BayCEER-Workshop
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Outline of instruments and objectives of subproject TP5 integrated in FORKAST project and first results

Investigation of carbon turnover in grasslands in Northern Bavarian low mountain ranges under extreme climate conditions

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Introduction

Grassland in low mountain ranges is considered as important carbon storage, but can this be affirmed in times of climate change? Subproject TP5, integrated in FORKAST project, investigates local carbon cycle and in particular adaptability of plant community's species to drought periods, predicted by long time climate research. Micrometeorological flux measurement techniques (eddy covariance "EC" and hyperbolic relaxed eddy accumulation "HREA") and tracing of ^{13}C as well as ^{15}N in plant and soil - based on ^{13}C chamber pulse labelling and ^{15}N fertilisation, help to achieve these objectives. Completely new is the evaluation of atmospheric background $^{13}CO_2$ fluxes' influence on tracer translocation in the course of a stable isotope labelling experiment.

Climate conditions

To evaluate the representativeness of the intensive observation periods' results, long-time climate of region and site has been investigated. Table 1 illustrates monthly temperature averages over the last 40 years. TP5 includes artificial droughts – induced by rain out shelters. For the choice of the appropriate time period, Figure 1 is essential. It points out precipitation deficits mainly in spring and August.

Voitsumra Climate Station - Air temperature at 02 m in °C, 624 m a.s.l. * gapfilled with neighbour station values

monthly means	month												
year	1	2	3	4	5	6	7	8	9	10	11	12	annual mean
2000				7.9	12.0	14.2	13.0	15.2	11.3	8.8	3.9	0.0	
2001	-2.1	-0.4	2.0	4.4	11.7	11.7	15.0	15.6	9.0	9.8	0.9	-3.2	6.3
2002	-2.6	2.2	1.6	4.2	10.5	13.8	13.2	14.5*	9.4	5.3	3.4	-2.6	6.1
2003	-3.1	-6.3	1.6	4.0	11.2	16.0	15.4	17.9	10.4	3.1	3.9	-1.1	6.2
2004	-3.7	-0.4	0.6	5.8	8.3	12.5	14.3	15.1	10.4	7.2	1.7	-2.4	5.8
2005	-0.9	-5.2	0.2	6.3	10.3	13.7	15.6	12.9	11.5	8.1	0.9	-2.2	6.0
2006	-6.5	-4.7	-1.9	5.2	9.7	13.7	17.8	12.0	12.8	8.7	3.5	1.2	6.0
2007	1.3	1.3*	3.3*	7.7	11.4	14.6	14.6	14.2	9.6	5.5	0.2	-1.6	6.9
2008	0.6	1.2	-0.1*	5.1	11.2	14.5	14.7	14.0	9.0	6.2	2.2	-1.4	6.4
2009	-5.1	-2.7	1.1	9.3	11.3*	12.3*	14.8*	15.3	11.2	4.0	3.0	-2.6	6.0
Avg 2000-2009	-2.5	-1.7	0.9	6.0	10.8	13.7	14.8	14.7	10.5	6.7	2.3	-1.6	6.2
Avg 1961-1990	-3.6	-2.0	0.8	4.8	9.1	12.5	14.1	13.1	10.5	6.1	1.4	-1.7	5.4
Avg 1971-2000	-2.9	-1.7	1.5	4.9	9.6	12.6	14.6	13.8	10.4	6.0	1.2	-1.3	5.8

Tab. 1: Monthly temperature averages (coldest / warmest), synthetic long-time averages 1961-2000 from Beierkuhnlein and Foken (2008)

