Polarisation measurements of clay, volcanic sand and snow: implications for the climate changes

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WG4 Meeting in Helsinki, 19-21 August 2013

Soot on Snow (SoS) campaign

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Soot on Snow (SoS) 2013 campaign with FMI

- Thickness of ash and other fragments that are thrown out by an exploding volcano determine effects that it has on the underlying snow
- The black cover absorbs extra sunlight (while if the layer is really thick the heat almost does not transmitted through to the snow)

Key questions to answer:

- How does the volcano dust affect climate changes, and in particular, light reflectance by snow?
- Study further effects on snow grains and their evolution with the time
- Melting rate of dusty snow

Key idea:

- Deposit soot of dust on a natural snow pack in a controlled way (known amount, certain area, no dust loss during deposition)

- Measure the snow albedo, BRDF, polarisation, and other snow properties preferably through the entire melting period

Key measurement components:

1. Snow

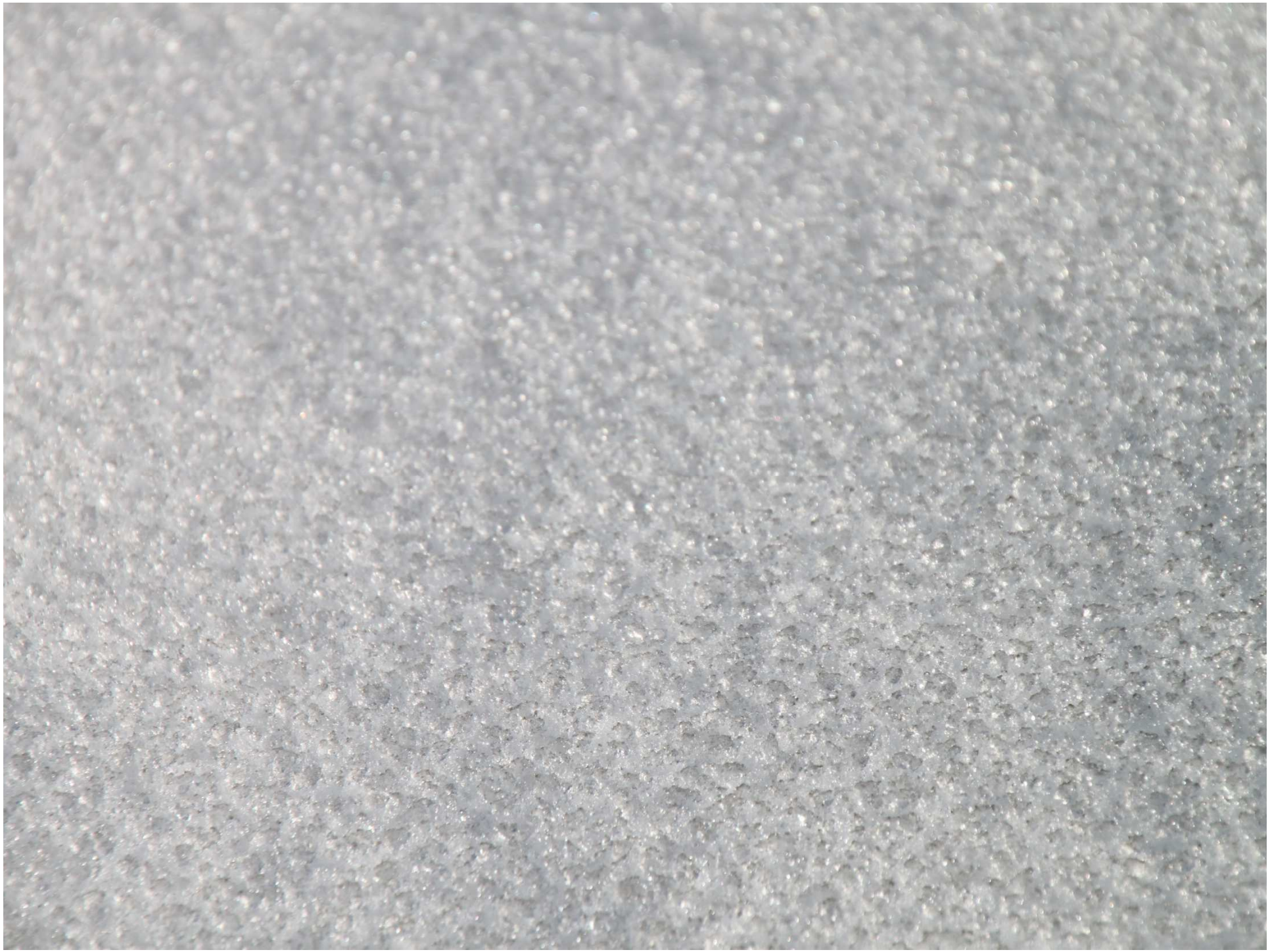
Primarily component for the experiment. Natural snow pack at Sodankylä airport. Begining of April, 2013

