

Final Report for Scientific Meeting:
“Snow grain size workshop: Measurements and applications”
Reference Number: 4679

Table of Contents

1. Summary.....	1
2. Description of scientific content and discussions.....	2
3. Assessment of the results and impact on future activities.....	3
4. Final programme.....	4
5. List of participants.....	8

1. Summary

From 02-05 April the first international „[Snow Grain Size Workshop - Measurements and Applications](#)“ was held in Grenoble, France. The workshop was organized by Ghislain Picard (LGGE), Henning Löwe (WSL/SLF) and Samuel Morin (CNRM-GAME/CEN), with local support from LGGE and CNRM-GAME/CEN.

The keynote lectures by Martin Schneebeli (Switzerland), S. McKenzie Skiles (USA) and Florent Dominé (Canada) attracted 50 participants from France, Switzerland, Japan, Finland, USA, United Kingdom, Netherlands, White Russia, Canada, Luxembourg, Norway, Germany and Turkey.

The goal of the workshop was to gather snow grain size specialists and initiate discussions and activities about i) the accuracy and comparability of existing methods, which provide objective grain size estimates in the field ii) the scope and limitations of commonly used grain size variables.

For each topical session, the workshop schedule included a dedicated discussion slot to collect the opinion of the community about emerging issues in sub-topics of snow grain size. Two poster sessions facilitated in-depth discussions about technical details. Several measurement devices were voluntarily brought to the workshop and demonstrated to the less experienced audience during the field day on the glacier La Girose. Several key scientific questions have been raised during the workshop which are summarized in Sec. 2.

The final day of the workshop was devoted to closing discussions and the concrete planning of future activities (cf. Sec 3). Future activities are organized within the IACS working group “From quantitative stratigraphy to microstructure-based modelling of snow” (http://www.cryosphericsscience.org/wg_quantStratMicroMod.html)

The programme is appended in Sec. 4, further details can be found on the workshop website (<http://snowgrain2013.sciencesconf.org/>). The workshop was co-sponsored by Labex OSUG@2020, Microdice (ESF), IACS, Meteo-France and LGGE. The workshop was free of registration of participation fees.

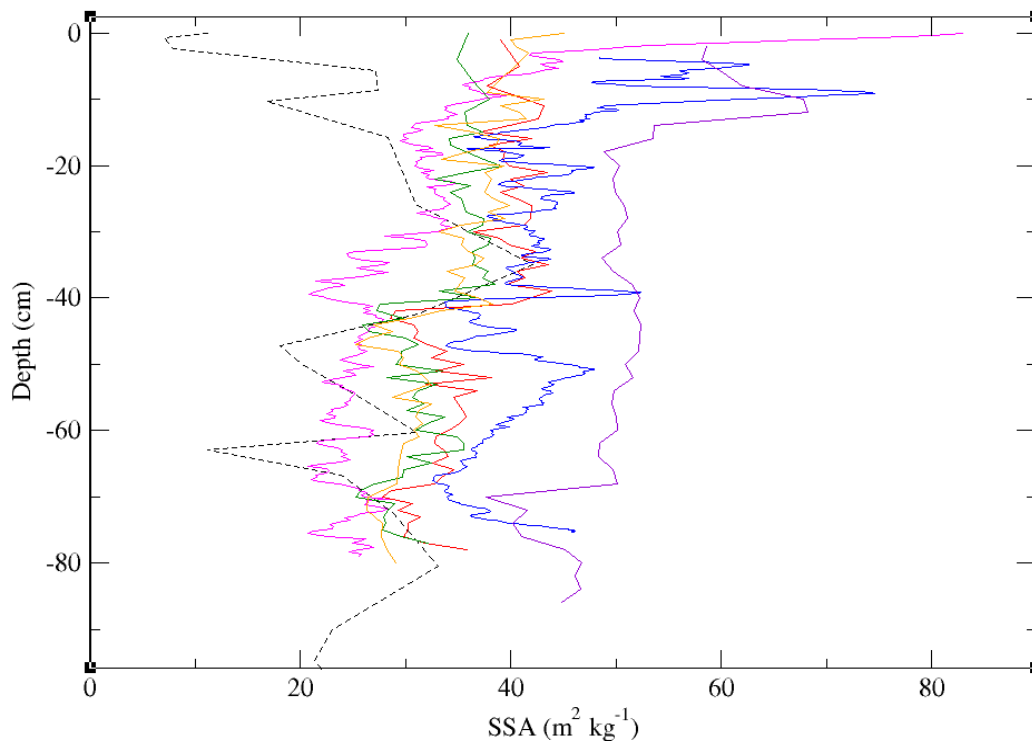
2. Description of scientific content and discussions

