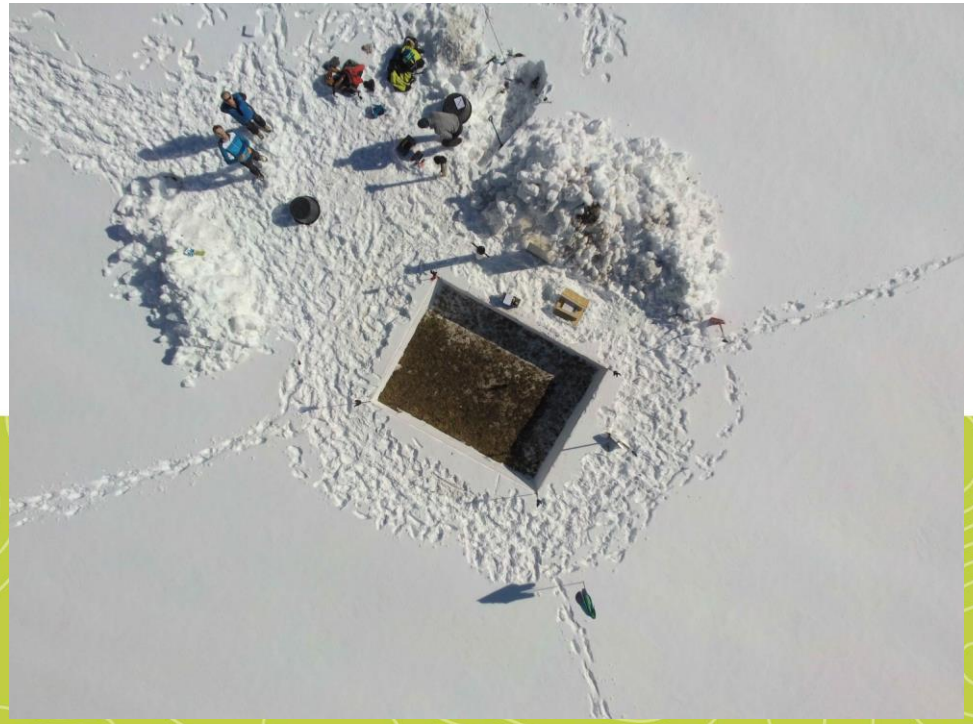
EGU 2023 – PICO Session

Validating manual measurements of SWE against a *reference* standard

… a new approach



GeoSphere Austria

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Motivation

We **do have**…

several methods of **SWE** measurements with
calibrations / validations *among themselves*[1,2] (mostly tubes):

tubes & gauges (wide variations in length, diameter, material…)
snow pillows & scales
other sensors (GNSS, cosmic ray neutrons, …)
remote sensing

We do ***not*** have…

Validations of these methods against the ***real* SWE**.

We are **asking for**…

The ***truth***.
What is the ***real* SWE** at any place?
Performance of practiced methods?

new approach to validate manual SWE measurements:

reference measurement by **weighting total snowpack** on defined area

(1) Beaudoin-Galaise, M. and Jutras, S.: Comparison of manual snow water equivalent (SWE) measurements: seeking the reference for a true SWE value in a boreal biome, The Cryosphere, 16, 3199–3214, https://doi.org/10.5194/tc-16-3199-2022, 2022.
(2) Lopez-Moreno, J.I. et al. Intercomparison of measurements of bulk snow density and water equivalent of snow cover with snow core samplers: Instrumental bias and variability induced by observers. Hydrological processes 34/14, 3120-3133, https://doi.org/10.1002/hyp.13785, 2020.

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SWE measurements & reference standard

(1) *Reference* measurement field:
defined area (4x3 m) **>>** area of measurement methods to minimize errors

(2a) Weigh total amount of snow on defined area:
edges cutted out precisely - total snowpack shoveled into troughts - troughts weighted separately – total snow mass divided by area (measured)
→ *this* is the ***REAL SWE*** for *reference*