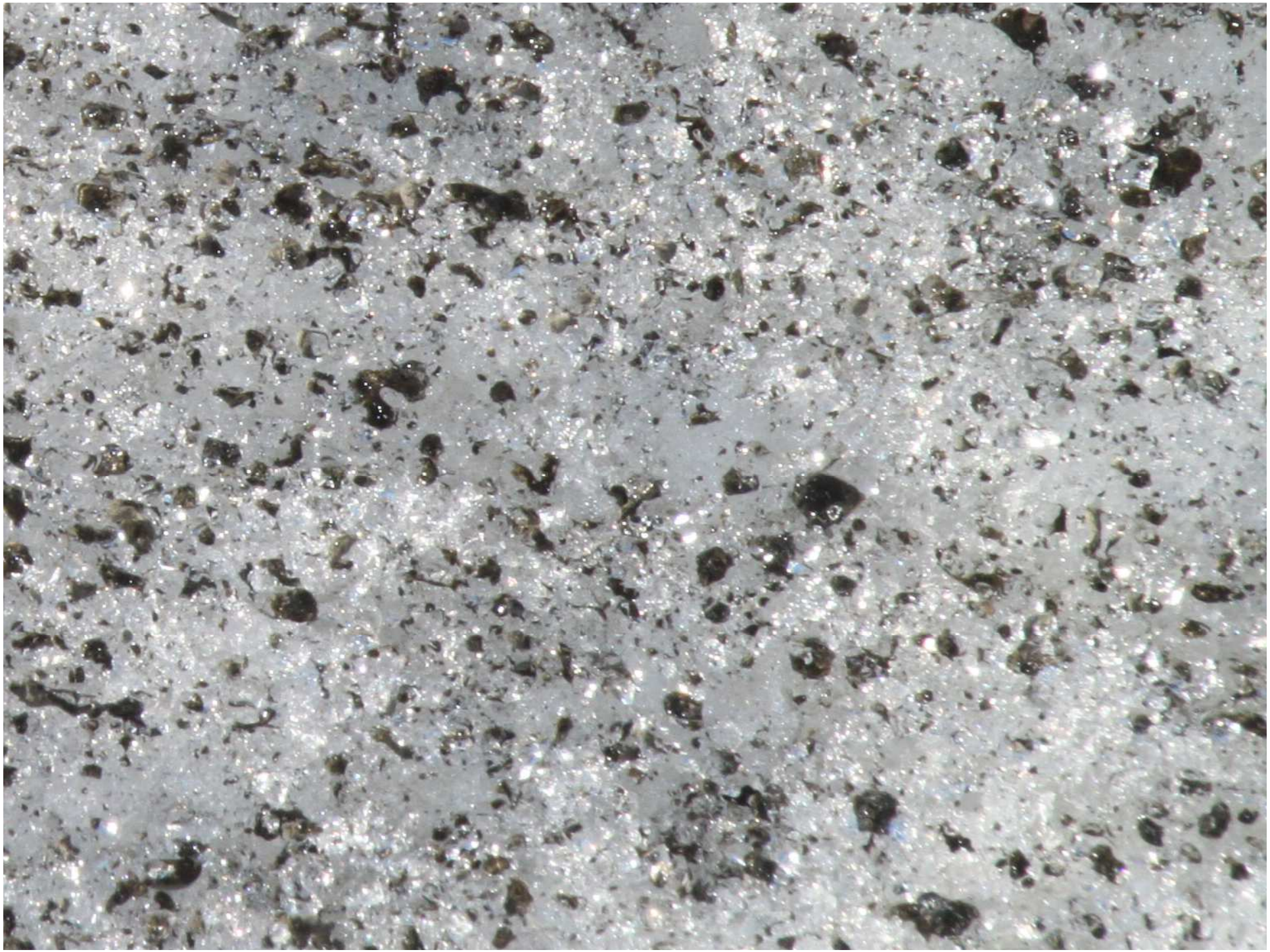
2. Volcanic sand

A near black mixture of the volcanic ash of glaciofluvial nature. Origin: under the Myrdalsjokull glacier

3. Glaciogenic silt

Collected from the glacial river Mulakvisl, it consists mainly of silt and some coarse clay sized particles





