ITALY

WMO SPICE
SITE COMMISSIONING PROTOCOL

FORNI GLACIER
(ITALIAN ALPS)

Site Manager: Guglielmina Diolaiuti guglielmina.diolaiuti@unimi.it
Assistant Intern: Antonella Senese antonella.senese@unimi.it
Department of Earth Sciences "A. Desio"
Università degli Studi di Milano
via Mangiagalli 34 - 20133 Milano (Italy)

TABLE OF CONTENTS

1. ORGANIZATION OF THE DOCUMENT

The Commissioning Protocol is organized into four parts:

1. **The site components,** data transfer and sharing pathways, and project organizational structure are outlined in Section 3;
2. **The site commissioning procedures**, including pre-commissioning activities and the Interaction with the Instrument Providers, Sections 4 to 6;
3. **SPICE Data Archive,** Section 7**.**
4. **Appendix A: the template for the Proof of Performance (POP) Report**, in which all site configuration details and commissioning activities are documented.

Appendix B outlines the SPICE Data Levels and Data Sets, and Appendix C includes a list of acronyms used throughout the document.

The first two sections are intended to provide background information on the commissioning process within the scope of the SPICE project, while the Appendix A contains the forms which are required to be filled out as part of the commissioning of the site. Once completed, these forms become the Commissioning Report.

The SPICE data archive section outlines the requirements regarding the SPICE data levels and datasets and the planned strategy for the archival of SPICE data to a central location(s).

2. PURPOSE AND SCOPE

This document is prepared by the WMO SPICE IOC. It outlines the procedures for post-installation testing and commissioning of the sites participating in the WMO SPICE experiment and documents the responsibilities for each aspect of the commissioning process.

Commissioning of a WMO SPICE site refers to the act of “turning it on” and marking the start of the collection of the “official” observations and measurements from the instruments included in the intercomparison (reference, instruments under test, ancillary measurements), and their archival on the designated Site Data Archive.
For this purpose, each site will designate a location for the Site Data Archive, which must protect the integrity of the intercomparison data.

End-to-end data quality and integrity for each instrument on each SPICE site will be verified before the commissioning can take place. It is essential that:

- Only agreed upon instruments are to be installed, in an accepted and standardized configuration;
- Each component be properly tested, and its performance verified, prior to commissioning;
- The transfer of instrument data to the Site Data Archive is validated and the archive secured.

Various individuals and organizations are referred to in this document as having responsibilities.

- SPICE IOC
- SPICE Project Team
- SPICE Data Analysis Team
- Site Manager
- Site (SPICE) Project Team
- ER refers to the Evaluation Representative, an individual named by the SPICE IOC
- IR, the Installation Representative, is identified by the Site Manager, responsible for the site configuration.
- Instrument Providers

3. CONFIGURATIONS AND ASSOCIATED COMMISSIONING REQUIREMENTS

3.1 SPICE SITE COMPONENTS

The SPICE Components include the following components:

- Field working reference systems (R4):
  - Snow on the ground data from **manual snow pits** (performed according to the AINEVA protocol since winter 2006, see www.AINEVA.it).
    Data output frequency to be transfer to NCAR: 1 pit per month
  - Snow data on the ground from **4 graduated stakes** (installed on 6th May 2014) at the corners of the automated snow depth sensor (a snow pillow). Graduated stakes feature cm graduations and each stake is placed 40 cm far from the snow pillow corner.
    Data output frequency to be transfer to NCAR: 1 measurement per month
  - Snow on the ground data from **hourly camera observations of the graduated stakes** (the four stakes installed on 6th May 2014 and which were above descripted) at a distance of 5.40 m.
    Data output frequency to be transfer to NCAR: 1 picture every hour
  - Snow on the ground data from **Enel-Valtecne snow weighing tube** (see http://www.valtecne.com/en/products/the-new-enel-valtecne-snow-weighing-tube/).
    Data output frequency to be transfer to NCAR: 1 snow weighing per month

- Ancillary measurements (active since autumn 2005 and recorded by an automatic weather station called **AWS1 Forni**, see http://www.evk2cnr.org/cms/en/share/monitoring-stations) :
  - Precipitation occurrence/type
  - Station pressure
  - Air Temperature
  - Relative humidity
  - Wind speed/direction at 5 m height;
  - Net radiation (SW and LW fluxes)
  - Icing occurrence
- Instruments under test provided by the host (sonic ranger and snow pillow, see the description below): for the SPICE experiment at the Forni Glacier site we will install another monitoring station called **AWS Forni SPICE** acquiring and comparing:
  - Snow on the ground data from a **Campbell sonic ranger SR-50** (which has been running at this site since Autumn 2005)
    Data output frequency to be transfer to NCAR: 1 value every hour
  - Snow on the ground data from a **Sommer sonic ranger USH-8** (installed on 6th May 2014)
    Data output frequency to be transfer to NCAR: 1 value every 10 minutes
  - Snow on the ground data from a **Park Mechanical snow pillow SS-6048** with a STS pressure transmitter ATM.1ST (installed on 6th May 2014)
    Data output frequency to be transfer to NCAR: 1 value every 10 minutes

The sample interval we applied is 10'. We applied such interval since it seems adequate to the SPICE instruments we installed (a snow pillow and a sonic ranger) and it also guarantees that in case the tele-transmission of the acquired data should be interrupted for a few period (please consider that our SPICE site is a glacier which in winter time is reachable only by skins and skis or by helicopter, see Figs. 1 and 2) the data logger memory could store all data without losses. The data loggers are a Babuc ABC LSI-Lastem, a Campbell Scientific CR1000 and a Campbell Scientific CR200 with Ethernet Campbell Scientific NL120 interface.
All the other weather parameters recorded by the permanent supraglacial AWS1 Forni during SPICE experiment will be acquired according to the AWS sampling frequency (mean, max, min and dev st values every hour).

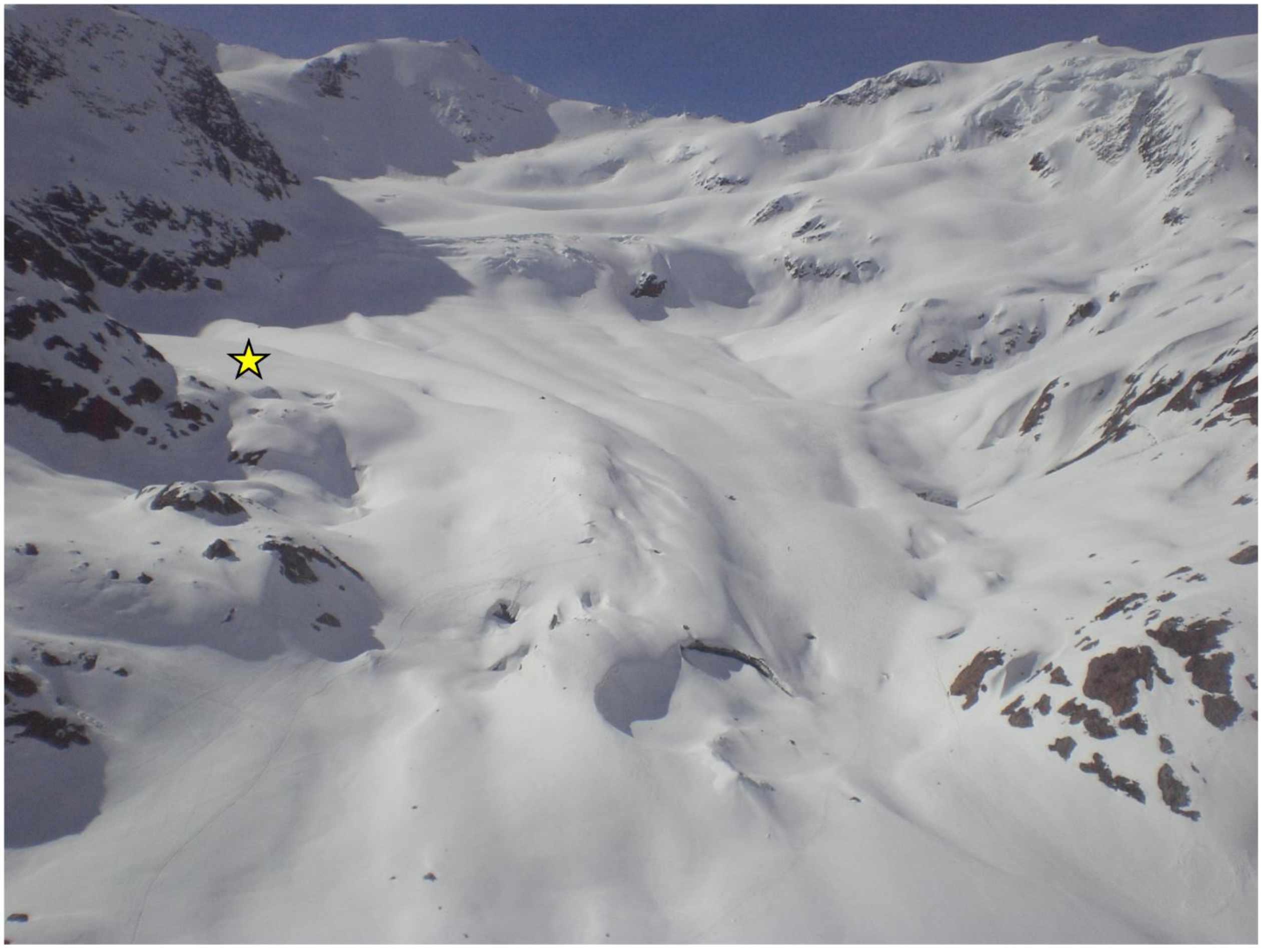

FIGURE 1: The Forni Glacier and the SPICE site (yellow star). The picture was taken from the helicopter on 6th May 2014.

FIGURE 2: The Forni Glacier and the SPICE site (yellow star). The picture was taken from the helicopter in summer.

3.2 COMMUNICATION INTERFACES

The AWS Forni SPICE data downloading will be carried out 4 times per day (at 6:00 am, 11:00 am, 3:00 pm and10:00 pm) by a Hughes 9502 satellite link (BGAN Inmarsat), with FTP protocol, only if the battery voltage is higher than 12.2 V. To allow a daily remote-control this satellite device will be switch on twice for 20 minutes (from 11:00 am to 11:20 am and from 3:00 pm to 3:20 pm). The IP address for the remote connection is 85.90.236.18:6785.

Regarding the AWS1 Forni, from summer 2009 it is online through a radio link and a GSM modem. More precisely a first radio has been installed at the AWS site and another one was installed on a hut located in the ski resort named Plaghera, easily accessible both in winter and in summer by car, and where we have installed also a GSM modem. Both the radio devices have amplified their signal by directive antennas. The communication system at the AWS site is supported by a dedicated solar panel and a gel battery 30 Ah. Instead, at the Plaghera hut radio and modem are supplied by a permanent 220 V system. The radio devices we use are synthesized radio modem devices, compatible with personal computer, working in UHF band (380 - 470 MHz) in half-duplex manner; the transfer speed ranges from 300 to 38.400 bit/sec and the modulation in air is equal to 19.200 bps (25 kHz channel) or 9.600 bps. The number of covered channels corresponds to a total band of 2 MHz at ±1 MHz from the chosen frequency. Then the connection is possible every hour per day for 10 minutes. In fact, to allow a remote-control and a remote-download, the AWS is scheduled to switch on the radio every hour for 10 minutes. During this time frame is possible to call the GSM modem and then the AWS.

For the SPICE Experiment we will take advantage from this already running communication system thus having the possibility of a daily quality check of the installed instruments and of a daily data downloading.

After the download process the snow data are subjected to a quality check and a validation procedure, and are firstly stored in the SHARE data base and then periodically (every month) sent to the SPICE account.

3.3 SPICE Site Project Team

PhD Guglielmina Diolaiuti is the site manager. She's assistant professor of Climatology and Glaciology at the University of Milan (UNIMI from here, Italy) and she's responsible of the SHARE supraglacial network of AWSs in the Italian Alps. In fact the chosen SPICE SITE, Forni Glacier, has been studied for describing its micro meteorology and energy budget by acquiring data through an Automatic Weather Station. This latter is part of a wider network developed by UNIMI and managed by UNIMI together with the EvK2CNR Association (EvK2CNR from here, Bergamo, Italy). The Italian AWS network (up to now 3 supraglacial AWSs) is part of the SHARE project (Stations at High Altitude for Research on the Environment) developed and managed by EvK2CNR.

The SPICE Site Project Team also include other scientists from UNIMI, from Politecnico di Milano (POLIMI from here) and from EvK2CNR, more precisely:

From UNIMI:

Prof. Maurizio Maugeri and PhD Antonella Senese, associate professor of Climatology and post doc scientist respectively, who take care AWS data processing, quality check and validation according to the SHARE protocol.

From POLIMI:

PhD Daniele Bocchiola, assistant professor of Mountain Hydrology, who's responsible of the hydrological monitoring network in the Forni valley (under the umbrella of a project named Hydrostelvio) and then who's performing since long time accurate snow measurements in this area also modelling snow distribution and seasonal evolution.

From EvK2CNR:

PhD Elisa Vuillermoz, responsible of the SHARE Project. She's managing this international monitoring program, she is responsible of data sharing and of the insertion of the monitoring stations also in other programs (e.g.: CEOP GEWEX among the others).

Gianpietro Verza, technician, responsible of the periodic quality check and maintenance activities of the supraglacial AWS network. He is also responsible of data transmission and of periodic data downloading from EvK2CNR Headquarter.

Mauro Reguzzoni, technician from the Italian company HORTUS srl, who provides instruments and supports EvK2CNR and UNIMI researchers in performing the SPICE experiment at the Forni Glacier.

In the SPICE Experiment the roles of the above listed people will be the following:

- Guglielmina Diolaiuti: site manager
- Maurizio Maugeri and Antonella Senese: quality check, validation and analysis of all meteorological and energy data acquired by the supraglacial AWS, site micro meteorological characterization and description
- Daniele Bocchiola: snow data analysis and evaluation of Snow Water Equivalent
- Gianpietro Verza and Mauro Reguzzoni: technical assistance on the field and in the lab for instrument installation and data downloading

4. PRE-COMMISSIONING ACTIVITIES

The pre-commissioning activities are an integral part of the process of ensuring the quality of the experiment. The following sections detail the pre-commissioning activities ensuring that site infrastructure and procedures are properly managed and documented.

4.1 STATION INSTALLATION AND SCHEDULING

Site drawings, instrument siting and installation according to national standards, IOC agreed guidelines, or manufacturer recommendations, and exceptions are documented as part of the POP Report.
The AWS1 Forni is already installed and has been running since Autumn 2005.
Snow data have been acquired by a Campbell sonic ranger SR50 and through periodic snow pits since winter 2006. Then the SPICE installation is limited to the snow pillow, a Sommer sonic ranger USH-8, an automated camera and 4 graduated stakes and was carried out on 6th May 2014.