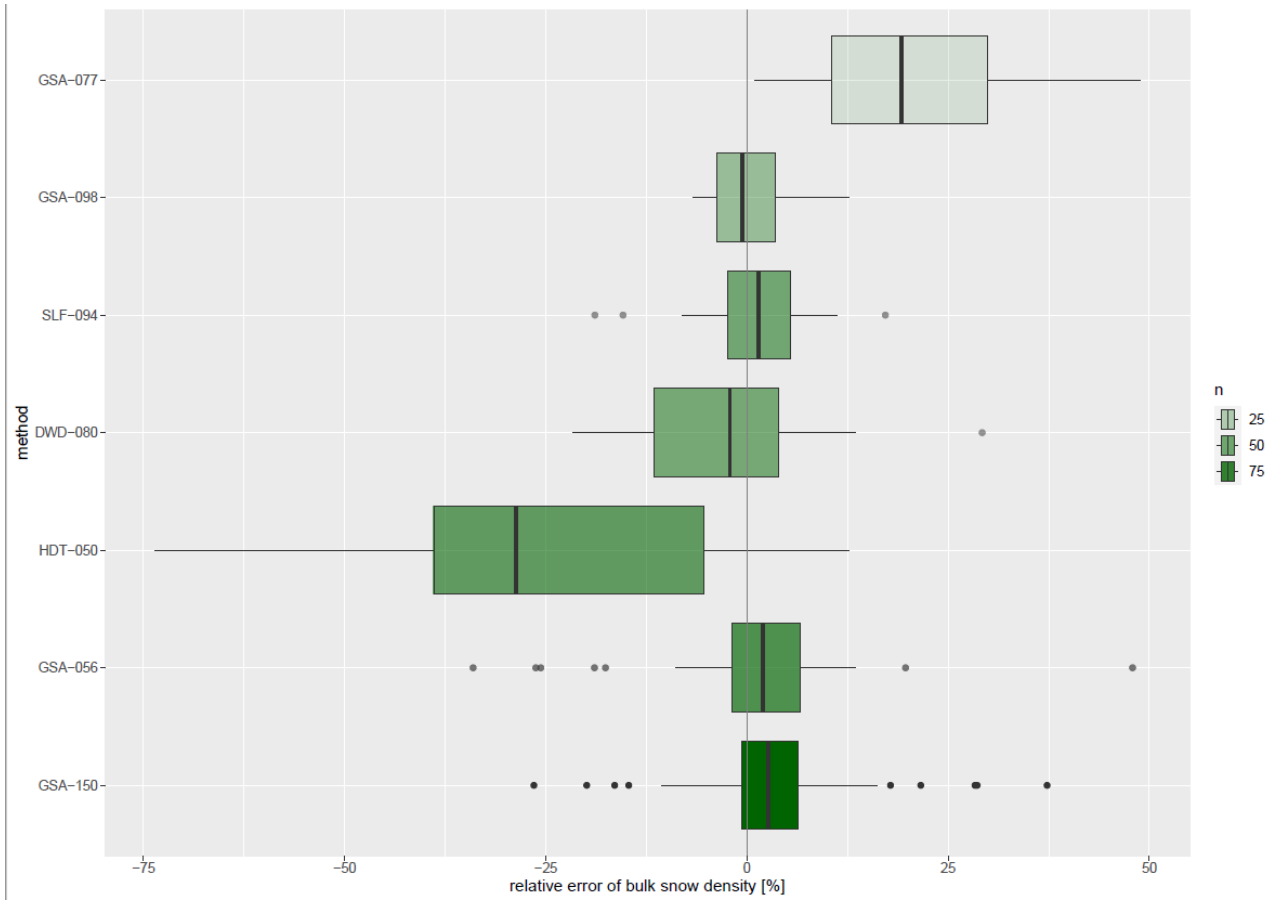
(2b) simultaneously: manual SWE measurements
numerous cut outs with different methods inside / beside *reference* field

(3) Validating different methods against *reference* (density rho)

Validating m **ere**

SWE measurements & reference standard

Outcome



We got **answers, …**

surprisingly **large variation** at all methods

slight improvement of accuracy with **larger diameter** (GSA-150, SLF-094, GSA-097)

error calculation: extreme **small errors** in permille range at *reference* measurement (large total mass, high number of weightings)

general* overestimation of bulk snow density / SWE

… assumptions, …

overestimation* due to partly **missing sharpness** of cutting edge?!?

… and remaining **questions**

impact of **tube material?**

performance of **other methods** against *reference*?

… tbc.

