UNIVERSITY OF BAYREUTH

Department of Micrometeorology

Documentation of the EVENT-HMMS Experiment 2012 – Microclimatological effects of rain-out shelters within EVENT II

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Arbeitsergebnisse
Nr. 55
Bayreuth, Juni 2013

Arbeitsergebnisse, Universität Bayreuth, Abt. Mikrometeorologie, Print, ISSN 1614-8916
Arbeitsergebnisse, Universität Bayreuth, Abt. Mikrometeorologie, Internet, ISSN 1614-8924
http://opus.ub.uni-bayreuth.de/opus4-ubbayreuth/solrsearch/index/search/searchtype/series/id/1
Eigenverlag: Universität Bayreuth, Abt. Mikrometeorologie
Vervielfältigung: Druckerei der Universität Bayreuth
Herausgeber: Prof. Dr. Thomas Foken

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1. Introduction

1.1. EVENT II

EVENT II is a part of a series of field experiments in the Ecological Botanical Garden of the University of Bayreuth (49°55'19"N, 11°34'55"E, 365 m a.s.l.) termed the "EVENT Experiments" with international and interdisciplinary research cooperations (Jentsch et al. 2007, Jentsch and Beierkuhnlein 2010).

The aim of the EVENT II experiment is to test the effects of intra-annual precipitation variability in interaction with land use schemes (Jentsch & Kreyling; DFG: JE 282/6-1), winter or summer warming (Beierkuhnlein & Kreyling; Bayerisches Staatsministerium für Umwelt und Gesundheit: ZKL01Abt7_18456), or winter rainfall addition (Jentsch; FORKAST TP8) on ecosystem performance. This experiment is set up in a semi-natural meadow and is running since 2008. Experimental manipulations in natural systems require long time-series to be analyzed as changes in the community composition are relevant here. First analyses show that enhanced rainfall variability reduces mid-summer productivity and leaf nitrogen and protein concentrations of target species, and the reduction in mid-summer productivity reduced aboveground net primary productivity by 15 % (Walter et al., 2012). Furthermore, litter decomposition decreases with increasing summer precipitation variability (Walter et al., 2013).

1.2. EVENT-HMMS

The EVENT-HMMS experiment has been carried out in 2012 within the EVENT II experiment. It aims at a spatially and temporally detailed quantification of the microclimate within and outside rain-out shelters used in EVENT II by a horizontal meteorological measuring system (HMMS) connected to an eddy-covariance complex. The temporal scale enables the comparison of artefacts during different general weather conditions. Furthermore, phytometers have been used to quantify the effect of contrasting general weather conditions on the built-up of drought stress for plants. See Figure 1 for an impression of the field site.

Figure 1 The horizontal meteorological measuring system (HMMS, measuring path is identifiable by the railway track) within the experiment area of EVENT II (Photo: Carsten Schaller, taken from Schaller, 2012)

1.3. Objectives of this report

The objective of this report is to describe and document the measurements made within the EVENT-HMMS experiment 2012.

2. Experimental setup of EVENT-HMMS

2.1. Site description

Location: Ecological-Botanical Garden, University of Bayreuth, Germany (49°55'19"N, 11°34'55"E, 365 m a.s.l.).

Climate: The regional climate is temperate and moderately continental, with a mean annual temperature of 7.9 °C (1971–2000). The mean annual precipitation of 724 mm (1971–2000) has a bimodal distribution with a major peak in June/July and a second peak in December/January (data: Ecological-Botanical Garden, Univ. of Bayreuth, Germany: Foken 2003).

Plant community: A semi-natural grassland which has not been ploughed for at least 25 years and not fertilized for more than 20 years prior to the installation of the experiment in 2008. Until the start of the EVENT II experiment, the meadow was mown twice a year for hay production. The semi-natural grassland community is dominated by tall grasses such as *Alopecurus pratensis* L. (meadow foxtail) and *Arrhenatherum elatius* (L.) P. Beauv. ex J. Presl & C. Presl (tall oat-grass) and belongs to the Galio molluginis-Alopecuretum pratensis Hundt (1954) 1968).

Substrate: The soil of the experiment is classified as Gleysol (Glaser et al., 2013). The homogeneous, loamy Ap horizon (42% sand, 43% silt, 15% clay) has a depth of 30 cm followed by a clayey Bg horizon. The groundwater table drops to -1.5 to -2 m during summer and can reach up to -30 cm in winter and after longer rainfall periods. Main rooting zone is within the upper 15 cm, hardly any roots reach the B horizon. The mean pH of the topsoil is 4.1 (1 M KCl). Permanent wilting point is around 10 vol. % soil moisture content.

2.2. Set up

In the early summer of 2012 the EVENT II experiment has been conducted together with the HMMS, an eddy-covariance (EC) complex, as well as additional measurements of standard meteorological variables above the respective grassland site. The location of all measurements can be seen in Figure 2.

Figure 2: Overview of the experiment area. EC: eddy-covariance complex; BR: Bowen ratio mast with standard meteorological measurements, nearby radiation measurements and soil measurement complex

2.3. Treatments of EVENT II

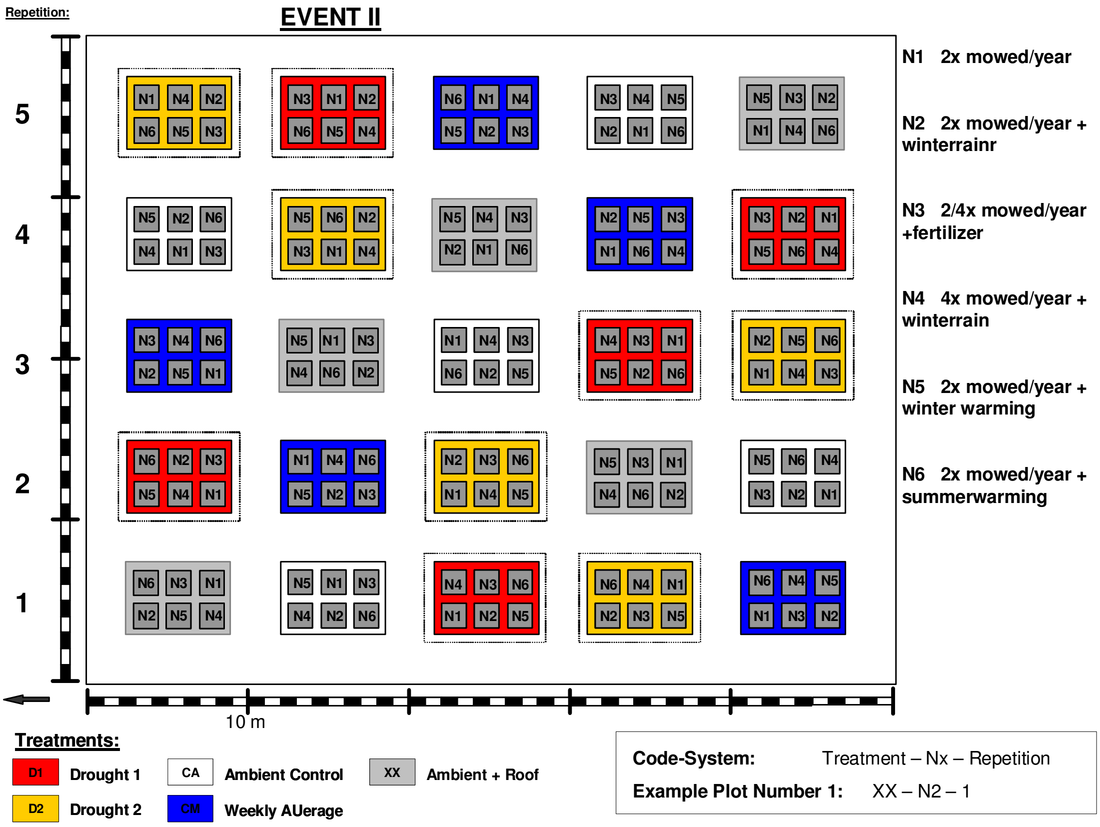

Figure 3: Experimental design of the EVENT II-experiment. Here, we are mainly interested in the comparison between climate treatments with rain-out shelters (bold outline) and without rain-out shelters (thin outline). For details about the treatments of the blocks see Table 1, and for the sub-block treatments (N1-6) within each block see Table 2. Size of shelters: 5.5 m x 7.5 m.

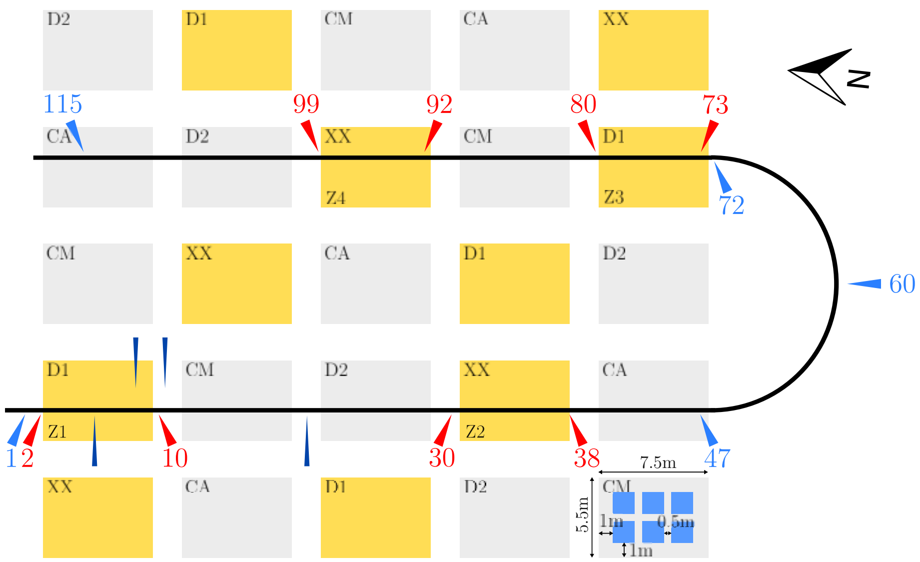

Figure 4: Experimental design of the HMMS path within EVENT II (black line). The yellow boxes indicate the treatments which were sheltered during the HMMS experiment; red and blue numbers indicate significant barcode positions (see Table Table 6) and the four dark blue arrows mark the positions of the fixed minimum thermometers. The sketch is modified from Schaller (2012).

The EVENT II-experiment is carried out in a two-factorial block design manipulating (1) the temporal precipitation variability over the growing season, and (2) the management intensity, temperature regime and winter precipitation sum as sub-block treatments (Figure 3, see Table 1 for treatment histories and treatments during the measurement campaign). The precipitation treatments consist of shelters, sized 5.5 m by 7.5 m, and separated from the surroundings by lateral barriers from +10 cm to -20 cm about 50 cm inside the shelters. An overview of the treatments is given in Table 1, the sub treatments are displayed in Table 2. Furthermore, the experimental design of the HMMS path within EVENT II is shown in Figure 4.

