NEPAL

WMO SPICE
SITE COMMISSIONING PROTOCOL

PYRAMID LABORATORY

Site Manager: Elisa Vuillermoz elisa.vuillermoz@evk2cnr.org
Assistant Intern: Antonella Senese antonella.senese@unimi.it
Ev-K2-CNR
Via San Bernardino 145 - Bergamo (Italy)

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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 density record** (performed according to the AINEVA protocol, see www.AINEVA.it).
    Data output frequency to be transfer to NCAR: 1 measurement per snowfall event once a day
  - Snow data on the ground from **4 graduated stakes** (installed on 1st June 2014 near the permanent automatic weather station). Graduated stake features cm graduations.
    Data output frequency to be transfer to NCAR: 1 measurement every hour during a snow fall event.
  - Snow on the ground data from **hourly camera observations of the graduated stake** taken both by an automatic camera and by local personnel. Photography and video equipment are useful for recording and archival of site conditions.
    Data output frequency to be transfer to NCAR: 1 picture every hour.
- Instruments under test provided by the host:
  - Snow on the ground data from **2 Sommer sonic ranger USH-8** sensors (one already present at the AWS and one installed in May 2014)

Data output frequency to be transfer to NCAR: 1 value every minute.

- Ancillary measurements(active since October 2000 and recorded by an automatic weather station called **AWS1 Pyramid**, see http://www.evk2cnr.org/cms/en/share/monitoring-stations):
  - Precipitation occurrence /rain
  - Atmospheric pressure
  - Air Temperature
  - Relative humidity
  - Wind speed/direction at 5 m height;
  - Soil temperature (-5 cm and -20 cm)
  - Soil Moisture
  - Soil heat flux
  - Net radiation (SW and LW)

For the SPICE experiment at the Pyramid International Laboratory Observatory site the sample interval we applied is 1 min for both the standard meteorological parameters and snow depth data. We applied such interval since it seems adequate to the SPICE instrument we installed. The data loggers are two E-logs (Lsi-Lastem).
A constant presence of local staff guarantees that in case the tele-transmission of the acquired data should be interrupted for a few period, the local staff will provide to store all data without losses until the maintenance activities will be performed.

3.2 COMMUNICATION INTERFACES

AWS1 Pyramid is connected with radio communication link. Data transfer is automatically done by radio modem to AWS data receiving server. Data is then uploaded to Italian server via VSAT connection and visualized on web site (limited graphic visualisation). Real time data are downloaded with 10 minutes interval.

For the SPICE Experiment after downloading, data will be subjected to a quality check and validation and will be firstly stored in the SHARE data base and then periodically (every four months) sent to SPICE data base. Moreover is available a web cam showing general view toward valley which image are updated on the server every 3 minutes.
During the snowfall, local technicians would regularly check (every hour) the snow level signed on the graduated rod and at the same time they will take a picture.
Data coming from the manual observations will be sent to Italy office and then sent periodically (every month) to SPICE data base.

3.3 SPICE SITE PROJECT TEAM

- *Elisa Vuillermoz* is the AWS at the Pyramid International Laboratory Observatory site manager. She's coordinator of scientific activities promoted by Ev-K2-CNR Association (Bergamo, Italy) in particular she is responsible of the SHARE – Stations at High Altitude for Research on the Environments- project. PhD in Earth Sciences at University of Milan.
- *Antonella Senese*, post doc scientist, takes care AWS data processing, quality check and validation according to the SHARE protocol
.-*Daniele Bocchiola,* Assistant professor of Mountain Hydrology at Department of Civil and Environmental Engineering (DICA) at Politecnico di Milano, is responsible of the set up of a hydrological modelling framework for Koshi Basin (Kumbu Valley, Nepal).
-*Giacomo Agrillo*, fellowship at Institute of Atmospheric Sciences and Climate (ISAC) of the Italian National Research Council(CNR). He is in charge for the execution of QC/QA for the AWS data as well as data processing and analysis in the framework of the SHARE and NextData Projects.
- *Gian Pietro Verza* and *Marcello Alborghetti*, both technicians at Ev-K2-CNR Committee, are responsible of the periodic quality check and maintenance activities of SHARE AWS network, including the AWS installed at Pyramid. They are also responsible of data transmission in real time from AWS to Pyramid server.
- 9 Local technicians (*Laxman Adhikari, Kaji Bista, Pema Sherpa, Tenzing Chhottar Sherpa, Lhakpa Tshering Sherpa, Lakpa Tenzi Sherpa, Sarki Dorjee Tamang, Tshering Dorjee Sherpa, Sonam Tharkey*), are responsible of manual observations and work in synergy with the Ev-K2-CNR technician to guarantee the right working of the stations.

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

The AWS Pyramid is already installed and has been running since October 2000, even if different experimental set-up were adopted throughout the years.
Snow data have measured since 2002 by a ultrasonic snow depth ranger Sommer USH-8. For SPICE experiment this sensor will continue to work and it will be put beside by a graduated rod to measure the snow level.
The 4 graduated rods were installed near the permanent AWS in June 2014.
In the same period, an additional new ultrasonic snow depth ranger Sommer USH-8 was installed in May 2014 in order to compare the results of the sensors.

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 established a simple procedure for monitoring the performance of the instruments:

- every day AWS data will be visually inspected by using an NRT data delivery/plotting system
- every day is scheduled a AWS data check after the daily downloading.
- every 3 minutes the web cam image is updated.

During the snowfall, local technician every hour will sign the snow level read on the graduated rod and will take a picture. In this case, every day, data coming from manual observations will be sent to researchers and compared with the snow level sensor data.
In the case the remote downloading would be impossible data from the AWS will be manually downloaded once a day by local technicians, and transferred to the research groups.
In the case data quality checking would reveal errors or problems, local technician will perform a technical intervention with the remote assistance of the research groups.
A monthly report of ordinary check and special technical intervention will be produced and stored in the SPICE data base.

4.2.3 SITE MAINTENANCE

The SPICE Site Manager and technicians ensure regular check of data and guarantee the timely intervention in case of sensor malfunctioning in order to limit the periods of 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 Pyramid
Reference town	Lobuche/SoluKhumbu/ Nepal
Station latitude	27°57’32.17”N;
Station longitude	86°48’47.23”E
Station elevation in metres	5050 m a.s.l.

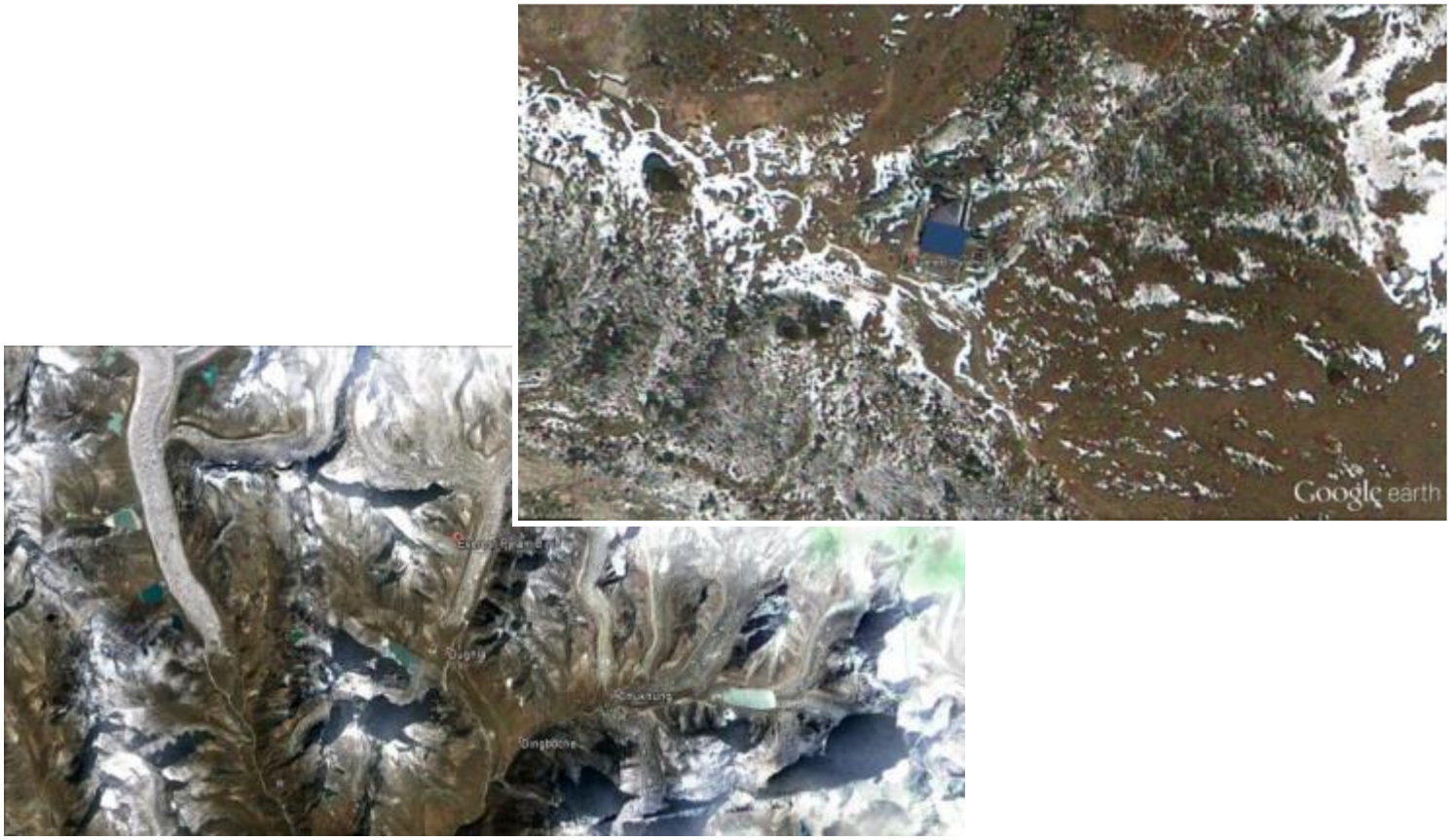


FIGURE 1: Location (red point) of the AWS1 Pyramid.

The AWS1 Pyramid (Figs. from 1 to 8) was installed on September 2000 and data of standard meteorological parameters are available from October 1, 2000. Later, in 2004 the station has been equipped with additional sensors including the ultrasonic snow level measurement. From the installation time, the AWS1 Pyramid was regularly checked both from local technicians and from Italian technicians in order to guarantee the regular operation.
The AWS is currently equipped with two loggers, both E-log (LSI-Lastem). In the following the configuration currently in use is described.

The E-log1, installed on a pole of 5 m height records the following parameters: air temperature and relative humidity, atmospheric pressure, wind speed and direction, total precipitation and global solar radiation. The E-Log2, installed on a pole of 2 m height, records the following parameters: four components of the radiation budget (longwave in and out, shortwave in and out), soil temperature (at -5 and -20 cm), soil moisture and heat flux (at -5 cm) and snow level.

Power is supplied by two solar panels (40 Watt) and a lead gel 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 by data-loggers over a 60-minute time period for most of the sensors (see the fourth column in Table 1), 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. The AWS is online through reliable UHF radiomodem link. The radio we use are synthesized radio modem devices, handling point to point serial communication, 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.

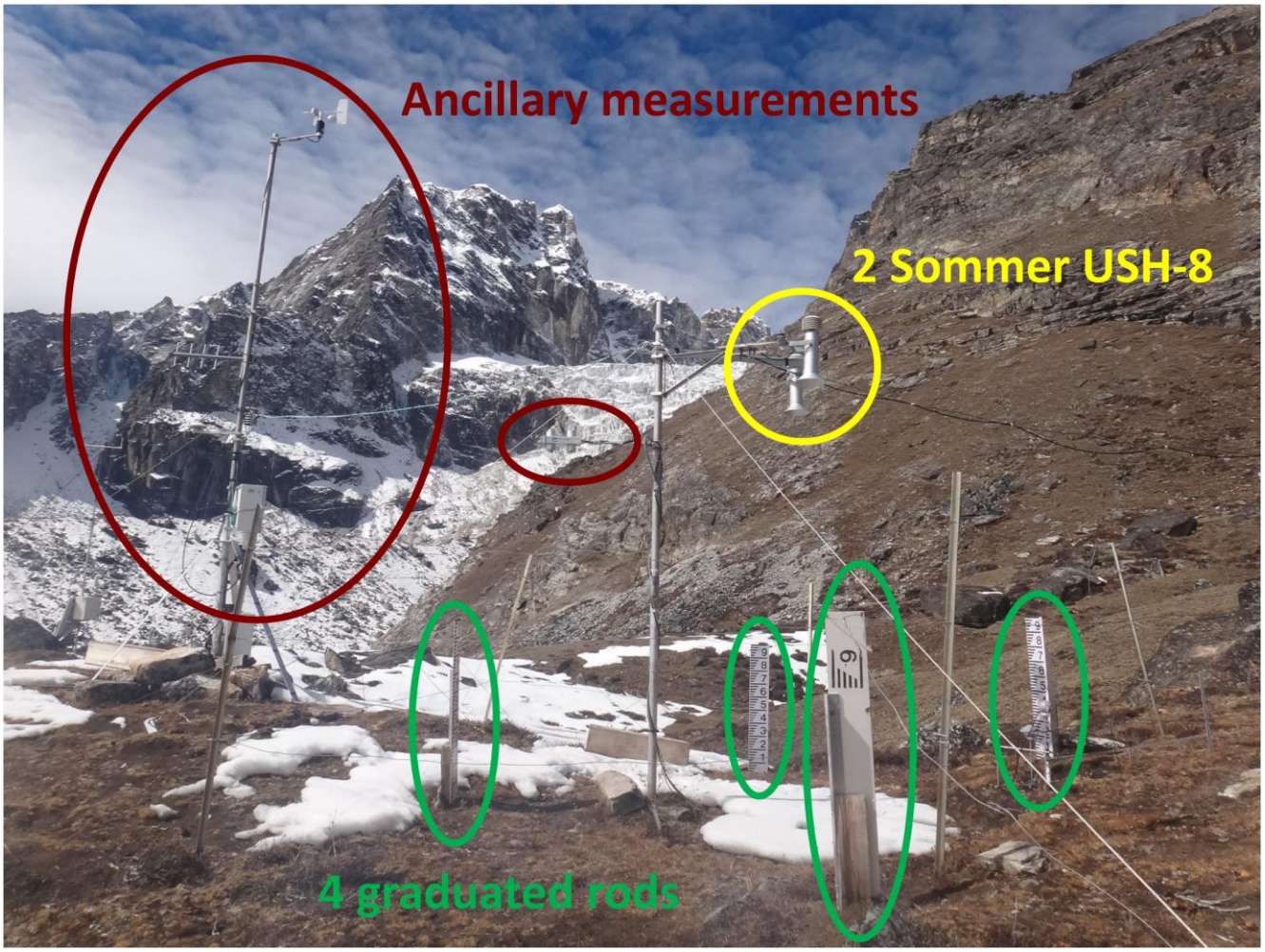


FIGURE 2: AWS Pyramid.