Talks on snow grain size were grouped in various topical sessions (cf. Section 4): 1) Tomography and 3D reconstruction 2) BET methods 3) Visual inspection of grains 4) Optical-based methods 5) Theoretical studies optics 6) Correlation function & length 7) Applications: Microwaves 8) Applications: Snowpack models

Several key questions have emerged from the topical discussions, most notably:

- Is the Brunauer-Emmett-Teller (BET) method as a quasi-reference for the specific surface area still worth to be maintained by the community or can micro-computed-tomography replace it as a new reference?
- Is it yet reasonable or necessary to define formal measurement standards (similar to WMO standards) for measuring grain size?
- What is the relevance of non-measurable corrections used in current snow microwave models (such as grain scaling factor or sticking coefficient) in view of different definitions of grain size?
- What are general requirements about instrument accuracy? In particular, if similar devices like micro-computed tomography systems are operated by different groups with different measurement protocols, how comparable are their results for key quantities like specific surface area?

Figure 1: SSA measurements (solid lines) and snowpack simulation (dotted line)



The theoretical discussions were completed by a practical exercise. The workshop included a field day to demonstrate the measurement methods and allow for in-depth discussions with the operators of the devices about handling, pitfalls and particularities. The field day was organized by Laurent Arnaud from the local organizing committee. Meteorological conditions were sufficiently good to accomplish this field exercise. For demonstration purposes, snowpits were initially prepared by the group of device experts on the glacier La Girose near La Grave, France. Afterwards, grain size measurements were demonstrated to the other participants within small practical lectures. To end up at least with an initial idea of the comparability of the measurements, a blind intercomparison was carried out in one of the snowpits. The preliminary results are shown in Fig. 1 signaling a significant scatter in the measurements. However conditions were not identical for all measurement groups and commonly employed measurement protocols have to be abandoned due to the main purpose of demonstration. So the results have to be taken as **confidential and should not be published anywhere to avoid confusion in the community**. Since the uncertainties of the SSA measurements have an immediate impact for many applications in cryospheric sciences, the results clearly demonstrate the necessity of a formal measurement intercomparison campaign.

3. Assessment of the results and impact on future activities

Given the unexpectedly high number of participants, their feedback and the concrete decisions on future activities, the workshop can be regarded as very successful. Among the participants, there was a broad agreement about the necessity of a “Grain size workshop” and the necessity of a functioning “grain size community” to connect measurements, modeling and applications in cryospheric sciences. The workshop was also the kick-off activity of the IACS working group “From quantitative stratigraphy to microstructure-based modeling of snow” (http://www.cryosphericosciences.org/wg_quantStratMicroMod.html). Future activities which emerged from the workshop are organized under the structure of the working group.

As a result from the discussions during the week and the main discussion on Friday, several follow-up activities and have been identified and grouped into small work packages for the next year:

A. Preparation of a review paper. To summarize the contents of the presentations it was decided to prepare a joint publication, which reports the current state of grain size related issues for the cryosphere community. The presentations, which were collected during the workshop and distributed among the participants provide the basis for the manuscript. All participants are invited for contributions and co-authorships, a first draft will be prepared during the next 3 months.