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Measurement systems

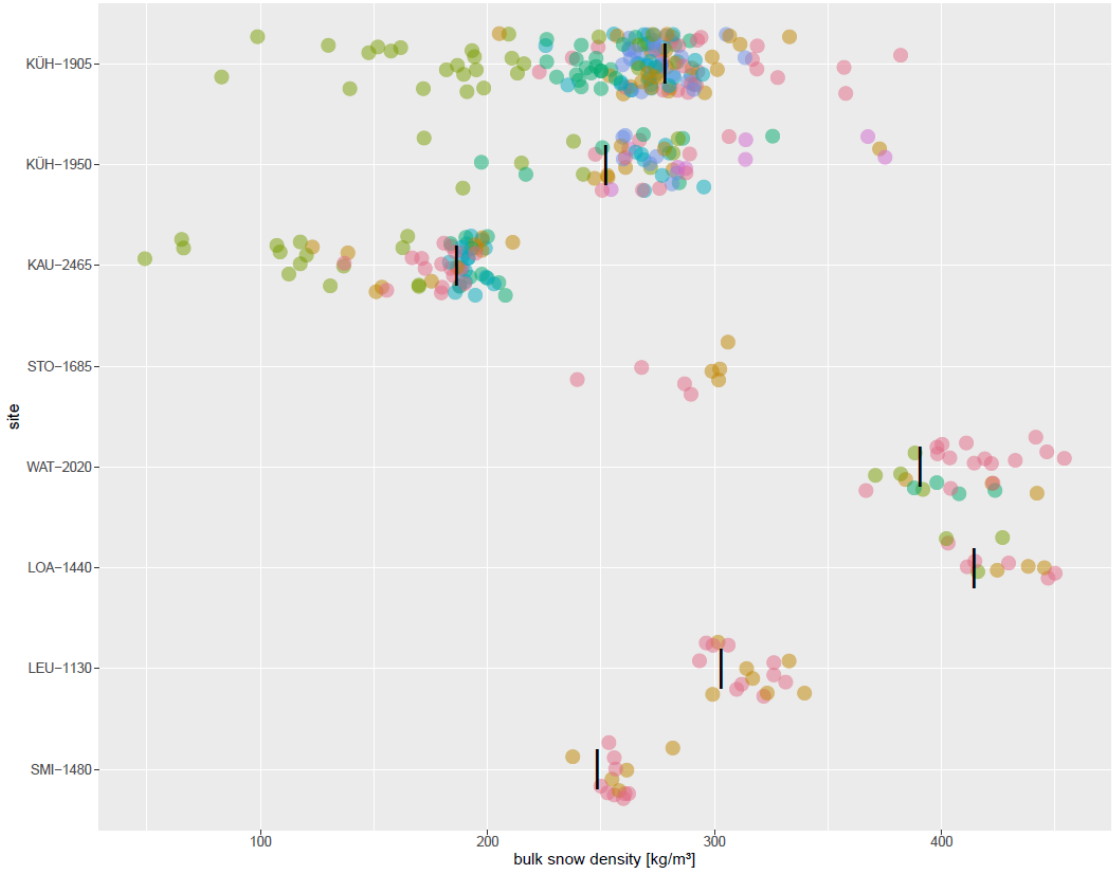
name / owner	D [mm]	L [m]	mat	N	M-RRMSE [%]	MED [%]	IQR [%]
GSA-056	56	0,2	Alu	62	4,30	2,01	8,43
GSA-150	150	1,0	PVC	94	2,57	2,70	7,05
HDT-050	50	0,45	Steel	55	6,48	-28,70	33,60
DWD-080	80	0,5	Alu / Steel	46	4,05	-2,16	15,37
SLF-094	94	0,6	Alu	48	2,58	1,43	7,83
GSA-097	98	0,6	Alu	32	2,79	-0,63	7,21