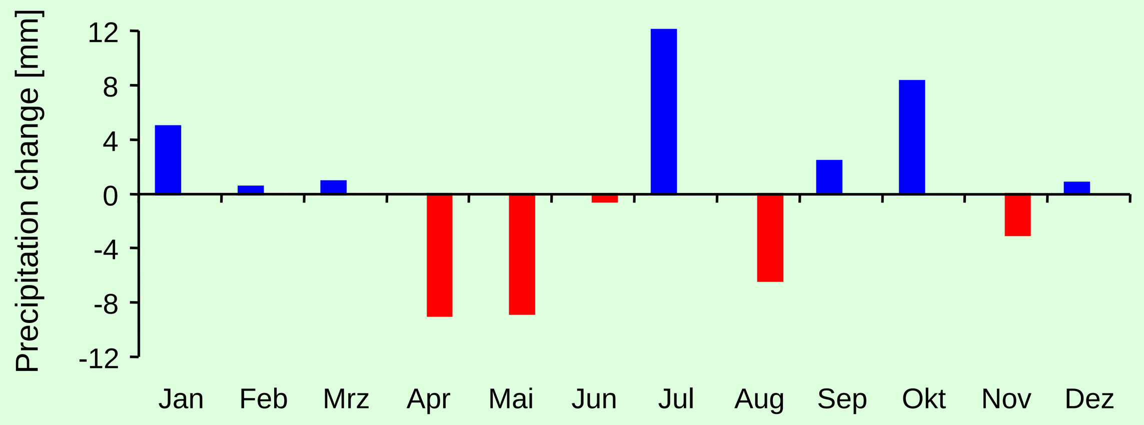

Fig.1: Precipitation 1971 - 2000 minus precipitation Abschnitt 1961 - 1990 at Waldstein site (775 a.s.l, 5,8 km northeast Voitsumra site, Foken, 2003)

Micrometeorological framework

In the course of preparation of eddy covariance based CO_2-flux measurements, a six year time series of wind speed and wind direction has been analysed (Figure 3). Additionally, footprint-modelling after Göckede et al. (2006, model: *TERRAFEX*) was required, to ascertain exclusively grassland as source for the fluxes (Figure 4).

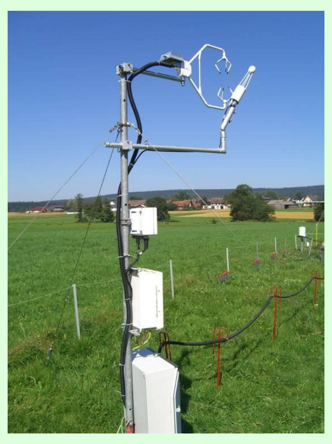

Fig. 2: Turbulence measurement complex (with LI-7500 IRGA and CSAT3 ultra sonic)

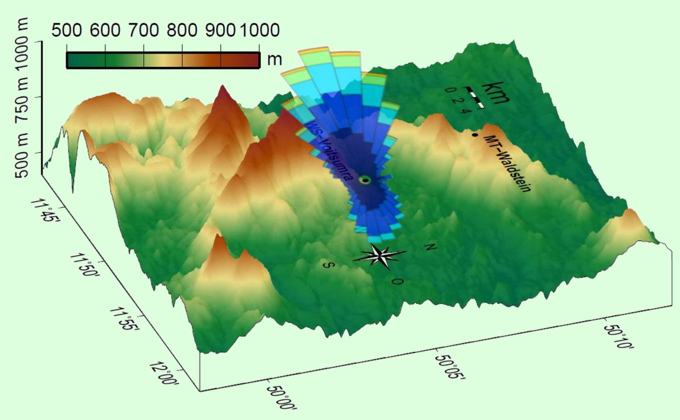

Fig. 3: Wind climatology and topography at Voitsumra site

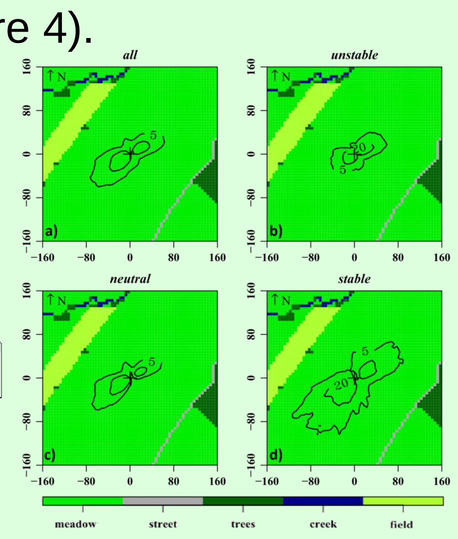

Fig. 4: Footprint and land-use (Tower: +, line labelled with 20: 80% of influence, line labelled with 5: 95%

