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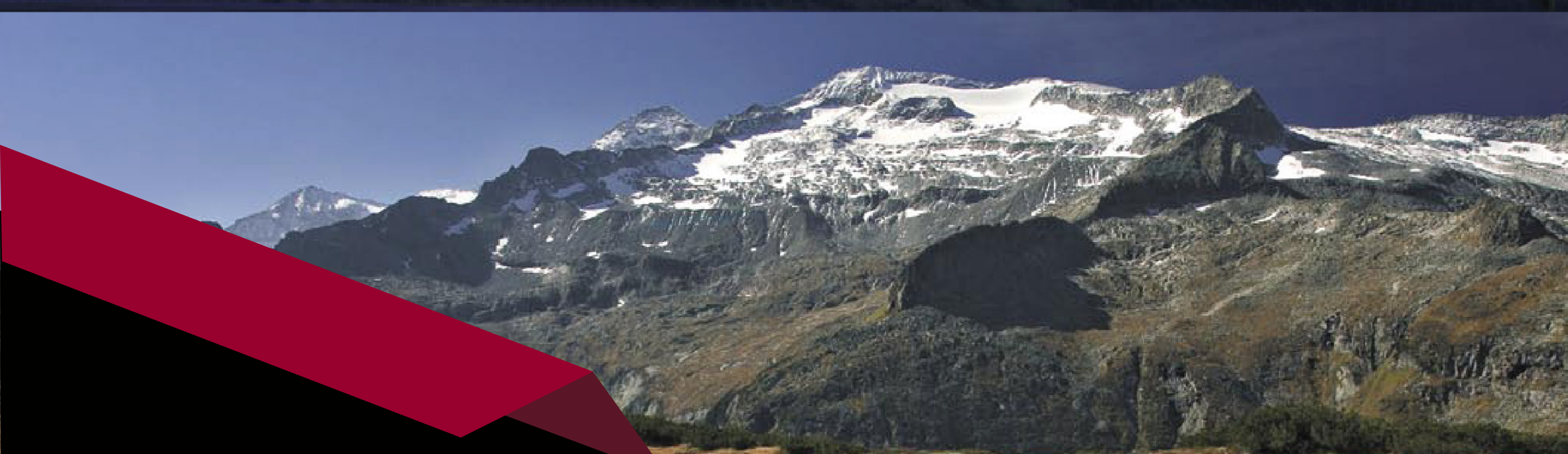
SCIENTIFIC

SOMMER

SNOW DEPTH
SNOW WATER MEASUREMENT
SNOW MELT AND WATER
DISCHARGE MEASUREMENT



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Our Environmental Department provides solutions for monitoring and sampling biological and chemical parameters in the environment. Our team of environmental sales representatives and diverse product range guarantee that you will find the right products for your application. Specific areas include: water quality, water quantity, soil moisture, plant science, weather stations, indoor air quality, aquatic sampling, and oceanography.

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SNOW DEPTH

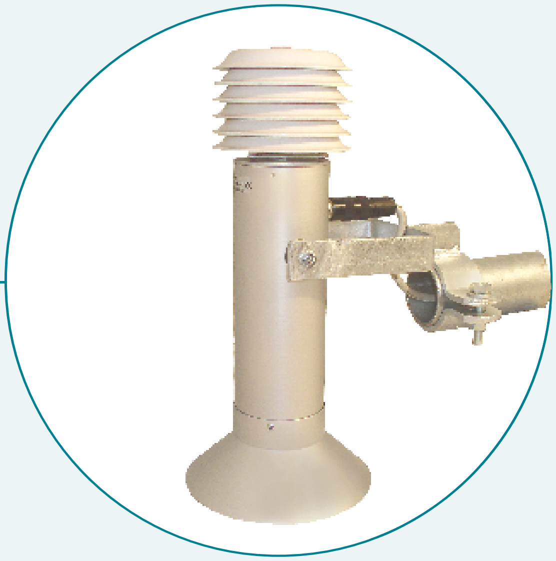
SNOW WATER MEASUREMENT

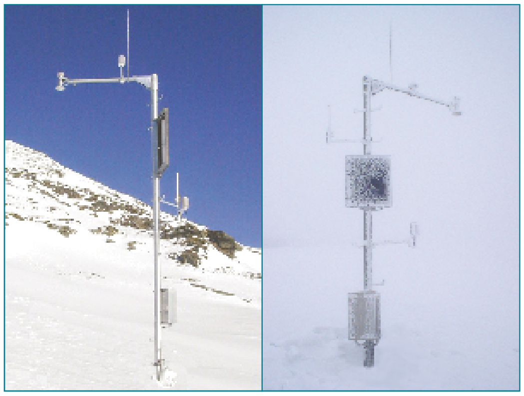
SNOW MELT AND WATER DISCHARGE MEASURMENT

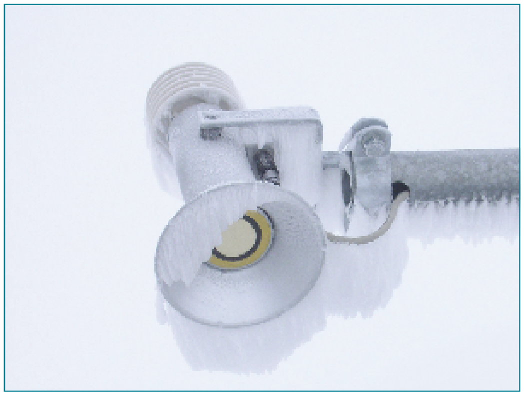
PRODUCT INFORMATION

USH-8

Ultrasonic Snow Depth Sensor







Properties and Advantages

» **Continuous and non-contact ultrasonic snow depth measurement**

» **Reliable sensor for extreme conditions**
- Correct measurement with snowfall and difficult reflection conditions
- Automatic de-icing of the ultrasound membrane and sensor head

» **High measuring accuracy**
- Integrated temperature compensation
- Intelligent measured signal conversion

» **Energy-saving sensor operation**
- “Standby” between the measuring phases
- Optimum for solar-powered stations

» **Simple sensor integration**
- Analogue and digital interface
- Parameterization via hyper terminal

Basis of Snow Depth Measurement

The measurement of snow depth is an important parameter for the measurement of the snow cover in the terrain. Its formation is subject to strong variance, based upon time and space factors. Influencing factors here are the development of snow cover, under the influence of further climatic events (air temperature, wind, global radiation), the characteristics of the land, as well as the spatial distribution of precipitation in an area. Because of these factors, the selection of a suitable location for measurement is decisively responsible for whether this is representative for an area or not.

Principle and Accuracy of Measurement

The sensor's principle of measurement deals with the transit-time measurement of an ultrasonic pulse. The sensor transmits several energy-charged pulses to the snow cover and subsequently receives its reflected signals. Based upon the required transit time of the ultrasonic signals, the USH-8 sensor calculates the current snow depth. The processing time of the ultrasonic pulses here is enormously influenced by the air temperature. For this reason, the snow depth sensor also possesses integrated temperature compensation. This takes into account the influence of the air temperature on the processing time of the ultrasonic signals, in the calculation of the snow depth. The calculation takes place in the sensor, so that the output signal provides the already converted snow depth. In this manner, optimum measuring results are achieved, with an accuracy of 0.1 % (FS).

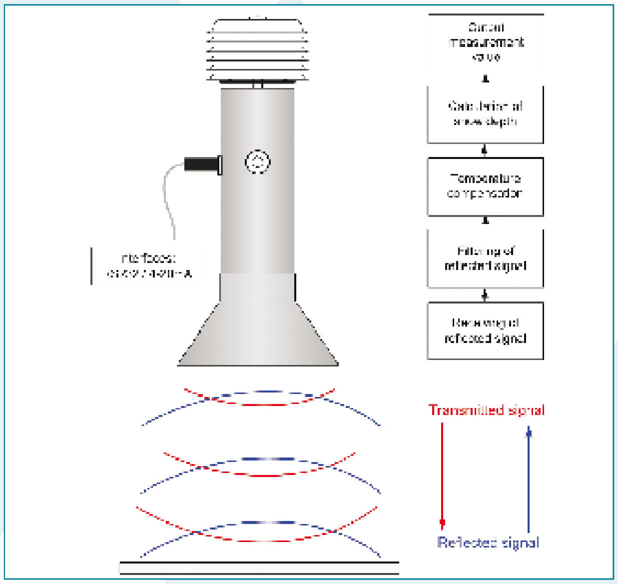


Fig. 1: Signal processing by the USH-8 snow depth sensor.

Reliable Sensor for Extreme Conditions

The USH-8 sensor is also highly reliable during extreme environmental conditions, thereby making possible a long-term reliability of in recording measured data.

This occurs with energy-charged 50 kHz ultrasonic pulses, and it also provides reliable results under the most difficult reflection conditions, as in the case of powder and new snow cover. By means of energy-charged ultrasonic pulses, the icing of the ultrasonic membrane and sensor head is hindered, and an automatic de-icing is carried out. Moreover, an intelligent measured signal conversion is compensated, by means of filtration of snow and rain precipitation, occurring in the signal path of the ultrasonic signals during measurement. In this manner, correct measurement is also assured during precipitation, and there are no negative effects on the results of measurement.

Energy-Saving Sensor Operation

The USH-8 sensor automatically switches between measuring and "standby" operation. The data logger must not switch the sensor on and off, and in this manner a highly energy-saving operation is achieved. For the transfer of measured data, the USH-8 is activated by the data logger via "transfer pin". For the measuring operation of the day, only 0.5 Ah is required per minute. Between the measuring phases, the sensor automatically switches to standby operation with <1 mA consumption. With this property of energy economy, the sensor is optimally suited for self-sufficient measuring stations using with solar power supplies.

