Documentation of the Weather Station on Top of the Roof of the Institute Building of the Max-Planck-Institute for Biogeochemistry

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Contents

1 Mast and Instrument Setup

Almost all instruments of the weather station are attached to a 10m high un-guyed stainless-steel mast of quadratic shape becoming smaller with increasing height on top of the roof of the institute building. This mast is used as well to temporarily carry other instruments for comparison or calibration purposes.

In the table below all the measured variables are listed together with their corresponding instrument and the company producing it:

Variable	**Instrument**	**Producer**
Air temperature	AKM.00.F148.520.7S8	Mela Sensortechnik
Relative air humidity	AKM.00.F148.520.7S8	Mela Sensortechnik
Air pressure	PTB101B	Vaisala
Wind velocity	4.3800.00.140	Thies
Wind direction	4.3800.00.140	Thies
Shortwave incoming radiation	CM11	Kipp & Zonen
Photosynthetic active radiation	PAR Lite	Kipp & Zonen
Precipitation amount	5.4032.35.008	Thies
Precipitation yes/no	5.4103.10.000	Thies
Precipitation spectra	Parsivel disdrometer	Ott HydroMet
CO_2-concentration	LI6262	Licor

Table 1: Instruments of the weather station

The following table shows the measured variables together with the method of the measurement:

Variable	**Measurement method**
Air temperature	PT100 resistor
Relative air humidity	Capacitive humidity sensor
Air pressure	Capacitive aneroid barometer
Wind velocity	2-D sonic anemometer
Wind direction	2-D sonic anemometer
Shortwave incoming radiation	Temperature gradient of a black area
Photosynthetic active radiation	Photodiode with filter
Precipitation amount	Tipping bucket with contact (0.1mm resolution)
Precipitation yes/no	Infrared photoelectric switch
Precipitation spectra	Laser light barrier
CO_2-concentration	Absorption of infrared radiation

Table 2: Variables and measurement method

All instruments, as well as the ambient air inlet to measure the CO_2 concentration by means of an infrared gas analyzer, are mounted next to the top of the mast except the rain gauge, the rain detector and the disdrometer which are fixed close to the base of the mast in a height of approximately 1m. A closed path gas analyzer is used here. The aspirated ambient air is pushed through a cuvette inside the gas analyzer by a diaphragm pump. This cuvette consists of two cells each of a volume of approx. $12cm^3$. The ambient air flows through one of the cells, a reference gas, in this case pure nitrogen (N_2) from a pressurized cylinder, flows through the second cell. In a rapid cycle infrared radiation of a wavelength of $4.26\mu m$ from one and the same radiation source is sent alternatingly through both cells. The CO_2 of the ambient air in the sample cell absorbs more or less of the infrared radiation depending on the actual concentration of the trace gas. At the same time no absorption takes place in the reference cell which is permanently flushed with N_2 at a very low flowrate. The comparison of the radiation from both cells reaching the detector allows the determination of the CO_2-concentration while system inherent fluctuations of the infrared radiation are eliminated. To ensure as precise concentration measurements as possible it is necessary to calibrate the gas analyzer regularly. This takes place automatically once per day always at midnight. For this reason, pure nitrogen is flushed through the sample cell for a period of one minute by means of a valve switching unit. For a second period of one minute a calibration gas with a well-known CO_2-concentration flows through the sample cell. The results of these two measurements give a calibration function which is then used for the next 24 hours. The CO_2-concentration of the calibration gas has been determined before by the institute gas lab at a very high precision of better than 0.1ppm.

Halfway up the mast a Mobotix M16B web camera is attached which faces to the North to the center of the city of Jena. The camera simultaneously captures two images with different zoom settings.

Climbing up the tower for assembly or maintenance work is only done by wearing the personal safety gear (PSA) which consists of a protection helmet and the climbing harness. Attached to the climbing harness there is a runner which fits into the rail of the mast safety system (Söll company). If protected like this the persons working on the mast can't fall.

