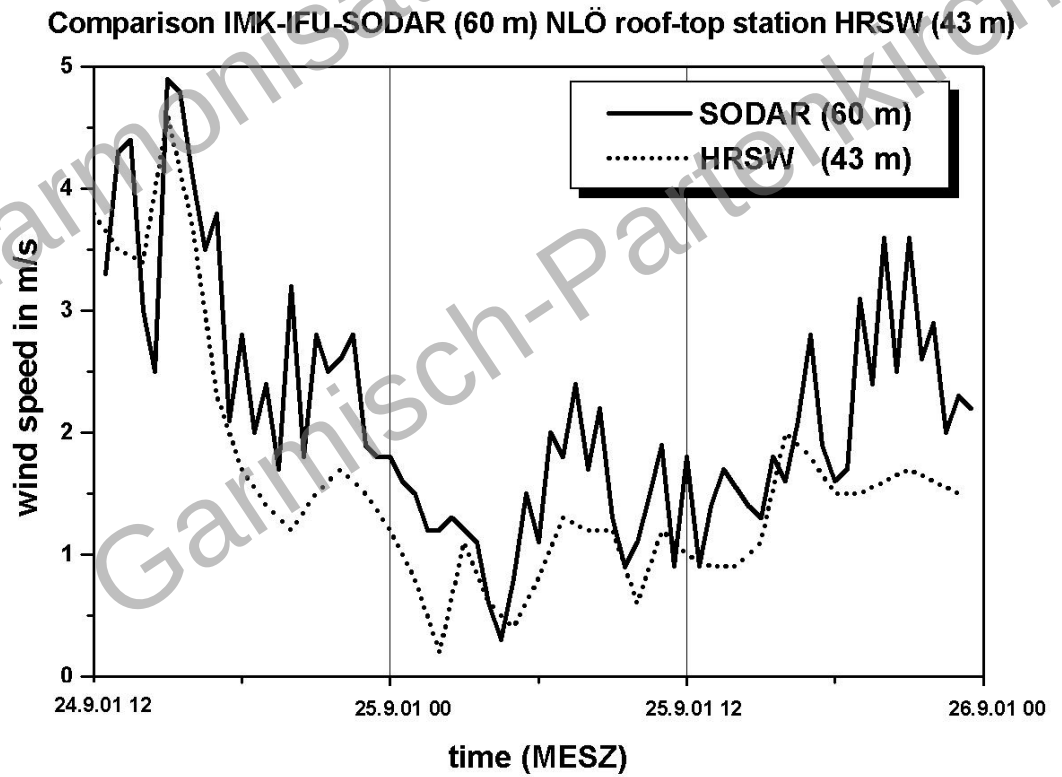
Long-term comparison of different measurement methods (ISO 13752 Air quality)

Comparisons of different measurement systems during 36 hours before / after IOPs

Measurement systems of NLÖ are references

Long-term meteorological investigations

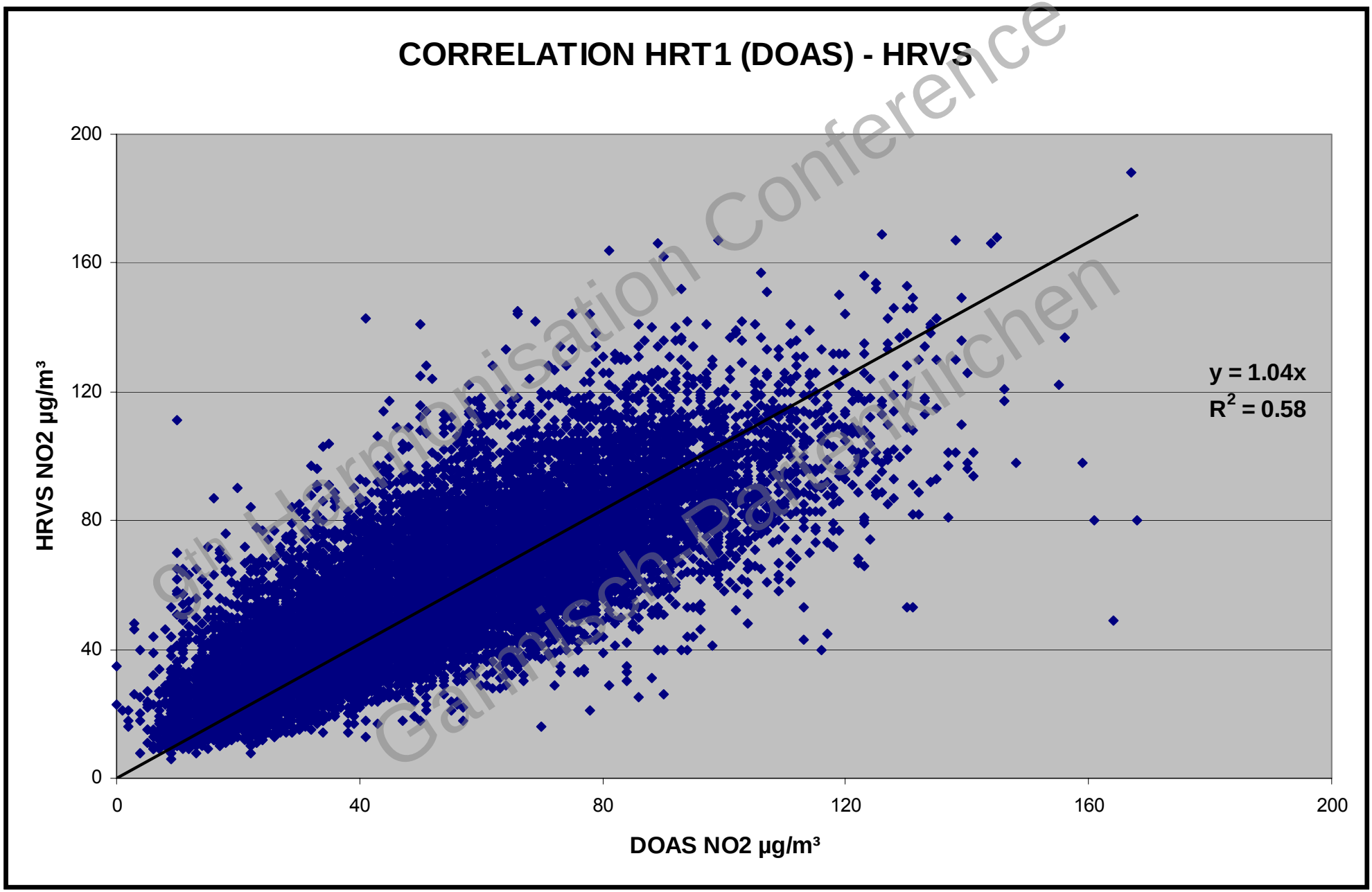
- Doppler-SODAR measurements with vertical resolution down to 12.5 m
- Comparison between wind data from SODAR and from roof-top station shows influence of surrounding buildings upon roof-top measurements
- Due to stable layering larger differences at night exist



Long-term NO_2 study of the path-integrated DOAS and in situ measurements at different stations from February 2001 until May 2002:

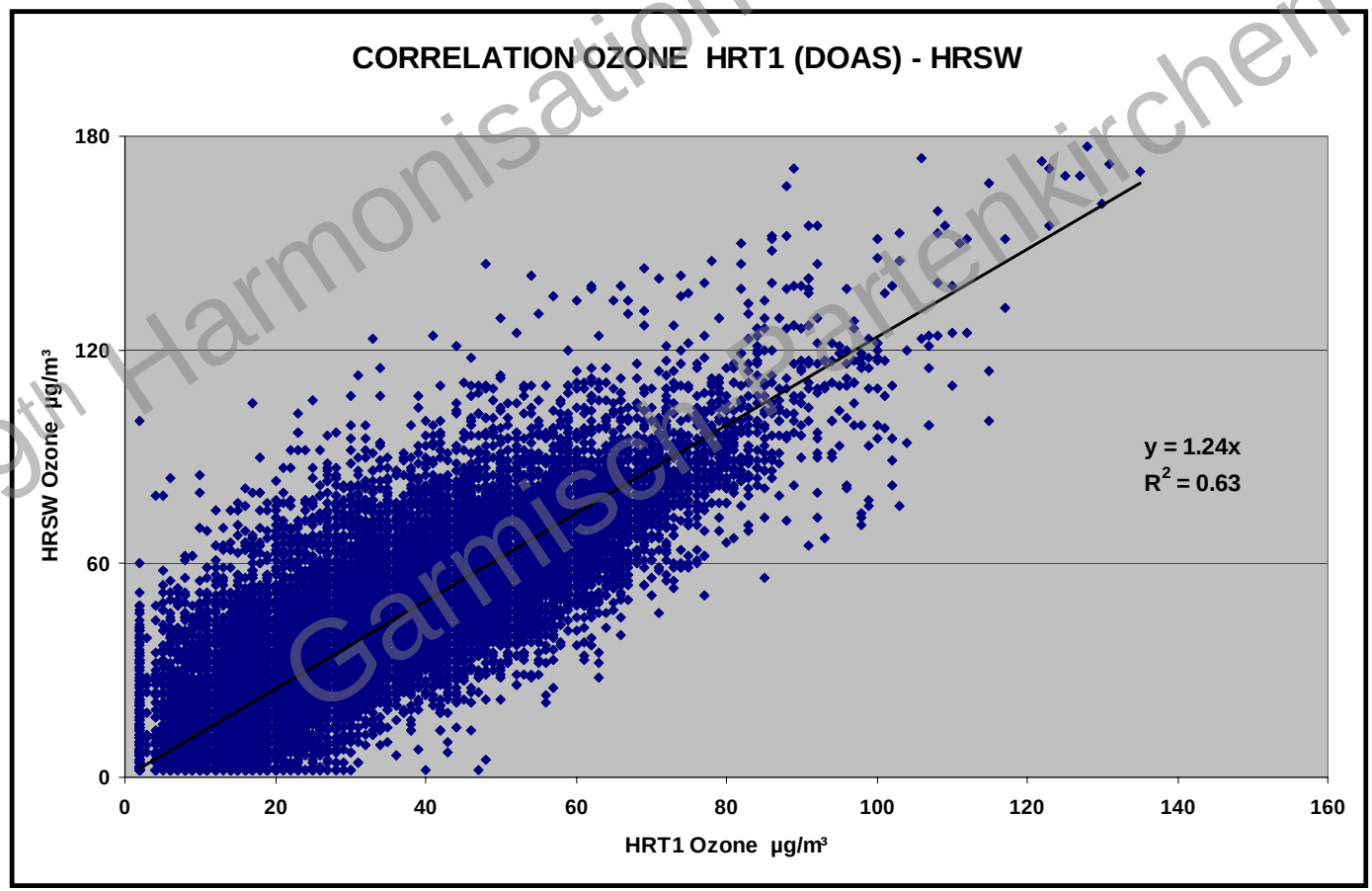
- Means of all simultaneous half-hourly means of the stations HRVS, HRV1, HRV2, HRV3: range from 30 up to 70 µg/m³
- Correlation of the DOAS measurement with single and averaged in situ measurement results including about 16,000 up to 18,000 values

Station	Correlated Station	Correlation		Standard Deviation S_r, [%]
		Gradient	R^2	
HRT1	HRVS	1.04	0.58	-
HRT1	HRV1	1.01	0.44	23.6
HRT1	HRV2	0.97	0.32	-
HRT1	HRV1/V2	1.00	0.46	24.1
HRT1	HRVS/V1/V2/V3	0.98	0.55	20.2
HRVS	HRV1	0.94	0.67	18.1



Ozone comparison

- HRV4 and HRV5 with R^2 equal to 0.96, HRV4 and HRSW 0.95
- HRT1 and HRSW with R^2 equal to 0.63, long-term mean 44 µg/m³ at HRSW and 34 µg/m³ at HRT1



Comparison of different measurement systems

- CO and CH_4 by both FTIR spectrometers with HRV5 (in situ device TE48) at that site (homogeneous mixing)

- Weather stations HRV5 and HRV8 with HRSW

Differences in the order of measurement accuracy

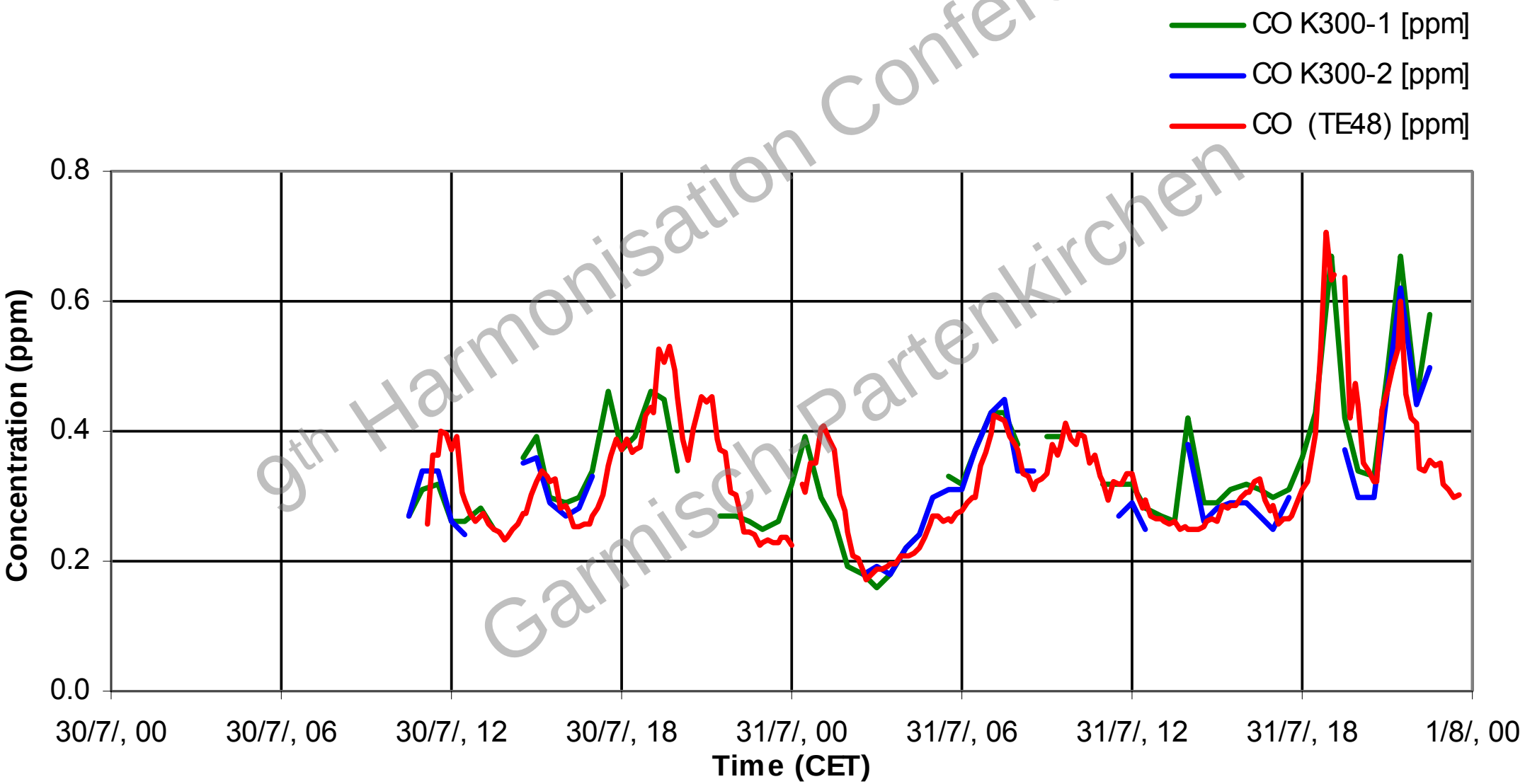
Comparison of tracer SF_6 measurements

- SF_6 by FTIR spectrometry with probe sampling / laboratory analysis in the UHH wind tunnel (15 January 2002)

