

The WMO SPICE Snow-on-Ground Intercomparison: An Overview of sensor assessment and recommendations on best practices

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**WMO SOLID PRECIPITATION
INTERCOMPARISON EXPERIMENT
(WMO-SPICE)
2012-2015**

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SPICE Snow-on-Ground Objectives

1) Assess instrument performance

- Instrument accuracy and bias relative to a reference
- Failure rates and data quality metrics

2) Issues with measuring SoG and impacts on data quality

- Target assessment and drift (snow depth)
- Spatial variability
- Measurement uncertainty
- Impacts of temperature errors on sonic adjustments
- Impacts of instrument design and installation
- Assessment of instrument measurement qualifier output

3) Linkages between SoG and snowfall

SoG Instrumentation

Snow Depth



Campbell Scientific
SR50ATH



Felix Technologies
SL300



Sommer Messtechnik
USH-8



Jenoptik/Lufft
SHM30

Snow Water Equivalent



Sommer Messtechnik
SSG1000



Campbell Scientific
CS725

SoG SPICE Sites

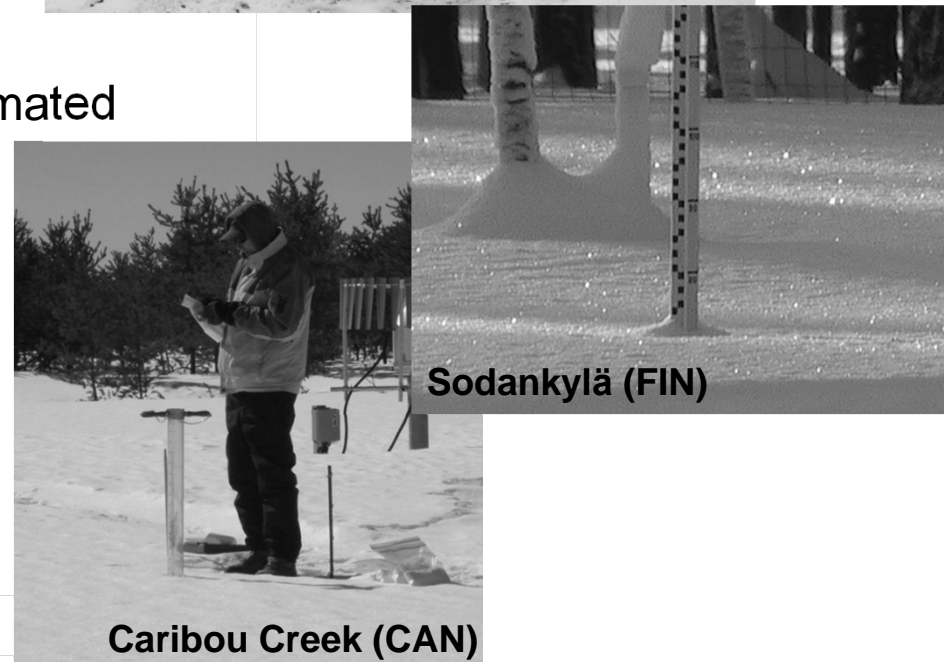
CARE (Canada)
Caribou Creek (Canada)
Col de Porte (France)
Formigal (Spain)
Sodankylä (Finland)
Weissfluhjoch (Switzerland)