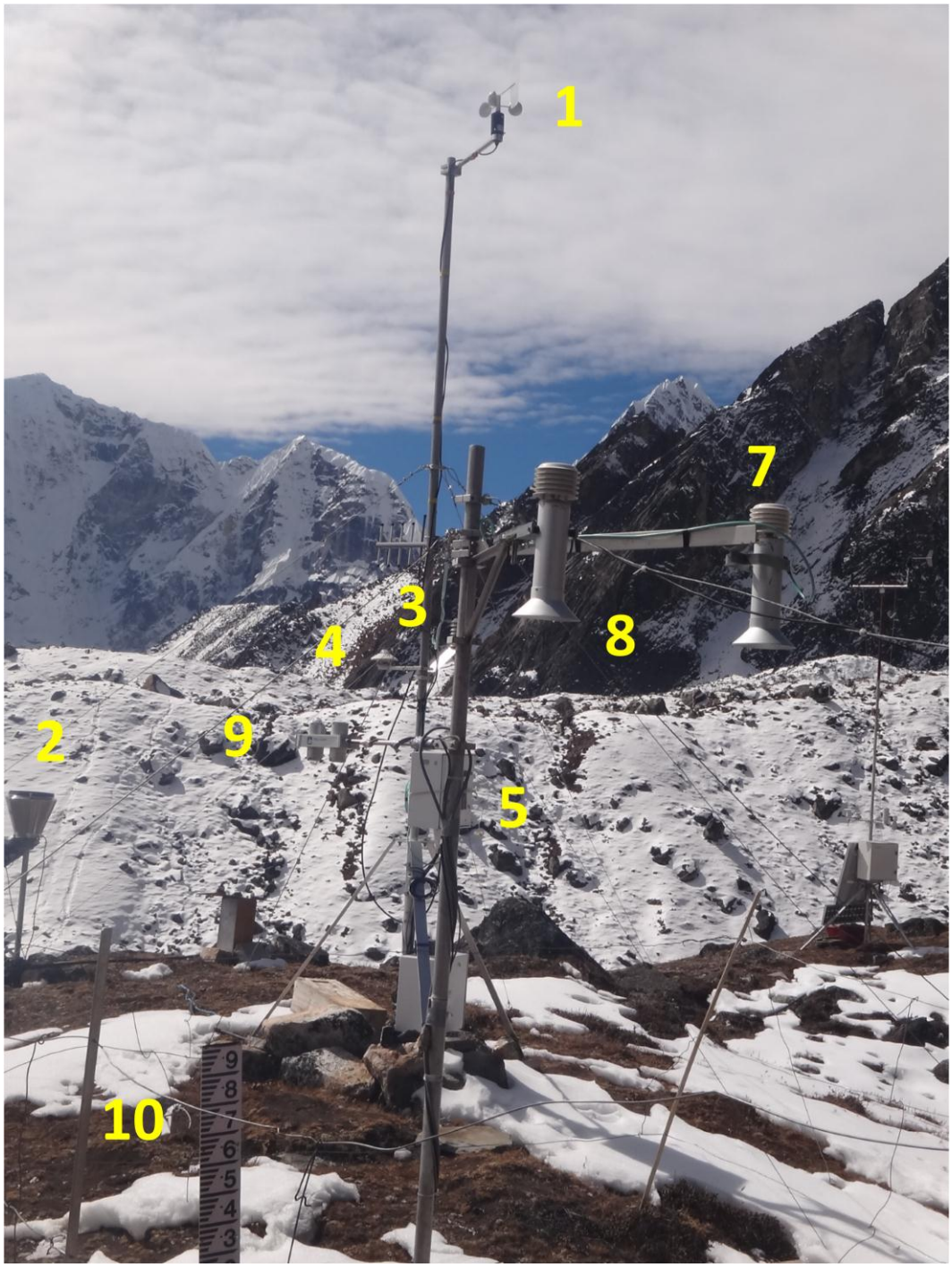


FIGURE 3: AWS Pyramid scheme underling the position of the instruments. (1) Wind speed and direction, (2) rain gauge, (3) Thermo-hygrometer, (4) global radiation, (5) pressure sensor inside the datalogger box 1, (6) solar panels, (7 and 8) Sommer snow level sensors, (9) net radiation CNR1, (10) graduated rods.

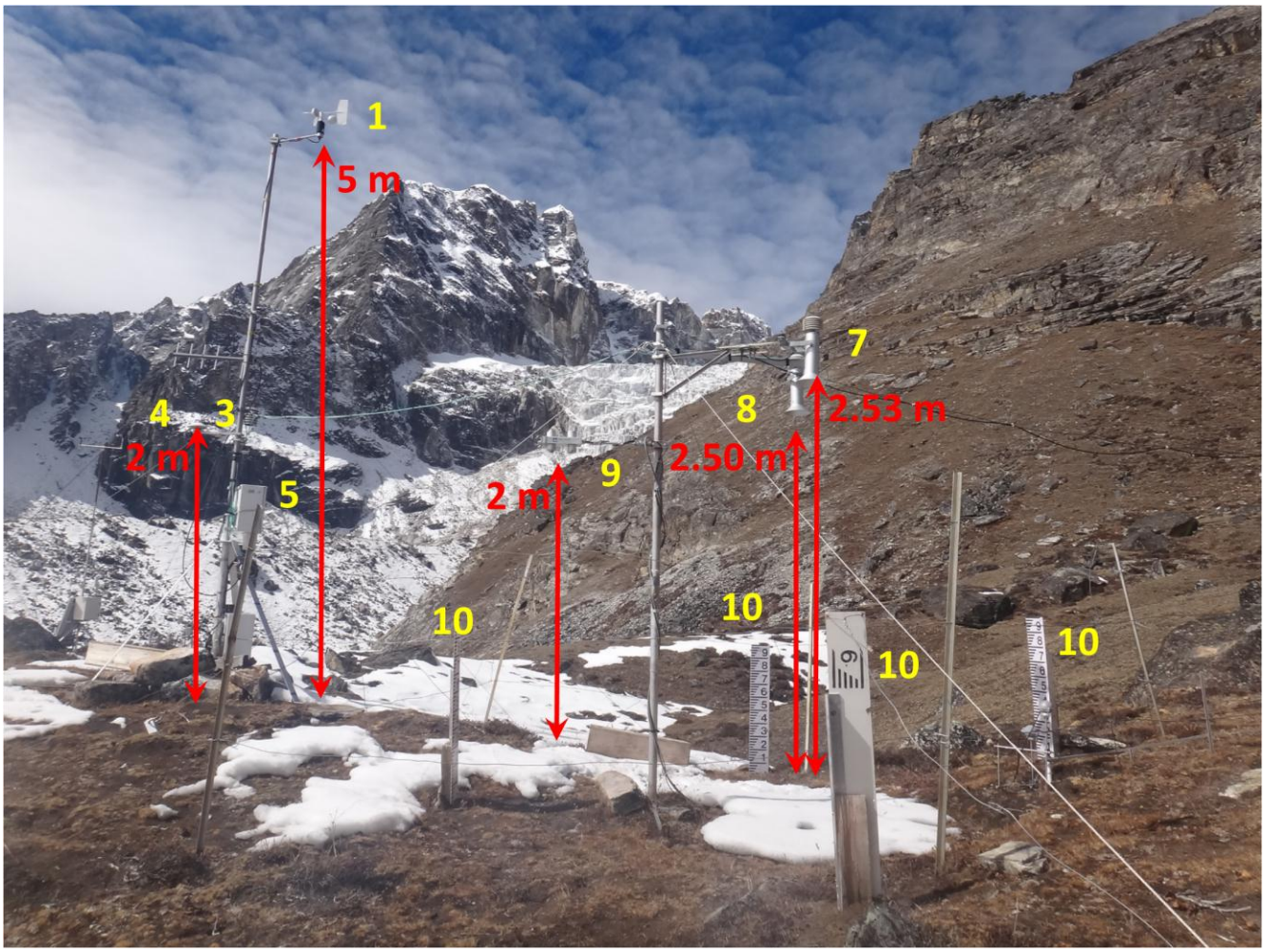
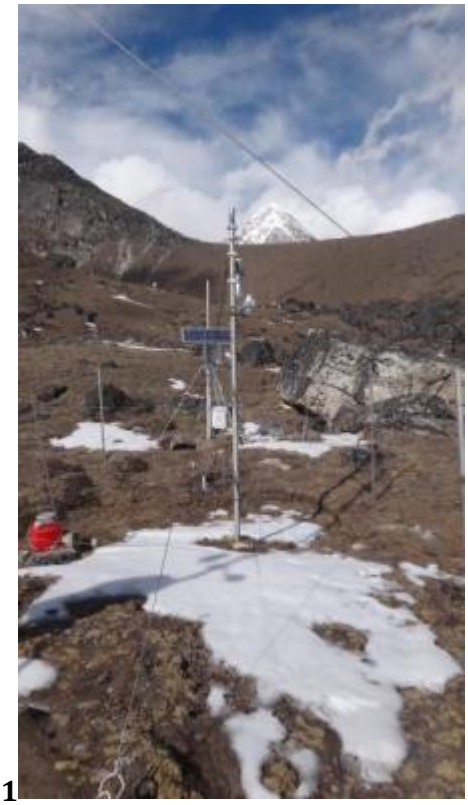


FIGURE 4: AWS Pyramid scheme underling the position of the instruments and the distance of the instruments from the surface. (1) Wind speed and direction, (2) rain gauge, (3) Thermo-hygrometer, (4) global radiation, (5) pressure sensor inside the datalogger box 1, (6) solar panels, (7 and 8) Sommer snow level sensors, (9) net radiation CNR1, (10) graduated rods


1


2


3


4

FIGURA 5: Complete set of pictures documenting the overall site installation - views from N (1), S (2),E (3), W (4).

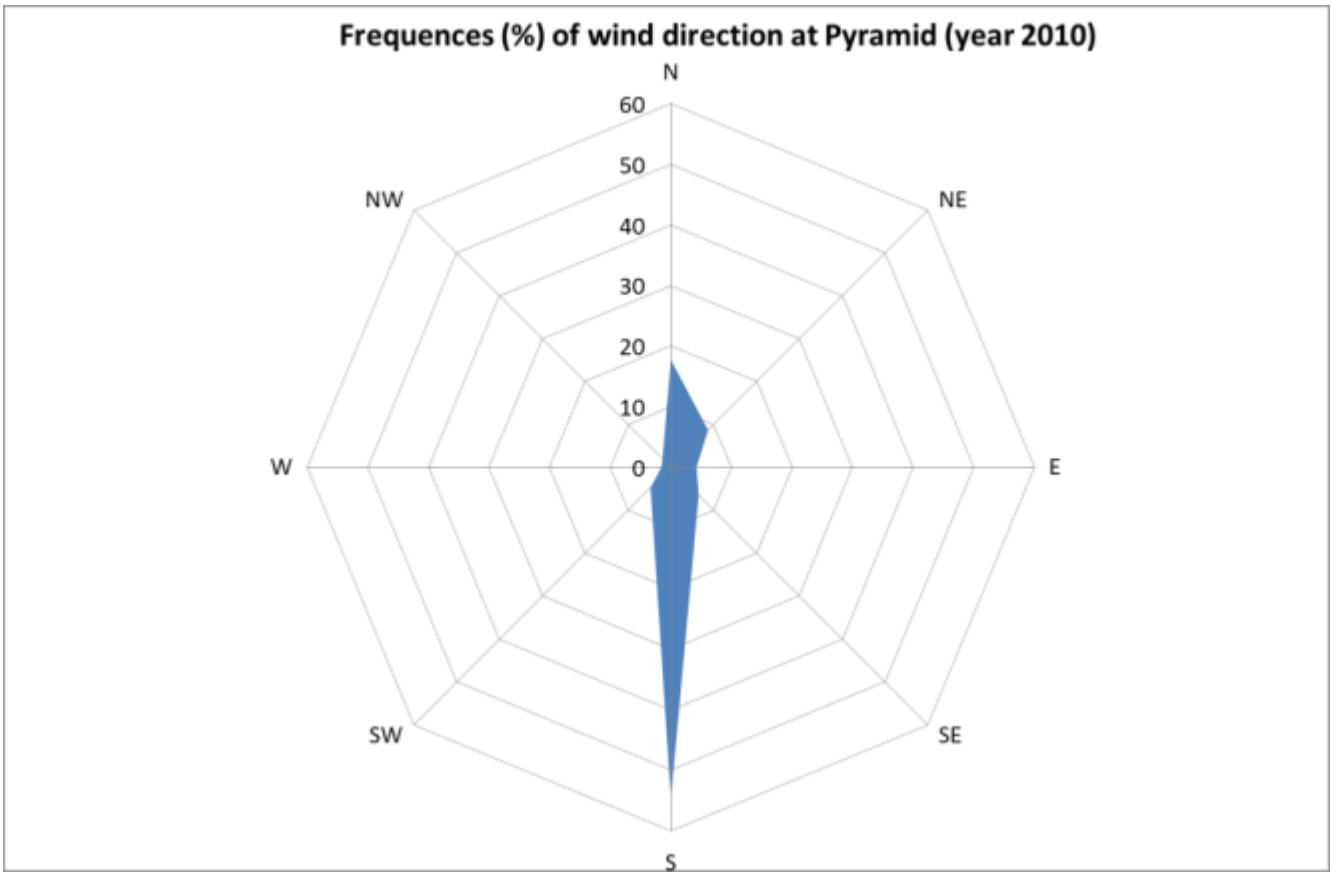


FIGURE 6: The frequency of dominant wind direction of provenance observed at the AWS1.