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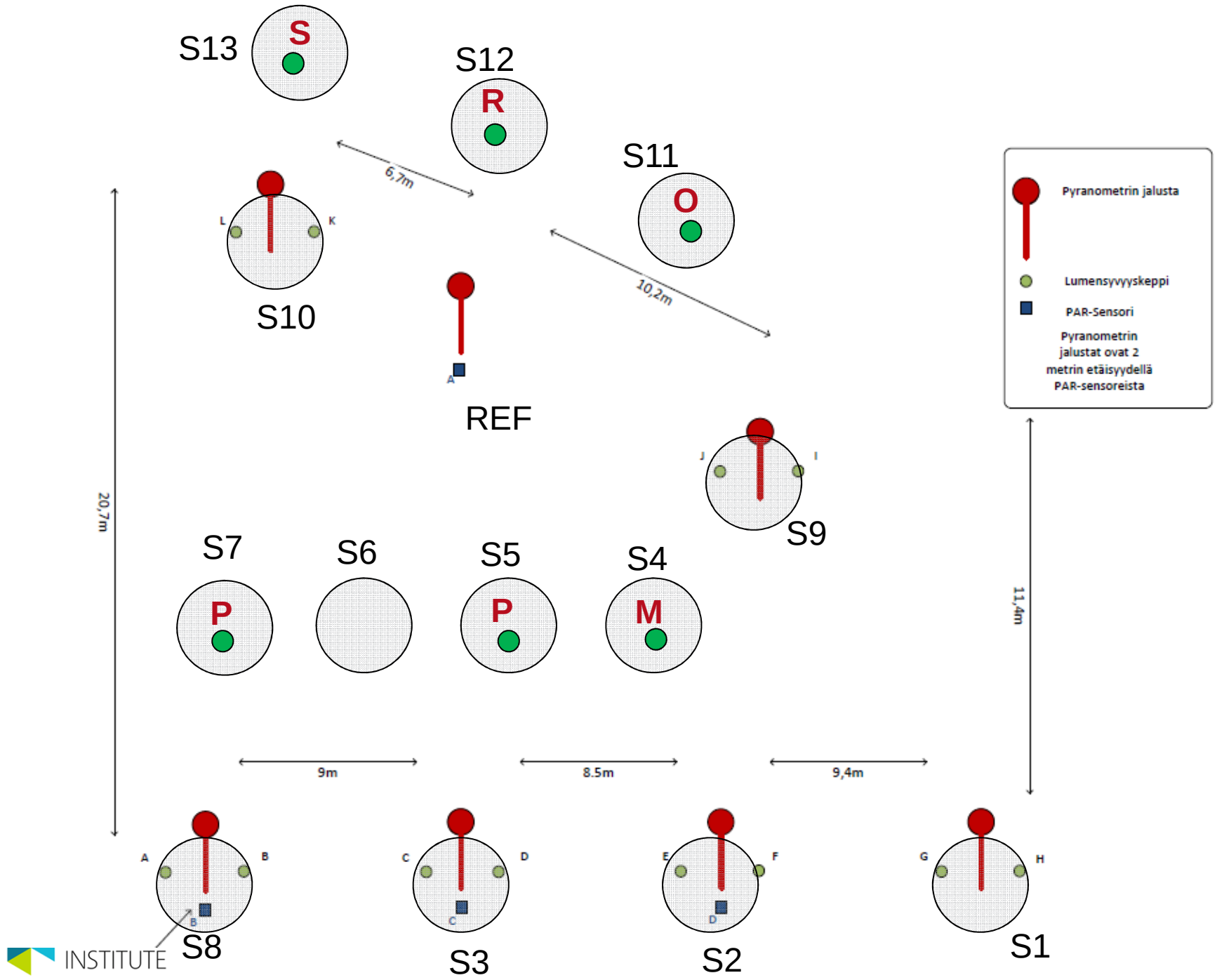
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S12
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Pyranometrin jalusta
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9,4m
A
B
B
S8
C
D
C
S3
E
F
D
S2
G
H
S1

FIGIFIGO measurements

http://www.polarisation.eu/index.php/list-of-instruments/view-submission/172

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Reflectance factor

- Radiance from the target divided by radiance from a white matte (Lambertian) surface
  - 0 for black surface
  - 1 for white diffuse surface (Lambertian)

Lambertian reflectance

- defines an ideal diffusely reflecting surface

- perfectly matte
- scatters same amount of light to all view direction
- is not affected by illumination direction

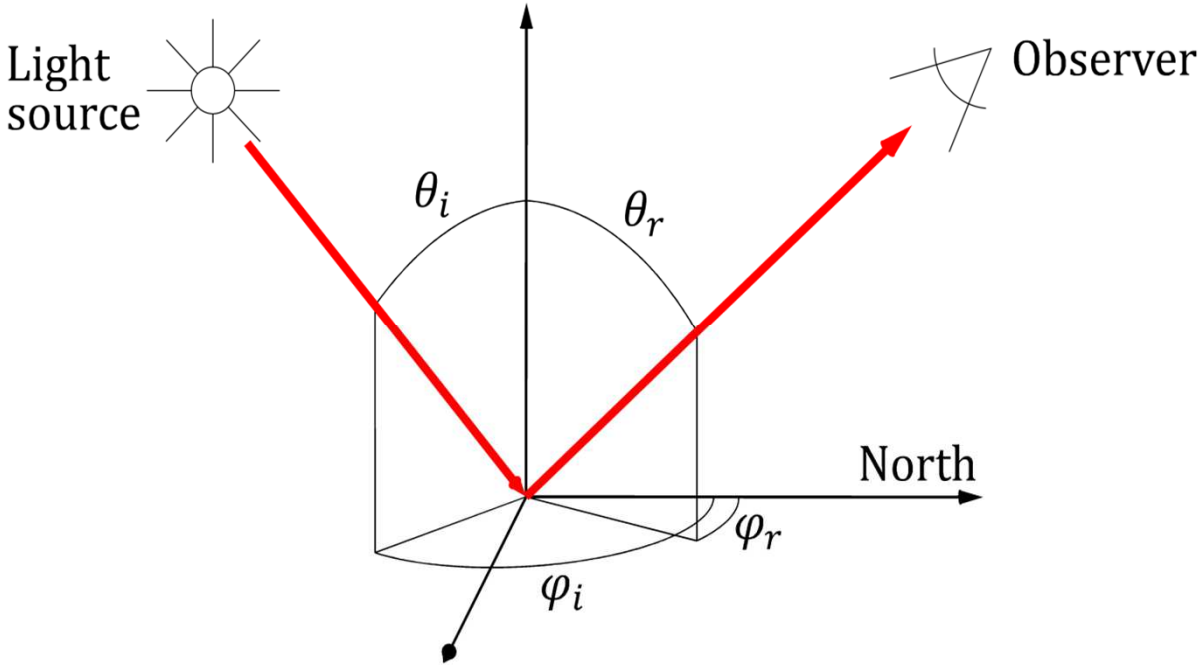
- Spectralon® is a fluoropolymer, which has the highest diffuse reflectance of any known material or coating over the ultraviolet, visible, and near-infrared regions of the spectrum