The main constrictions in organizing the installation of the new instruments were due to the fact that the site is located on the surface of an Alpine glacier (not simple to be reached during wintertime, see Fig. 1) considered as a Site of Community Importance (SCI, code IT2040014) and inside a wide natural protected area (the Stelvio National Park) thus also requiring a deep analysis of the possible expected impacts of instruments and devices before their installation. Moreover the energy supply is represented only by solar panels and leadgel battery. Finally, the glacier is a dynamic body and the ice surface is not smooth.

4.2 TESTING OF INSTRUMENTS INCLUDED IN THE INTERCOMPARISON

The testing of instruments is conducted by the SPICE Site Project Team. Based on the results, the Site Manager will determine the readiness of instruments and the site for the formal phase of the experiment.

4.2.1 SITE DOCUMENTATION

Technical documentation for each SPICE component will include, but not limited to, the site layout, instruments details and configuration, data collection (including the data format), number of similar instruments, installation details, maintenance standards.
Specific information on the Site Documentation is provided in Appendix A.

4.2.2 *Monitoring of Performance*

The Site Manager and the site team established a simple procedure for monitoring the performance of the instruments:
- every day is scheduled a data quality check after the daily downloading.
In the case the downloading should be impossible (tele-connection failure) it will be done other three attempts (the following three days) in the case the problem will not be solved a mission on the field will be performed on the 4th day to re-allow tele-connection and data downloading.
In the case data quality checking should reveal errors or problems with data as soon as possible (by three days from the discovery of such problems) a mission on the field will be planned to verify the instruments and their activity.
A report of each missions and remedial actions will be produced and stored in the SPICE data base.

4.2.3 *Site Maintenance*

The SPICE Site Manager ensures that site maintenance is available to limit the periods or data outage.

5. COMMISSIONING ACTIVITIES

The SPICE POP Report documents the status of the site operation at the start of the intercomparison.

5.1 Determination of Site Readiness

This sub-section details the activities to be conducted following the installation of instruments, and which are completed prior to the official start of the SPICE experiment on the site.

5.1.1 *Site Readiness Evaluation*

The Site Manager will initiate the evaluation of the SPICE Site and will provide to the IOC adequate notice of the SPICE site commissioning.

The IOC will name a representative (the ER) to conduct the evaluation of the Site Documentation prepared by the Site Manager. The ER will work with the Site Manager on the evaluation of the POP Report.

The site readiness evaluation should be sufficient to ensure proper operation of all instruments and interfaces. The assessments will include:

- Satisfactory performance of the field reference system(s).
- Satisfactory performance of each instrument under test.

- Satisfactory performance of instruments providing ancillary measurements.
- Satisfactory performance of site communication components and interfaces.
- Satisfactory performance of the data transmission to the Site Data Archive;
- Proper functioning of service backup capabilities for that particular site, if available.
- Maintenance capacity.

5.1.2 *Completion of POP Report*

The SPICE Site POP Report documents the readiness of the site and is approved by the IOC.

The POP Report includes:

- A form for recording station information and configuration, including the site layout;
- A form for documenting the configuration of SPICE field working reference configurations, including both manual and automatic measurements;
- Forms for recording the specifications of instruments under test and instruments used to provide ancillary measurements ;
- Details of tests conducted for instrument data validation;
- Details of tests conducted for end-to-end data validation;
- A checklist for all additional documentation to be recorded and submitted ;
- A table for recording commissioning milestones.

The Site Manager will provide the POP Report to the IOC, for final review.

5.1.3 *Invoking Workarounds*

A workaround is a temporary solution to a system limitation that requires special attention and will be removed eventually. Any workarounds will be documented and included as part of the POP Report. Each work-around will be tracked as an open item until resolved.

5.2 Approval of Site Commissioning

The Site Manager will notify and update the IOC on the organization and completion of the tests outlined in Appendix A. Once all tests results are verified, the IOC and the Site Manager will agree on the start date of the formal experiment on the site.

In case some of the instruments under test are not ready for the start of the experiment as planned (currently Nov. 15, 2012), the experiment could commence in steps, provided that all field references and key ancillary parameters (wind speed and direction, temperature) have been commissioned.

Commissioning of additional instruments would follow as their configurations are finalized; this will allow for their inclusion in the experiment as early as feasible, with no compromise to the data quality. The Data Analysis Team will take into consideration the commissioning data for each instrument.

5.3 Implementation of Approved SPICE Site Commissioning

Upon commissioning, the site will commence the official collection of the SPICE project dataset and ancillary measurements/observations.

6. Interaction with the Instrument Providers

Instrument Providers are responsible for the delivery of their instruments to the SPICE Sites and for supporting the Site Managers in verifying their proper functioning before and during SPICE.

6.1 Pre-Commissioning Activities: Engagement of the Instrument Providers

During the installation, the Site Manager or a representative will engage the Instrument Provider regarding the preparation of their instruments, to ensure the operation within recommended standards.

The Site Manager would confirm with the Instrument Provider the functioning of the instrument prior to the commissioning of the site. This could be done by the sharing of instrument and/or ancillary data and pictures, coordinated site visits, or any other method agreed upon by the two parties.

The Site Manager should be able to indicate in the Commissioning Report the confirmation from the Instrument Provider that the instrument operates as expected.

6.2 Engagement of Instrument Providers during the Experiment

During the experiment, each Instrument Provider will be given access to the unprocessed output from its own instrument(s), and a minimum set of corresponding ancillary data consisting of air temperature, relative humidity, and wind speed. These data are provided only for ensuring the proper functioning of the instruments, and will neither be reported nor published prior to publication of the SPICE Final Report.

The Site Manager will coordinate the data transfer to the Instrument Provider(s), including such aspects as the frequency, methodology, etc. It is desired that this data transfer is in place prior to the start of the experiment. The Instrument Provider is expected to alert the Site Manager in the event that a malfunction of an instrument is noted, and provide support to the Site Project team (including site visits), if needed, to address the failure.

The Instrument Providers could visit the intercomparison sites, after prior arrangements are made with the Site Manager.

7. SPICE Data Archival

The SPICE Project Team will establish and maintain a SPICE Archive on at least one SPICE designated Server where the Site Intercomparison Datasets and the Input Documentation will be stored. This will facilitate the preparation of data for the individual and comparative data analysis and the preparation of the Final Report. A description of the data levels and datasets for SPICE, as currently defined, is provided in Appendix B.

The National Centre for Atmospheric Research (NCAR), USA, will host the SPICE Archive and provide quick view capabilities of (near) real time data. Options for a second SPICE Archive are being explored by Environment Canada, Canada.

Each Site Manager will work towards preparing the transfer of Level 1 and Level 2a datasets to the SPICE Archive(s). The IOC will provide to the Site Managers the requirements regarding the data transfer to enable the preparation of datasets (format change, setup of data uploads/availability, etc…)

The data transfer between the Site Data Archive and the SPICE Archive is expected to be established and validated within 3 months of the official start of the experiment, and implemented based on site specific conditions and limitations.

APPENDIX A: PROOF OF PERFORMANCE (POP) FORMS

SECTION A1: STATION INFORMATION

Station name	AWS1 Forni and AWS Forni SPICE
Reference town	Forni Glacier (Sondrio, Italy)
Station latitude	46°23'56"N
Station longitude	10°35'25"E
Station elevation in meters	2631 m a.s.l.

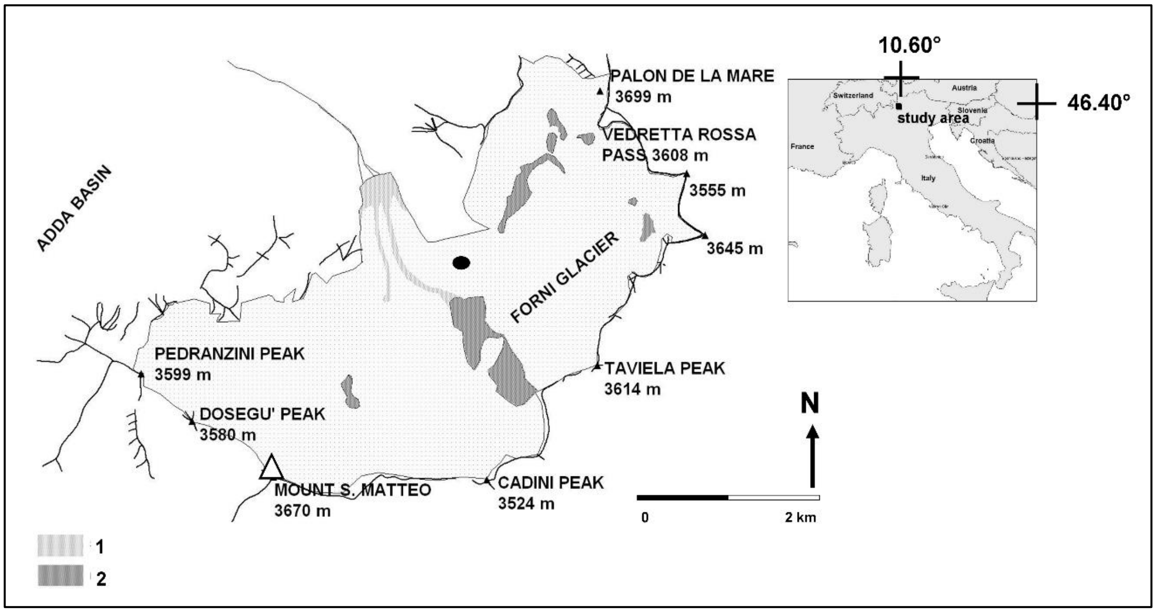

FIGURE 3: Location (black dot) of the AWS1 Forni and the AWS Forni SPICE. The light grey areas are used to mark supraglacial debris coverage, the dark grey areas are used to indicate rock exposures and nunataks.

FIGURE 4: Forni Glacier and the two AWSs, AWS1 Forni and AWS Forni SPICE (black dot). The picture was taken from the summit of Monte San Matteo (3670 m) (see Fig. 3).

The AWS1 Forni was installed on 26th September 2005 on the lower sector of the Forni Glacier, at 800 m from the glacier terminus (Figs. from 1 to 4). In the following years the AWS was checked several times, particularly during the first year, without any problem being observed (Citterio et al., 2007). The **AWS1 Forni** is equipped with sensors (Figs. from 5 to 8) for measuring air temperature and humidity (naturally ventilated sensor), wind speed and direction, air pressure, and the four components of the radiation budget (longwave in and out, solar in and out). A 1000 cm^2 unheated rain gauge and two sonic rangers (Campbell SR-50 and Sommer USH-8) are also set up to measure, respectively, rain and snow depth.
The second station (named **AWS Forni SPICE**, Fig. 9) was installed on 6th May 2014 close to the AWS1 Forni (at a distance of 17 m, see Fig. 10). The AWS Forni SPICE is equipped with sensors for measuring the snow on the ground (snow pillow) and the air pressure. This latter will permit to calibrate the output values recorded by the snow pillow. On the mast, an automated camera was installed to photograph the graduated stakes located at the 4 corners of the snow pillow.
As regards the **AWS1 Forni**, two data loggers are installed: a LSI-Lastem Babuc ABC and a Campbell Scientific CR200. This latter allows the correct working of the Young wind sensor and the Sommer sonic ranger. All the other sensors are connected to the LSI-Lastem Babuc ABC. A Campbell Scientific CR1000 was installed at the **AWS Forni SPICE**.
The whole systems of both AWS1 Forni and AWS Forni SPICE are supported by a four-leg, 5 m and 6 m high stainless steel mast (for AWS1 Forni and AWS Forni SPICE, respectively) standing on the ice surface

according to the construction and setting proposed and tested by the Institute for Marine and Atmospheric Research Utrecht (IMAU) (Oerlemans, 2001). In this way the AWSs stand freely on the ice, and adjust to the melting surface during summer. Regarding the **AWS Forni SPICE**, at the installation time the structure was placed at the snow surface and not directly at the ice surface, then after snow ablation (snow cover resulted completely melt by the end of July 2014) the station was at the ice surface as well. In fact at the moment of the installation (on 6th of May 2014) a snow cover 2 m thick was present at the glacier surface thus avoiding the mast installation directly at the ice surface.

Supraglacial morphologies (e.g. bedières or crevasses) may develop at the location where the AWSs are set, and this can compromise their stability. In this case, the AWSs need to be moved to a more stable surface. Moreover, the AWSs' location is a good compromise between the need to minimize local topographical effects (almost flat surface and absence of huge crevasses) and to decrease the probability of snow avalanches during winter in the AWSs' vicinity.

The height where instruments (Fig. 7) are placed was chosen in order to permit their activity also during wintertime when snow covers the glacier surface and partially buries the AWS mast. The both sonic ranger sensors (Campbel and Sommer ones) were installed on the AWS1 Forni mast, measuring only the snow accumulation and ablation but not ice ablation as well. An important feature of the thermo-hygrometer is the radiation shield with natural ventilation, thus permitting an air flow around the sensor, limiting the error due to radiation overheating. Due to the naturally ventilated sensor our air temperature measurements could be overestimated (up to a few degrees) during high radiation/low wind speed conditions; on the other hand, such conditions seem to be dominating only during limited periods (early spring). The albedo values during snowfall events are overestimated due to snow presence on the upfacing pyranometer. To solve this problem, the values affected by the overestimations were filtered and labelled in the records of data we produce for SHARE data base. No problems of rime ice accumulation on instruments of AWS1 Forni were observed during the 4 years of data collection from 2005 to 2009 (Senese et al., 2012), based on the analysis of wind speed and direction data (which are consistent over the entire period).