Selection of the Measuring Location

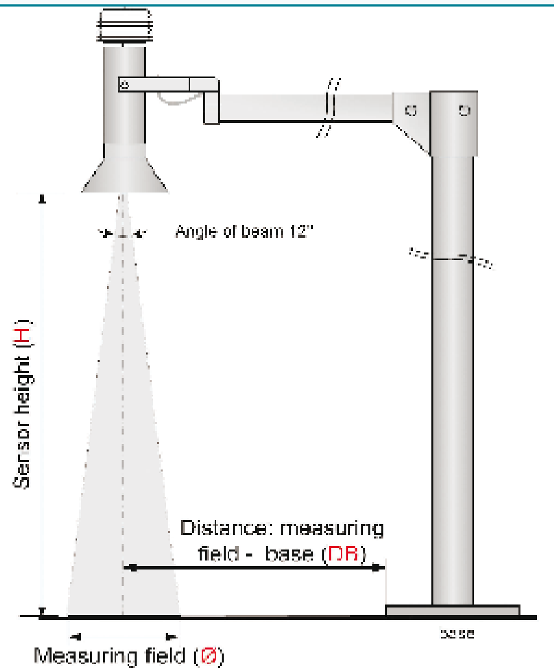
The right selection and positioning of the measuring location is of very great importance. The field of measurement to be recorded should be most preferably flat, protected from wind and secured against avalanches. Steep hillsides, hollows, terrain edges or large rocks in the immediate vicinity of the measuring location should be avoided. Steeply sloping fields of snow harbour the danger that the snow cover could begin to slide, thereby falsifying the measuring results. To ensure a problem-free measurement, the sensor must be aligned parallel to the ground. A minor incline of the ground can be compensated for by a correct alignment of the sensor, using the holding fixture provided. Furthermore, the expected snow depth at the location should be estimated, in order to assure a suitable mounting height for the sensor.

Assembly

The sensor has already been calibrated (temperature compensation) and preconfigured prior to delivery. In addition to the customer-specific settings (interface, protocol, …), the zero point parameter for the location must be set after the installation. This is implemented easily and comfortably via the Windows Hyperterminal.

The optimal mounting height of the sensor is 3m or more. The maximum permissible mounting height is 10m. Care must be taken here that the diameter of the field of measurement in this case is greater than 3m. In order that the field of measurement is not disrupted, two distances must be kept in mind when setting up the station. Firstly, there is the distance between the sensor and the field of measurement, and secondly, there is the distance between the sensor and pole / pole base. When the field of measurement is disrupted, this can lead to undesired reflections, and therefore to incorrectly measured data. Objects in the vicinity of the field of measurement (i.e. terrain edges, buildings, ...) also create snow drifts, thereby causing undesired disruptions of the field of measurement.

The material of the field of measurement's surface must be representative of the area to be examined, since differing materials produce differing defrosting capacities, and may thereby lead to undesired disruptions of the field of measurement. For measurement in natural terrain, we recommend fine gravel or crushed rock for the preparation of the field of measurement's surface.



Sensor height H [m]	Measuring field Ø [m]	Minimum distance DB [m]
2	0,6	1,0
3	1,0	1,2
4	1,3	1,4
5	1,6	1,6
6	1,9	1,8
7	2,2	2,0
8	2,5	2,2
9	2,9	2,4

Fig. 2: Overview of the assembly dimensions of the USH-8 sensor.

Simple Integration into Existing Weather Stations

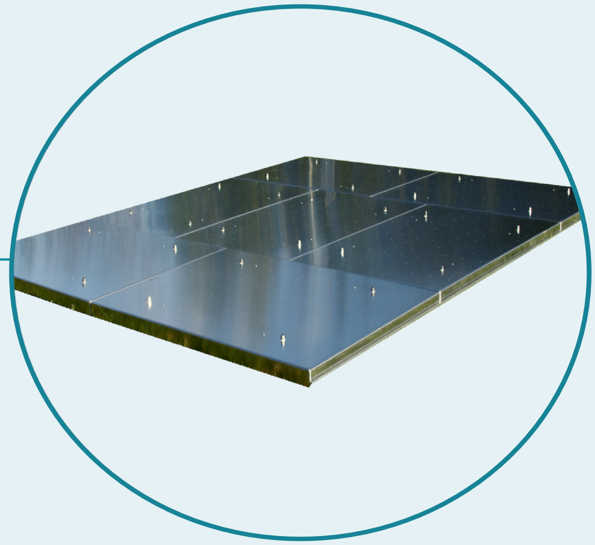
The measured value of the USH-8 snow depth sensor can be integrated into an already existing station, using either an analogue (0/4-20mA signal) or a digital interface (RS 232). In addition, the provided pole-holding fixture allows for easy assembly.

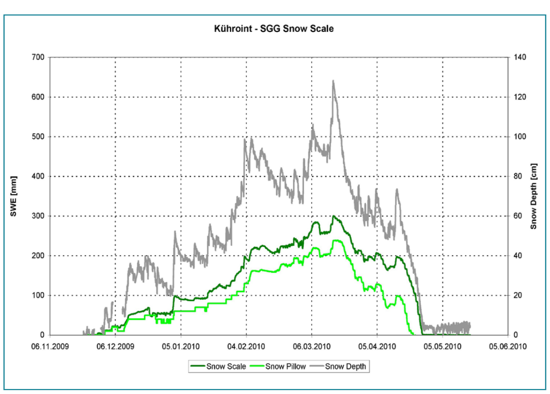
Snow Depth Measurement	
Range of measurement	0 to 8 m
Minimum distance to the maximum expected snow depth	1 m
Accuracy	0,1 % (FS)
Resolution	1 mm
Principle of measurement	Ultrasonic (Frequency 50 kHz; Angle of reflected beam 12°)
Integrated Compensation of the Air Temperature	
Temperature sensor	Integrated air-temperature sensor in self-venting radiation shield
Range of measurement	-35 to 60 °C
Resolution	0,1 °C
Non-linearity	≤ 0,15 %
Interfaces	
Analogue	Snow depth measurement 0/4 - 20 mA signal (configurable) Resolution: 12 Bit Max. load: 300 Ω
Digital	Snow depth measurement; air temperature; quality flag RS 232; serial interface Protocol: Various ASCII formats
Other	
Power supply	Supply voltage: 10,5 to 15 VDC Current consumption: Measuring phase: max. 200 mA (approx. 3 sek) Stand by: <1 mA Power consumption: 0,5 Ah / day (with measuring interval of 1 min)
Operating temperature	-35 to 60 °C
Housing	Dimensions: Ø 110 mm, length 350 mm Material: anodized aluminium Weight: 2 kg
Protective system	IP 66
Lightning protection	Integrated (discharge capacity 0.6 kA)
Accessories (not included in the price)	
Pole arm	Pole arm with tilting function for comfortable sensor assembly and maintenance: Holder for pole Ø 114 mm, Hot-dip galvanized, Dimensions: Ø 61 mm (2“), length: 1600 mm

PRODUCT INFORMATION

SSG

Snow Scale for Snow Water Equivalent (SWE) measurement





Functions and advantages

- Automatic Measurement of Snow Water Equivalent (SWE)
- Realistic represenation of actual snow
- High representativness of the measured value and minimisation of ice bridging effect
- Optimised thermal flow between sensor and ground for high accuracy during the melting process
- Reliable, light and long life aluminium construction
- Measure up to 200 / 500 / 1.000 mm of SWE
- Simple and easy installation and setup
- NO antifreeze liquid required
- Simple systems integration
- Flat construction design

Description

The SGG Snow Scale is a precision Snow Water Equivalent measuring device which is developed for quick and easy installation and implementation in the field. The SGG uses exactly for SWE measurement designed aluminium plates which garuantee accurate measuring values. A broad outer frame of plates minimises the effects of ice bridging commonly experienced late in the measurment season. The use of lightweight aluminum materials minimize thermal resistance improving heat flow throughout the device for better emulation of natural conditions. Integration and connection to weahter stations or other signal processing systems are kept easy and simple.

Functioning characteristics

The working principle of the SGG is based on the measuring principle of load cells. The sensor consists of seven, perforated plates each plate of the size of 0.8 x 1.4 m. The center panel and six surrounding panels allow water to percolate through the sensor. Water percolation minimizes thermal differences between the sensor and surrounding panels act to buffer the center panel, where SWE is measured, from stress concentrations which are developed along the perimeter of the sensor. This systems allows accurate measurement even during periods of rapid snow settlement followed by large snow accumulations. Also when the rate of snowmelt at the sensor/ snow interface was significantly different from the snowmelt rate at the soil/ snow interface on the surrounding ground.

Installation guide

The SGG is designed for modular and easy installation and maintenance in the field. The snow scale consists of an intrumented center panel surrounded by six panels that act to buffer the center panelform edge stress condition (Figure 1). Each panel is constructed and consists of a top plate of aluminum perforated with holes to allow water flow through the sensor. The SGG is supported by angle beams to provide strength and stiffness.

