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COST Action ES1404

2nd Snow Science Winter School

14-20 February 2016, Preda, Switzerland

STSM Report

1. Introduction

I have attended 2nd Snow Science Winter School which was held in 14-20 February 2016, Preda and Davos, Switzerland. The host organization was SLF, WSL (Swiss Federal Institute for Forest, Snow and Landscape Research) Institute for Snow and Avalanche Research. There were 26 attendees coming from European countries, USA, Canada, Russia and Turkey who are studying in snow science with different backgrounds (physics, chemistry, engineering, etc.)

The objective of the Snow Science Winter School was to teach advanced techniques to measure snow properties, as micro-tomography, measurement of specific surface area by reflection and spectroscopy, near-infrared photography and high-resolution penetrometry, and to introduce the modern concepts of snow science.

The school can be divided into three sections which will be explained in detail in the next section:

a) Lectures, given by 9 lecturers introducing different parts of latest concepts of snow science.

b) Field Measurements, were held in Preda, which is located in the east of Switzerland with 1800m altitude, at three different locations (open site, forest site, above tree line).

c) Laboratory visit was one day trip to Davos, SLF Main Building. Laboratory infrastructure and Instruments used in snow science were introduced.

2. Activities during Snow Science Winter School

2.1 Lectures:

Lectures were very useful, each one introducing different aspects of snow science like snow microstructure, advanced field measurement methods, remote sensing of snow properties, snow albedo and affects on energy balance, snow-forest interactions and snowpack modeling.

Also spending whole week at the same place with the lecturers was a great opportunity to ask questions about their studies and questions about snow science.

2.2 Measurements:

First day, we were divided into groups of 3 or 4 for field measurements. Starting from digging a pit, several measurement techniques were introduced:

2.2.1 Basic Snow Profiling Measurements

Depth: First the snow pit depth was measured as seen in the Fig. 1.

Figure 1. Snow pit depth and temperature measurement

Temperature: air temperature, surface temperature and snow temperature at every 5 cm were noted by a digital thermometer to get a temperature profile of the snowpack.

Snow-water equivalent: A metal cylinder tube with a certain depth was weighed with a spring scale and calibrated as zero while it is empty, then it is inserted into snow and weighed with the scale calibrated according to SWE mm values.

Density was measured with the tool named density cutter, seen in the figure. It was a 100cc density cutter and inserted in the snow, excess snow was cut by the cover lid and weighed by a digital scale. Density is calculated as ρ=Mass/Volume

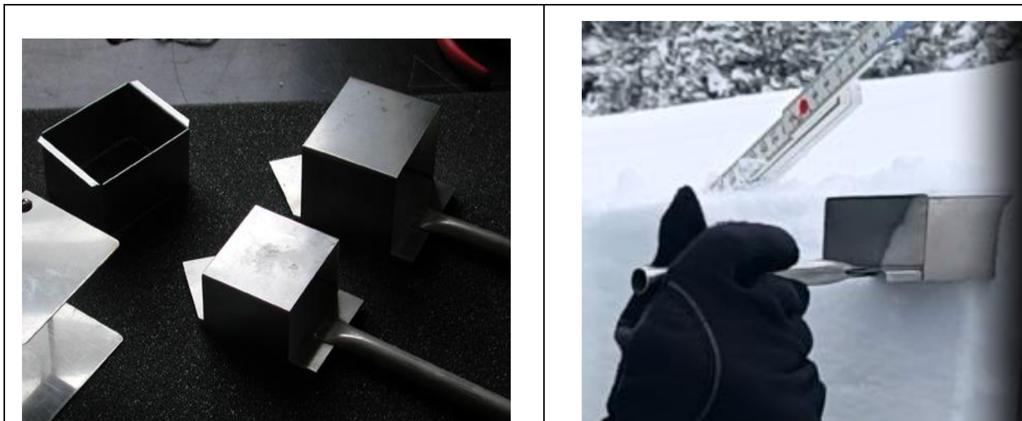
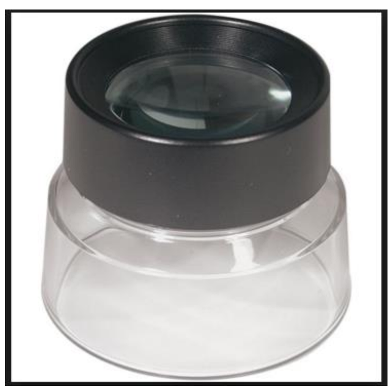