Table 1 Overview of the temporal precipitation variability treatments (block level) applied at EVENT II before and during the measurement campaign in 2012

Year	**CA**	**D1**	**D2**	**CM**	**XX**
	Medium Precipitation Variability (medVar)	High Precipitation Variability with early drought ($highVar_{early}$)	High Precipitation Variability with late drought ($highVar_{late}$)	Low Precipitation Variability (lowVar), irrigated if $N_{week} < \overline{N}_{1971-2000}$)	Roof artefact Control
2008	Ambient precipitation	Early drought 19.05. - 30.06.	Late drought 26.06. - 08.08.	weekly adjustment 01.04. - 05.09.	Ambient precipitation
2009	Ambient precipitation + adjustment to CM four times per year	Early drought 19.05. - 29.06. + adjustment to CM four times per year	Late drought 30.06. - 10.08. + adjustment to CM four times per year	weekly adjustment 01.04. - 30.09.	Roof artefact control 19.05. - 29.06. + adjustment to CM four times per year
2010	Ambient precipitation + adjustment to CM four times per year	Early drought 11.05. - 21.06. + adjustment to CM four times per year	Late drought 22.06. - 02.08. + adjustment to CM four times per year	weekly adjustment 01.04. - 30.09.	Roof artefact control 11.05. - 21.06. + adjustment to CM four times per year
2011	Ambient precipitation + adjustment to CM four times per year	Early drought 24.05. - 04.07. + adjustment to CM four times per year	Late drought 05.07. - 15.08. + adjustment to CM four times per year	weekly adjustment 01.04. - 30.09.	Roof artefact control 24.05. - 04.07. + adjustment to CM four times per year
2012	Ambient precipitation + adjustment to CM four times per year	Early drought 22.05. - 02.07. + adjustment to CM four times per year	Late drought 03.07. - 13.08. + adjustment to CM four times per year	weekly adjustment 01.04. - 30.09.	Roof artefact control 22.05. - 02.07. + adjustment to CM four times per year

The manipulations of the precipitation regime are realized by rain-out shelters (Hochtunnel, E & R Stolte GmbH, Germany, covered with a transparent plastic sheet: 0.2 mm polyethylene, SPR 5, Hermann Meyer KG, Germany) during the drought period of the High Precipitation Variability with early drought treatment ($highVar_{early}$) which included an extreme drought event of 1000-year local recurrence, i.e. 42 days without rainfall in May/June. Greenhouse effects due to rain-out shelters were minimized by having an 80 cm clearance between the roof and the ground, allowing for near-surface air exchange. During this time, identical rain-out shelters are set up on the highVar$_{early}$ treatment and on an artefact control treatment (XX:Roof Artifact Control). The latter plots receive the same amount of precipitation as occurs naturally, added by irrigation on a daily basis if necessary. The Medium Precipitation Variability (medVar) treatment receives the ambient rainfall and the Low Precipitation Variability (lowVar) treatment receives at least the long-term (30 years of local climate data series) mean precipitation per week, added at the end of each week if the natural precipitation sum does not reach the long-term average sum for this specific week. Precipitation sums for all other treatments are adjusted to the sum for the lowVar treatment by adding the missing amount at four times per year (before the early drought, after the early drought, after the late drought, end of September). The highVar$_{late}$ treatment is identical to the highVar$_{early}$ treatment except for the timing of the drought period timing (July/ August). With this setting, all treatments receive the same amount of precipitation throughout the year. The actual daily precipitation amounts, naturally occurring and received by the different treatments, for 2012 have been recorded in the appendix, Table A1.

Table 2 Overview of the sub treatments applied at EVENT II. For 2012, harvests in the two times mowed treatments took place at July 2nd and September 18th; four times mowed treatments were additionally cut at May 29th and August 14th.

	mowed	Additional manipulations
N1	2 times	-
N2	4 times	Winter precipitation addition (15mm in mid of Nov, Dec, Jan, Febr, 60mm in total) since winter 2009/2010
N3	2 times	Factorial combination of fertilization and delayed first harvest (2010-2012) (four times mowed and no further manipulation before) on four subplots 0.75 x 0.75 m² separated by stainless steel frames down to -25 cm: - F2: fertilized at the 30th day of the D1 manipulation (except for D2 which is fertilized at the 30th day of the D2 manipulation) with NPK-fertilizer "Linzer Top 12/12/17", 14 g/Plot; mowed two times (end of drought D1 (except for D2 which is mowed at the end of drought D2) and September) - F4: same fertilization as F2; mowed two times (10 days after end of drought D1 (except for D2 which is mowed 10 days after the end of drought D2) and September) - U2: no fertilization; mowed according to F2 - U4: no fertilization; mowed according to F4
N4	4 times	Winter precipitation addition (15mm in mid of Nov, Dec, Jan, Febr, 60mm in total) since winter 2009/10
N5	2 times	winter warming by IR-heaters from October to End of March
N6	2 times	summer warming by IR-heaters from April to End of September

2.4.Synoptic situation and weather maps

In order to characterise the synoptic situation during the measurement period, weather maps from Berliner Wetterkarte e.V. (http://wkserv.met.fu-berlin.de/, visited on July

5, 2012) have been gathered. Furthermore, photographs have been taken each minute from May 9 up to June 4 by a web cam mounted on the EC mast and oriented towards SW. Maps and photos can be found in the data archive (see Section 7). The general synopsis analysed by the German Weather Service is summarised in , a textual description can be found in the appendix C.

Table 3: General synopsis during EVENT-HMMS and cloudiness elaborated from visual inspection of global radiation measurements (Section 6). For a description of the general synoptic classification (GWL Hess/Brezowski) see appendix C.

Date	General synoptic	morning	noon	evening
05/30/2012	HNa	cloudy	partly cloudy	clear
05/31/2012	HNz	clear	partly cloudy	cloudy
06/01/2012	HNz	cloudy	partly cloudy	partly cloudy
06/02/2012	HNz	clear	cloudy	partly cloudy
06/03/2012	HNz	cloudy	cloudy	cloudy
06/04/2012	HNz	cloudy	partly cloudy	cloudy
06/05/2012	HNz	cloudy	partly cloudy	partly cloudy
06/06/2012	SWz	cloudy	partly cloudy	partly cloudy
06/07/2012	SWz	clear	partly cloudy	partly cloudy
06/08/2012	SWz	partly cloudy	partly cloudy	partly cloudy
06/09/2012	SWz	cloudy	partly cloudy	partly cloudy
06/10/2012	WS	partly cloudy	partly cloudy	partly cloudy
06/11/2012	WS	partly cloudy	partly cloudy	cloudy
06/12/2012	WS	clear	partly cloudy	partly cloudy
06/13/2012	WS	cloudy	partly cloudy	partly cloudy
06/14/2012	WS	cloudy	partly cloudy	partly cloudy
06/15/2012	SWz	partly cloudy	partly cloudy	clear
06/16/2012	SWz	clear	partly cloudy	partly cloudy
06/17/2012	SWz	partly cloudy	partly cloudy	clear
06/18/2012	SWz	partly cloudy	partly cloudy	partly cloudy
06/19/2012	SWz	partly cloudy	partly cloudy	partly cloudy
06/20/2012	SWz	partly cloudy	partly cloudy	partly cloudy
06/21/2012	SWz	partly cloudy	partly cloudy	partly cloudy
06/22/2012	SWz	partly cloudy	partly cloudy	partly cloudy
06/23/2012	SWz	clear	partly cloudy	clear
06/24/2012	Wa	partly cloudy	partly cloudy	cloudy
06/25/2012	Wa	partly cloudy	partly cloudy	partly cloudy
06/26/2012	Wa	partly cloudy	partly cloudy	clear
06/27/2012	Wa	partly cloudy	partly cloudy	cloudy
06/28/2012	Wa	partly cloudy	partly cloudy	partly cloudy
06/29/2012	TrW	partly cloudy	clear	clear
06/30/2012	TrW	clear	clear	partly cloudy

3. Phytometer measurements

We used *Plantago lanceolata* as our phytometer species because it showed fast stomatal response under drought condition in a former trial and it is naturally common at the experimental site. Moreover, this species has already been used as model plant for stomatal conductance measurements by Clark et al. (1999) and as phytometer by Temperton et al. (2007). *Plantago lanceolata* was grown as temporal cohorts, so that they could be transferred to the field site at different dates with the same age. Individuals of *Plantago lanceolata* were grown from seeds, using standardized soil substrate (20% washed sand, 20% fine lava (sand and lava- steamed at 90°C); 60 % white peat and black peat). The plants were germinated and grown in climate chambers under light at 20°C for 15 hours and without light at 10°C for 9 hours. The pots were kept moist on daily basis if necessary. After germination of seeds (20th day) we transplanted 40 single vigorous individuals into pots (9 x 9 x 9.5 cm3), using soil a loamy sand (82 % sand, 13 % silt, 5 % clay; pH = 4.5) as soil substrate. Pot size and substrate was selected after pre-trials which showed that this volume and substrate would induce severe drought stress after one week during warm & dry conditions. The first cohort of plants was sown on March 22nd, after then over the next five weeks we grew another five sets of plants for 2nd, 3rd, 4th, 5th and 6th cohort respectively, with the intention to expose each set of plants at the experimental site with same age (62 days). Before exposure in the field we soaked each pot in water for 2 min, to keep moisture balance equal for all. The first cohort of phytometers was taken out in the experimental site on 23rd of May, 2012.

Contrasting outside weather conditions during this time were evaluated by six temporal cohorts of phytometers, which were set under four precipitation manipulation treatments (Medium Precipitation Variability (medVar) (received natural rainfall); High Precipitation Variability with early drought (highVar$_{early}$) (remained without precipitation); Low Precipitation Variability (lowVar) (received at least the weekly long-term average precipitation by adding missing amount if weekly precipitation was less than long-term averages for the same week); Roof Artefact Control (received the same amount of precipitation as occurred naturally, added by irrigation on a daily basis if necessary). Each cohort was exposed to the weather conditions in the respective precipitation manipulation for 7 days. For each treatment we used two replications of each treatment block which were also covered by the HMMS (in total 8 precipitation variability blocks, see Figure 4). We exposed 5 replicates in each block, i.e. 10 replicates for each treatment and 40 replicates for each temporal cohort.

The following response parameters were investigated, the timing of the measurements is documented in Table 4.

- Stomatal conductance at noon (at 12 pm, maximum stress) was measured four times per week at the centre of medium aged leaves through a leaf porometer (SC-1, Decagon Devices).
- Leaf fluorescence was measured at mid night on the 7th day (maximum stress) once per week at the centre of medium aged leaves through a Chlorophyll fluorometer (PAM 2000).
- Chlorophyll content was measured during mid-day on the 7th day per week at the centre of medium aged leaves through a Chlorophyll content meter (SPAD 502, Konica Minolta).
- Leaf water potential was measured on the 7th day (maximum stress) with one medium aged leaf through Scholander pressure bomb technique (PMS 600 pressure bomb, PMS Instrument Company, Albany, USA).
- Above ground net primary production was quantified after exposure of each week by harvesting all standing plant materials including dead and alive. The harvested biomass was dried to a constant weight at 70 °C and weighed.

Table 4: Timing of phytometer study in 2012

	Cohort1	**Cohort2**	**Cohort3**	**Cohort4**	**Cohort5**	**Cohort6**
Start of exposure	23.05.	30.05	06.06.	13.06	20.06	26.06
Stomatal conductance 1	23.05	30.05	06.06.	13.06	20.06	26.06
Stomatal conductance 2	24.05	31.05	07.06.	14.06	21.06	27.06
Stomatal conductance 3	25.05	01.06	08.06.	15.06	22.06	28.06
Stomatal conductance 4	29.05	05.06	12.06.	19.06	26.06	02.07
Leaf fluorescence	29.05	05.06	12.06.	19.06	26.06	02.07
Chlorophyll content	29.05	05.06	[1])	19.06	26.06	02.07
Leaf water potential	[1])	05.06	12.06.	19.06	26.06	02.07
Aboveground biomass harvest	30.05	06.06	13.06.	20.06	27.06	03.07

[1]) Due to some instrumental failure, leaf water potential and chlorophyll content measurements were unsuccessful during 1st and 3rd cohort, respectively.