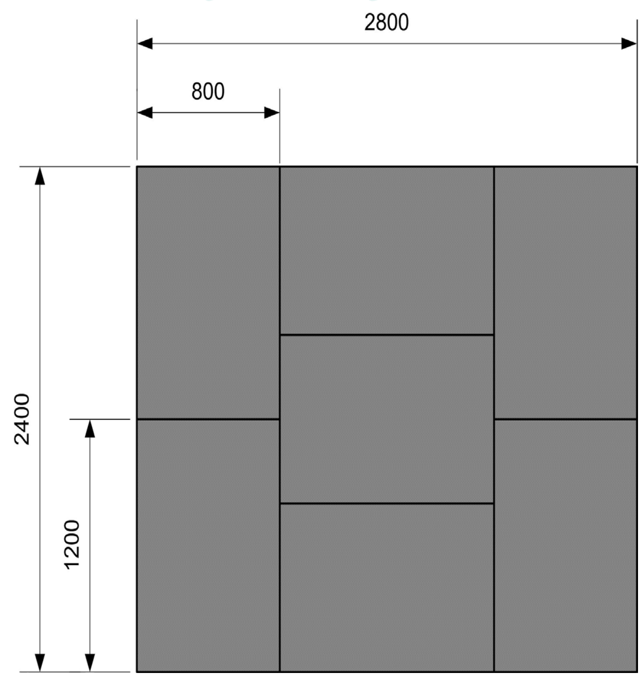


Figure 1: SGG snow scale Design

Set up

The measuring device can be set up in even inclined (up to 5°) areas. The site should be, for optimal measuring values, prepared as followed. Remove the ground and fill the trench with a thin layer of gravel or sensor so in the end the SGG is flush with the surrounding ground. The support pedestals and load cells rest on aluminium base plates, placed on this gravel pad (Figure 2)

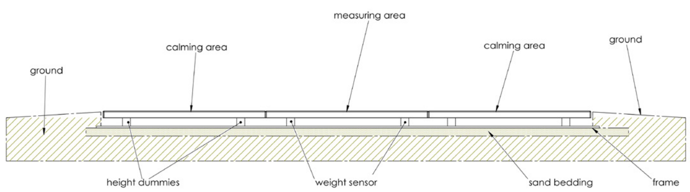


Figure 2: SGG snow scale set up

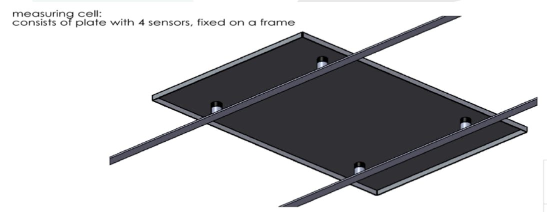


Figure 3: SGG measuring cell construction

Set up example:

In Switzerland, Davos (2.660 m) the SGG snow scale has been set up in the ground. So the SGG and the surrounding ground are on the same level. Aim is that the snow scale takes over the characteristics of the ground and therfore the measuring values should have a higher informative value.

Figure 4 Preparation measuring site Davos

Figure 5: SGG snow scale set up Davos

System applications

- Water resource management
- Flood risk management
- Monitoring of precipitation
- Automatic snow load monitoring

SGG Snow Scale - water equivalent measurement	
Range of measurement	3 ranges: 0 to 200 mm SWE, 0 to 500 mm SWE, 0 to 1000 mm SWE
Resolution	0,1 Kg/m² ≙ 0,1 mm SWE (*)
Accuracy	0,3 % FS (*)
Measuring surface	6,72 m²
Total weight	110 Kg
Dimension (mm)	L = 2800 B = 2400 H = 70
Packaging (mm)	7 x L = 800, B = 1200, H = 40; bars: L = 2800
Protection	IP 68
Power supply	10 - 30 VDC
Power input	max. 70 mA
Operating temperature	-40 to 80°C
Max. inclination	5°
Output	SGG 200 4 - 20 mA ≙ 0 ... 200 mm SWE SGG 500 4 - 20 mA ≙ 0 ... 500 mm SWE SGG 1000 4- 20 mA ≙ 0 ... 1000 mm SWE
Order information	SGG 200: range 0 ... 200 mm SWE SGG 500: range 0 ... 500 mm SWE SGG 1000: range 0 ... 1000 mm SWE
Others	Connecting box with high voltage protection

** All declarations of weight and accuracy refering to standardised weights*

Snow Pack Analyser (SPA) for snow water equivalent (SWE) and liquid water content

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State: November 2009

MESS-SYSTEMTECHNIK

Snow Pack Analyser (SPA) for snow water equivalent (SWE) and liquid water content

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1. ABSTRACT

Improved estimation of the spatial snow water equivalent (SWE) distribution is a key task in current snow research. Quantifying the complex variability of the SWE both in time and space is essential for hydropower production, risk assessment with regard to natural hazards (avalanches, floods, debris flows), as well as for tourism issues in alpine areas.
The Snow Pack Analyser (SPA) is an automatic in-situ measurement system to determine the characteristics of snow covers. Along a flat ribbon sensor the complex capacitances at low and high frequencies are measured for real-time determination of the snow density, snow water equivalent and liquid water content.
The system can operate with up to four sensors. They are either installed sloping through the complete snow cover or they are arranged horizontal at the ground or defined levels. The combination of sensors allows to optimize the information on specific tasks.
The determination of the liquid water content in the snow cover is unique. In periods of thaw the liquid water content rises. This enables a forecast of the point in time when the water run-off of the snow starts and provides important information for rationing of reservoirs, flood prediction or for avalanche services to estimate wet slab avalanches.

2. INTRODUCTION

Efficient energy management of hydro power resources requires accurate forecasting of water capacity from snow melt and run-off. At present the precision of melt water prognoses for hydro power reservoirs is between 30 and 50 %. As an example, a 10 % gain in forecast precision at the ‘La Grande Rivière’ catchment in Quebec (Canada) would correspond to a yield of 2,2 TWh. Improved accuracy of SWE measurements will enhance the economic efficiency of hydro power plants or drinking water reservoirs as well.
Prognosis of melt water run-off are relevant for flood prevention. Not only mountainous and alpine regions are affected by floods, but all the areas where rivers are fed by these catchments. As an example, rapid snow melting in the Alps is known to be one reason for flooding along the River Rhine valley from Germany to the Netherlands. The precise monitoring and modeling of SWE, liquid water content and the point in time of water run-off will enhance the accuracy of flood predictions and may reduce the danger or effects of natural catastrophes.
The determination of liquid water content in the snow cover or in the ground layer of the snow cover is an additional parameter to SWE. It is an indicator for avalanche services to predict wet snow avalanches in periods of thaw, especially in spring.
Moreover, the realization of long-term monitoring helps to reduce dangerous and expensive adoption of human resources in the wintry area.

3. HISTORICAL OVERVIEW

The initial development of the SPA was performed during the international EU-funded research project SNOWPOWER [1][2][3] in the years 2001 to 2004. The objective of the project was to increase the precision of filling prognosis to at least 20% by calibrating remote sense data with ground truth data determined by a new snow measurement method.
A new electromagnetic sensor allowing a monitoring of an area of up to 2000 m² was developed. A PC Software to calculate the snow water equivalent SWE and density from field data was written. Based on the results and experiences with the laboratory-scale instrument, a new field measurement instrument was designed.
Field tests were carried out during three winter periods at two measurement sites in Switzerland and Canada. The measurement site at the Weissfluhjoch in Davos was operated by the Swiss Federal Institute for Snow and Avalanche Research (SLF). It was a high Alpine test field and harsh winter conditions with air temperatures below -20 °C and wind speeds of 25 to 30 m/s occurred occasionally. Intermediate snow melt was rare during the accumulation phase. The main melts started in April wetting the snow pack from its top to the bottom. The second measurement site was located in the Bras d'Henri watershed in Quebec [4]. The conditions were arctic, the field had a smooth surface with a maximum slope of 0.5 %, and the snow cover remained relatively dry.
Continuous measurements of snow depth and snow temperatures were conducted at both sites throughout the entire investigation period. Also air temperature, wind speed, relative humidity, solar radiation and precipitation were recorded automatically.
At Weissfluhjoch, a detailed snow profile description was made twice a month. At these occasions, snow density, SWE, snow temperature and the degree of wetness were determined manually for each snow layer. Outflow of melt water from the snow pack was measured continuously in a lysimeter of 2x2-m ground area.
At the test field in Canada, six snow cores were collected twice a week to measure snow depth, the mean snow density and the SWE. At the same time, a detailed snow profile description was made to determine the liquid water content, density and temperature at every 10 cm, using a denoth meter, snow density sampling and the dial stem thermometer.
These field test with its accurate data collection resulted in a prototype for the measurement system.
In the years 2004 to 2008 the system was continuously improved by Sommer Mess-Systemtechnik. The sensor and its installation were re-engineered, the calculation algorithm was improved, and the measurement and controlling device was designed to calculate the parameters in situ. In 2009 the SPA system was finalized.

4. SNOW PACK ANALYSER (SPA)

The SPA is a complete measurement system to detect the snow water equivalent, snow density and liquid water content of snow. The sensor system consists of:

- SPA-Sensor: 6 cm wide and between 3 and 10 m long flat ribbon sensor including three copper wires.
- Control unit: performing of measurements, switching between up to four sensors and calculation of snow parameters.
- Ultrasonic snow depth sensor
- Mechanical suspension to ensure tight and upright position of the sensors.

