TALL TOWER CARBON BUDGET MONITORING AND RESEARCH PROGRAMS IN HUNGARY

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ABSTRACT

The mixing ratio and the surface-atmosphere exchange of carbon dioxide have been monitored at different elevations on a tall tower in West Hungary (Hegyhátsál, 46°57'N, 16°39'E, 248 m asl) since 1994 and 1997, respectively. The vertical mixing ratio profile measurements along the 115 m tall tower has been completed with occasional aircraft measurements up to 3000 m above the ground. The poster presents the Hungarian tall tower site and the temporal variation of carbon dioxide observed here. We discuss the region of influence determining the mixing ratio variability, the so-called concentration footprint, as well as that of the flux measurements. Methodological problems caused by the elevated monitoring levels, and their solutions, are also given. The environmental factors governing the net ecosystem exchange (NEE) of the vegetation are analyzed by means of a process oriented ecosystem simulation model. It might be used to estimate the future behavior of the region as the climate is changing. On the basis of the measurements at Hegyhátsál a boundary layer model has been developed which can give rough surface-atmosphere carbon dioxide flux estimate for sites where only surface mixing ratio monitoring is available.

TEMPORAL VARIATION OF CARBON DIOXIDE MIXING RATIO

At Hegyhátsál, West Hungary (46°57'N, 16°39'E, 248 m - also a NOAA flask sampling site [HUN]), the atmospheric mixing ratio of carbon dioxide has been being monitored in a plain, rural, mid-continental environment at four elevation levels (10 m, 48 m, 82 m, 115 m) on a TV/radio-transmitter tower since 1994. An early study (Haszpra, 1999) showed that the spatial representativeness of the night-time measurements are rather limited, however, the daytime footprint analysis based on the method of Gloor et al. (2001) indicates that the daytime values may be characteristic up to a region of 100 thousand km^2. Due to the geographical position of the station the CO_2 mixing ratio shows remarkable diurnal and seasonal variations. The maximum daytime average concentrations are measured in December-January, well before the net uptake period of the biosphere, similarly to a few other Central European stations. The phenomenon emphasizes the importance of the advection in the formation of the regional CO_2 concentration field. It is also supported by the temporal variation in the vertical profile of the CO_2 mixing ratio.

The extended spatial representativeness of the daytime data allows the combination of the data series from Hegyhátsál and another Hungarian CO_2 monitoring station (K-puszta, 46°58'N, 19°33'E, 125 m) operated between 1981 and 1999. The 24-years long combined data series shows a 1.7 ppm/year linear increase from 343 ppm in mid-1981 to 384 ppm in mid-2005. The CO_2 mixing ratio in the middle of this highly industrialized, densely populated continent is about 3.7 ppm higher on average than the corresponding marine boundary layer reference (GLOBALVIEW-CO2, 2004). The time series follows the interannual variation in the global background fairly well, however, the amplitudes of the fluctuations are higher indicating the importance of the biosphere in the process.

NET ECOSYSTEM EXCHANGE

Hegyhátsál is also the site of regional scale biosphere-atmosphere carbon exchange monitoring. The poster gives the results of the multiannual CO_2 NEE measurements performed at the tall tower site. The eddy covariance measuring system is operated at 82 m elevation on the tower, above an area covered by agricultural fields and forest patches. NEE of CO_2 is determined as the sum of the eddy flux at 82 m and the rate of change of CO_2 storage below the measurement level. During the dormant season typical net exchange is around 1 g C m^{-2} day^{-1}, while the vegetation adsorbs around 2 to 4 g C m^{-2} day^{-1} in the growing season. During the period of 1997-2004 (year 2000 is missing) the region mostly behaved as a weak net CO_2 sink on annual scale. Year-round NEE was in the range of -107±48 g C m^{-2} $year^{-1}$ and 69±37 g C m^{-2} $year^{-1}$ (Table 1). Climate data are presented on the poster to explain the interannual variability of NEE, gross primary production (GPP) and total ecosystem respiration (R_{eco}). The region of representativeness of the direct flux measurements are estimated for daytime unstable conditions using the surface layer footprint model of Schmid (1994). The peak location of the footprint function is also estimated using the simple parameterized mixed layer footprint model of Kljun et al. (2004). The two different footprint estimates are compared well which means that the source area of the measured NEE signal is well established though the vegetation around the tower is rather heterogeneous

Table 1. Net ecosystem exchange (NEE), gross primary production (GPP) and total ecosystem respiration (R_{eco}) at Hegyhátsál. The uncertainties of NEE, GPP and R_{eco} are determined using Monte-Carlo analysis.

period	**1997**	**1998**	**1999**	**2001**	**2002**	**2003**	**2004**
NEE (g C m^{-2})	-37±34	-79±44	-63±44	10±29	-40±38	69±37	-107±48
GPP (g C m^{-2})	-1099±44	-1160±64	-1260±104	-932±51	-1049±86	-829±65	-1346±74
R_{eco} (g C m^{-2})	1062±39	1081±68	1197±107	942±48	1009±91	898±67	1239±78

ECOSYSTEM SIMULATION MODEL

The environmental factors governing the net ecosystem exchange of the vegetation are analyzed by means of the BIOME-BGC process oriented ecosystem simulation model. The model was adopted to reconstruct the present state of carbon balance of the vegetation, and to give an estimate of the future changes in the carbon budget. As a first step the carbon budget of the semi-natural grassland located at the tall tower site was simulated. The results of the eddy-covariance measurement, specially designed for the grassland and covering 1999-2000, were used for the model validation. The first results are promising since the BIOME-BGC model was able to capture the order of magnitude of the measured NEE, GPP and R_{eco} without any special refinement. The poster presents the most recent results together with the reference NEE data.

BOUNDARY LAYER BUDGET MODEL

The parallel measurements of NEE and CO_2 mixing ratio has the unique opportunity to challenge the boundary layer budgeting in the region. It is assumed that during well mixed conditions the CO_2 mixing ratio measured at the highest monitoring level on the tower (115 m) is a good estimate of the average CO_2 concentration of the convective boundary layer (CBL). Daytime regional scale surface flux can be calculated using the mass conservation equation for the CBL (*Denmead et al*., 1992) from the measured changes in the CO_2 mixing ratio and CBL height. The CBL model results available in the literature cover only a few days. We have made attempts to extend the temporal applicability of the CBL model in order to investigate the dependence of the model error on the input data. The CBL model was tested for 2003. We present the dependency of the model results on the different input parameters.

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