

Small Scale Variability of the Aerosol Vertical Distribution

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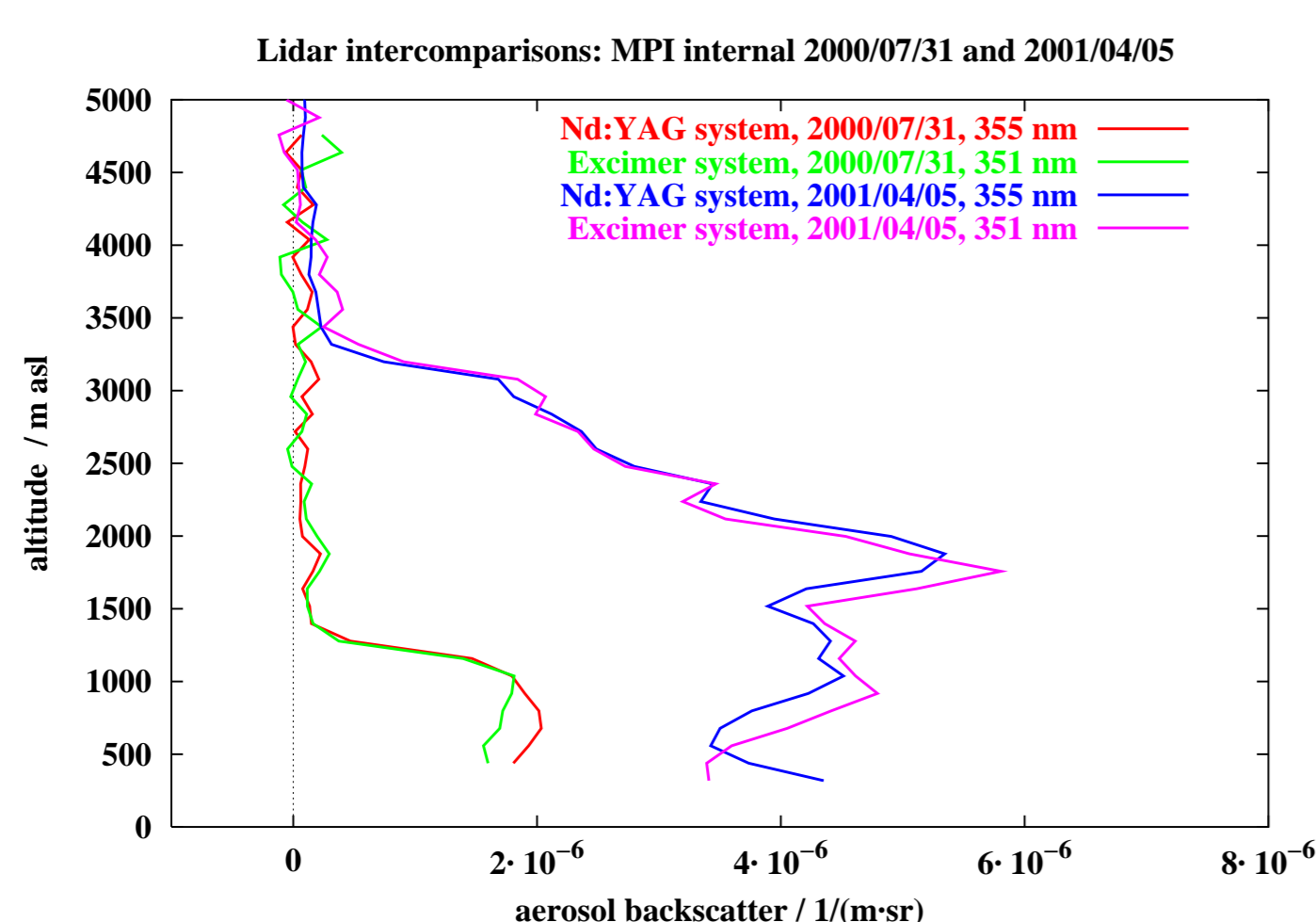
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EARLINET is a network of 22 lidar stations which are operated on a routine basis. The stations are typically separated by a few hundred kilometers or more, many of them are located in big cities.

The observation of aerosol vertical profiles by lidar reflects the aerosol distribution in a small air volume. Therefore the question of representativeness of the lidar measurement for a larger area is essential, especially for comparisons with models or satellite observations. This is in particular true for lidar stations in big cities where inhomogeneities in the aerosol distribution due to various local sources of atmospheric aerosols can be expected.