Analyzing **wind direction** data (Fig. 11), it appears that the wind blows steadily from SE, hence down the glacier, that is along the glacier fall line. Even if no measurements at different elevations above the surface are available, the direction data show a similar behaviour than the one found by Smeets & alii (1998) on other glaciers where katabatic-type flows are described. In fact this situation characterizes several melting glacier surfaces during a large part of the summer and high latitude areas in wintertime, like Antarctica, where the boundary layer does not show a clear daily cycle. In this period of the year, temperature and vapor pressure at the surface have no a marked daily cycle. Moreover the katabatic-type flows are described as boundary layer flows, in which surface friction and the turbulent sensible heat flux are important components of momentum and the heat budget (Oerlemans, 2005). The cooling of air over a melting and sloping glacier surface generates a downward katabatic-type flow (Oerlemans, 2010). Therefore the forcing of a glacier boundary layer from below is fairly constant and variations in its structure will be related to what happens higher up (Hoinkes, 1954). Katabatic term, in fact, refers to winds that flow down the topographic gradient or out of a valley due to surface cooling that gives this air a greater density than the free atmospheric air. This cooling of slope surfaces, which is due primarily to a net negative surface radiative balance, produces a temperature difference between the air adjacent to the slope and the ambient air away from the slope. Winds then accelerate from the slope toward the ambient

air, where gravity forces the dense flow to follow the sloping surface. In wind direction vs wind speed (Fig. 12a), the more frequent wind directions (cluster around a provenance from ca. 120°) occur with a speed of a few meters per second; these features of direction and speed are characteristics of the katabatic regime (Oerlemans, 2010). However wind directions of ca. 70° and ca. 170° also take place frequently. The faster winds reach speeds of about 20 m s^{-1} with a direction of 40°-80° and 250°-290°, always during wintertime. The wind speed shows a daily cycle more clear than the direction values. The annual mean speed results 4.9 m s^{-1} averaged from 2006 to 2010 (Table 1). Analyzing wind speed and air temperature hourly data (Fig. 12b), a positive trend between air temperature and wind speed is found and the increase is clearly nonlinear. In fact, higher wind speeds become more frequent for higher temperatures when air temperature is above melting point. Considering the speeds higher than 5 m s^{-1}, the 46% occurs with positive temperatures, increasing the speed threshold to 10 m s^{-1} the percentage decreases until the 25%.
Regarding the **AWS1 Forni** the power is supplied by two solar panels (40 Watt) and a leadgel battery; the battery voltage over time is recorded by the data-logger. The battery-only power supply in the present configuration is estimated in excess of 2 months, with the solar panels permanently obscured by snow accumulation and accounting for low temperature operation and self-discharge. Data points, sampled at 60-second intervals and averaged over a 30-minute time period for most of the sensors, are recorded in the flash memory card, including the basic distribution parameters (minimum, mean, maximum, and standard deviation values). Wind data are sampled every 5 seconds, and then processed to obtain an hourly data set of information, including minimum, maximum and average speed, and dominant wind direction. From summer 2009, the AWS is online through a radio link and a GSM modem. More precisely a first radio has been installed at the AWS site and another one was installed on a hut located in the ski resort named Plaghera, easily accessible by car, and where we have installed also a GSM modem. Both the radio have amplified their signal by directive antennas. The communication system at the AWS site is supported by a dedicated solar panel and a gel battery 30 Ah. Instead, at the Plaghera hut radio and modem are supplied by a permanent 220 V system. The radio devices we use are synthesized radio modem devices, compatible with personal computer, working in UHF band (380 - 470 MHz) in half-duplex manner; the transfer speed ranges from 300 to 38.400 bit/sec and the modulation in air is equal to 19.200 bps (25 kHz channel) or 9.600 bps. The number of covered channels corresponds to a total band of 2 MHz at ±1 MHz from the chosen frequency. Then the connection is possible every hour per day for 10 minutes. In fact, to allow a remote-control and a remote-download, the AWS is scheduled to switch on the radio every hour for 10 minutes. During this time frame is possible to call the GSM modem and then the AWS.
Moreover, regarding the **AWS Forni SPICE** the power is supplied by a solar panel (60 Watt) and a leadgel battery (40 Ah); the battery voltage over time is recorded by the data-logger. Data points, sampled at 5-minute intervals, are averaged over a 10-minute time period. The AWS is online through a Hughes 9502 satellite link (BGAN Inmarsat) and a modem Edge Sierra Wireless Xtend. The connection is possible twice per day for 20 minutes (from 11:00 am to 11:20 am and from 3:00 pm to 3:20 pm). To allow a remote-control and a remote-download, the AWS is scheduled to switch on the satellite 4 times per day (at 6 am, 11 am, 3 pm and10 pm). The FTP and the WEB server is managed by the Hortus company (HMS-WEB).

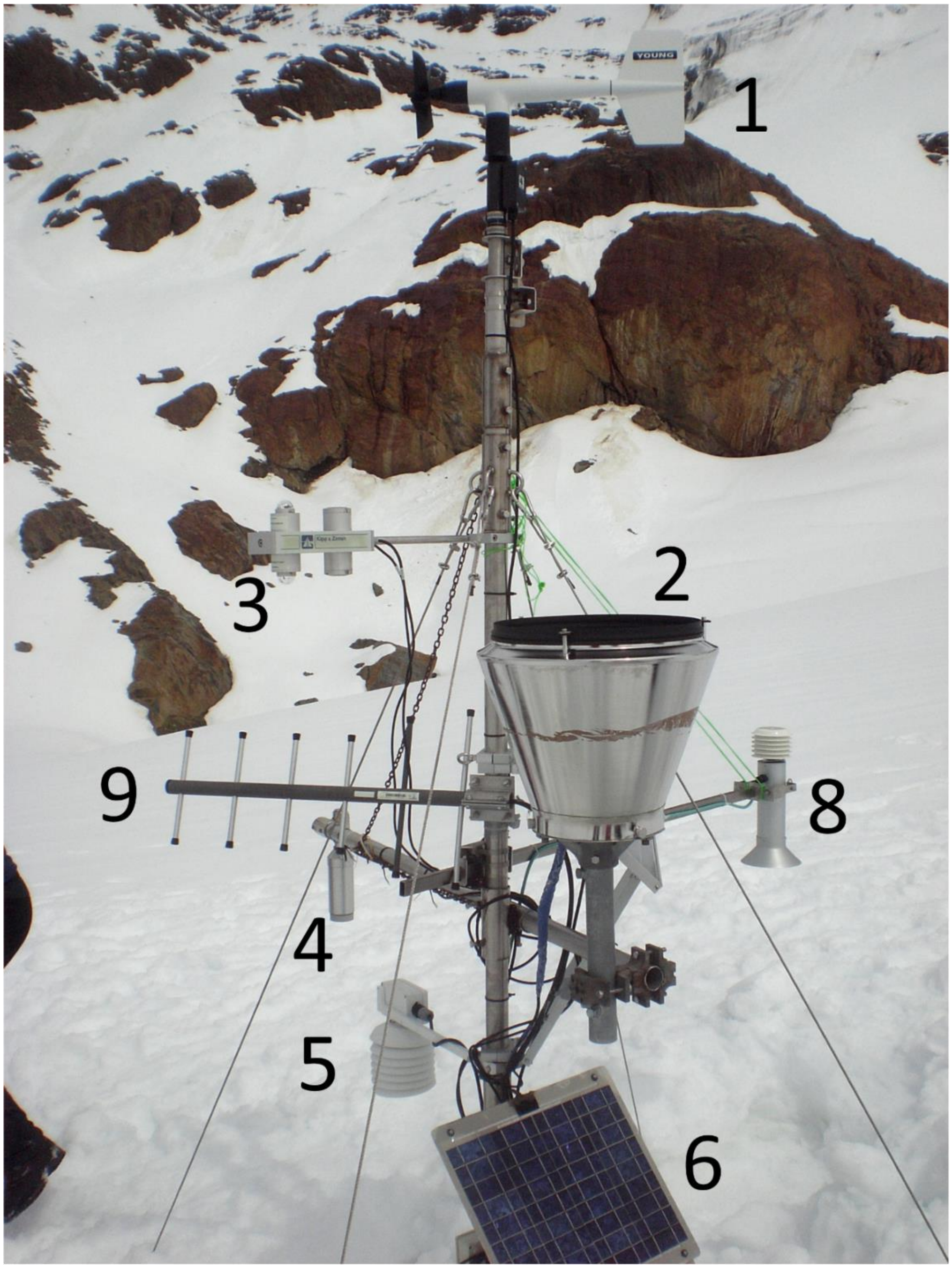

FIGURE 5: AWS1 Forni photographed from the South-West (on 6th May 2014, winter time). The instruments are marked with numbers: (1) wind speed and direction, (2) rain gauge, (3) net radiometer CNR1, (4) sonic ranger (Campbell SR50), (5) thermo-hygrometer, (6) solar panels, (8) sonic ranger (Sommer USH-8), and (9) antenna.

FIGURE 6: AWS1 Forni photographed from the South (summer time) during one of the periodic maintenance activities. The instruments are marked with numbers: (1) wind speed and direction, (2) rain gauge, (3) net radiometer CNR1, (4) sonic ranger, (5) thermo-hygrometer, (6) solar panels, and (7) barometer inside the data-logger box. From summer 2009 the AWS is online through a radio link and a GSM modem. The communication system is supported by a dedicated solar panel (8) and a gel battery 30 Ah.

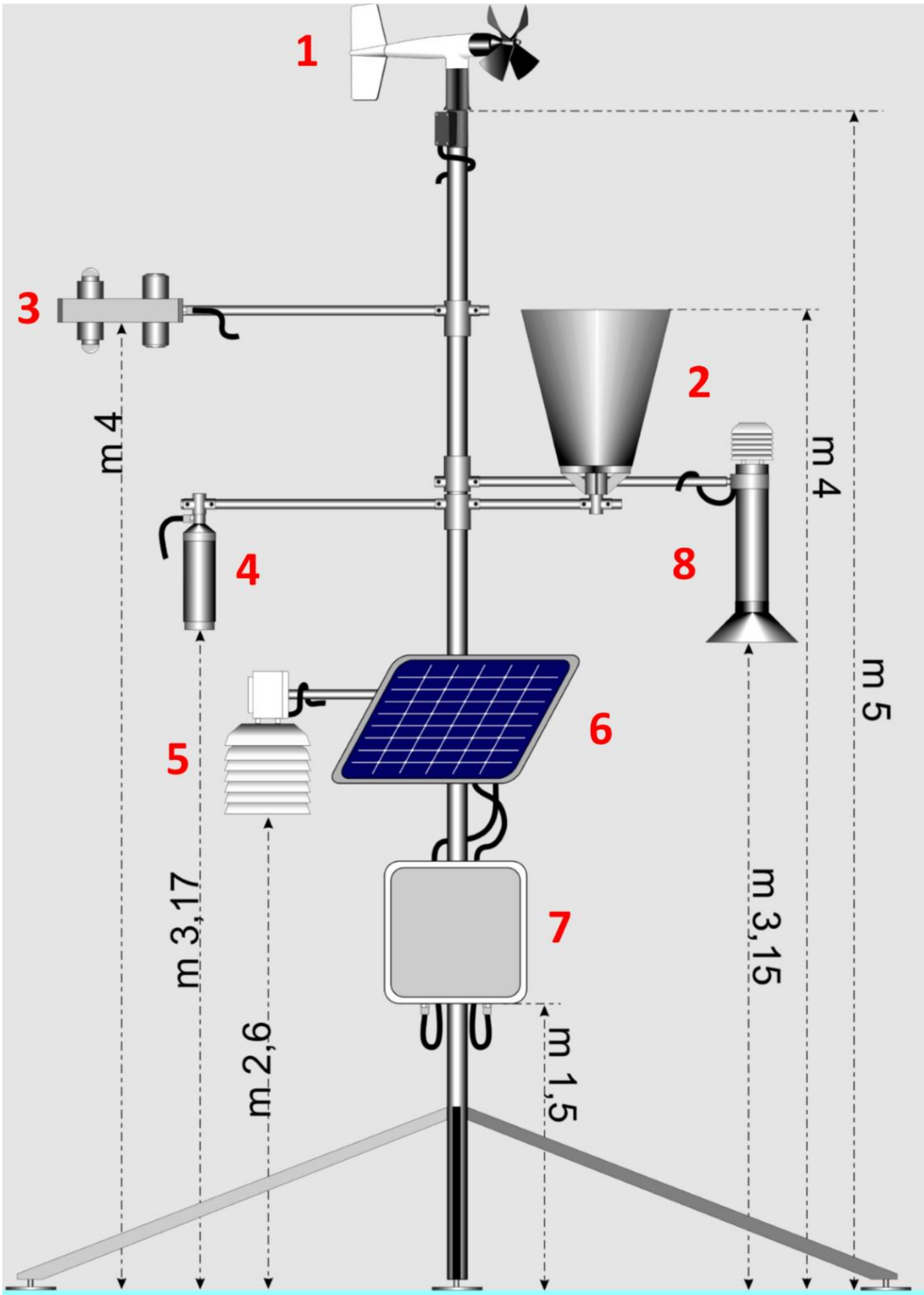

FIGURE 7: AWS1 Forni scheme underling the distances of the instruments from the glacier ice surface. The instruments are marked with numbers: (1) wind speed and direction, (2) rain gauge, (3) net radiometer CNR1, (4) sonic ranger (Campbell SR50), (5) thermo-hygrometer, (6) solar panels, (7) barometer inside the data-logger box, and (8) sonic ranger (Sommer USH-8).

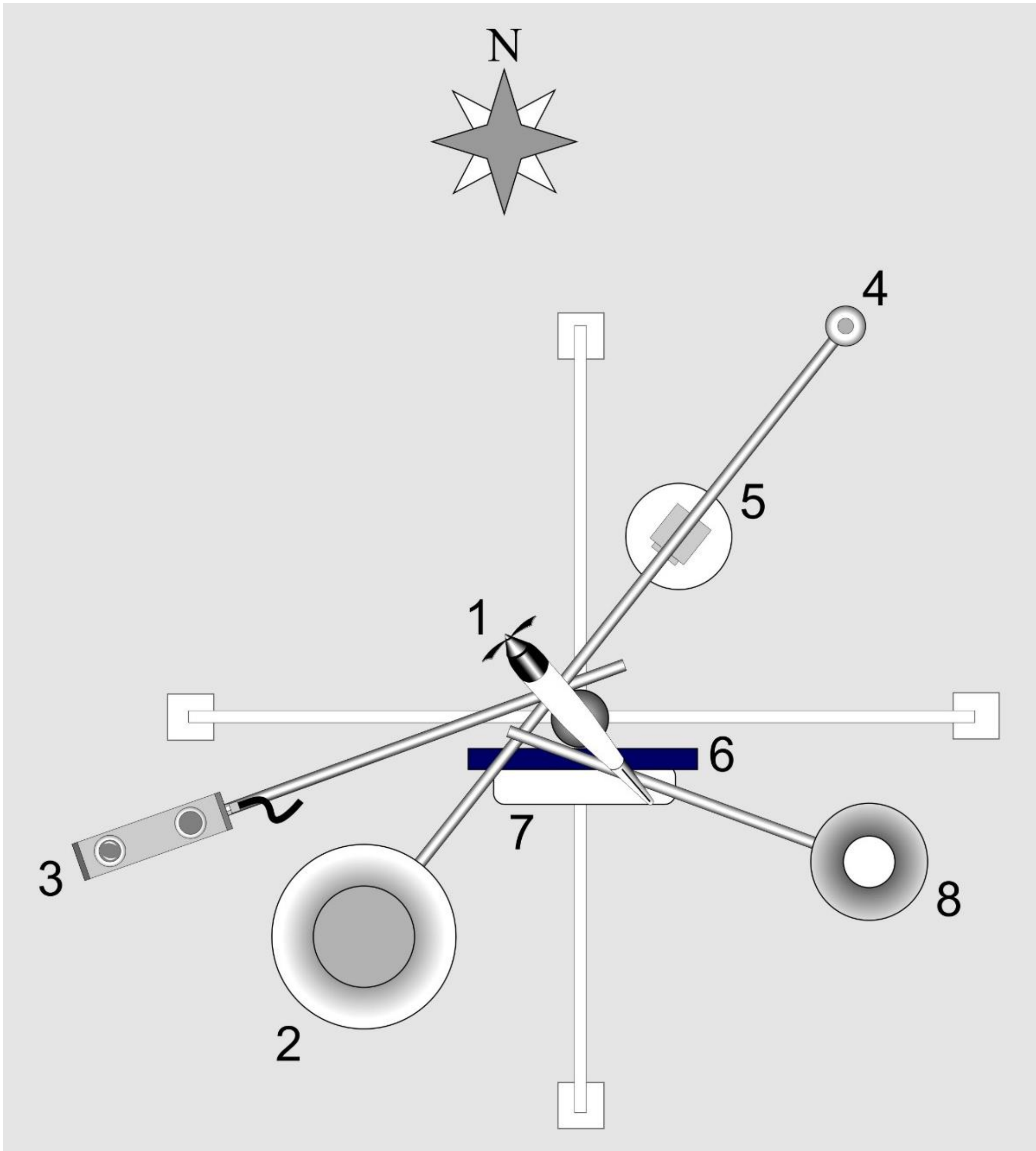

FIGURE 8: Sky view of AWS1 Forni instruments. The instruments are marked with numbers: (1) wind speed and direction, (2) rain gauge, (3) net radiometer CNR1, (4) sonic ranger (Campbell SR50), (5) thermo-hygrometer, (6) solar panels, (7) barometer inside the datalogger box, and (8) sonic ranger (Sommer USH-8).