Bidirectional Reflectance Factor

- Anisotropy of reflectance is described with concept Bidirectional Reflectance Factor (BRF)
- Bidirectional geometry is defined by illumination and view directions

θ zenith angle

φ azimuth angle



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How to measure BRF?

- Reflectance factor refers to certain illumination and view geometry

- Thus reflectance must be measured from multiple along with notes on illumination and view direction

FIGIFIGO

FGI's Field Goniospectrometer

Primary targets:

Vegetation and snow

Extra Applications:

Planetary science

(e.g. meteorite measurements and their matches with asteroids)

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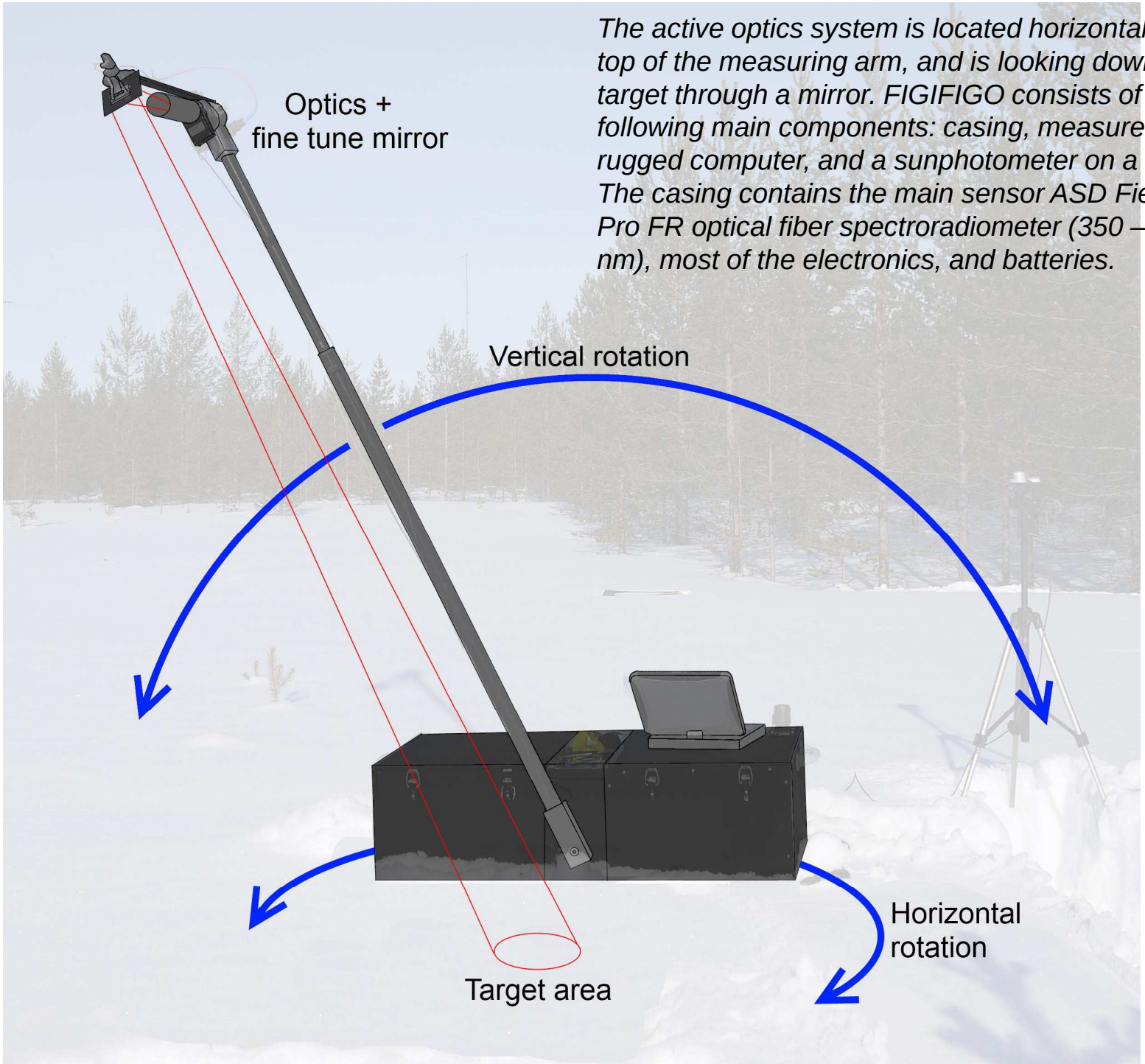
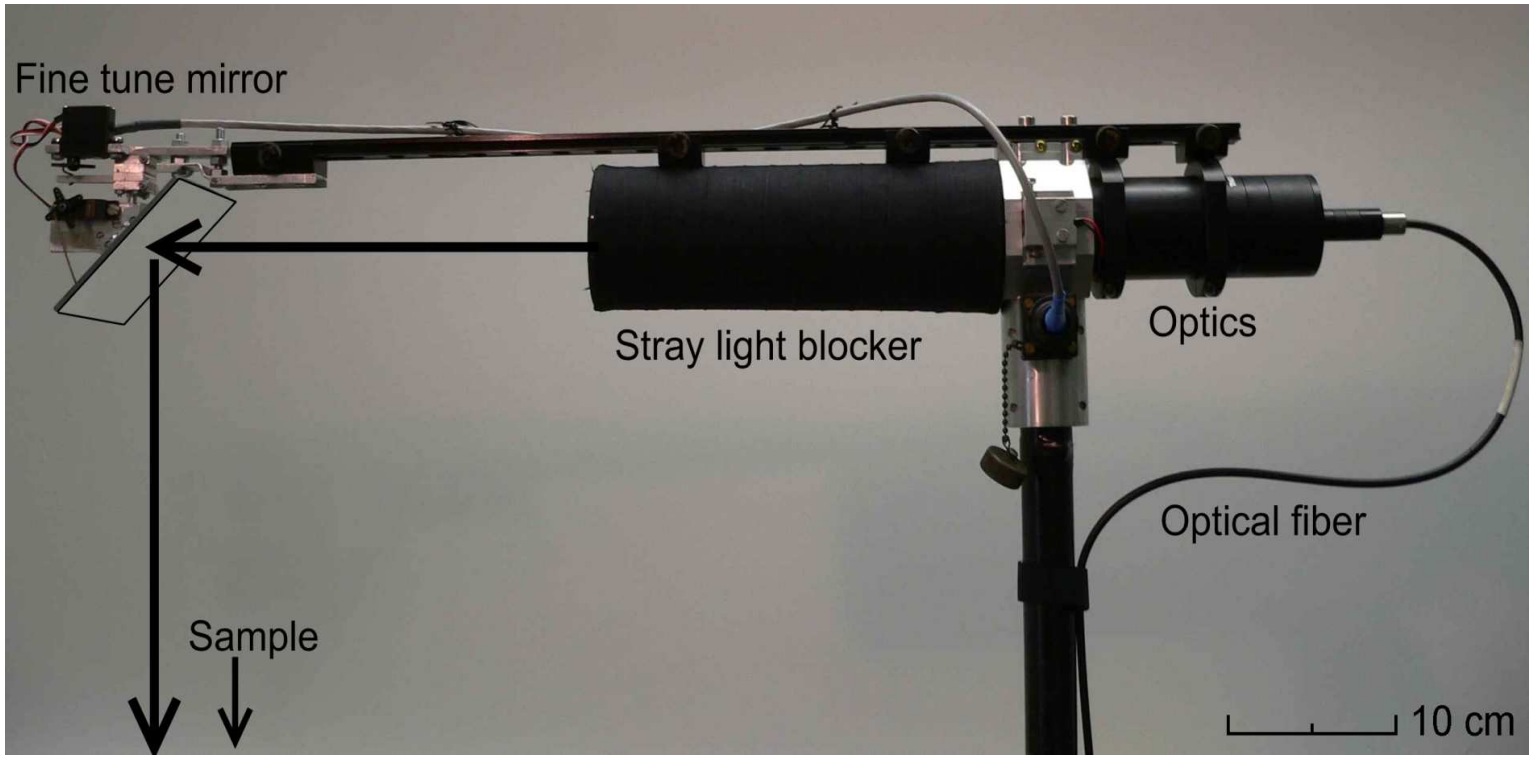
The active optics system is located horizontally at the top of the measuring arm, and is looking down to the target through a mirror. FIGIFIGO consists of the following main components: casing, measurement arm, rugged computer, and a sunphotometer on a tripod. The casing contains the main sensor ASD FieldSpec Pro FR optical fiber spectroradiometer (350 – 2500 nm), most of the electronics, and batteries.



laser pointer & active optics



- Spectrometer optics have laser pointers to show the footprint position
- Sample elevation is entered and a servo controlled mirror adjusts the footprint according to tilt