4. HMMS measurements

A fully automatic horizontal mobile measuring system (HMMS) has been developed by the Department of Micrometeorology, University of Bayreuth, for measurements of horizontal atmospheric gradients (Hübner et al., 2011). It is based on a garden railway system of the manufacturer LGB, using their railroad tracks to realise the measuring path and moving the railway carriage. Hübner et al., 2011 give a detailed technical description of the device complex including drive mechanism, design, power supply, speed and position control, and safeguarding. Further they describe the HMMS software. An impression of the HMMS is given in Figure 5.

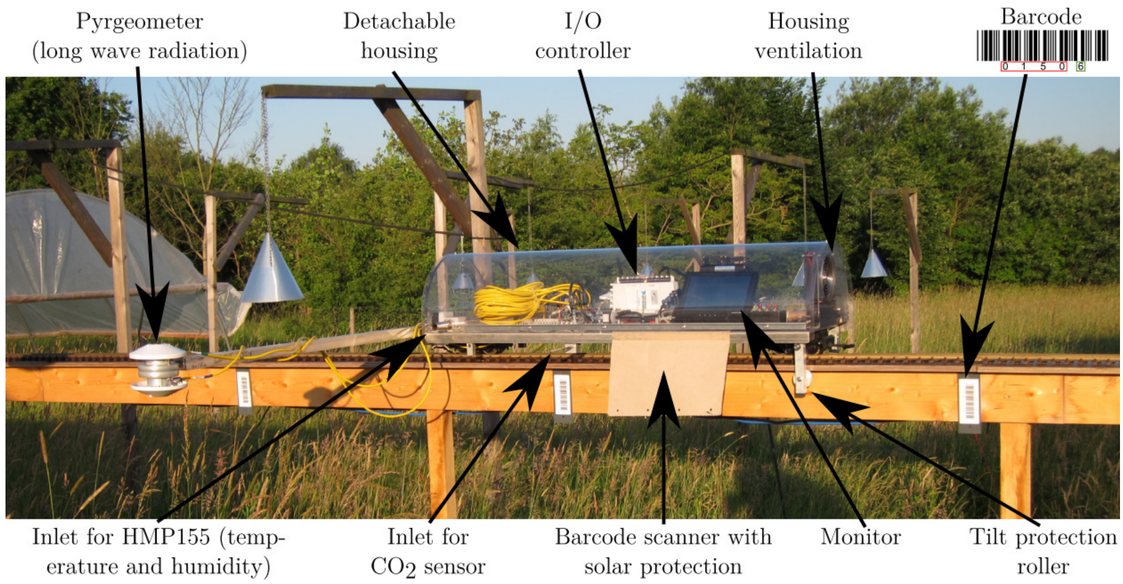

Figure 5 The HMMS and its instruments as used in EVENT; the pyranometer (short wave radiation sensor) is hidden behind the vehicle. The barcodes determine the position of the vehicle

The sensors used in EVENT-HMMS is summarised in Table 5, details can again be found in Hübner et al., 2011. The actual location of the HMMS is determined with barcodes attached for each metre along the rail track of the HMMS with running numbers ranging from 0001 to 0115. Important numbers are displayed in Figure 4, details of location can be found in Table 6. Furthermore the times of operation are displayed in Figure 6. The operating velocity of the HMMS has been determined, 68.4% of the data has been collected at a velocity of $\approx 0.2\,ms^{-1}$, 28.7% at a velocity of $\approx 0.1\,ms^{-1}$ or less, 2.7% at a velocity of $\approx 0.3\,ms^{-1}$ and only 0.2% of the data were collected at velocities $> 0.3\,ms^{-1}$.

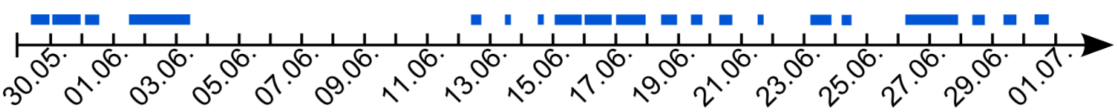

Figure 6 HMMS times of operation displayed as blue blocks on a time axis, the ticks represent 00:00 CET of the respective day in 2012.

Table 5 Specification of the used sensors in the HMMS; the measured parameter were shortwave downward radiation $K_\downarrow$, shortwave upward radiation $K_\uparrow$, longwave downward radiation $L_\uparrow$, longwave upward radiation $L_\uparrow$, air temperature T_{air}, relative humidity RH, and carbon dioxide concentration $[CO_2]$; the time constant τ_{63} (time required for the measuring system to reach 63% of its final or equilibrium value) has been determined in laboratory investigations (from Hübner et al, 2011).

Variable	Sensor	Accuracy	τ_{63}	Calibration factors	Remarks
$K_\downarrow$	CMP3[a]	< 15 W m^{-2}	4s	16.92 µV/W m^{-2}	Amplified 50-fold
$K_\uparrow$	CMP3[a]	< 15 W m^{-2}	4s	13.70 µV/W m^{-2}	Amplified 100-fold
$L_\downarrow$	CGR3[a]	< 15 W m^{-2}	4s	9.25 µV/W m^{-2}	Amplified 500-fold
$L_\uparrow$	CGR3[a]	< 15 W m^{-2}	4s	11.09 µV/W m^{-2}	Amplified 500-fold
T_{air}	HMP155[b]	± 0.1 K	12s	100 K/V, offset 40 K	Shielded, ventilated
RH	HMP155 [b]	± 1 %	20s	100 %/V	Shielded, ventilated
$[CO_2]$	Gascard® NG [c]	± 40 ppm	1s	Internal software	flow rate of 1.2 Lmin^{-1}

[a] Kipp & Zonen

[b] Vaisala

[c] Edinburgh Instruments

Table 6 Position of characteristic features in the measuring path and their position relative to the next barcode, see also Figure 4.

Barcode		Characteristica		
No.	Pos [m]	Pos [m]	offset	Description
0001	1.0	1.00	0.00	Begin of path (change direction)
0002	2.0	2.20	+0.20	Begin shelter Z1
0006	6.0	5.70	-0.30	Minimum temperature sensor
0009	9.0	8.55	-0.45	Minimum temperature sensor
0010	10.0	9.46	-0.54	End shelter Z1
0010	10.0	10.45	+0.45	Minimum temperature sensor
0019	19.0	19.00	0.00	Minimum temperature sensor
0031	31.0	30.62	-0.38	Begin shelter Z2
0038	38.0	37.91	-0.09	End shelter Z2
0047	47.0	47.00	0.00	Begin U-turn
0060	60.0	60.00	0.00	Vertex U-turn
0072	72.0	72.20	+0.20	End U-turn
0073	73.0	72.67	-0.33	Begin shelter Z3
0080	80.0	80.00	0.00	End shelter Z3
0092	92.0	91.64	-0.36	Begin shelter Z4
0099	99.0	9.04	+0.04	End shelter Z4
0115	115.0	115.00	0.00	End of path (change direction)

5. Eddy-covariance measurements

5.1. The Eddy-covariance complex

The turbulence fluxes of momentum, sensible heat, latent heat, and CO2 were measured on a mast equipped with an ultrasonic anemometer (USA-1, Meteorologische Messtechnik GmbH, Germany) and a fast-response open-path H_2O/CO_2 analyzer (LI-7500, LI-COR Inc., USA) at a sampling frequency of 20 Hz. The measured parameters and measuring devices are listed with installation details in Table 7. For more details of the installation, see Figure 7 and Figure 8. The connection between the devices and cables can be found in Figure 9 and Figure 10. Further sensor specifications are given for the USA-1, the Li-7500, the net radiation sensor NR-LITE from Campbell Scientific Ltd., the amplifier and the inclinometer are given in Zhao et al. (2011).

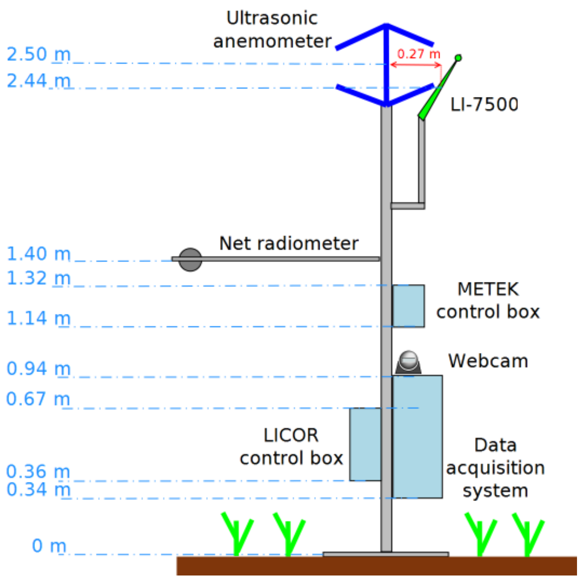

Figure 7 Installation of the eddy-covariance mast

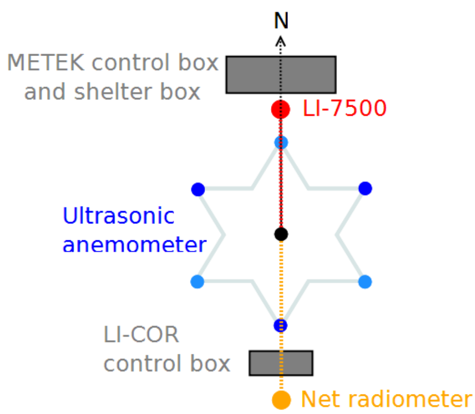

Figure 8 Orientation of the eddy-covariance complex

Table 7 Devices and measured parameters of the eddy-covariance complex

Parameter	**Instrument**	**Serial number.**	**Uni. Inventory**	**Calibr. factor**	**Output**	**Height**	**Vertical /Horizontal displacement**	**Orientation**
Wind vector	USA-1 „Scientific“	010202 1865	78787	/	[m s^{-1}]	2.50 m	/	360
Sonic temperature					[°C]			
H_2O concentration	LI-7500	75B-1632 (Control Box) 75H-1632 (Head)	78674	0 V–0 mmol m^{-3}, 5 V–2000 mmol m^{-3}	[V]	2.44 m	0.06 m/0.27 m	360
CO_2 concentration				0 V– 5 mmol m^{-3}, 5 V–30 mmol m^{-3}				
Pressure				/	[kPa]	approx.0.5 m	/	/
Net radiation	NR-LITE	980165	/	15.2 µV W^{-1} m^2	[V]	1.4 m	/	180
	Amplifier (Ina 118)	/	/	/	[V]	/	/	/
Inclination	AccuStar II/DAS 20	/	/	/	[V]	1.65 m	/	/