<http://www.wmo.int/pages/prog/www/IMOP/intercomparisons/SPICE/SPICE.html>

Assessment of Instrument Performance

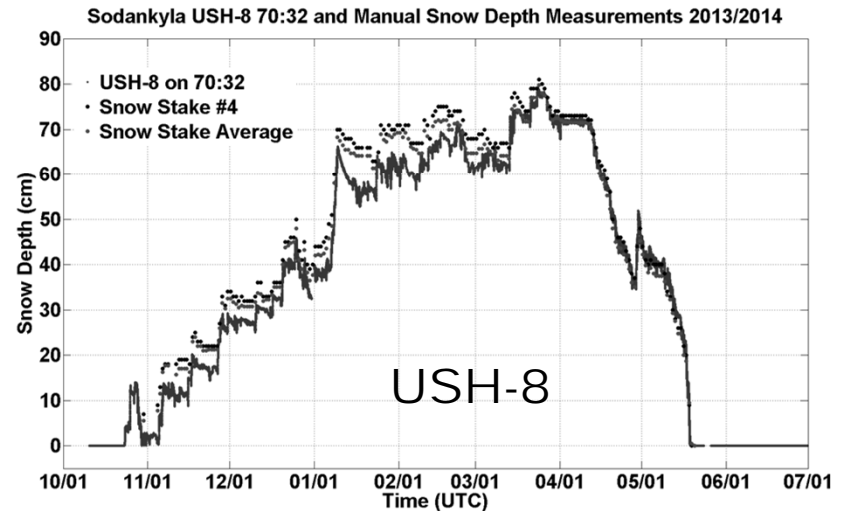
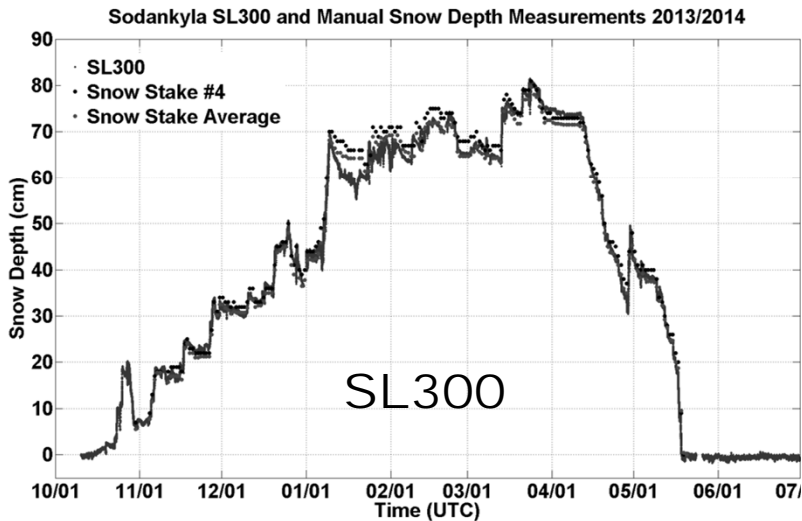
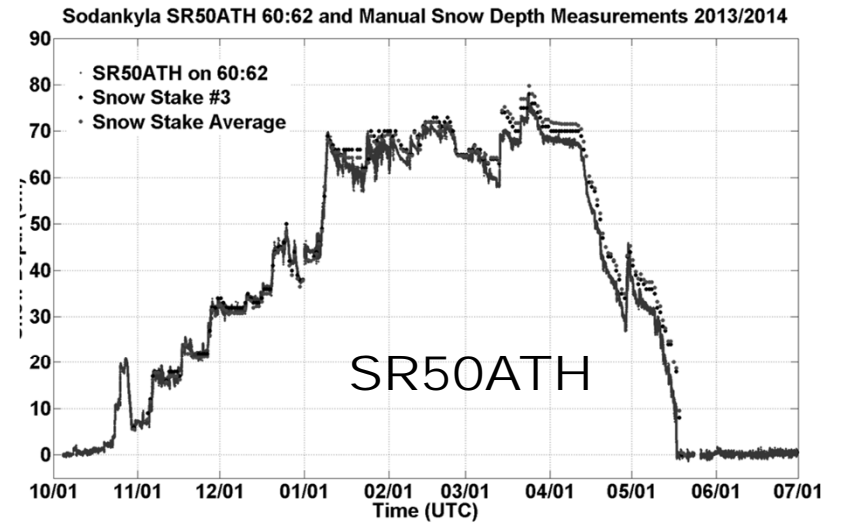
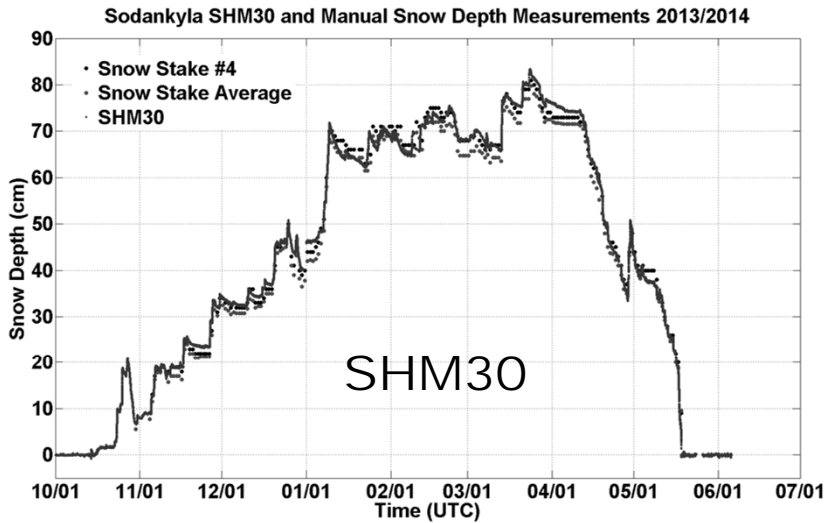
The References