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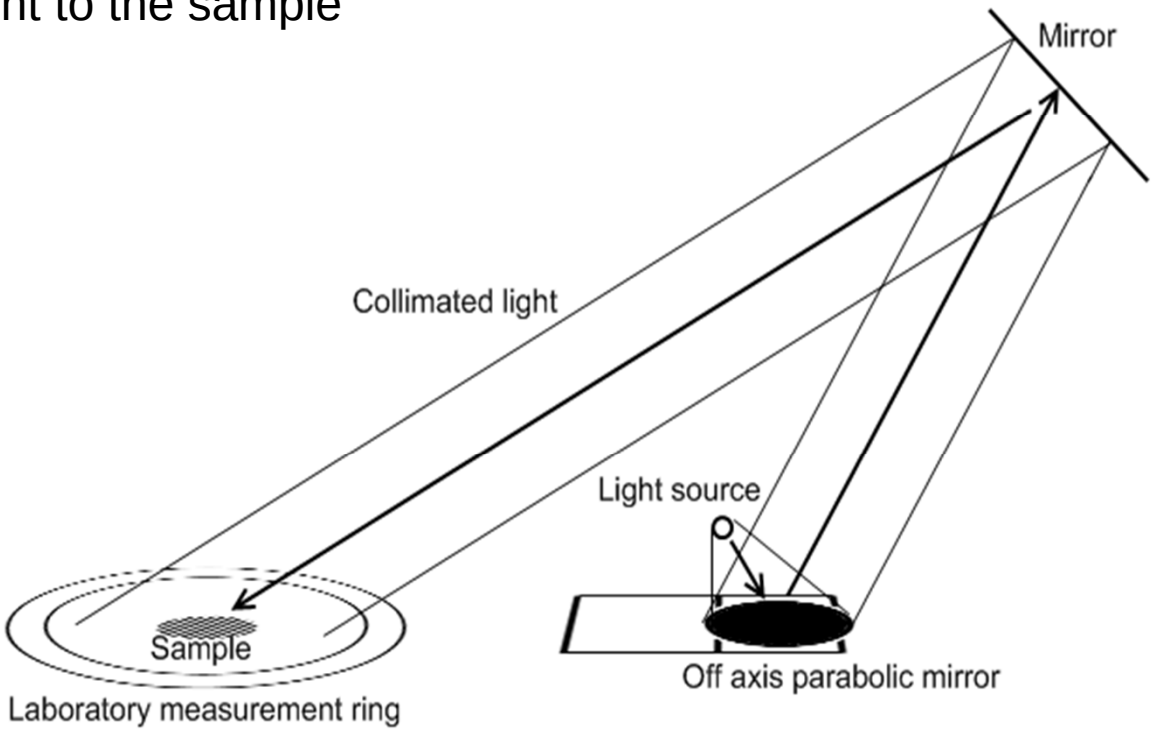
The laboratory lighting setup

The light source and the off axis parabolic mirror are mounted in same frame to keep the geometry constant. A large flat mirror is placed on a heavy tripod, and is used to reflect the light to the sample



The laboratory lighting setup

Examples of analyzed measurements

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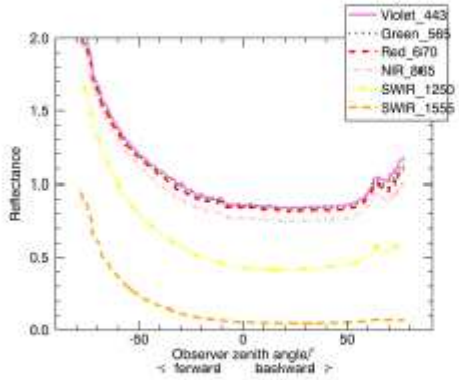
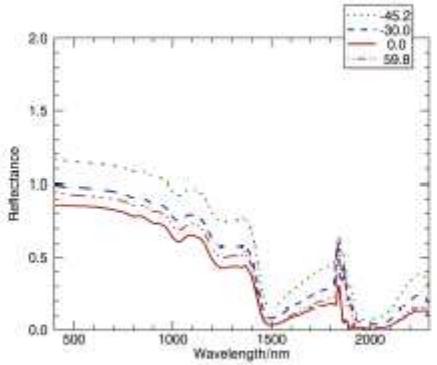
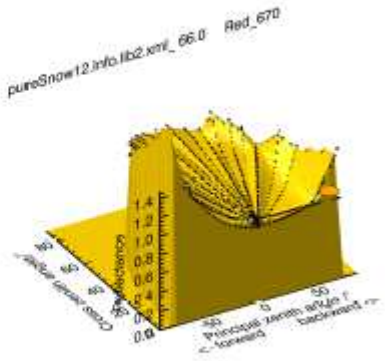
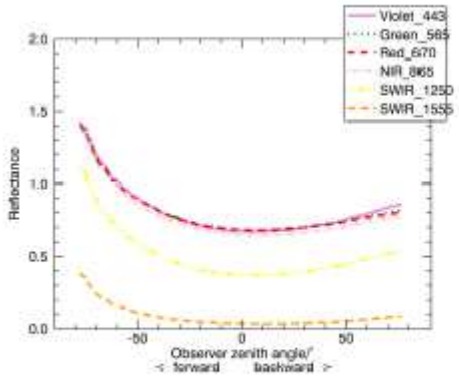
Snow

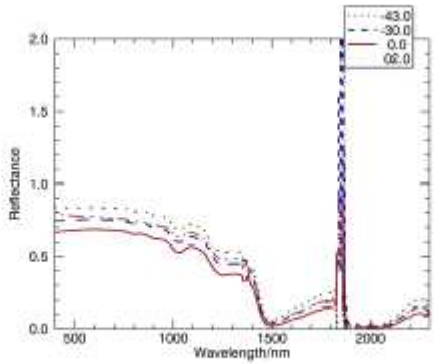

Violet_443
Green_565
Red_670
NIR_865
SWIR_1250
SWIR_1555
Reflectance
Observer zenith angle/°
< forward backward >