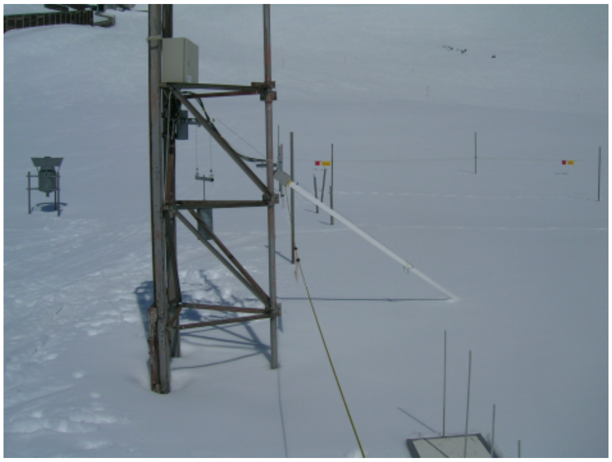


Fig. 1: Test site at Weissfluhjoch (Switzerland)

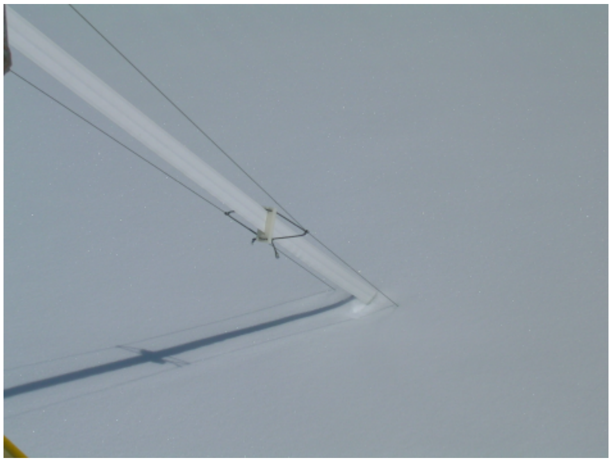


Fig. 2: Sloping SPA Sensor entering snow cover

4.1. Configurations of the SPA-system

The SPA-system can operate with up to four SPA-sensors. Their quantity and assembly is related to the desired measurement demands. The sensors are either installed sloping through the complete snow cover, or they are spanned horizontally in the snow at defined levels.

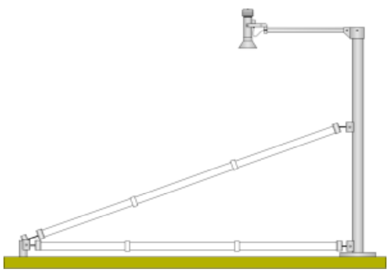
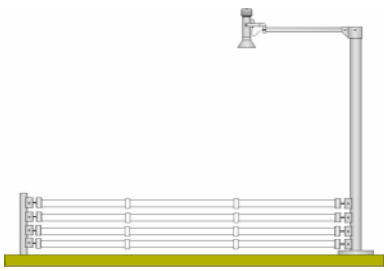
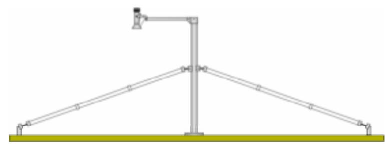
4.1.1. Integral measurement of snow cover

To measure the integral parameters of the snow cover the sensor is installed sloping from a mast to the ground through the complete snow cover. The sloping sensor determines the snow density, the snow water equivalent and the ice and liquid water contents of the complete snow cover. Horizontal sensors can be installed for additional information.

4.1.2. Snow parameters at defined levels

Horizontally installed sensors determine the liquid water content and the snow density at specific levels. Either the sensors are placed at the ground or they are installed at defined levels.

4.1.3. Configuration Examples

Common setup	Profile setup	Areal setup
A sloping sensor and a horizontal sensor are installed. The sloping sensor determines the parameters of the complete snow cover, the horizontal sensor supplies additional information about the snow conditions close to the ground layer.	Up to four horizontal sensors are installed at the ground or at defined levels. The transit of snowmelt water through the snow pack can be detected and a snow profile can be generated.	Four sloping sensors are installed in star shape. The measurements of the individual sensors are averaged. This results in a high areal resolution, that corresponds to the pixel size of remote sensing data.
Fields of application: • Reservoir management • Flood prediction	Fields of application: • Flood prediction • Avalanche forecast for wet slab avalanches	Fields of application: • Calibration of remote sense data • Calibration of SWE numeric models
 **Fig. 3: Combined assembly**	 **Fig. 4: Profile assembly**	 **Fig. 5: Areal assembly with 4 sensors in star shape**

4.2. Measurement parameters

The presented measurement data are from the test site at the Weissfluhjoch in Davos (Switzerland). It is operated by the Swiss Federal Institute for Snow and Avalanche Research (SLF). The sea level of the test site is around 2500 m.
The reference data are from a snow pillow of 3x3 m extent. Additional manual profiles were taken every two weeks during the complete winter season. These data are compared to the measurement values of the SPA.

SPA	Manual measurements	Snow pillow
• Snow water equivalent • Snow density • Liquid water content • Snow depth	• Snow water equivalent • Snow density • Snow depth	• Snow water equivalent

4.2.1. Snow water equivalent (SWE)

The trend of the SWE data measured by the SPA correlates to the reference measurements of the snow pillow and the manual measurements. The relation between SWE and snow depth is conform to the natural process of settlement of the snow cover. After snow fall the snow depth decreases due to the compression of the snow cover, but the snow water equivalent remains constant. With the start of the melting period in April the snow depth and SWE decrease.

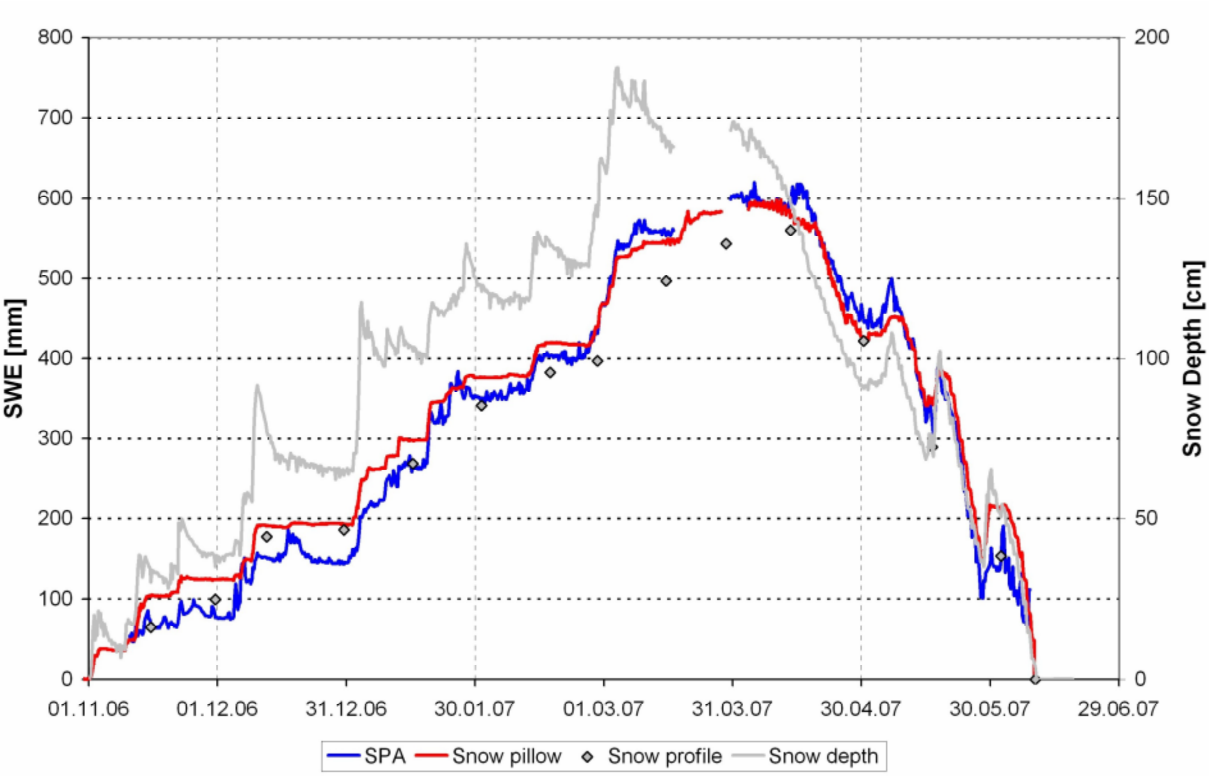


Fig. 6: SWE data from SPA compared to snow pillow and manual measurements.

4.2.2. Snow density

The density measured by the SPA is similar to the measurements of the snow pillow and the manual data. During snow fall the density decreases and in time periods of snow compression the density increases.