- **Snow Depth**
 - **Manual**
 - graduated snow stakes
 - visual or photographed
 - 1 to 4 stakes
 - daily to weekly
 - **Automated**
 - Mean of all (4 to 6) automated sensors
 - 1-minute resolution
- **SWE**
 - bulk density snow tube
 - bi-weekly

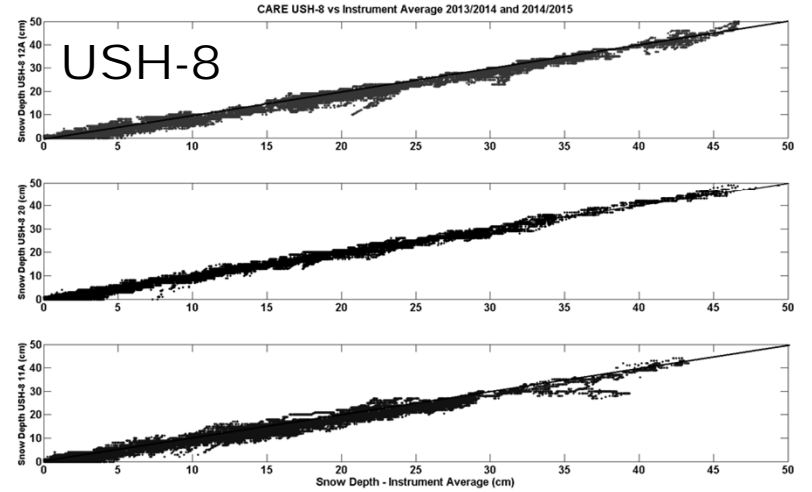
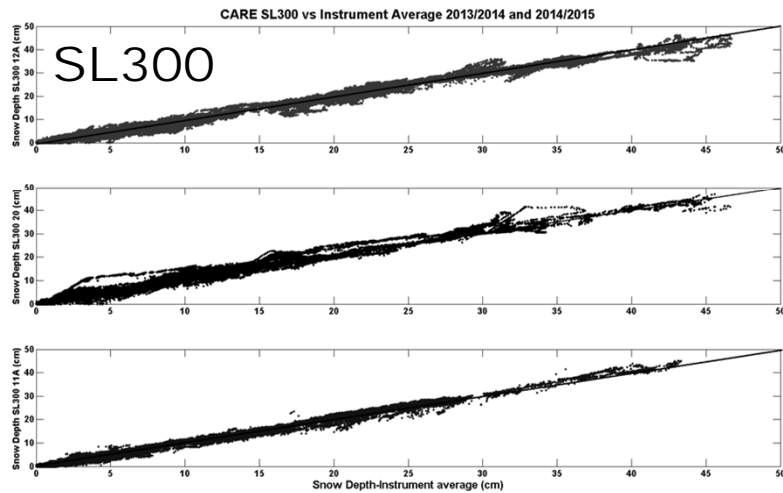
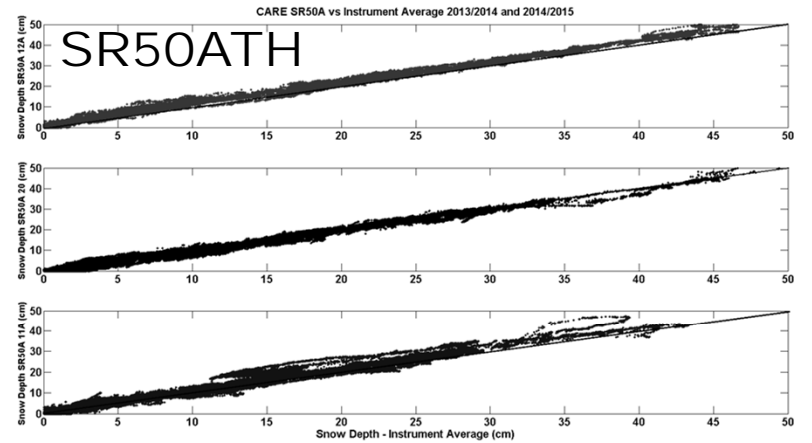
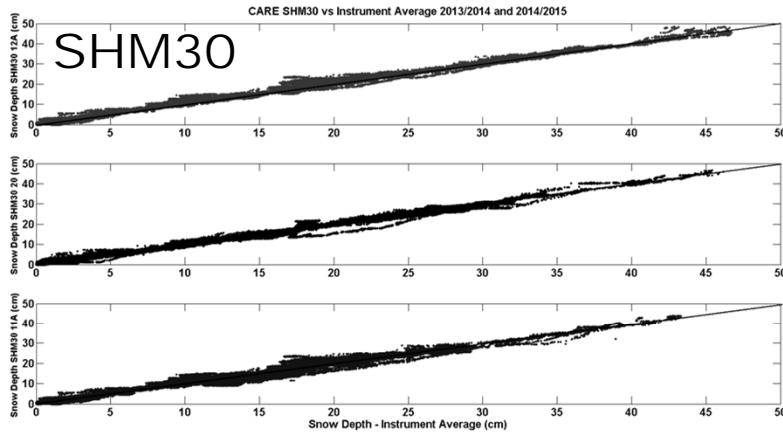


