Technical comments on the data records from the Vernagtbach station for the period 1974 to 1986

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1) Introduction

The Vernagtferner region has a long tradition of glaciological research performed by groups from Munich. It started in 1889, when Prof. Sebastian Finsterwalder from the Technical University in Munich produced the first map of a complete glacier based on terrestrial photogrammetry. Since then, numerous maps of the glacier have been made, describing the change in surface elevation for more than a century. These maps form the basis of the geodetic method of glacier mass balance determination, which provides volume changes as average data for the period between two surveys, i.e. typically for 10 years. Since the start of the glaciological method on Vernagtferner in 1964, annual as well as winter and summer mass balance data are available continuously. But only since 1973, the construction of the Vernagtbach station, approximately 1 km below the glacier margin at that time, provided the means to record a larger number of hydrological and meteorological parameters with a temporal resolution of typically 1 hour.

2) Special research program A1 'Runoff in and from glaciers'

The station and the data records formed the experimental basis for the research project A1. It was started 1974 under the title 'Runoff in and from glaciers' as part of the special research program SFB 81 'Runoff in channels' ('Abfluss in Gerinnen'), hosted by the Technical University Munich and funded by the German Research Foundation. The project comprised hydrological, meteorological and glaciological research in the Vernagtferner basin (Oetztal Alps, Austria, 2635 m a.s.l. to 3633 m a.s.l., 81 % glacierized by the Vernagtferner in 1986). Its main research purpose was the complete modeling of the runoff processes in a glacier with a physical approach. Therefore, an energy balance model was developed to determine the melt water production at the glacier surface (Escher-Vetter, 1980); with a hydrological model the storage and the outflow of the water from different parts of the glacier with different hydraulic properties were analyzed (Baker et al., 1982, Oerter et al., 1981). The records from the Vernagtbach station were partly used as input for the melt water production model, partly to validate the model output. The complete model was run for the ablation periods of the years 1978 to 1985 (Moser et al., 1986).

After the end of the special research program the Commission for Glaciology of the Bavarian Academy of Sciences in Munich (now: Commission for Geodesy and Glaciology, Section Glaciology) continued to run the station until this very day, and as a result, long series of several climate parameters are now available from this high alpine site. With this first data delivery, the records for the early period are published in the Pangaea system; the series after 1986 will be submitted in due course.

In this short comment the background of the records will be described in order to provide a realistic picture of the quality of the meteorological and hydrological time series from the Vernagtbach station between 1974 and 1986.

The basic quantities recorded then comprise 1) total discharge from the basin (Q), based on water stage records; 2) water temperature (Temp), 3) precipitation (Precip), 4) air temperature (TTT), 5) air humidity (RH), 6) air pressure (PoPoPoPo), 7) global radiation (SWD), 8) reflected short-wave radiation (SWU), 9) long-wave radiation from the air (LWD), 10) long-wave radiation from the ground (LWU), both determined as the difference between all-wave and shortwave radiation components, 11) wind speed (ff) and 12) wind direction (dd). (Abbreviations in brackets give the respective names in the Pangaea data description). Due to power supply limitations, no ventilation was installed for the air temperature and radiation instruments. Daily sums or averages of discharge, precipitation, air temperature and global radiation were already published in Moser et al., Part II (1986). Compared to that early publication, the data which are now submitted to the Pangaea database have been partly corrected and revised.

The Vernagtbach station (Fig. 1 shows the meteorological instruments, Fig. 2 the runoff channel) has no permanent observers, but is visited periodically, typically once a month between May and October and only once or twice between November and April. This leads to two types of restrictions, which have to be considered when using these early records, i.e. limitations due to the type of the recording devices and due to unnoticed failures of the instruments.

Limitations of the recording devices were induced primarily by three factors: lack of power supply, early expiration of paper charts and tapes and wrong dating of the registrations on paper. Power supply for instruments as well as loggers was implemented partly by dry cells and partly by huge accumulators which were recharged by a wind generator for the first years, afterwards by solar panels. Until 1978, all data were recorded on paper charts (Ottschreiber for water stage, Schenkschreiber for all temperatures, humidity and radiation components, Wölfle anemometer for wind velocity and direction, Fuess and Belfort paper charts for precipitation, Thiess barograph for air pressure, Bureau Technique Wintgens (BTW) long-term thermo- and hygrograph). From 1979 until 1985 the records were partly on paper charts, partly on a tape recorder (Microdata M 1600 L), i.e. already in digital format. Due to the power supply and the length of the paper charts/tapes, most of these recording devices could only be run in summer, only the BTW and the precipitation gauge charts lasted up to several months and could therefore also provide data for the winter season. In 1984 the solid state storage device Modas 84 replaced the M1600 L, and only then, most of the – now nearly completely digitally available - records became gradually available for the whole year. Additional information on loggers and instruments for the early period is provided by Moser et al. (1986), pp.42 to 45.