First result: CO_2-fluxes

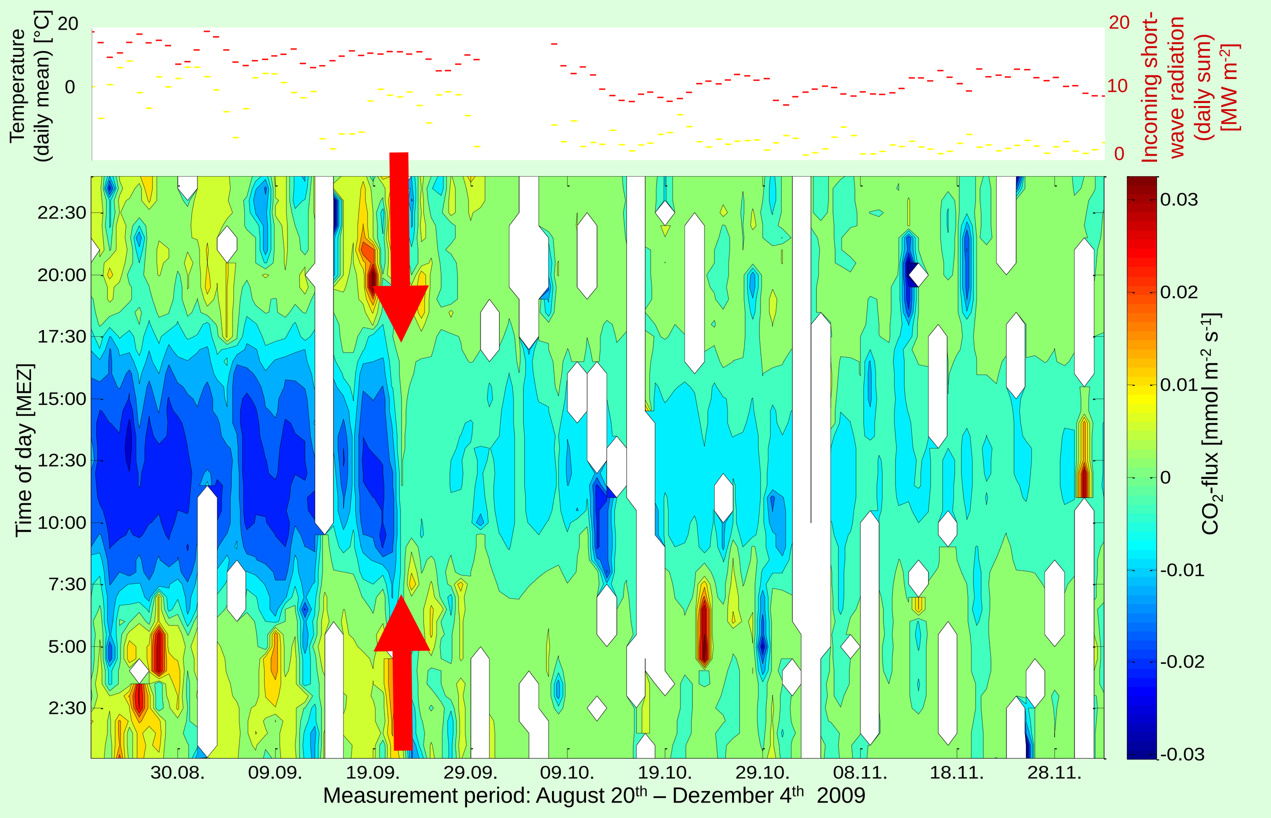

Fig. 5: Temperature, incoming shortwave radiation and CO_2-flux (red arrows highlight date of mowing)