Caribou Creek (CAN)

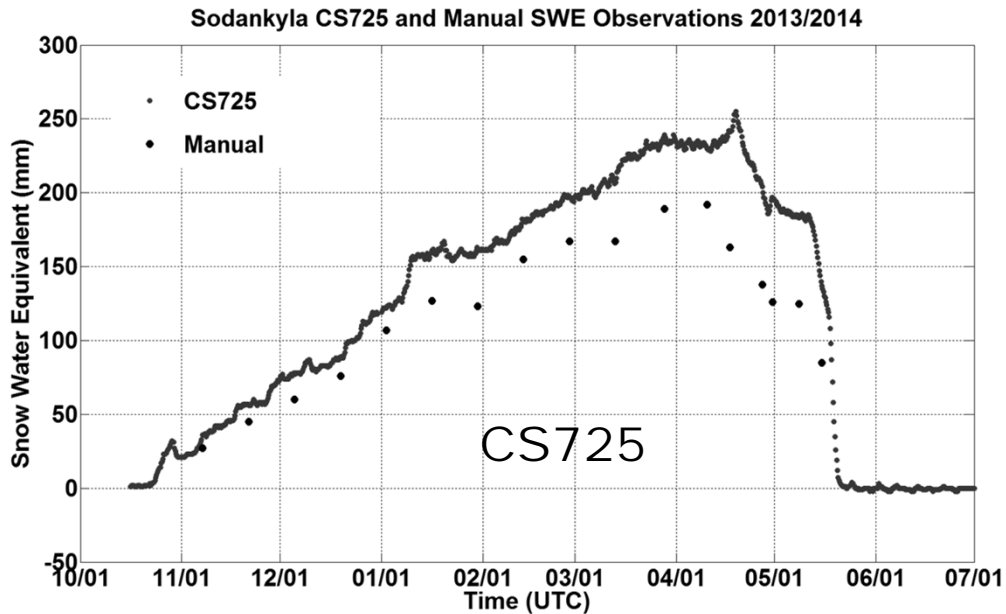
Sodankylä Snow Depth Intercomparison (manual reference)