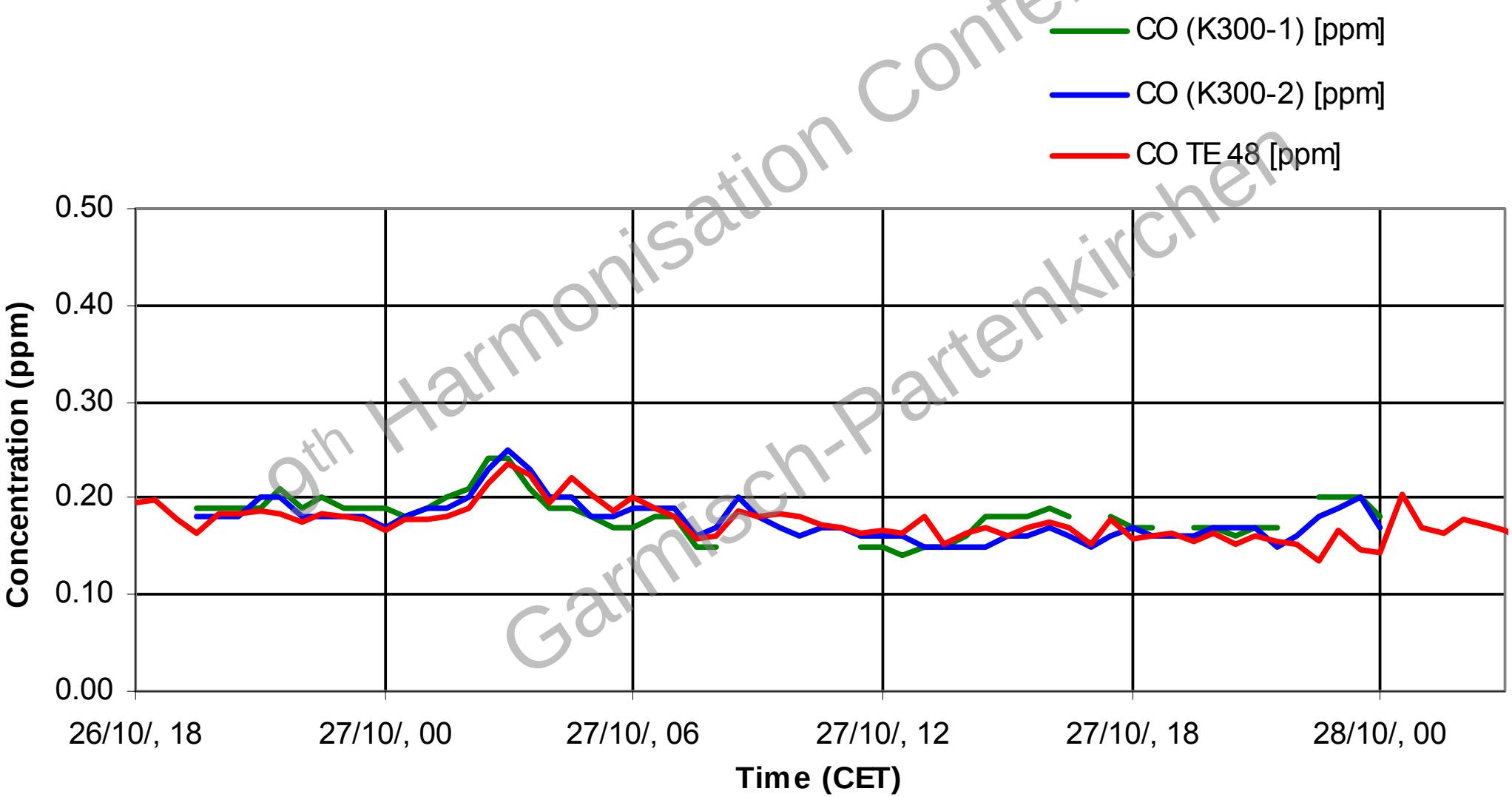
-Path-averaging of sample analyses results and FTIR

No systematic differences between path-averaging and probe sampling measurement techniques

30 July 2002, about 10:00 until 31 July 2002, about 23:00



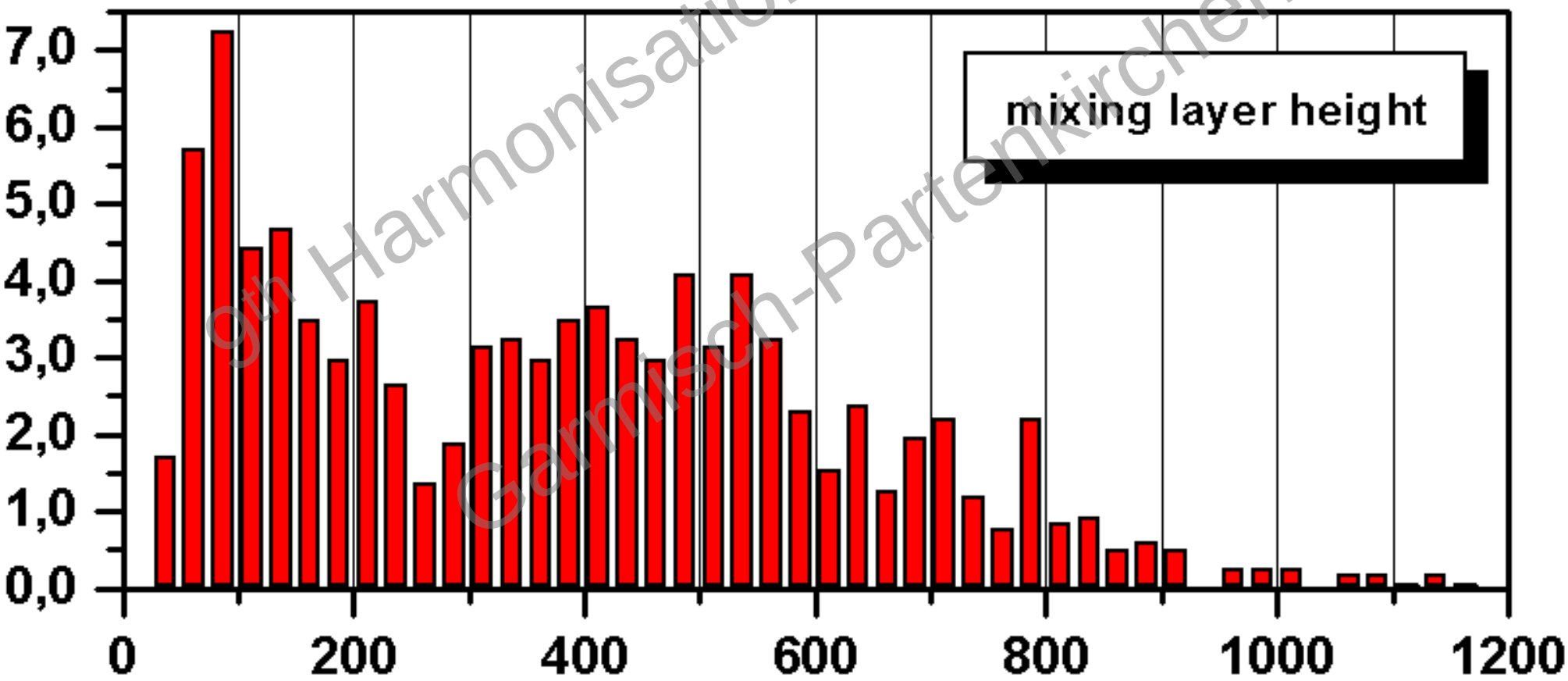
26 October 2002, about 19:00 until 27 October 2002, about 24:00



Mixing layer height (MLH) from SODAR data

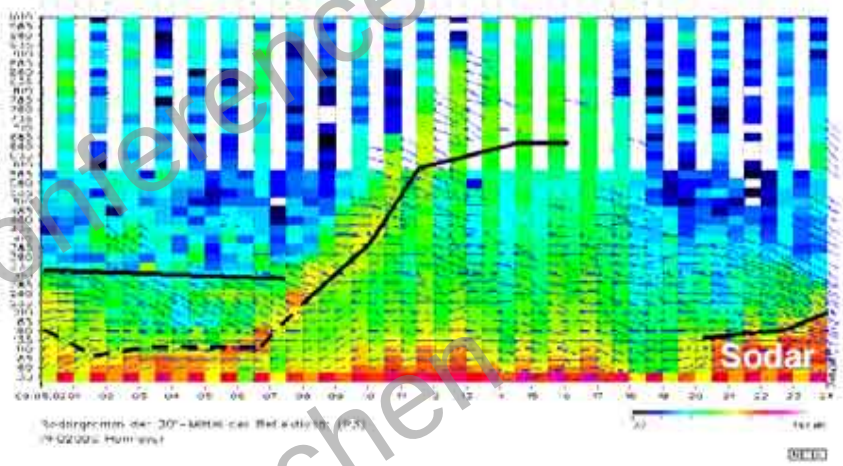
Minimum of two criteria: height of sharp decrease of echo intensity and height of elevated echo maximum

