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Aggregation of CO_2 fluxes

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The distribution of CO2 flux to sea and land surfaces is a critical factor in the estimate of the uptake of carbon when derived by mesoscale atmospheric models. Neither the land nor the sea surface can be considered homogeneous with respect to sensible and latent heat and CO2 fluxes. Therefore both flux measurements and aggregation of fluxes are important topics of research.

The present study formulates the mass budget for CO2 from the surface to the top of the atmospheric boundary layer, taking into account the entrainment of air from above the boundary layer caused by the growth of the boundary layer, as well as the effect of subsidence and the uptake of CO2 by the vegetation.

Micrometeorological measurements including fluxes and concentrations of CO2 were carried out in Denmark over a grassland site near Risø (RIMI) and over a beech forest in the centre of Sealand (near the town of Sorø). During an intensive measuring campaign in June 2006 additional measurements were performed.

The growth of the boundary layer as function of time was determined from measurements by radiosondes, that were released at intervals of 3 hours at 06, 09, 12, 15 and 18 local time (=GMT+2). The sonde measures temperature by use of a thermistor, humidity by a capacitor. A 3D GPS module build into the sonde provides the position, including the height, from which the horizontal wind speed components are derived. Measurements are performed every 1 second.

A Sky Arrow 650 ERA aircraft was used to measure vertical profiles over the RIMI

site on 12 and 13 June 2006. The profiles extended from about 100 meters above ground up to 3000 meters. A nose mounted intake connected to a LiCor 7500 open path infrared gas analyzer allowed fast measurements (50 Hz) of CO2 and H2O gas concentrations. Boundary-layer height

The height of the boundary layer was determined by simultaneously considering several parameters in the radiosonde profile such as jumps in the temperature, wind-direction, wind-speed and humidity. It is also considered that the turbulence inside the boundary layer is more vigorous as compared to the air above, this effect is seen mainly in the fluctuation of the wind direction but also sometimes in the wind speed.

Interpolation of the height of the boundary layer was performed by use of a formula for the height of the boundary layer (for details see Gryning and Batchvarova (1990) and Batchvarova and Gryning (1991))

It was found that the CO2 concentration within the boundary layer is near constant with height from the surface up to 500 m where a jump of 5 ppm in the CO2 concentration marks the top of the growing boundary layer. This is in agreement with the estimate of the boundary layer height from the radiosonde measurements, Fig. 2. It can be seen that the next jump takes place at about 1700 m which marks the top of the residual layer (top of boundary layer from the foregoing day). Above the residual layer the CO2 concentration is about 380 ppm.

It was found that the aggregated flux of CO2 in broad terms follows the behavior of the flux of CO2 at RIMI (grassland) and Sorø (deciduous forest). It is promising that to see that the aggregated flux is comparable not only in size but also in the general diurnal cycle of CO2 fluxes at RIMI and Sorø.