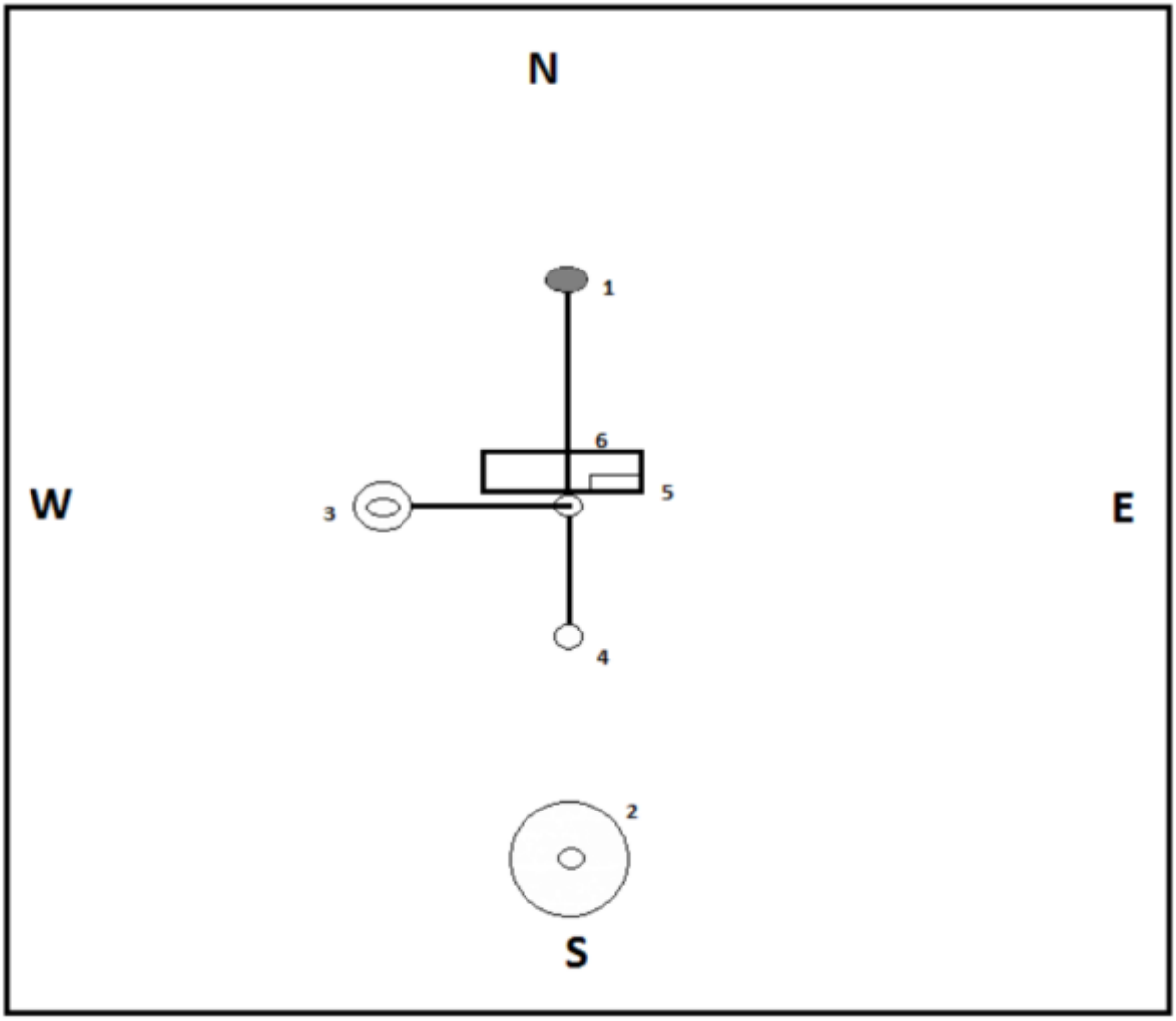


FIGURE 7: Sky view of AWS1 Pyramid instruments installed on the pole with E-Log1 logger. The instrument are marked with numbers:(1) wind speed and direction, (2) rain gauge, (3) thermo-hygrometer, (4) global radiation, (5) pressure sensor inside the datalogger box , (6) solar panels.

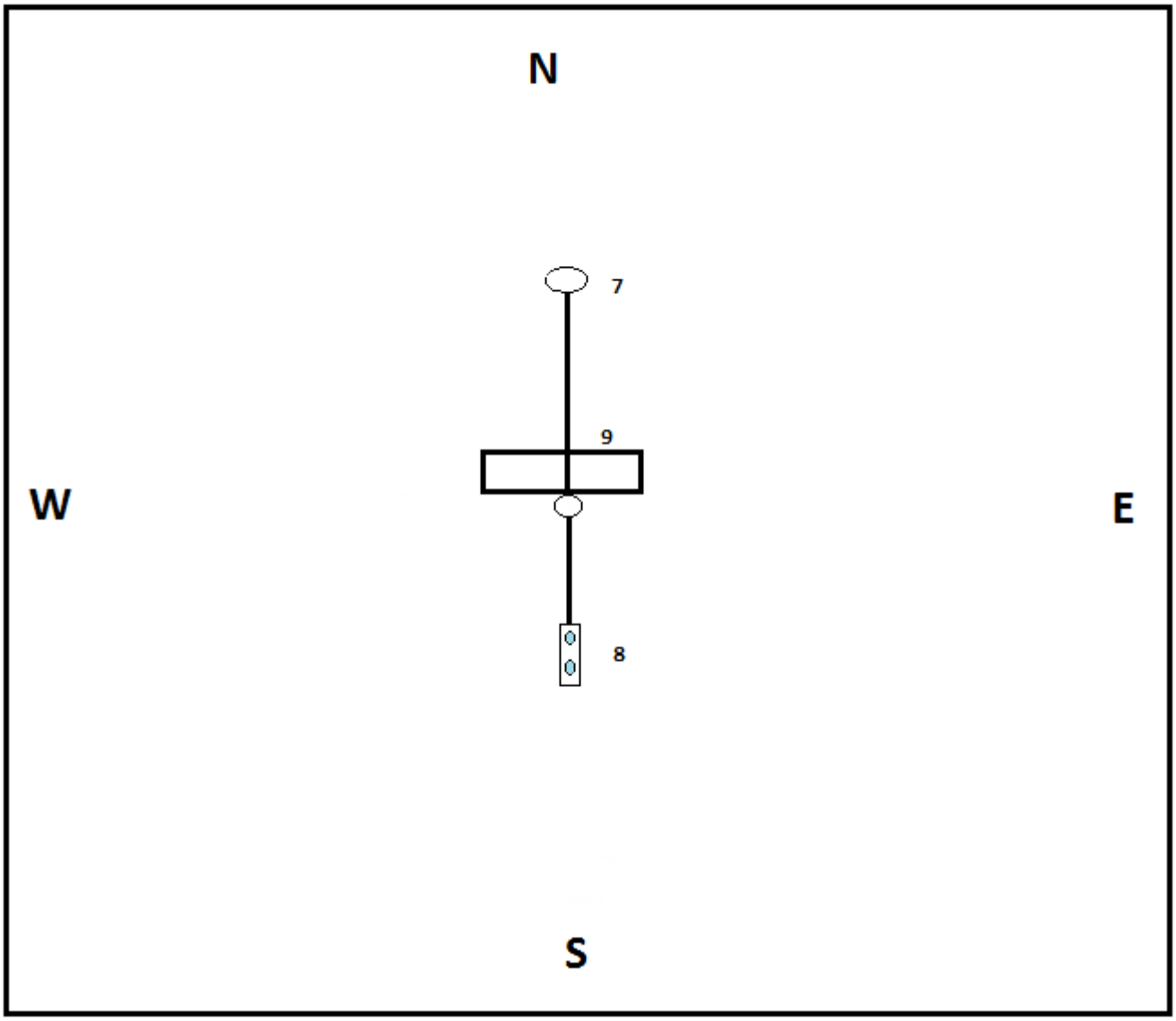


FIGURE 8: Sky view of AWS1 Pyramid instruments installed on the pole with E-log2 logger. (7) snow level, (8) net radiometer CNR1, (9) Datalogger E-log

SECTION A2: SPICE FIELD WORKING REFERENCE SYSTEM CONFIGURATION

Field Reference for the Measurement of Snow on the Ground

Method used	**Snow density**
Equipment used	**Following AINEVA protocol**
Frequency of measurement	**Every snowfall event**

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

FIGURE 9: Detailed pictures of a field snow density survey close the AWS1 Pyramid. The thickness (h_{snow}) and the snow density (ρ_{snow}) are measured for estimating the snow water equivalent of each layer:

$$SWE = h_{snow} \cdot \frac{\rho_{snow}}{\rho_{water}}$$

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 1st June 2014:

Sample N°	Date	Time	HN (cm)	Check SWEN ?	SWEN (g)	HS1 (cm)	HS2 (cm)	HS3 (cm)	HS4 (cm)	Temp (°C)
1	06/01/2014	08:00	13	yes	170	16(north)	10(east)	14(west)	13(south)	0.3
2	06/01/2014	09:00	13	yes	150	14(north)	9(east)	13(west)	13(south)	0.56
3	06/01/2014	10:00	15	yes	120	14(north)	9(east)	13(west)	12(south)	0.4
4	06/01/2014	11:00	12	yes	155	163(north)	8(east)	12(west)	12(south)	0.4
5	06/01/2014	12:00	12	yes	160	13(north)	8(east)	11(west)	11(south)	0.5
6	06/01/2014	13:00	13	yes	155	12(north)	7(east)	11(west)	10(south)	0.2
7	06/01/2014	14:00	12	yes	130	11(north)	7(east)	10(west)	10(south)	0.2

Field Reference for the Measurement of Snow on the Ground

Method used	**Graduated stakes photographed by the camera**
Equipment used	**4 graduated stakes**
Frequency of measurement	**Every hour during snowfall event**

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

FIGURE 10: Detailed pictures of the four graduated stakes (South, East, North, West).

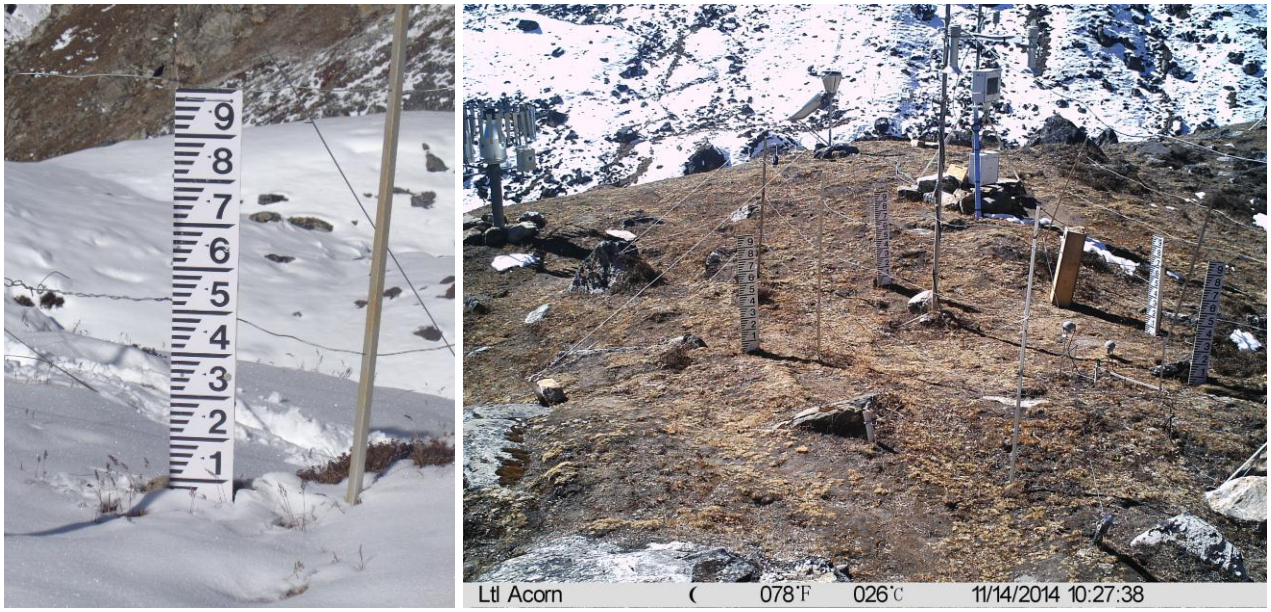


FIGURE 11: Detailed picture hourly taken by the local staff (on the left) and by the automatic camera (on the right).

