# A new low-cost ultrasonic and meteorological sensor for observation of snow hydrological processes

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HYDROLOGY

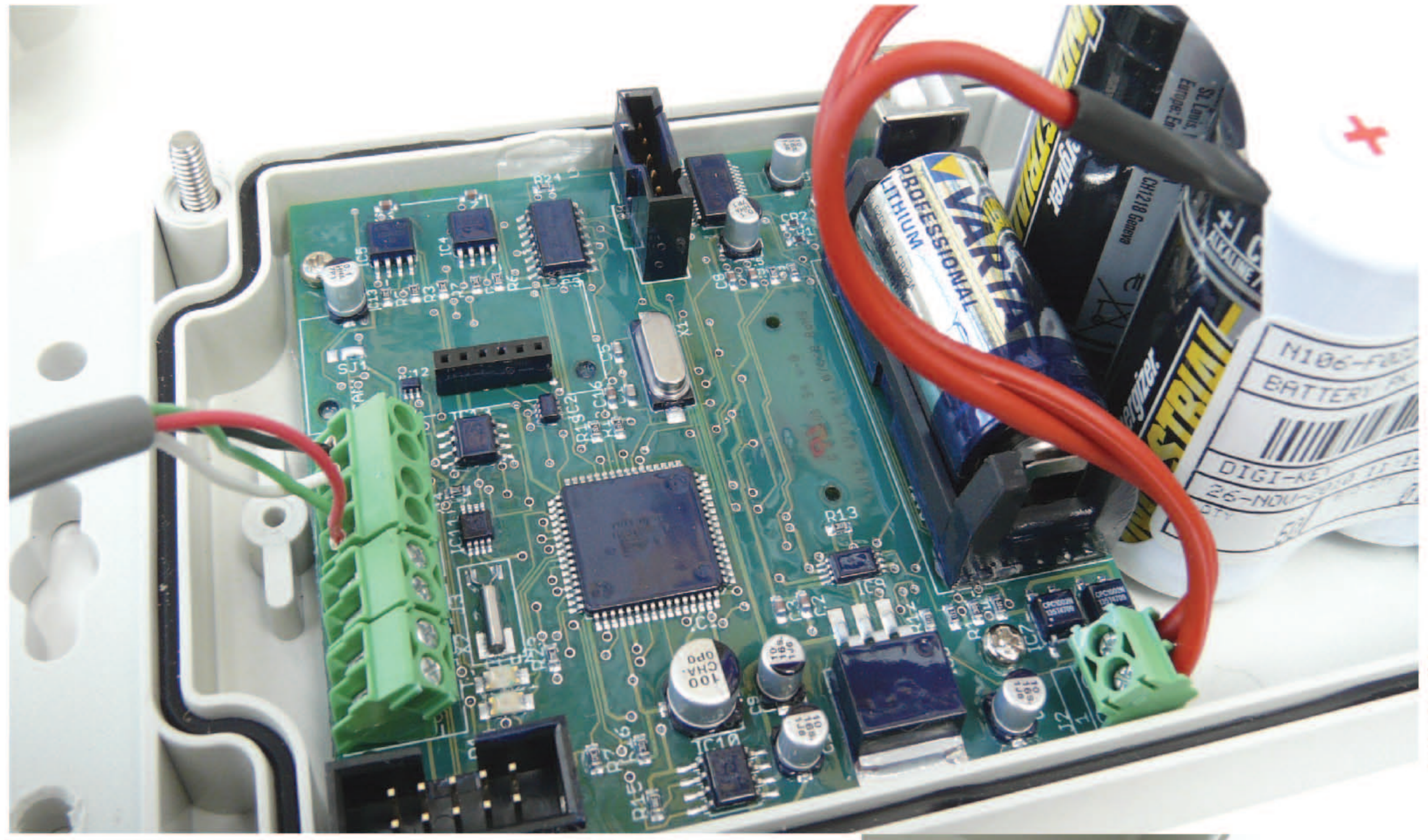
## Description of the SnoMoS

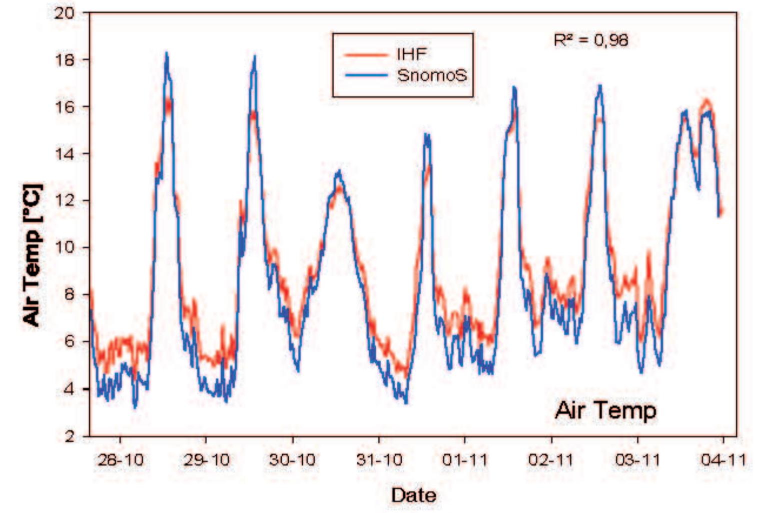
The recently developed SnoMoS (Snow Monitoring Sensor) are battery-powered standalone systems with a built-in datalogger. The distance between the sensor and the (snow) surface is measured with an ultrasonic range finder. The distance readings need to be corrected for pitch and roll of the sensor (which are recorded by the sensor) and for the air temperature at which they occur. Recordings are triggered at 1 hr intervals and consist of a number of consecutive