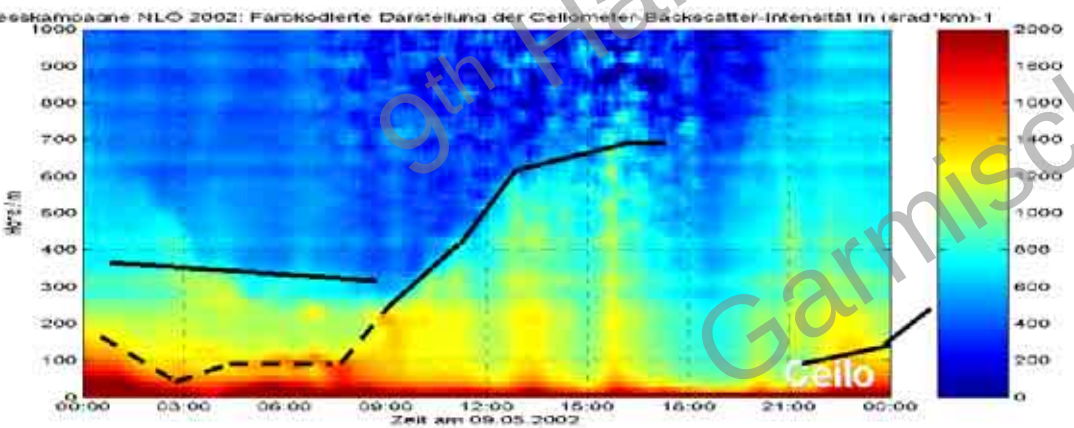
Frequency of occurrence (in % per 25 m height interval) in October 2001:

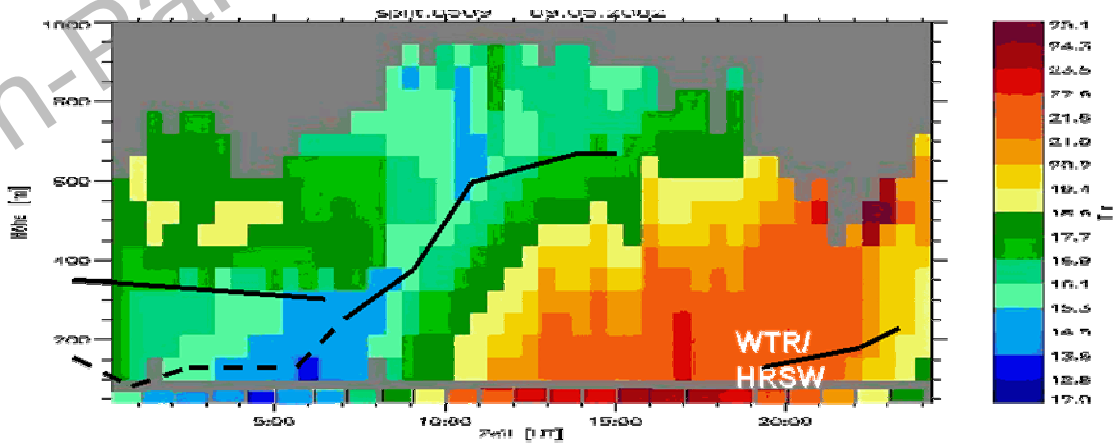


Comparison of SODAR

measurements with data from a Wind-Temperature-RADAR (WTR) of IMK-ASF and a ceilometer of Vaisala (backscatter at 0.9 µm) for 09 May 2002







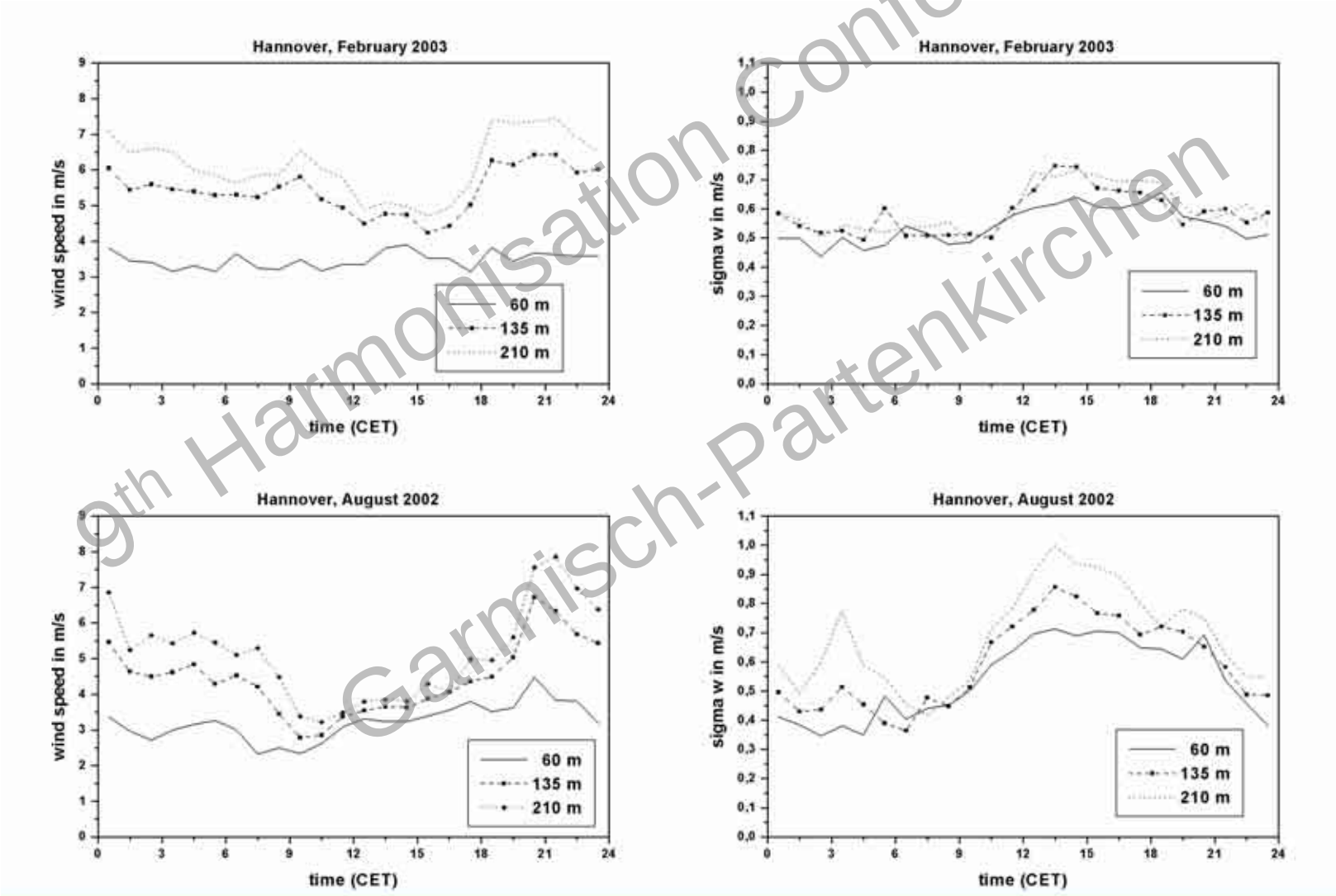
Interpretation of measurement results

SODAR measurement results of urban boundary layer

- Missing daily course of wind speed 40 m above roof level like over rough forests
- Daytime increase of variance of vertical wind speed with height up to 200 to 350 m agl, in summer and autumn even at night
- Daytime increase in turbulence intensity in summer stronger than over level terrain

Vertical profiles and the diurnal course of the variance are coined by the thermal properties of the urban surface and cannot be found over other rough surfaces