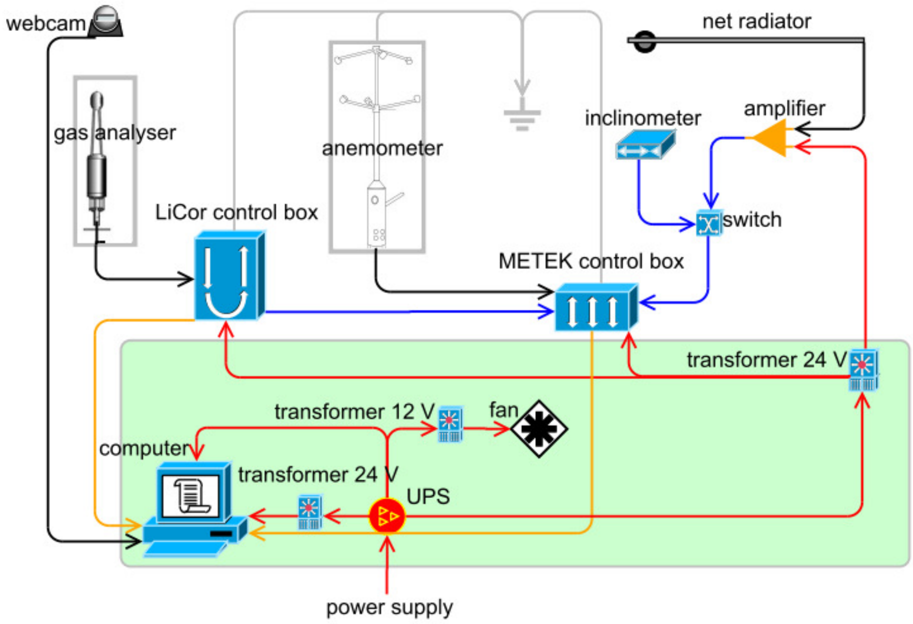

Figure 9 Schematic diagram of eddy-covariance device connection (red lines: power cables; black lines: original signal cables from the sensors; blue lines: analogue signal cables; orange lines: RS-232 signal cables, from Zhao et al., 2011)

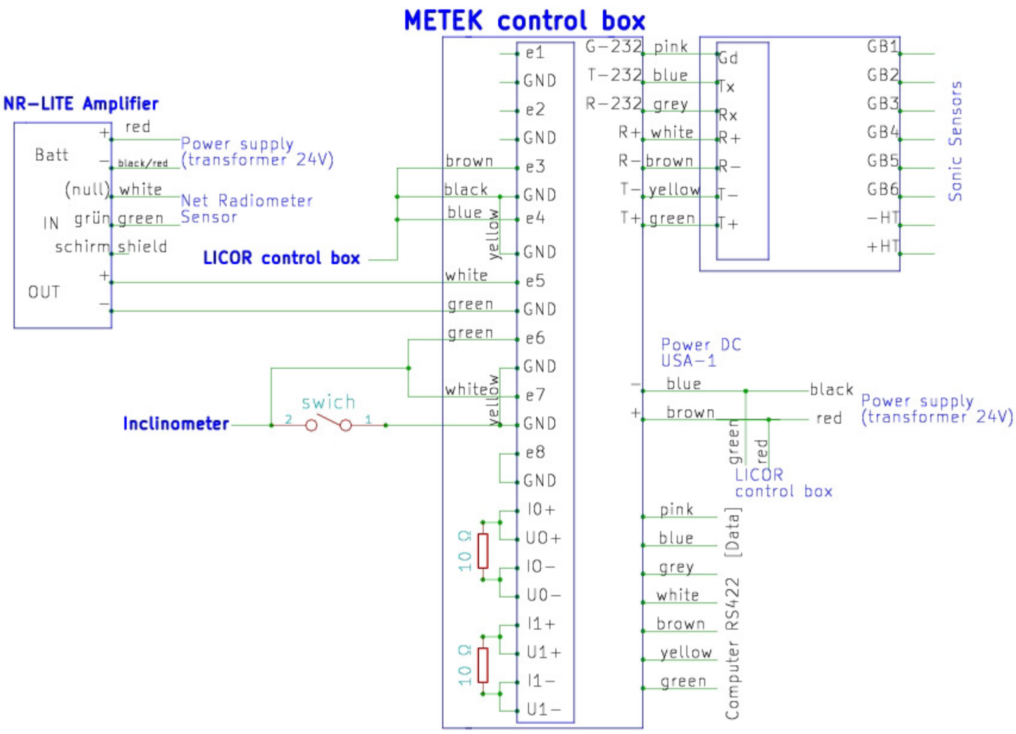

Figure 10 Connection in METEK control box (from Zhao et al., 2011).

5.2. Data acquisition

5.2.1. Data flow

Raw data from METEK control box include ultrasonic data, gas analyzer data, net radiation data, and inclinometer data, which were downloaded by tcopy.exe. The command line is:

tcopy.exe /b 38400 /lh /t COM2

Raw data from LI-Cor control box RS-232 output include gas analyzer data, air pressure, inside temperature, diagnosis information, which were downloaded by tcopy.exe. The command line is:

tcopy.exe /b 38400 /lh /t COM1

5.2.2. LI-7500 Settings

Content of the Licor configuration file during EVENT II was:

(Ack(Received FALSE)(Val 0.000000))(Calibrate(SpanCO2(Date "20 11 2008 02:40")(Target 600.2000)(Tdensity 23.90000)(Val 0.9987253))(SpanH2O(Date "20 11 2008 03:25")(Target 11.91000)(Tdensity 455.6560)(Val 0.9897679))(ZeroCO2(Date "20 11 2008 02:37")(Val 0.9082303))(ZeroH2O(Date "20 11 2008 03:04")(Val 0.8764094)))(Coef(Current(Band(A 1.150000))(CO2(A 152.7640)(B 6243.750)(C 4.806400e+07)(D -1.583770e+10)(E 2.147180e+12)(XS 0.001300000)(Z -0.001900000))(H2O(A 5435.080)(B 4408670.)(C -3.101910e+08)(XS -0.001400000)(Z 0.01580000))(Pressure(A0 10.13000)(A1 26.03600))(SerialNo "75H-1632")))(Data(Aux 0.000000)(CO2D 14.66722)(CO2Raw 0.08008862)(Cooler 1.590364)(DiagVal 248)(H2OD 1059.809)(H2ORaw 0.1078892)(Ndx 4118)(Pres 96.08419)(Temp 25.40787))(Diagnostics(Chopper TRUE)(DetOK TRUE)(PLL TRUE)(Path 52.00000)(SYNC TRUE))(EmbeddedSW(Model "LI-7500 CO2/H2O Analyzer Application")(Version 3.0.1))(Error(Received FALSE))(Inputs(Aux(A 1.000000)(B 0.000000))(Pressure(Source Measured)(UserVal 98.00000))(Temperature(Source Measured)(UserVal 25.00000)))(Outputs(BW 10)(Dac1(Full 30.00000)(Source CO2MMOL)(Zero 5.000000))(Dac2(Full 2000.000)(Source H2OMMOL)(Zero 0.000000))(Delay 2)(RS232(Aux TRUE)(Baud 38400)(CO2D TRUE)(CO2Raw TRUE)(Cooler TRUE)(DiagRec TRUE)(DiagVal TRUE)(EOL 0A)(Freq 20.00000)(H2OD TRUE)(H2ORaw TRUE)(Labels TRUE)(Ndx TRUE)(Pres TRUE)(Temp TRUE))(SDM(Address 7)))|(Chart(LV None)(Lmax 100.0000)(Lmin 0.000000)(RV None)(Rmax 100.0000)(Rmin 0.000000)(Scroll(Coarse FALSE)(Smooth TRUE))(Units(Mins FALSE)(Secs TRUE))(Xmax 20))(Connect(Baud 9600)(Freq 1.000000)(Port 1))(Log(CI TRUE)(Del(Space FALSE)(Tab TRUE))(LogVals(CV TRUE)(Cabs TRUE)(Cden TRUE)(CdenMg TRUE)(Cmf TRUE)(Dew TRUE)(Habs TRUE)(Hden TRUE)(HdenMg TRUE)(Hmf TRUE)(PortB TRUE)(Pres TRUE)(RelTime TRUE)(Temp TRUE))(Name "D:\Program Files\LI7500v3_0_2\LogFile.txt")(Rem FALSE)(TS TRUE))

5.2.3. USA-1 Settings

USA-1 settings during EVENT II were:

AD=0	AE=0	AO=0	AT=0
AV=1	AZ=0	BM=0	BR=38400
D1=0	D2=0	D3=0	D4=0
D5=0	D6=0	D7=0	D8=0
FR=0	HC=1	HT=1	LC=23.03.09 10:43:22
LD=0	M1=	M2=	M3=
MD=20	N0=	N1=urcall	N2=urcall
N3=urcall	NO=31	O1=2564	O2=2547
O3=2455	O4=2454	O5=2386	O6=2392
OA=0	OD=141	P1=1746	P2=1753
P3=1754	PR=3	SA=0	SF=2000
SO=0	SY=0	TC=2205	TI=15.01.11 01:25:35
TR=4000	TV=0	VR=6000	ZR=100
version 4.42 serial no. 0102021865	vbatt = 3471	free 15359 used 0 unread 0	

5.2.4. Amplifier Setting

The amplifier for NR-LITE was set with a factor as 501, i.e. the output signal is 501 times as large as the original signal from NR-LITE.

5.2.5. Raw Data Format

An example of the records from METEK control box is below:
120704000000 W. Europe Daylight Time H:04.07.12 06:45:53 x =   164 y =   30 z =   -1 t =   929 e1= -145 e2=   68 e3= 21072 e4= 14703 e5= -2728 e6=-31509 e7=-31546 e8=   -3
The format of this record is shown in Table 8.

Table 8 Format of METEK output

Record*	Explanation
120704000000 W. Europe Daylight Time	Time stamp given by the data acquisition computer, YYMMDDhhmmss
H:04.07.12 06:45:53	Time stamp given by METEK control box, H:DD.MM.YY hh:mm:ss
x = 164 y = 30 z = -1	wind velocity x, y, z equal to 1.64 m s^{-1}, 0.30 m s^{-1}, −0.01 m s^{-1}, respectively
t = 929	sonic temperature is 9.29 °C
e1= -145 e2= 68	PT100 temperture (not installed)
e3= 21072	Analogue output of H_2O measurement is 2107.2 mV
e4= 14703	Analogue output of CO_2 measurement is 1470.3 mV
e5= -2728	Analogue output of net radiator is −272.8 mV
e6=-31509 e7=-31546	Analogue output of inclinometer is −3150.9 mV and −3154.6 mV
e8= -3	Analogue output for potential use (vacant)

* e3 to e8 are displayed from −9999.9 mV up to +9999.9 mV.

An example of the records from LI-7500 RS-232 output is below:

120704000000 W. Europe Daylight Time 12140425 248 0.08235
15.1412 0.04090 291.945 14.64 96.9 -0.00099
1.3499

The format of this record is shown in Table 9.

Table 9 Format of LI-7500 serial output

Record	Explanation
120704000000 W. Europe Daylight Time	Time stamp given by the data acquisition computer, YYMMDDhhmmss
12140425	The index value, which is incremented approximately every 6.5 milliseconds (e.g. 152 Hz) and ranges from approximately －2.0E8 to ＋2.0E8.
248	Diagnostic value
0.08235	Absorptance of CO_2 measurement
15.1412	CO_2 concentration in mmol m^{-3}
0.04090	Absorptance of H_2O measurement
291.945	H_2O concentration in mmol m^{-3}
14.64	Temperature inside the control box in °C
96.9	Air pressure inside the control box in kPa
-0.00099	Auxiliary input (not installed)
1.3499	Detector cooler voltage in V

5.3.Footprint and fetch analysis

In order to define the wind sector where the source contribution is sufficiently representative for the target land use “meadow” a footprint analysis approach by Göckede et al. (2004,2008) has been conducted. The underlying footprint model used in this site characterisation approach is a Lagrangian stochastic forward model by Rannik et al. (2000), providing two dimensional source area contributions for each time step of turbulent flux data (30 minutes). The footprint climatology can be seen in Figure 11. As one would expect, the measurement period is dominated by westerlies for day time conditions (unstable and neutral stratifications), frequent contributions from the forest only occur during night time (stable) conditions. The mean contribution of the target land use “meadow” and a fetch analysis according to Raabe (1991), conducted for wind sectors of 30°, are shown in Table 10.

