3.5.2. Diurnal Variations of c(CO_2)

During the last two years of project Phymoes, a Valtronics NDIR CO_2 sensor which works by pure diffusion (see Part 2, chapter 3) was functioning at a location situated in the cliff, about 1 m above the main entrance of the cave. This position was chosen to avoid outflowing air reaching the sensor. Frequent breakdowns were due to the sensitivity of the instruments to high humidity levels; a heavy or continuous rain-fall nearly always drove the sensor into saturation, which gave impossible high readings. The time-span to reach again a good working condition was often many days. Thus we have only relatively short periods which are usable to study the outside CO_2 variations and to look for a synchronism with inside c(CO_2) changes.

The period from 1 to 10 May 1994 is a good example demonstrating the synchronism between outside and inside diurnal CO_2 concentrations: for that time span the outside temperature was practically always higher than 10°C, resulting in inflow of fresh air into the cave. The synchronism between the c(CO_2) at all stations can be seen in the plot of the 3 data series; a spectral analysis very clearly shows a common 24 hour peak.

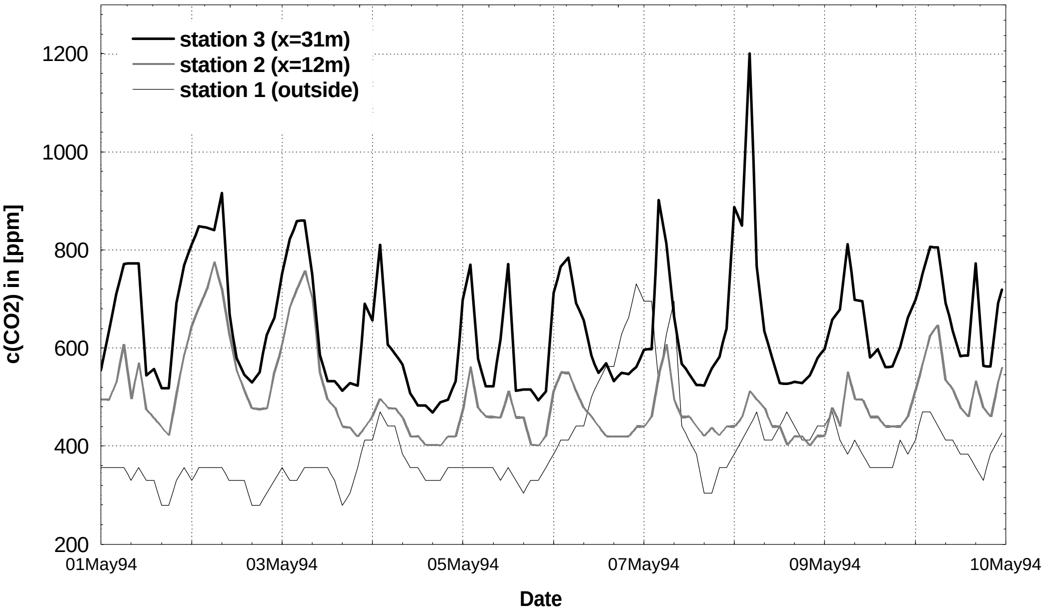

Fig. 3.5.2. Variations of CO_2 at the outside, station 2 and station 3

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3.5.5. c(CO_2) and Cave Air Wind

The thermally induced air movements into or out of the cave are caused by the temperature difference between the outside and inside of the cave; as the deep cave temperature is practically constant, cave wind is a function of the sole outside air temperature when no external wind blows! We found in the preceding chapter that outside wind gust does not change noticeably the mean CO_2 concentrations measured over long periods. This cannot be the case if we analyze short time series, which should show the influence of air movements caused by outside wind. To study the impact of outside gusts, we will take the special case where $T_{outside} \approx T_{cave}$, which means that there should be practically no thermally induced flow. This situation happens over a longer time range in autumn; we will use the data from October 1994 and retain only those 106 values where the absolute value of the difference between outside and deep cave temperature is less than 0.5°C:

$$\left|T_{outside} - T_{station3}\right| < 0.5°C$$

Any air movements that exist will be caused by outside wind (gust is measured with a resolution of 0.5 m/s). Figure 3.5.12 shows the corresponding $c(CO_2)$, local air velocities and outside gusts. Two observations are obvious:

- At the end of the month, CO_2 concentrations drop sharply
- This drop coincides with an increase of the outside gusts and the local air velocities caused by the external wind, which blows fresh air into the cave.