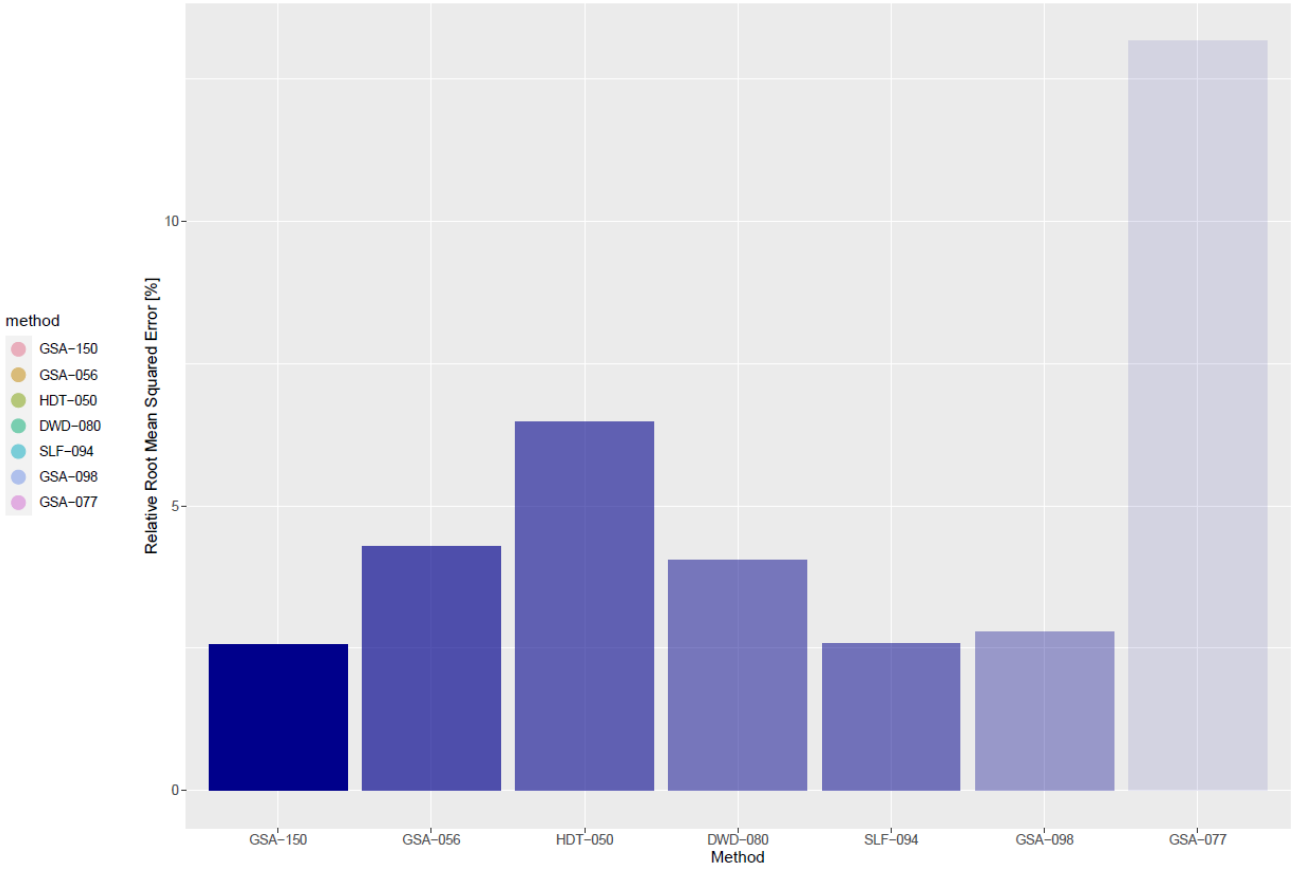
N … total number of probings
M-RRMSE … mean relative rooted mean squared error

MED … median relative error
IQR … interquartile range

SWE measurements & reference standard

Outcome





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Details of field measurements

8 measurement days from 01/2022 to 03/2023

- mainly in Tyrol 1200 – 2500 m.a.s.l.
- snow depths 40 – 85 cm
- different conditions: dry and loose old snow (early winter), hard packed and frozen (late winter), wet (spring); missing: fresh snow conditions
- mostly 15 – 40 and up to 125 measurements / day