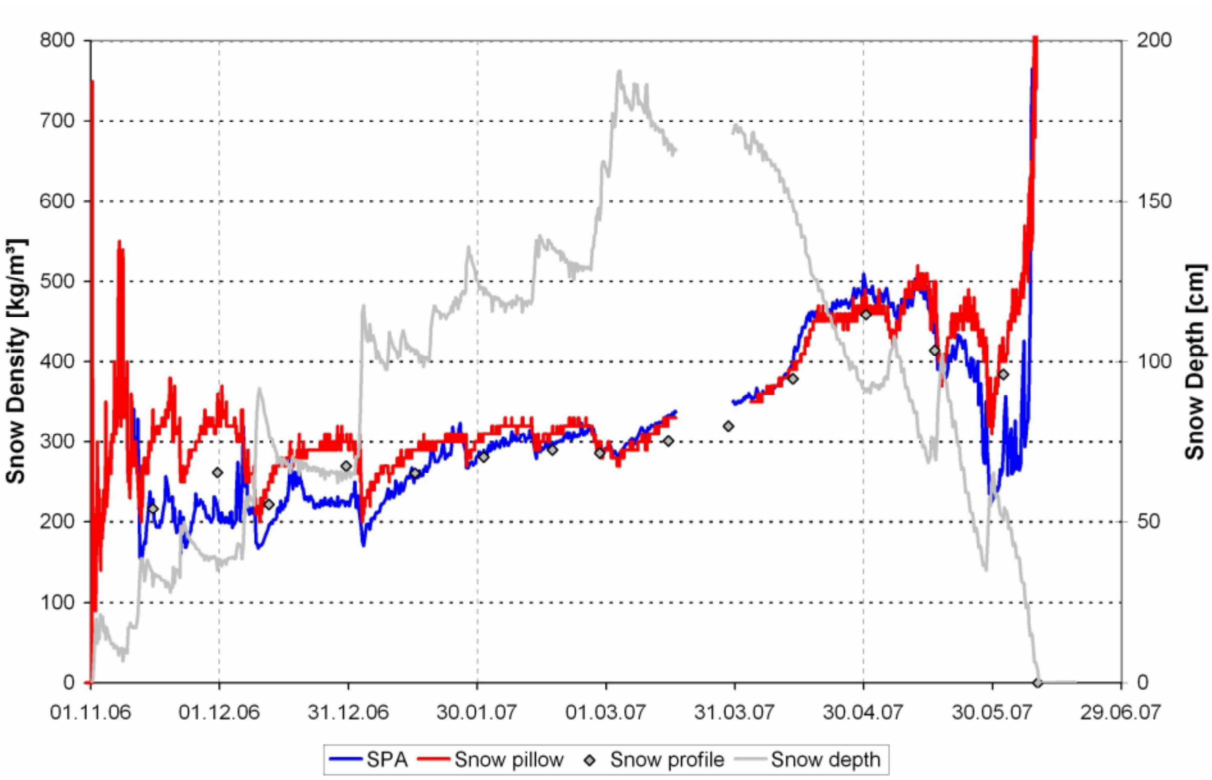


Fig. 7: Snow density data from SPA compared to snow pillow and manual measurements.

4.2.3. Liquid water content of the snow cover

The liquid water content stays constant at a relative low level during the winter season until the middle of April. With the start of the melting season a significant increase occurs. The peaks at the end of the data show daily variations, the liquid water content rises during day time due to melting processes that result in water run-off from the snow cover, which in return reduces the liquid water in the snow.

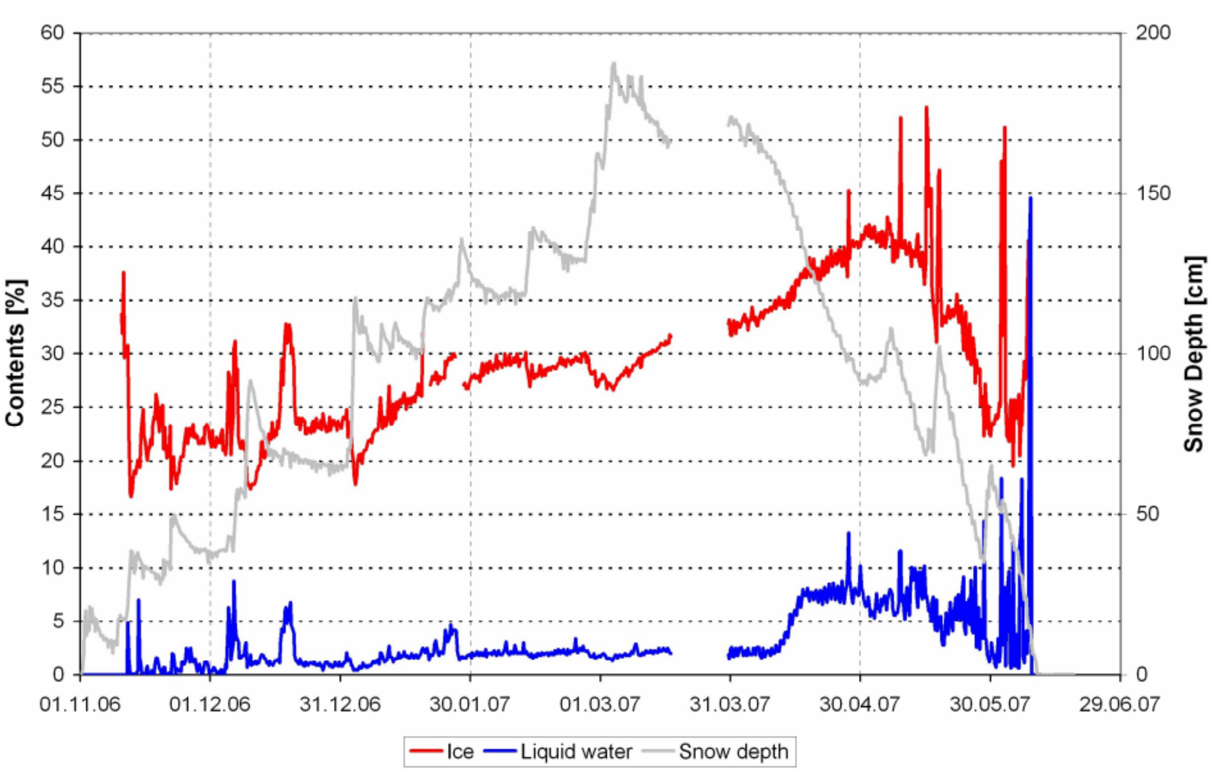


Fig. 8: Ice and liquid water content of the snow cover.

4.2.4. Forecast of water run-off

At the begin of March (point A) the snow cover is compressed while the SWE stays constant. The start of the melting period is defined by the decrease of the SWE (point B) when the water run-off of the snow cover starts. A significant increase of liquid water content is measured prior to the start of melting period (point C). The measurement of liquid water provides a forecast of the point in time of the water run-off.

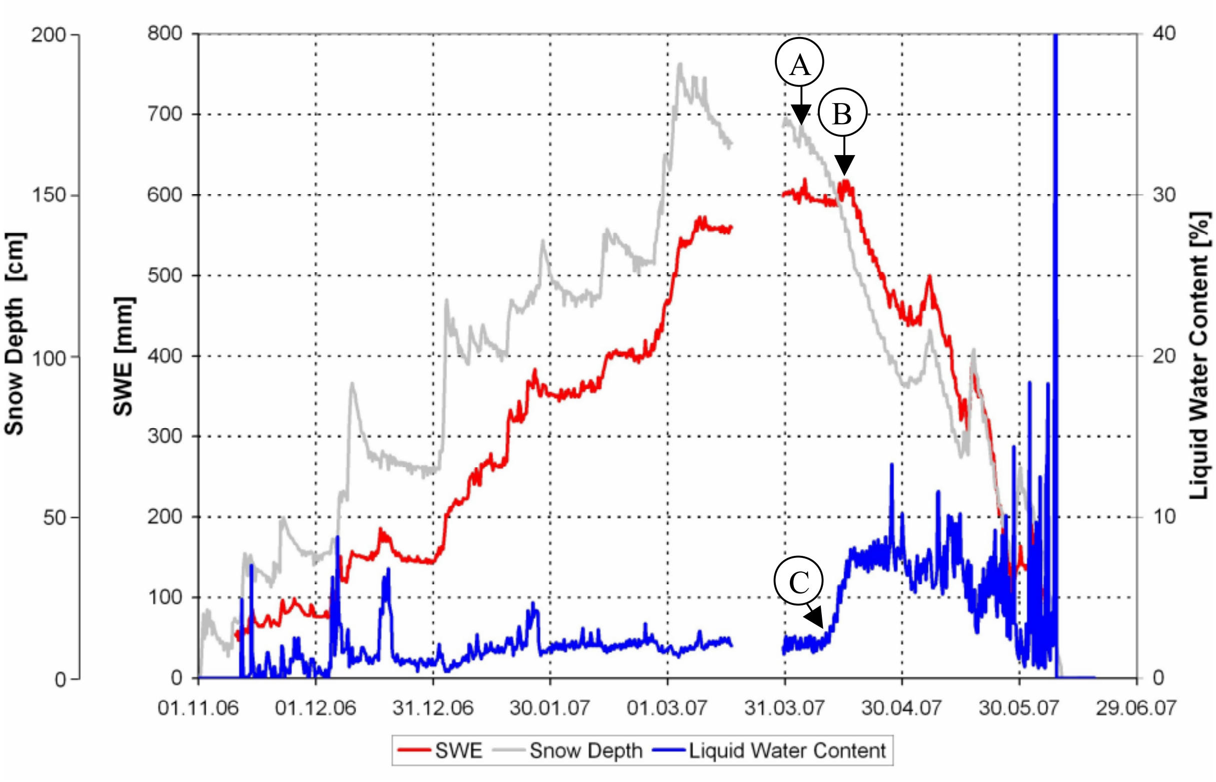


Fig. 9: Determination of the starting point of run-off from the snow cover.

5. CONCLUSION

The SPA-system is an in-situ measurement system for snow density and snow water equivalent. The unique determination of the liquid water content enables a wide field of new applications. The possibility to arrange up to four SPA-sensors in sloping or horizontal installation enables to optimize the information depending on demands.