Daily variation of wind speed and turbulence parameter σ_w in different altitudes from SODAR measurements in February 2003 and August 2003



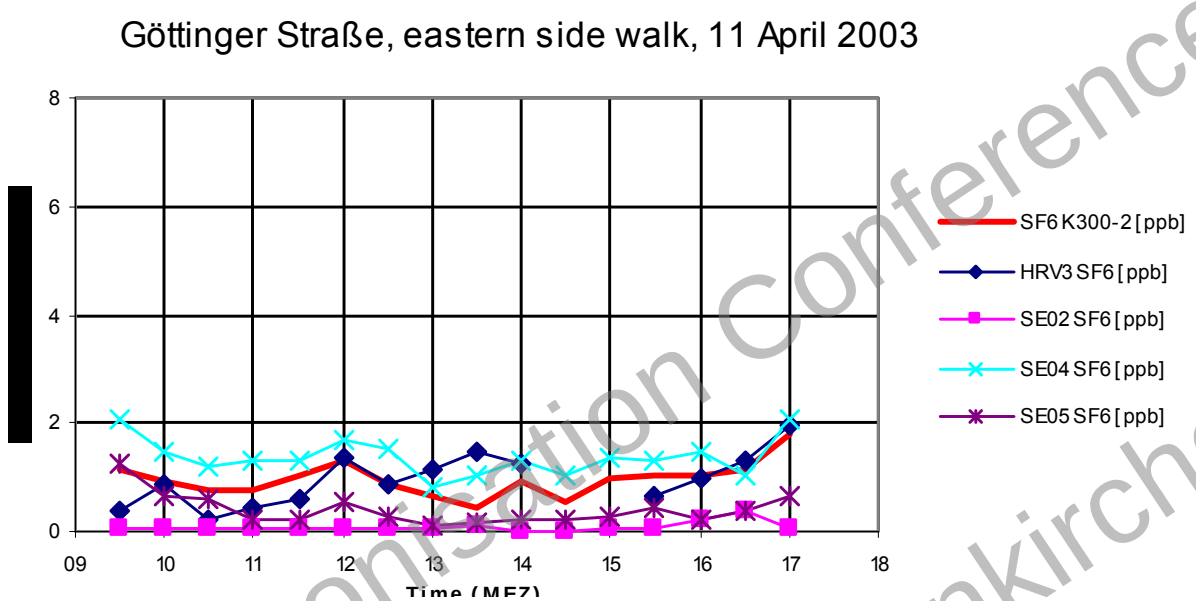
Results for representativity of measurement sites and methods

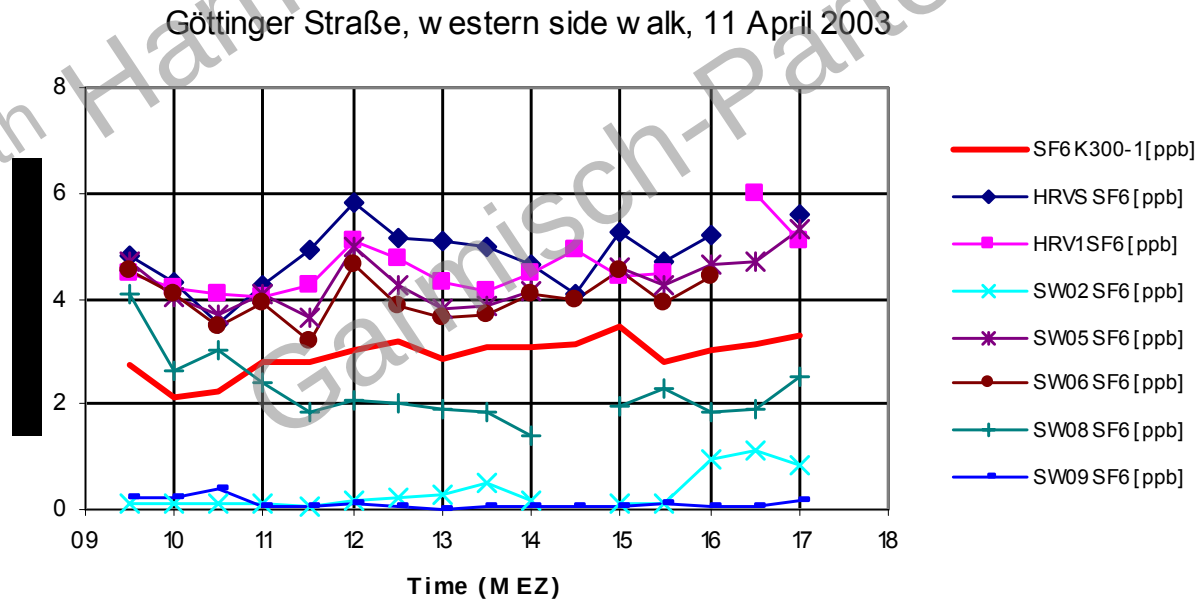
- Investigation of in situ and path-averaged measurements of SF_6

- In situ measurements are characterised by higher temporal variations - in correspondence with the high spatial variation of the in situ measurements along the measurement paths

- The highest differences between the results of both measurement techniques were found during street-parallel wind directions

- Spatial and temporal SF_6 distribution at ground level during a cross-wind episodes shows a rotor-like circulation pattern

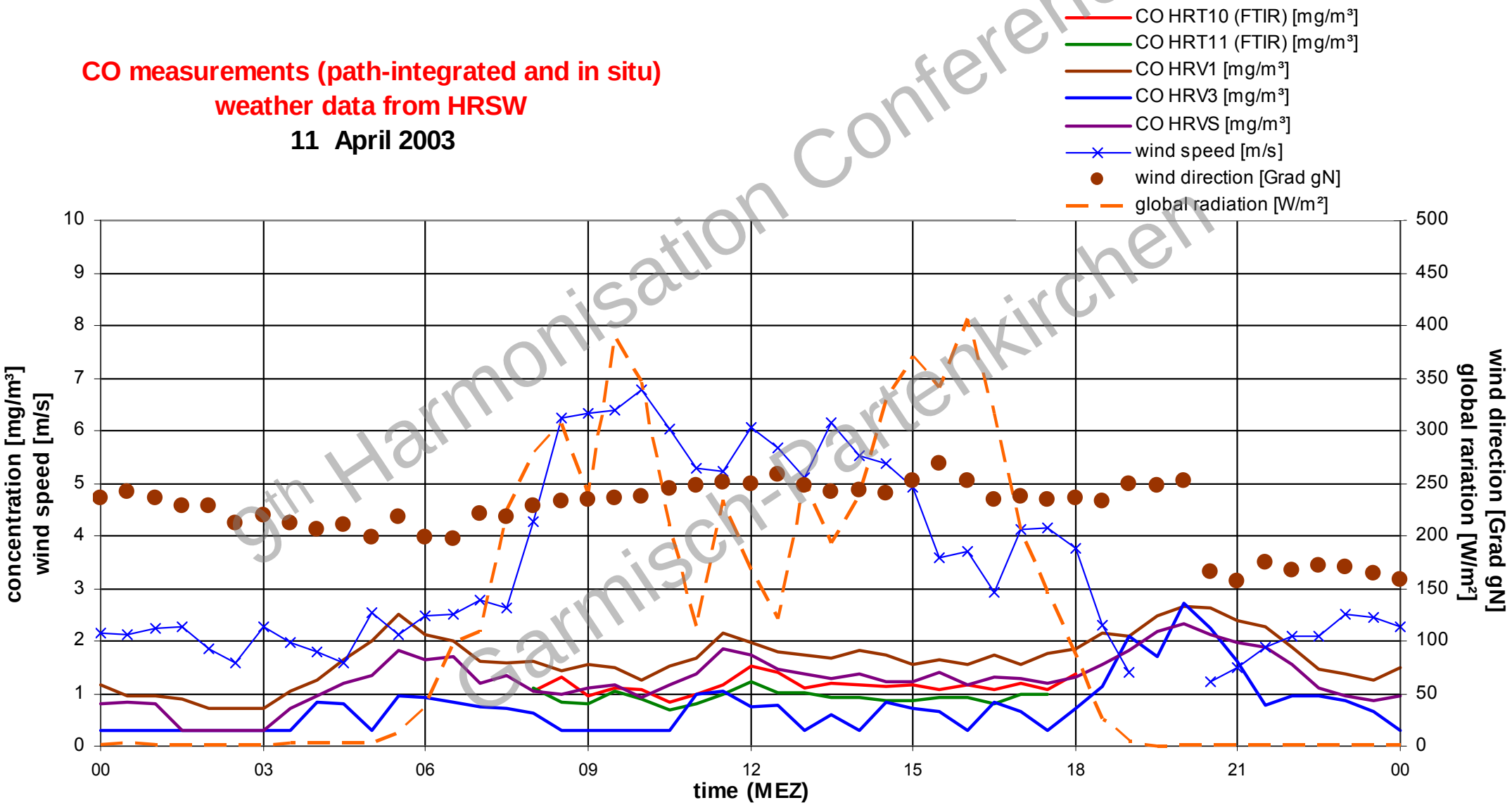




Circulation patterns inside the street canyon – the rotor

- Air pollutant concentrations (CO, NO_2) measured in situ and path-averaged by FTIR and DOAS
- at both sides near the ground of the Göttinger Straße
- at roof-top level and near the ground at the western side of Göttinger Straße
- cross-wind air flow conditions