B. Organization of a microwave workshop.

Since applications, in particular microwave remote sensing were only represented by a small number of groups, it was decided to plan a dedicated workshop on grain size related issues in microwave remote sensing for 2014. The workshop will be organized under the lead of Melody Sandells, National Centre for Earth Observation, University of Reading, UK (Contact:

m.j.sandells@reading.ac.uk) The workshop is planned for 2014 and already announced on http://www.cryosphericsscience.org/wg_quantStratMicroMod.html

C. Organization of a measurement intercomparison campaign.

The “results” obtained for the specific surface area from different measurement techniques during the field day highly suggest the necessity of a systematic measurement intercomparison campaign. This campaign will take place in March 2014 in Davos Switzerland and organized under the lead of Martin Schneebeli, WSL-SLF, Davos, Switzerland (Contact: schneebeli@slf.ch). The workshop is also announced on http://www.cryosphericsscience.org/wg_quantStratMicroMod.html

4. Final programme

2 April 2013

- 09:15 - 10:00 **Registration, welcome of participants at LGGE (coffee)**
10:00 - 10:30 **Introduction and goals of the workshop - Ghislain Picard, Henning Löwe, Samuel Morin, Charles Fierz**
- 10:30 - 12:35 **Tomography and 3D reconstruction (chair Henning Löwe)**
10:30 - 11:20 › **KEYNOTE** The geometry of snow as seen by tomography and near-infrared photography - *Martin Schneebeli, WSL Institute for Snow and Avalanche Research SLF*
11:20 - 11:45 › Computation of grain sizes from microtomographic images of snow - *Frederic Flin, CEN, CNRM - GAME UMR 3589*
11:45 - 12:10 › Tomography-based snow morphology characterization via direct and indirect approaches - *Sophia Haussener, Ecole Polytechnique Fédérale de Lausanne*
12:10 - 12:35 › Specific surface area computed with X-ray micro-tomography: impact of the segmentation technique and the effective resolution - *Pascal Hagenmuller, Erosion torrentielle neige et avalanches*
- 12:35 - 14:00 **Lunch (Buffet, will be provided at LGGE)**
- 14:00 - 14:55 **Tomography and 3D reconstruction cont'd (chair Henning Löwe)**
14:00 - 14:25 › 3D-structure of snow constructed with successive section planes - *Kouichi NISHIMURA, Nagoya University*
14:25 - 14:55 › *General discussion on tomography and 3D reconstruction*
- 14:55 - 16:30 **BET methods (chair Samuel Morin)**
14:55 - 15:45 › **KEYNOTE** Measuring the specific surface area of snow using methane adsorption and IR reflectance: difficulties and some progress - *Florent Domine, Takuvik Joint International Laboratory*
15:45 - 16:10 › Measurement of snow specific surface area by the BET theory — investigation of suitable adsorbent for field use — - *Akihiro Hachikubo, Kitami Institute of Technology*
16:10 - 16:30 › *General discussion on BET methods*

16:30 - 17:00 **Coffee break**

17:00 - 18:35 **Visual inspection of grains** (*chair Samuel Morin*)

17:00 - 17:25 › Snow grain size measurements in Dronning Maud Land, Antarctica - *Roberta Pirazzini, Finnish Meteorological Institute*

17:25 - 17:50 › Photographic methods for Antarctic snow crystal evaluation - *Katherine Leonard, cryos*

17:50 - 18:15 › Comparison of Visual Grain Size and Specific Surface Area of Snow - *Leena Leppänen, Finnish Meteorological Institute, Arctic Research Centre - Anna Kontu, Finnish Meteorological Institute, Arctic Research Centre*

18:15 - 18:35 › *General discussion on visual inspection of grains*

18:35 - 20:00

Poster session (Snacks and Drinks will be provided)