Figure 2. Density cutter (left) inserted into the snow layer (right)

Figure 3. Excess snow is cutted with the lid (left) DC fulled with snow is weighed by digital scale

Grain Size and Type: Grain size and type measurements are rather subjective measurements. From each layer of the pit some snow was taken onto the milimetric part of the crystal card seen in the figure. Then we looked at the grains by the magnifier and decide the size and shape by comparing the pictures at the below part of the plate.



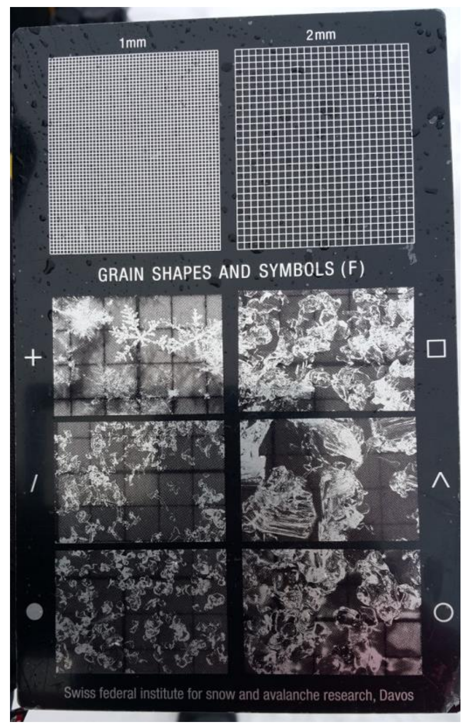


Figure 4. Magnifier (left) and crystal card (right).

2.2.2 Near-infrared photography (NIP)

NIR photography is used to detect the layers of the snowpack and determine the snow grain size or Specific Surface Area (SSA). Digital cameras in which a special filter blocks all wavelengths outside the near-infrared (NIR) spectrum are used for NIR photography. Different intensities in the NIR image indicate different snow grain sizes (or different SSA). NIR images allow the individual layers of the snowpack to be clearly distinguished, while the photograph in visible light shows hardly any contrasts. First, camera is calibrated with a white styrofoam plate, then picture of the snow layer is taken.

