INFRASNOW – USER MANUAL

OVERVIEW

1) Graphical Display (102x64 with Backlight)
2) Abort Button
3) Enter Button
4) Navigation Buttons
5) Power Button
6) Connection to Sensor or Computer (USB)
7) Battery Compartment (back side)
8) Calibration target
9) Adapter Plate (ø 80 mm and ø 120 mm available)
10) Connection to Control Unit

SPECIFICATION

Parameter	Value	Unit
SSA range	2,5 to 80	1 / mm
Snow density range	50 to 685	kg / m³
Meas. Wavelength	945	nm
Battery run time	>10	hrs
Temperature range	-25 to +60	°C
Memory size	325	samples
Battery	3 x 1,5 V	AAA cells*
Data download	via USB	
Display	102 x 64 px with backlight	
Measurement surface	ø 38 mm Sphere	
Contact Surface	ø 50 mm ø 80 mm or ø 120 mm by using adapter plate	

* We recommend using Energizer Ultimate Lithium or Varta Lithium batteries for best performance at low temperatures.

WORKING PRINCIPLE

The InfraSnow device measures the specific surface area (SSA) of snow with an optical sensor. The method consists of diffuse near-infrared reflectance measurements using a compact integrating sphere setup to derive SSA. Diffuse reflectance is measured at a NIR wavelength, where impurities have only a weak influence on the reflectance of snow. For a sufficiently thick snow block, there exists a unique correlation between diffuse hemispherical reflectance and SSA according to multiple-scattering radiative transfer theory.

The correlation between snow SSA and reflectance is calculated by applying Monte-Carlo ray tracing to a 3D implementation of the measurement geometry. Snow density is required as second input parameter to the SSA analysis and can be measured e.g. by means of the SLF snow sensor.

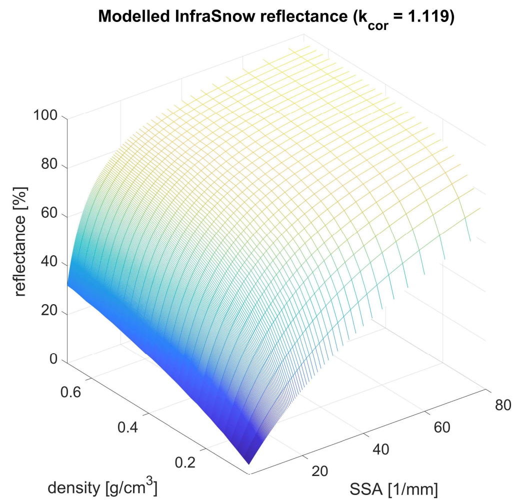


Fig. 1: SSA-density-reflectance correlation numerically modelled and adapted referring to 16 micro-CT reference measurements.

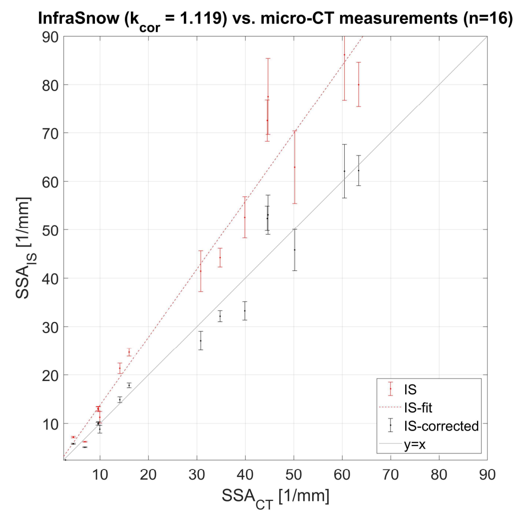


Fig. 2: Comparison of SSA measurements using the InfraSnow with the original and the corrected SSA-density-reflectance correlation versus micro-CT.

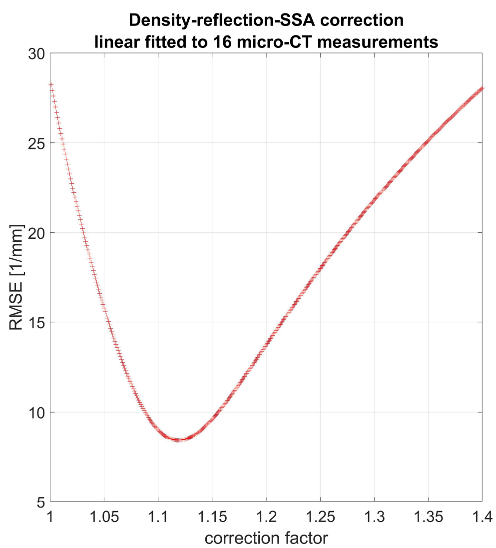


Fig. 3: Correction factor of the SSA-density-reflection correlation.