FIGURE 9: AWS Forni SPICE photographed from the North-East (after the installation on 6th May 2014). The instruments are marked with numbers: (1) graduated stakes, (2) snow pillow, (3) automated camera, (4) antenna for the telecommunications, (5) solar panel, and (6) the data-logger box.

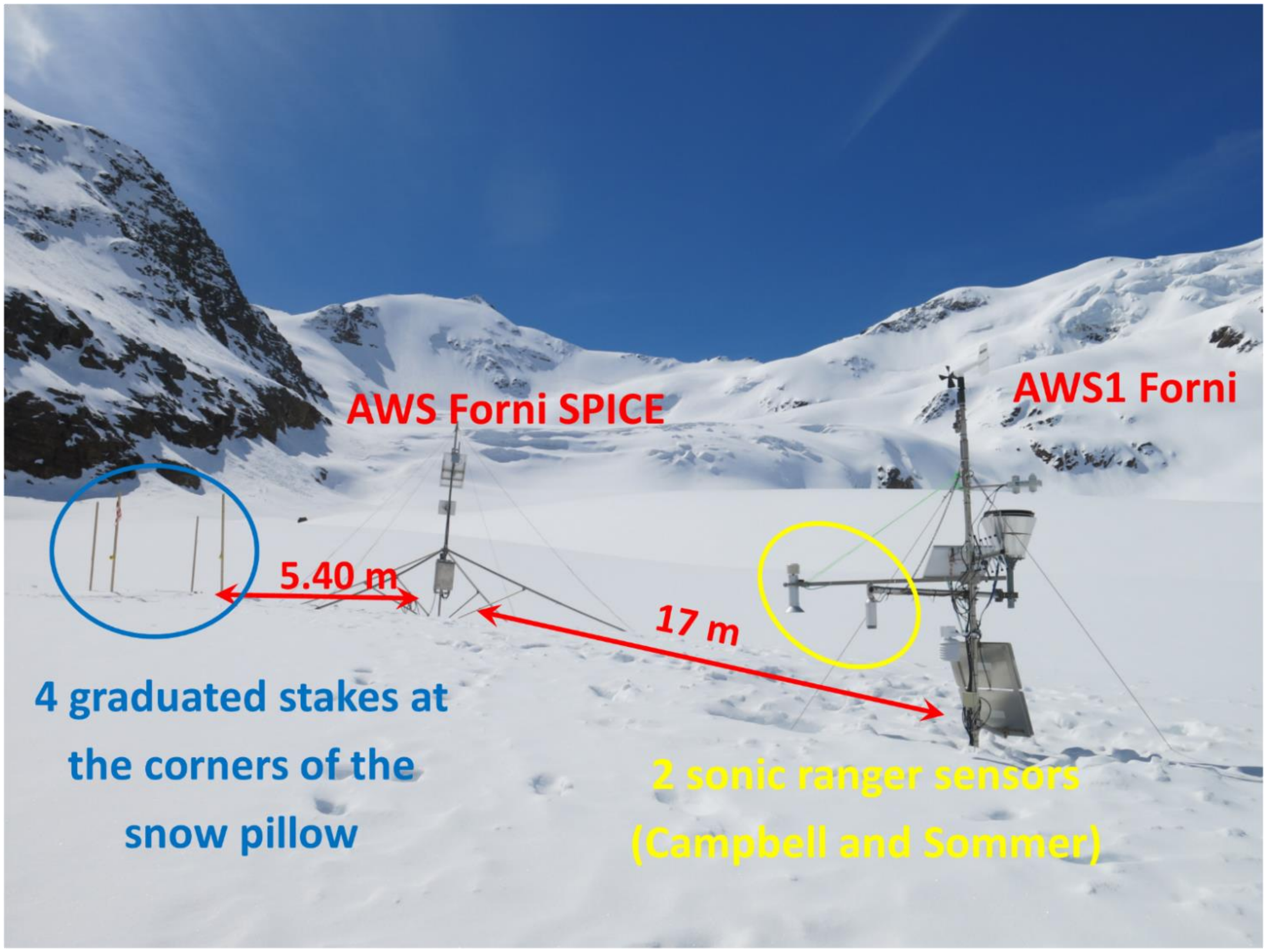

FIGURE 10: AWS Forni SPICE (on the left) and AWS1 Forni (on the right) photographed from the North-East (after the installation of the AWS Forni SPICE). The distances between the stations are shown.

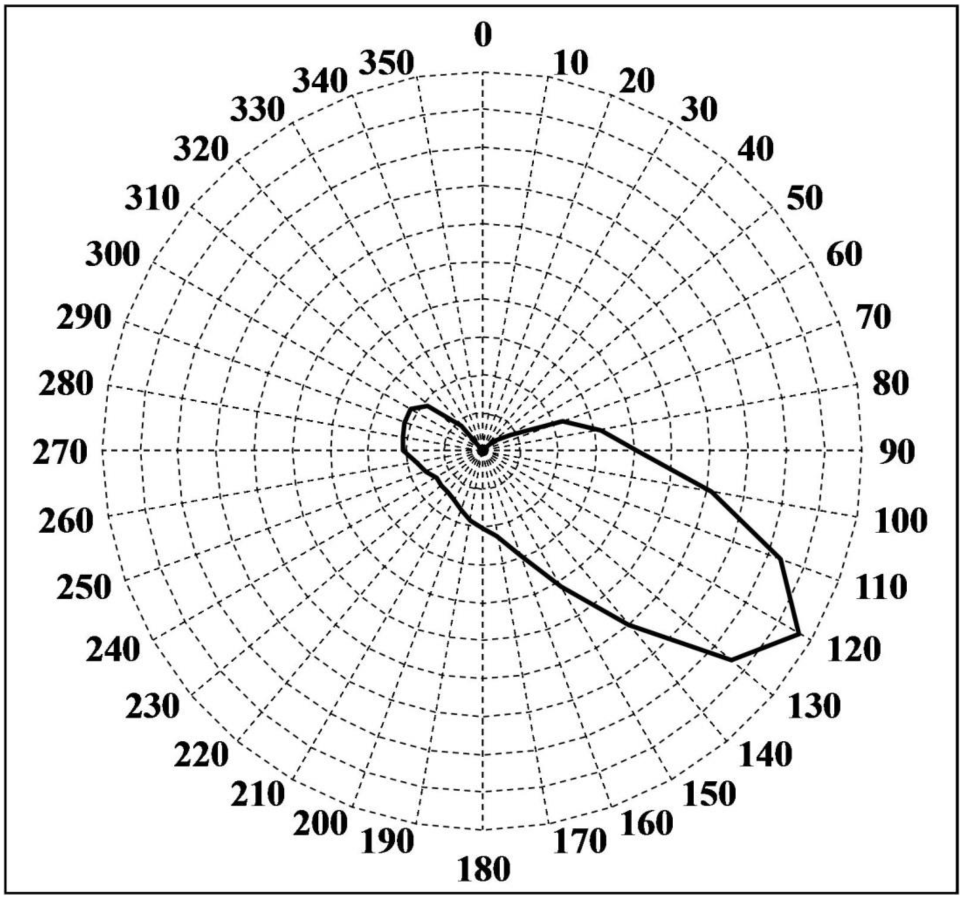

FIGURE 11: The frequency of dominant wind direction of provenance observed at the Forni AWS during 2009-2010 (dashed circular grid spaced by 1% probability of occurrence).

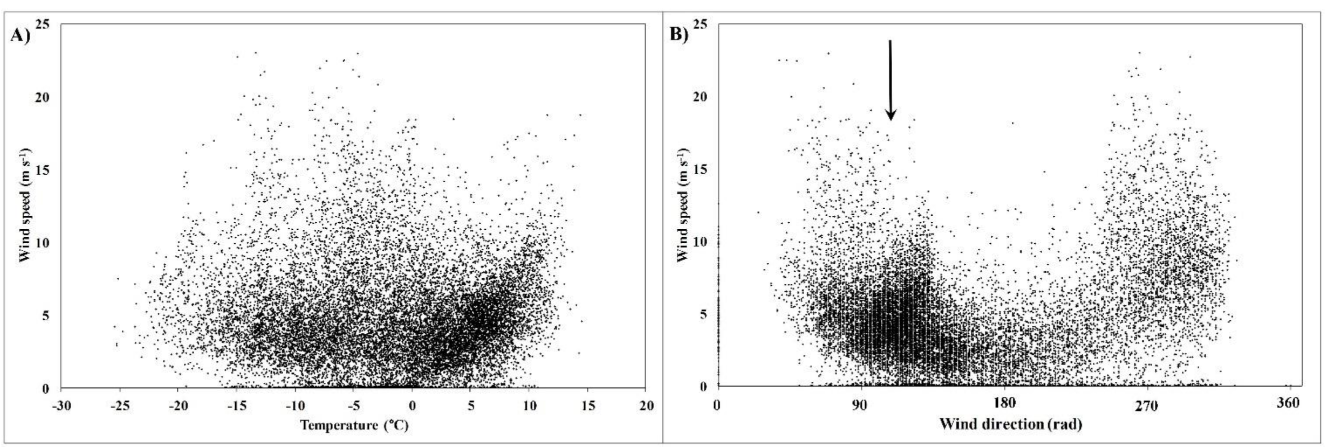

FIGURE 12: Scatter plots showing relations between wind direction (a) and air temperature (b) vs wind speed. Two years (2009 and 2010) of measurements from AWS1 Forni are shown and every dot represents a hourly average value (so every plot contains 17133 points). The arrow indicates the direction of the local fall line of the glacier.

TABLE 1: Site characteristics, meteorological and energy balance data of the Forni Glacier (data are averaged by annual mean values from 2006 to 2010).

Coordinates	46° 23' 56" N; 10° 35’ 25" E
Elevation range (m a.s.l.)	2600 - 3670
Length (km)	4.7
Area (km^2)	12
AWS elevation (m a.s.l.)	2631
	Annual mean (2006-2010)
net SW (W m^{-2})	67
net Lw (W m^{-2})	-36
SH (W m^{-2})	17
LE (W m^{-2})	-4
R_S (W m^{-2})	38
SW in (W m^{-2})	154
SW out (W m^{-2})	93
SW in extra (W m^{-2})	267
Air temperature (°C)	-1.4
Snow albedo	0.77
Ice albedo	0.23
Wind speed (m s^{-1})	4.9

SECTION A2: SPICE FIELD WORKING REFERENCE SYSTEM CONFIGURATION

Field Reference for the Measurement of Snow on the Ground

Method used	**Snow pit**
Equipment used	**Following AINEVA protocol (www.AINEVA.it)**
Frequency of measurement	**Every month**

Picture. Field Reference for the Measurement of Snow on the Ground

FIGURE 13: Detailed pictures of a field snow pit survey close the AWS1 Forni. The thickness (h_i) and the snow density (ρ_i) of each layer (i) are measured for estimating the snow water equivalent of each layer and then the total *SWE* of the whole snow cover (*n* layer):

$$SWE = \sum_{i=1}^{n} h_i \cdot \frac{\rho_i}{\rho_{water}}$$

Table. Field Calibration for the Measurement of Snow on the Ground

Not Available

48h Observation Table. Field Reference for the Measurement of Snow on the Ground

Snow on the ground data collected by a snow pit close the AWS1 Forni carried out on 6th May 2014:

	Density (ρ) [kg m^{-3}]	**Thickness (h) [mm]**	**SWE [mm w.e.]**
surface	330	221	73
	430	60	26
	430	70	30
	440	59	26
	480	110	53
	917	20	183
		20	
	500	80	40
	460	89	41
	917	10	92
	480	50	24
	917	10	92
	460	80	37
	917	10	92
	480	240	115
	917	20	183
	470	140	66
	917	10	92
	480	371	178
	917	10	92
	410	361	148
	450	129	58
ice	450	100	45
TOT		**2271**	**1785**

Field Reference for the Measurement of Snow on the Ground

Method used	**Graduated stakes photographed by the camera**
Equipment used	**4 graduated stakes and an automatic camera**
Frequency of measurement	**Every hour**

Picture. Field Reference for the Measurement of Snow on the Ground

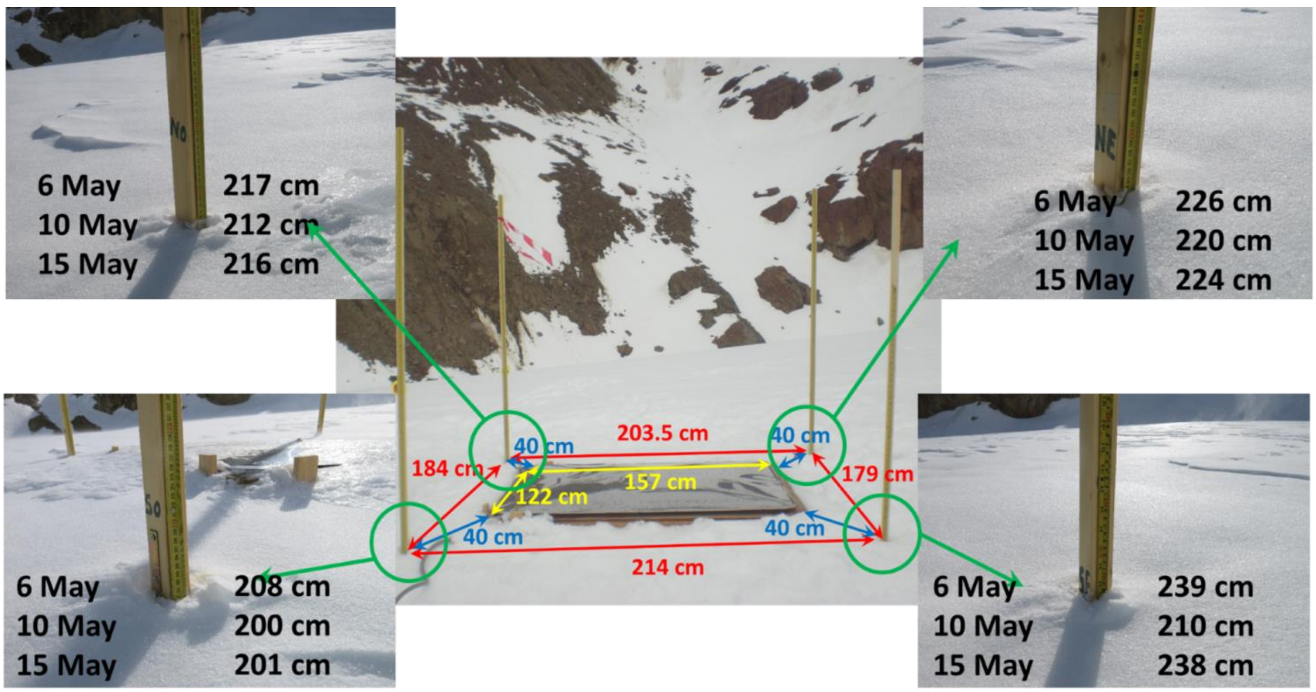

FIGURE 14: Detailed pictures of the four graduated stakes and the measured data of snow on the ground.