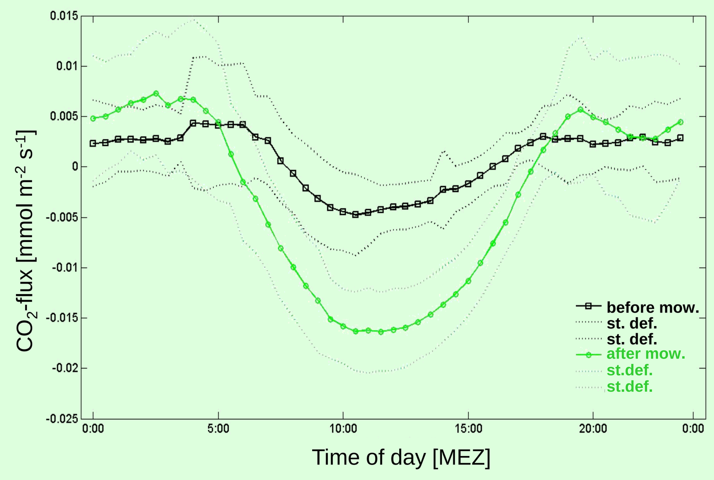

Fig. 6: CO_2-flux 30 days before and after mowing (mean diurnal cycle)

Date of mowing becomes clearly apparent in CO_2-flux data. In December plants still assimilate CO_2 around noon (Figure 5). The flux before and after mowing differs significantly during the day (Fig. 6).

Pulse labelling experiment

Stable isotope pulse labelling and tracing provides evidence about influences on and reactions of the plant community composition, depending on the recovery rates in the particular species, according to the given treatment "drought" and "normal" (see principal in Figure 7).

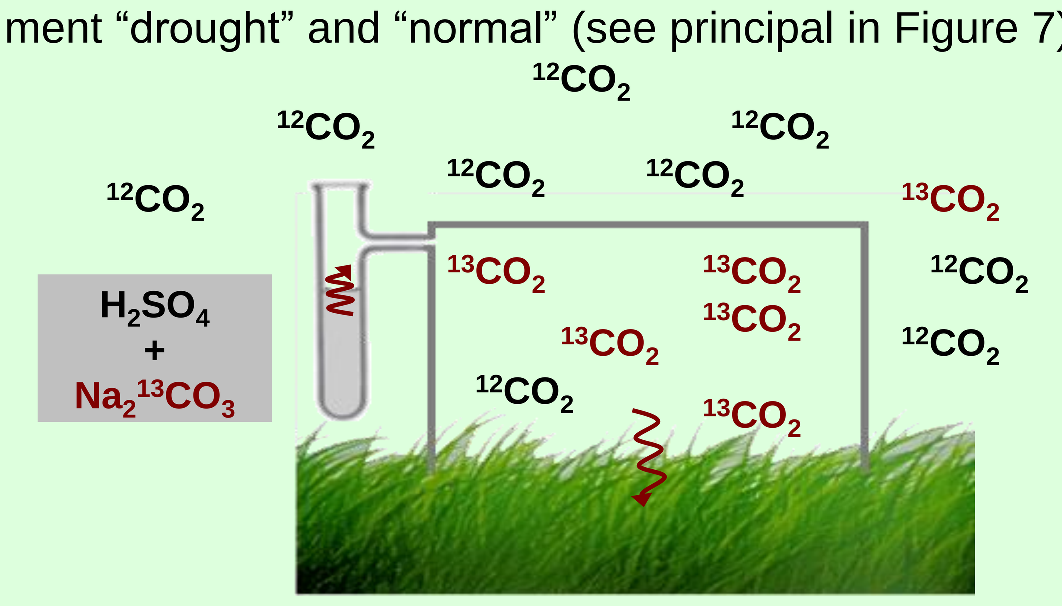

Fig. 7: Schematic illustration of $^{13}CO_2$ pulse labelling

Atmospheric ^{13}C-fluxes

The application of the relaxed eddy accumulation technique with a hyperbolic deadband allows sampling of trace gases and isotopes in the updraft and downdraft air. Concentration and isotope ratio of trace gases are determined by subsequent performed mass spectrometry. Measuring the isotopic composition of CO_2-fluxes provides additional information on ecosystem gas exchange processes, when those, like e.g. assimilation, discriminate against heavier isotopes. Consequently different mass-balances for bulk CO_2 and its $^{13}CO_2$ or $CO^{18}O$ isotopes can be used to separate respiration from assimilation.