To investigate this effect, additional to the MPI lidar in the centre of Hamburg, a second lidar has been operated at the South East border of the city. The comparison shows only minor differences with on the average slightly larger values of the integrated aerosol backscatter at the city border.

Lidar systems



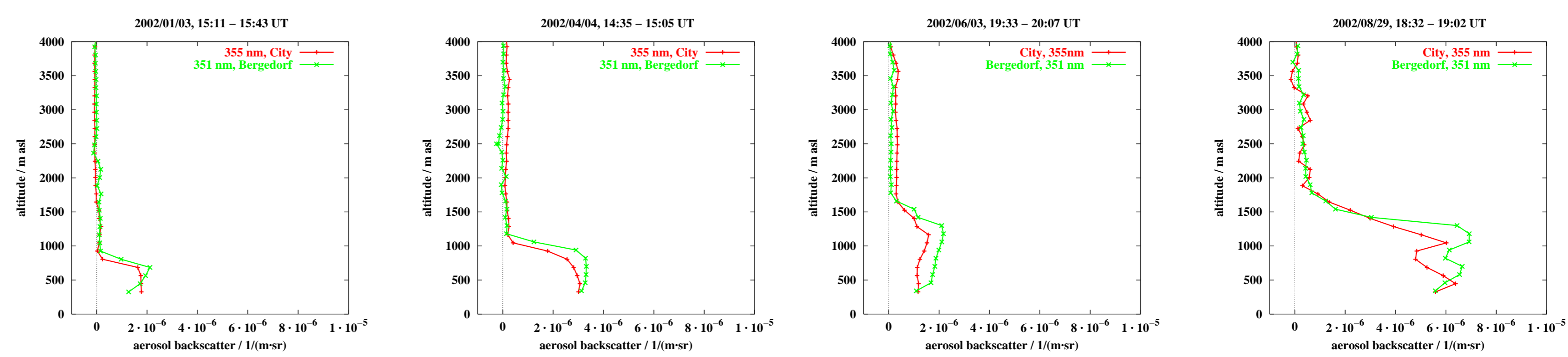
The Aerosol Raman Lidar of the MPI Hamburg is equipped with a Nd:YAG laser operating at 355 nm, 532 nm and 1064 nm. Two receiving telescopes lead to a covered height range between 0.3 and 10 km for aerosol backscatter profiles. The system is located in the centre of Hamburg.

The second lidar system is based on a XeF excimer laser (351 nm). The covered height range is also 0.3 - 10 km, but the signal statistics is worse due to lower output power.