FIGURE 15: Detailed picture of the camera installed at the AWS Forni SPICE.

Table. Field Calibration for the Measurement of Snow on the Ground

Not Available

48h Observation Table. Field Reference for the Measurement of Snow on the Ground

Snow on the ground data measured at the 4 graduated stakes close the AWS Forni SPPICE on 6th May 2014:

Stake location	Thickness (cm)
SO	208
SE	239
NE	226
NO	217

Field Reference for the Measurement of Snow on the Ground

Method used	**Snow weighing tube**
Equipment used	**Enel-Valtecne snow weighing tube**
Frequency of measurement	**Every month**

Picture. Field Reference for the Measurement of Snow on the Ground

FIGURE 16: Detailed picture of the Enel-Valtecne snow weighing tube during measurements performed near to the AWS Forni SPICE.

Table. Field Calibration for the Measurement of Snow on the Ground

Not Available

48h Observation Table. Field Reference for the Measurement of Snow on the Ground

Snow on the ground data measured by the Enel-Valtecne snow weighing tube around the AWS1 Forni on 31st May 2014:

ID	Thickness (cm)	Density (Kg/dm^3)	SWE (mm)	Note
1	158	0.412	650.8	2.80 m East from the AWS1 Forni
2	166	0.392	650.8	9.00 m North-East from the Sonic Ranger Campbell
3	157	0.392	615.4	2.65 m East from Snow Pillow

SECTION A3: Instrument Metadata Report

For each instrument under test and each instrument used to provide ancillary measurements, an Instrument Metadata Report should be completed in full and submitted as part of the POP Report.

Instrument Metadata Report

IMPORTANT: Please copy this form (as necessary) and complete separately for each instrument under test and each instrument that will be used to provide ancillary measurements during WMO SPICE.

Instrument Name: **Sonic Ranger Campbell SR50**
Instrument number 1 of 1

Manufacturer	Campbell
Model	SR50
Serial number	C4229
Firmware version (if applicable)	NA

Field configuration

Location on site	Installed on the mast of the AWS1 Forni (4 in Fig. 5)
Orientation	40° from the North
Height (measured at top)	317 cm
Shield (if applicable)	NA
Heating (if applicable)	Unheated

Data output

<table>
<tr><td>Data communication protocol</td><td>Analogic</td></tr>
<tr><td>Output data message format (include description of fields)</td><td><table><tr><td>Channel</td><td>Sub-Channel</td><td>Sub-Channel</td><td>Date time</td><td>Data quality</td><td>Value</td></tr></table></td></tr>
<tr><td>Data sampling frequency</td><td>Instantaneous value</td></tr>
<tr><td>Data output to NCAR</td><td>60 min</td></tr>
<tr><td>Data logger</td><td>Babuc ABC LSI-Lastem</td></tr>
</table>

Instrument Picture.

FIGURE 17: Detailed picture of the Campbell sonic ranger installed at the AWS1 Forni in autumn 2005.

Field Calibration (carried out on 6th May 2014)

Manual observation	Measured value
74 cm	78 cm

48h Plot

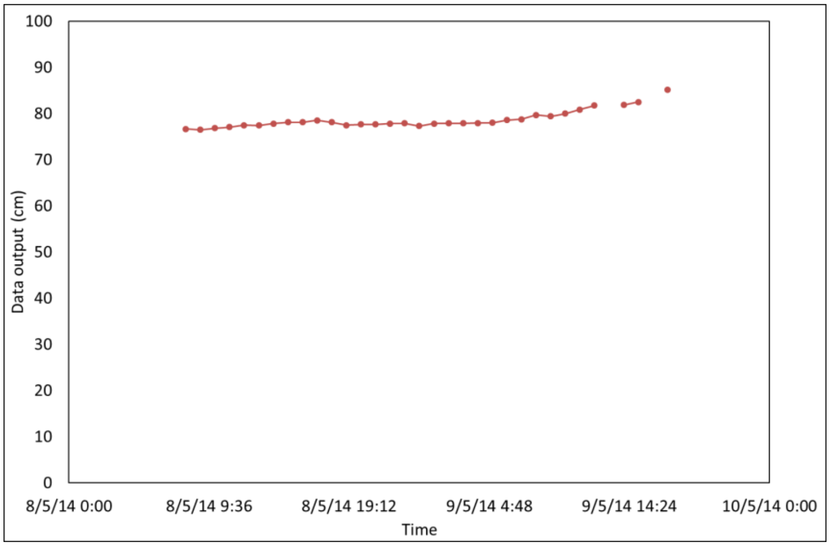

FIGURE 18: Plot showing 48h of snow thickness measured by Campbell sonic ranger on 8th and 9th May 2014.

Instrument Name: **Sonic Ranger Sommer USH-8**
Instrument number 1 of 1

Manufacturer	Sommer
Model	USH-8
Serial number	37120870
Firmware version (if applicable)	NA

Field configuration

Location on site	Installed on the mast of the AWS1 Forni (8 in Fig. 5)
Orientation	110° from the North
Height (measured at top)	315 cm
Shield (if applicable)	NA
Heating (if applicable)	Unheated

Data output

<table>
<tr><td>Data communication protocol</td><td>Analogic</td></tr>
<tr><td>Output data message format (include description of fields)</td><td><table>
<tr><td>TOA5</td><td>CR200Series</td><td>CR2xx</td><td>No_SN</td></tr>
<tr><td>TIMESTAMP</td><td>RECORD</td><td>VBatt_Min</td><td>Nivo_neve_cm_Avg</td></tr>
<tr><td>TS</td><td>RN</td><td></td><td></td></tr>
<tr><td></td><td></td><td>Min</td><td>Avg</td></tr>
</table></td></tr>
<tr><td>Data sampling frequency</td><td>Instantaneous value</td></tr>
<tr><td>Data output to NCAR</td><td>10 min</td></tr>
<tr><td>Data logger</td><td>Campbell CR200</td></tr>
</table>

Instrument Picture.

FIGURE 19: Detailed picture of the Sommer sonic ranger installed at the AWS1 Forni on 6th May 2014.

Field calibration performed on 6th May 2014.

Manual observation	Measured value
114 cm	115 cm

48h Plot.

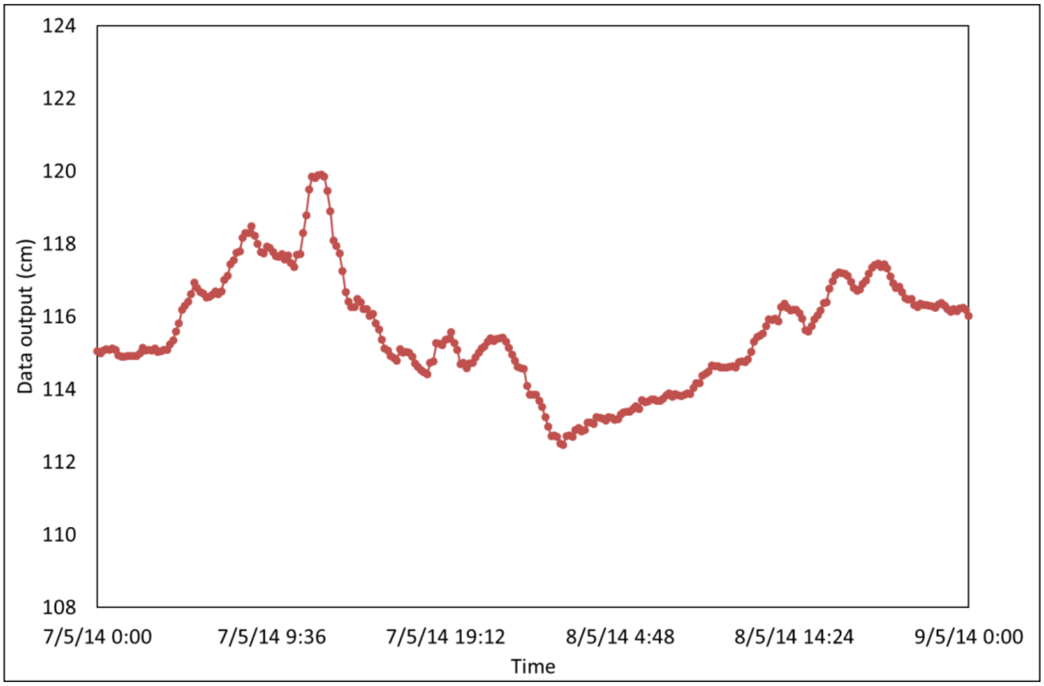

FIGURE 20: Plot showing 48h of snow data measured by Sommer sonic ranger on 7th and 8th May 2014.

Instrument Name: **Snow pillow**
Instrument number 1 of 1

Manufacturer	Park Mechanical Inc. / STS
Model	SS-6048 SNOW PILLOW / ATM.1ST
Serial number	796398
Firmware version (if applicable)	Not applicable

Field configuration

Location on site	Closed to the AWS Forni SPICE (2 in Fig. 9)
Orientation	East respect to the AWS Forni SPICE mast
Height (measured at top)	At the surface of the snow cover
Shield (if applicable)	NA
Heating (if applicable)	Unheated

Data output

Data communication protocol	Analogic
Output data message format (include description of fields)	code | data | time | value | Data quality
Data sampling frequency	5 minutes
Data output to NCAR	10 min
Data logger	Campbell CR1000

Details regarding the pressure transmitter:

Manufacturer	STS
Model	ATM.1ST
Range	0 - 250 mBar
Precision	±0,1%
Output	4 - 20 mA
Compensated temperature range	-10°C / +100°C
Supply voltage	10...30 Vdc

Instrument Picture.

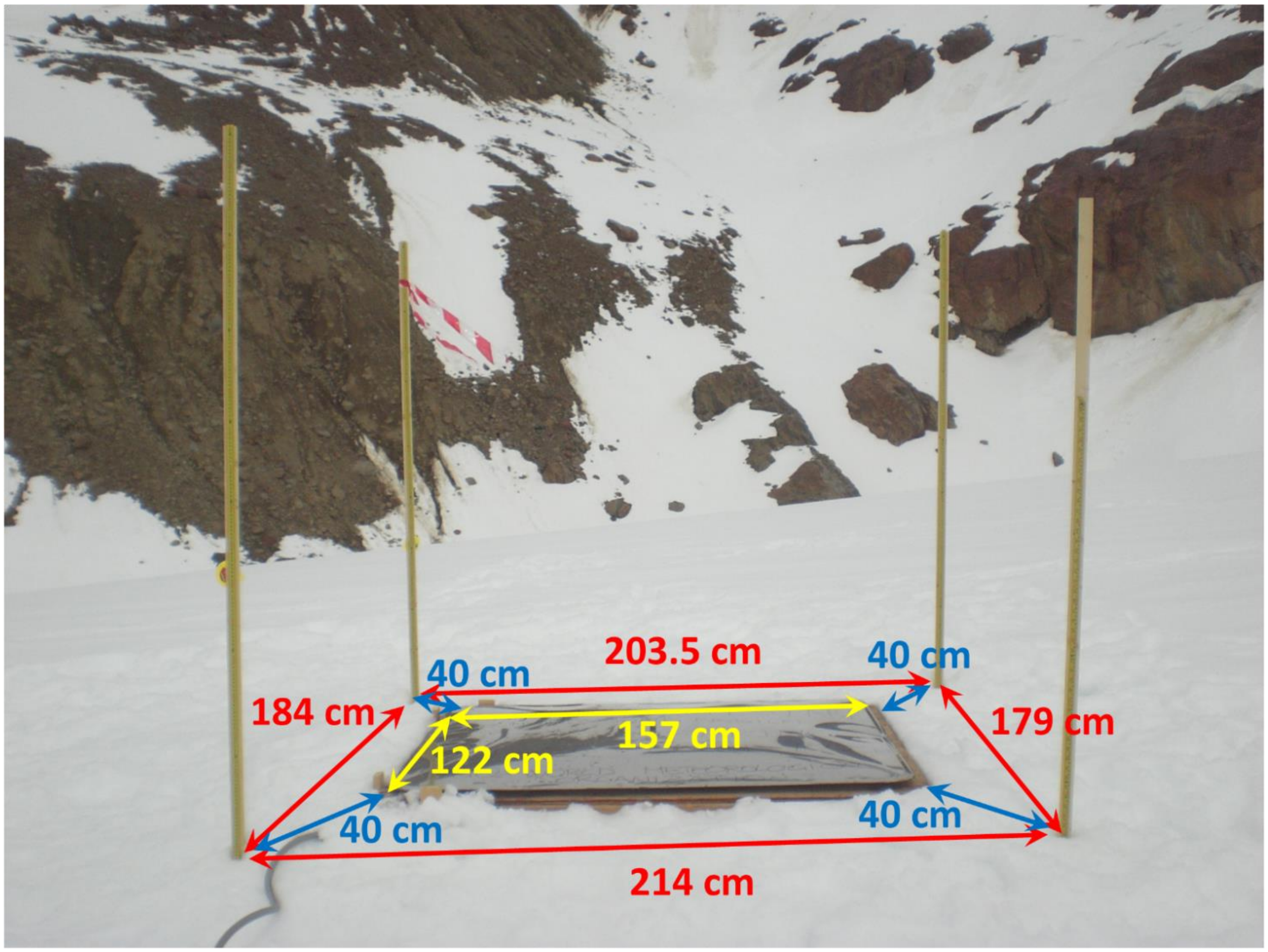

FIGURE 21: Detailed picture of the snow pillow and the four graduated stakes (the size of the snow pillow and the distances between stakes and snow pillow are shown).

FIGURE 22: Detailed picture of the snow pillow downfacing side.

