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CONTACT

-Research coordinator:
Guglielmina Adele Diolaiuti
University of Milano, Italy
"A. Desio" Department of Earth Sciences
via Mangiagalli, 34
20133 Milano
Italy
E-mail: guglielmina.diolaiuti@unimi.it
Telephone: +39 0250315510
Fax: +39 0250315494

-Collaborators:
Antonella Senese
University of Milano, Italy
"A. Desio" Department of Earth Sciences
E-mail: antonellasenese@yahoo.com

GianPietro Verza
EvK2CNR Committee, Bergamo, Italy
E-mail: gianpietro.verza@evk2cnr.org

PhD Michele Citterio
GEUS, Koppenhagen, Denmark

-Technicians:
EvK2CNR Roberta Toffolon
Committee, Bergamo, Italy
E-mail: roberta.toffolon@evk2cnr.org

Roberto Chillemi
Italian Alpine Club-Italy
E-mail: roberto.chillemi@tin.it

Meraldi Eraldo
Alpine Guide, Regione Lombardia, Italy
E-mail: eraldomeraldi@libero.it

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1. 0 DATASET OVERVIEW

1.1 Introduction

Forni is the largest Italian valley glacier (c. 12 km^2 of surface area in the Ortles-Cevedale group, Stelvio National Park, Lombardy Alps). The glacier presents a North aspect and an elevation range between 2600 and 3670 m a.s.l. The length of the glacier is 3.5 km, from the ridge (3200 - 3700 m a.s.l.), to the terminus (slightly above 2600 m a.s.l.). The width, measured along the three accumulation basins, is over 4.5 km. The Forni Glacier can be considered a debris free glacier: on the ablation tongue is not present a complete debris cover, even if two medial moraines (Smiraglia, 1989) develop from the central sector up to the terminus.
Forni Glacier is included in the official "Geosites Inventory" of the Sondrio Province, Lombardy Region (Italy) and it is located in an area identified as SCI (Site of Community Importance) according to the 92/43/CEE
Moreover Forni Glacier is inserted in the list of the glaciers monitored by the Italian Glaciological Committee (CGI) to evaluate its recent volume, area and length changes. From the CGI's data base it results Forni Glacier to have experienced a strong area and length decrease: it passed from 17.80 km^2 at the end of the Little Ice Age LIA (~1860) to 11.62 km^2 in 2003 (–34.7%), in the same time frame its tongue retreated of about 2 km.
The Automatic Weather Station (AWS) here located (named AWS1 Forni) has been set up on the ablation tongue at the base of the Eastern icefall. It is the first permanent AWS on the melting surface of an Italian glacier. In fact, on Italian Alpine glaciers, in spite of the long tradition in field surveying (i.e.: length variation and mass balance data started to be collected respectively in 1895 and in 1967) (Smiraglia, 2003), meteorological data and solar fluxes measured on glacier melting surface were not available until the 26th of September 2005 when the AWS1 Forni was installed (Citterio et al., 2007; Diolaiuti et al., 2009; Smiraglia & Diolaiuti, 2008; Senese et al., in press). All other past Italian AWSs in glacial environments, in fact, were located on rock exposures or buildings such as mountain huts thus making their data representative of high mountain atmospheric conditions but not usable for knowing and understanding the supraglacial micrometeorology.
The choice of Forni Glacier for installing the first Italian AWS on glacier ablation area was also due to the possibility of comparison between Forni and Morteratsch glaciers. The latter, in fact, is a Swiss glacier where was installed (by the IMAU of Utrecht, NL) a permanent AWS which permitted to obtain the best meteo data set (Oerlemans, 2001) for describing glacier micrometeorology due to the possibility to visit regularly it and the favourable atmospheric conditions (little icing). Then the Morteratschgletscher AWS was used as a valuable example for the installation of the first permanent AWS on the ablation area of a glacier on the Italian Alps and the suggestions and recommendations of IMAU's researchers were of fundamental importance. Forni and Morteratsch glaciers have similar glacier type, geometry, size and aspect thus making possible data comparisons.
The AWS1 Forni location is a good compromise between the needs for minimizing local topography effects and lowering the probability of avalanches destroying the AWS. The station is located on the lower glacier sector, about 800 m far from the glacier terminus. The surrounding mountains are typically 3000-3500 m high. The highest mountains (Mount S. Matteo, 3678 m a.s.l. and Palon de La Mare, 3703 m a.s.l.) are to the South, to the East and to the West providing efficient shading.
The equipment for setting up the AWS has been transported by helicopter to the selected location on September 26th, 2005. In the following years the AWS was checked for proper operation several times, particularly during the first year, without any problem being