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 from 4 graduated stakes close the AWS carried out on 19th October 2014:

TIME	Graduated rod 1 (East)	Graduated rod 2 (West)	Graduated rod 3 (North)	Graduated rod 4 (South)	Additional information (if any)
07:00	Snow Level (cm) 2cm Picture n° 1	Snow Level (cm) 12cm Picture n° 2	Snow Level (cm) 10cm Picture n° 3	Snow Level (cm) 8cm Picture n° 4	
08:00	Snow Level (cm) 2cm Picture n° 1	Snow Level (cm) 12cm Picture n° 2	Snow Level (cm) 10cm Picture n° 3	Snow Level (cm) 8cm Picture n° 4	
09:00	Snow Level (cm) 2cm	Snow Level (cm) 8cm	Snow Level (cm) 10cm	Snow Level (cm) 8cm	

	Picture n° 1	Picture n° 2	Picture n° 3	Picture n° 4	
10:00	Snow Level (cm)2cm Picture n° 1	Snow Level (cm)8cm Picture n° 2	Snow Level (cm) 10cm Picture n° 3	Snow Level (cm) 8cm Picture n° 4	
11:00	Snow Level (cm) 1cm Picture n° 1	Snow Level (cm)8cm Picture n° 2	Snow Level (cm) 8cm Picture n° 3	Snow Level (cm) 8cm Picture n° 4	
12:00Pm	Snow Level (cm) :- 1cm Picture n° :-1	Snow Level (cm) 7cm Picture n° :- 02	Snow Level (cm) 8cm Picture n° 3	Snow Level (cm) :- 8cm Picture n° :- 4	
13:00	Snow Level (cm):- NO snow around Picture n° :- 1	Snow Level (cm) 4cm Picture n°:-2	Snow Level (cm)):- No snow around Picture n° :- 3	Snow Level (cm) 8cm Picture n° :- 4	
14:00	Snow Level (cm) :- No snow around Picture n° :- 1	Snow Level (cm) No snow around Picture n°:- 2	Snow Level (cm) :- No snow around Picture n° :-3	Snow Level (cm) 8cm Picture n° :- 4	
15:00	Snow Level (cm) :- NO snow around Picture n°:- 1	Snow Level (cm) NO snow around Picture n°:-2	Snow Level (cm) :- NO snow around Picture n° :- 3	Snow Level (cm) 8cm Picture n° :- 4	
16:00	Snow Level (cm) No snow around Picture n° :- 1	Snow Level (cm) No snow around Picture n° :- 2	Snow Level (cm) :- No snow around Picture n° :- 3	Snow Level (cm) 8cm Picture n° -4	
17:00	Snow Level (cm) :- No snow around Picture n°:-1	Snow Level (cm) NO snow around Picture n° :- 2	Snow Level (cm) :- No snow around Picture n° :- 3	Snow Level (cm) 7cm Picture n°:- 4	

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 Sommer USH-8**
Instrument number 1 of 2

Manufacturer	Sommer
Model	USH-8
Serial number	29080442
Firmware version (if applicable)	NA

Field configuration

Location on site	At the AWS1 Pyramid (8 in Fig. 3)
Orientation	North
Height (measured at top)	2.53 m
Shield (if applicable)	NA
Heating (if applicable)	Unheated

Data output

Data communication protocol	Analogic
Output data message format (include description of fields)	SNOWLev (mm) Msr.6 Inp.6 Min Ave Max StdDev ValidDataPerc
Data sampling frequency	1 minute
Data output to NCAR	1 min

Specification of the snow level sensor

Range	0 – 8 m
Accuracy	±0.1% FS

Instrument Picture.

FIGURE 12: Detailed picture of the Sommer sonic ranger 1 (in the yellow circle).

Field calibration (if any).

Date -18/11/2014	
1st Test 104cm	
Time	**Sommer**
10:13	106.4
10:14	106.4
10:15	106.4
10:16	106.4
10:17	106.4
2nd Test 123cm	
Time	**Sommer**
10:26	126.1
10:27	126.2
10:28	126.2
10:29	126.1
10:30	126.2
10:31	126.3
3rd Test 7cm	
Time	**Sommer**
11:15	8.2
11:16	8
11:17	8
11:18	8.1
11:19	8.1
11:20	8.1

48h Plot.

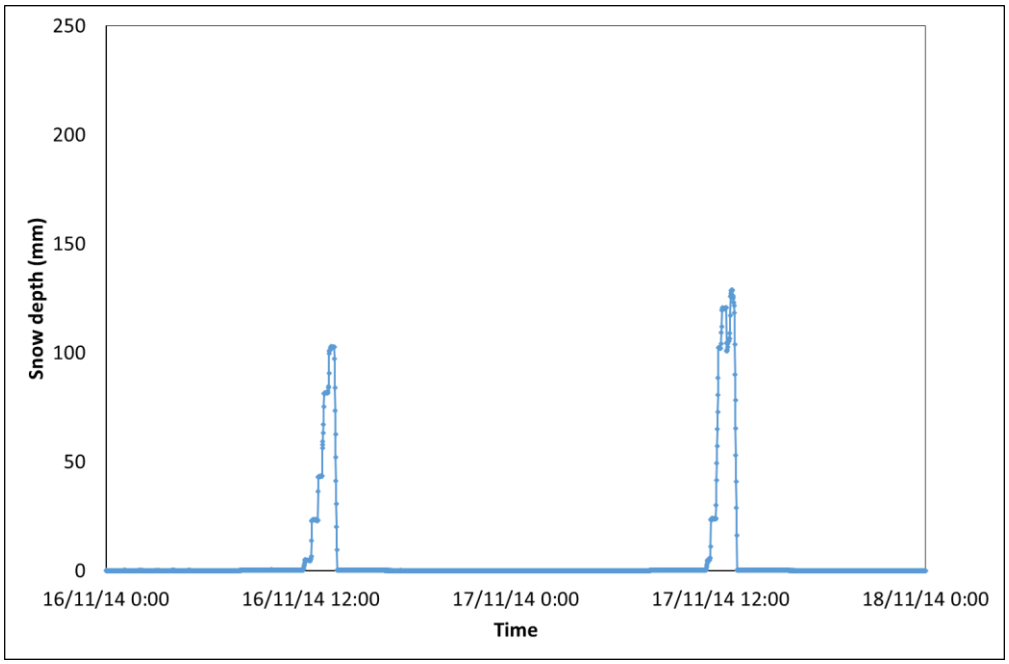


FIGURE 13: Plot showing a test with 48h of Sommer 1 readings recorded from 16th to 17th November 2014.

Instrument Name: **Sonic Ranger Sommer USH-8**
Instrument number 2 of 2

Manufacturer	Sommer
Model	USH-8
Serial number	37120859
Firmware version (if applicable)	NA

Field configuration

Location on site	At the AWS1 Pyramid (7 in Fig. 3)
Orientation	North
Height (measured at top)	2.50 m
Shield (if applicable)	NA
Heating (if applicable)	Unheated

Data output

Data communication protocol	Analogic
Output data message format (include description of fields)	SNOWLev2 (m) Msr.8 Inp.6 Min Ave Max StdDev ValidDataPerc
Data sampling frequency	1 minutes
Data output to NCAR	1 min

Specification of the snow level sensor

Range	0 – 8 m
Accuracy	±0.1% FS

Instrument Picture.

FIGURE 14: Detailed picture of the Sommer sonic ranger 2 (in the yellow circle).

Field calibration (if any).

Date -18/11/2014	
1st Test 104cm	
Time	**Sommer**
10:11	101.7
10:12	101.7
10:13	101.7
10:14	101.7
10:15	101.7
10:16	101.7
10:17	101.7
2nd Test 123cm	
Time	**Sommer**
10:27	121.3
10:28	121.3
10:29	121.2
10:30	121.2
10:31	121.2
3rd Test 7cm	
Time	**Sommer**
11:16	4.4
11:17	4.4
11:18	4.4
11:19	4.3
11:20	4.2

48h Plot.

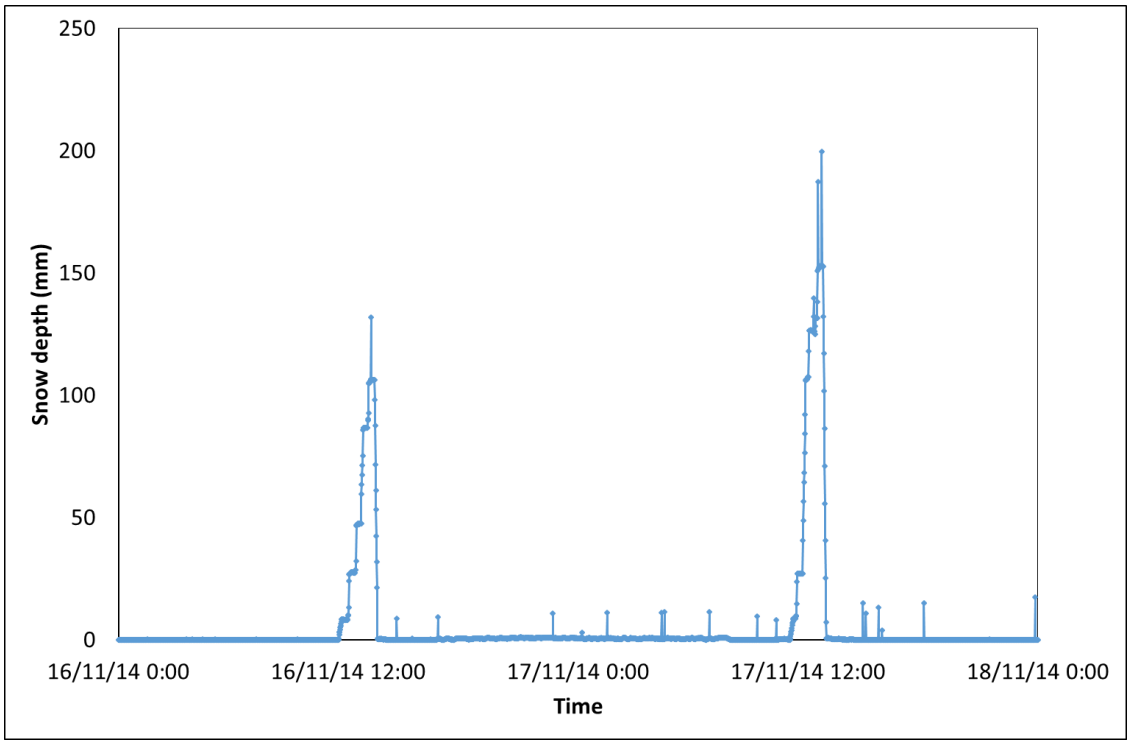


FIGURE 15: Plot showing a test with 48h of snow depth recorded by the Sommer 2 from 16th to 17th November 2014.

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 Pyramid (3 in Fig. 3)
Orientation	West
Height (measured at top)	2 m from the 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)	AIR Temp	('C)	Msr.2	Inp.2		REL Humidity	(%)	Msr.3	Inp.1	
	Min	Ave	Max	Std Dev	Valid Data Perc	Min	Ave	Max	Std Dev	Valid Data Perc
Data sampling frequency	1 min									
Data output to NCAR	1 min									

Specification of the temperature sensor

Range	-30 - +70°C
Accuracy	±0.1°C

Specification of the relative humidity sensor

Range	0 - 100%
Accuracy	±2.5%

Instrument Picture.

FIGURE 16: Detailed picture of the thermo-hygrometer.

Field calibration (if any).

The calibration was performed by the manufacturer.

48h Plot.

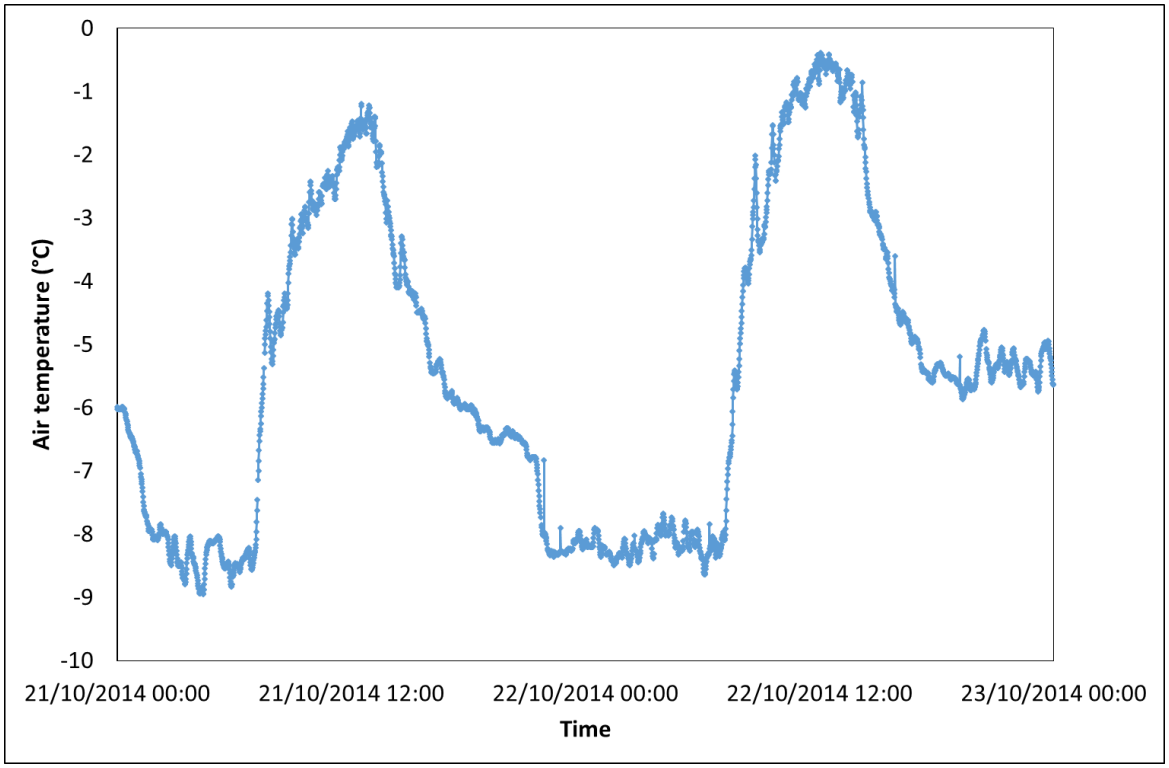


FIGURE 17: Plot showing a test with 48h of air temperature values recorded from 21st to 22nd October 2014.