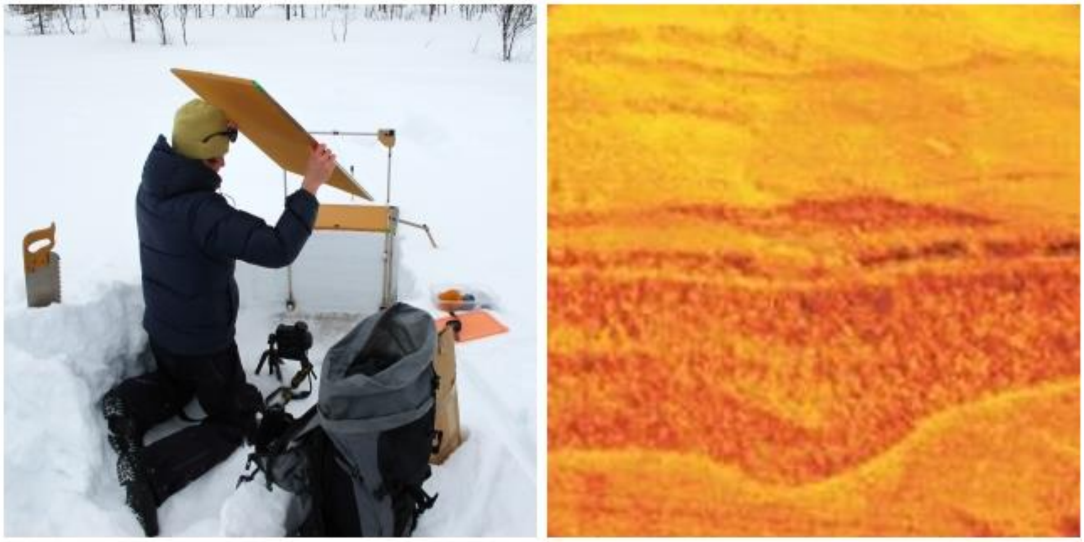


Figure 5: Preparing to take an NIR photograph of a snow profile (left). Image of a snow profile captured by NIP (right). The picture clearly reveals the individual layers, even if they are very thin.

2.2.3 Laser Reflectometry is used to find Specific Surface Area (SSA) of snow (Gallet et al, 2009). Snow SSA is defined as the surface area per unit mass.

Two devices IRIS (InfraRed Integrating Sphere) and IceCube were introduced depending on the same principle. The working principle of these devices relies on the relationship between the infrared hemispherical reflectance of snow and SSA. A snow sample is illuminated directly by the collimated beam of a laser diode at 1310 nm. Light reflected by the snow is collected via an integrating sphere by an InGaAs photodiode and converted to voltage. A calibration curve, obtained using certified standards, provides the signal-to-reflectance relationship. This reflectance is then converted into SSA using a radiative transfer model and calibration using the well-established methane adsorption method.

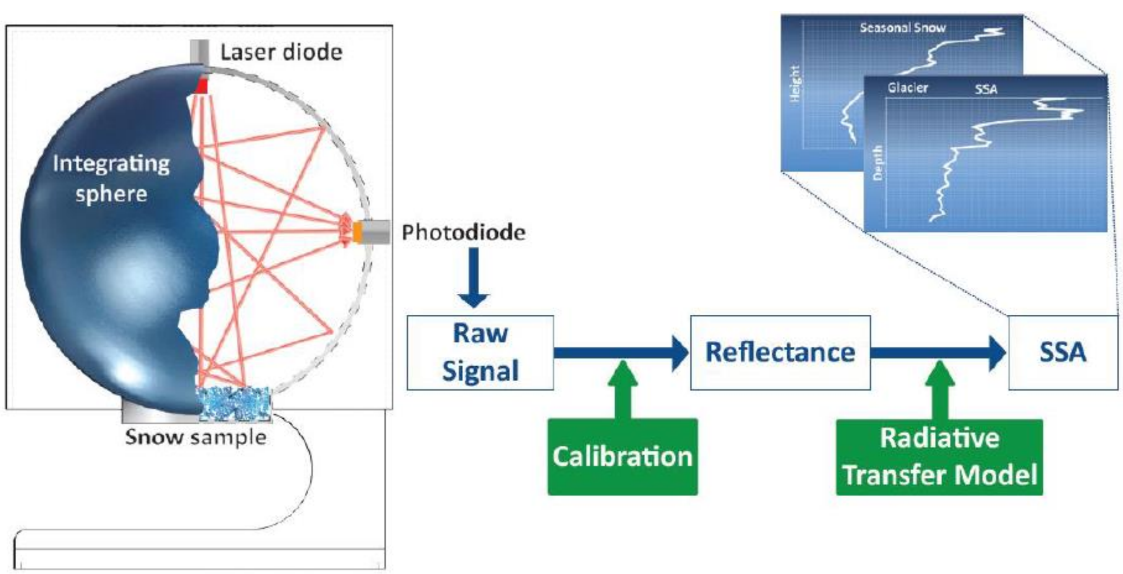


Figure 6. Working principle of laser reflectometer

The main difference between the IRIS and IceCube systems is the sphere geometries. IRIS sphere has 10 cm inner diameter whereas, IceCube has a larger inner diameter (15 cm) and wider ports.