readings (set to 20 in this study). Sample readings are flagged as corrupt should the sample variance exceed a user-defined threshold.

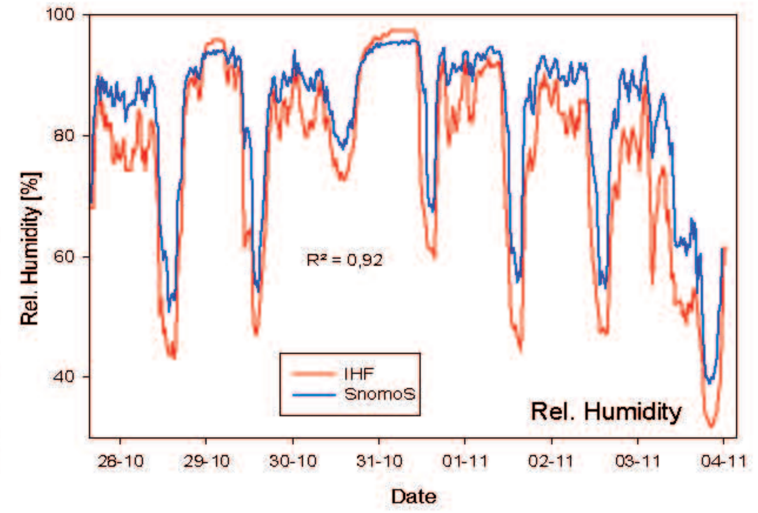
The sensors are mounted on a L-bar and can run unattended for the full winter period. Selected sensors were additinally outfitted with a standard precipitation recording tipping bucket and/or a small cup anemometer. Additional meteorological data collected by the sensor are: air temperature and humidity, surface temperature, incoming global radiation, and air pressure. The SnoMoS can also record time-lapse photos with a low-resolution camera and transfer the data by a modem connection. Both features are not implemented yet and have not been tested.