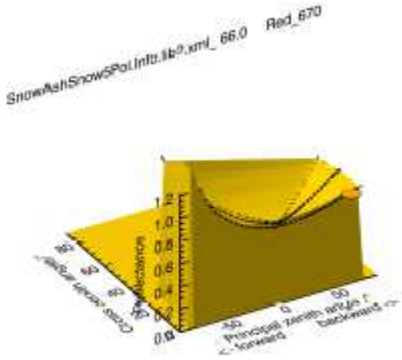

-45.2
-30.0
0.0
59.8
Reflectance
Wavelength/nm


pureSnow12.info.lib2.xml_ 66.0
Red_670

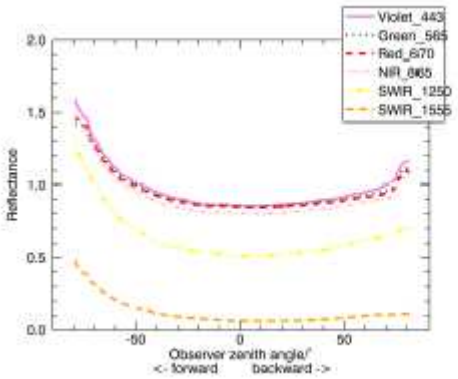
Sooted snow

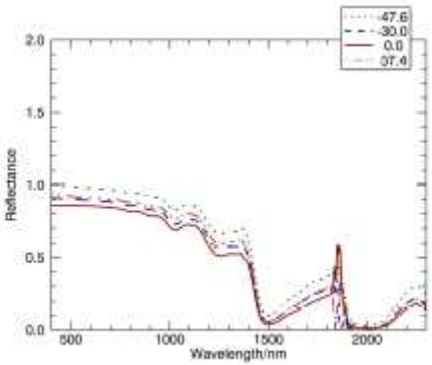

Violet_443
Green_565
Red_670
NIR_865
SWIR_1250
SWIR_1555
Reflectance
Observer zenith angle/°
< forward backward >

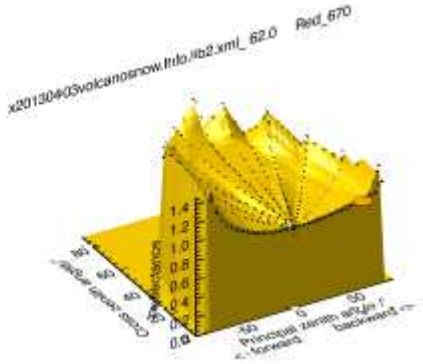

-43.0
-30.0
0.0
02.0
Reflectance
Wavelength/nm


Red_670
Reflectance

Snow with volcanic sand







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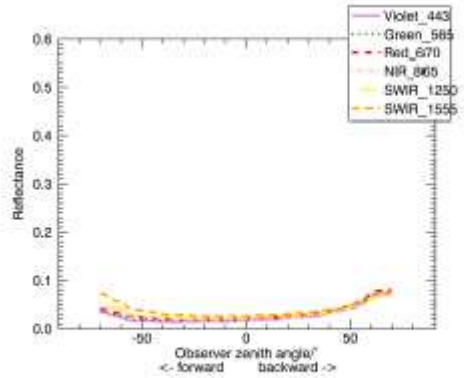
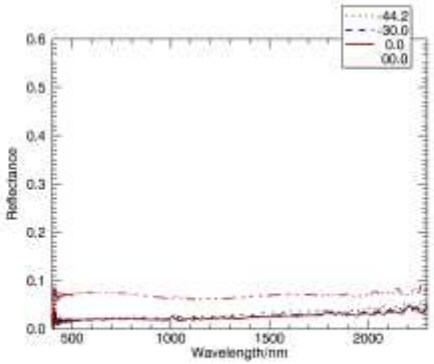
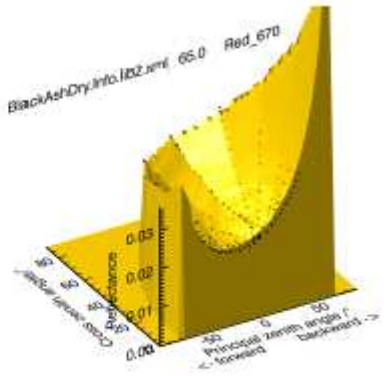
Volcanic sand