The advantages of the SPA are:

- In-situ measurement of snow water equivalent (SWE) and snow density
- Unique in-situ determination of liquid water content of the snow cover which enables new applications
- Accurate forecast of the point in time when the water run-off of the snow starts to improve management of reservoirs, flood prediction and avalanche forecast.
- Accurate measurement even for large amounts of snow and different type of snow conditions.
- Measurement at large areas to determine an integral snow parameters for calibration of numeric models or remote sensing
- Realization of long-term monitoring instead of manual measurements
- Simple installation even at hillsides

6. REFERENCES:

[1] Stähli, M., Völksch, I., Sommer, W., und Meister, R. SNOWPOWER – ein neuer automatischer Sensor für Schneewasserwert-Messungen. Wasser-Energie-Luft, 2006 / Heft 2

[2] Stähli, M., Gustafsson, D., Stacheder, M., Sommer, W., Schneebeli, M., Test of a new in-situ snow sensor for validation of remote sensing images at a high alpine site in eastern Switzerland, 2004

[3] http://www.project-snowpower.de

[4] Niang, M., Bernier, M., Gauthier, Y., Fortin, G., Van Bochove, E., Stacheder, M., Brandelik, A., On the Validation of Snow Densities Derived from SNOWPOWER Probes in a Temperate Snow Cover in Eastern Canada: First Results, 2003

7. CONTACT AND FURTHER INFORMATION

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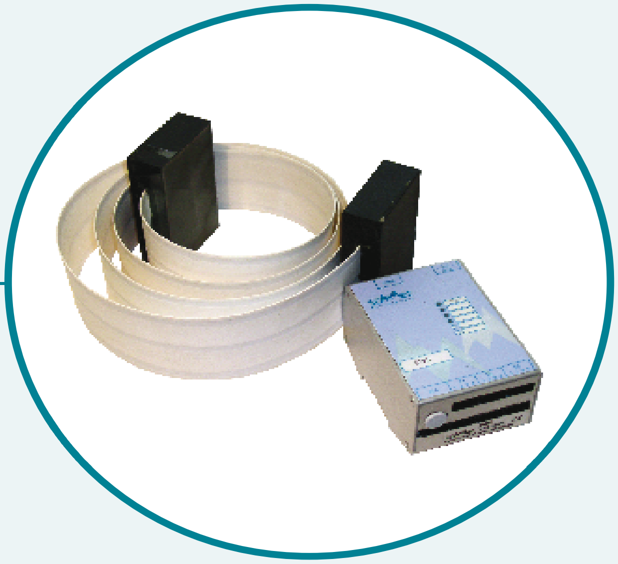
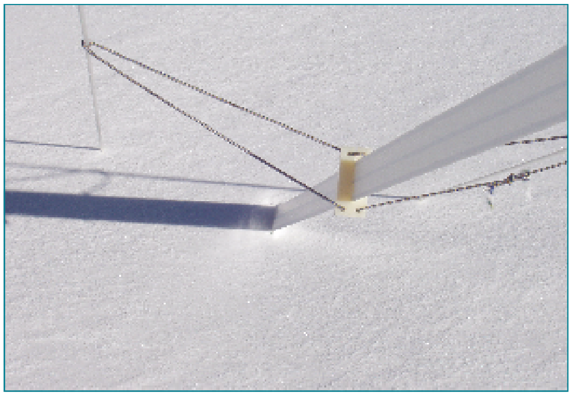
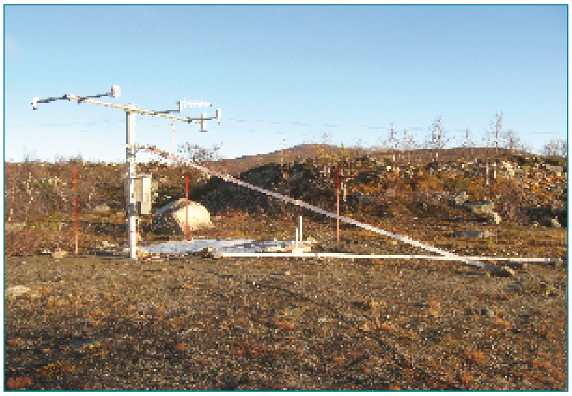
PRODUCT INFORMATION

SPA

Snow Pack Analysing System







Properties and Advantages

» **Registration of the snow parameters:**
- Snow depth
- Snow density
- Snow water equivalent
- Contents of liquid water and ice

» **System assembly on demand**
- Information above the whole snow cover
- Information above a specific snow depth level
- Information above an extended area, by measuring with up to 4 SPA- sensors

» **No measurement errors caused by ice layers in the snow cover**

» **Simple and convenient installation even at hillsides**

» **Automatic, continuous measurement**

» **Energy- saving sensor operation**
- „Standby“ between the measuring phases
- Optimum for solar- powered stations

Introduction

Automatic and continuous measurement

Getting information about snow by measurements is very difficult. There is the necessity to registrate many parameters to make reliable statements about the snow pack. Additionally, snow has an enormous variability in space and time. Until now there are only punctual measurements available for the relevant parameters. The *Snow Pack Analysing System* (SPA) constitutes a revolutionary innovation in snow measurement. It´s a world unique system for automatic and continuous measurement of all the relevant snow parameters like snow depth, snow density, snow water equivalent and contents of liquid water and ice. Due to that, there generates a huge gain of information about the state of the snow pack. The SPA offers a modern and highly time delayed data gathering. There are several possibilities to install the system, depending on demand. Moreover, the system helps to reduce dangerous and expensive adoption of human resources in the wintry area.

Principles of the measurement

Snow depth

The sensor´s principle of measurement deal´s with the transit- time measurement of an ultrasonic pulse between the sensor and the snow surface. The influence of the temperature is getting compensated automatically.

Measuring the dielectric constant

Snow consists out of the three components ice, water and air. Using different measurement frequences, these components show different dielectric constants. Measuring the complex impedance along a flat ribbon sensor (SPA- sensor) with at least two frequencies allows to estimate the volume contents of the individual component.

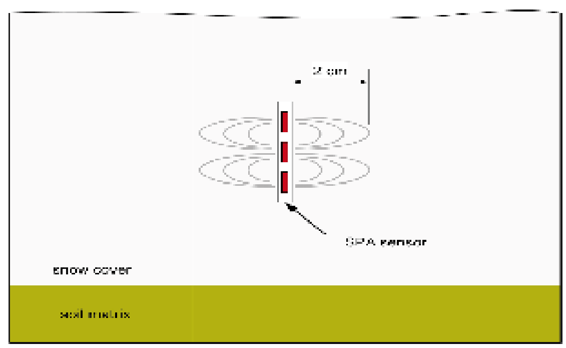


Fig. 1: Measurement principle of the SPA- sensor.

Liquid water and ice content, snow density and snow water equivalent

The specific volume contents equate the liquid water and ice content in the snow pack. With this information the snow density can be calculated. Combining the data of snow density with the snow depth defines the snow water equivalent.

Installation of the system

The SPA- system can be installed simply and conveniently into existing weather stations, also it can be realized in new stations. Even hillside installations are possible. The snow depth sensor is getting fixed on a mast system with a beam. One side of the SPA- sensor is fixed by a suspension on a mast, too. The other side is getting anchored in the soil. The sensor length can varay between 3 and 10 m. Central part of the SPA- system is the measurement and control device. It analyses the input data and transfers it by a RS 232 to a data logger.

Fields of application

For hydropower companies and flood prevention authorities the precise monitoring of water resources on catchment scales is indispensable for the prognosis of snowmelt run- off, which in return is relevant for flood prevention. In agriculture and mining estimations of the infiltration of melting water into the soil or underground are of basic interest.

The information about the liquid water content of the snow pack makes it possible to estimate the point of saturation and snowmelt run- off. This point can be measured by the SPA- system. Thereby the system offers an important upgrading information for hydrological models. Furthermore these information is also important for snowmelt models, refering to remote- sensing data. The SPA can be a ground control for calibration. Snow density and liquid water content are fundamental parameters for the risk assessment of wet snow avalanches. The SPA helps to improve the quality and density of data for the responsible authorities. Thereby the systems contributes to increase the security of alpine villages and ski- regions.

No influence by ice layers

Snow pillows often have problems by ice layers in the snow pack. This phenomenon occurs often in regions with many melting and freezing periods in one winter- season and influences the result of the measurement. The SPA- system is not affected by ice layers.

System assembly on demand

The SPA- system can operate with up to four SPA-sensors. Their quantity and assembly is related to the desired measurement demand. The sensors can be spaned slopingly or horizontally into the snow pack. Resulting of that there are several different possibilities for installing the system to optimize the information on demand. Three of them are presented here:

Combination

This version consists of a sloping and an horizontal SPA- sensor. The snow density, the snow water equivalent and the ice and liquid water contents of the complete snow cover are determined by the sloping sensor, the horizontal sensor supplies additional information about the snow conditions close to the ground layer.

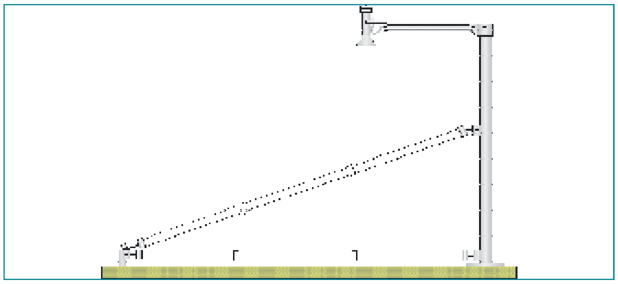


Fig. 2: Schematically figure of the system assebly Combination.

Profile

The SPA- sensors are installed horizontally with increasing levels and result in getting a profile of snow densities and liquid water contents at the defined positions in the snow pack. With this arrangement it is possible to detect the transit of snowmelt water through the snow pack and to generate a snow density profile.

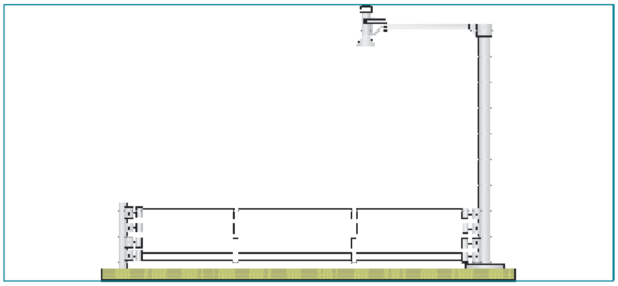


Fig. 3: Schematically figure of the system assebly Profile.