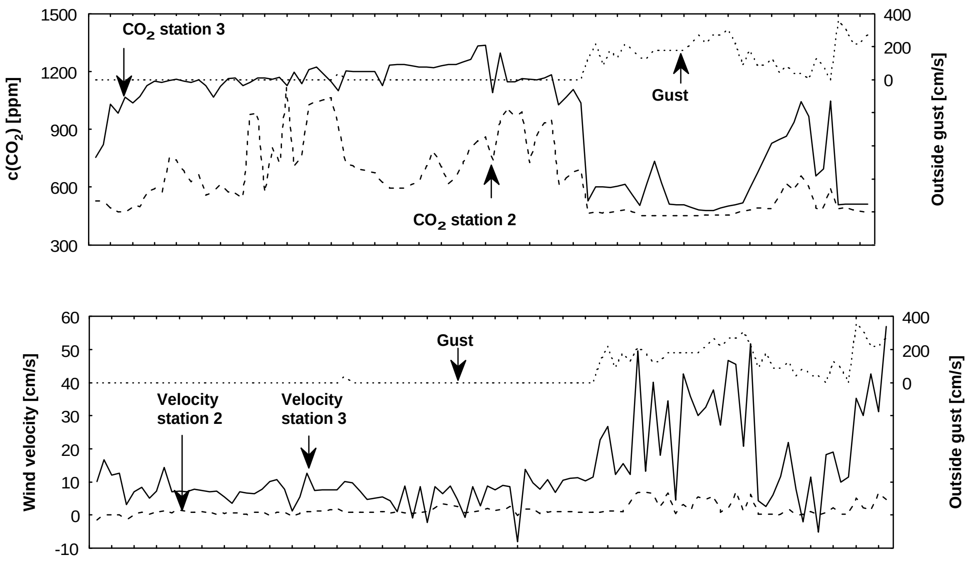

Fig. 3.5.12. CO_2 levels, local wind velocities and outside gusts (Oct.94, $T_{outside}$ » T_{cave})

If we plot CO_2 concentrations against the inflowing quantity of fresh air at station 2, we see that CO_2 levels at the entrance fall abruptly in a step-wise manner when inflow exceeds 200 m^3/h. The decrease at station 3 is more gradual and smooth: less of the air entering the cave reaches that station, as a major part escapes from the main gallery into the other pathways, and as a consequence ambiant cave air is less diluted at station 3 than at station 2. (fig. 3.5.13).

To predict the influence of outside gusts on $c(CO_2)$, we need a good empirical fit; computations show that the best one is exponential. The results given by applying a Newton-Simplex algorithm are found in table 3.5.6.

The damping factors in both expressions are reasonably close, that of station 2 being higher, as the influence of outside wind is stronger near the entrance. A theoretical infinite high gust would push the CO_2 levels at both stations down to similar asymptotic values (420 and 475), which should correspond to the outside concentration (see fig. 3.5.14).