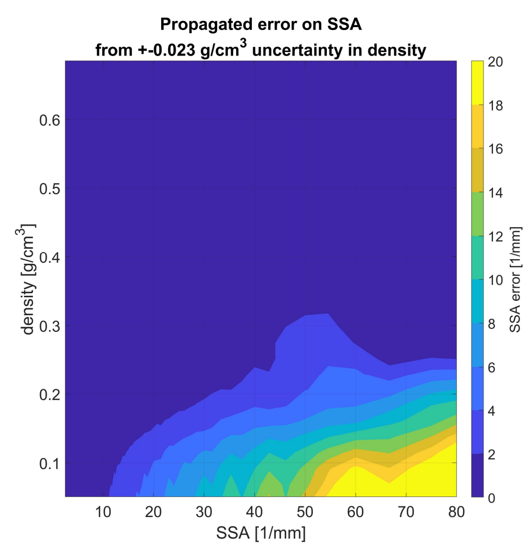


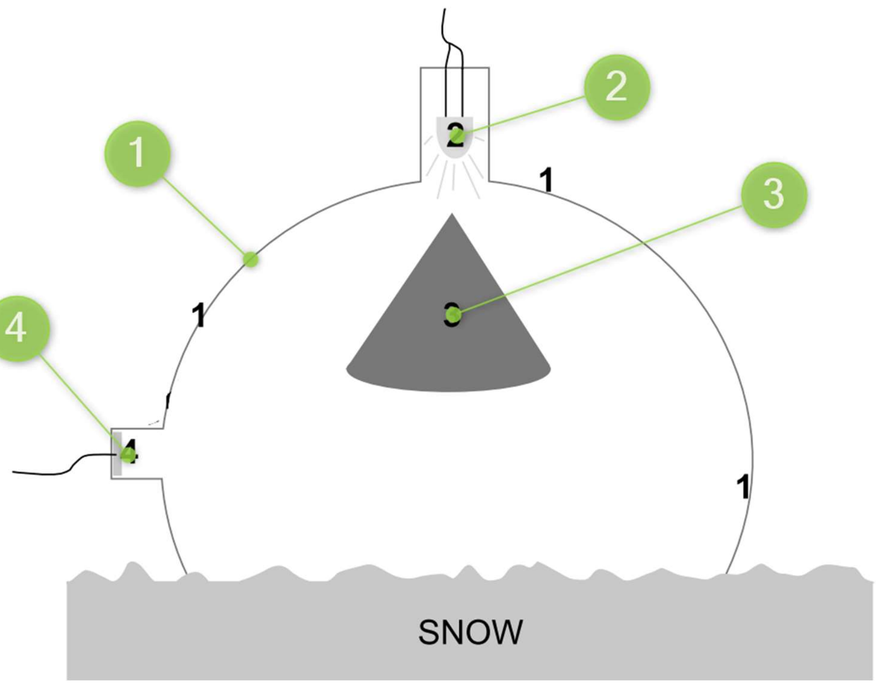
Fig. 4: Propagated absolute SSA error due to density uncertainty.

The modelled SSA-density-reflectance correlation from Gergely et al. (2014) was implemented but linearly corrected by a factor of 1.119 (Fig. 1), which can be adjusted by the user. The recommended correction factor resulted from a minimal least square fit to high resolution (6 to 10 µm) micro-CT measurements of 16 snow samples (Fig. 2 & 3). The recommended correction appeared necessary, as the validation of the first InfraSnow prototype described by Gergely et al. (2014) did not include high SSA snow samples. It can be assumed that for high SSA snow, the used optical snow model from Wiscombe (1980) is limited, as a simplified snow microstructure of ice spheres are assumed a priori. Nevertheless, uncertainties exist also for micro-CT based SSA measurements, especially for higher SSA values due to the limited resolution of the micro-CT (Kerbrat et.

al, 2009). Minor changes of the new sensor specifications (light source, NIR sensor, sphere coating) were found neglectable, conducting additional optical simulations according to those of Gergely et al. (2014).