Field calibration (if any).

Not available

48h Plot.

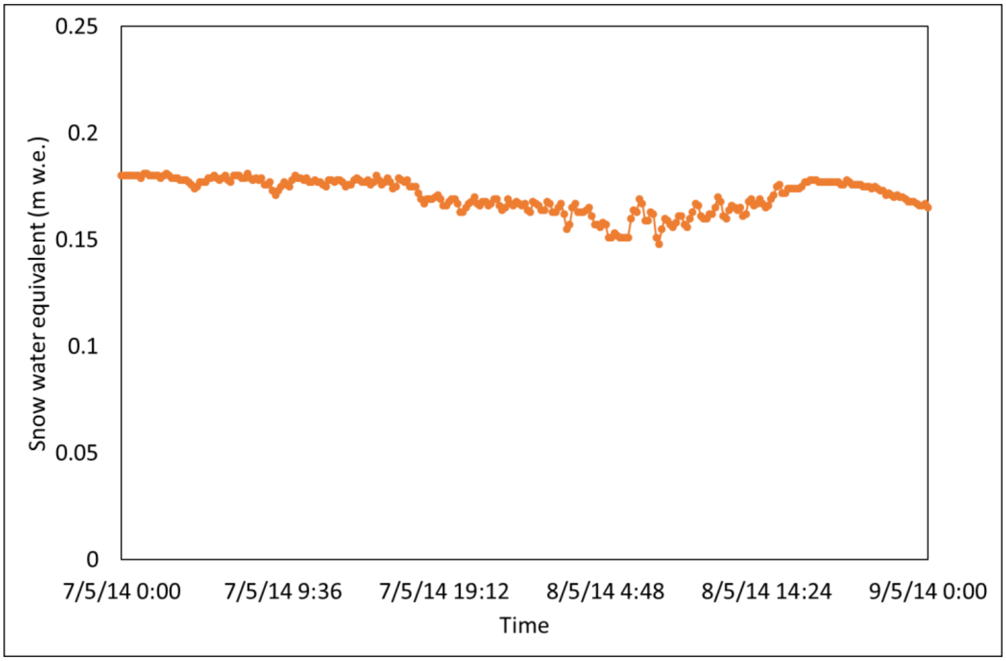

FIGURE 23: Plot showing 48h of snow on the ground measured by snow pillow on 7th and 8th May 2014.

Instrument Name: **Thermo-hygrometer**
Instrument number 1 of 1

Manufacturer	LSI-Lastem
Model	DMA570
Serial number	/
Firmware version (if applicable)	NA

Field configuration

Location on site	Installed on the mast of the AWS1 Forni (5 in Fig. 5)
Orientation	40° from the North
Height (measured at top)	2.6 m from the glacier surface
Shield (if applicable)	White radiation shield with natural ventilation
Heating (if applicable)	Unheating

Data output

Data communication protocol	Analogic								
Output data message format (include description of fields)	Channel	Sub-Channel	Sub-Channel	Date time	Data quality	Min	Ave	Max	D St
Data sampling frequency	1 min								
Data output to NCAR	30 min								
Data logger	Babuc ABC LSI-Lastem								

Specification of the temperature sensor

Range	-30 - +70°C
Accuracy	±0.001°C

Specification of the relative humidity sensor

Range	0 - 100%
Accuracy	±1%

Instrument Picture.

FIGURE 24: Detailed picture of the thermo-hygrometer.

Field calibration (if any).

The calibration was performed by the manufacturer.

48h Plot.

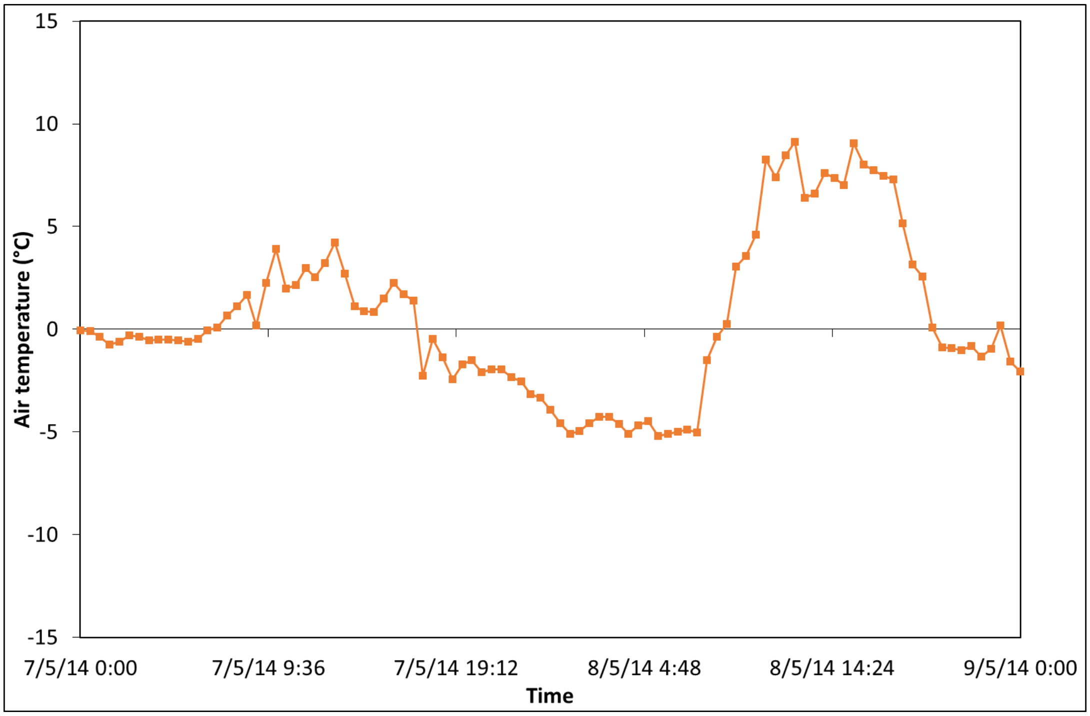

FIGURE 25: Plot showing a test with 48h of temperature values recorded on 7th and 8th May 2014.

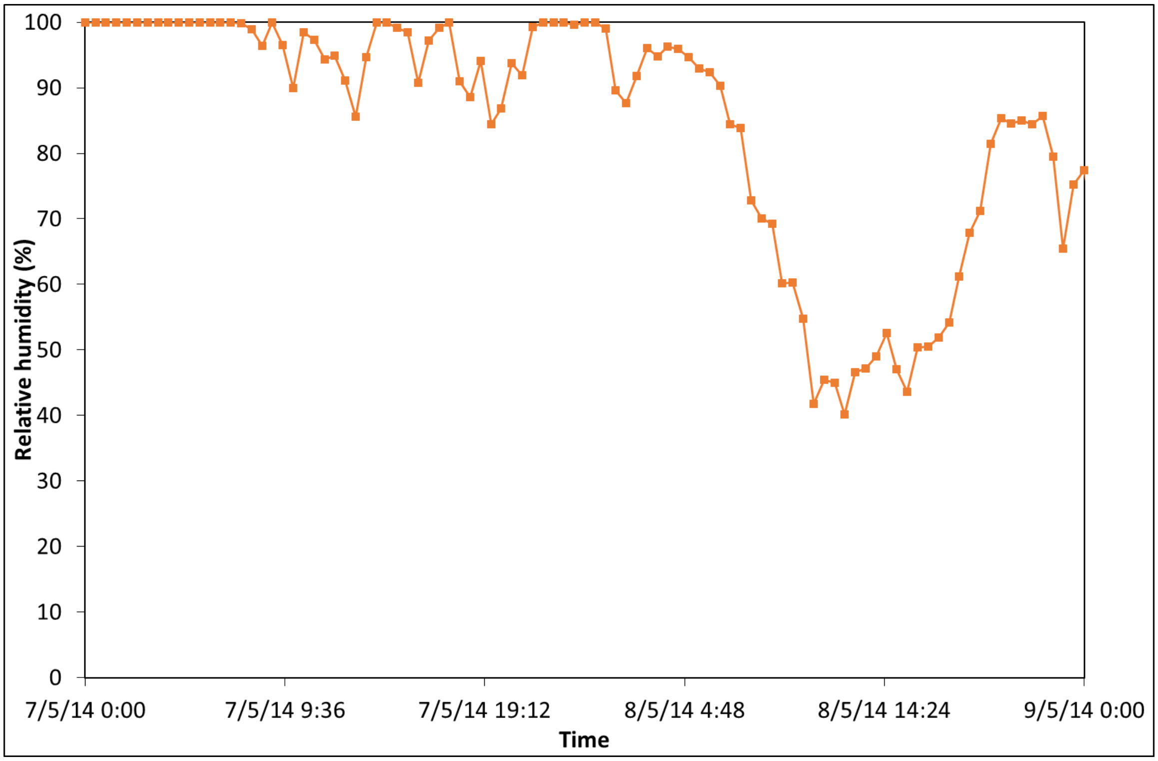

FIGURE 26: Plot showing a test with 48h of relative humidity values recorded on 7th and 8th May 2014.

Instrument Name: **Barometer**
Instrument number 1 of 1

Manufacturer	LSI-Lastem
Model	DQA223
Serial number	/
Firmware version (if applicable)	NA

Field configuration

Location on site	Installed on the mast of the AWS1 Forni, inside the logger box (7 in Fig. 6)
Orientation	180° from the North
Height (measured at top)	1.5 m from the glacier surface
Shield (if applicable)	NA
Heating (if applicable)	Unheating

Data output

Data communication protocol	Analogic
Output data message format (include description of fields)	Channel | Sub-Channel | Sub-Channel | Date time | Data quality | Min | Ave | Max | D St
Data sampling frequency	1 min
Data output to NCAR	60 min
Data logger	Babuc ABC LSI-Lastem

Specification of the pressure sensor

Range	400 - 800 hPa or mBar
Accuracy	±10hPa

Instrument Picture.

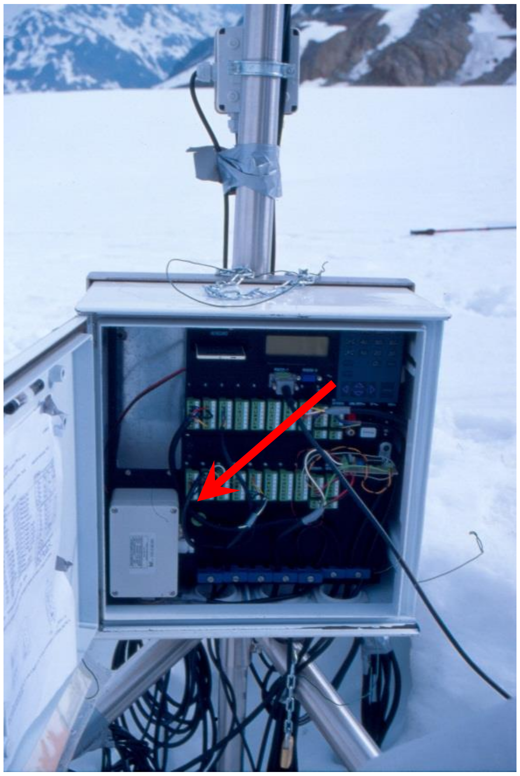

FIGURE 27: Detailed picture of the barometer.

Field calibration (if any).

The calibration was performed by the manufacturer.

48h Plot.

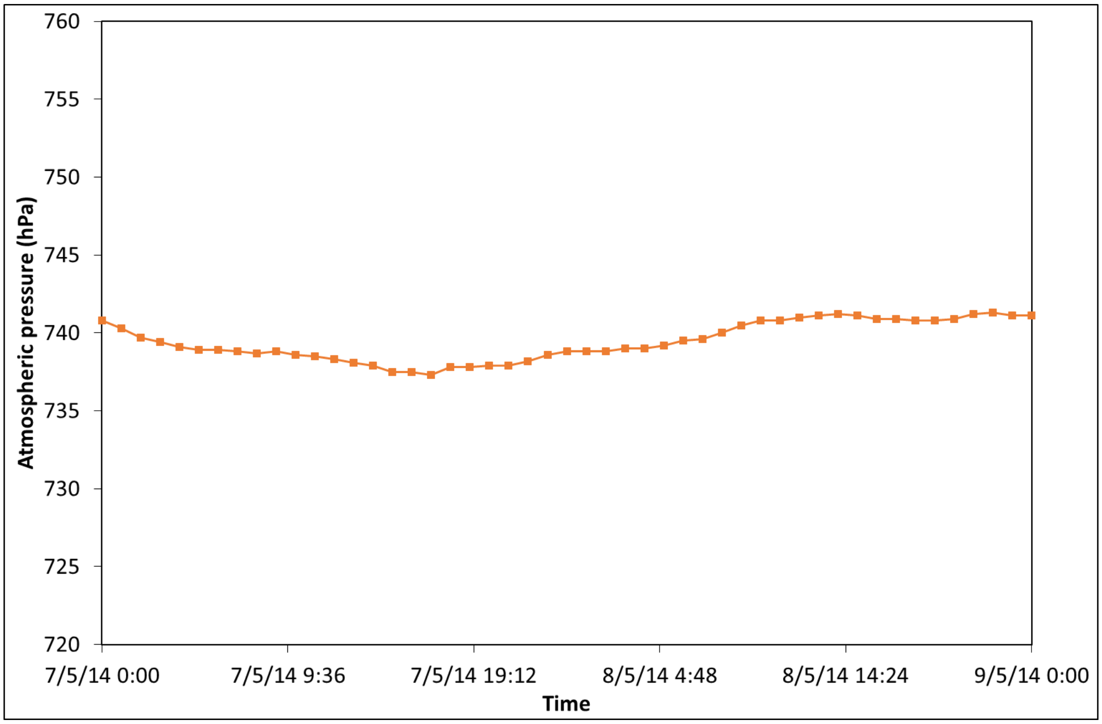

FIGURE 28: Plot showing a test with 48h of atmospheric pressure values recorded on 7th and 8th May 2014.

Instrument Name: **Net radiometer**
Instrument number 1 of 1

Manufacturer	Kipp and Zonen
Model	CNR1
Serial number	/
Firmware version (if applicable)	NA

Field configuration

Location on site	Installed on the mast of the AWS1 Forni (3 in Fig. 5)
Orientation	110° from the North
Height (measured at top)	0.53 m from the top of the mast
Shield (if applicable)	NA
Heating (if applicable)	Unheating

Data output

Data communication protocol	Analogic								
Output data message format (include description of fields)	Channel	Sub-Channel	Sub-Channel	Date time	Data quality	Min	Ave	Max	D St
Data sampling frequency	1 min								
Data output to NCAR	30 min								
Data logger	Babuc ABC LSI-Lastem								

Specification of the solar radiation sensor

Range	0.3 - 3 μm
Accuracy	±5% of the value

Specification of the infrared radiation sensor

Range	5 - 50 μm
Accuracy	±5% of the value

Instrument Picture.

FIGURE 29: Detailed picture of the net radiometer.