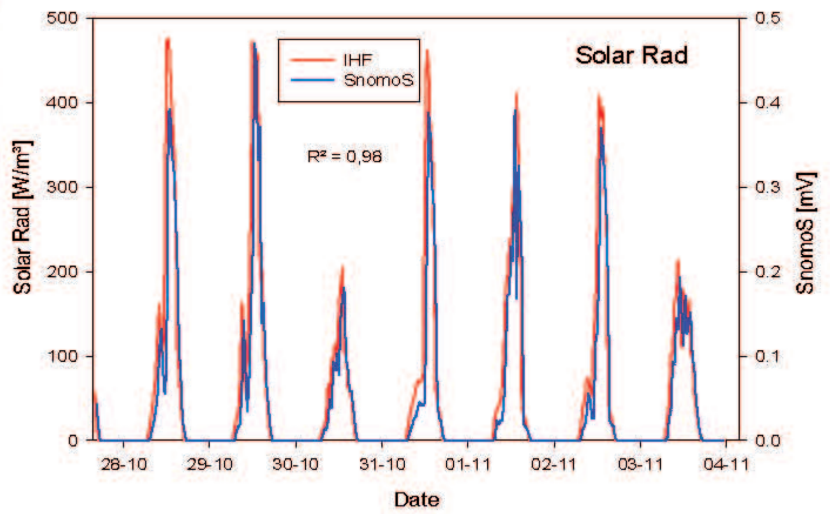
## Data Quality

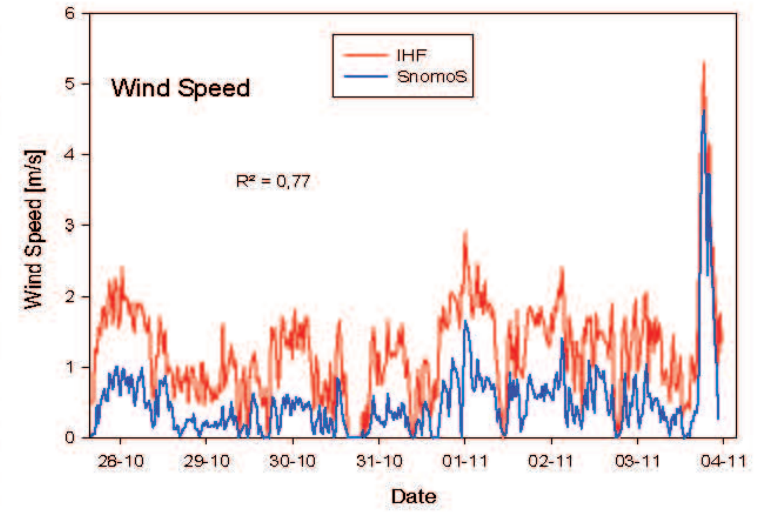
The measurements of the SnoMoS were tested against a WMO standard weather station. Air temperature and incoming solar radiation compared very well. Relative humidity values seem to be at times slightly overestimated possibly due to the proximity of the SnoMoS to the wooden L-bar which is often wet during the winter period. The wind speed values show an underestimation of the real values especially at low wind speeds. The reason appears to be the small anemometer used. It has a significant lagged response at low windspeeds which causes the lower readings. However, higher windspeeds, which are much more important for snow cover redistribution and snowmelt, are captured by the SnoMoS.