From these results a wind sector of 80° to 300° can be regarded as representative for the target land use. Taking into account a typical standard deviation of 20° for half-hourly mean values of wind direction, a wind direction criterion of 100° < wdir < 280° is recommended for further analysis. With an analysis of data quality in dependence on wind direction no significant structures or disturbances could be detected within the target wind sector defined before (not shown).

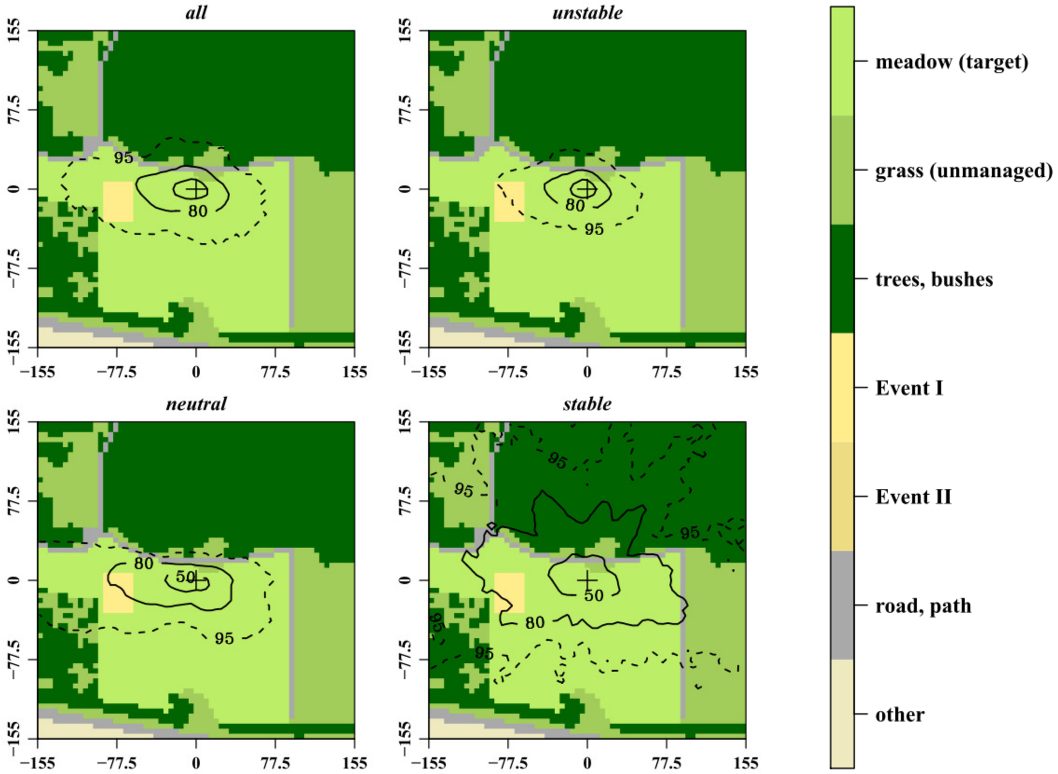

Figure 11 Footpint climatology for the EC measurements during EVENT-HMMS. Effect level rings include the areas contributing with 50%, 80% (solid lines) and 95% (dashed lines) to the measured flux on average for the whole campaign.

Table 10 Fetch length x, height of the new equilibrium layer δ, and flux contribution of the target lend use "meadow", dependent on the wind direction and atmospheric stratification as mean conditions for the EVENT-HMMS campaign.

Wind direction [°]	30	60	90	120	150	180	210	240	270	300	330	360
x [m]	25	40	100	110	160	110	140	100	200	50	27	20
δ [m]	1.5	1.9	3	3.1	3.8	3.1	3.5	3	4.2	2.1	1.6	1.3
Flux contribution from target land use "meadow" in %												
stable	19	56	87	88	94	94	91	84	86	69	44	37
neutral	47	69	92	93	97	96	96	92	93	89	69	61
unstable	61	77	97	98	100	99	100	98	98	94	85	76

6. Bowen ratio mast, radiation and soil measurements

The Bowen ratio mast (BR) and the radiation measurement complex were set up on the grassland site of the Ecological Botanical Garden of the University of Bayreuth within the framework of the student internship 2012. Data are available from 2012-04-24 until 2012-07-04. The Bowen ratio mast was equipped with two cup anemometers and two Frankenberger psychrometers in two heights (Figure 12, Table 12, Table 13). The measuring heights were 2m and 0.25m above displacement height and were regularly adapted to the growing meadow with the help of a carriage (Table 11). Furthermore, two soil heat flux plates, two TDRs and five soil thermometers were installed (See Table 12, Table 13). The radiation measurement complex (Figure 12) was equipped with a pyranometer and a pyrgeometer for measuring shortwave and longwave incoming and ougoing radiation components. The data (10 min values) were stored with a Vaisala logger. Configurations are given in Table 12 and Table 13.

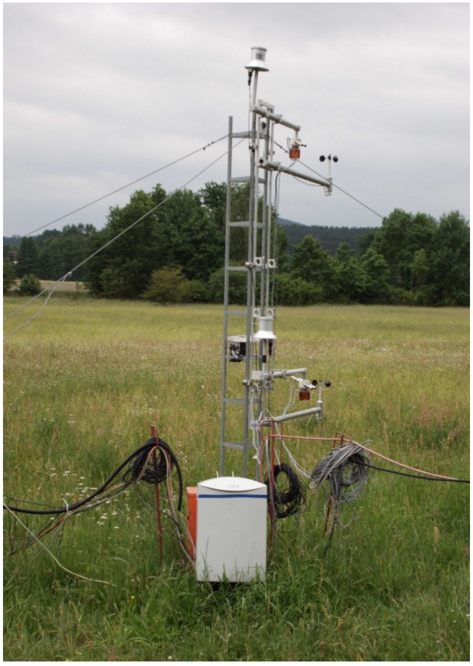

Figure 12 Bowen ratio mast with cup anemometers and psychrometers in two heights (left) and the radiation measurement complex (right)

Table 11 Lower measuring height of the Bowen ratio mast and the canopy height of the grassland during the field campaign.

Date	Lower measuring height (m)	Canopy height (m)
2012-04-25	0.55	0.45
2012-05-09	0.7	0.66
2012-05-15	0.85	0.9
2012-07-04	0.85	0.9

Table 12 Recorded parameters, instrumentation, measuring heights and logger configurations of the Vaisala logger QLC R44303 during the field campaign.

Parameter	Instrument	Serial No.	Calibration factor	Conversion in logger	Height [cm]	Orienta tion [°]	Logger QLC R44303	Chan nel
xPsy_H_T	Frankenberger psychrometer	0095		Conv. to °C	200	SW	internal QLI	CH00
xPsy_H_F	Frankenberger psychrometer	0085		Conv. to °C	200	SW	internal QLI	CH01
xPsy_L_T	Frankenberger psychrometer	0045		Conv. to °C	25	SW	internal QLI	CH02
xPsy_L_F	Frankenberger psychrometer	0134		Conv. to °C	25	SW	internal QLI	CH03
xAT_05	Pt100	0054		Conv. to °C	-2	S	internal QLI	CH04
xBT_05	Pt100	0055		Conv. to °C	-5	S	internal QLI	CH05
xBT_10	Pt100	0053		Conv. to °C	-10	S	internal QLI	CH06
xBT_20	Pt100	0056		Conv. to °C	-20	S	internal QLI	CH07
xBT_50	Pt100	0057		Conv. to °C	-50	S	internal QLI	CH08
xBW_a	HP3	65653	24.3 µV $W^{-1}m^{-2}$	10^6	-10	W	external QLI	CH00
xBW_b	HFP01	003630	62.8 µV $W^{-1}m^{-2}$	10^6	-10	E	external QLI	CH01
xTDR_a	TDR-IMKO	31148		10^2	-5 to -15	E	external QLI	Ch08
xTDR_b	TDR-IMKO	31147		10^2	-15 to -25	E	external QLI	Ch09
xCNR_T	CNR1	970059		Conv. to °C	200	S	external QLI	CH03
xCNR_Glb	CNR1	970059	9.64µV $W^{-1}m^{-2}$	10^6	200	S	external QLI	CH04
xCNR_Ref	CNR1	970059	9.84 µV $W^{-1}m^{-2}$	10^6	200	S	external QLI	CH05
xCNR_Geg	CNR1	970059	9.68 µV $W^{-1}m^{-2}$	10^6	200	S	external QLI	CH06
xCNR_Aus	CNR1	970059	9.84 µV $W^{-1}m^{-2}$	10^6	200	S	external QLI	CH07
xWS_L	Climatronics[a]	4713		Conv. to ms^{-1}	25	SW	external QLI	Nr 57
xWS_H	Climatronics[a]	4522		Conv. to ms^{-1}	200	SW	external QLI	Nr 58

[a] Climatronics F460 cup anemometer

Table 13 Channel allocation for QLC R44303 with logger program GeoP2011.qsp

R44303	Instrument	Variable Name	Measurement	Channel	E	H	L	C
Internal QLI	Frankenberger psychrometer	xPsy_H_T	PT100 4 wire #0095	CH00	x yellow	x green	x brown	x white
Internal QLI	Frankenberger psychrometer	xPsy_H_F	PT100 4 wire #0085	CH01	x yellow	x green	x brown	x white
Internal QLI	Frankenberger psychrometer	xPsy_L_T	PT100 4 wire #0045	CH02	x yellow	x green	x brown	x white
Internal QLI	Frankenberger psychrometer	xPsy_L_F	PT100 4 wire #0134	CH03	x black	x green	x brown	x blue
Internal QLI	Pt100	xAT_05 (Minimum temperature)	PT100 4 wire #0054	CH04	x black	x brown	x red	x orange
Internal QLI	Pt100	xBT_05 (Soil temperature)	PT100 4 wire #0055	CH05	x black	x brown	x red	x orange
Internal QLI	Pt100	xBT_10 (Soil temperature)	PT100 4 wire #0053	CH06	x black	x brown	x red	x orange
Internal QLI	Pt100	xBT_20 (Soil temperature)	PT100 4 wire #0056	CH07	x black	x brown	x red	x orange
Internal QLI	Pt100	xBT_50 (Soil temperature)	PT100 4 wire #0057	CH08	x black	x brown	x red	x orange
External QLI	HP3	xBW_a	Voltage diff (V) #65653	CH00		x brown	x blue	
External QLI	HFP01	XBW_b	Voltage diff (V) #003630	CH01		x white	x green	
External QLI	TDR-IMKO	xTDR_a (TDR probe)	Voltage single (+VE), #31148	CH08		x green		
External QLI	TDR-IMKO	xTDR_b (TDR probe)	Voltage single (+VE), #31147	CH09		x green		
External QLI	CNR1	xCNR_T (instrument temperature)	PT100 4 wire, #970059	CH03	x gray	x green	x yellow	x pink
External QLI	CNR1	xCNR_Glb (global radiation)	Voltage diff (V) #970059	CH04		x red	x blue	
External QLI	CNR1	xCNR_Ref (reflected irradiance)	Voltage diff (V) #970059	CH05		x white	x black	
External QLI	CNR1	xCNR_Geg (longwave down-ward radiation)	Voltage diff (V) #970059	CH06		x grey	x yellow	
External QLI	CNR1	xCNR_Aus (longwave up-ward radiation)	Voltage diff (V) #970059	Ch 07		x brown	x green	
External QLI	Climatronics F460 cup anemometer	xWS_L	Voltage single (+VE), #4713	Nr 57			x yellow	
External QLI	Climatronics F460 cup anemometer	xWS_H	Voltage single (+VE), #4522	Nr 58				x yellow

7. Data archive

The data from the HMMS, EC complex and BR complex is stored on a Data archive hard drive of the Department of Micrometeorology, University of Bayreuth, “MM - Data archive - Drive 1”.