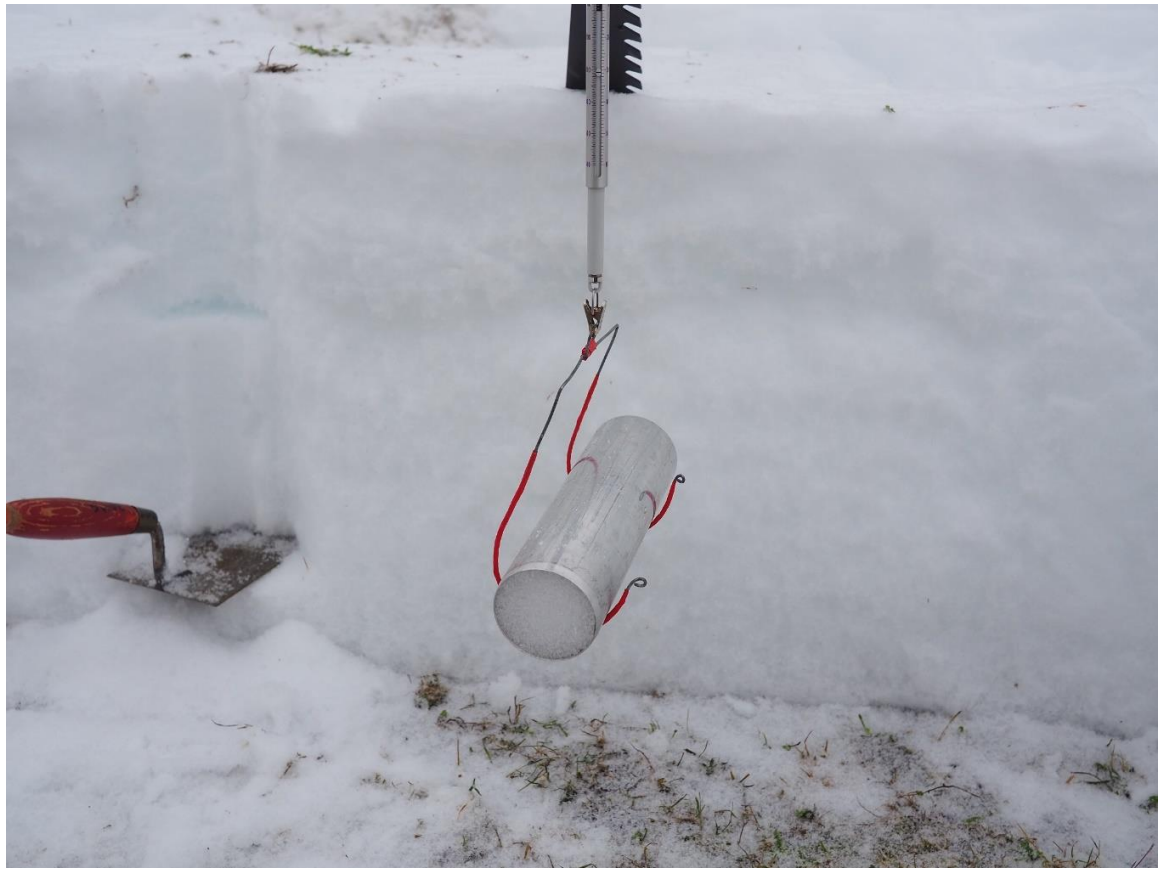
Measurement systems

- **GSA-056:** GeoSphere (ZAMG), widespread in (eastern) alps; aluminium tube d 56 mm / l 200 mm; analog spring balance
- **GSA-150:** developed @ ZAMG Innsbruck during winter 2022; PVC tube, d 150 mm / l 900 mm; electronic spring balance
- **HDT-050:** Hydrographic Service Tyrol; stainless steel tube, d 50 mm / l 500 mm; analog spring balance
- **DWD-080:** Deutscher Wetterdienst Germany; aluminium tube with coarse incisors; aluminium tube, d 80 mm / l 500 mm; extremely precise manufactured analog balance with output SWE (not mass!)
- **SLF-094:** Schnee Lawinenforschung Schweiz; aluminium tube, d 94 mm / l 500 mm, analog spring balance; elegant fixation similar to dustpan
- **GSA-097:** freshly plagiated from SLF @ GeoSphere; aluminium tube, d 97 mm / l 500 mm, electronic spring balance, fixation similar dustpan

Measurement systems

swe56: GeoSphere (ZAMG), widespread in (eastern) alps; aluminium tube d 56 mm / l 200 mm; analog spring balance

Susceptible for loss of little snow in some probings – thus small error due to many probings; analogue scales not perfect, edge not very sharp; slow measurement (many probings, carful digging out)



Measurement systems

swe150: developed @ ZAMG Innsbruck during winter 2022; PVC tube, d 150 mm / l 900 mm; electronic spring balance

very precise (large diameter), fast (very often only one probe per measurement, just sticking in and pulling out); unwieldy and potentially heavy