observed (Citterio, 2007). From summer 2009 the AWS is connected with the UNIMI and EvK2CNR Labs by a radio link and a GSM modem which permitted daily data downloading and instrument checking.

1.2 Time period covered by the data

Start: January 1, 2008, 00:00
End: December 31, 2008, 23:00

1.3 Temporal characteristics of the data

All parameters are recoded hourly.

1.4 Physical location of the measurement (WGS84 coordinates)

Latitude: 46° 23' 56.0" N (46.399° N)
Longitude: 10° 35' 25.2" E (10.590°E)
Elevation: 2669 m (ellipsoidal elevation)

1.5 Data source

Original data provided by the University of Milano, Italy "A. Desio" Department of Earth Sciences.

1.6 WWW address references

http://users.unimi.it/glaciol

2.0 INSTRUMENTATION DESCRIPTION

2.1 Platform

The whole system is supported by a four-leg, 5 m high stainless steel mast standing on the ice surface according to the construction proposed and tested by IMAU (Oerlemans, 2001). The AWS stands freely on the ice, and sinks with the melting surface.

2.2 Description of the instrumentation

Parameter	Model	Manifacturer
Air Temperature	DMA570	Lsi-Lastem (Italy)
Liquid Precipitation	DQA035	Lsi-Lastem (Italy)
Relative Humidity	DMA570	Lsi-Lastem (Italy)
Atmospheric Pressure	DQA223	Lsi-Lastem (Italy)
Wind Speed	DNA022	Lsi-Lastem (Italy)
Wind Direction	DNA022	Lsi-Lastem (Italy)
Downward Shortwave Radiation	CNR-1	Kipp&Zonen (The Netherlands)
Upward Shortwave Radiation	CNR-1	Kipp&Zonen (The Netherlands)
Downward Longwave Radiation	CNR-1	Kipp&Zonen (The Netherlands)
Upward Longwave Radiation	CNR-1	Kipp&Zonen (The Netherlands)
Snow Depth	SR-50	Campbell

2.3 Instrumentation specification

Parameter	Sensor Type	Height of sensor (m)	Accuracy	Resolution
Air Temperature	Thermoresistance	2.6	±0.001°C	0.025°C
Liquid Precipitation	Rain gauge	2.5	±1 mm	0.2 mm
Relative Humidity	Capacitive Plate	2.6	±1%	0.2%
Atmospheric Pressure	Slice of Silica	1.5	±10 hPa	0.1 hPa
Wind Speed	3-cup anemometer	5	±1%	0.05 m/s
Wind Direction	Potentiometer	5	±1°	0.1°
Downward Shortwave Radiation	Thermopile	3.17	±5% of the value	-
Upward Shortwave Radiation	Thermopile	3.17	±5% of the value	-
Downward Longwave Radiation	Thermopile	3.17	±5% of the value	-
Upward Longwave Radiation	Thermopile	3.17	±5% of the value	-
Snow Depth	Ultrasonic	3.17	±2 cm	0.1 cm

3.0 DATA COLLECTION AND PROCESSING

3.1 Description of data collection

With a daily frequency data are downloaded from the AWS through a radio link and a GSM modem. Moreover periodically the flash memory card is changed and all the instrument memory downloaded.

