Vertical Profiles of CO_2 in an Urban Street Canyon

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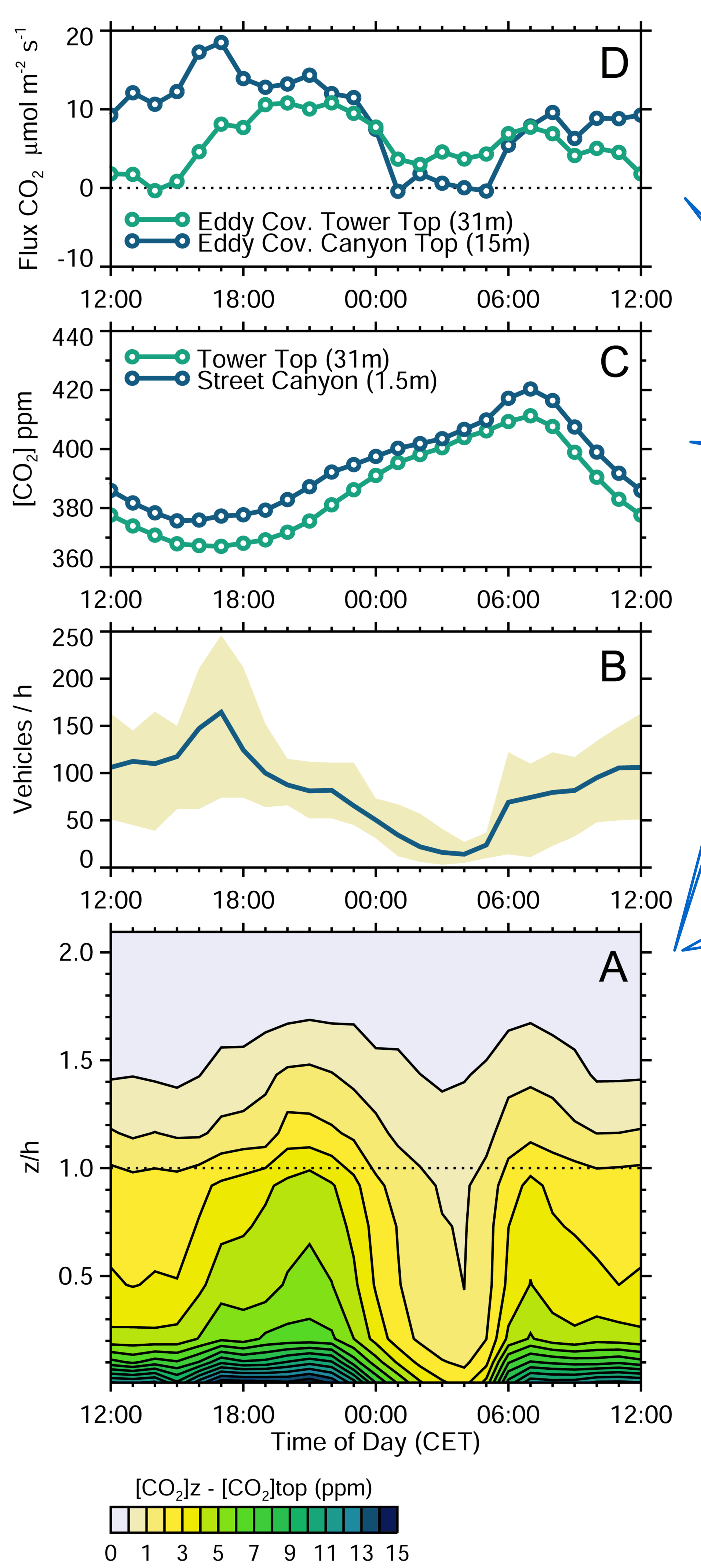
Measurements of CO_2-fluxes over urban surfaces are rare, even though cities are an important source of CO_2. However, the morphologically complex surfaces and the non-homogeneous distribution of CO_2-sources form methodological difficulties (Grimmond et al., 2002).

It is the aim of BUBBLE (Basel Urban Boundary Layer Experiment, a COST 715 action) to increase the knowledge of mass, momentum and energy exchange over urban surfaces (Rotach, 2001). Results from profile measurements of mean CO_2-concentrations should help explaining the exchange processes rather than quantifying urban emissions. The presented results focus on diurnal mean courses combined with traffic data and selected turbulence parameters.