At an unmanned station, several failures of the instruments can occur unnoticed:

1) The radiation devices can deviate from the horizontal alignment and the deviation can even be different for the short-wave and the all-wave components, thus affecting the calculated long-wave radiation;

2) The upper cup of the short-wave radiation device can be covered with snow, so recorded global radiation is smaller than reflected radiation;

3) The soft ('Lupolen') cups of the all-wave radiation device can be damaged by snow, so long-wave radiation components are not available in winter and partly even in summer;

4) The air temperature sensor is mounted within a Stevenson screen, which can be filled with snow in winter due to wind drift;

5) The humidity of the air, which is measured with a hair hygrometer, was also mounted within the screen for selected periods; therefore, it can also be disturbed by snow inside the hut;

6) The cups of the anemometer can be afflicted by ice accretion;

7) The water temperature sensor is installed within the stream, but during periods of low water stage, its position may lie outside the water;

8) The discharge records may be interrupted due to disruptions in the measuring channel, which disable the registration of the water stage;

9) Year-round precipitation is measured with a weighing gauge, i.e. both snowfall and rainfall can be measured; however, the device can be covered with snow during winter;

10) The tipping bucket precipitation device is not heated, therefore snowfall is mainly recorded too late in this instrument, i.e. only after the snow has melted. The problems with the correct dating of precipitation events have to be considered for all years until 2002, as the first digital weighing gauge was installed only in October 2001.[1]

The records may be affected by all these disturbances, but it is difficult to know the periods when they occur. In some cases it is possible to localize the period approximately, for example in the case with snow on the upper radiation cup by comparison with the reflected radiation, or for the tipping bucket data by comparing them to the weighing gauge records. But ice accretion on the anemometer cups, for example, may go unnoticed. Sometimes the combination of the information from the different instruments helps to some extent in the decision whether the data can be correct or not. Sometimes, even the data from the next climate station are used for comparison; for the period under discussion the Austrian weather service station in the Rofen valley at Vent (1890 m a.s.l.) served for these purposes. In addition, the already mentioned model results could be used to control the quality of the records. We used all these methods to get the best quality records, but in spite of these controls, some parameters during some periods may still contain unrealistic values.

3) Calibration of the devices and recording tools

Calibrations of the instruments were performed in various ways. The recording tools were calibrated several times within their lifetime, for example by applying constant voltage

[1] The hourly sums of precipitation from the Fuess paper chart analyses were determined as follows: precipitation sums smaller than 0.1 mm were assigned to one hour within the precipitation period, larger sums were evenly distributed over the length of the interval. If precipitation continued until the next day or even longer, the hourly sums were calculated over the whole period. Just to give an example: precipitation started on July, 1, 14^h and ended on July, 2, 8^h with a total amount of 5 mm. The hourly average then is 5 mm / 18 h = 0.28 mm/h.

sources in the appropriate range. As far as possible, sensors were calibrated individually, partly in the lab (Pt-100 thermometers), partly in the field (discharge, radiation, precipitation). In order to homogenize the series of one parameter recorded by different sensors, parallel data sets were compared, most important for air temperature and precipitation, which were sometimes recorded on three different devices.

4) Continuation after 1986

Although it was not intended from the start to study these data with respect to climate change and in spite of all the problems mentioned records of long duration for many parameters have been obtained for this high alpine site in the meanwhile. For discharge, continuous data series are available for all years since 1974, based on continuous records from May to October and on selected single measurements for the winter months (see Table 1 for the years 1974 to 1986). Precipitation, wind, air temperature and humidity also have long continuous records, whereas water temperature and the long-wave components of radiation are somewhat poorly represented even in summer. As a whole, however, these early data sets which are now submitted to the Pangaea data base prepared the ground for the continuation and enlargement of the recording program in the Vernagtferner basin for the decades to follow.

References

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Fig. 1: Meteorological site of the Vernagtbach station; from left to right: Fuess precipitation gauge with wind shield, radiation instruments, Belfort precipitation gauge, Gertsch tipping bucket, solar panel and hair hygrometer, Thiess anemometer, Wölfle anemometer, Stevenson screen with air temperature and BTW long-term thermo- and hygrograph inside. (Photo taken by Markus Weber, October 1984).

Fig.2: Hydrological part of the Vernagtbach station; from left to right: Stevenson screen and Wölfle anemometer (the same as in Fig.1), wind generator for power supply, gauging station Vernagtbach. (Photo taken by Hans Oerter, September 1979).

Year	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1974	0.025	0.019	0.019	0.020	0.056	0.284	1.049	2.037	0.973	0.100	0.040	0.035
1975	0.025	0.019	0.019	0.020	0.115	0.443	1.789	2.006	1.064	0.404	0.060	0.035
1976	0.025	0.019	0.019	0.020	0.129	0.917	2.514	0.743	0.321	0.148	0.050	0.035
1977	0.025	0.019	0.019	0.020	0.150	0.800	1.751	1.126	0.958	0.213	0.060	0.035
1978	0.025	0.019	0.019	0.020	0.028	0.504	0.999	1.633	0.663	0.190	0.050	0.035
1979	0.025	0.019	0.019	0.020	0.197	0.868	1.580	1.925	1.254	0.285	0.040	0.035
1980	0.025	0.019	0.019	0.020	0.063	0.382	0.643	2.679	1.198	0.283	0.055	0.035
1981	0.025	0.019	0.019	0.020	0.119	0.927	1.519	2.068	0.964	0.192	0.055	0.035
1982	0.025	0.019	0.019	0.020	0.156	1.099	3.068	2.550	2.054	0.187	0.055	0.035
1983	0.025	0.019	0.019	0.020	0.056	0.648	3.503	2.236	1.441	0.441	0.060	0.035
1984	0.025	0.019	0.019	0.020	0.064	0.357	1.455	1.638	0.743	0.118	0.050	0.035
1985	0.025	0.019	0.019	0.020	0.117	0.399	2.394	2.242	1.357	1.028	0.070	0.035
1986	0.025	0.019	0.019	0.020	0.374	1.102	1.909	3.202	1.233	1.231	0.075	0.035

Table 1: Monthly averages of discharge in m^3/s as recorded at the Vernagtbach station for the period 1974 to 1986