As the measured InfraSnow reflection depends on the SSA and on the snow density, the latter can contribute significant uncertainty to the measurement result (Fig. 4). An uncertainty in density of ± 23 kg/m3 (= 0.023 g/cm3) can lead to an absolute SSA error of up to 25 mm-1 for low density snow (Fig. 4). For snow with a density above 150 kg/m the error propagation due to density remains below about 12 mm-1 (= 15 % for maximal SSA).

InfraSnow Measurement Principle [Gergely et. al, 2014]



(1) Integrating Sphere, (2) NIR Light Source, (3) Diffusor, (4) Photodiode Detector

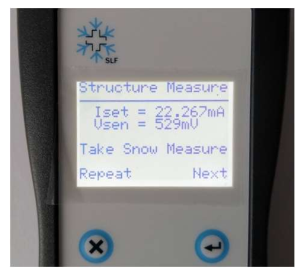
MEASUREMENT POCEDURE

0) Verify the absence of liquid water in the snow (T_{snow} < 0 °C).FOLLOW THE STRUCTURE MEASUREMENT MENU:

1) Start “Structure SSA” menu

2) Enter dry density: A value between 50 to 685 kg / m^3 is accepted. The snow density value can be either derived by
   a. performing a measurement using the SLF snow sensor
   b. manually entering a value for the density that can be an estimate or from reported values for typical snow types in the literature [e.g. Fierz et al., 2009; Wolfsperger et al., 2018].
   c. or calculated based on measuring the weight of a well-defined snow volume.

3) Execute target calibration: Make sure the metal target is clean and free from dust particles or moisture. Apply the metal target and check that it is firmly closed and hold by the magnets.
   Target calibration needs to be repeated whenever the ambient temperature conditions have significantly changed (5°C +)



4) Prepare for snow measurement:
   a. Remove the calibration target and fix it to the top cover were it is hold by magnets.
   b. If measuring fresh snow with low density values it is advisable to apply an adapter plate.
   c. Prevent snow and dust from entering the sphere.
   d. Prepare a perfectly flat snow surface (e.g. use a scraper) to ensure the opening is in full contact with the snow surface.

5) Take snow measurement: After pushing the “Next” button the snow reflectance measurement takes place immediately and SSA is calculated based on density-reflection correlation calibration curve. Each measurement is assigned to a constantly increased measurement number that is stored in memory and can be transferred over USB to the computer. The remaining memory space is shortly displayed after the measurement is saved. For consecutive measurements the device uses the same snow density value until the density measurement menu is left. Pressing the repeat button, the snow SSA measurement will be repeated and overwritten.

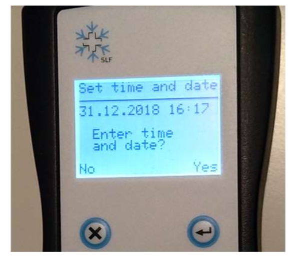
6) Repeat the snow measurement 3 to 5 times at the region of interest due to the inherent variablity of snow, unevenness of the prepared snow surface and small variations of the device-snow contact.

CONFIGURATION MENU

Show Info

Displays information regarding control unit and snow sensor:

1) Software version of control unit
2) Firmware version of InfraSnow
3) Calibration voltage of InfraSnow
4) Serial number of snow sensor / InfraSnow
5) Current date and time that is used for timestamps. Can be changed if during power-up the POWER button is pressed.



Enter Meas Nr

Allows to set the continuously increased measurement number to any value.

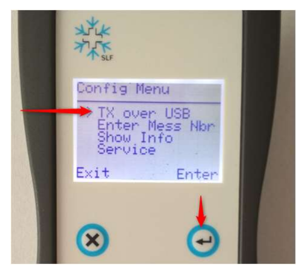
Service

Service menu to set calibration constants of InfraSnow and reflectance fitting functions. Only accessible with password.

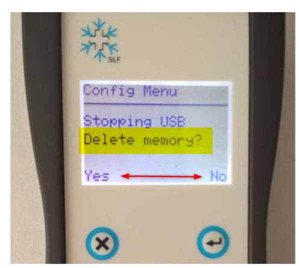
TX Over USB

See below

DATA TRANSFER TO COMPUTER



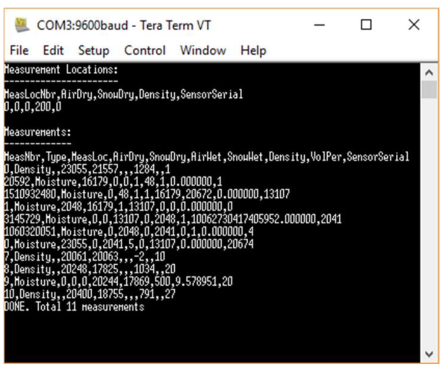
1) Disconnect InfraSnow
2) Go to Config Menu and start "TX over USB"
3) Connect USB adapter cable between computer and control unit.
4) On Windows Computer:
   a. Windows 10 should recognize "STMicroelectronics Virtual COM Port" and start installing driver if not already present. For old Windows versions driver can be downloaded on ST.com website.
   b. Open Terminal Window (e.g. Tera Term) and connect to virtual COM port.
   c. Press "Start TX" Button.