7.1. Synoptic situation

The synoptic situation in Central Europe during the HMMS campaign has been downloaded from Berliner Wetterkarte e.V. (http://wkserv.met.fu-berlin.de/, visited on July 5, 2012) and stored in ‘.\Event_synoptic\’. It includes daily sea level pressure fields as well as 500 hPa topography and temperature fields at 00 UTC, and a textual description. In addition, photographs have been taken each minute from May 9 up to June 4 by a web cam mounted on the EC mast and oriented towards SW (‘.\Event_webcam\’).

7.2. HMMS data

The raw data from the HMMS is stored in ASCII format in the folder ‘.\Event_HMMS_data\’, for variables see Table 14.

Table 14: Variables in the HMMS data; 6 variables were supplied in raw voltage signal as well in the files with the corresponding ending “*_inV.txt”

Variable	Unit	Description
T	°C	Air temperature
rF	%	Relative humidity
GlbST	Wm^{-2} and V	Shortwave downwelling radiation
RflST	Wm^{-2} and V	Shortwave upwelling radiation
GegST	Wm^{-2} and V	Longwave downwelling radiation
AusST	Wm^{-2} and V	Longwave upwelling radiation
PT100oben	K and V*	Housing temperature CGR3 top (excitation current 1mA, therefore)
PT100unten	K and V*	Housing temperature CGR3 bottom
CO2	ppm	CO2 concentration
v	ms^{-1}	Velocity of the HMMS
Richtung	-	Movement direction (“>” or “<”, “>” corresponds to ascending barcode numbers)
Barcode	-	Last barcode number passed by

* excitation current 1mA, therefore 1 V equals 1kΩ

7.3.Eddy-covariance data

The raw data is stored in the folder ‚01_raw_data‘ (\EVENT_EC_data_processing \TK3_processing\01_raw_data). First of all the raw data was converted by the Matlab routine in order to make the data format suitable to process it with TK3.

The evaluation of the data was performed by the TK3 routine. First of all the routine generates physical correct data by using the calibration settings and processes a spike detection. Secondly the calculation of the raw covariance's without any correction is carried out. Finally the calculation of the corrections is performed. For more detailed information see Foken and Mauder (2011).

The calculation was performed using reference data. The reference data consists of the air pressure, the temperature and the humidity. The air pressure in two meter height is measured at the weather station in the Ecological Botanical Garden of the University of Bayreuth (ÖBG). The dry and humid temperature in two meter height is measured by a Frankenberger psychrometer at the tower of the Bowen Ratio measurement in the ÖBG (for more details see documentation of the Bowen Ratio Tower). Through these temperature measurements the calculation of the humidity is possible. The reference data is stored in the folder ‚reference_data‘ (\EVENT_EC_data_processing\reference_data). The results of the flux-calculation and the QA/QC tests are stored in the output directory (\EVENT_EC_data_processing\TK3_processing\06_TK3\out). The binary and statistic files (both 30 and 5 minutes) are stored in the working directory, with a time stamp in the file (\EVENT_EC_data_processing\TK3_processing\06_TK3\work). The detailed settings, by which the calculation was performed (for example canopy height, treatment of missing values etc.) can be found in the parameter file, documented for each run of TK3, stored in the folder ‚06_TK3‘ (\EVENT_EC_data_processing\TK3_processing \06_TK3).

In the folder ‚07_TK_quicklook\EVENT\output ‘are the so called ‚Quicklooks‘ stored, which is a plot of the TK3 results, created by R, each day in a own plot (\EVENT_EC_data_processing\TK3_processing\07_TK_quicklook\EVENT\output).

An overview of the storage directories for the EC data gives Table 15.

Table 15 Overview of the storage directories of the EC data.

Data	Path
raw data	\EVENT_EC_data_processing\TK3_processing\01_raw_data
reference data	\EVENT_EC_data_processing\reference_data
TK3 output	\EVENT_EC_data_processing\TK3_processing\06_TK3\out
binary and statistic files	\EVENT_EC_data_processing\TK3_processing\06_TK3\work
quicklooks	\EVENT_EC_data_processing\TK3_processing\07_TK_quicklook\EVENT\output
parameter files	\EVENT_EC_data_processing\TK3_processing\06_TK3

7.4.BR, radiation, and soil data

An excel sheet with the data of the Bowen ratio complex is stored for each day of the field campaign in the folder ‚Tagesfiles' (\Event_BR_data\Tagesfiles). Graphical displays in a diurnal course are provided in the sheets. An excel sheet with the entire data of the field campaign can be additionally found in \Event_BR_data.

8. Literature

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A. Daily precipitation on the different treatments

Table A1: Daily sums of precipitation naturally occurred at the field site in 2012 and the amount of precipitation received by the different treatments. Compensatory artificial precipitation is highlighted.

	Daily sum of precipitation in mm on the different treatments						
Date	natural	CA	CM	D1	D2	XX	Compensation irrigation
3/1/2012	0.4	0.4	0.4	0.4	0.4	0.4	
3/2/2012	0.3	0.3	0.3	0.3	0.3	0.3	
3/3/2012	0.2	0.2	0.2	0.2	0.2	0.2	
3/4/2012	0	0	0	0	0	0	
3/5/2012	0.3	0.3	0.3	0.3	0.3	0.3	
3/6/2012	0.1	0.1	0.1	0.1	0.1	0.1	
3/7/2012	0	0	0	0	0	0	
3/8/2012	4	4	4	4	4	4	
3/9/2012	0	0	0	0	0	0	
3/10/2012	0.1	0.1	0.1	0.1	0.1	0.1	
3/11/2012	1.9	1.9	1.9	1.9	1.9	1.9	
3/12/2012	0.4	0.4	0.4	0.4	0.4	0.4	
3/13/2012	0	0	0	0	0	0	
3/14/2012	0	0	0	0	0	0	
3/15/2012	0	0	0	0	0	0	
3/16/2012	0	0	0	0	0	0	
3/17/2012	0.2	0.2	0.2	0.2	0.2	0.2	
3/18/2012	0.1	0.1	0.1	0.1	0.1	0.1	
3/19/2012	3.1	3.1	3.1	3.1	3.1	3.1	
3/20/2012	0.3	0.3	0.3	0.3	0.3	0.3	
3/21/2012	0.1	0.1	0.1	0.1	0.1	0.1	
3/22/2012	0.1	0.1	0.1	0.1	0.1	0.1	
3/23/2012	0.1	0.1	0.1	0.1	0.1	0.1	
3/24/2012	0.1	0.1	0.1	0.1	0.1	0.1	
3/25/2012	0.3	0.3	0.3	0.3	0.3	0.3	
3/26/2012	0.1	0.1	0.1	0.1	0.1	0.1	
3/27/2012	0.1	0.1	0.1	0.1	0.1	0.1	
3/28/2012	0	0	0	0	0	0	
3/29/2012	0.1	0.1	0.1	0.1	0.1	0.1	
3/30/2012	0	0	0	0	0	0	
3/31/2012	0.9	0.9	0.9	0.9	0.9	0.9	
4/1/2012	0.2	0.2	0.2	0.2	0.2	0.2	
4/2/2012	0	0	0	0	0	0	
4/3/2012	0	0	0	0	0	0	
4/4/2012	0	0	0	0	0	0	
4/5/2012	1	1	1	1	1	1	
4/6/2012	0	0	0	0	0	0	
4/7/2012	1.9	1.9	1.9	1.9	1.9	1.9	
4/8/2012	0	0	0	0	0	0	

4/9/2012	0.1	0.1	9.9	0.1	0.1	0.1	
4/10/2012	0	0	0	0	0	0	
4/11/2012	6.2	6.2	6.2	6.2	6.2	6.2	
4/12/2012	1.2	1.2	1.2	1.2	1.2	1.2	
4/13/2012	0.1	0.1	0.1	0.1	0.1	0.1	
4/14/2012	0.1	0.1	0.1	0.1	0.1	0.1	
4/15/2012	0.5	0.5	0.5	0.5	0.5	0.5	
4/16/2012	0	0	0	0	0	0	
4/17/2012	0	0	0	0	0	0	
4/18/2012	0	0	0	0	0	0	
4/19/2012	0.1	0.1	0.1	0.1	0.1	0.1	
4/20/2012	1.4	1.4	1.4	1.4	1.4	1.4	
4/21/2012	6.4	6.4	6.4	6.4	6.4	6.4	
4/22/2012	0.8	0.8	0.8	0.8	0.8	0.8	
4/23/2012	1.42	1.42	1.42	1.42	1.42	1.42	
4/24/2012	1.92	1.92	1.92	1.92	1.92	1.92	
4/25/2012	0.59	0.59	0.59	0.59	0.59	0.59	
4/26/2012	0	0	0	0	0	0	
4/27/2012	0	0	0	0	0	0	
4/28/2012	0	0	0	0	0	0	
4/29/2012	0	0	0	0	0	0	
4/30/2012	0	0	7.5	0	0	0	
5/1/2012	2	2	2	2	2	2	
5/2/2012	0.2	0.2	0.2	0.2	0.2	0.2	
5/3/2012	8.1	8.1	8.1	8.1	8.1	8.1	
5/4/2012	0	0	0	0	0	0	
5/5/2012	6.6	6.6	6.6	6.6	6.6	6.6	
5/6/2012	4.2	4.2	4.2	4.2	4.2	4.2	
5/7/2012	0.7	0.7	0.7	0.7	0.7	0.7	
5/8/2012	0.1	0.1	0.1	0.1	0.1	0.1	
5/9/2012	0	0	0	0	0	0	
5/10/2012	0.1	0.1	0.1	0.1	0.1	0.1	
5/11/2012	5.2	5.2	5.2	5.2	5.2	5.2	
5/12/2012	2.4	2.4	2.4	2.4	2.4	2.4	
5/13/2012	0	0	0	0	0	0	
5/14/2012	0.1	0.1	5.4	0.1	0.1	0.1	
5/15/2012	1.6	1.6	1.6	1.6	1.6	1.6	
5/16/2012	2.6	2.6	2.6	2.6	2.6	2.6	
5/17/2012	0.1	0.1	0.1	0.1	0.1	0.1	
5/18/2012	0	0	0	0	0	0	
5/19/2012	0.4	0.4	0.4	0.4	0.4	0.4	
5/20/2012	0	0	0	0	0	0	
5/21/2012	0	28.3	5.7	28.3	28.3	28.3	28.3
5/22/2012	1.3	1.3	1.3	0	1.3	0	
5/23/2012	0.1	0.1	0.1	0	0.1	0	
5/24/2012	0	0	0	0	0	0	