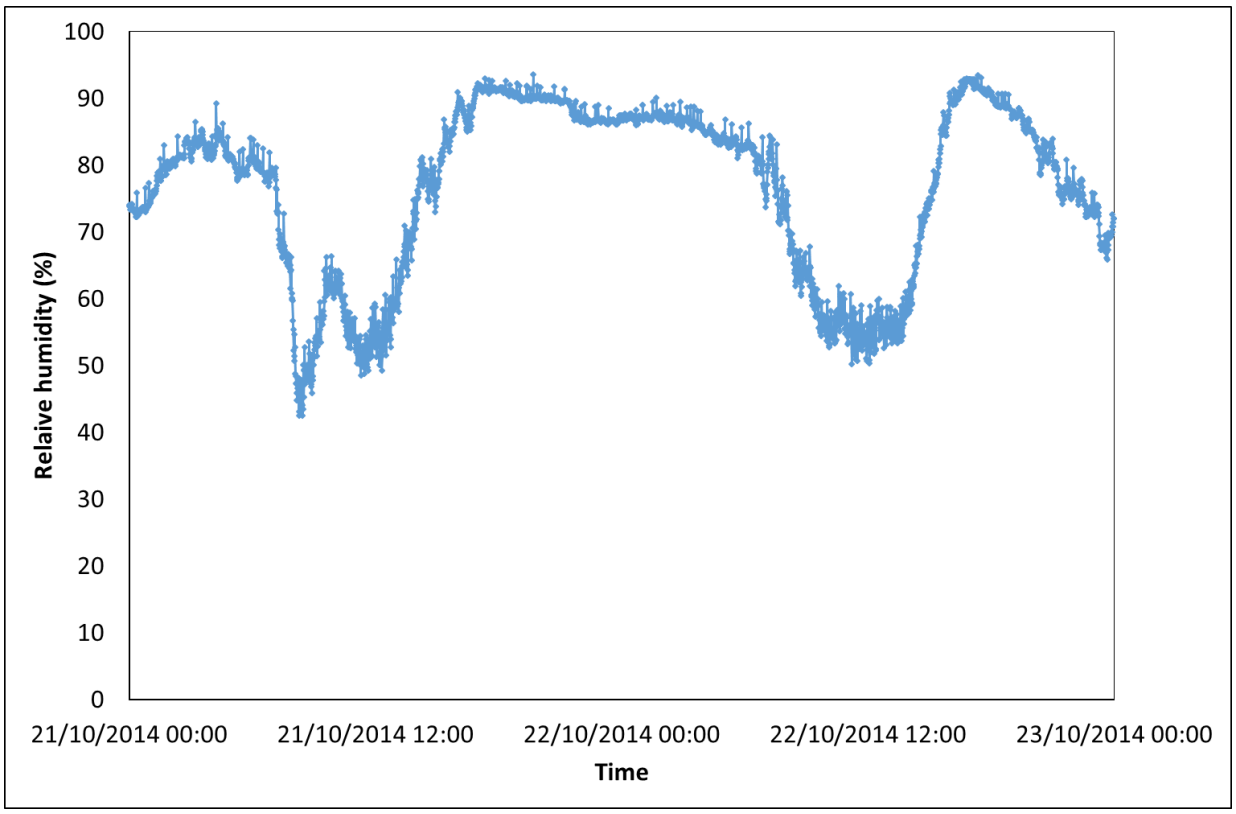


FIGURE 18: Plot showing a test with 48h of relative humidity values recorded from 21st to 22nd October 2014.

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

Manufacturer	LSI-Lastem
Model	CX115P
Serial number	/
Firmware version (if applicable)	NA

Field configuration

Location on site	Installed on the mast of the AWS1 Pyramid, inside the logger box (5 in Fig. 3)
Orientation	North
Height (measured at top)	2 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)	ATMPressure	(hPa)	Msr.1	Inp.3		
	Min	Ave	Max	StdDev	ValidDataPerc	
Data sampling frequency	1 min					
Data output to NCAR	1 min					

Specification of the pressure sensor

Range	500 - 800 hPa or mBar
Accuracy	±1hPa

Instrument Picture.

FIGURE 19: Detailed picture of the barometer.

Field calibration (if any).

The calibration was performed by the manufacturer.

48h Plot.

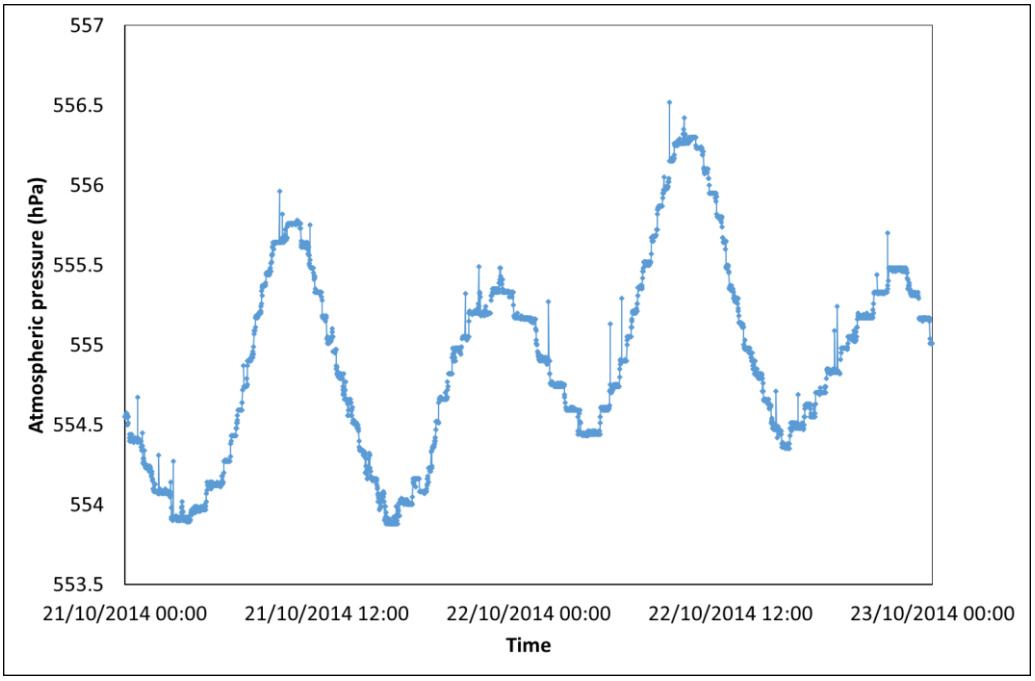


FIGURE 20: Plot showing a test with 48h of atmospheric pressure values recorded from 21st to 22nd October 2014.

Instrument Name: **Soil heat flux**
Instrument number 1 of 1

Manufacturer	LSI-Lastem
Model	DPE260
Serial number	/
Firmware version (if applicable)	NA

Field configuration

Location on site	At the AWS1 Pyramid
Orientation	/
Height	/
Shield (if applicable)	NA
Heating (if applicable)	Unheating

Data output

Data communication protocol	Analogic			
Output data message format (include description of fields)	ThermFlux	(W/m2)	Msr.9	Inp.7
	Inst	Ave	StdDev	ValidDataPerc
Data sampling frequency	1 min			
Data output to NCAR	1 min			

Specification of the pressure sensor

Range	<2000 W/m^2
Accuracy	±3%

Instrument Picture.

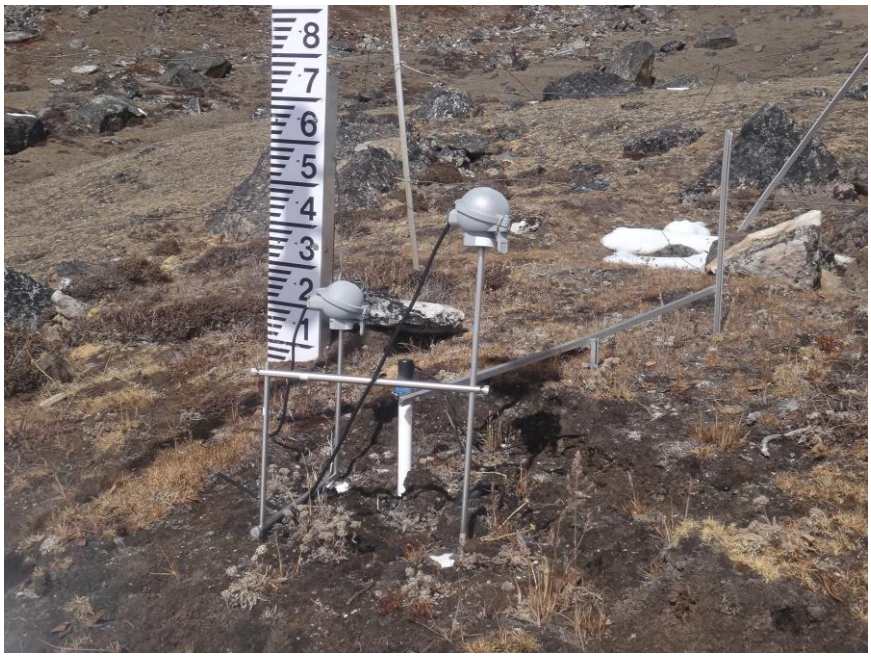


FIGURE 21: Detailed picture of the soil heat flux sensors.

Field calibration (if any).

The calibration was performed by the manufacturer.

48h Plot.

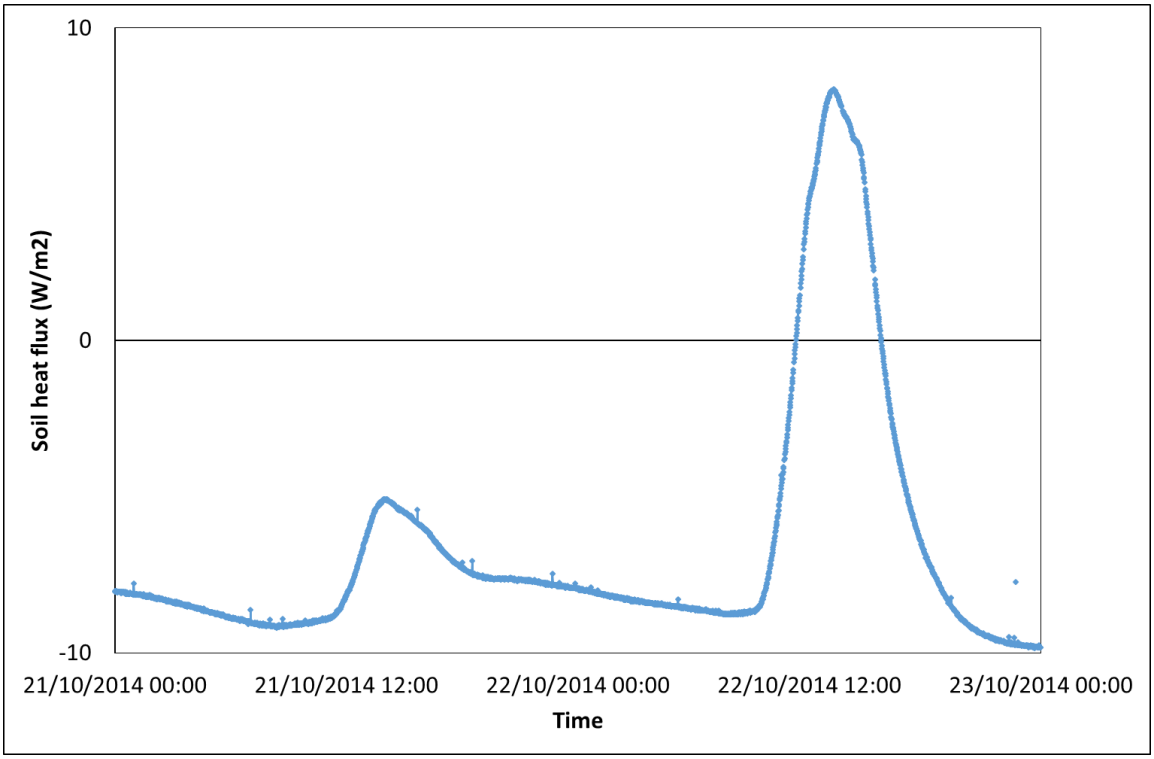


FIGURE 22: Plot showing a test with 48h of soil heat flux values recorded from 21st to 22nd October 2014.

Instrument Name: **Soil moisture**
Instrument number 1 of 1

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

Field configuration

Location on site	At the AWS1 Pyramid
Orientation	/
Height	/
Shield (if applicable)	NA
Heating (if applicable)	Unheating

Data output

Data communication protocol	Analogic
Output data message format (include description of fields)	Permettivit ('C) Msr.7 Inp.7 Inst Ave StdDev ValidDataPerc
Data sampling frequency	1 min
Data output to NCAR	1 min

Instrument Picture.

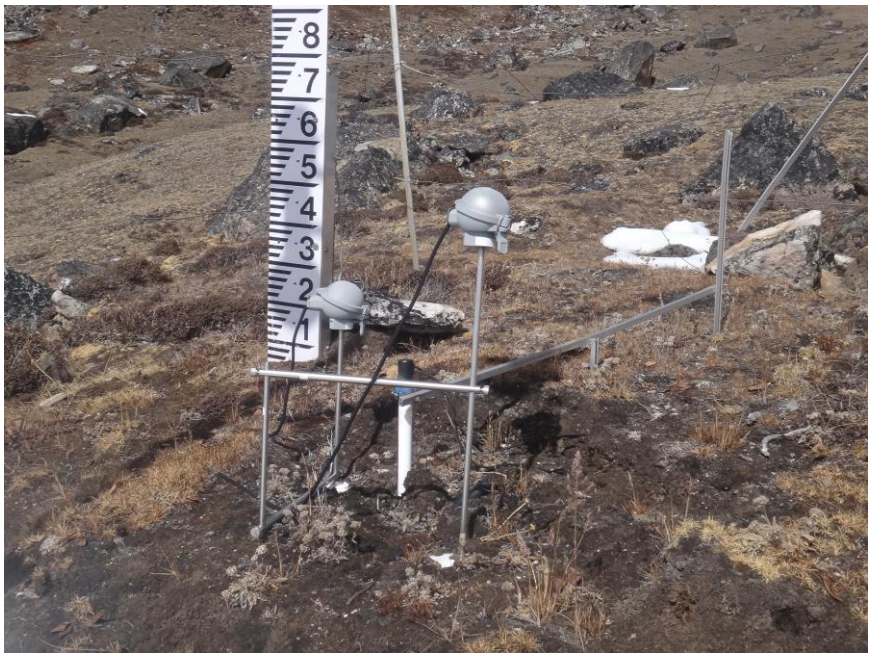


FIGURE 23: Detailed picture of the soil moisture sensors.

Field calibration (if any).

The calibration was performed by the manufacturer.

48h Plot.