CO measurements (path-integrated and in situ)
weather data from HRSW
11 April 2003



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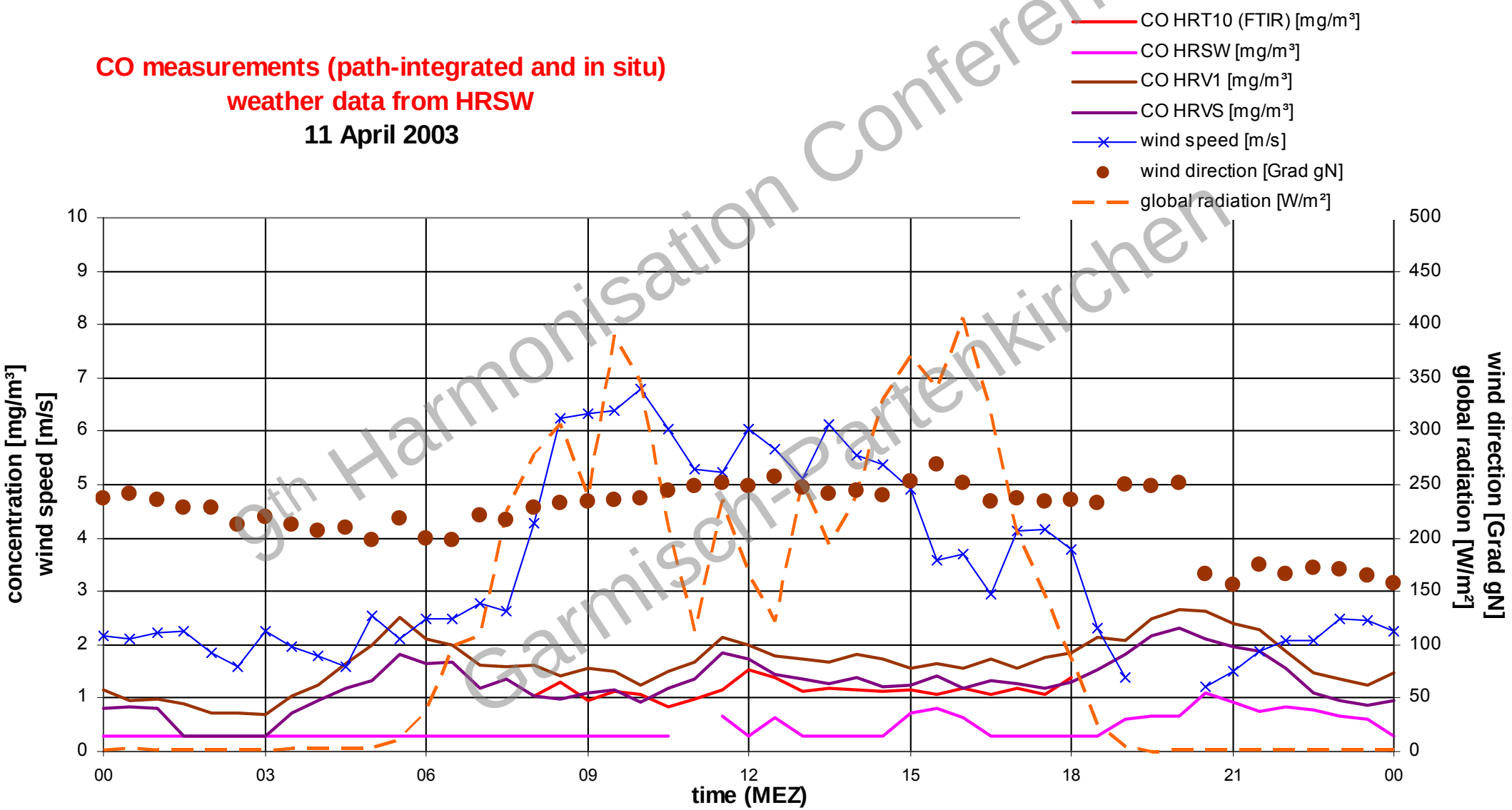
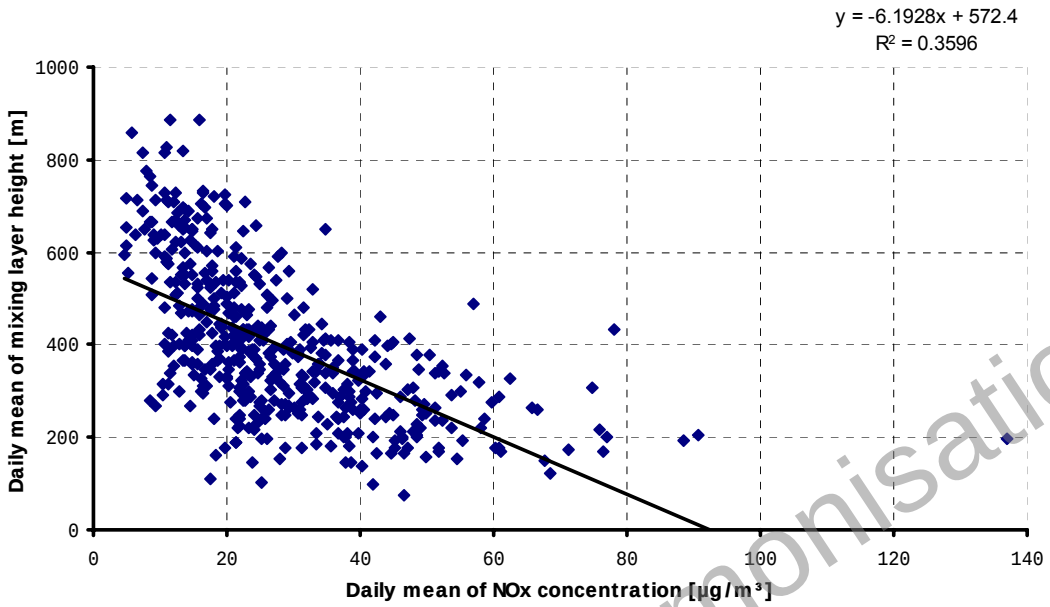
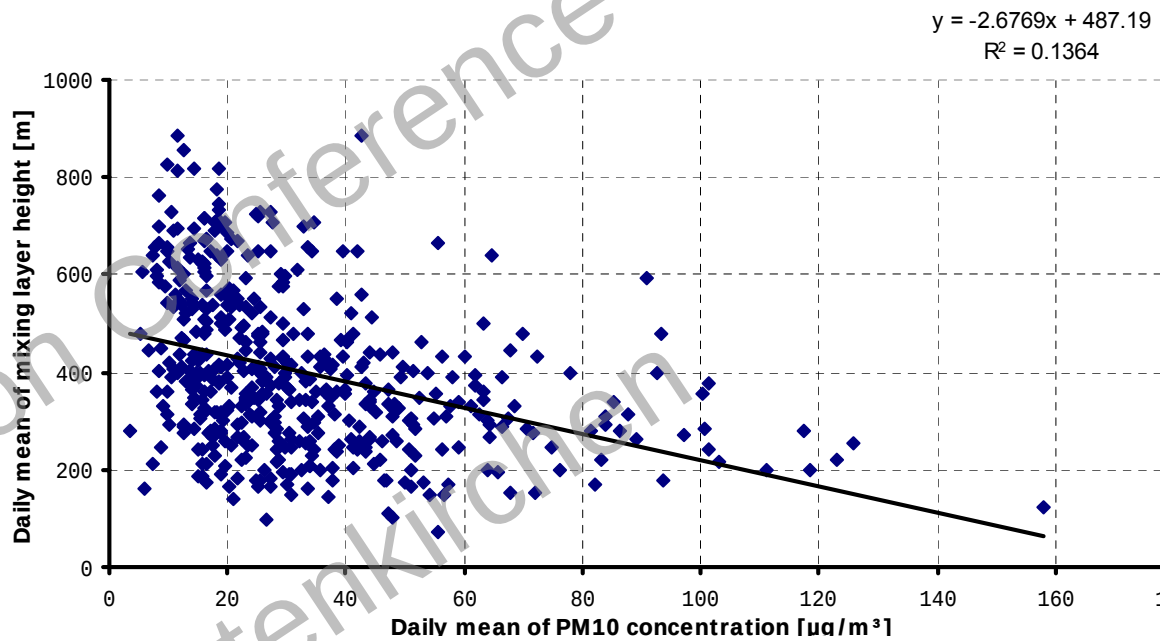
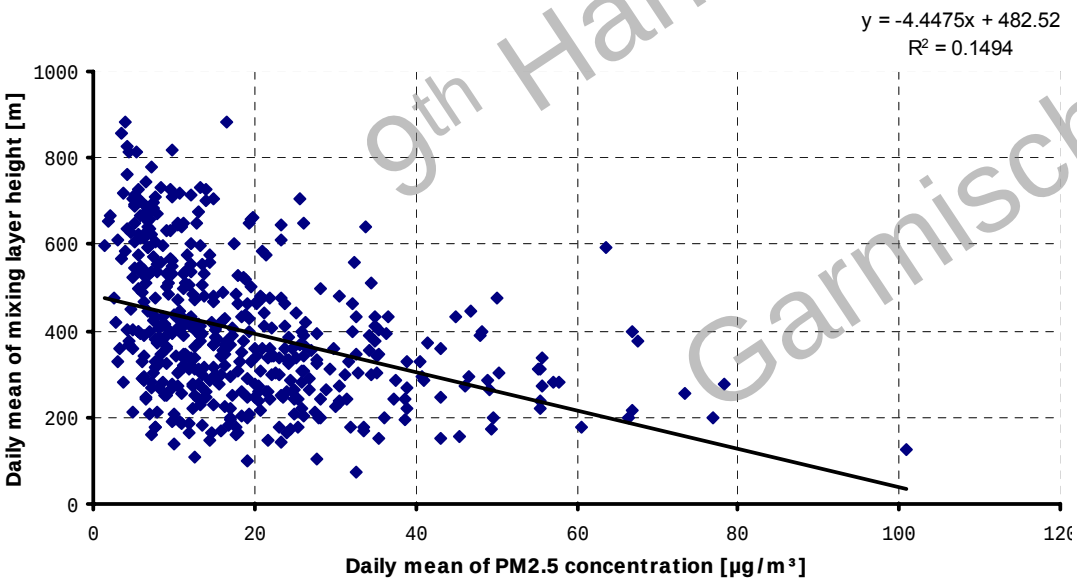