	prop. coeff. b	deadband H
Bowling et al. (1999)	0.22 ± 0.05	~ 1.1
Ruppert et al. (2006)	0.15 - 0.27	~ 1
Hübner (2010)	0.16 - 0.24	~ 1

Tab. 2: Literature values for b and H compared to results of recent simulations

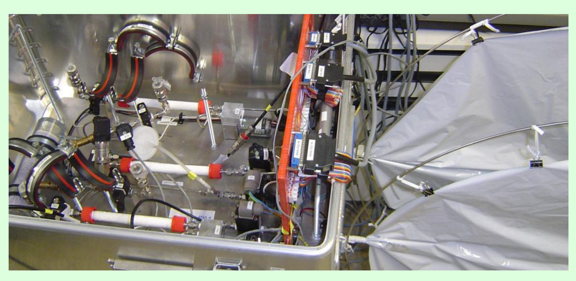

Fig. 8: REA system with 90cm foil ballons and the sampling unit with drying traps

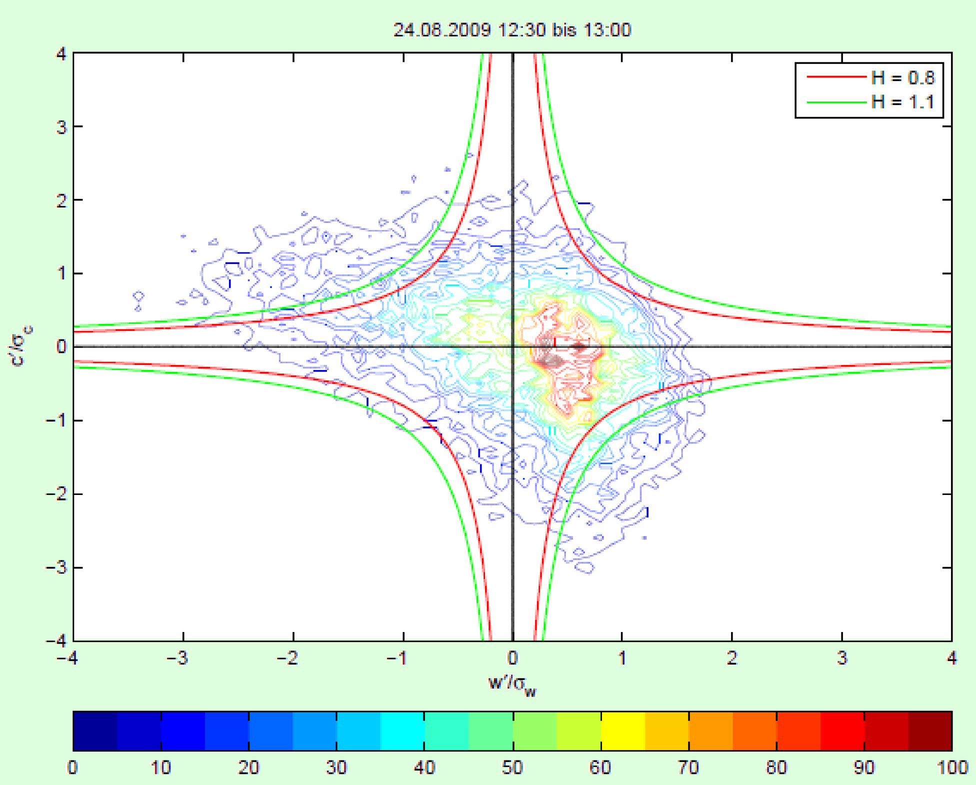

Fig. 9: Isoline plot of absolute frequency of c'/σ_c CO_2 and w'/σ_w vertical wind speed (30 min period)

Further steps: field experiment in Mai 2010 (^{13}C-pulse-labelling and tracing combined with measurement of atmospheric background $^{(13)}CO_2$-fluxes to evaluate following hypotheses:

Field-grown ^{13}C-pulse-labelling-experiments are influenced by atmospheric background $^{(13)}CO_2$-fluxes.

Climate change has a considerable impact on carbon sink charakteristics of grassland ecosystems.

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