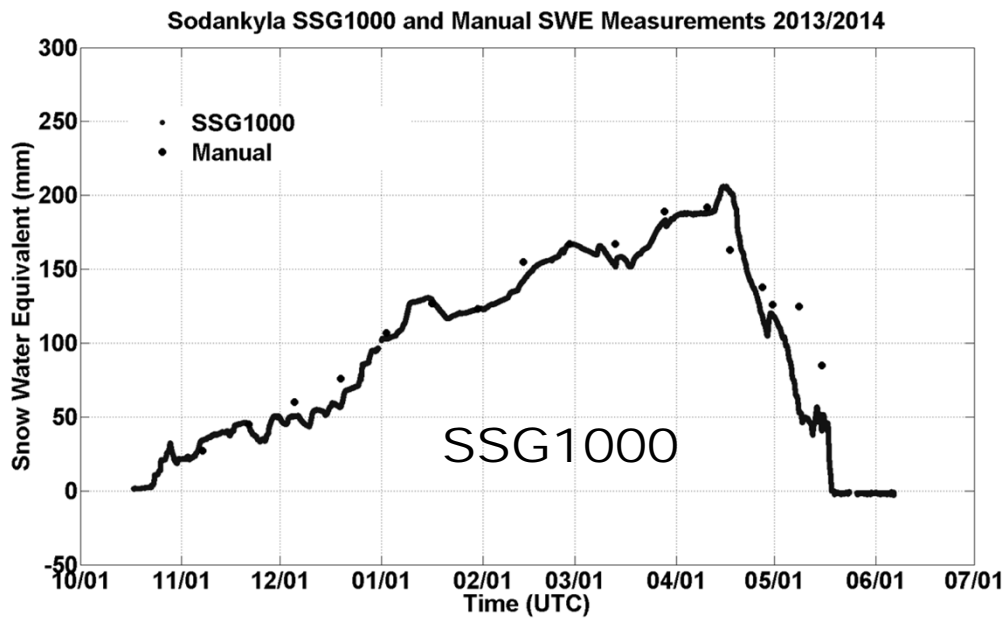
CARE Snow Depth Intercomparison (automated reference)