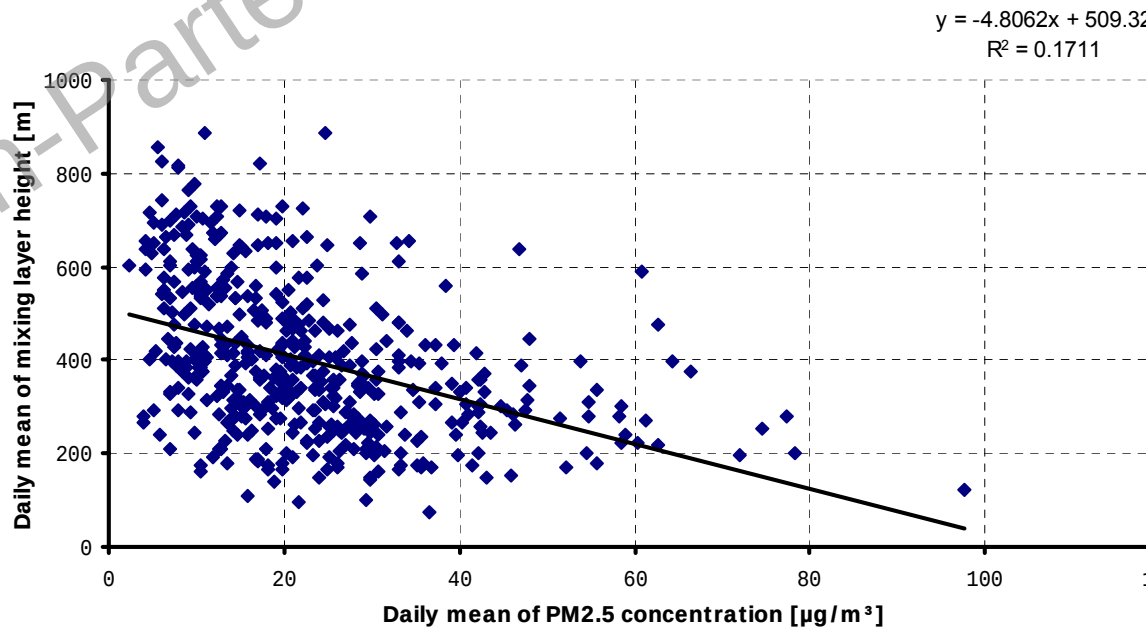
Correlation between MLH and air pollutants in the street canyon and at roof-top level

- About 36 % of NO_x concentration variations at roof-top level are caused by the MLH
- At ground-level stations no such correlation is found
- The correlation for PM10 and PM2.5 with MLH is not significant at both levels
- PM10 and PM2.5 concentrations at ground level inside the street canyon are higher than at roof-top level by a factor of 1.5 and 1.25 respectively whereas the factor is 6 for NO_x
- Roof-top and background monitoring stations are representative for the urban boundary layer









ValiData - Database and pre-analysis tool

Air monitoring data: Gaseous components, particle matter PM10, PM2.5

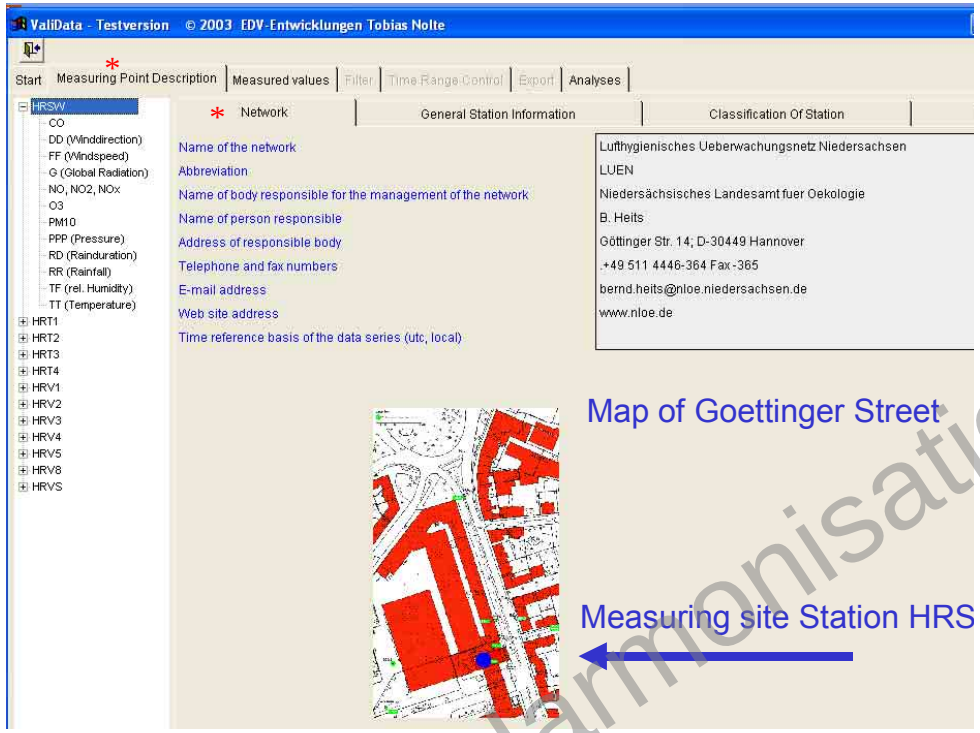
Meteorological data: Temperature, pressure, humidity, solar radiation, wind and turbulence fields, mixing layer height

