AUTOMATIC WEATHERSTATION OUTER HOCHEBENKAR

Description of Instruments

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1 Introduction

The automatic weather station (AWS) Hochebenkar (HEK) was installed near the Hochebenkar rock glacier on the 12th of October. An overview of the entire area and the location of the AWS can be seen in Figure 2.1 and in Figure 2.2 from the opposite side of the valley. The AWS was set up to record meteorological data such as the net radiation balance, wind- and wind speed, snow high, pressure, precipitation during the summer months, temperature and humidity as well as soil temperature and the temperature of the snowpack at two levels. Power supply is provided with battery and a solar panel. Data communication can be both, direct connection with laptop and via a GSM modem. This report gives a summary of the development and testing phase of the AWS and the executed fieldwork in this project.

2 The automatic weather station Hochebenkar

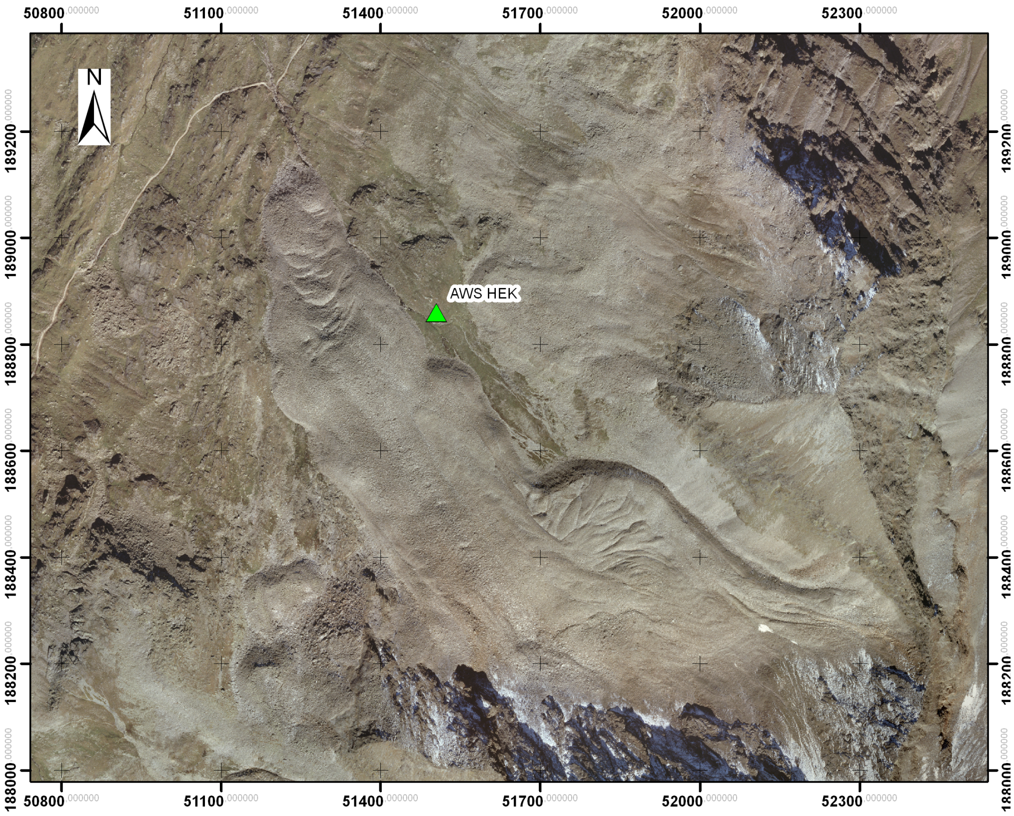

Figure 2.1: Overview: Hochebenkar rock glacier and the location of the AWS. Coordinate system: GK M28

Instruments as well as cables and enclosures of the automatic weather station were ordered from Campbell Scientific and delivered on the 25th of May 2010. All the other parts such as the telescope mast, anchoring bolts and cables were ordered from different companies and compiled at the IMGI. In August the station and the datat logger program were accomplished end therefore ready for testing at the IMGI, together with a second station of similar type as can be seen in Figure 2.3. During the testing phase the results were compared to the second station and to to the automtic weather station of the IMGI. On the 6th of October the AWS were

Figure 2.2: View to Hochebenkar rock glacier and the location of the AWS from the opposite side of the valley

brougth to the outer Hochebenkar by helicopter and finally installed on the 12th of October. Data scans take place every minute and get stored as a ten minutes mean, minimum, maximum, sum or vector depending on each measured parameter.