Sodankylä SWE Intercomparison



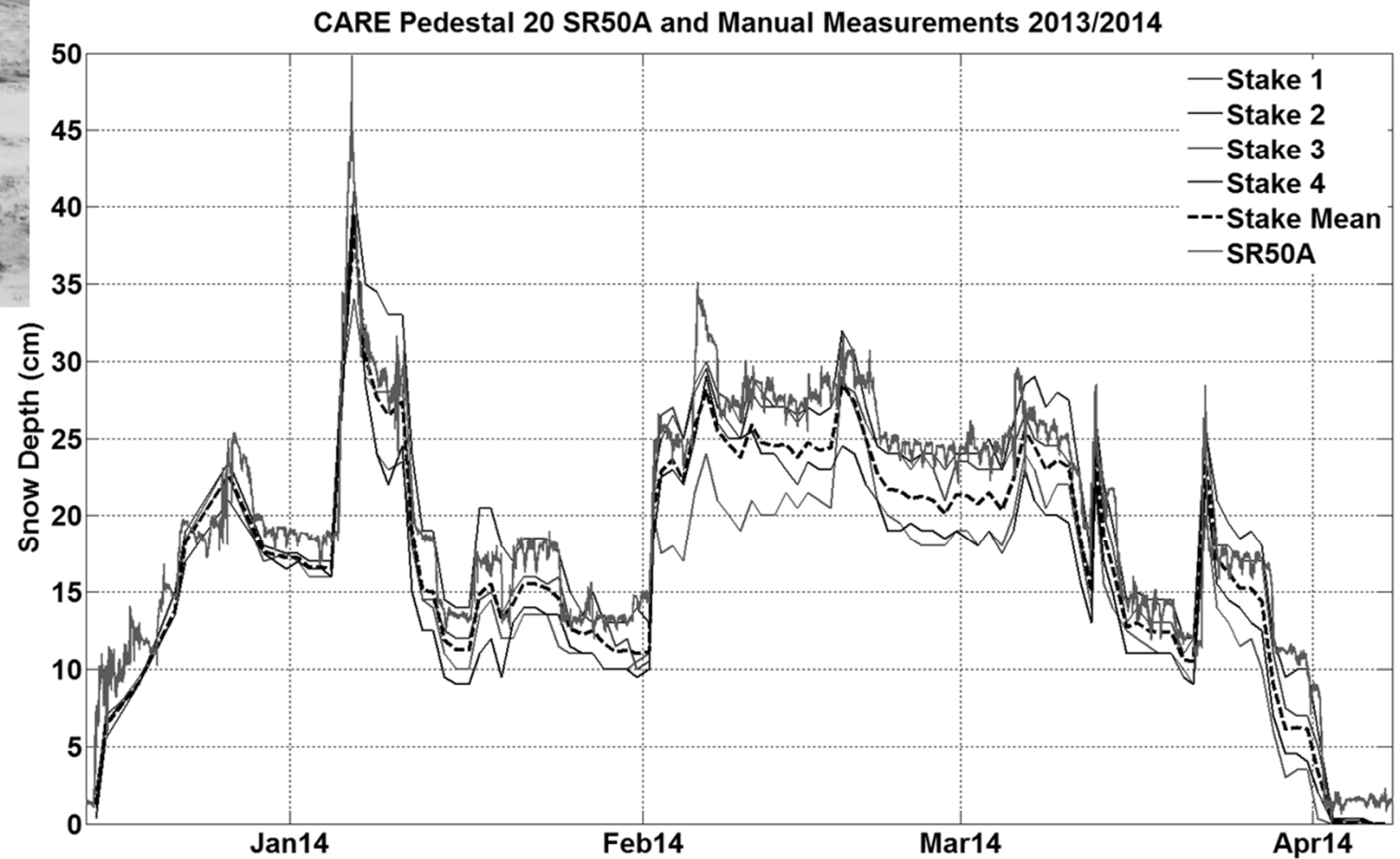
Passive Gamma



Load Cell

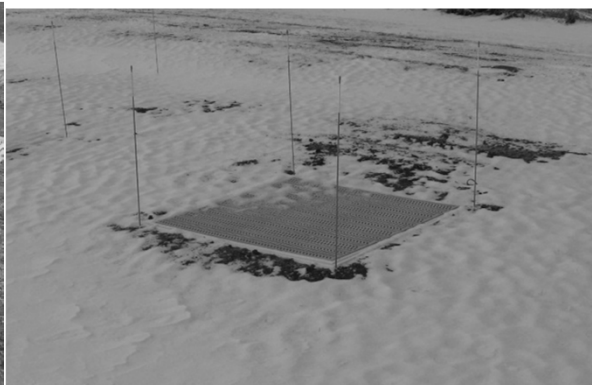
(Smith et al., 2016, submitted to The Cryosphere SPICE special issue)