Area

Multiple SPA- sensors are installed in a star shape. The measurement values of the sensors are averaged and supply information with a high spatial extent as it is used for example to calibrate remote- sensing data.

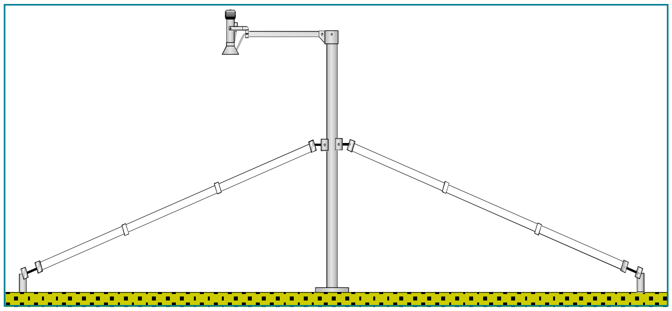


Fig. 4: Schematically figure of the system assebly Area.

Example for application

The SPA- system measured high resolution data in the winter season 2006/2007 for the parameters snow water equivalent, snow density, snow depth and liquid water content of the snow pack. The snowmelt period in april is the most interesting period. First the snow depth is decreasing (A), then the liquid water content is rising (B) and ten days after that the snow water equivalent is decreasing (C). At that point the snowmelt run- off starts. That shows, that the SPA- system can improve the prediction of snowmelt run- off.

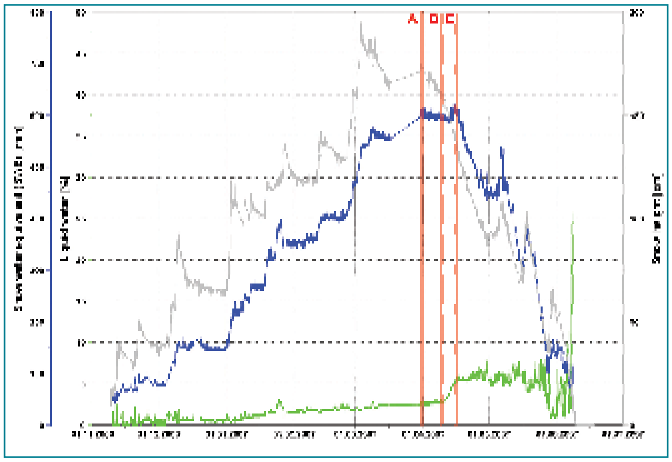


Fig. 5: Data of the SPA- System in the winter season 2006/2007.

Components of the system

Component	Description
SPA- sensor	1-4 sensors mountable
	3-10 m sensor length
	Weatherproof and UV-resistant flat band that includes three wide copper wires
	4 cm depth of penetration of the measurement field
Suspension of the SPA- sensor	Mechanic for fixing and spaning of the SPA- sensors
	Sloping sensors featured with a displacement sensor to improve the calculations of the sensor length
Measurement and control unit	Impedance analyser performing the measurements of the complex impedance along the SPA- sensor
	Multiplexer controls the switching between multiple sensors and connects the snow depth sensor
	Control unit performs the measurements and the calculations of the snow parameters; serial interface RS 232; ASCII format
Snow depth sensor	Ultrasonic snow depth sensor with integrated temperature compensation
Optional components	Integration of up to two sensors for temperature (snow, soil, surface)
	Mast & mechanics
	Power supply
	Data logging & data transfer

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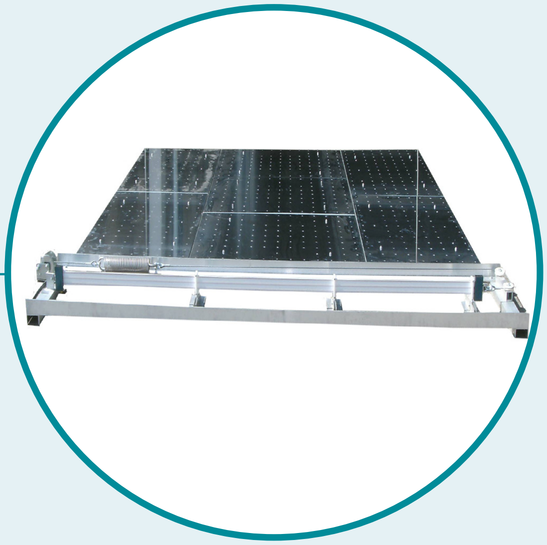
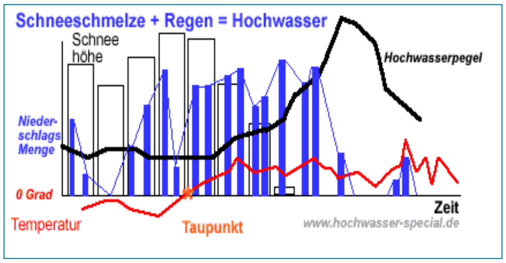
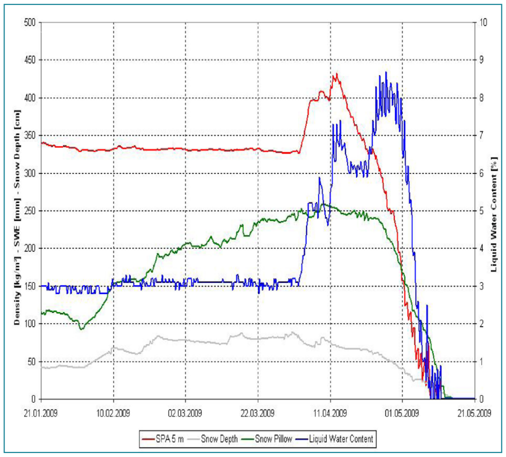
SMP

Snowmelt Prediction







Applications

- Flood prediction
- Water management

Measuring parameters

- Snow Water Equivalent (SWE)
- Liquid water and ice content in the snow pack

Functions and advantages

- Prediction of snowmelt flow from the snow pack
- Weeks in advance recognition of increase of liquid content in snow pack
- Automatic measurement of snow water equivalent (SWE) and liquid water content
- Realistic representation of measured snow parameteres
- Simple and easy installation and set up
- Lowest power consumption
- No calibration required

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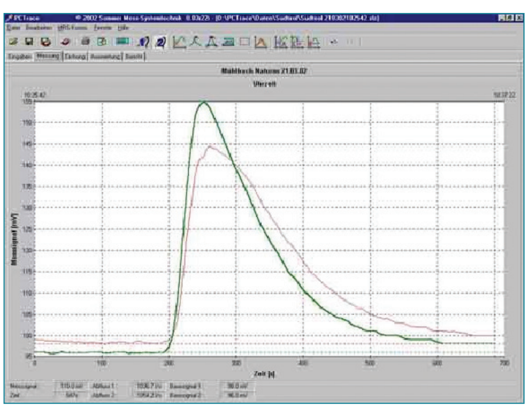
Flow Tracer

Mobile Flow Measurement



Functions and advantages

- Simple and mobile discharge measurement especially for alpine and difficult to access rivers
- Reliable measuring values also in turbulent water with a lot of sediments
- Insensitive against soiling and pollution
- No regular and defined river profile necessary
- Discharge measuring data immediatley availa-ble
- Bluetooth transmission on smartphones or PC (up to Windows 7)
- Unlimited storage and unlimited numbers of measurements possible
- Plausibility check of measurement through up to 4 sensors
- System works with conductivity or/and fluore-scene sondes (Uranin/ Rhodamine)
- Easy change between the 2 versions of sondes through simple repluging
- Compact and robust measuring system inclu-ding accessories
- Measuring range from lowest water quantity up to several cubic metres

	Conductivity	Fluorescence
General		
Discharge Measurement	yes	yes
Measurment principle	Salt dilution method with conductivity tracer	Dilution method with fluorescenne tracer
Applications field	Discharge measurement from minimal quantity up to 10 m³/s	Discharge measurement (all seizes of rivers)
Recording system		
Storage capacity	unlimited	
Storage frequency	1 s	1 s
Data transmission	Bluetooth Class 1, V2.1	
Operating temperature	-20 °C to +60 °C	
Measuring amplifier with Bluetooth		
Power supply	3 x 1,5 V battery seize AA or 3 x 1,5 V / 2500 mA/h NiHM accu seize AA	
Operating time	3 x 25000 mA/h accu 50 h with conductivity sonde 25 h with fluorescence sonde	
Charging time	ca. 10 h	
Charger	Charger 230 V / 12 V 110mA DC Optional: car adapter 12 V	
Accessories		
Pipette (version 1 / 2)	500 µl (fix) / multi pipette 1 - 5ml (adjustable)	
Others	Bottle for calibration (250 ml), measuring cylinder (250 ml), volumetric flask (250 ml), measuring cup (500 ml), thermos flask (with fluorescence), charger for measuring device	

Conductivity sonde	
	4- conductor sensor with integrated temperature sensor Measuring range: 0 - 2000 µS/cm Resolution: 0,1 µS/cm Accuracy: 0,5 % Operating temperature: -20 °C to +60 °C Measuring data linearisation: EN 27888:1993 Measuring range temperature measurement: -20°C to +60°C Resolution: 0,1°C Accuracy: 0,2°C
Fluorescence sonde	
	Measuring sondes for : URANIN , EOSIN, RODAMIN WT Measuring range Uranin/ Rodamin: 0 µg/l ... 100 µg/l Resolution: 0,1 µg/l Operating temperature: 0°C to +50°C Wattter temperature: -2°C to +50°C

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Water level

Water level sensor – UPM-8

Ultrasonic level sensor UPM-8 brings you all the advantages of non-contact level measurement. Silting up and damage caused by water borne debris are a thing of the past with this sensor. The non-contact measurement principle enables simple installation and ensures low-maintenance trouble-free operation.