Field calibration (if any).

The calibration was performed by the manufacturer.

48h Plot.

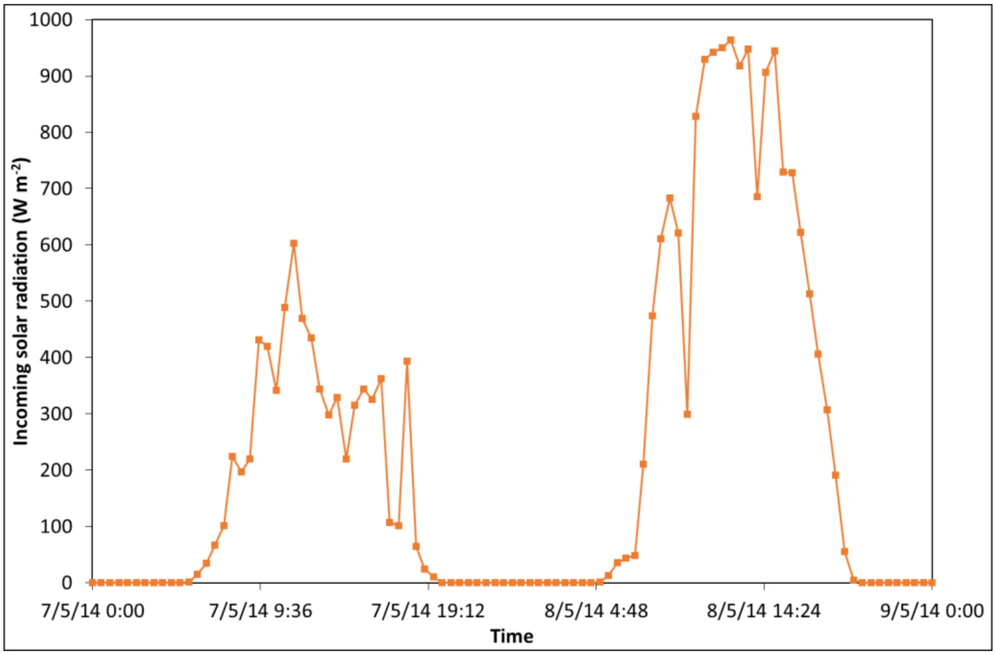

FIGURE 30: Plot showing a test with 48h of incoming solar radiation values recorded on 7th and 8th May 2014.

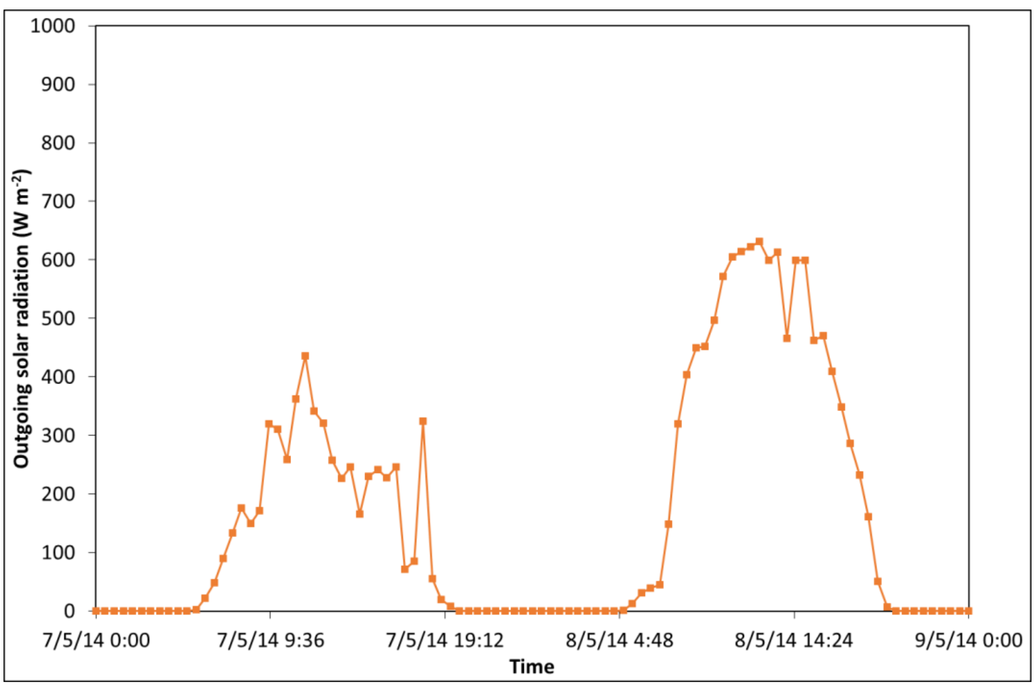

FIGURE 31: Plot showing a test with 48h of outgoing solar radiation values recorded on 7th and 8th May 2014.

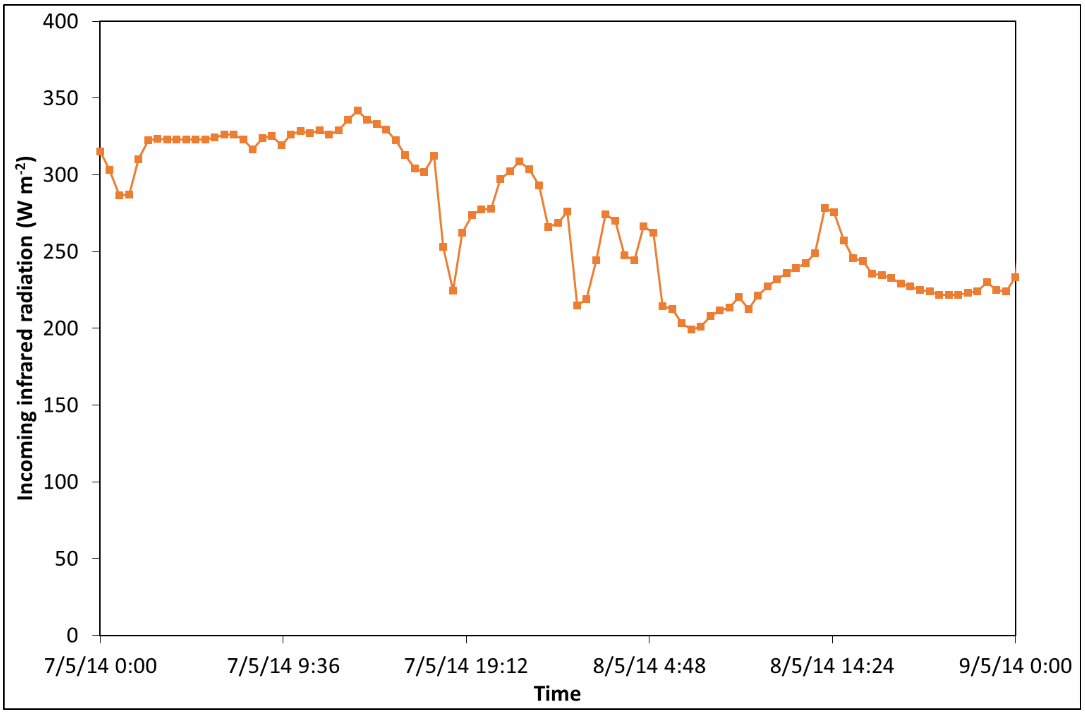

FIGURE 32: Plot showing a test with 48h of incoming infrared radiation values recorded on 7th and 8th May 2014.

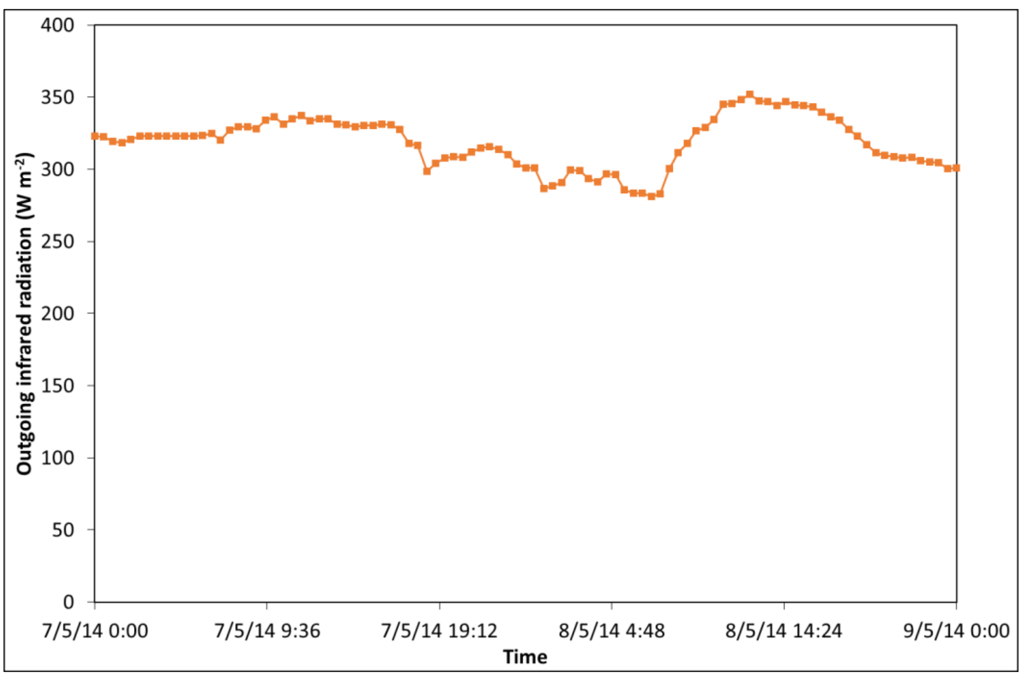

FIGURE 33: Plot showing a test with 48h of outgoing infrared radiation values recorded on 7th and 8th May 2014.

Instrument Name: **Pluviometer**
Instrument number 1 of 1

Manufacturer	LSI-Lastem
Model	DQA035
Serial number	/
Firmware version (if applicable)	NA

Field configuration

Location on site	Installed on the mast of the AWS1 Forni (2 in Fig. 5)
Orientation	220° from the North
Height (measured at top)	4 m from the glacier surface
Shield (if applicable)	NA
Heating (if applicable)	Unheating

Data output

<table>
<tr><td>Data communication protocol</td><td>Impulse sensor with reading of counts</td></tr>
<tr><td>Output data message format (include description of fields)</td><td><table><tr><td>Channel</td><td>Sub-Channel</td><td>Sub-Channel</td><td>Date time</td><td>Data quality</td><td>Value</td></tr></table></td></tr>
<tr><td>Data sampling frequency</td><td>1 min</td></tr>
<tr><td>Data output to NCAR</td><td>30 min</td></tr>
<tr><td>Data logger</td><td>Babuc ABC LSI-Lastem</td></tr>
</table>

Specification of the liquid precipitation sensor

Range	0 – 1000 mm
Accuracy	±1mm

Instrument Picture.

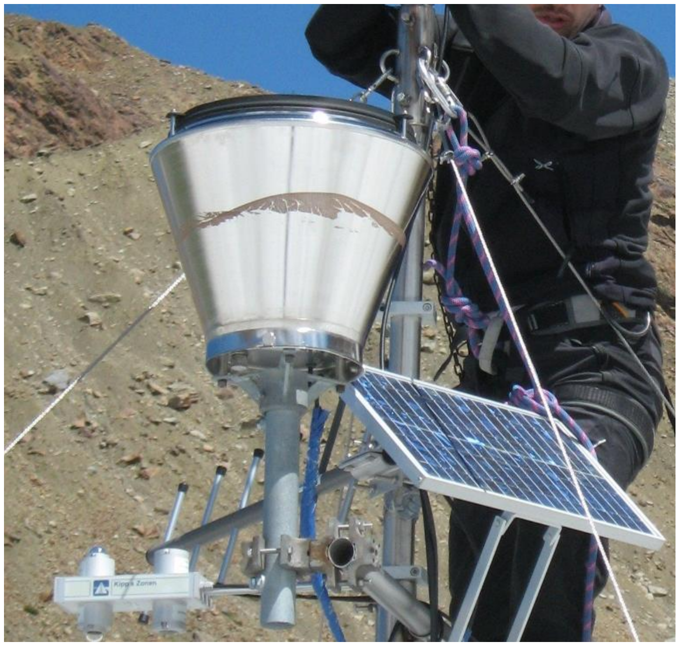

FIGURE 34: Detailed picture of the pluviometer.

Field calibration (if any).

The calibration was performed by the manufacturer.

48h Plot.

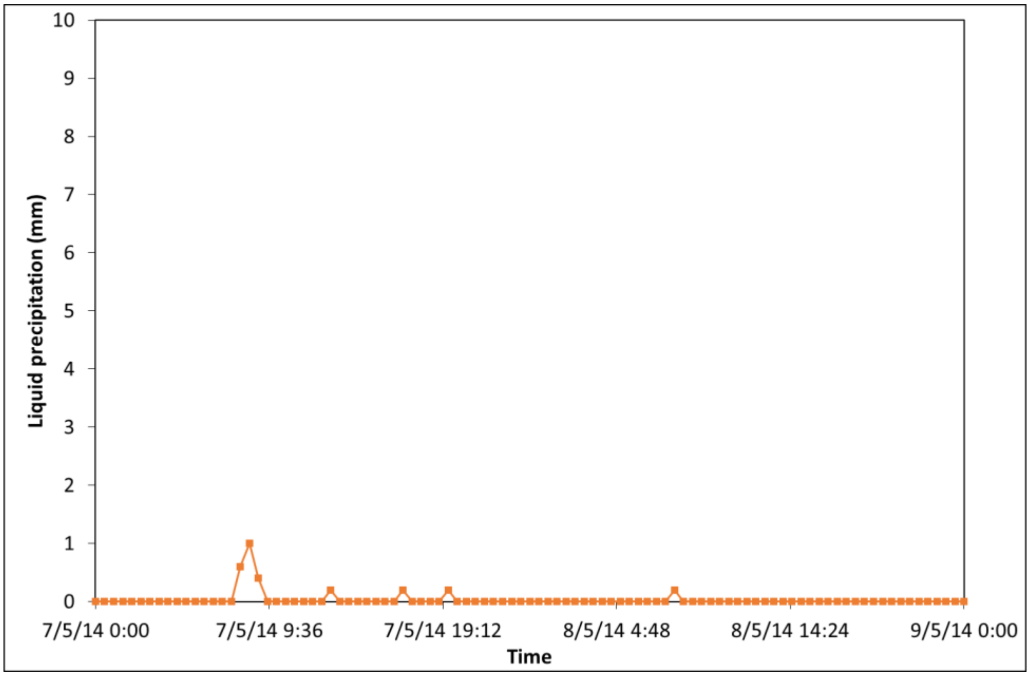

FIGURE 35: Plot showing a test with 48h of liquid precipitation values recorded on 7th and 8th May 2014.