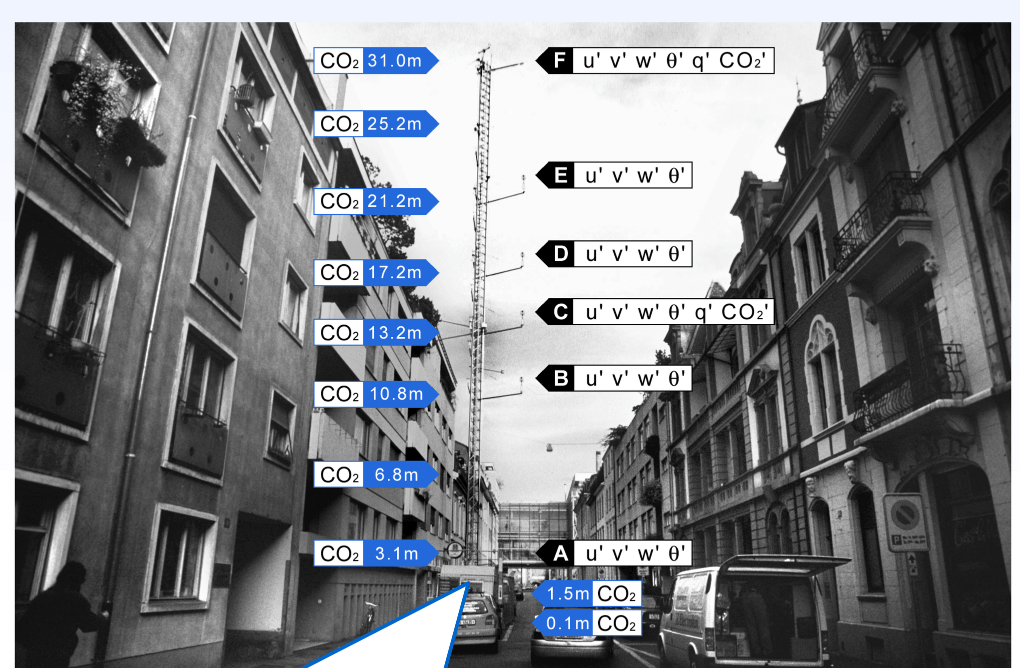


▲ **A:** Average diurnal course of the vertical CO_2 gradient: CO_2-concentration difference from all 10 levels to the measurement at tower top. Data from March 1 to July 15 2002 are shown. **B:** Average diurnal course of the traffic load in the canyon. The grey area indicates maximum and minimum values. **C:** Average diurnal course of CO_2 concentrations inside the street canyon (1.5m) and above the urban surface at 31.7m from the LICOR 6262 system. **D:** CO_2-fluxes from the two LICOR 7500 open path analyzers that were operated in June / July 2003 during 4 weeks.

Site

The instrumented canyon ("Basel-Sperrstrasse") is located in a densely built-up part of the city of Basel. The surface has a high plane area density λ_p of 0.57 and an average building height *h* of 14.6 m.

A triangular lattice tower was installed 3 m off the northern building wall and operated over nearly one year. It supported 6 ultrasonic anemometer-thermometers, full radiation components at tower top and inside the canyon, a temperature / humidity profile of 5 levels, 12 levels of cup anemometers and 10 levels with inlets for the CO_2/H_2O-analyzer. The traffic load in this particular canyon was counted to be 2000 vehicles per day.