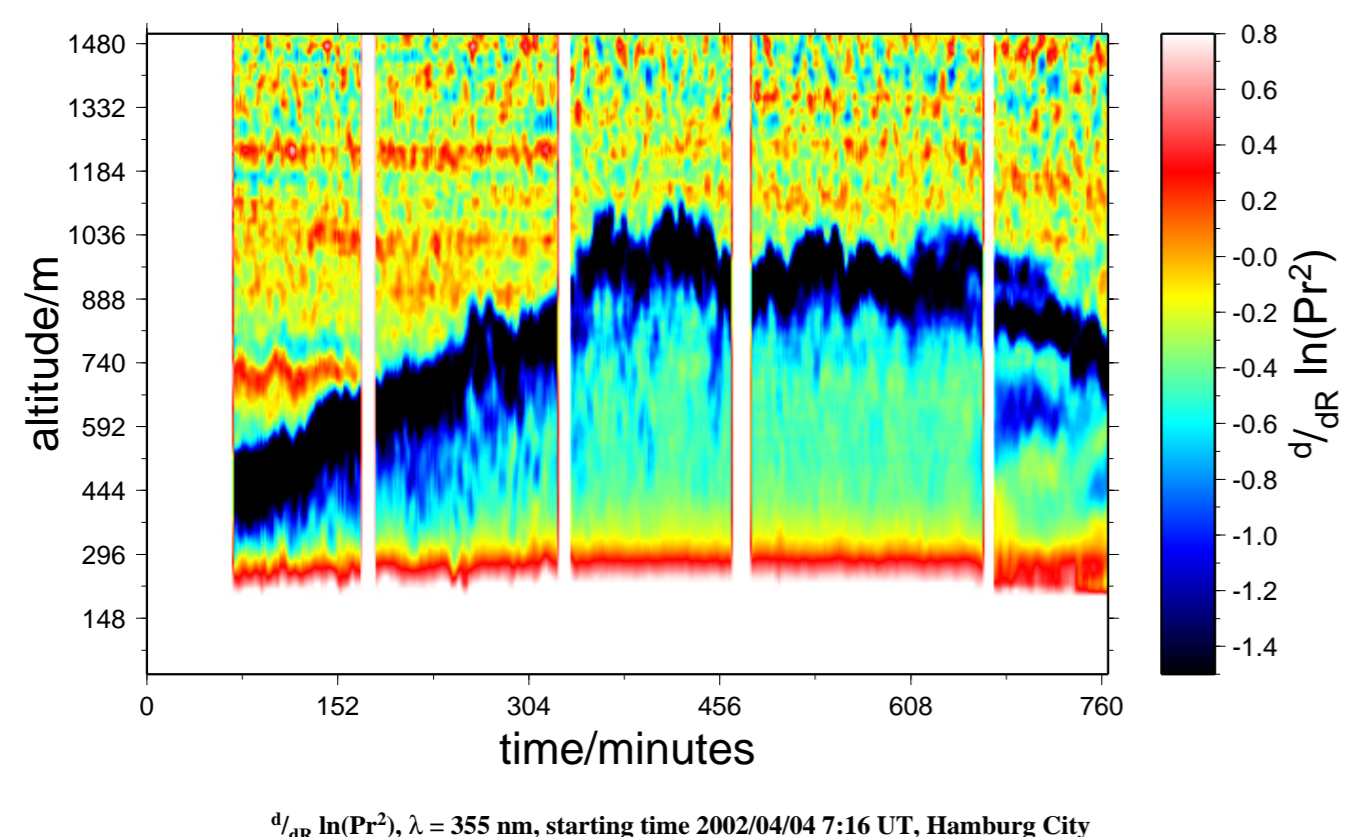
Profiles

The XeF lidar was operated for one year between Dec. 2001 and Nov. 2002 at the Astronomical Observatory of the University of Hamburg in Bergedorf. It was located directly at the South East border of the city of Hamburg, the horizontal distance to the system in the centre was ca. 25 km.

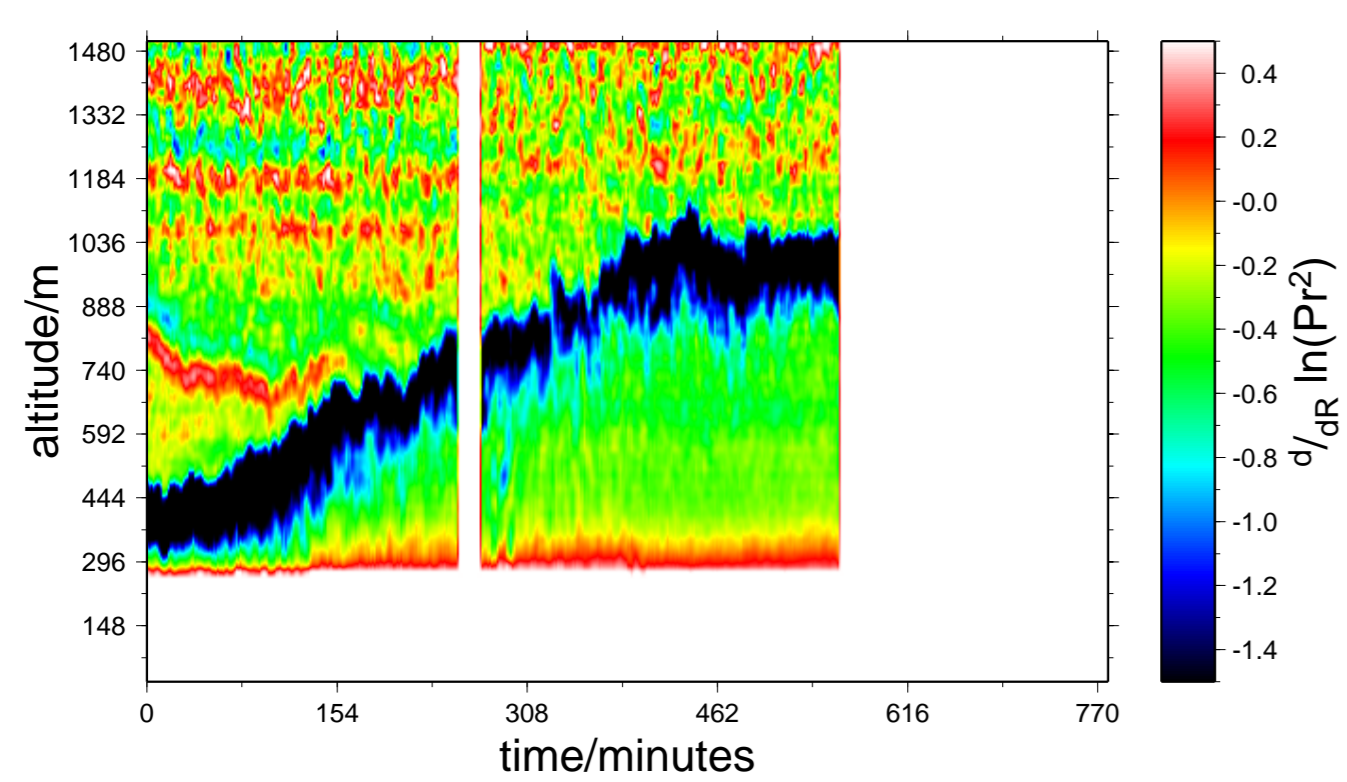
Measurements have been taken on cloud free days and during weather situations which permitted homogeneous conditions in a large terrain. On most of the days the lidars have been operated from morning to sunset to observe also the temporal development of the planetary boundary layer. The profiles for the day to day comparisons have preferably been taken in the evening when turbulence has decreased and the aerosol vertical distribution is relatively stable. During the one-year observation period, measurements on 14 different days, distributed over all seasons, have been taken. Aerosol backscatter values were ranging between less than 10^{-6} 1/(m-sr) and more than 10^{-5} 1/(m-sr), dust layer heights were ranging between a few hundred and 3000 m.