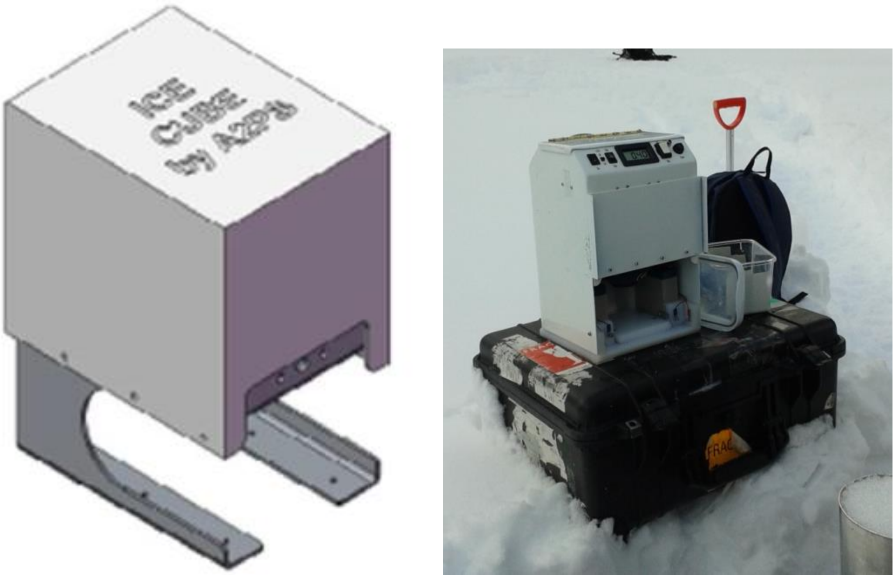


Figure 7. Laser reflectometer devices. IceCube (right) IRIS (left)

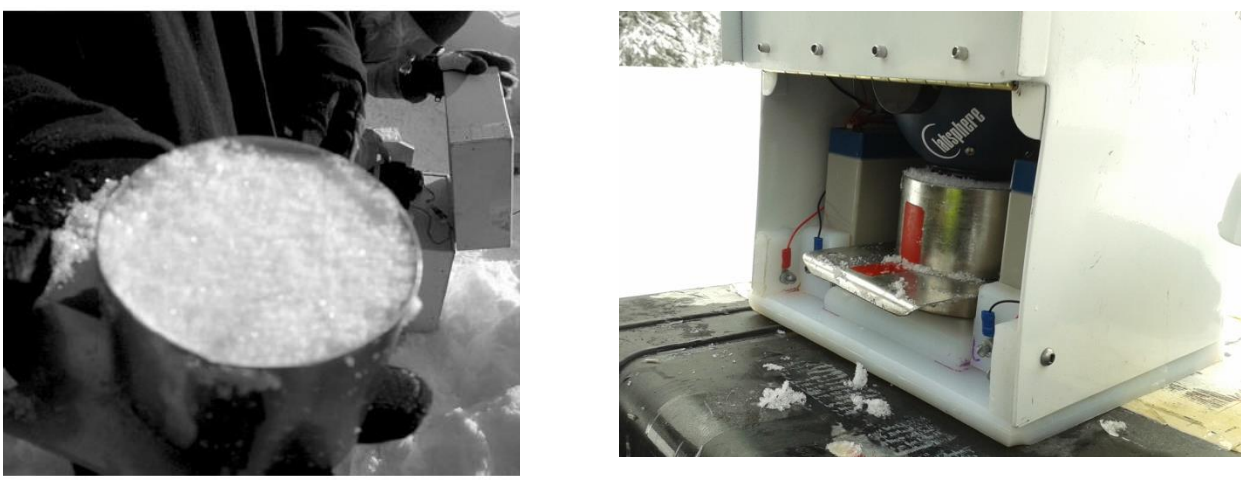


Figure 8. Extracted sample for IRIS measurement (left) Sample is placed inside IRIS under the sphere

2.2.4 Snow MicroPen (SMP)

The SMP is a high-resolution snow penetrometer. It is capable of measuring the bonding force between snow grains. The SMP can be used in different application areas as snow profiling (avalanche forecasting, snow stratigraphy, remote sensing ground truth), ski track characterization (ski racing) or snow runway characterization (stability testing). The SMP is composed of a piezoelectric force sensor that is fixed on the head of a 1.5 m long rod which is driven into the snow pack by a motor unit and a controller unit.