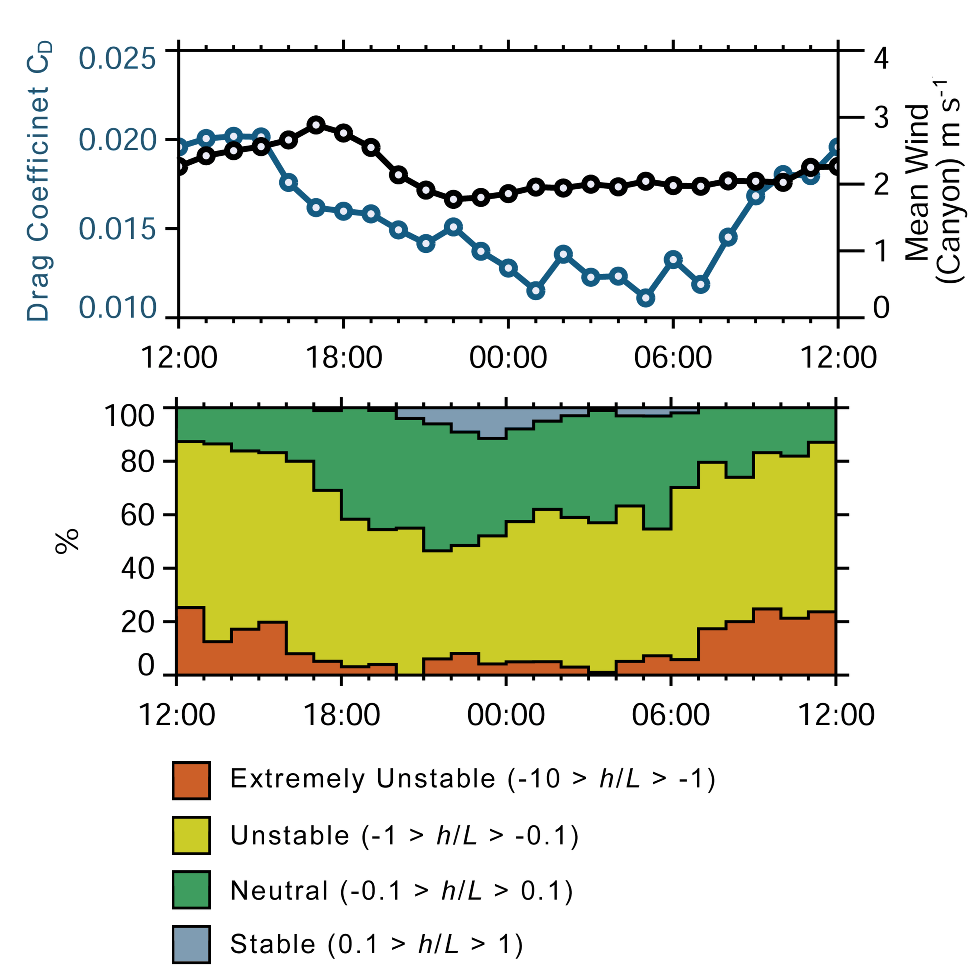
The setup allows unique possibilities to study CO_2-exchange inside an urban street canyon and in the urban roughness sublayer. Both, eddy covariance CO_2-fluxes and mean CO_2-concentration profiles are available.

Observations of CO2-gradients derived from profiles fit with eddy covariance flux measurements (open path).

Maximums of CO_2-concentrations are observed during morning hours with relatively high traffic and low mixing.

Good correlation between traffic load as well as mechanical mixing (which depends mainly on wind speed) and CO_2-gradients (fluxes of CO_2): higher emissions (higher traffic) and lower mechanical mixing both increase the absolute value of gradients (spring and summer data, no firing).

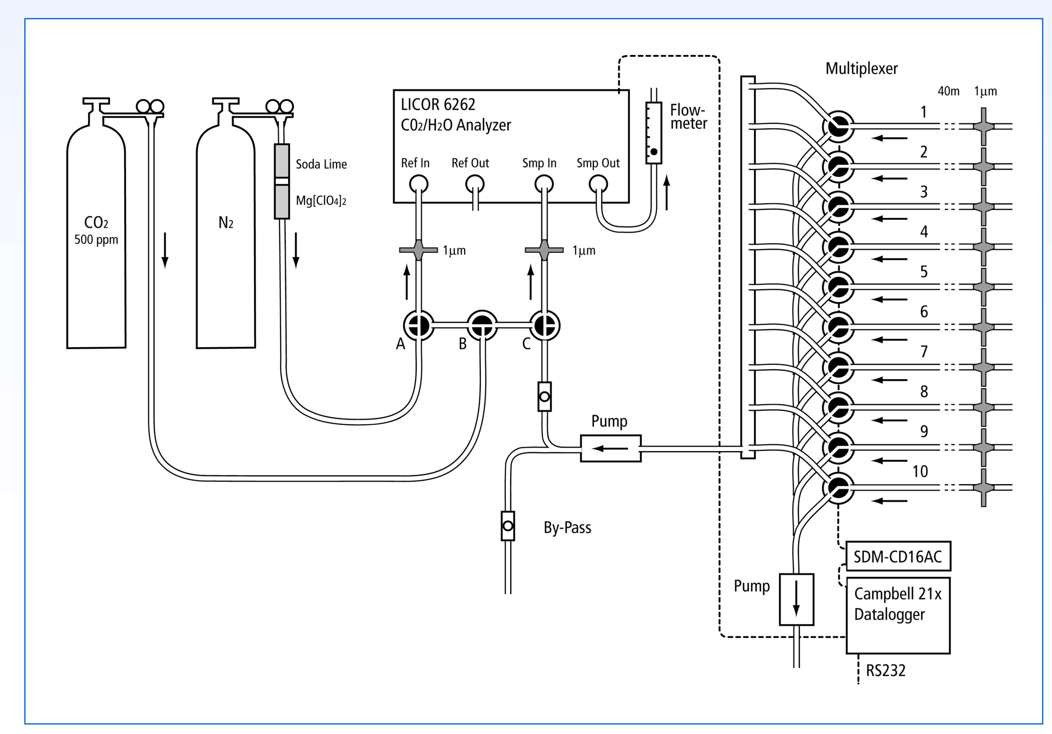
Concentrations are always decreasing with height. This results in positive fluxes of CO_2 away from the urban surface all the time. This is in agreement with other urban CO_2-studies (Nemitz et al., 2002) and in contrast to suburban surfaces, where a daytime CO_2-uptake was measured (Offerle et al., 2001). Smallest gradients are observed during early morning hours with low traffic.