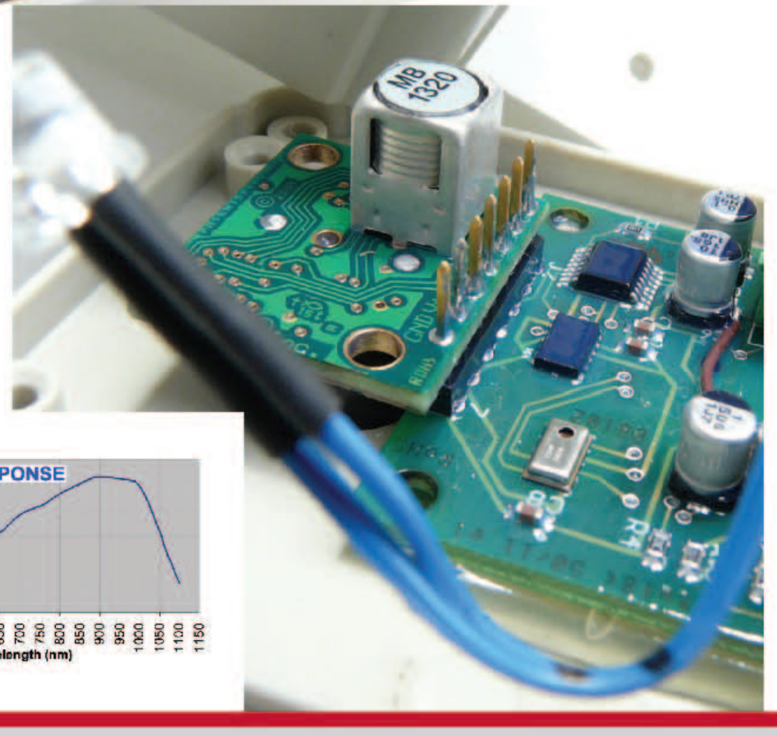



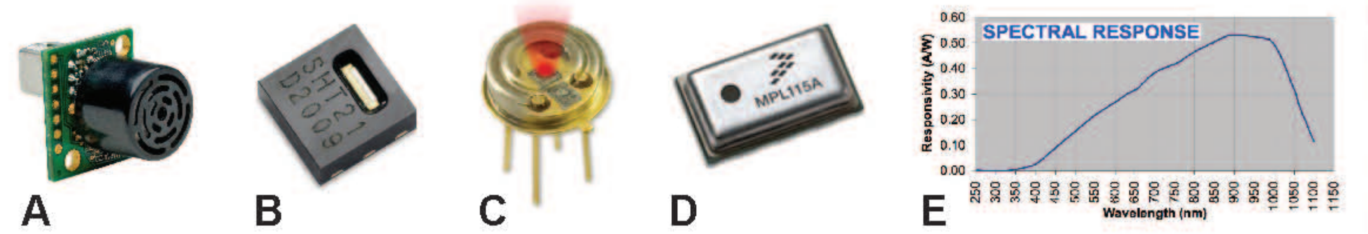




## Sensors used by the SnoMoS

| | Sensor | Company and Type | Resolution | Accuracy |
|---|---|---|---|---|
| A | Ultrasonic | MaxBotix MB 1320 | 1 cm | 2-4 cm |
| B | Air temperature | Sensirion SHT 21 | 0.01°C | 0.3-1.0 °C |
| | Air humidity | Sensirion SHT 21 | 0.04%RH | 2-5%RH |
| C | IR Thermometer | Melexis MLX90614 | 0.02°C | 0.5°C |
| D | Barometer | Freescale MPL115A | 0.15 kPa | 1.0 kPa |
| E | Photodiode for Pyranometer | Advanced Photonix PDB-C139 | | |