5/25/2012	0	0	0	0	0	0	
5/26/2012	0	0	0	0	0	0	
5/27/2012	0	0	0	0	0	0	
5/28/2012	0	0	13.1	0	0	0	
5/29/2012	0	0	0	0	0	0	
5/30/2012	0	0	0	0	0	0	
5/31/2012	7.4	7.4	7.4	0	7.4	0	
6/1/2012	5.8	5.8	5.8	0	5.8	0	
6/2/2012	0	0	0	0	0	0	
6/3/2012	10.6	10.6	10.6	0	10.6	0	
6/4/2012	3	3	3	0	3	27.8	
6/5/2012	3.3	3.3	3.3	0	3.3	0	
6/6/2012	4.1	4.1	4.1	0	4.1	5.8	
6/7/2012	3.63	3.63	3.63	0	3.63	0	
6/8/2012	2.89	2.89	2.89	0	2.89	0	
6/9/2012	0.8	0.8	0.8	0	0.8	0	
6/10/2012	0	0	0	0	0	0	
6/11/2012	0.4	0.4	2.1	0	0.4	9.3	
6/12/2012	0.1	0.1	0.1	0	0.1	0	
6/13/2012	13.1	13.1	13.1	0	13.1	2.8	
6/14/2012	19.5	19.5	19.5	0	19.5	29.9	
6/15/2012	0.2	0.2	0.2	0	0.2	0	
6/16/2012	0.2	0.2	0.2	0	0.2	0	
6/17/2012	0	0	0	0	0	0	
6/18/2012	0	0	0	0	0	0	
6/19/2012	0	0	0	0	0	0	
6/20/2012	0.6	0.6	0.6	0	0.6	0	
6/21/2012	0.1	0.1	0.1	0	0.1	0	
6/22/2012	0.6	0.6	0.6	0	0.6	0	
6/23/2012	0	0	0	0	0	0	
6/24/2012	2	2	2	0	2	0	
6/25/2012	1.9	1.9	17	0	1.9	4.2	
6/26/2012	0.1	0.1	0.1	0	0.1	0	
6/27/2012	0	0	0	0	0	0	
6/28/2012	0	0	0	0	0	0	
6/29/2012	0.9	0.9	0.9	0	0.9	0	
6/30/2012	15.1	15.1	15.1	0	15.1	0	
7/1/2012	17.35	17.35	17.35	0	17.35	0	
7/2/2012	4.8	34.7	4.8	0	34.7	32.7	29,9 mm on XX,CA,D2
7/3/2012	2	2	2	53.8	2	36.4	151,8 on D1
7/4/2012	0	0	0	100	0	0	
7/5/2012	5.7	5.7	5.7	5.7	0	5.7	
7/6/2012	0.1	0.1	0.1	0.1	0	0.1	
7/7/2012	0.9	0.9	0.9	0.9	0	0.9	
7/8/2012	1.9	1.9	1.9	1.9	0	1.9	

B. Logger set up for BR and radiation complex

Logger system: Vaisala Finland, type:QLC50 (with CPU board) and QLI501(sensor board only), s/n R44303

Logger configuration: Vaisala software QSETUP

Name: GeoP2011.qsp

Definition of variables DVRX.BIN(*.CFG)

```
GROUP 0 ;
0,Log_Task,INTEGER,,-1 ;Log_Task Variablenliste
GROUP 1 ;
1,xPsy_H_T,REAL,,-1 ;Psychrometer oben trocken 10 min Mittel
1,xPsy_H_F,REAL,,-1 ;Psychrometer oben feucht 10 min Mittel
1,xPsy_L_T,REAL,,-1 ;Psychrometer unten trocken 10 min Mittel
1,xPsy_L_F,REAL,,-1 ;Psychrometer unten feucht 10 min Mittel
1,xAT_05,REAL,,-1 ;Pt100 +05 cm kein Strahlungsschutz 10 min Mittel
1,xBT_05,REAL,,-1 ;Pt100 -05 cm Bodentemperatur 10 min Mittel
1,xBT_10,REAL,,-1 ;Pt100 -10 cm Bodentemperatur 10 min Mittel
1,xBT_20,REAL,,-1 ;Pt100 -20 cm Bodentemperatur 10 min Mittel
1,xBT_50,REAL,,-1 ;Pt100 -50 cm Bodentemperatur 10 min Mittel
1,xCNR_T,REAL,,-1 ;CNR1 Geraetetemperatur 10 min Mittel
1,xCNR_Glb,REAL,,-1 ;CNR1 Globalstrahlung 10 min Mittel
1,xCNR_Ref,REAL,,-1 ;CNR1 Reflexstrahlung 10 min Mittel
1,xCNR_Geg,REAL,,-1 ;CNR1 Gegenstrahlung 10 min Mittel
1,xCNR_Aus,REAL,,-1 ;CNR1 Ausstrahlung 10 min Mittel
1,cWDir,REAL,,-1 ;Umrechnung Vect. WDir in Grad
1,xWS_L,REAL,,-1 ;Climatronic Wind Speed unt. Anem. Mittel
1,xWS_H,REAL,,-1 ;Climatronic Wind Speed ob. Anem. Mittel
1,cWS_H,REAL,,-1 ;Climatronic obere Windges. m/s 1 sec
1,cWS_L,REAL,,-1 ;Climatronic untere Windges. m/s 1 sec
1,xTDR_a,REAL,,-1 ;TDR Bodenfeuchte A 10 min Mittel
1,xTDR_b,REAL,,-1 ;TDR Bodenfeuchte B 10 min Mittel
1,xBW_a,REAL,,-1 ;Bodenwaermeplatte 65658 10 min Mittel
1,xBW_b,REAL,,-1 ;Bodenwaermeplatte 69813 10 min Mittel
1,xWDir,REAL,,-1 ;Vector W200P Windfahne 10 min Wert
GROUP 2 ;
2,Psy_H_T,REAL,,-1 ;Psychrometer oben trocken Ch00
2,Psy_H_F,REAL,,-1 ;Psychrometer oben feucht Ch01
2,Psy_L_T,REAL,,-1 ;Psychrometer unten trocken Ch02
2,Psy_L_F,REAL,,-1 ;Psychrometer unten feucht Ch03
2,AT_05,REAL,,-1 ;Pt100 +05 cm kein Strah.schutz Ch04
2,BT_05,REAL,,-1 ;Pt100 -05 cm Bodentemperatur Ch05
2,BT_10,REAL,,-1 ;Pt100 -10 cm Bodentemperatur Ch06
2,BT_20,REAL,,-1 ;Pt100 -20 cm Bodentemperatur Ch07
2,BT_50,REAL,,-1 ;Pt100 -50 cm Bodentemperatur Ch08
2,TDR_a,REAL,,-1 ;TDR Bodenfeuchte A [Vol%] Ch08
2,TDR_b,REAL,,-1 ;TDR Bodenfeuchte B [Vol%] Ch09
2,BW_a,REAL,,-1 ;Heatflux plate A [uV] Ch00
2,BW_b,REAL,,-1 ;Heatflux plate B [uV] Ch01
2,CNR_T,REAL,,-1 ;CNR Geraetetemperatur Ch03
2,Wdir,REAL,,-1 ;Windrichtung Vect. W200P Ch02
2,CNR_Glb,REAL,,-1 ;CNR Globalstrahlung [uV] Ch04
2,CNR_Ref,REAL,,-1 ;CNR Reflexstrahlung [uV] Ch05
2,CNR_Geg,REAL,,-1 ;CNR Gegenstrahlung [uV] Ch06
2,CNR_Aus,REAL,,-1 ;CNR Ausstrahlung [uV] Ch07
2,WSf_L,REAL,,-1 ;Frequenz unteres Anemometer F1
2,WSf_H,REAL,,-1 ;Frequenz oberes Anemometer F2
----------------------------------
```

Programmed calculations and/or conversions MATH.BIN (*.CFG)

```
00:10:00,0
600,(x10min) ;10 min Mittel

;10 min (600 sec) Mittel PT100
[1,xAT_05]= AVG([2,AT_05],600 )
[1,xBT_05]= AVG([2,BT_05],600 )
[1,xBT_10]= AVG([2,BT_10],600 )
[1,xBT_20]= AVG([2,BT_20],600 )
[1,xBT_50]= AVG([2,BT_50],600 )

;10 min (600 sec) Mittel Psychrometer
[1,xPsy_H_T] = AVG([2,Psy_H_T],600 )
[1,xPsy_H_F] = AVG([2,Psy_H_F],600 )
[1,xPsy_L_T] = AVG([2,Psy_L_T],600 )
[1,xPsy_L_F] = AVG([2,Psy_L_F],600 )

;10 min (600 sec) Mittel Bodenwaermeplatten HP
;HP kein Kalibrierfaktor Ausgabe uV
[1,xBW_a]= (AVG([2,BW_a],600 )) * 1000000
;HP kein Kalibrierfaktor Ausgabe uV
[1,xBW_b]= (AVG([2,BW_b],600 )) * 1000000

;CNR 1 oder 4 Kipp&Zonen
;keine Kalibrierfaktoren Ausgabe uV
[1,xCNR_Aus]= AVG([2,CNR_Aus] ,600 ) * 1000000
[1,xCNR_Geg]= AVG([2,CNR_Geg] ,600 ) * 1000000
[1,xCNR_Glb]= AVG([2,CNR_Glb] ,600 ) * 1000000
[1,xCNR_Ref]= AVG([2,CNR_Ref] ,600 ) * 1000000
[1,xCNR_T]= AVG([2,CNR_T] ,600 )

;10 min (600 sec) Mittel Windgeschw. m/s
[1,xWS_H]= AVG([1,cWS_H] ,600 )
[1,xWS_L]= AVG([1,cWS_L] ,600 )

;TDR-Sonde Imko
;keine Kalibrierfaktoren Ausgabe Volumen %
[1,xTDR_a]= AVG([2,TDR_a],600 ) * 100
[1,xTDR_b]= AVG([2,TDR_b],600 ) * 100

[0,Log_Task] = 1
00:00:00,0
1,(Windspeed) ;Umrechnung Wind in m/s bzw Grad
;Umrechnung Frequenz Anemometer in m/s je 1 sec
[1,cWS_H]= (([2,WSf_H] / 9.511 + 0.3) / 2.237) - 0.13
[1,cWS_L]= (([2,WSf_L] / 9.511 + 0.3) / 2.237) - 0.13

;Vector Instr. Windfahne 32 m Main Tower top:
;Finne S/N: Y73 - Koerper S/N: 3526
;Kalibrier-Faktor 2.92 Ohm pro Grad
[1,cWDir] = [2,Wdir] * 0.34246
-----------------------------------
```

Logger: QLC50 internal sensor board: sensor / channel allocation MPX1.BIN (*.CFG)

```
=B38400
=X0
=L3
=P3
=F5
=U1
=S1,00:00:00,100,60
:r,2,RTC_TEMP;0,0,1 TIN
:r,2,Psy_H_T;0,0,1,-50.0000,160.0000,50.0000 0PT100
:r,2,Psy_H_F;0,0,1,-50.0000,160.0000,50.0000 1PT100
:r,2,Psy_L_T;0,0,1,-50.0000,160.0000,50.0000 2PT100
```

```
:r,2,Psy_L_F;0,0,1,-50.0000,160.0000,50.0000 3PT100
:r,2,AT_05;0,0,1,-50.0000,160.0000,50.0000 4PT100
:r,2,BT_05;0,0,1,-50.0000,160.0000,50.0000 5PT100
:r,2,BT_10;0,0,1,-50.0000,160.0000,50.0000 6PT100
:r,2,BT_20;0,0,1,-50.0000,160.0000,50.0000 7PT100
:r,2,BT_50;0,0,1,-50.0000,160.0000,50.0000 8PT100
=END
------------------------
```