- › Accuracy of simulated snow grain size and shortwave albedo by a 1-D physical snowpack model SMAP: Model validation at Sapporo, Japan and Greenland - *Masashi Niwano, Meteorological Research Institute*
- › Attempt of modeling water movement in snow cover using specific surface area - *Satoru Yamaguchi, National Research Institute for Earth Science and Disaster Prevention - Akihiro Hachikiubo, Kitami Institute of Technology - Hayato Arakawa, YAGAI-KAGAKU Co., Ltd. - teruo Aoki, Meteorological Research Institute*
- › Comparison between co-located high-resolution specific surface area and snow-micropenetrometry profiling in a mid-altitude alpine snowpack - *Carlo Carmagnola, Centre d'Etudes de la Neige (CNRM-GAME)*
- › From optical snow grain radius to microwave grain size parameterization: DMRT-ML simulations and validation analysis - *Alain Royer, Centre d'Applications et de Recherches en Télédétection*
- › Grain size in new generation snow-cover models: lessons from the past? - *Charles Fierz, WSL Institute for Snow and Avalanche Research SLF*
- › IceCube: an innovative optical instrument for measurement of the specific surface area of snow - *Nicolas ZUANON, A2 Photonic Sensors*
- › In situ measurements of snow properties and surface albedo at Kohlen Station, East Antarctic Plateau to improve prognostic snow models - *Gerit Birnbaum, Alfred Wegener Institute for Polar and Marine Research*
- › In-Situ Probe for Optical Snow Grain Size Measurement - *Noah Molotch, Jet Propulsion Laboratory [NASA], University of Colorado*
- › Intercomparison of retrieval algorithms for the specific surface area of snow from near-infrared satellite data in mountainous terrain, and comparison with the output of a semi-distributed snowpack model - *Marie Dumont, Groupe d'étude de l'atmosphère météorologique*
- › Modeling of snow grain size with SNOWPACK and comparison to in situ measurements - *Anna Kontu, Finnish Meteorological Institute*
- › Run-length dependence of specific surface area and intrinsic permeability in seasonal snow - *Hayato Arakawa, YAGAI-KAGAKU Co., Ltd.*
- › Snow LAYer Probing device (SLAP) - *Ali Arslan, Finnish Meteorological Institute*
- › Snow measurement methods for mountainous areas in Turkey - *Basar Bozoglu, Middle East Technical University*
- › Study of snowpacks using 3-D SAR imaging at X and Ku bands and meteorological data assimilation - *laurent Ferro-Famil, University of Rennes 1, IETR*
- › Talking about grain size (in different languages) - *Maria Hörhold, Institute of Environmental Physics, University of Bremen - Stefanie Linow, Alfred-Wegener-Institute for Polar and Marine Research*

3 April 2013

- 08:30 - 10:10 **Optical-based methods** (chair Ghislain Picard)
- 08:30 - 09:20 › **KEYNOTE** Utilizing Contact Spectroscopy for Retrieval of Snow Optical Grain Size Stratigraphy - *S. McKenzie Skiles, Joint Institute for Regional Earth System Science and Engineering, Department of Geography*
- 09:20 - 09:45 › "Alpine Snowpack Specific Surface Area Profiler" (ASSSAP): a new instrument to retrieve snow specific surface area with a 1cm resolution using infrared reflectance - *Ghislain Picard, Laboratoire de glaciologie et géophysique de l'environnement*
- 09:45 - 10:10 › A New shortwave infrared camera approach for snow specific surface area retrieval - *Benoit Montpetit, Centre d'Application et de Recherche en Télédétection*
- 10:10 - 10:40 **Coffee break**
- 10:40 - 12:15 **Theoretical studies optics** (chair Ghislain Picard)
- 10:40 - 11:05 › Stereology approach to snow optics - *Aleksey Malinka, B.I. Stepanov Institute of Physics of National Academy of Sciences of Belarus*
- 11:05 - 11:30 › Influence of the grain shape on the albedo and light extinction in snow - *Quentin Libois, Laboratoire de glaciologie et géophysique de l'environnement*
- 11:30 - 12:15 › *General discussion on optical approaches*
- 12:15 - 14:00 **Lunch (Buffet, will be provided at LGGE)**
- 14:00 - 14:50 **Correlation function & length** (chair Ghislain Picard)
- 14:00 - 14:25 › Correlation function studies for snow revisited - *Henning Loewe, WSL Institute for Snow and Avalanche Research SLF*
- 14:25 - 14:50 › SnowMicroPen derived correlation length of snow - *Martin Proksch, WSL Institute for Snow and Avalanche Research SLF*
- 14:50 - 16:25 **Applications: Microwaves** (chair Alain Royer)
- 14:50 - 15:15 › Comparing field measurements of grain size for forcing microwave emission models - *Michael Durand, Ohio State University*
- 15:15 - 15:40 › Heterogeneity of snow stratigraphy and grain size within ground-based passive microwave radiometer footprints: implications for emission modelling - *Nick Rutter, Northumbria University*
- 15:40 - 16:05 › Campaign results and preparations for the Candidate Core Explorer mission CoReH2O - *Michael Kern, European Space Agency*
- 16:05 - 16:25 › *General discussion on correlation length and microwave applications*
- 16:25 - 16:55 **Coffee break**

