We present results from an airborne experiment designed to investigate the regional carbon dioxide budget and an attempt of relating local fluxes to underlying biological surface structures and anthropogenic emission sources. We investigated the impact of local surface inhomogeneities on the spatial and temporal distribution of trace gases in the near surface boundary layer during an airborne observation campaign in August 2004. Atmospheric concentrations of H$_2$O and CO$_2$ as well as several meteorological parameters were recorded with high spatial and temporal resolution over the heterogeneous, intensively managed farmland of the Jülicher Börde. A hyperspectral sensor and a high speed video camera were deployed in downward-looking mode in order to quantify coverage and biological activity of the vegetation below the aircraft. Additionally trace gases (CO, NO, NO$_2$, NO$_y$, PAN, O$_3$) as well as aerosols have been measured in parallel.

CO$_2$ and H$_2$O show pronounced small scale structures, both in the mixing ratios and in the fluxes (Fig. 1). The anti correlation between CO$_2$ and H$_2$O fluxes suggest that the fluxes are due to biological activity, i.e., photosynthesis and transpiration. The results suggest too that vegetation structures with a size of 500 meters can be identified in their contributions to the local CO$_2$ and H$_2$O budget. The highest CO$_2$ flux along the flight path are produced by a small natural preserve area with a poplar stand, whereas the areas covered by sugar beets seem to have substantially smaller CO$_2$ and H$_2$O fluxes (Fig.2). This will be further
investigated from simultaneous surface measurements of the CO$_2$ uptake and water vapour conductance.

The airborne measurements of CO and NO$_x$ proved extremely valuable for eliminating structures imposed on the CO$_2$ field by anthropogenic emission sources. The influence of traffic emissions from a business district and a motorway south of the area was clearly identified by the pronounced positive NO$_x$ fluxes in the southern part of the experimental area (Fig. 1). Using the NO$_x$/CO$_2$ emission ratios taken from emission inventories for the experimental area the contribution to the overall CO$_2$ budget can be quantified. Road traffic represents about 95% of the total NO$_x$ emissions in this area according to the emission inventory. The large coal-fired power plant Weisweiler, located upwind of the measuring area, was intercepted several times during the campaign causing strong enhancements in CO$_2$, CO and NO$_x$. From the slope of the correlation of data collected in the plume (see Fig. 3), the average CO/CO$_2$ emission ratio is estimated to 0.65 ppb/ppm, which is in good agreement with the ratio of 0.6 ppb/ppm calculated from the reported emissions of the power plant. Other industrial sources were detected occasionally, but their influence on the measured concentrations was generally small.

The combination of airborne flux measurements and high resolution emission inventory will provide information on the contributions of different anthropogenic sources to the CO$_2$ budget and will hence allow a better assessment of the exchange fluxes with the biosphere.

Fig. 2 Photosynthetic uptake of CO$_2$ and transpiration by sugar beat leafs underneath the flight tracks (a LAI of 4 has been assumed)

Fig. 3: Relation of CO to CO$_2$ in the plume of the power plant Weisweiler