Instrument Name: **Anemometer**
Instrument number 1 of 1

Manufacturer	Young
Model	05103V
Serial number	/
Firmware version (if applicable)	NA

Field configuration

Location on site	Installed on the mast of the AWS1 Forni (1 in Fig. 5)
Orientation	NA
Height (measured at top)	5 m from the glacier surface, on the top of the mast
Shield (if applicable)	NA
Heating (if applicable)	Unheating

Data output

<table>
<tr><td>Data communication protocol</td><td>Analogic</td></tr>
<tr><td>Output data message format</td><td>
<table>
<tr><td>TOA5</td><td>CR200Series</td><td>CR2xx</td><td>CR200X.Std.02</td><td>Forni - SPICE_v1_20140502.cr2</td><td>31853</td><td>DatiRT</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TIMESTAMP</td><td>RECORD</td><td>VBatt_Min</td><td>WindDir_gd_Avg</td><td>WindDir_gd_Min</td><td>WindDir_gd_Max</td><td>WindSpeed_ms_Min</td><td>WindSpeed_ms_Max</td><td>WindSpeed_ms_Std</td><td>WindSpeed_ms_WVc(1)</td><td>WindSpeed_ms_WVc(2)</td><td>WindSpeed_ms_WVc(3)</td></tr>
<tr><td>TS</td><td>RN</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Min</td><td>Avg</td><td>Min</td><td>Max</td><td>Min</td><td>Max</td><td>Std</td><td>WVc</td><td>WVc</td><td>WVc</td></tr>
</table>
</td></tr>
<tr><td>Data sampling frequency</td><td>5 min</td></tr>
<tr><td>Data output to NCAR</td><td>10 min</td></tr>
<tr><td>Data logger</td><td>Campbell CR200</td></tr>
</table>

Specification of the wind speed sensor

Range	0-100 m/s
Accuracy	±0.3 m/s

Specification of the wind direction sensor

Range	0- 360°
Accuracy	±3°

Instrument Picture.

FIGURE 36: Detailed picture of the anemometer.

Field calibration (if any).

The calibration was performed by the manufacturer.

48h Plot.

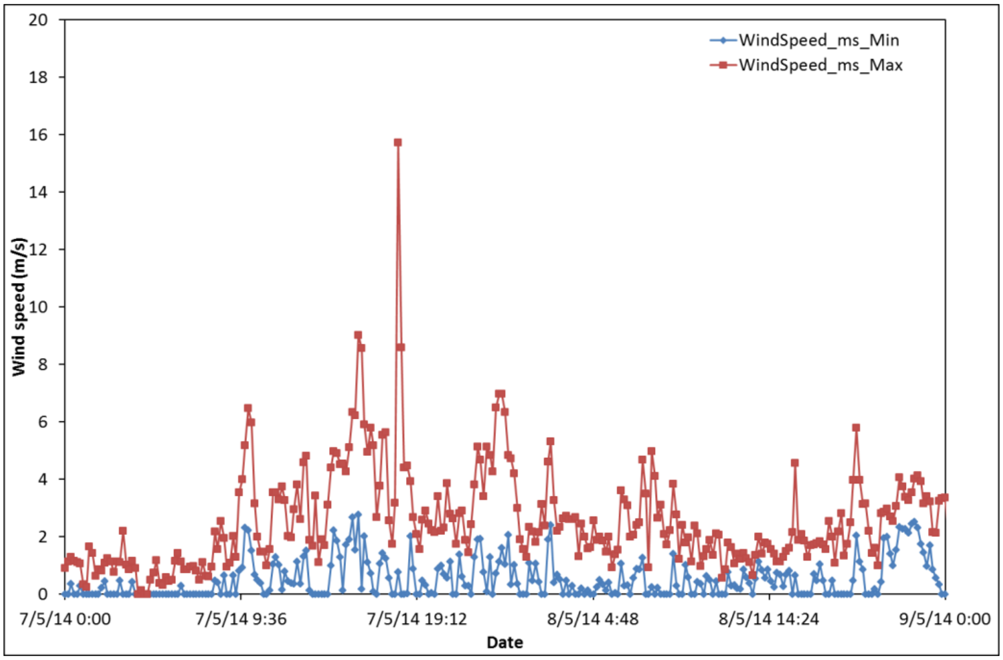

FIGURE 37: Plot showing a test with 48h of wind speed values recorded on 7th and 8th May 2014.

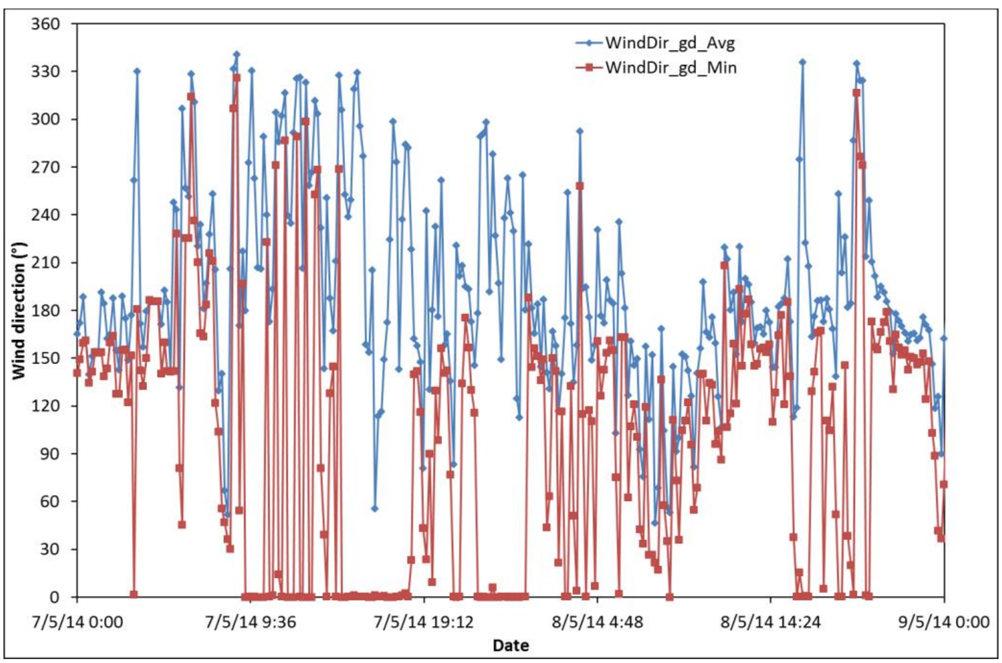

FIGURE 38: Plot showing a test with 48h of wind direction values recorded on 7th and 8th May 2014.

SECTION A4: CONFIRMATION OF EXPERIMENT CONFIGURATION

TEST 1: INSTRUMENT CALIBRATION AND CHECKS

The Site Manager will organize the check and calibration of each instrument included in the experiment (as part of the reference, or as an instrument under test). The check sheets and calibration results will be included in the designated areas of Sections A2 and A3.

- The calibration and check of the WG used as part of the reference will be conducted based on the guidelines adopted by the SPICE IOC.
- The calibration and check of the instruments under test will be conducted as specified by the manufacturer prior to the installation on the SPICE site, as well as following the installation in the field.

TEST 2: INSTRUMENT VALIDATION

After the field installation of each instrument (both those that are part of the reference and those that are instruments under test), at the minimum, a **continuous 48 hour data set** of the entire test setup will be stored and examined as an indication of instrument performance**.** The data sets for each instrument included in the intercomparison will be reviewed for data integrity and representativeness, against the predefined data format.

The evaluation of the instrument performance at this stage will be conducted using the 48 hour time series plots provided in Sections A2 and A3. The readiness state of each instrument will be reported in the Instrument Data Validation table below.

Any discrepancies will be investigated, addressed, and documented. Following the resolution of the discrepancies, the 48-hour end to end (e2e) test will be repeated. Notes, plots, logs, will be appended to the POP table of the reference/instrument under test, and the readiness state and date will be updated in the Instrument Data Validation table.

TEST 3: SITE-TO-ARCHIVE TRANSFER VALIDATION

Once the transfer of site data files to the SPICE Data Archive at NCAR has been initiated, compare the site data with those received at the SPICE Data Archive for a 24 hour period to ensure that no errors occurred during archival or transmission.
If any errors occur, log them and following the resolution of the discrepancies, repeat the 24-hour validation test.

When the Test 3 is passed mark the check box YES in the Instrument Data Validation table below (this means that they have been also validated), with the starting date of the data transfer.

If Test 3 is not passed at the time of the Commissioning Report tick the checkbox NO and provide the expected date.

(Plots, datasets, errors logs, referred to Test 3 are **NOT** included in this document but archived by the site manager if further tests or analysis are required),

IMPORTANT: *Test 2 and Test 3 may be conducted simultaneously, depending on the site configuration.*

Instrument Data Validation

Instrument	Readiness (if Yes, indicate the date)	Data transfer to NCAR archive (**Test 3**) (If the answer is No report the expected date)	Comments
			The historic dataset isn't available as the Forni Glacier is located in a remote area, then a more detailed analysis couldn't be performed.
Sonic Ranger Campbell SR50	☒ Yes ☐ No Date: 6th May 2014	☐ Yes ☒ No Date: September 2014	
Sonic Ranger Sommer USH8	☒ Yes ☐ No Date: 6th May 2014	☐ Yes ☒ No Date: September 2014	
Snow pillow	☒ Yes ☐ No Date: 6th May 2014	☐ Yes ☒ No Date: September 2014	
Thermo-hygrometer	☒ Yes ☐ No Date: 6th May 2014	☐ Yes ☒ No Date: September 2014	Continuous values of 100% can be due to the slowly desaturation of the sensor
Barometer	☒ Yes ☐ No Date: 6th May 2014	☐ Yes ☒ No Date: September 2014	
Net radiometer	☒ Yes ☐ No Date: 6th May 2014	☐ Yes ☒ No Date: September 2014	The nighttime solar values are set to 0 W m^{-2}. The incoming solar radiation has to be higher than the

			outgoing one.
Pluviometer	☒ Yes ☐ No Date: 6th May 2014	☐ Yes ☒ No Date: September 2014	Whenever the air temperature is null, the values are not reliable thus conferring a Dubious flag. If when the air temperature arises up to 0°C the sensor measures a precipitation amount, this can be due to melted snow, thus conferring a Dubious flag.
Anemometer	☒ Yes ☐ No Date: 6th May 2014	☐ Yes ☒ No Date: September 2014	Whenever speed is 0 m/s and the direction is 360°, then the sensor is blocked, conferring a Bad flag. If the sensor is partially braked, the speed is low and the direction is 360° and then it varies when the air temperature increases. Generally whenever the air temperature is negative or null, a Dubious flag has to be conferred.

SECTION A5: SITE DOCUMENTATION CHECKLIST

A **Site Documentation Checklist** is provided below to track the inclusion of requisite documentation, data plots, and photos in sections A1 to A4.

Site Documentation Checklist

Site information and layout (Section A1)	☒ Included
Complete set of pictures documenting the overall site installation - views from N, E, S, W (Section A1)	☒ Included
Details of manual measurement procedure (Section A2)	☒ Included ☐ Not Applicable
Instrument Metadata Reports for all instruments under test and all instruments used to provide ancillary measurements (Section A3)	☒ Included
Calibration results and check sheets for all instruments (Sections A2, A3)	☒ Included ☐ Not yet Applicable
Instrument data validation:, 48h time series plots (Sections A2, A3)	☒ Included ☐ Not yet Applicable
Instrument data validation table (Section A4)	☒ Included ☐ Not yet Applicable
48h Instrument data validation: discrepancy reports (Section A4)	☐ Included ☒ Not yet Applicable
Pictures of installations of all reference instruments, instruments under test, and instruments used to provide ancillary measurements (Sections A2, A3)	☒ Included ☐ Not yet Applicable
End-to-end data validation (Section A4; see Instrument data validation table).	☐ Full (all gauges) ☐ Partial (some gauges) ☐ No ☒ Not yet Applicable
SPICE archive end-to-end data validation: discrepancy reports (Section A4)	☐ Yes ☐ No ☒ Not yet Applicable
Details of any workarounds (Sections A2, A3, A4)	☐ Included ☒ Not yet Applicable

APPENDIX B: SPICE DATA LEVELS AND DATASETS

Details of the different levels of data and associated datasets for SPICE are included below. **The present document addresses only data up to and including Level 2a.** Data of higher levels, and the associated datasets, are tentatively defined here for completeness.

Data Levels:

Level 1 data: are those collected as the output of each individual instrument, which have been converted into geophysical measurements (e.g. weight, mass, intensity), generally with high temporal resolution, and before any significant data quality control has been applied. A **Level 1** dataset contains data from only one instrument at one site.

Level 2a data: are time-synchronized data resulting from the sampling, averaging or some other signal/data processing having been applied to **Level 1** data from an individual instrument in order to separate signal from noise. These data have not been quality controlled, and should be used only for monitoring an instrument's status. A **Level 2a** dataset contains data from only one instrument at one site.

Level 2b data: are time-synchronized **Level 2a** data after a basic data quality control procedure has been applied. Basic data quality flags for validity and quality have been added. Missing records have been created and filled with a missing data quality indicator. A **Level 2b** dataset contains data from only one instrument at one site.

Level 3 data: derived by combining and further processing all **Level 2b** datasets from a site. At this level, advanced and multiple instrument data quality techniques have been applied. A **Level 3** dataset contains data from all instruments at an individual site.

Level 4 data: derived after performing an intercomparison of the **Level 3** data from one or more sites, taking into account snow climatology, wind regimes, temperatures, etc., and where applicable, differences in these from one site to another.

Datasets:

SPICE Site Dataset: A dataset comprising all **Level 1, 2a, 2b and 3** datasets from that Intercomparison Site.

SPICE Intercomparison Dataset: this is the Level 4 dataset that combines the **Level 3** data from all SPICE intercomparison sites. The **Project Team** will develop the **SPICE Intercomparison Dataset** using the Level 3 datasets from each **Intercomparison Site.** It contains summary Level 3 data and intercomparison data for all instruments and all sites.

The SPICE Dataset: The total SPICE dataset including all **SPICE Site Datasets**, **Site Documentation** and **Instrument Documentation** for all participating sites and instruments, the **SPICE Intercomparison Dataset,** and all SPICE analysis and assessment documentation.

APPENDIX C: ACRONYMS AND ABBREVIATIONS

DFIR	Double-Fence Intercomparison Reference
e2e	End-to-end
ER	Evaluating Representative
IOC	International Organizing Committee
IR	Installation Representative
NCAR	National Center for Atmospheric Research (USA)
POP	Proof of Performance
QC	Quality control
R0	Working field reference configuration 0: manual or automatic precipitation gauge in bush
R1	Working field reference configuration 1: manual precipitation gauge in DFIR
R2	Working field reference configuration 2: automatic weighing gauge in DFIR
R3	Working field reference configuration 3: two automatic weighing gauges; one shielded (single-Alter), one unshielded
SPICE	Solid Precipitation Intercomparison Experiment
SWE	Snow water equivalent
WG	Weighing gauge
WMO	World Meteorological Organization