PBL development



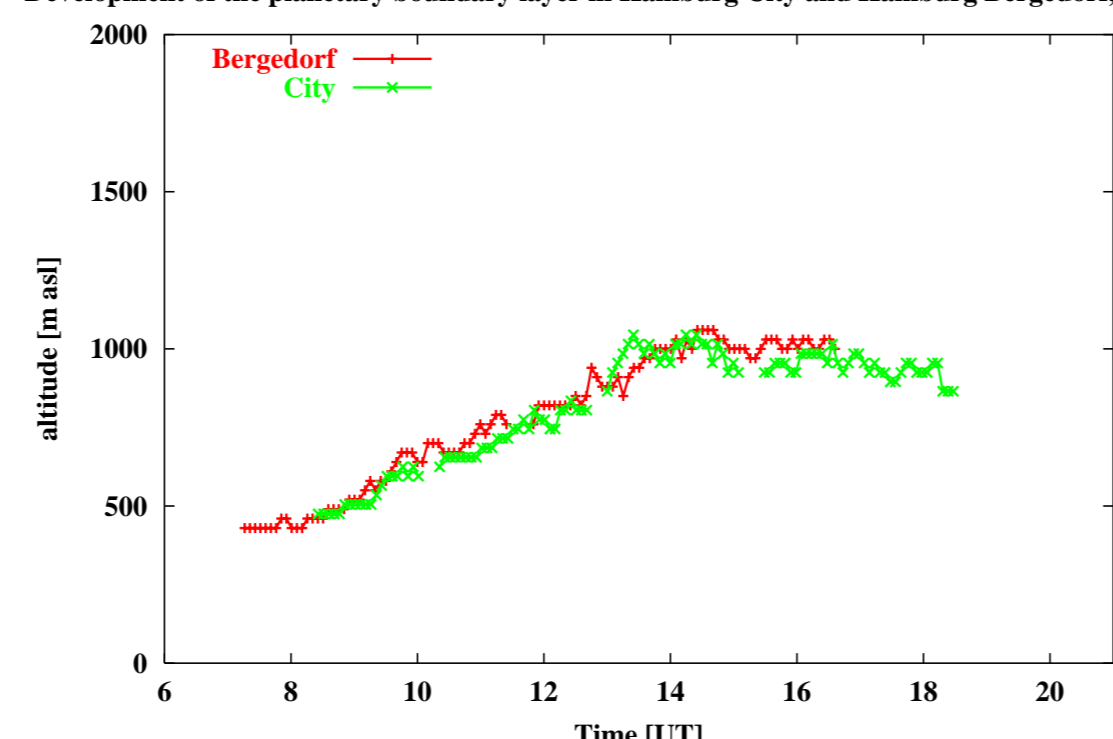
$d_{GR} \ln(P_r^2)$, $\lambda = 355$ nm, starting time 2002/04/04 7:16 UT, Hamburg City