3 April 2013 cont'd

- 16:55 - 18:00 **Applications: Snowpack models** (chair Charles Fierz)
- 16:55 - 17:20 › Prediction of snow grain size - Richard Essery, University of Edinburgh
- 17:20 - 17:45 › Implementation and evaluation of prognostic representations of the optical diameter of snow in the detailed snowpack model SURFEX/ISBA-Crocus – Carlo Carmagnola, CNRM-GAME/CEN
- 17:45 - 18:00 › General discussion on snowpack models
- 18:00 - 18:30 › Planning and information for field trip
- 18:30 - 20:00 › Poster session (Snacks and Drinks will be provided)

4 April 2013

- 06:30 - 18:00 › Field trip - Presentation of snow grain size instruments and methods in the mountains nearby Grenoble (La Grave). Detailed schedule subject to weather *conditions*. **Packed lunch will be provided**

5 April 2013

- 08:30 - 10:10 **General discussion and outcome of the workshop** (Picard, Morin, Löwe)
- 10:10 - 10:40 **Coffee break**
- 10:40 - 12:15 **Planning next activities** (Picard, Morin, Löwe)
- 12:15 - 14:00 **Lunch (Buffet, will be provided at LGGE), End of the workshop**

5. List of participants

1 Arakawa Hayato	YAGAI-KAGAKU Co., Ltd., Japan	Japan	hayato.arakawa@gmail.com
2 Arnaud Laurent	LGGE, Grenoble, France	France	larnaud@ujf-grenoble.fr
3 Arslan Ali	Finnish Meteorological Institute, Helsinki, Finland	Finland	ali.nadir.arslan@fmi.fi
4 Birnbaum Gerit	Alfred Wegener Institute for Polar and Marine Research, Germany Middle East Technical University (METU), Ankara, Turkey	Germany	Gerit.Birnbaum@awi.de
5 Bozoglu Basar	CNRM-GAME/CEN, Grenoble, France	Turkey	bozoglubasar@hotmail.com
6 Calonne Neige	CNRM-GAME/CEN, Grenoble, France	France	neige.calonne@meteo.fr
7 Carmagnola Carlo	CNRM-GAME/CEN, Grenoble, France	France	carlo.carmagnola@meteo.fr
8 Davy Matthieu	University of Rennes 1, IETR, Rennes, France	France	matthieu.davy@univ-rennes1.fr
9 Dedieu Jean-Pierre	LTHE, Grenoble, France Takuvik Joint International Laboratory, Université Laval and CNRS, Québec City, Canada	France	jean-pierre.dedieu@ujf-grenoble.fr
10 Domine Florent	CNRM-GAME/CEN, Grenoble, France	Canada	florent.domine@gmail.com
11 Dufour Anne	CNRM-GAME/CEN, Grenoble, France	France	anne.dufour@meteo.fr
12 Dumont Marie	CNRM-GAME/CEN, Grenoble, France	France	marie.dumont@meteo.fr
13 Durand Michael	Ohio State University, USA	USA	durand.8@osu.edu
14 Essery Richard	Univ. Edinburgh, Edinburgh, UK	UK	richard.essery@ed.ac.uk
15 Ferro-Famil Laurent	University of Rennes 1, IETR, Rennes, France	France	Laurent.Ferro-Famil@univ-rennes1.fr
16 Fierz Charles	WSL-SLF Davos, Switzerland The Goodyear Tire & Rubber Company, Innovation Center	Switzerland	fierz@slf.ch
17 Fulop Tibor	Norsk Polar Institute, Tromso, Norway	Luxembourg	tibor_fulop@goodyear.com
18 Gallet Jean-Charles	IPAG, Grenoble, France	Norway	Jean-Charles.Gallet@npolar.no
19 Grisolte Florence	Irstea/ETNA, Grenoble, France	France	florence.grisolte@obs.ujf-grenoble.fr