3.2 Description of derived parameters and processing techniques used

Data points, sampled at 60 seconds and averaged over a 30 minutes time period for most of the sensors, are recorded in the flash memory card together with basic distribution parameters (maximum, minimum and standard deviation values). Wind velocity is sampled every 5 seconds and 60 minutes of observations are processed by the datalogger producing a comprehensive set of information including minimum, maximum and average speed, dominant wind direction and azimuth sectors statistics, which are stored in the flash memory. Conversion of the observed analogical and digital signals into the corresponding physical values by applying programmed calibration factors or tables is carried out inside the datalogger prior to storage in memory. Basic validation checks such as out-of-range values and cables connection faults are also performed in the datalogger, returning an error code in the saved record. On the other hand, most calculations involving data from more than one sensor, such as sound speed corrections for air temperature in snow level measurement or radiometer instrument temperature for infrared radiation have carried out later on a PC using spreadsheet software. Snow accumulation on the sky-facing radiometers can be detected from the recorded data, which needs to be checked carefully for such occurrences.

The four parameters indicated below were computed by using “CEOP Derived Parameter Equations” available at: http://www.joss.ucar.edu/ghp/ceopdm/refdata_report/eqns.html. These data have the flag “I”. In the case of calculated by using dubious value flagged “D”, the data flag was put D”.

Dew Point Temperature was computed by using (Bolton 1980):

es = 6.112 * exp((17.67 * T)/(T + 243.5));
e = es * (RH/100.0);
Td = log(e/6.112)*243.5/(17.67-log(e/6.112));
where:
T = temperature in deg C;
es = saturation vapor pressure in mb;
e = vapor pressure in mb;
RH = Relative Humidity in percent;
Td = dew point in deg C

Specific Humidity was computed by using (Bolton 1980):

e = 6.112*exp((17.67*Td)/(Td + 243.5));
q = (0.622 * e)/(p - (0.378 * e));
where:
e = vapor pressure in mb;
Td = dew point in deg C;
p = surface pressure in mb;
q = specific humidity in kg/kg.

U,V Components were computed by using (GEMPAK):

U = -sin(direction) * wind_speed;
V = -cos(direction) * wind_speed;

Net radiation was computed by using (GEMPAK):

NET_radiation = down(in)short + down(in)long - up(out)short - up(out)long

4.0 QUALITY CONTROL PROCEDURES

For all parameters, the data has been visually checked, looking for extremely and unusual low/high values and/or periods with constant values. Nocturnal shortwave radiation data has been checked for non-zero values; wind speed and direction for sensor freezing; precipitation data has been checked for delayed measurement due to the melting of solid precipitation. Snow depth values have been checked to delete hourly/daily fluctuations of the measured snow (in absence of real snow fall) due to the dependence of the sensor signal on air density; in fact, though the sensor is temperature compensated, more or less regular fluctuations (no greater than ± 1-2 cm) are still recognisable.
Cross-checking among the variation of different measured parameters (ground heat flux, snow cover, etc.) was also performed to assure the consistency among the variations of different variables under the same conditions. The consistency of downward and upward shortwave radiation was also verified calculating the albedo (at high sun elevations).
The quality control flags follow the CEOP data flag definition document.

5.0 GAP FILLING PROCEDURES

No gap filling procedure was applied.

6.0 DATA REMARKS

6.1 PI's assessment of the data

Very good.

6.1.1 Instruments problems

None.

6.1.2 Quality issues

Due to sensor freezing, in some cases wind speed and direction were recorded as 0 and 360, respectively, and, thus, considered bad. Due to slow melting of solid precipitation in the not-heated rain gauge, precipitation is sometimes recorded with delay. These values were considered dubious. There is a general tendency of the sensor to over-estimate relative humidity and to reach saturation conditions. Dew deposition could be observed on the radiation sensor. Snow depth measured values have fluctuations related to air density variations.

6.2 Missing data periods

All data: from 5th October 2008 11:00 to 11th October 2008 12:00.
Moreover:
Wind Speed: 1st January 2008 00:00.
U Wind Component: 1st January 2008 00:00.
V Wind Component: 1st January 2008 00:00.

7.0 REFERENCE REQUIREMENTS

The AWS 1 Forni was installed by the University of Milano in close cooperation with the EVK2CNR Committee and it is actually managed by both these institutions. The AWS is part of the SHARE/ SHARE Italy monitoring network (managed by the Ev-K2CNR Committee).

8.0 REFERENCES

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