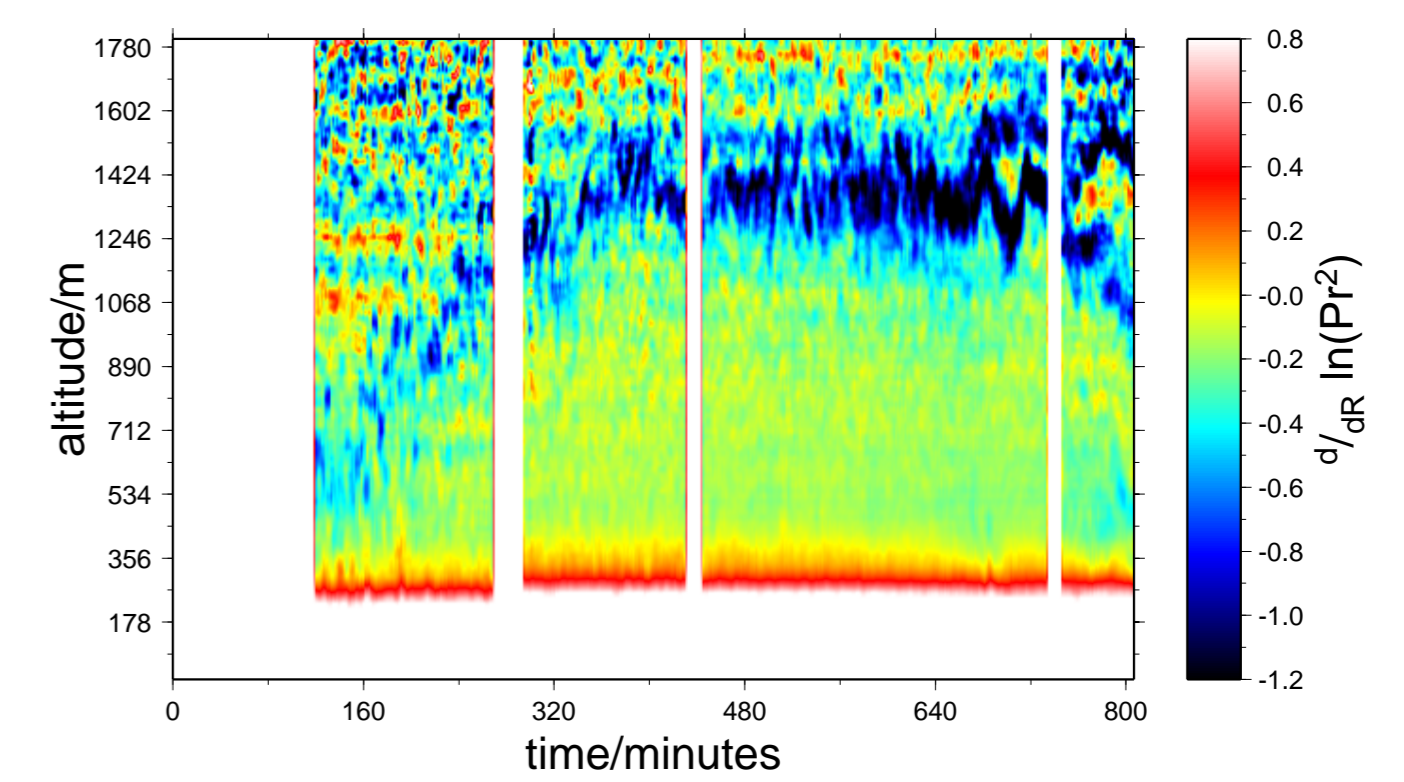
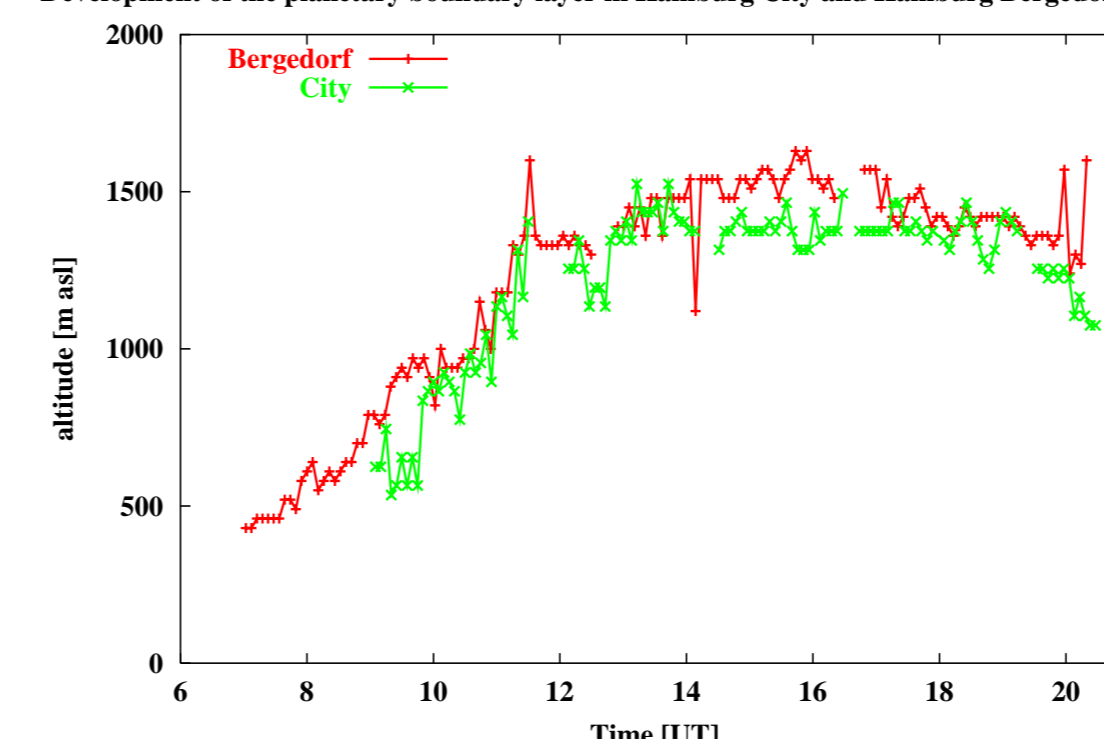
$d_{GR} \ln(P_r^2)$, $\lambda = 351$ nm, starting time 2002/04/04 7:16 UT, Hamburg Bergedorf