20 Hagenmuller Pascal	EPFL Lausanne, Switzerland	France	pascal.hagenmuller@gmail.com
21 Haussener Sophia	EPFL Lausanne, Switzerland Institute of Environmental Physics, University of Bremen, Bremen, Germany	Switzerland	sophia.haussener@epfl.ch
22 Hörhold Maria	LGGE, Grenoble, France	Germany	m_hoerhold@iup.physik.uni-bremen.de
23 Jacobi Hans-Werner	European Space Agency, ESTEC, Mission Science Division, Noordwijk, The Netherlands	France	Jacobi@lgge.obs.ujf-grenoble.fr
24 Kern Michael	Finnish Meteorological Institute, Sodankylä, Finland	The Netherlands	Michael.Kern@esa.int
25 Kontu Anna	CRYOS, ENAC, EPFL, Lausanne, Switzerland	Finland	anna.kontu@fmi.fi
26 Leonard Katherine	Finnish Meteorological Institute, Sodankylä, Finland	Switzerland	leonard@slf.ch
27 Leppanen Leena	CNRM-GAME/CEN, Grenoble, France	Finland	leena.leppanen@fmi.fi
28 Lesaffre Bernard	LGGE, Grenoble, France	France	bernard.lesaffre@meteo.fr
29 Libois Quentin	Alfred-Wegener-Institute for Polar and Marine Research, Germany	France	quentin.libois@lgge.obs.ujf-grenoble.fr
30 Linow Stefanie	WSL-SLF Davos, Switzerland	Germany	stefanie.linow@awi.de
31 Loewe Henning	National Academy of Sciences of Belarus, Minsk, Belarus	Switzerland	loewe@slf.ch
32 Malinka Aleksey	University of Bern, Switzerland	Belarus	mal@light.basnet.by
33 Mätzler Christian	CARTEL, Univ. Sherbrooke, Sherbrooke QC, Canada	Switzerland	christian.matzler@iap.unibe.ch
34 Montpetit Benoit	CNRM-GAME/CEN, Grenoble, France	Canada	benoit.montpetit2@usherbrooke.ca
35 Morin Samuel	Nagoya University, Nagoya, Japan	France	samuel.morin@meteo.fr
36 Nishimura Kouichi	Meteorological Research Institute, Japan	Japan	knishi@nagoya-u.jp
37 Niwano Masashi	Turkish State Hydraulic Works	Japan	mniwano@mri-jma.go.jp
38 Ozkaya Mustafa	LGGE, Grenoble, France	Turkey	mozkaya@dsi.gov.tr
39 Picard Ghislain	Finnish Meteorological Institute, Helsinki, Finland	France	ghislain.picard@lgge.obs.ujf-grenoble.fr
40 Pirazzini Roberta	Irstea/ETNA, Grenoble, France	Finland	roberta.pirazzini@fmi.fi
41 Podolskiy Evgeny	WSL-SLF Davos, Switzerland	France	evgeniy.podolskiy@gmail.com
42 Proksch Martin	CARTEL, Univ. Sherbrooke, Sherbrooke QC, Canada	Switzerland	proksch@slf.ch
43 Royer Alain	Northumbria University, UK	Canada	Alain.Royer@USherbrooke.ca
44 Rutter Nick	University of Reading (UOR), UK	UK	nick.rutter@northumbria.ac.uk
45 Sandells Mel	WSL-SLF Davos, Switzerland	UK	m.j.sandells@reading.ac.uk
46 Schneebeil Martin	UCLA-JIFRESSE, Los Angeles CA, USA	Switzerland	schneebeil@slf.ch
47 Skiles Mckenzie	Norwegian Computing Center, Oslo, Norway	USA	mskiles@ucla.edu
48 Solberg Rune	Snow and Ice Research Center, National Research Institute for Earth Science and Disaster Prevention, Japan	Norway	rune.solberg@nr.no
49 Yamaguchi Satoru	A2 Photonic Sensors, Grenoble, France	Japan	yamasan@bosai.go.jp
50 Zuanon Nicolas		France	nzuanon@a2photonicssensors.com