Intensive operating phases data: SF_6 tracer experiments, open-path measurement systems (DOAS, FTIR)

Location of measurement sites: Inside street canyon, above roof sites, background sites

Description: Measurement sites, measurement equipment, quality data

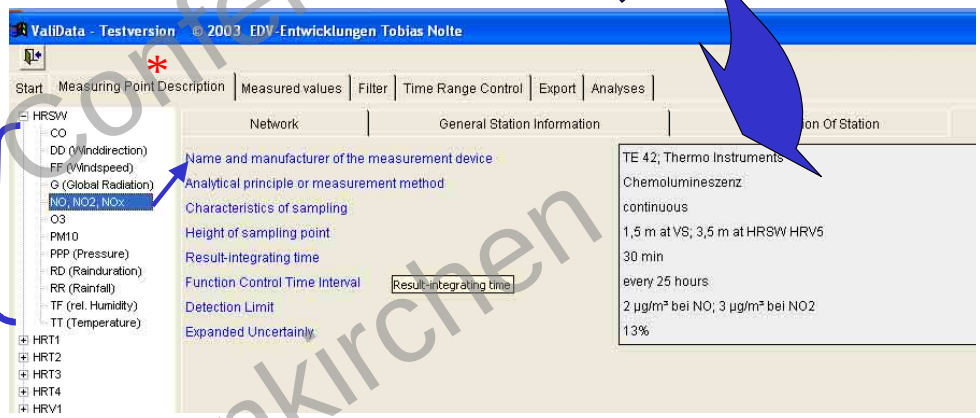
Time: Duration of continuous, measurements: 2001 – 2003, minimum temporal resolution: 30 minutes, Central European Time



Map of Goettinger Street

Measuring site Station HRS

2.4 Measurement device information



Components of station HRSW

25 components at each >30 continuous and temporary sites

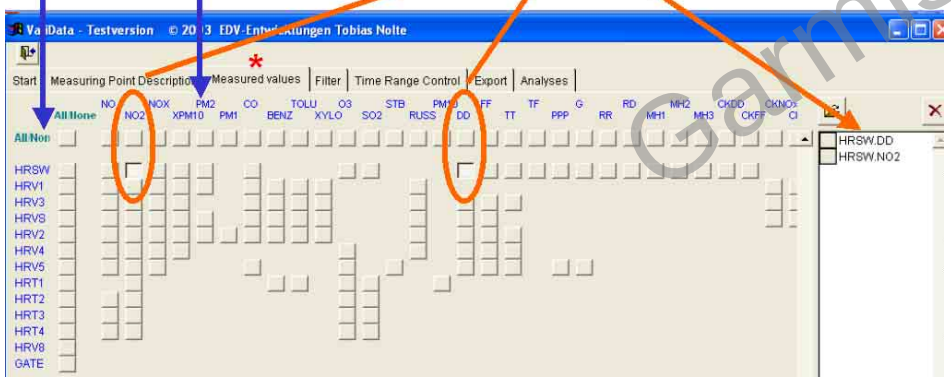
Description following EU Guidelines for Air Quality

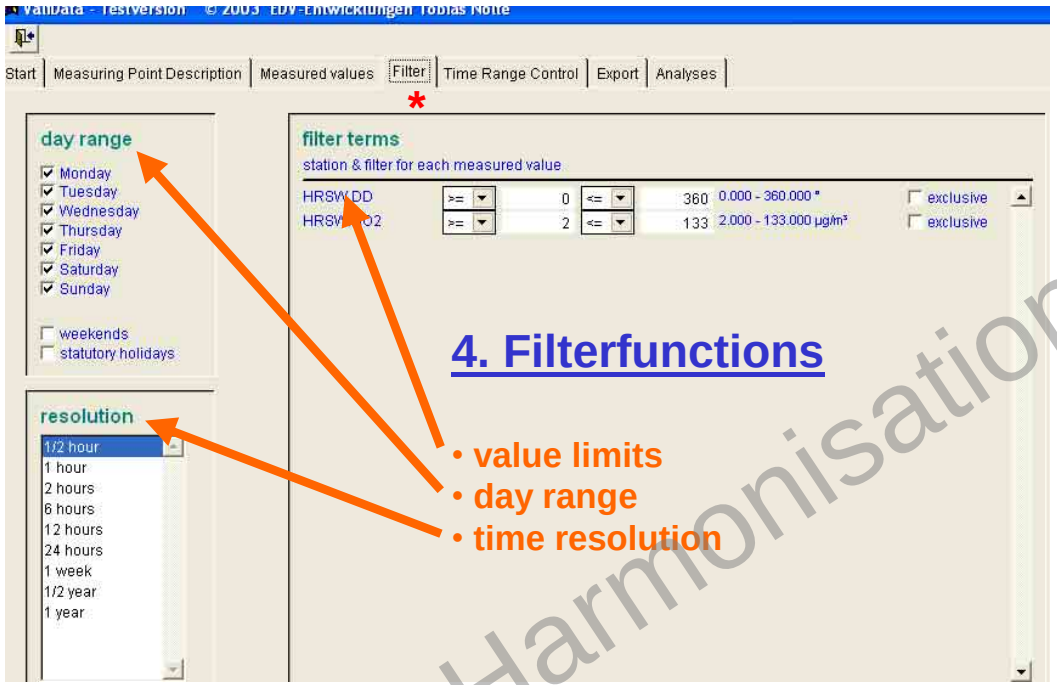
Quality Assurance parameters for each component

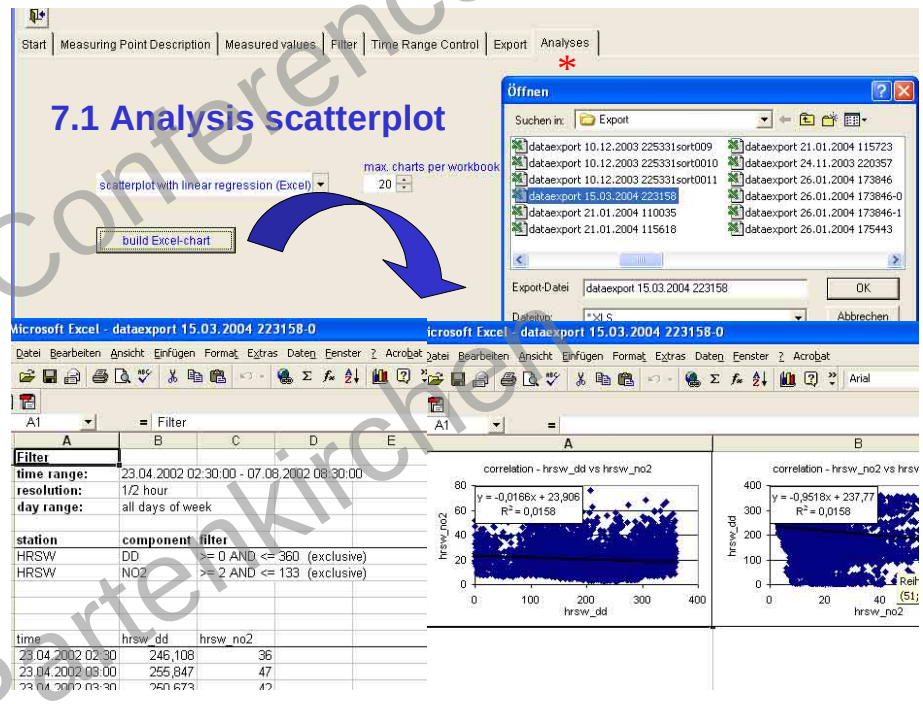
3. Measured values

Matrix Component/ station

Choice of dataset







7.2 Analysis polardiagram