Additional to the aerosol values also the temporal development of the planetary boundary layer at Hamburg centre and Bergedorf has been investigated. Again, very high correlations have been found. Deviations can mainly be attributed to individual turbulence elements, which are of course different at both sites. Differences that have been found in the integrated backscatter on some occasions were mainly due to differences in the aerosol backscatter, not due to different boundary layer heights. An "heat island" effect with an elevated dust layer in the centre of the city compared to the outskirts could not be observed in Hamburg. On the contrary, if differences could be measured, the PBL height was slightly higher in Bergedorf than in the city centre.

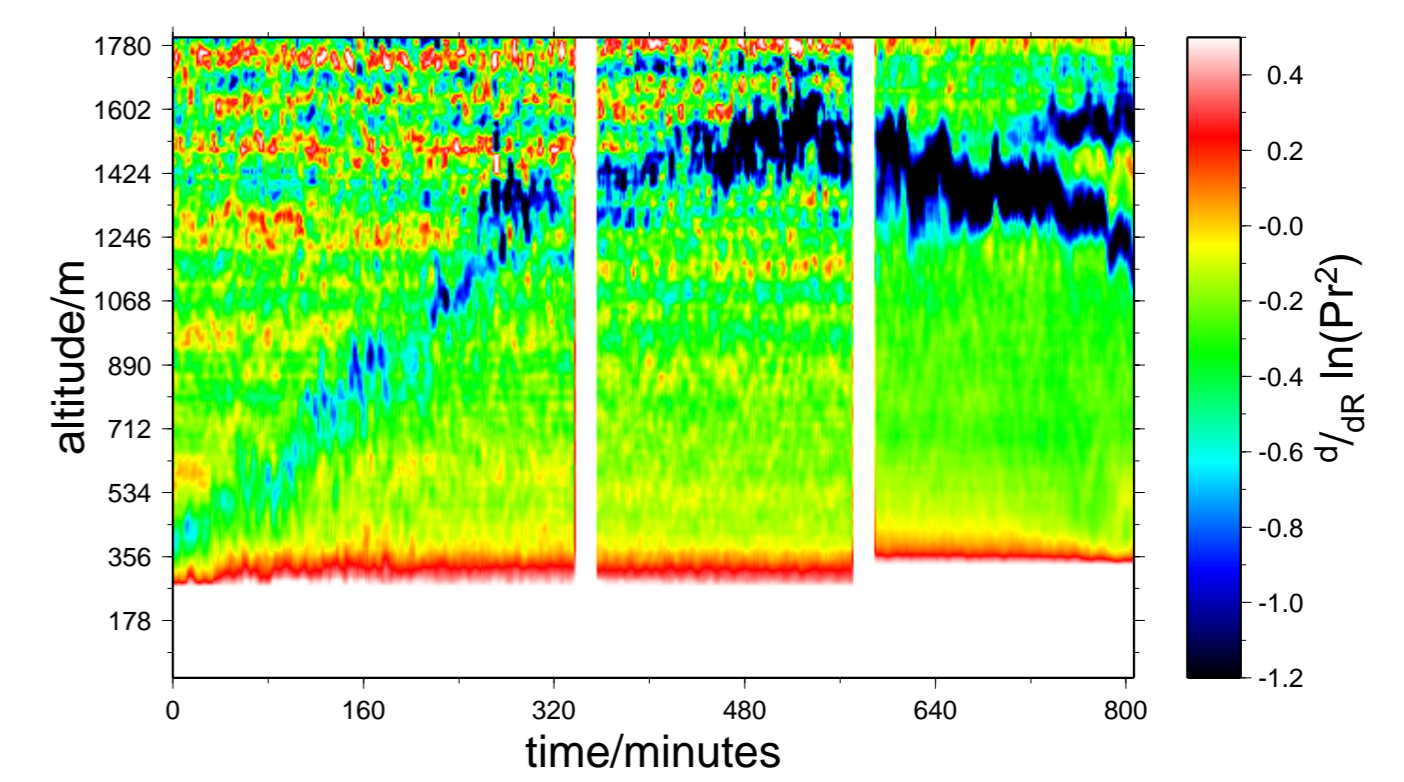
Development of the planetary boundary layer in Hamburg City and Hamburg Bergedorf, 2002/04/04