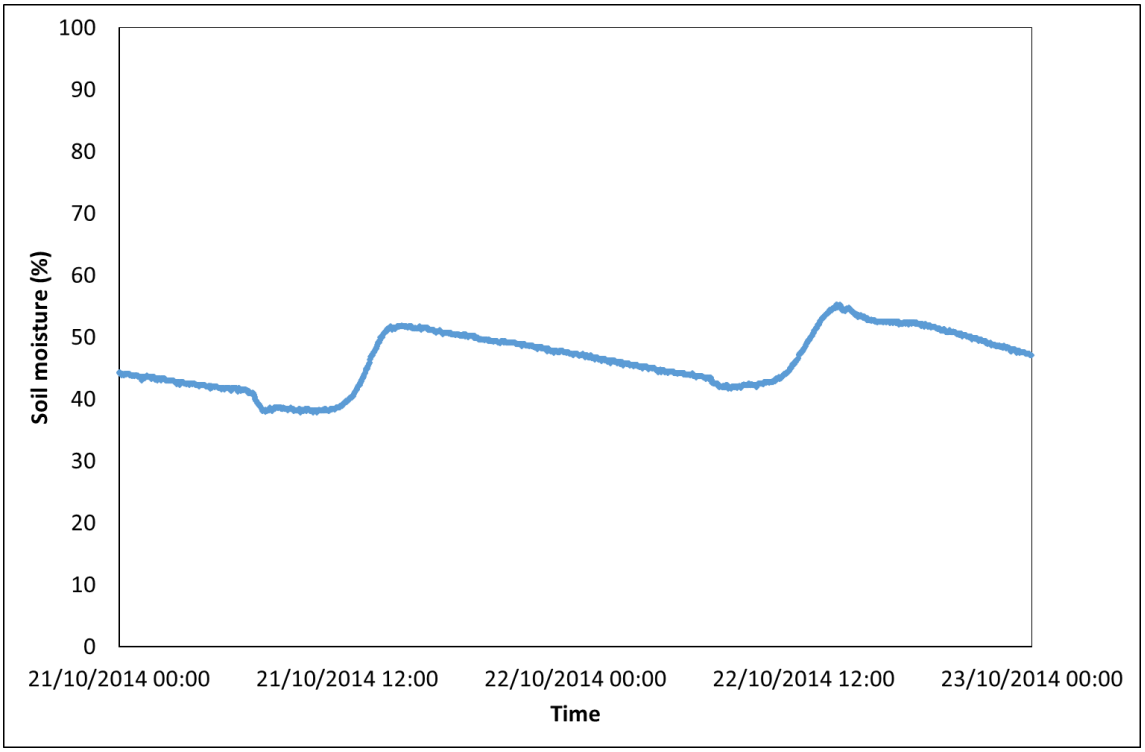


FIGURE 24: Plot showing a test with 48h of soil moisture values recorded from 21st to 22nd October 2014.

Instrument Name: **Soil temperature**
Instrument number 1 of 1

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

Field configuration

Location on site	At the AWS1 Pyramid
Orientation	/
Height	-5 and -20 cm into the soil
Shield (if applicable)	NA
Heating (if applicable)	Unheating

Data output

Data communication protocol	Analogic
Output data message format (include description of fields)	Upper SOIL ('C) Msr. 9 Inp. 7 Lower SOIL ('C) Msr. 10 Inp.8 Min Ave Max Std Dev Valid Data Perc Min Ave Max Std Dev Valid Data Perc
Data sampling frequency	1 min
Data output to NCAR	1 min

Instrument Picture.

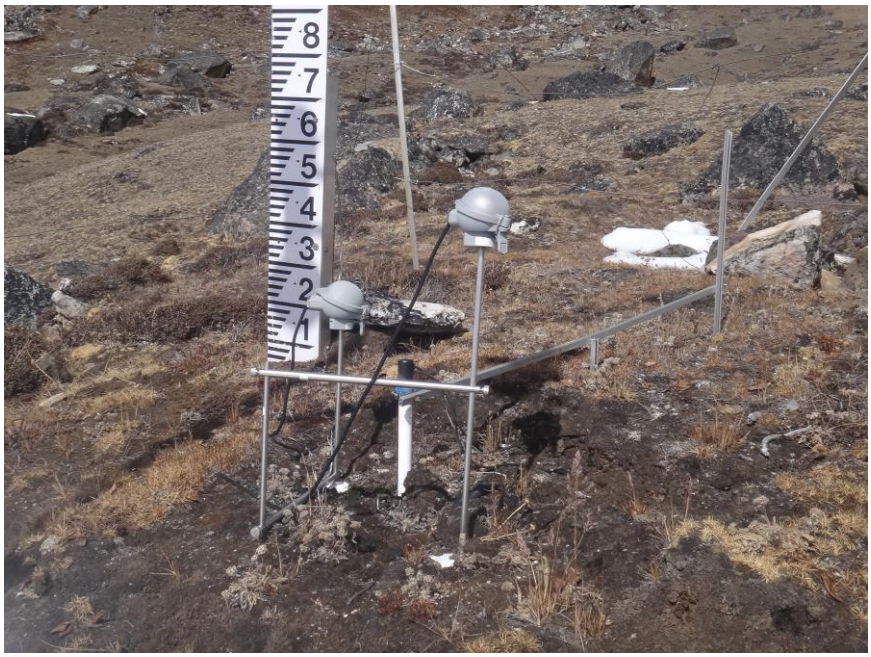


FIGURE 25: Detailed picture of the soil temperature sensors.

Field calibration (if any).

The calibration was performed by the manufacturer.

48h Plot.

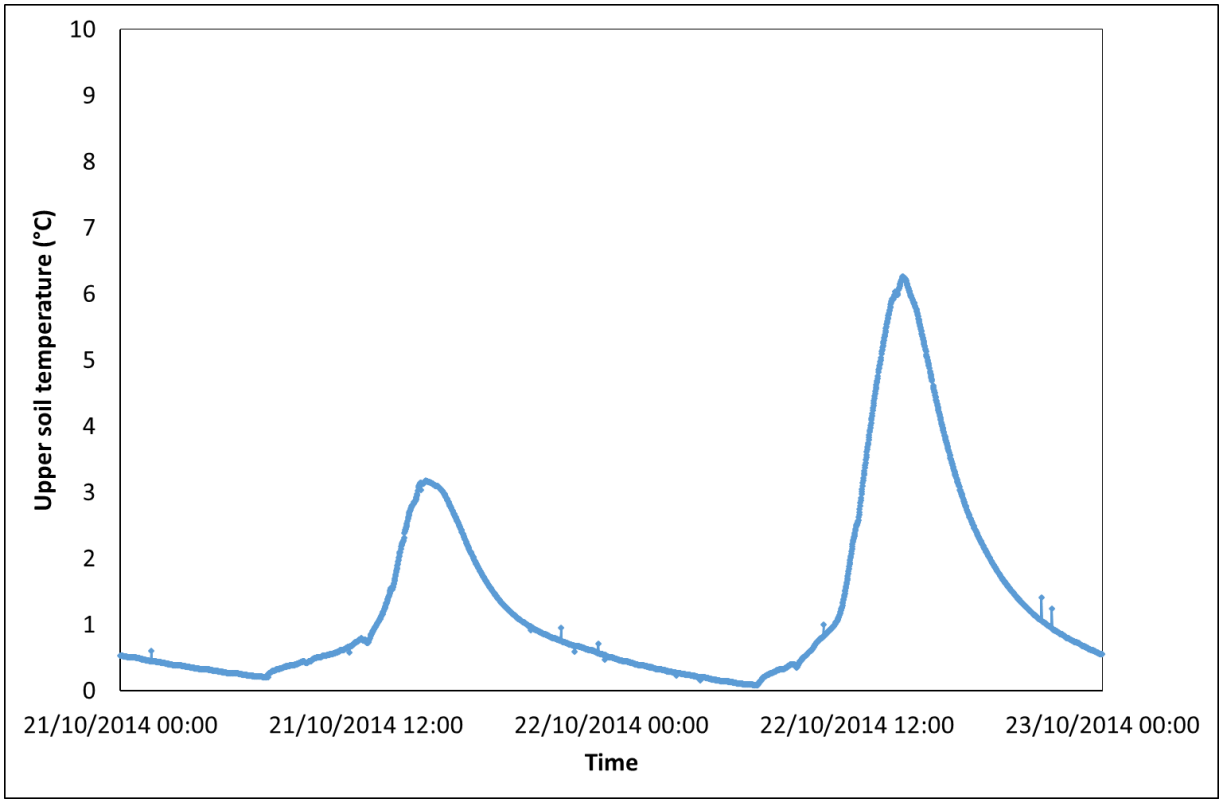


FIGURE 26: Plot showing a test with 48h of upper (-5 cm) soil temperature values recorded from 21st to 22nd October 2014.

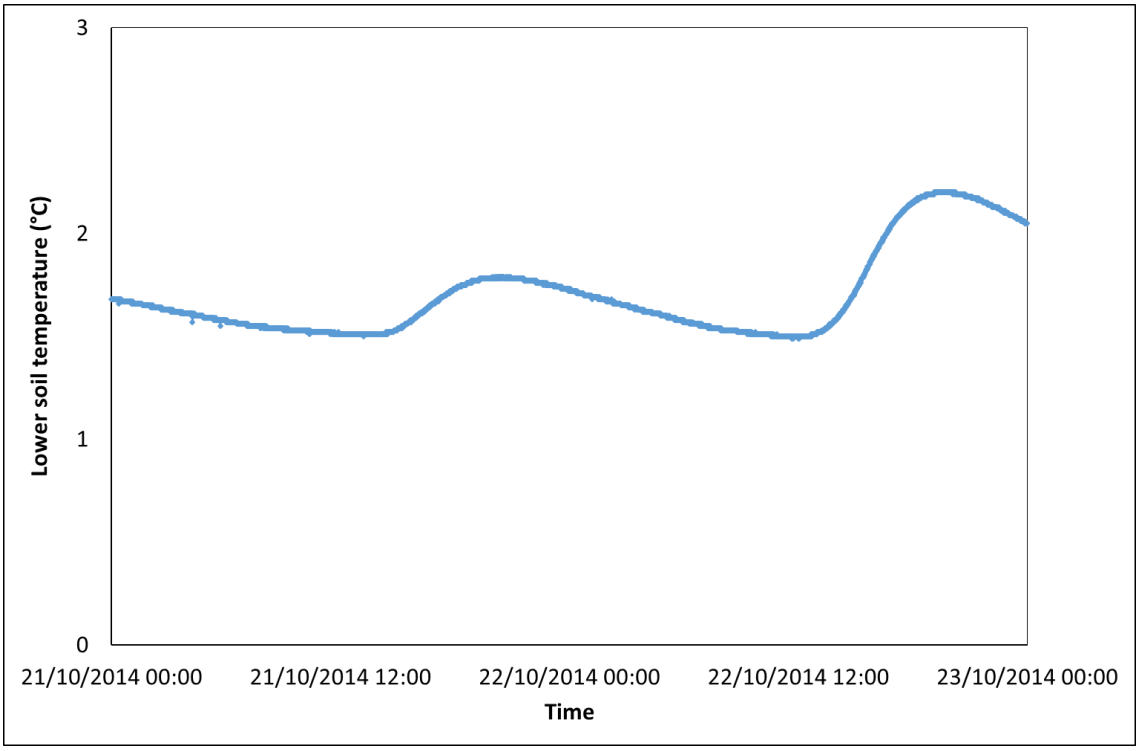


FIGURE 27: Plot showing a test with 48h of lower (-20 cm) soil temperature values recorded from 21st to 22nd October 2014.

Instrument Name: **Global Solar Radiation**
Instrument number 1 of 1

Manufacturer	Kipp and Zonen
Model	CM6B
Serial number	004569
Firmware version (if applicable)	NA

Field configuration

Location on site	Installed on the mast of the AWS1 Pyramid (4 in Fig. 3)
Orientation	South
Height (measured at top)	2 m from the surface
Shield (if applicable)	NA
Heating (if applicable)	Unheating

Data output

Data communication protocol	Analogic				
Output data message format (include description of fields)	GLOBALRad	(W/m2)	Msr.7	Inp.5	
	Min	Ave	Max	StdDev	ValidDataPerc
Data sampling frequency	1 min				
Data output to NCAR	1 min				

Specification of the solar radiation sensor

Range	0-2000 W/m^2
Accuracy	/

Instrument Picture.

FIGURE 28: Detailed picture of the Global Solar Radiation sensor.

Field calibration (if any).

The calibration was performed by the manufacturer.

48h Plot.

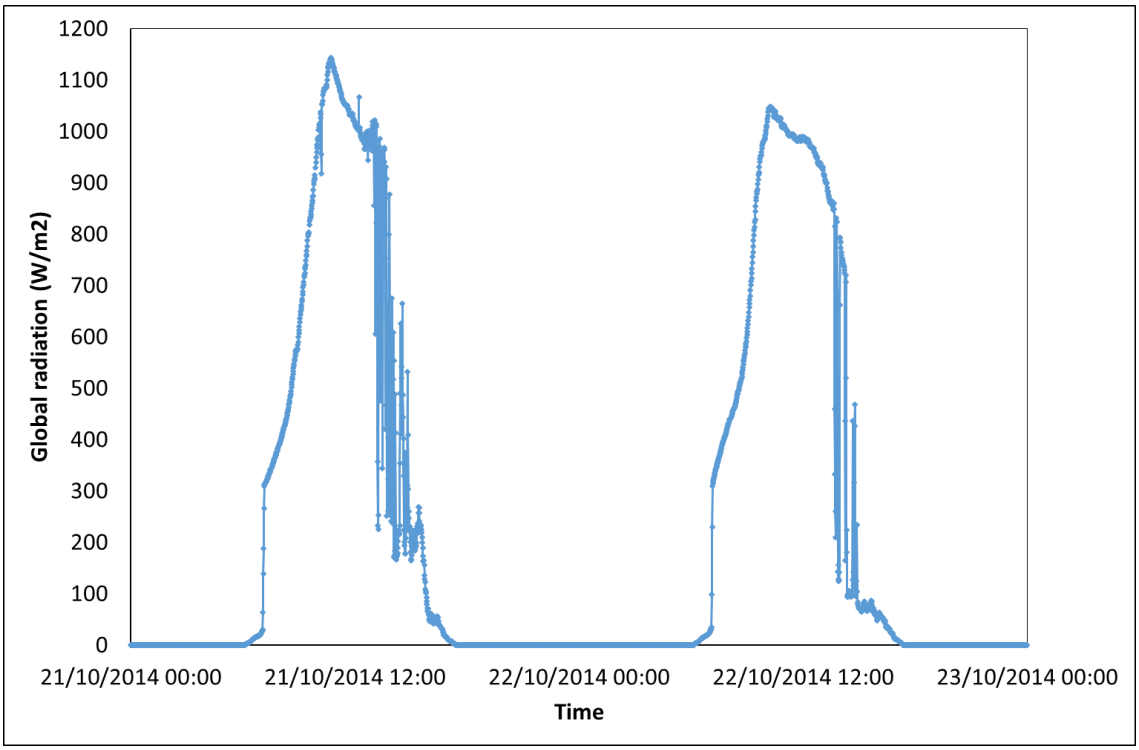


FIGURE 29: Plot showing a test with 48h of global solar radiation values recorded from 21st to 22nd October 2014.