2.1 Setup

The setup of the AWS can be seen in Figure 2.4. The mast consists out of to parts, to enable the adjustment of the instruments high, which is in particular important during winter to ensure that the instruments protrude the snowpack and to preserve power supply to the station. During winter the solar panel and the instruments except the pressure measurement are located at heights between three and four meters above ground. The pressure measurement is located inside the enclosure of the AWS which cannot be adjusted in height. Therefore the interpretation of the pressure data during winter has to be done carefully. Precipitation is recorded only during the summer months because of the risk of icing and therefore damaging of the rain gauge. Three temperature probes are installed for measuring soil and snowpack temperature. The first one is located about 1.5 meters in the front of the station at a depth of 15 centimeters for measuring the soil temperature. The probes for the snowpack temperature profile are mounted on the mast to a height of 10 and 70 centimeters above ground. During summer months these two measurements do not have any purpose.

Figure 2.3: Comparing two AWS of the same type during the testing phase on the IMGI.

Figure 2.4: Setup of the AWS in the outer Hochebenkar.

2.2 Instruments

The following section summarizes all the instruments and gives a brief technical overview of each. The information in the following subsections and further information is given in the manuals provided by Campbell Scientific.

2.2.1 Windspeed and direction

Horizontal wind speed and direction is measured using the Young Wind Monitor 05103-45 which is mounted on the top of the mast as can be seen at the pictures above. The wind monitors with the specification number 45 is especially designed for alpine environment to discourage ice build-up. Wind speed and direction are stored as a wind vector every ten minutes. The wind gust is stored as the maximum value out of ten minutes.
Technical data for wind speed:

- accuracy: ± 0.3 ms^{-1}, 1 to 60 ms^{-1}; ± 1 ms^{-1}, 60 to 100 ms^{-1}
- range: 1 to 60 ms^{-1} for maximum accuracy, gust survival 100 ms^{-1}
- threshold sensitivity: 1 ms^{-1} (max.), 0.5 ms^{-1} typical

Technical data for wind direction:

- accuracy: $\pm 3°$
- range: $360°$ mechanical, $355°$ electrical ($5°$ open; parallel resistor prevents floating signal in deadband)
- threshold sensitivity: 1.0 ms^{-1} at $10°$ displacement 1.5 ms^{-1} at $5°$ displacement

Physical specifications:

- serial number: WM9997
- operating temperature: $-50°$ to $50°$C, assuming non-riming conditions
- dimensions overall: 37 x 55 cm
- main housing diameter: 5 cm
- propeller diameter: 18 cm
- weight: 1.5 kg

2.2.2 Precipitation

Only during the winter months precipitation is measured using the Young Tipping Bucket Rain gauge 52203, which is the unheated version of the same gauge 52202. The problem with heating to avoid icing and thus getting precipitation rates during winter is the required energy. The heater needs much more power than the whole AWS does and is therefore not energy-efficient in such an environment. The stored precipitation data is the number of tipping actions between a scan interval and added ten minutes each, in which one tip equates 0.1 mm which is the hydrostatic head per square meter.
Technical data for the raingauge:

- serial number: TB7310
- gauge catchment area: 200 cm^2
- resolution: 0.1 mm per tip
- accuracy: 2% up to 25 mm/hour; 3% up to 50 mm/hour
- instrument diameter: $18,5$ cm
- instrument height: 36 cm

2.2.3 Radiation

The Kipp&Zonen four component net radiometer CNR4 measures the energy balance between incoming and outgoing shortwave as well as incoming and outgoing longwave radiation. Therefore the CNR4 consists out of a pyrgeometer pair and a pyranometer pair in which one of each facing up- and the other one facing downwards. With the CNR4 body two temperature sensors, a thermistor and a PT-100 are integrated to enable the correction of the longwave radiation, which is necessary because of instrument housing. The CNR4 is used without the expansion of the heater/ventilation unit CNF4 because of the same energy-insufficiency as it is described for precipitation measurements above. All the measured parameters as well as the corrected values are stored as a ten minutes mean.
CNR4 specifications:

- serial number: 100254
- operating temperature: -40 to $+80$°C
- operating humidity: 0 to 100% RH
- sensor weight: 0.85 kg

Pyranometer specifications:

- spectral range: 305 to 2800 nm
- sensitivity upper sensor: 17.59 μVW^{-1}m^{-2}
- sensitivity lower sensor: 16.69 μVW^{-1}m^{-2}
- temperature dependence of sensitivity: $< 4\%$ ($-10°$ to $40°$C)
- field of view upper detector: $180°$
- field of view lower detector: $150°$
- maximum solar irradiance: 2000 Wm^{-2}
- expected accuracy for daily totals: $\pm 10\%$