Logger: 1x QLI501 as external sensor board of the QLC50 connected via RS485-signal: sensor / channel allocation MPX2.BIN (*.CFG)

```
=B19200
=X0
=L3
=P3
=F5
=U2
=S1,00:00:00,100,60
:r,2,BW_a;0,0,1 0V
:r,2,BW_b;0,0,1 1V
:r,2,CNR_T;0,0,1,-50.0000,160.0000,50.0000 3PT100
:r,2,Wdir;0,0,1 2RI
:r,2,CNR_Glb;0,0,1 4V
:r,2,CNR_Ref;0,0,1 5V
:r,2,CNR_Geg;0,0,1 6V
:r,2,CNR_Aus;0,0,1 7V
:r,2,TDR_a;0,0,1 8+V
:r,2,TDR_b;0,0,1 9+V
:r,2,WSf_L;0,0,1 F1
:r,2,WSf_H;0,0,1 F2
=END~~~~~~~~~~~~~~
-------------------------
```

List of logged and saved variables QLCLOG.BIN (*.CFG)

```
;
= FROUND
Log_Task r 0 m m0
[1,xAT_05]
[1,xBT_05]
[1,xBT_10]
[1,xBT_20]
[1,xBT_50]
[1,xBW_a]
[1,xBW_b]
[1,xTDR_a]
[1,xTDR_b]
[1,xCNR_Aus]
[1,xCNR_Geg]
[1,xCNR_Glb]
[1,xCNR_Ref]
[1,xCNR_T]
[1,xPsy_H_F]
[1,xPsy_H_T]
[1,xPsy_L_F]
[1,xPsy_L_T]
[1,xWDir]
[1,xWS_H]
[1,xWS_L]
[0,Log_Task]
---------------------------
```

Statistics STAT.BIN (*.CFG)

```
00:00:00,0
2,Psy_H_T,600,1
00:00:00,0
2,Psy_H_F,600,1
00:00:00,0
2,Psy_L_T,600,1
00:00:00,0
2,Psy_L_F,600,1
00:00:00,0
2,AT_05,600,1
00:00:00,0
2,BT_05,600,1
00:00:00,0
2,BT_10,600,1
00:00:00,0
2,BT_20,600,1
00:00:00,0
2,BT_50,600,1
00:00:00,0
2,BW_a,600,1
00:00:00,0
2,BW_b,600,1
00:00:00,0
2,CNR_Aus,600,1
00:00:00,0
2,CNR_Geg,600,1
00:00:00,0
2,CNR_Glb,600,1
00:00:00,0
2,CNR_Ref,600,1
00:00:00,0
2,CNR_T,600,1
00:00:00,0
2,TDR_a,600,1
00:00:00,0
2,TDR_b,600,1
00:00:00,0
1,cWS_H,600,1
00:00:00,0
1,cWS_L,600,1
---------------------------------
```

C. General synopsis analysis by the German Weather Service

Table A2: General synopsis in May 2012

Mai 2012	GWL nach Hess & Brezowsky	Kurzbeschreibung
1.5	HNz	Vor der europäischen Atlantikküste hält sich zäh ein Cut-off-Tief. Demgegenüber ist das Geopotential über dem Nordatlantik und Island deutlich erhöht. Antizyklonaler Einfluss erstreckt sich dabei über Teile des Nordmeeres hinweg bis zum Baltikum. Mitteleuropa liegt im Bereich einer langgestreckten Tiefdruckrinne.
2.5	HNz	
3.5	HNz	
4.5	HNz	
5.5	SWz	Die Reste des Cut-off-Tiefs vor Westeuropa werden von einer umfangreichen Austrogung über dem Atlantik wieder in die planetare Zirkulation integriert und langsam über Mitteleuropa hinweggeführt. Es stellt sich zwischen dem atlantischen Langwellentrog und dem osteuropäischen Langwellenrücken über dem Kontinent eine südwestliche Grundströmung ein, in der Randtiefs vom Atlantik her mit westsüdwestlicher Zugbahn nach Skandinavien und Nordrussland gelenkt werden. Dabei überwiegt in Mitteleuropa meist ein leicht zyklonaler Witterungscharakter.
6.5	SWz	
7.5	SWz	
8.5	SWz	
9.5	SWz	
10.5	SWz	
11.5	SWz	
12.5	Wa	Kurzwellentröge ziehen vom Nordatlantik her über Mitteleuropa hinweg. Anschließend tropft ihr südlicher Teil nach Südosteuropa ab, während der nördliche Teil verzögert nach Nordosten abgedrängt wird. Die Wetterlage zeigt zeitweise Ähnlichkeiten mit einer winkelförmigen Westlage, einer Hochdruckbrücke, kurzfristig auch einer Troglage, ohne jedoch lange genug die typischen Ausprägungen dieser Großwetterlagen auszubilden. Aufgrund der Weststeuerung über Zentraleuropa und der nur kurzen zyklonalen Abschnitte wird für diesen Zeitraum "Wa" klassifiziert.
13.5	Wa	
14.5	Wa	
15.5	Wa	
16.5	Wa	
17.5	Wa	
18.5	Wa	
19.5	SEz	Ein ausgedehntes Cut-off-Tief über dem Südwesten Europas sorgt in weiten Teilen Mitteleuropas für eine südöstliche bis östliche Strömung. Mit ihr wird warme, feuchte, potentiell labil geschichtete Luft advehiert, in der sich tagesgangbedingt unter zyklonalem Einfluss stellenweise unwetterartige Gewitter bilden.
20.5	SEz	
21.5	SEz	
22.5	SEz	
23.5	HNFa	Über dem nördlichen Europa baut sich eine hochreichende Antizyklone auf, deren Wirkungsbereich sich nach und nach bis zu den Alpen ausdehnt. Die anfängliche vorhandene schwülwarme Luft wird von Osten her durch Kontinentalluft ersetzt.
24.5	HNFa	
25.5	HNFa	
26.5	HNa	Das kräftige Hochdruckgebiet über dem Nordmeer und Fennoskandien verlagert seinen Schwerpunkt allmählich retrograd in den Bereich Island - Nordmeer. Dabei bleibt ein Keil mehr oder weniger beständig in Richtung westliches Mitteleuropa und Mitteleuropa gerichtet, so dass der Witterungscharakter dort zunächst überwiegend antizyklonal ausfällt.
27.5	HNa	
28.5	HNa	
29.5	HNa	
30.5	HNa	
31.5	HNz	Druckfall über Skandinavien modifiziert die Großwetterlage in zyklonale Richtung.

Table A3: General synopsis in May 2012

Juni 2012	GWL nach Hess & Brezowsky	Kurzbeschreibung
1.6	HNz	Von der Ostküste Grönlands über Island und Teile des nördlichen Nordmeeres herrscht hoher Luftdruck. Ein Keil dieses Hochs erstreckt sich dabei über die Britischen Inseln hinweg bis ins westliche Europa. Über der Ostsee und dem südlichen Skandinavien bestimmt dagegen niedriges Geopotential das Witterungsgeschehen. Dadurch wird auch Mitteleuropa vorwiegend zyklonal beeinflusst.
2.6	HNz	
3.6	HNz	
4.6	HNz	
5.6	HNz	
6.6	SWz	Ein langwelliger Trog über dem Nordatlantik drängt die Frontalzone nach Süden ab. Sie trifft über Spanien auf den Kontinent und verläuft von dort nach Ostnordost weisend über das zentrale Europa hinweg. So findet sich die Hauptwetteraktivität dieser Tage zwischen Iberischer Halbinsel und Baltikum.
7.6	SWz	
8.6	SWz	
9.6	SWz	
10.6	WS	Der ausgedehnte Trog verlagert sich vom Atlantik zum Kontinent. Dabei nimmt die Frontalzone über Europa einen für die Jahreszeit ungewöhnlich südlichen Verlauf an - etwa von der Iberischen Halbinsel über das westliche Mittelmeer und Italien zum Balkan. In die Strömung eingelagerte kurzwellige Troganteile ziehen dabei ungefähr auf Höhe des 50. Breitengrades über Mitteleuropa hinweg ostwärts.
11.6	WS	
12.6	WS	
13.6	WS	
14.6	WS	
15.6	SWz	Auf der Vorderseite einer markanten, sich im Laufe des Zeitabschnitts durch Kaltluftvorstöße wiederholt regenerierenden Austrogung über dem östlichen Nordatlantik stellt sich über weiten Teilen Europas eine südwestliche Grundströmung ein. Dabei werden im betrachteten Zeitraum mehrfach kurzwellige Randtröge über eine Zugbahn, die etwa von der Iberischen Halbinsel über Frankreich, Deutschland und Polen hinweg zum Baltikum führt, über den Kontinent hinweggeschwenkt. Zwischen den Trögen stellen sich kurzzeitig auch mal antizyklonale Verhältnisse ein. Im Großen und Ganzen gibt es jedoch ein leichtes Übergewicht der zyklonal geprägten Witterungsphasen.
16.6	SWz	
17.6	SWz	
18.6	SWz	
19.6	SWz	
20.6	SWz	
21.6	SWz	
22.6	SWz	
23.6	SWz	
24.6	Wa	Nach Durchschwenken eines Frontensystems, das zu einem von Schottland zum Baltikum ziehenden Tief gehört, steigt der Luftdruck über Mitteleuropa rasch an. Am Alpenrand kommt es durch Staueffekte anfangs noch zu größeren Niederschlägen. In der Folgezeit bestimmt im Süden leicht antizyklonaler Einfluss das Wettergeschehen. Nach Norden hin macht sich später eine in zonaler Richtung verlaufende Luftmassengrenze bemerkbar.
25.6	Wa	
26.6	Wa	
27.6	Wa	
28.6	Wa	
29.6	TrW	Ein markanter Trog baut sich vor der westeuropäischen Küste auf und verlagert seine Achse bald auf eine Linie Südwesteuropa - Skandinavien.
30.6	TrW	

Table A3: Description of the General synopsis classification according to Hess and Brezowski (from http://www.pik-potsdam.de/~uwerner/gwl/welcome.htm, downloaded on June 07, 2013)

Bezeichnung	**Abkürzung**
A. Großwetterlagen der *zonalen Zirkulationsform*	
1. Westlage, antizyklonal	*WA*
2. Westlage, zyklonal	*WZ*
3. Südliche Westlage	*WS*
4. Winkelförmige Westlage	*WW*
B. Großwetterlagen der *gemischten Zirkulationsform*	
5. Südwestlage, antizyklonal	*SWA*
6. Südwestlage, zyklonal	*SWZ*
7. Nordwestlage, antizyklonal	*NWA*
8. Nordwestlage, zyklonal	*NWZ*
9. Hoch Mitteleuropa	*HM*
10. Hochdruckbrücke (Rücken) Mitteleuropa	*BM*
11. Tief Mitteleuropa	*TM*
C. Großwetterlagen der *meridionalen Zirkulationsform*	
12. Nordlage, antizyklonal	*NA*
13. Nordlage, zyklonal	*NZ*
14. Hoch Nordmeer-Island, antizyklonal	*HNA*
15. Hoch Nordmeer-Island, zyklonal	*HNZ*
16. Hoch Britische Inseln	*HB*
17. Trog Mitteleuropa	*TRM*
18. Nordostlage, antizyklonal	*NEA*
19. Nordostlage, zyklonal	*NEZ*
20. Hoch Fennoskandien, antizyklonal	*HFA*
21. Hoch Fennoskandien, zyklonal	*HFZ*
22. Hoch Nordmeer-Fennoskandien, antizyklonal	*HNFA*
23. Hoch Nordmeer-Fennoskandien, zyklonal	*HNFZ*
24. Südostlage, antizyklonal	*SEA*
25. Südostlage, zyklonal	*SEZ*
26. Südlage, antizyklonal	*SA*
27. Südlage, zyklonal	*SZ*
28. Tief Britische Inseln	*TB*
29. Trog Westeuropa	*TRW*
Übergang	*U*

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