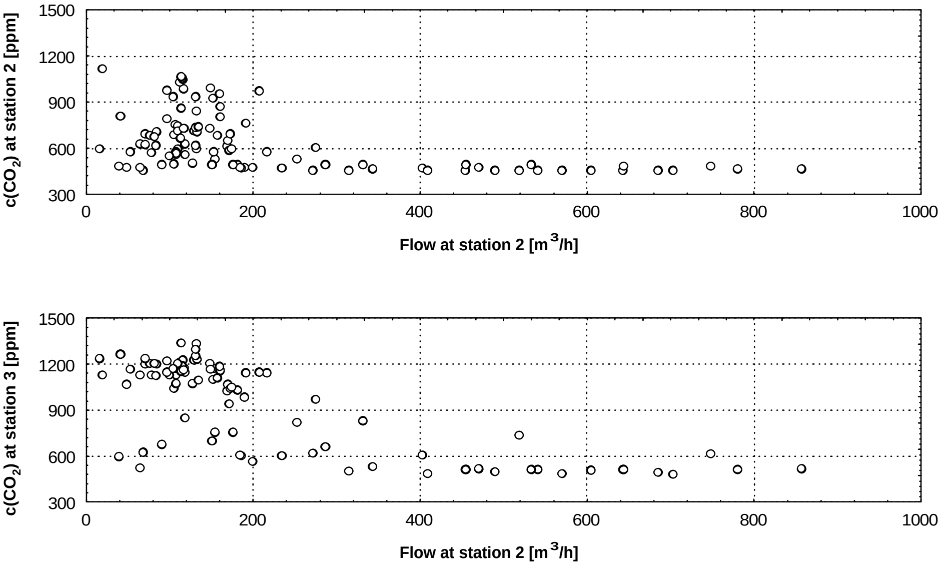

Fig. 3.5.13. CO_2 levels versus forced inflowing air quantity (Oct.94, $T_{outside}$ » T_{cave})

Table 3.5.6.

station	*fit of c(CO2) in [ppm] to gust in [m/s]*	
station 2	$c(CO_2) = 446 + 273 * e^{-1.334*gust}$	r=0.63
station 3	$c(CO_2) = 470 + 680 * e^{-1.094*gust}$	r=0.92

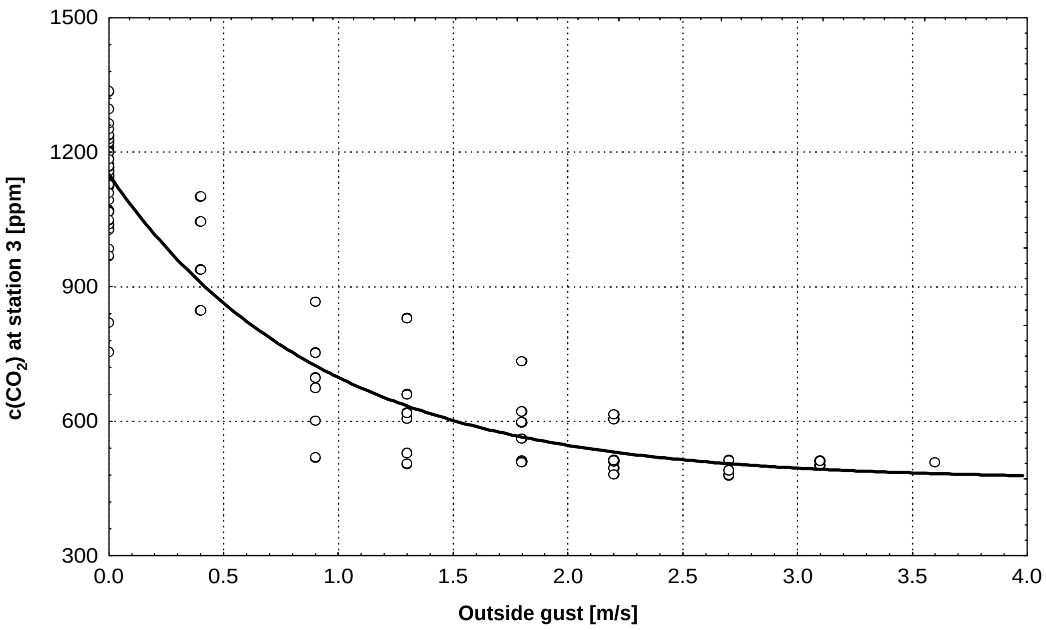

Fig. 3.5.14. CO_2 concentrations (here values at station 3) can be fitted to outside gust by an exponential curve