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

Manufacturer	Kipp and Zonen
Model	CNR1
Serial number	020435
Firmware version (if applicable)	NA

Field configuration

Location on site	Installed on the mast of the AWS2 Pyramid (9 in Fig. 3)
Orientation	South
Height (measured at top)	2 m from the surface
Shield (if applicable)	NA
Heating (if applicable)	Unheating

Data output

Data communication protocol																								Analogic	
Output data message format (include description of fields)																									
SW IN (W/m^2) Msr.1 Inp.1							SW OUT (W/m^2) Msr.2 Inp.3						LW IN (W/m^2) Msr.3 Inp.2							LW OUT (W/m^2) Msr.4 Inp.4							TEMPCNR1 ('C) Msr.5 Inp.5				
Inst	Min	Ave	Max	StdDev	ValidDataPerc		Inst	Min	Ave	Max	StdDev	ValidDataPerc	Inst	Min	Ave	corretta	Max	StdDev	ValidDataPerc	Inst	Min	Ave	corretta	Max	StdDev	ValidDataPerc	Min	Ave	Max	StdDev	ValidDataPerc
Data sampling frequency																								1 min	
Data output to NCAR																								1 min	

Specification of the solar radiation sensor

Range	0-25 mV
Accuracy	±10% on daily totals

Specification of the infrared radiation sensor

Range	±5 mV
Accuracy	non linearity: < 1%

Instrument Picture.

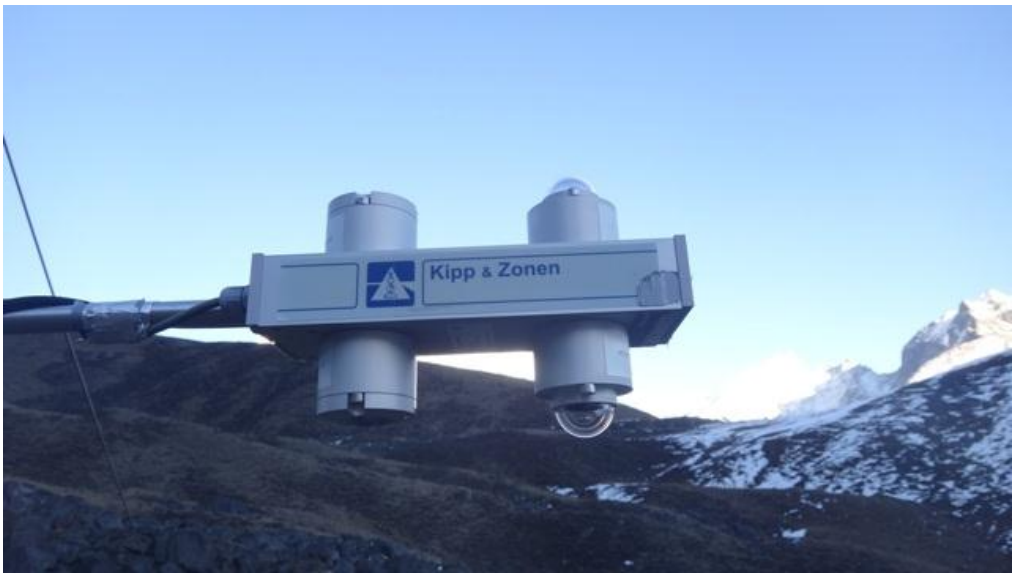


FIGURE 30: Detailed picture of the net radiometer.

Field calibration (if any).

The calibration was performed by the manufacturer.

48h Plot.

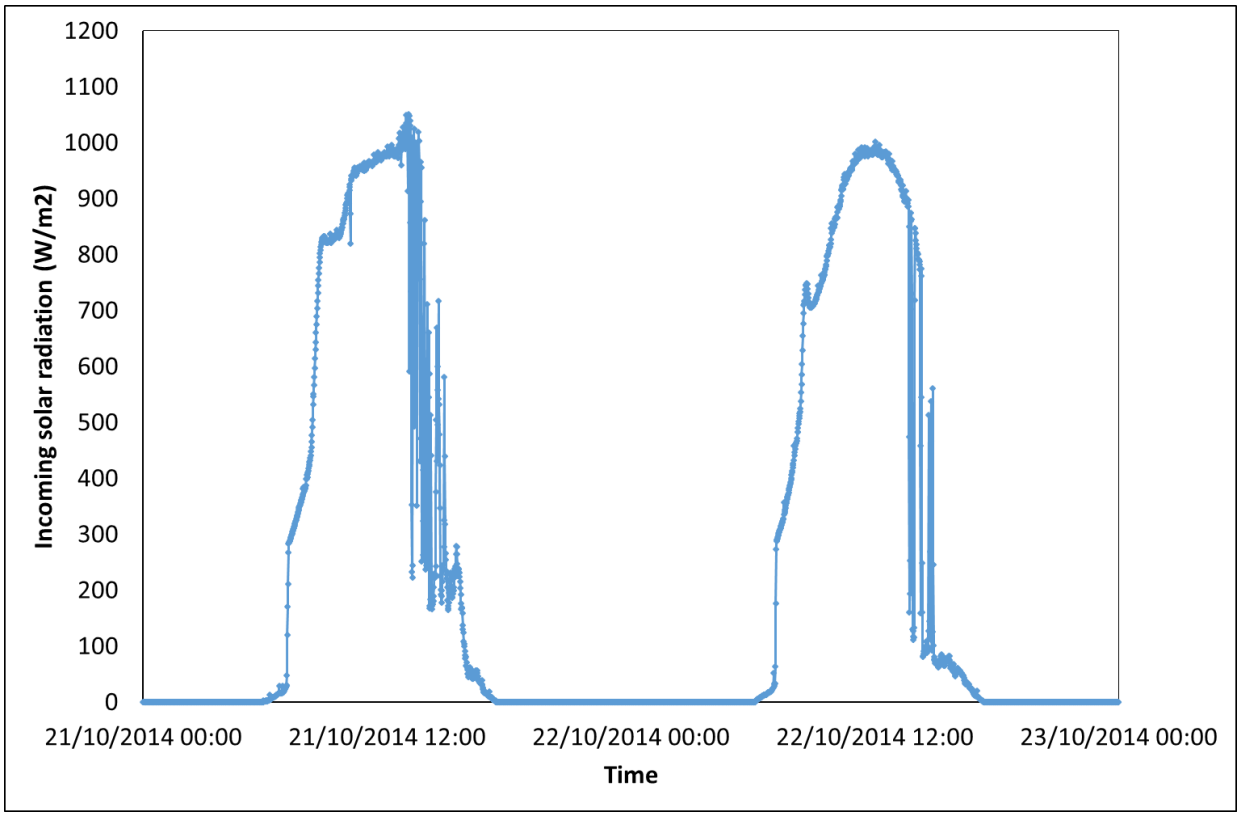


FIGURE 31: Plot showing a test with 48h of incoming solar radiation values recorded on 21st and 22nd October 2014.

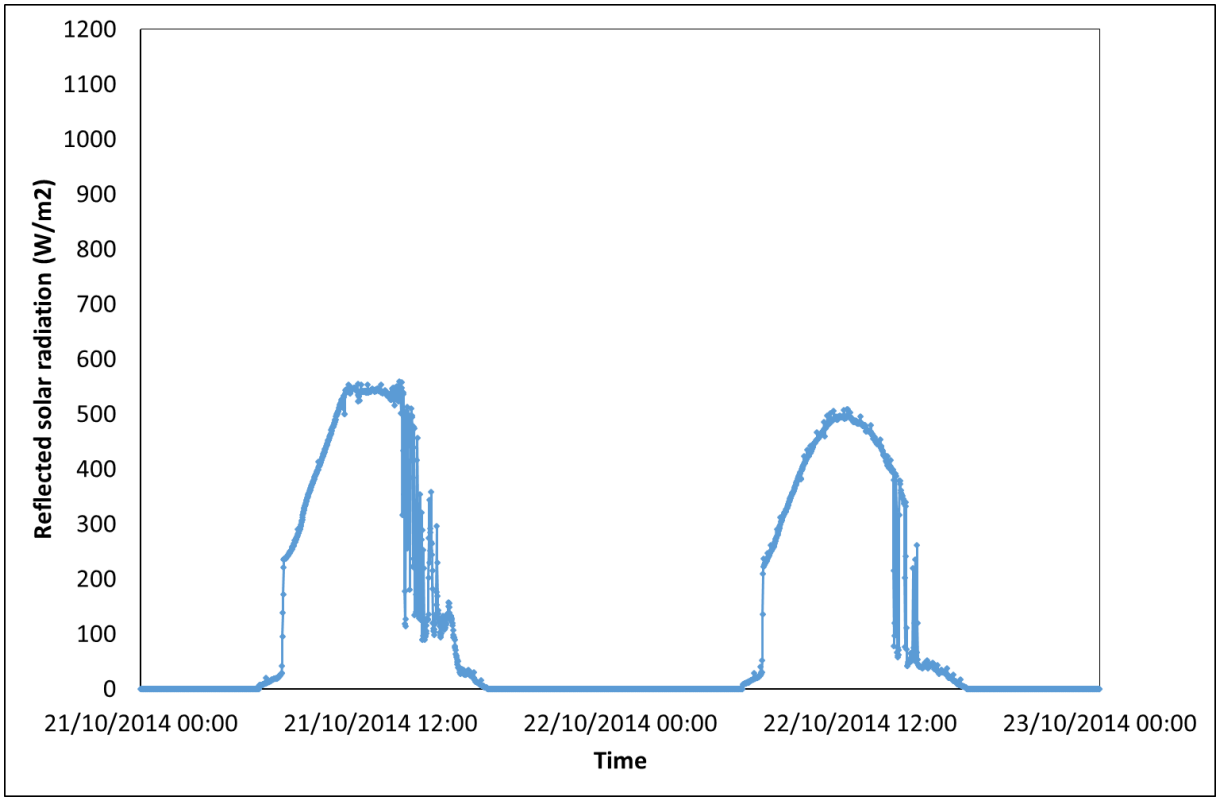


FIGURE 32: Plot showing a test with 48h of outgoing solar radiation values recorded on 21st and 22nd October 2014.

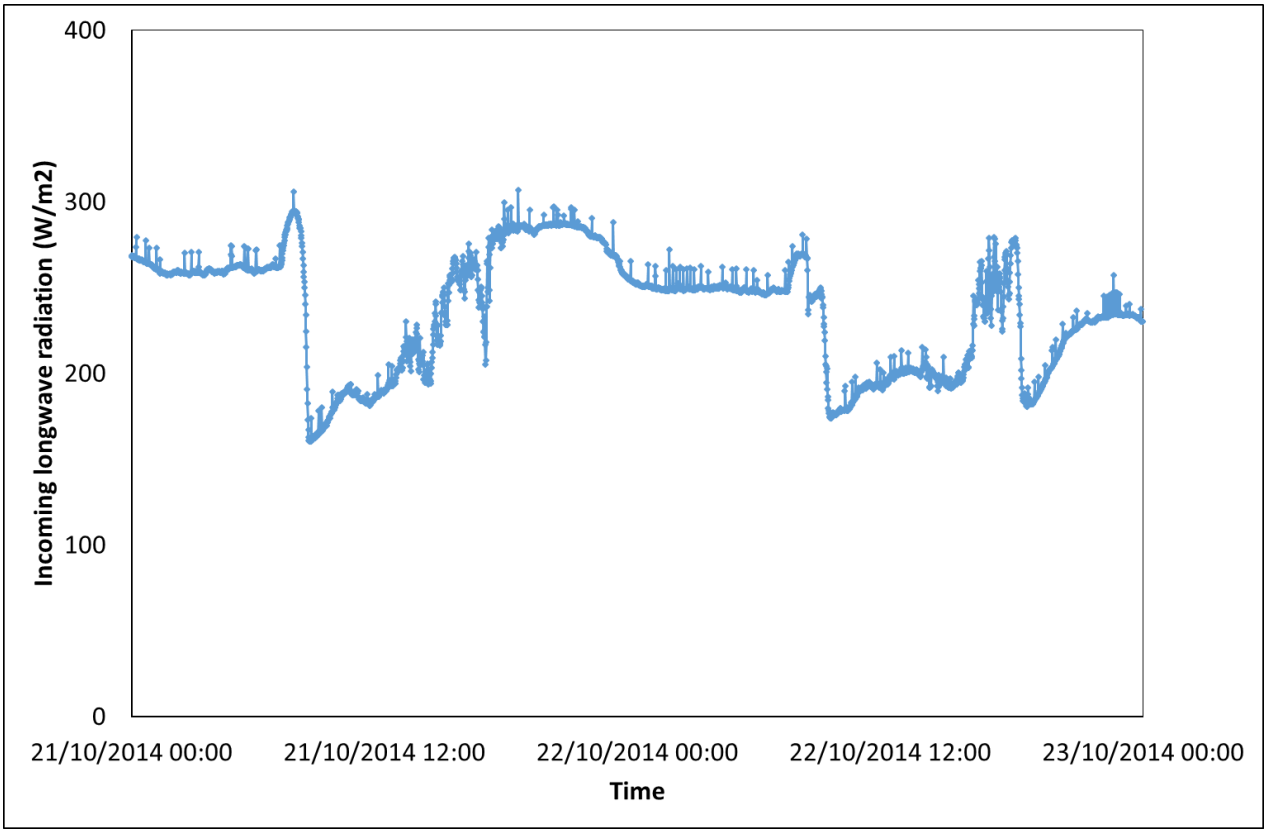


FIGURE 33: Plot showing a test with 48h of incoming infrared radiation values recorded on 21st and 22nd October 2014.