SWE measurements & reference standard

Measurement systems

HDT-050: Hydrographic Service Tyrol; stainless steel tube, d 50 mm / l 500 mm; analog spring balance

low accuracy, sticking (freezing) snow inside due to material (high heat capacity), often less snow inside tube due to small diameter and untidy edge

SWE measurements & reference standard

Measurement systems

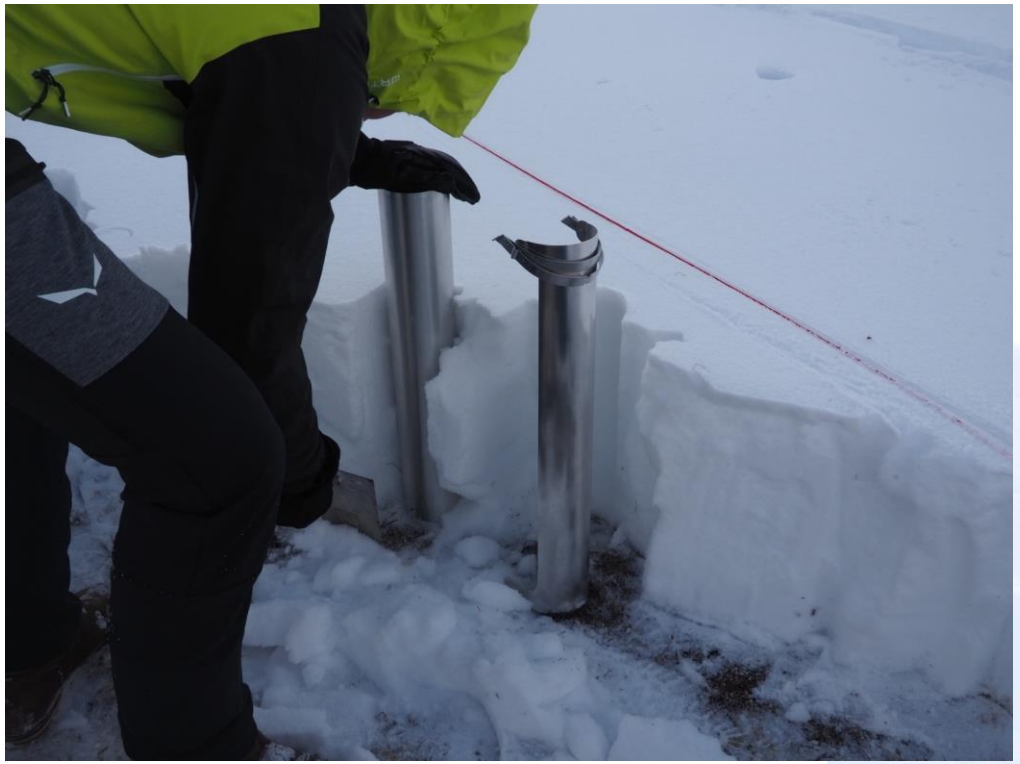
DWD-080: Deutscher Wetterdienst Germany; aluminium tube with coarse incisors; aluminium tube, d 80 mm / l 500 mm; extremely precise manufactured analog balance with output SWE (not mass!)

Cutting edge (incisors) way too coarse, no exact cutting (depending on snow conditions), low accuracy because of much snow not going inside tube

Measurement systems

SLF-094: Schnee Lawinenforschung Schweiz; aluminium tube, d 94 mm / l 500 mm, analog spring balance; elegant fixation similar to dustpan

Highly precise, very good cutting, fast because of good length and well working mechanism, attention on resting snow on dustpan / between tube - shell



Measurement systems

GSA-097: freshly plagiated from SLF @ GeoSphere; aluminium tube, d 97 mm / l 500 mm, electronic spring balance, fixation similar dustpan

Highly precise, attention on snow between pan / shell and tube

nearly identically to SLF-094

Background

SWE-measurements @ ZAMG with small diameter tube SWE56 (aluminium): d 56 mm / l 200 mm & old fashioned spring balance

→ doubts on reliability, accuracy

Anything better? Other techiques? Greater diameters better (smaller volume-to-surface-ratio)?

NEW DEVELOPMENT: GSA-150 … PVC-tube: d 150 mm / l 900 mm & **modern** electronic spring balance

first comparisons between GSA-056, GSA-150 and ***reference***

… other methods taken to account later on …

due to high trust in precisely worked out SLF-tool we tried to copy this system in "**GSA-097**"