Impact of Spatial Variability



Snow Depth Sensor Target Assessment

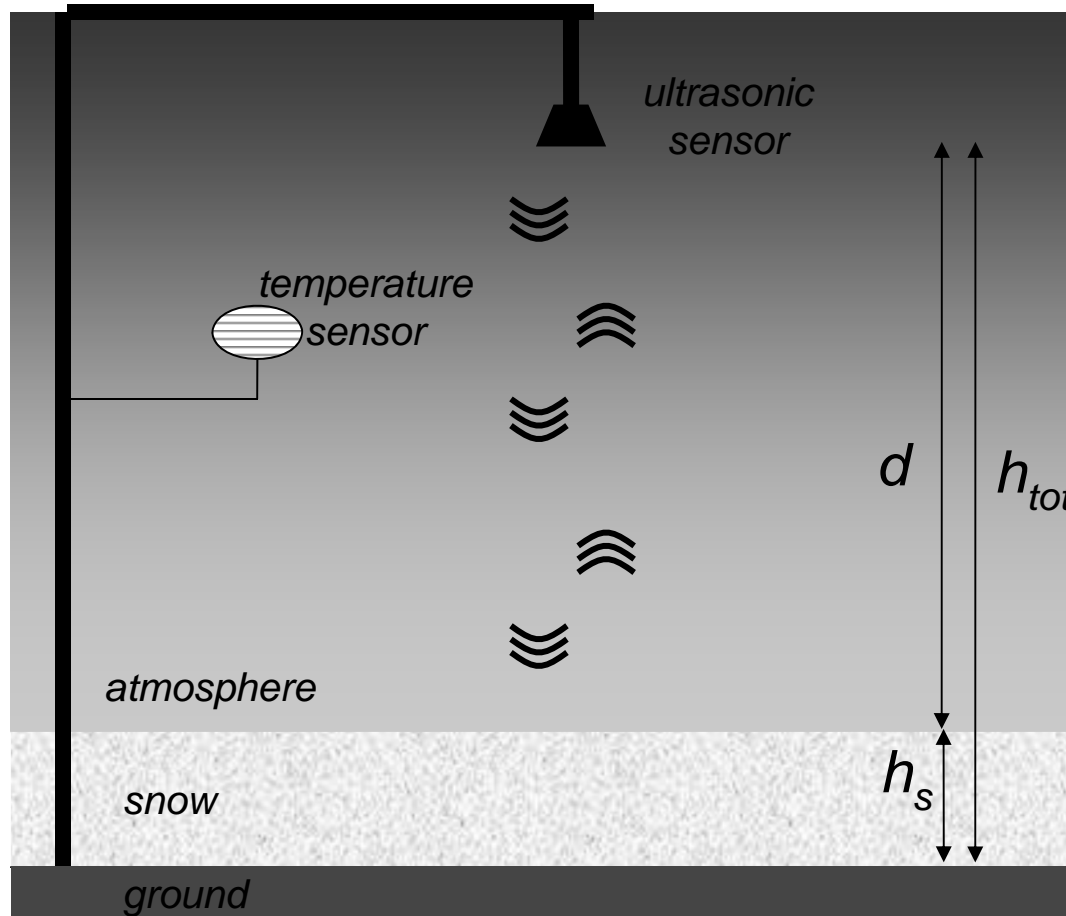
Grey Textured Plastic (CARE, Caribou Creek)



Green Artificial Turf (Sodankylä)

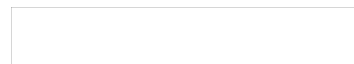


Sonic Temperature Correction Errors



Ta Measured at Ultrasonic Sensor Height

	Error
5K Linear Profile	0.5%
10K Linear Profile	1%
2K Bias	1.5%

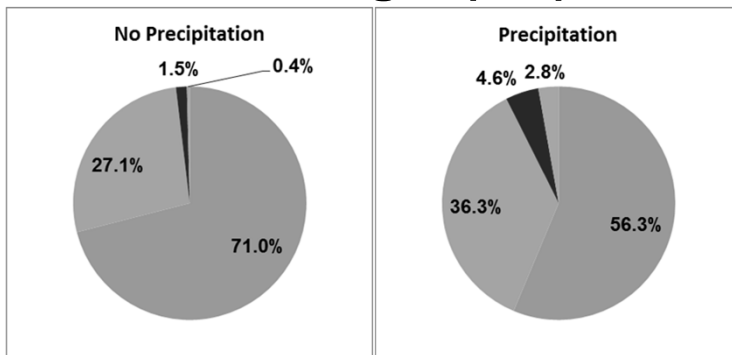


Sensor Measurement Qualifier Output

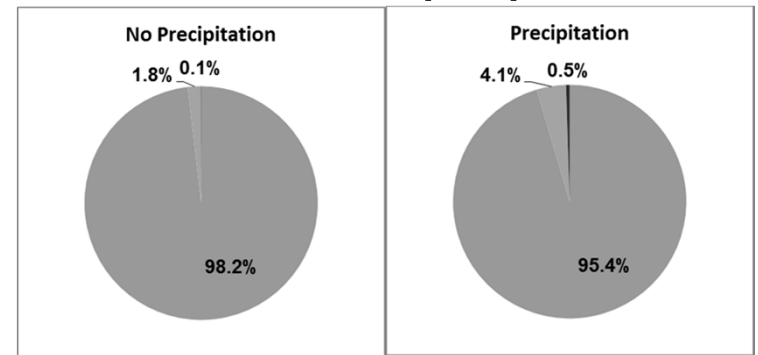
Poster P3(15)

SR50A Output of Measurement Quality

Formigal (4m)