The motor unit of the SMP is the part which drives up and down the rod. At the front side of the rod, a piezo electric force sensor is fixed. On the force sensor there is a conical and really thin tip which actually breaks the bonds between the snow grains. The black ski poles are used to hold the SMP on the same position above the snow surface during the measurement.

Figure 9. Measuring tip at the end of the rod (left) Motor unit, black poles and the tip (middle) measurement by an SMP (right)

In the next days we have used these measurement techniques in an open site, forest site to see the effect of trees on snow properties, and the above tree line to see the effect of elevation and slope. Detailed data analysis of each site will be presented in our group report submitted to the Snow School organization committee.

2.3 Laboratory Visit

Laboratory was in the SLF main building in Davos. The facilities in the lab were introduced and data analysis methods for Micro-CT measurements were explained. Also we brought snow samples, taken from the sites in Preda, to the lab in Styrofoam boxes filled with dry ice.

There were 5 temperature-controlled cold chambers that can be operated between -35 to 0 °C. These cold chambers are used for making of nature-identical snow; the conduct of mechanical, optical and thermodynamic experiments; producing computer tomography scans, machining snow samples (by sawing, turning and drilling); and storing snow samples.

In the cold lab we cut the snow samples to get ready for the micro-CT measurements.

The instruments seen in the cold lab were:

Snowmaker machine is used to make nature-identical snow in the cold laboratory with reproducible conditions. Working principle is similar to the nature, cold air is saturated with water vapour, then channelled into a colder chamber, where the further reduction in temperature inevitably prompts the release of moisture from the air. The excess moist air freezes on suspended nylon threads serving as condensation cultivators.

Figure 10. *: SnowMaker (left) and nature-identical dendritic snow on the cultivating threads (right).*

Computertomograph (CT)

There were two X-ray computed tomography scanners used to perform three-dimensional analyses of the snow structure in a non-destructive imaging procedure with a resolution of up to 10 µm. So they are called as micro-CT. Besides examining stationary snow structures, they can also be used to investigate processes taking place within the snow structure over time (snow metamorphism).

The CT scanners were located in the cold laboratory at -20°C as standard.

Figure 11 . Two Computer tomographs in the cold lab. µCT80 (left), µCT40 (right)

Our samples were given to a researcher for micro-CT measurements. Images were taken after the snow school to be used in the report. The SSA and density calculated from CT images will be compared to ground data.

3. Conclusion

It was a great opportunity to meet lecturers and students from all over the world to have a broader perspective on snow science. Also it was a good experience working in groups with people from different backgrounds and cultures.

Hands-on field work was very instructive, we did not only see the measurements but also experienced all steps, digging the pit, taking the samples, doing the measurements.

References:

Gallet, J.-C., F. Domine, C. S. Zender, and G. Picard (2009), Measurement of the specific surface area of snow using infrared reflectance in an integrating sphere at 1310 and 1550nm, The Cryosphere, 3, 167–182.

Montpetit, B., A. Royer, A. Langlois, P. Cliche, A. Roy, N. Champollion, G. Picard, F. Domine, R. Obbard, (2012) Instruments and Methods: New shortwave infrared albedo measurements for snow specific surface area retrieval, Journal of Glaciology, Vol. 58, No. 211.

Proksch, M., H. Löwe, and M. Schneebeli (2015), Density, specific surface area, and correlation length of snow measured by high-resolution penetrometry, J. Geophys. Res. Earth Surf., 120, 346–362,

http://www.slf.ch/ueber/organisation/schnee_permafrost/schneephysik/Infrastruktur/index_EN