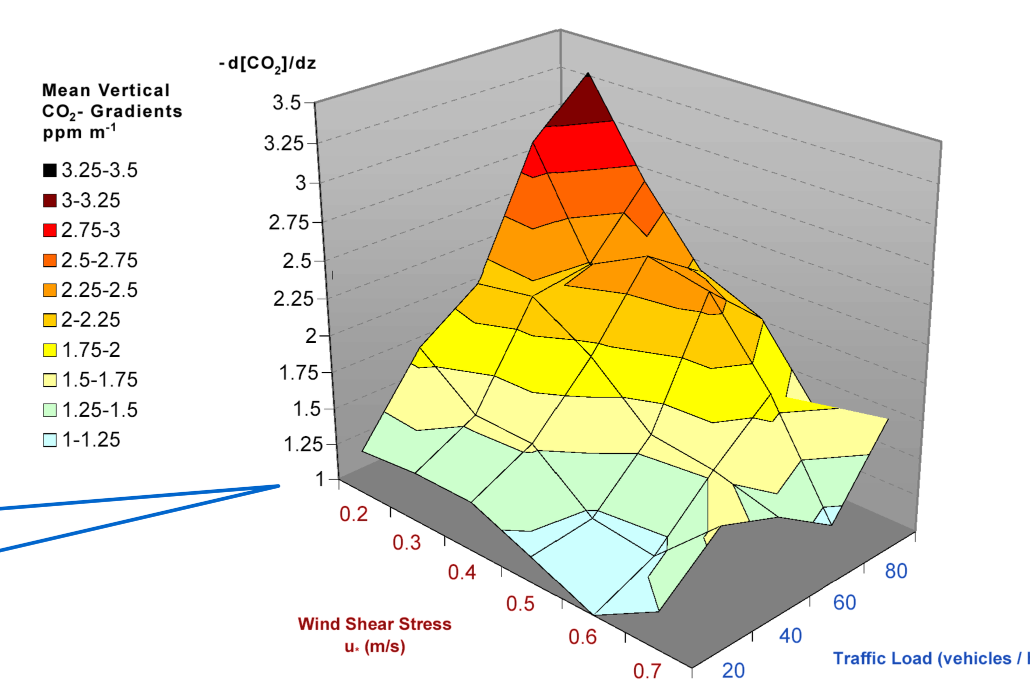


▲ Average diurnal course of the drag coefficient $C_D = (u_*/u)^2$ and wind speed inside the canyon (top) and stability at tower top (bottom) Data is shown for the period March 1 to July 15 2002. Note that stable situations are rarely observed over an urban surface.

Instrumentation

A CO_2/H_2O gas-multiplexer system sampled sequentially air from 10 tower levels. Air is sucked from each inlet at the tower through a 40 m tube down into a van, where a gas multiplexer and a LICOR 6262 gas-analyzer were operated. Each channel is sampled 30 s, the first 10 s after switching are discarded. Mean values over the remaining 20 s are stored. This results in mean profiles (10 levels) with a resolution of 5 minutes. The gas-analyzer was operated from December 2002 until July 2003 in differential mode, i.e. measuring continuously a zero gas in the reference cell. During the IOP in Summer 2002 additional instrumentation was deployed including two LICOR 7500 open path analyzers at *z*/*h*=1.0 (14m) and *z*/*h*=2.2 (31m).





▲ Surface plot illustrating the mean value of the vertical CO_2-gradient in ppm m^{-1} for given u* and traffic load on 1h blocks for March 1 to July 15 2002.

References

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Additional Information

http://www.unibas.ch/geo/mcr/Projects/BUBBLE/
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