Pyrgeometer specifications:

- spectral range: 4.5 to 42 μm
- sensitivity upper sensor: 10.28 μVW^{-1}m^{-2}
- sensitivity lower sensor: 8.59 μVW^{-1}m^{-2}
- temperature dependence of sensitivity: $< 4\%$ ($-10°$ to $40°$C)
- field of view upper detector: $180°$
- field of view lower detector: $150°$
- uncertainty in daily total: $< 10\%$

The longwave correction (LWinCor and LWoutCor) using the sensor temperature (CNR4TC) is given in formula 2.1 and 2.2.

$$LWinCor = LWin + 5.67 * 10^{-8} * (CNR4TC + 273.18)^4 \tag{2.1}$$

$$LWoutCor = LWout + 5.67 * 10^{-8} * (CNR4TC + 273.18)^4 \tag{2.2}$$

2.2.4 Barometric pressure

As can be seen in Figure 2.5 the Setra Barometric Pressure Sensor CS100 is mounted inside of the enclosure. The barometric pressure is stored as a ten minutes average.
Specifications:

- serial number: 42889886

- measurement range: 600 mb to 1100 mb (hPa)
- operating temperature range: -40°C to 60°C
- humidity range: non-condensing (up to 95% RH)
- resolution: 0.01 mb
- total accuracy:
  - ± 0.5 mb at 20°C
  - ± 1.0 mb at 0°C to $+40$°C
  - ± 1.5 mb at -20°C to $+50$°C
  - ± 2.0 mb at -40°C to $+60$°C
- long-term stability: ± 0.1 mb per year

Physical specifications:

- dimensions: 9.1 x 6.1 x 2.5 cm
- weight: 135 g

2.2.5 Temperature and humidity

The Vaisala HMP45AC temperature and relative humidity probe contains a Platinum Resistance Temperature detector (PRT) and a Vaisala Humicap 180 capacitive relative humidity sensor. To avoid an uncaptured radiation error the HMP45AC is located inside of the large radiation shield which is mounted at the sensor cross arm. Both, temperature and relative humidity are stored as averages every ten minutes.
Temperature sensor specifications:

- sensor: $1000\ \Omega$ PRT, IEC $7511/3$ Class B
- temperature measurement range: -40°C to 60°C
- temperature uncertainty: ± 0.13°C (95% confidence level)

Humidity sensor specifications:

- sensor: Vaisala Humicap 180
- relative humidity measurement range: 0 to 100% non-condensing
- accuracy at 20°C:
  - $\pm 2\%$ (0 to 90% relative humidity)

    - ±3% (90 to 100% relative humidity)

- temperature dependence of relative humidity measurement: ±5% RH/°C
- typical long term stability: better than 1% RH per year

Physical specifications:

- serial number: F1110018
- operating temperature: −40°C to 60°C
- probe length: 25.4 cm
- probe body diameter: 2.5 cm
- filter: 0.2 μm Teflon membrane
- filter diameter: 1.9 cm

2.2.6 Temperature of soil and snowpack

For measurements of soil and snowpack temperatures three thermistor 107 probes are used. Soil temperature is measured at a depth of 15 cm and 1.5 m in the front of the station. The probes for snowpack temperature are mounted at the mast at 10 and 70 cm above ground. Because of the uncaptured radiation error these two snowpack temperatures are significant in cases of snow coverage only. Temperature values are stored as a ten minutes mean.
Specifications:

- sensor: BetaTherm 100K6A Thermistor
- temperature measurement range: −35° to 50°C
- thermistor interchangeability error: $< \pm 0.18$°C over −25 to 50°C
- temperature survival range: −55° to 100°C
- worst case accuracy: ±0.3°C over −25 to 50°C

2.2.7 Distance

Snow depth is calculated out of the distance measurements using the Campbell SR50A Sonic Ranging Sensor without the heater option (SR50AH). The reason for usage without the heater option is mentioned above. The SR50A is an acoustic sensor which determines the distance to the surface by emitting an ultrasonic pulse and then measuring the elapsed time between the emission and return of pulse. Air temperature is necessary to correct the signal because of the temperature depending propagation speed.
Specifications:

- serial number: 3103
- measurement time: < 1.0 second
- measurement range: 0.5 to 10 m
- beam acceptance: $\approx 30^\circ$
- resolution: 0.25 mm
- accuracy: 1 cm or 0.4% of distance to target
- operating temperature: -45° to 50°C
- length: 10.1 cm
- diameter: 7.5 cm
- weight: 1.0 kg