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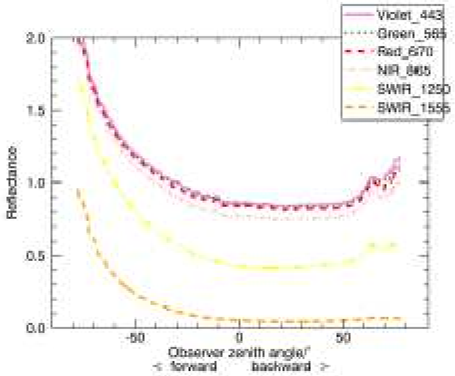
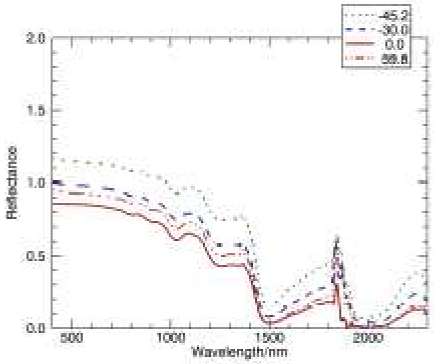
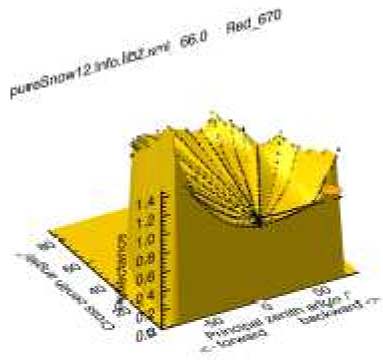
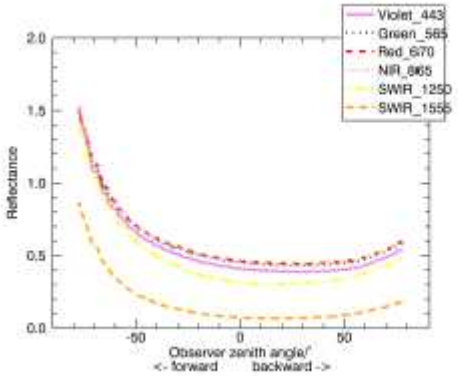
Snow

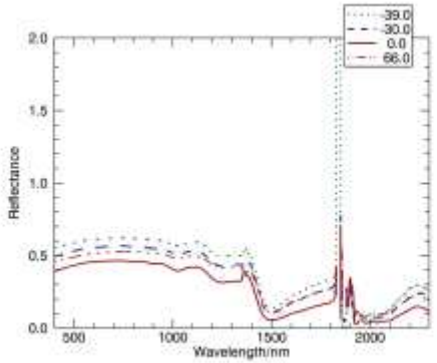

Violet_443
Red_670
NIR_865
SWIR_1250
SWIR_1555
Reflectance
2.0
1.5
1.0
0.5
0.0
-50
0
50
Observer zenith angle/°
<- forward backward ->

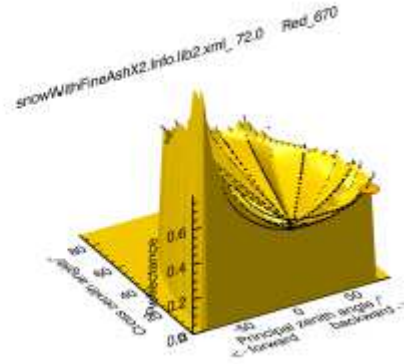

-45.2
-30.0
0.0
Reflectance
2.0
1.5
1.0
0.5
0.0
500
1000
1500
2000
Wavelength/nm


Red_670
1.4
1.2
1.0

Snow with glaciogenic silt







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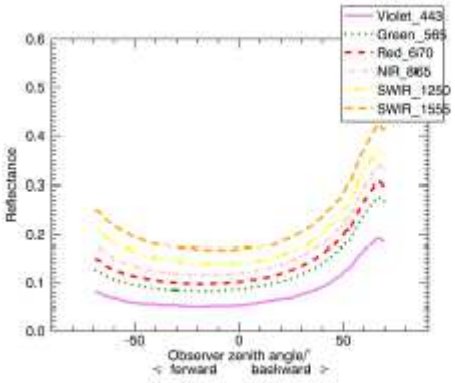
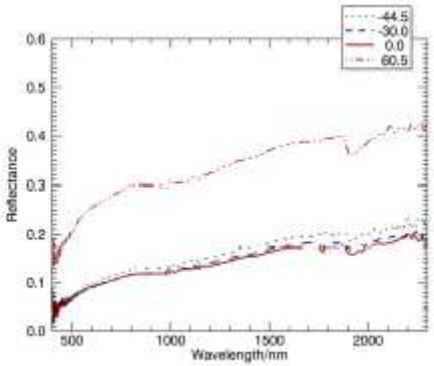
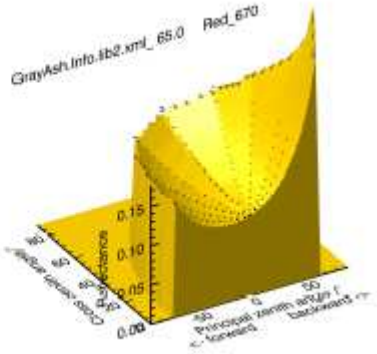
Glaciogenic silt







Conclusions

- Using FIGIFIGO we have conducted light scattering measurements of snow, volcanic sand, and glaciogenic silt, as well as their mixtures in different proportion
- Increase of the volcanic sand or glaciogenic silt concentration can be very logically seen through data reduction steps and on final graphs
- Negative polarisation has been detected in a number of cases
- Joint publications in preparation

THANK YOU

BRF retrieval accuracy

- The general accuracy of FIGIFIGO BRF measurement is between 1-5% for a well defined sample

- Accuracy depends especially on wavelength, sample reflectance factor, and solar zenith angle
  - Spectrometer noise causes error that is proportional to reflected radiance
  - Levelling of Spectralon panel