The UPM-8 is the ideal solution for measuring tasks where the use of conventional measuring systems is problematic or where a metering point needs to be implemented quickly.

Integral filters in the level sensor deliver reliable results even when the surface of the water is choppy. Acquiring the air temperature guarantees accurate depth measurement.

This sensor is impressive thanks to its high level of operating reliability, low energy consumption and ease of use in the field.

The operating parameters and adjustment settings of the UPM-8 are assigned conveniently using a standard terminal program installed on a PC or laptop computer.

Features and characteristics

- Reliable, low-maintenance operation
- Simple installation without the need for expensive construction works
- Durable and extremly robust test probe
- Wide range of applications thanks to non-contact measurement
- Analog and digital interface ensures universal application
- Intelligent processing of measured values in order to compensate and filter environmental conditions
- Watertight design for outdoor use under harsh conditions

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Technical specifications

UPM-8

Measurement range – Water level	Measurement range: 0 to 10 m; resolution: 1 mm; accuracy: 0.1 % (FS) Measurement principle / sensor: ultrasonic (frequency 50 kHz; beamwidth 12°)
Measurement range – Temperature	Measurement range: -35 °C to +60 °C; resolution: 0.1 °C; non-linearity: ≤0.15 % Measurement principle / sensor: semiconductor (external sensor in air-cooled radiation shield)
Functions	Distance or level measurement (configurable)
Interface – Analog	Distance / water level Signal: 4 to 20 mA (configurable); resolution: 12 bit; max. load 100 Ω
Interface – Digital	Distance / water level and air temperature Interface: RS 232; data transmission rate: 1.2 to 19.2 kBd Protocol: various ASCII protocols
Power supply	Supply voltage: 11 to 15 VDC Current consumption: max. 200 mA (measuring phase, approx. 3 seconds); 5 mA (standby) Energy consumption: 0.5 Ah / day (with measuring interval of 1 minute)
Lightning protection	Discharge capacity: built in lightning protection with 0.6 kA discharge capacity
Range of application	Operating temperature: -35 °C to +60 °C
Housing	Basic dimensions: diameter: 80 mm; length: 230 mm Thermal shield: diameter: 110 mm; length: 120 mm Material: Anodised natural aluminium Total weight: 2 kg
Protection rating	IP 66
Installation	Mast-mounting device for 61 mm (2 ") pipe

PRODUCT INFORMATION

RL-35

Contact free radar level measurement

The RL-35 measures the level of the water surface without contact in a safe position based on a radar runtime measurement. The technology enables automatic, maintenance-free, continuous and high accurate measurements.

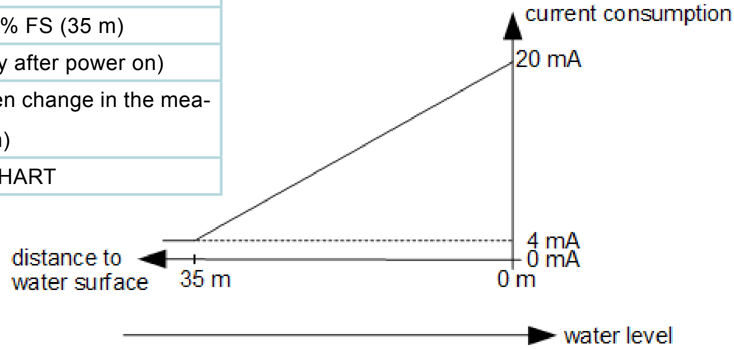
Properties and Benefits

- high accuracy: +/- 2 mm (0.006 % of range)
- 35 m measurement range
- analogue resolution
- compact design
- horn radar antenna with 26 GHz (K-band)
- beam angle 10°
- field of application: -40 ... + 80°C
- 4-20 mA / HART output
- 9.6 - 36 VDC supply
- sensor protection type: IP 68 (waterproof until 1 m)
- powder-coated aluminium housing

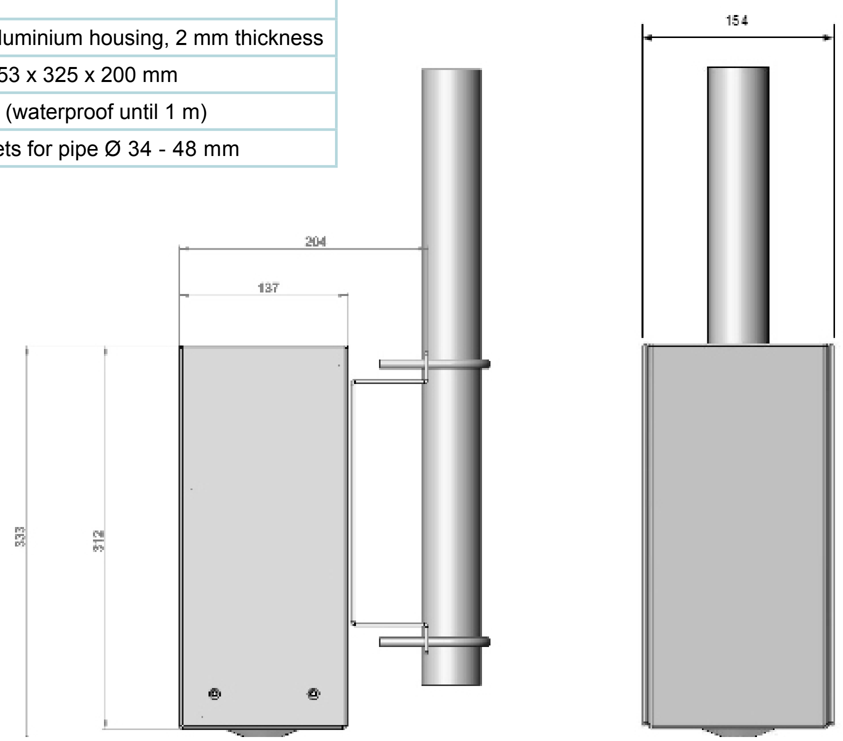
Technical Data

General Information	
Field of application	-40 ... +80°C
Power supply	9.6 ... 36 VDC
Cable length	6 m (customer specific length is possible)
Measurement frequency	26 GHz (K-band)

Level Measurement Output	
Depth measurement	0 to 35 m
Resolution	1 mm
Accuracy	+/- 2 mm; +/- 0.006 % FS (35 m)
Holdback time	recommended 60 s (only after power on)
Step response time	< 3 s (timespan after a sudden change in the measured distance to max. 0.5 m)
Output	4 ... 20 mA / HART



Housing information	
Material	powder-coated aluminium housing, 2 mm thickness
WxHxD	153 x 325 x 200 mm
Sensor protection type	IP68 (waterproof until 1 m)
Installation	2 brackets for pipe Ø 34 - 48 mm



PRODUCT INFORMATION

RQ 30

Non Contact Flow Measurement in Open Channels

The RQ 30 non contact flow measurement sensor is the improved and upgraded successor model for the RQ 24. Based on the non contact Doppler radar technology, surface velocity and level are measured and the flow quantity is automatically calculated.

Properties and Benefits

- Waterproof IP 68
- Fast measurement and calm measuring signal
- Dynamic of measuring process
- Automatic and internal inclination sensor
- Flow direction recognition
- Small, compact design
- External input for additional sensors e.g. water temperature
- Digital output for alarm systems or activation of sampler
- High velocity measurable - up to 15 m/s
- Easier integration and update possibility
- More interfaces - SDI 12, RS 485, analog
- Bed river changes measurable
- Low power consumption
- User-friendly operation

General	
Dimensions (mm)	appr. 220 x 190 x 130 mm
Protection	IP 68
Power supply	5.5 V ... 30 V
Power consumption	Sleep modus ... 1 mA Active ... appr. 130 mA (Measurement 10 ... 60 sec)
Operating temperature	- 35° to 60° C
Storage temperature	- 40° to 60°
Lightning protection	Integrated lightning protection with discharge capacity 0.6 kW Ppp
Connector 1 (12pin)	
Interface	1x RS 485 1x SDI - 12 Transmission rate (1.2 KBaud to 115 KBaud)
Analog Output 4 x 4 ... 20 mA	Water level Velocity Discharge Ext Input (AUX sensor)
Digital Output	1 x Switching output (max. 1.5 A)
Digital input	1 x Trigger input (0 = 0 - 0.6 V) (1 = 2 - 30 V)
Connector 2 (4 pin connector)	
	1. Level 4 ... 20 mA 2. Power supply level sensor 17 V 3. GND
Connector 3 (4 pin female)	
	1. Ext analog input 0 ... 2.5 V 2. Power supply sensor (U power - 1 V) 3. GND
Level Measurement	
Depth measurement	0 to 15 m - Standard oprating range 0 to 35 m - Optional extended operating range
Resolution	1 mm
Accuracy	+/- 5 mm; +/- 0.025 % FS (15 m)
Measurment frequency	K-Band (26 GHz)
Velocity Measurement	
Range	0.15 to 15 m/s
Accuracy	+/- 0.02 ms; +/- 0.5 %
Resolution	1 mm/s
Direction recognition	+/-
Measurement duration	10 to 240 sec
Measurement period	min 2 sec (aktiv 10 ... 60 sec)
Frequency of sampling	2 khz
Measurement interval	min 5 sec max. 5 h
Distance to water surface	min 0.5 m max. 30 m

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Geotechnical & Materials Testing
Environmental Monitoring
Test & Measurement Instrumentation

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