2.2.8 Datalogger

The data logger used in this setup is the Campbell CR3000 which can measure almost any sensor with an electric response. Measured electric signals are converted to engineering units. Even calculations and data reduction to statistical values can be done. The CR3000 will store data in memory awaiting transfer to the PC via external storage devices or telecommunications. Specifications:

- serial number: 4771
- analog inputs: 14 differential or 28 singel ended voltage measurements
- accuracy without sensor and measurement noise:
  - $\pm(0.04\%$ of reading $+$ offset), 0° to 40°C
  - $\pm(0.07\%$ of reading $+$ offset), -25° to 50°C
  - $\pm(0.09\%$ of reading $+$ offset), -40° to 85°C
- accuracy of built-in junction thermistor:
  - $\pm 0.3^\circ$C -25° to 50°C
  - $\pm 0.8^\circ$C -40° to 85°C
- analog outputs: 4 switched valtage and 3 switched current outputs, 2 continuous voltage outputs
- resistance measurements: 4- and 6-wire full bridges and 2-, 3- and 4-half bridges

- dedicated pulse counters: 4 inputs individually selectable for switch closure, high frequency pulse, or low-level AC
- digital control ports: 8 digital control ports
- switched 12 V: two independent 12 V unregulated sources
- communication: RS-232, CS I/0, SDI-12, SDM and peripheral ports available
- clock accuracy: ±3 min per year
- size: 24.1 x 17.8 x 9.6 cm
- weight: 1.6 kg

2.2.9 Others

Power supply is given by a 40 watt solar panel and a 12 V and 34 Ah battery. If the battery is charged the regulator disconnects battery and solar panel to avoid overcharge. The AWS is equipped with the Wavecom CS-GSM modem and a low-cost dual-band antenna by Campbell Scientific to enable communication via two modems. The reception at the location of the AWS has been tested and the system will be completed with a T-Mobile SIM card as soon as possible. A wiring plan is fixed inside the enclosure box as can be seen in Figure 2.5

The automatic camera which will complement the atmospheric data will be installed when the proposed funding is available.

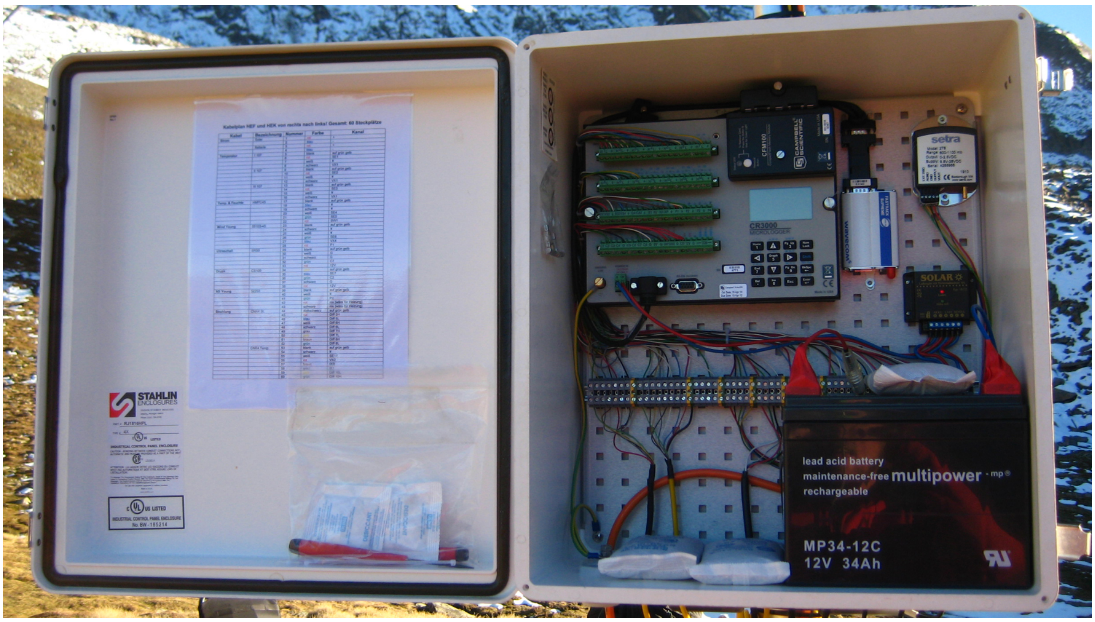

Figure 2.5: Enclosure of the AWS Hochebenkar.