Development of the planetary boundary layer in Hamburg City and Hamburg Bergedorf, 2002/06/03



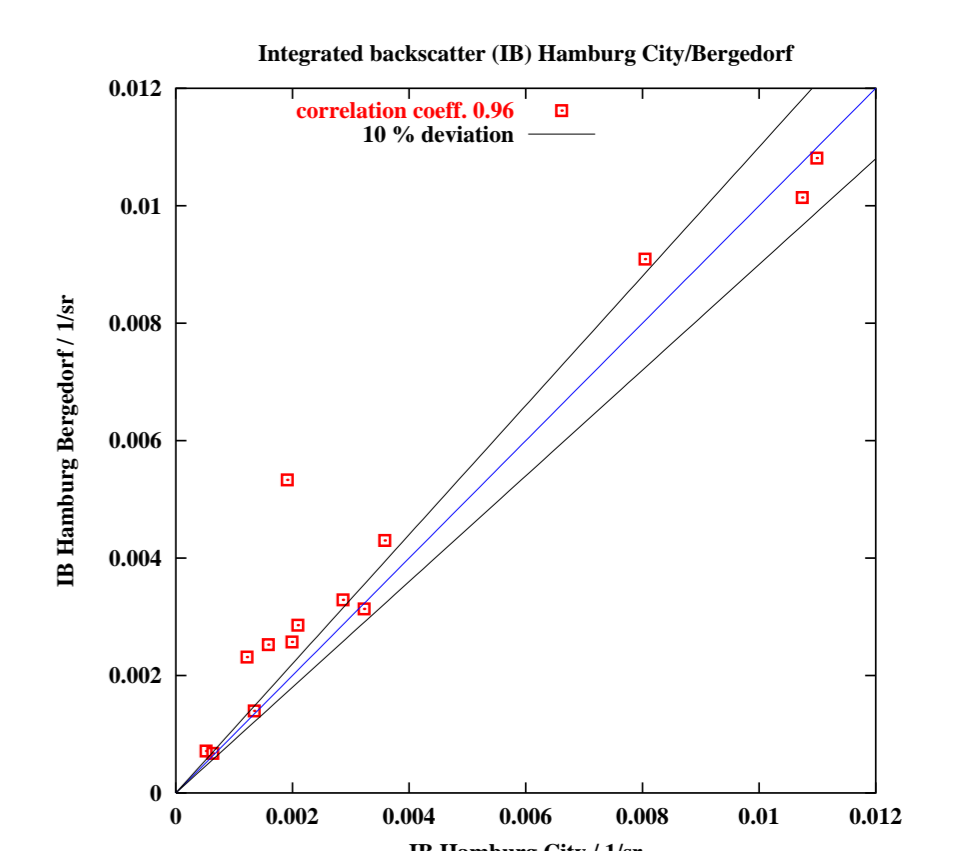
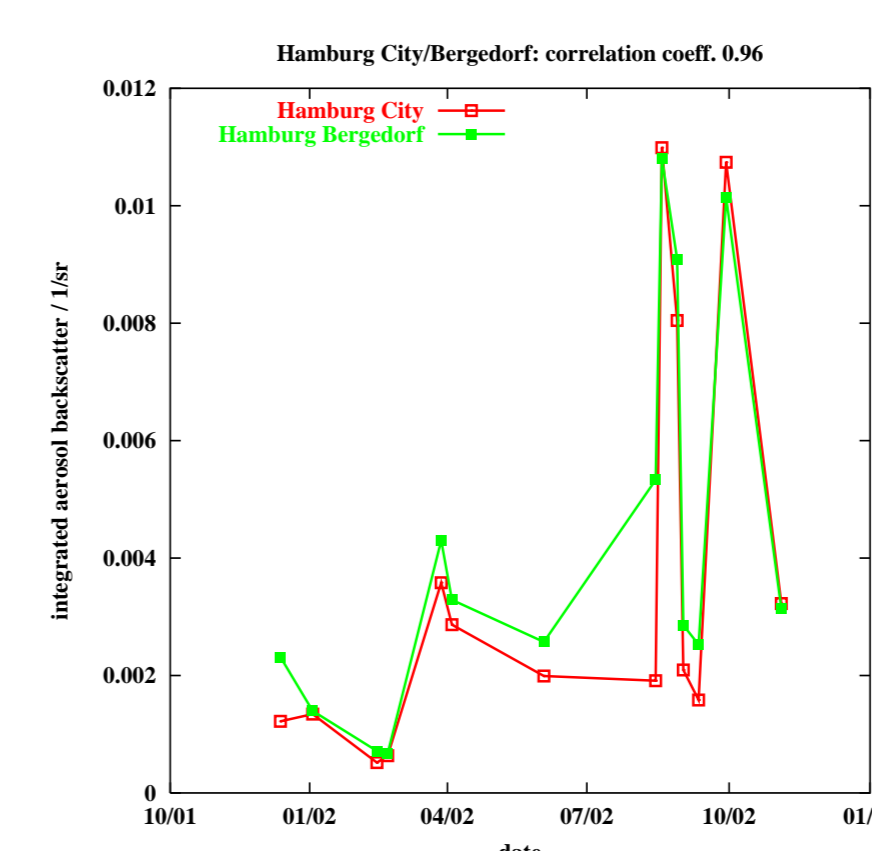
$d_{GR} \ln(P_r^2)$, $\lambda = 355$ nm, starting time 2002/06/03 7:02 UT, Hamburg City