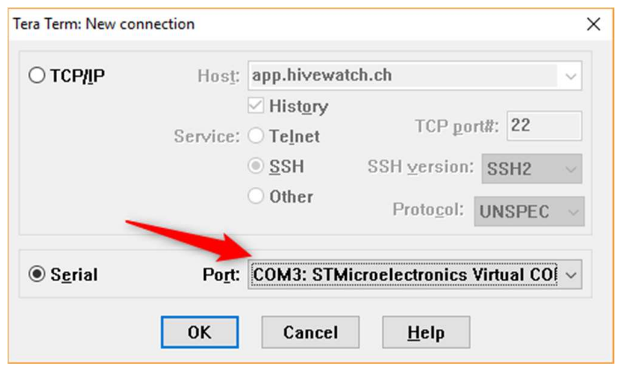


5) On Apple Computer:
   a. MacOSX recognizes virtual COM port without any extra driver.
   b. Open terminal application.
   c. Check if the device is visible to your computer. The name is always "usbmodem???".
      $ ls -l /dev/.usb**
      crw-rw-rw- 1 root wheel 21, 11 Oct 23 09:24 /dev/cu.usbmodemFD131
      crw-rw-rw- 1 root wheel 21, 10 Oct 23 09:24 /dev/tty.usbmodemFD131
   d. Now open the "tty" device for the transfer.
      $ screen /dev/tty.usbmodemFD131
   e. Press "Start TX" Button
   f. The data are transferred now and shown on the terminal.

6) On Linux Computer:
   a. Open terminal and check if the device is visible:
      *sudo ls -la /dev/tty**
   b. The most recent device belongs to the sensor, e.g.
      0 crw-rw---- 1 root 166, 0 Jan 22 16:32 /dev/ttyACM0
   c. Make sure you have the following line in your ~/.screenrc configuration file, it will prevent the screen window to shutdown as the process terminates (either variant will work based on your Linux configuration):
      Variant A: *zombie kr*
      Variant B: *termcapinfo * ti=:te=*
   d. Open the device for transfer
      sudo screen /dev/ttyACM0
   e. Press "Start TX" Button
   f. The data are transferred now and shown on the terminal.

7) Copy and paste comma delimited data to spreadsheet (e.g. Excel).
8) After USB download memory can be deleted if desired and measurement index set back to zero.





SSA POST-PROCESSING

For the case the SSA needs to be recalculated with a corrected input density, this can be done with a provided script coded in python. The script reads an InfraSnow raw data file and looks up the SSA (or the optical equivalent diameter OED [μm] = 6/SSA[mm^{-1}]*1000) for a measured reflectance and the new input density. The look-up table, which contains the modeled correlation of InfraSnow reflectance, density and SSA is given as .txt file. The code uses the same linear interpolation of the SSA as implemented in the InfraSnow devices, as the look-up data table has a limited resolution (Δdensity = 23 kg/m^3; ΔOED = 10 μm).

LITERATURE

Wolfsperger, F., Ziegler, S., Schneebeli, M., Löwe, H. (2022). Evaluation of the InfraSnow: a handheld device to measure snow specific surface (SSA). Poster at the IGS International Symposium on Snow, Davos.

Gergely, M., Wolfsperger, F., & Schneebeli, M. (2014). Simulation and validation of the InfraSnow: an instrument to measure snow optically equivalent grain size. IEEE Transactions on Geoscience and Remote Sensing, 52(7), 4236-4247. https://doi.org/10.1109/TGRS.2013.2280502

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W. J. Wiscombe, “Improved Mie scattering algorithms,” Appl. Opt., vol. 19, pp. 1505–1509, May 1980

M. Kerbrat, B. Pinzer, T. Huthwelker, H. W. Gäggeler, M. Ammann, and M. Schneebeli, “Measuring the specific surface area of snow with X-ray tomography and gas adsorption: Comparison and implications for surface smoothness,” Atmos. Chem. Phys., vol. 8, no. 5, pp. 1261–1275, 2008.

SUPPORT

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