2 Acquisition and Processing of the Data

Data acquisition systems, power supplies, laptops and similar devices are placed within a so called outdoor-modular-locker (Rittal company) next to the mast base. The inside temperature of the locker is regulated by ventilation and heating between 5°C and ambient temperature. The gas analyzer and its peripheral devices (valve switching unit and so on) are also located inside this locker.

For the acquisition of the signals of the above-mentioned instruments a CR1000X datalogger (Campbell Scientific) is used. The datalogger is directly connected to the internal institute network via Ethernet cable. The sensors are scanned by the logger every 10 seconds - averages, totals and maxima of the variables over periods of 10 minutes are internally calculated and stored in the datalogger ring memory.

The program LoggerNet (Campbell Scientific), running on a separate computer within the local institute network (Windows 10 operating system), connects every 10 minutes to the datalogger via the institute network to download the latest data or all those which had not yet been downloaded, respectively. The computer clock is regularly being synchronized with a time server, and the computer itself synchronizes the datalogger clock.

With a homemade software the raw data which are mainly given in units of a voltage, are automatically and online converted into meaningful units, checked for plausibility and saved to a server as ASCII-files.

The Web camera images are transferred directly via network automatically every 10 minutes to a server.

3 Visualizing and Archiving of the Data

On the computer which collects the datalogger data, another software named RTMC (Real-Time Monitoring and Control, Campbell Scientific) is running which automatically detects if there are new data available in the raw data file. If this is the case then the new data are read from the file, some necessary calculations are performed, and the diagrams are updated. After this all the single graphs are sent to the server as png-files.

A script running on the sever puts all the information together and updates the Web page. All data since the data collection of the weather station started are freely available and can be downloaded from the Web page as compressed archives. One ZIP-file always contains data of half a calendric year or, since 2024, a full year. The unpacked files are so called CSV-files (comma separated values), where the single data are separated by commas. The dot is used as decimal delimiter, the format for time and date are as used in Germany. Below is an example of such a file with only a few lines which are themselves not complete (less columns):

```
"Date Time","p (mbar)","T (degC)","Tpot (K)","Tdew (degC)","rh (%)" .....
08.09.2004 12:00, 1004.39, 18.54, 291.34, 9.23, 54.57 .....
08.09.2004 12:10, 1004.35, 18.92, 291.72, 9.35, 53.72 .....
08.09.2004 12:20, 1004.37, 18.82, 291.62, 8.93, 52.55 .....
08.09.2004 12:30, 1004.36, 18.88, 291.68, 8.18, 49.78 .....
```

In the table below all column headers together with their units and a description of the corresponding measured variable are listed:

Symbol	**Unit**	**Variable**
Date Time	dd.mm.yyyy hh.mm (MEZ)	Date and time of the data record (the timestamp represents the end of the averaging period)
p	mbar	air pressure
T	°C	air temperature
Tpot	K	potential temperature
Tdew	°C	dew point temperature
rh	%	relative humidity
VPmax	mbar	saturation water vapor pressure
VPact	mbar	actual water vapor pressure
VPdef	mbar	water vapor pressure deficit
sh	gkg-1	specific humidity
H2OC	mmolmol-1	water vapor concentration
rho	gm^{-3}	air density
wv	ms^{-1}	wind velocity
max. wv	ms^{-1}	maximum wind velocity
wd	^{o}	wind direction
rain	mm	precipitation
raining	s	duration of precipitation
SWDR	Wm^{-2}	short wave downward radiation
PAR	$mmolm^{-2}s^{-1}$	photosynthetically active radiation
max. PAR	$\mu molm^{-2}s^{-1}$	maximum photosynthetically active radiation
Tlog	°C	internal logger temperature
CO2	ppm	CO_2-concentration of ambient air

Table 3: Variables, their symbols and units

The images of the camera are also archived with a picture every 5 minutes.