$d_{GR} \ln(P_r^2)$, $\lambda = 351$ nm, starting time 2002/06/03 7:02 UT, Hamburg Bergedorf

Results

Most of the comparisons show only smaller differences between the profiles. Having in mind that lidar intercomparisons show typical deviations between the systems of 5 - 10 %, in most cases the aerosol distribution at Bergedorf was virtually the same as in the centre. This was also true for the boundary layer heights and therefore most of the integrated backscatter values are very close. This leads to the conclusion that lidar profiles of the aerosol vertical distribution are representative for a larger area, at least in the order of a few tens of kilometers, even if they were taken in the centre of a big city. However, in Bergedorf also values more than 20 % higher than in the city could be found. Remarkably, if significant deviations occurred, higher values were always found at the border of the city and not in the centre, regardless of wind direction. The differences between the profiles typically increase with height and therefore they might be explained by higher humidity values at the top of the boundary layer in the more rural environment.



Comparison of Hamburg-City and Hamburg-Bergedorf Data

Date	IB		Trajectory 19 UT	Time of Measurement		
	City	Bergedorf		Morning	Noon	Evening
	[10^{-3} sr $^{-1}$]	[10^{-3} sr $^{-1}$]				
01/12/13	1.22	2.31	SE			x
02/01/03	1.34	1.40	SE			x
02/02/14	0.52	0.71	E			x
02/02/21	0.63	0.67	NW			x
02/03/28	3.58	4.30	SE			x
02/04/04	2.87	3.29	E		x	
02/06/03	1.99	2.57	SE			x
02/08/15	1.91	5.33	N		x	
02/08/19	10.99	10.81	SE			x
02/08/29	8.05	9.09	NW (950hPa) SW (850hPa)			x
02/09/02	2.09	2.86	E			x
02/09/12	1.58	2.53	E			x
02/09/30	10.74	10.14	SW			x
02/11/05	3.23	3.13	SE			x
mean	3.62	4.22				