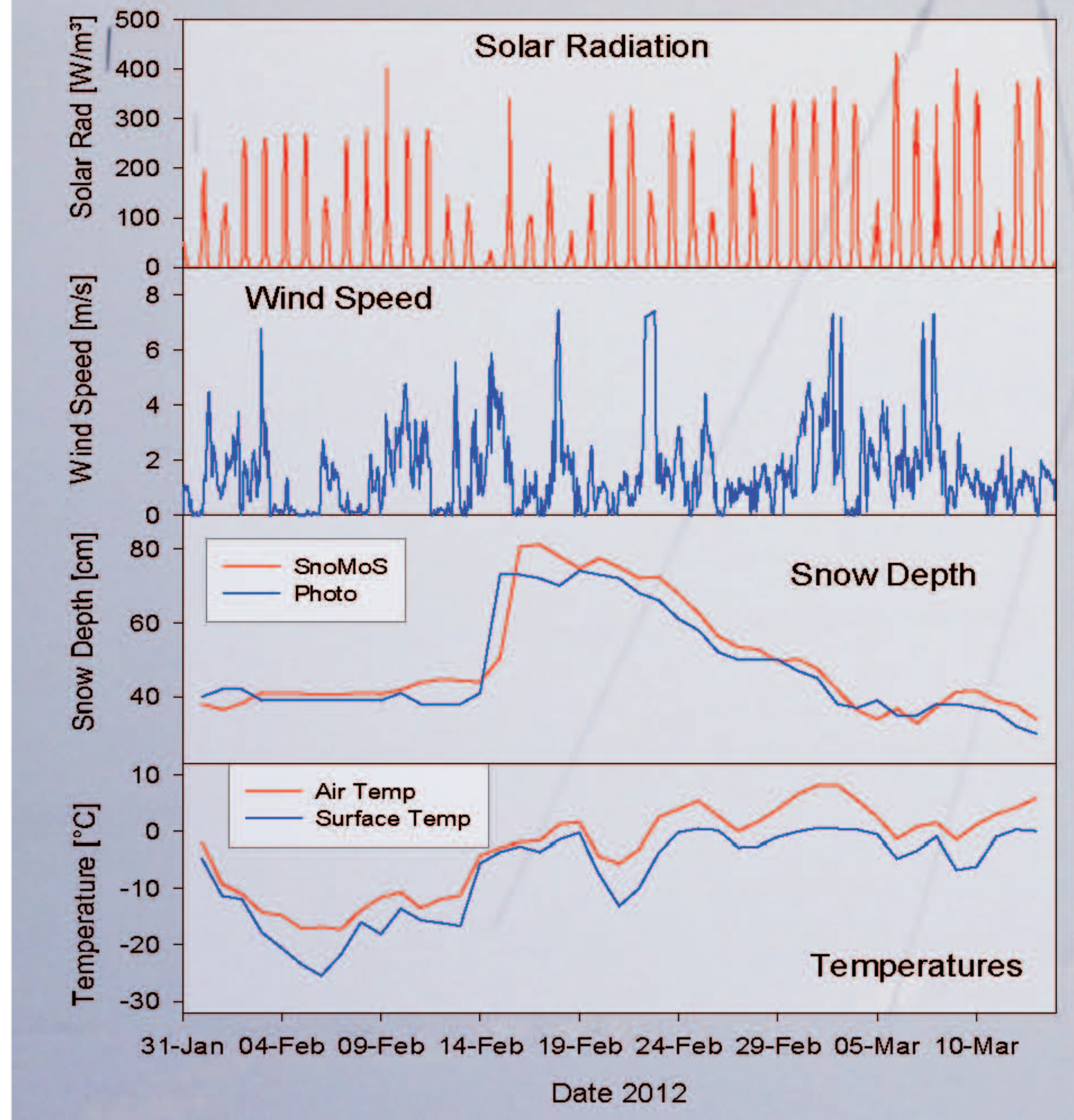



## SnoMoS Measurements

The time series on the right show an example output from the SnoMos for a 44-day period in spring 2012. The graphs show hourly values of incoming solar radiation and wind speed and daily average values of snow depth, air and surface temperature. The diurnal variation of the incoming solar radiation are clearly captured by the SnoMoS. The absolute lowest values occurred on February 15th, when a significant snowstorm occurred as can be seen from the snow depth recordings.

The snow depth readings from the SnoMos was compared to observations from an interval camera installed close by. This camera took hourly pictures. reaching and staying at 0°C for much of the melt period in March. A snow stake was placed in the view of the camera allowing the visual reading of snow depth from the pictures. The comparison shows that the snow depths recorded by the SnoMoS follow the ones taken from the camera very closely. The apparent slight „trailing" of the SnoMoS values, especially evident during the snowfall event around Feb. 15th can be attributed to the fact that the SnoMoS values are daily averages while the camera values were determined at 12:00 for each day.

The comparison of the average daily air and surface temperatures observed by the SnoMoS shows that the snow surface was consistently slightly colder than the air. It also shows the snow surface temperature reaching and staying at 0°C for much of the melt period in March.




## The future of the SnoMoS

The SnoMos have been tested for the last 3 month at over 50 several locations in the black forest to observed the spatial and temporal variability of snow processes. There are still additional test necessary to ensure a robust performance. Several SnoMoS are tested in parallel during the summer period in the mountains to measure the relative accuracy of the sensors. In addition, the sensors will be tested on Svalbard under more extreme conditions.

We also plan to use the sensors for water level measurements in streams, where the meteorological observations can help to capture the energy balance of streams. We hope that the sensors will be useful for a variety of hydrological observations where autonomous, stand-alone and relative cheap sensors are essential.

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