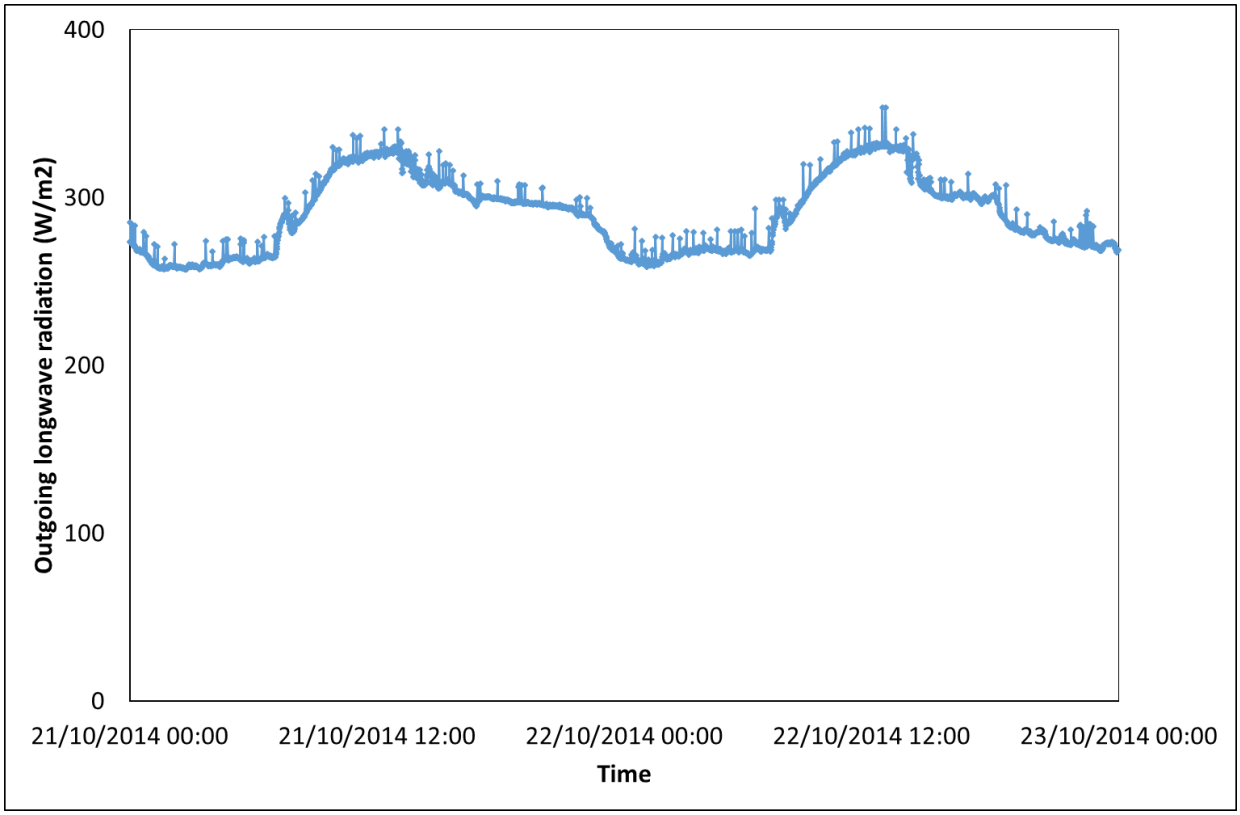


FIGURE 34: Plot showing a test with 48h of outgoing infrared radiation values recorded on 21st and 22nd October 2014.

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 Pyramid (2 in Fig. 3)
Orientation	South
Height (measured at top)	1.5 m from the glacier surface
Shield (if applicable)	NA
Heating (if applicable)	Unheating

Data output

Data communication protocol	Impulse sensor with reading of counts
Output data message format (include description of fields)	RAIN (mm) Msr.6 Inp.10 Tot ValidDataPerc
Data sampling frequency	1 min
Data output to NCAR	1min

Specification of the liquid precipitation sensor

Range	180 mm/hr
Accuracy	0-1 mm/min: 1% 1-3 mm/min: 2% 3-5 mm/min: 4% 5-10 mm/min: 8%

Instrument Picture.

FIGURE 35: Detailed picture of the pluviometer.

Field calibration (if any).

The calibration was performed by the manufacturer.

48h Plot.

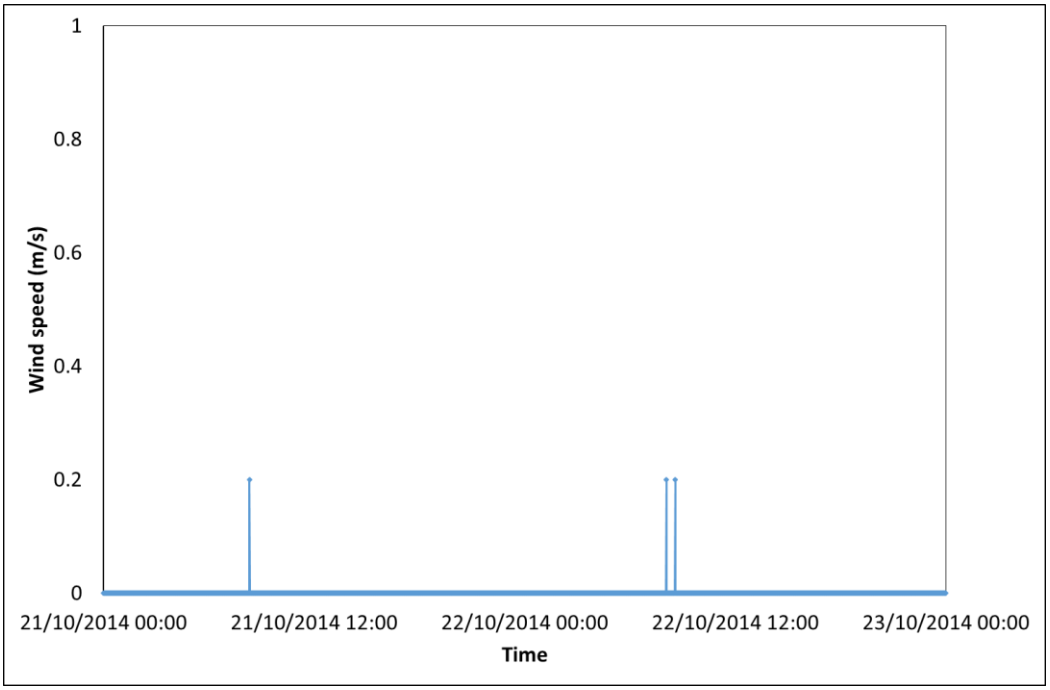


FIGURE 36: Plot showing a test with 48h of liquid precipitation values recorded on 21st and 22nd October 2014.

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

Manufacturer	Lsi-Lastem
Model	DNA022
Serial number	/
Firmware version (if applicable)	NA

Field configuration

Location on site	Installed on the mast of the AWS1 Pyramid (1 in Fig. 3)
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

Data communication protocol	Analogic
Output data message format	Wind DIR (>) Msr.4 Inp.4 Wind SPEED (m/s) Msr.5 Inp.9 Prev Dir Ris Dir Ris Vel Std Dev Dir Calm Perc Valid Data Perc Min Ave Max Std Dev Valid Data Perc
Data sampling frequency	1 min
Data output to NCAR	1 min

Specification of the wind speed sensor

Range	0-60 m/s
Accuracy	±0.1 m/s

Specification of the wind direction sensor

Range	0- 360°
Accuracy	±1% FS

Instrument Picture.

FIGURE 37: Detailed picture of the anemometer.

Field calibration (if any).

The calibration was performed by the manufacturer.

48h Plot.

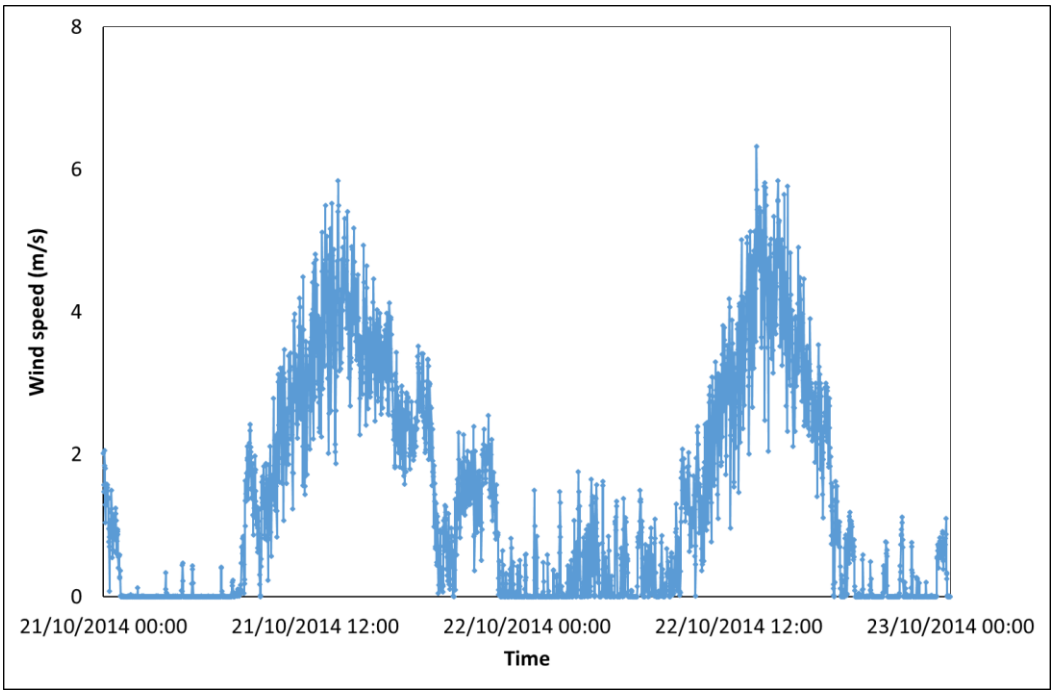


FIGURE 38: Plot showing a test with 48h of wind speed values recorded on 21st and 22nd October 2014.

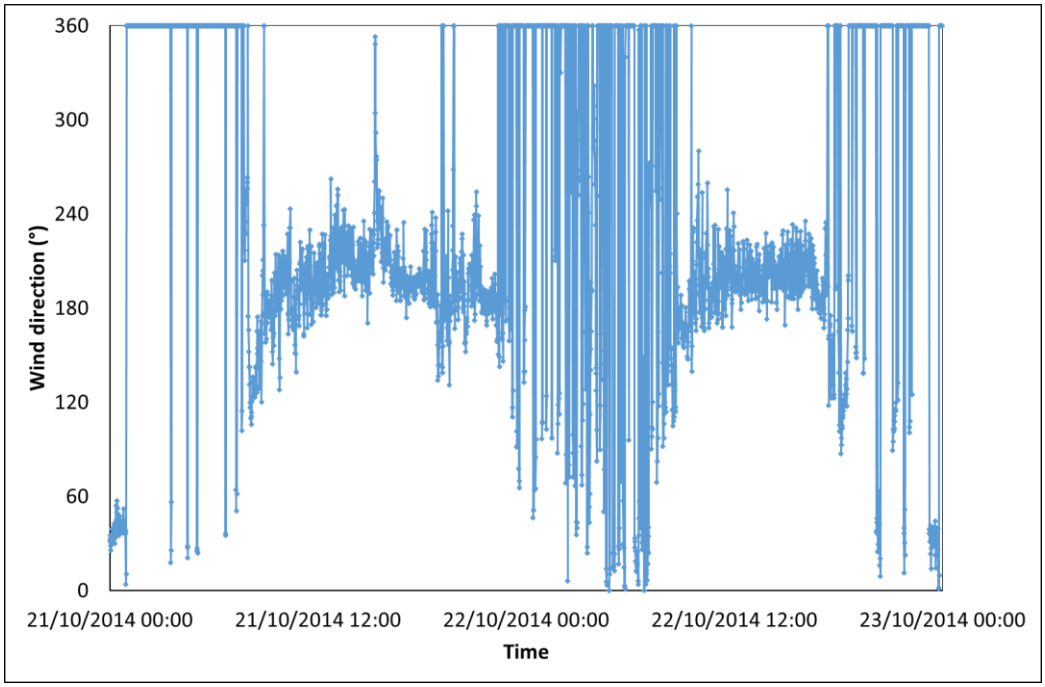


FIGURE 39: Plot showing a test with 48h of wind direction values recorded on 21st and 22nd October 2014.

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.
Sommer sonic ranger USH-8	☒ Yes ☐ No Date: 1st May 2014	☐ Yes ☒ No Date: December 2014	
Global solar radiation	☒ Yes ☐ No Date: 1st May 2014	☐ Yes ☒ No Date: December 2014	
Pluviometer	☒ Yes ☐ No Date: 1st May 2014	☐ Yes ☒ No Date: December 2014	
Thermo-hygrometer	☒ Yes ☐ No Date: 1st May 2014	☐ Yes ☒ No Date: December 2014	
Anemometer	☒ Yes ☐ No Date: 1st May 2014	☐ Yes ☒ No Date: December 2014	
Sonic Ranger Campbell SR50	☒ Yes ☐ No Date: 1st May 2014	☐ Yes ☒ No Date: December 2014	
Soil temperature	☒ Yes ☐ No Date: 1st May 2014	☐ Yes ☒ No Date: December 2014	
Soil moisture	☒ Yes ☐ No Date: 1st May 2014	☐ Yes ☒ No Date: December 2014	

Soil heat flux	☒ Yes ☐ No Date: 1st May 2014	☐ Yes ☒ No Date: December 2014	
Net radiation	☒ Yes ☐ No Date: 1st May 2014	☐ Yes ☒ No Date: December 2014	

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 Applicable
Instrument data validation:, 48h time series plots (Sections A2, A3)	☒ Included ☐ Not Applicable
Instrument data validation table (Section A4)	☒ Included ☐ Not Applicable
48h Instrument data validation: discrepancy reports (Section A4)	☐ Included ☒ Not Applicable
Pictures of installations of all reference instruments, instruments under test, and instruments used to provide ancillary measurements (Sections A2, A3)	☒ Included ☐ Not 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 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