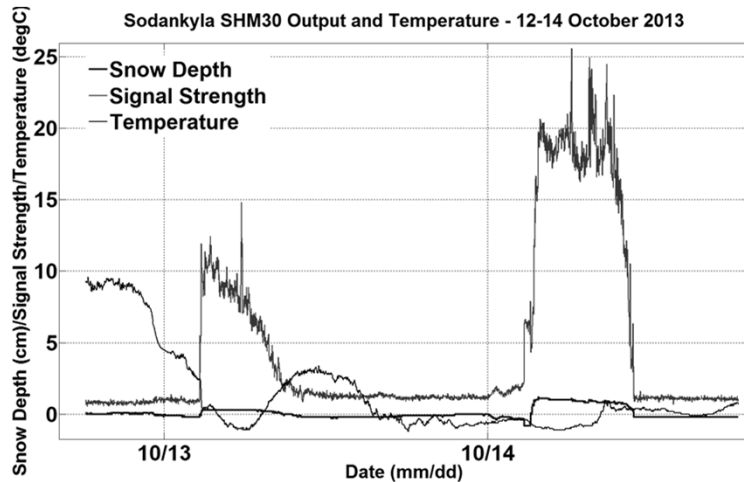


CARE (2m)

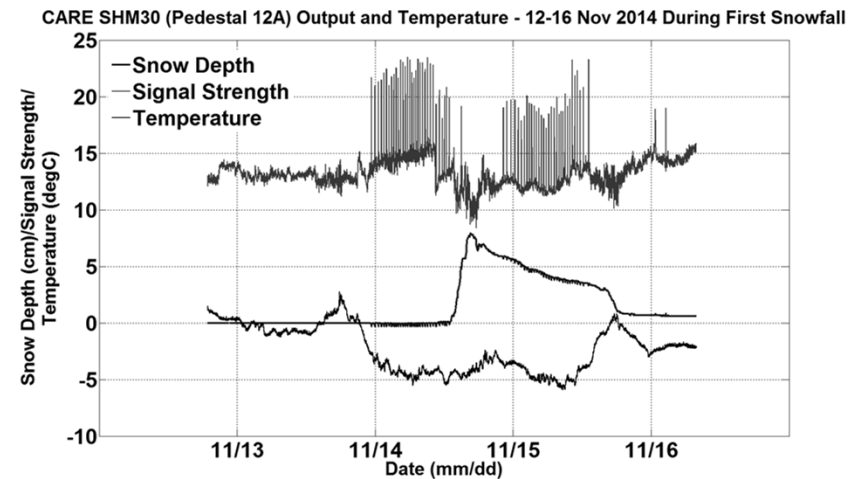


SHM30 Signal Strength Output

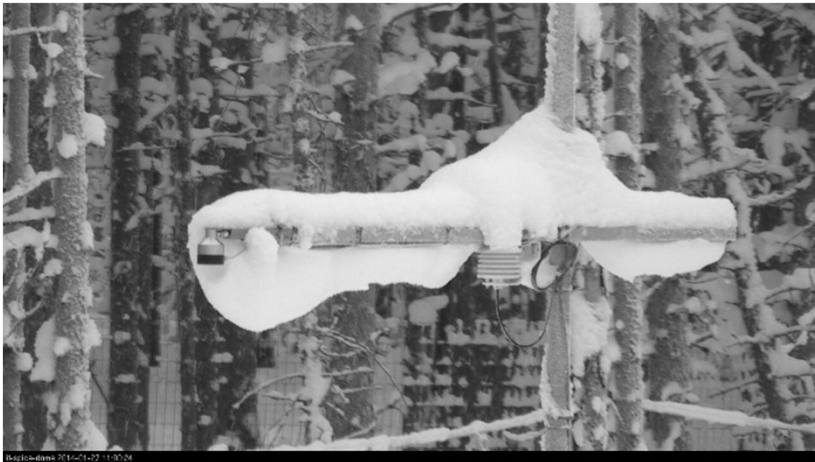
Green Artificial Turf (Sodankylä)



Grey Plastic (CARE)



Instrument and Infrastructure Design



Heated sensor, unheated horizontal boom



Unheated sensor, unheated horizontal boom



Heated sensor, heated angled boom

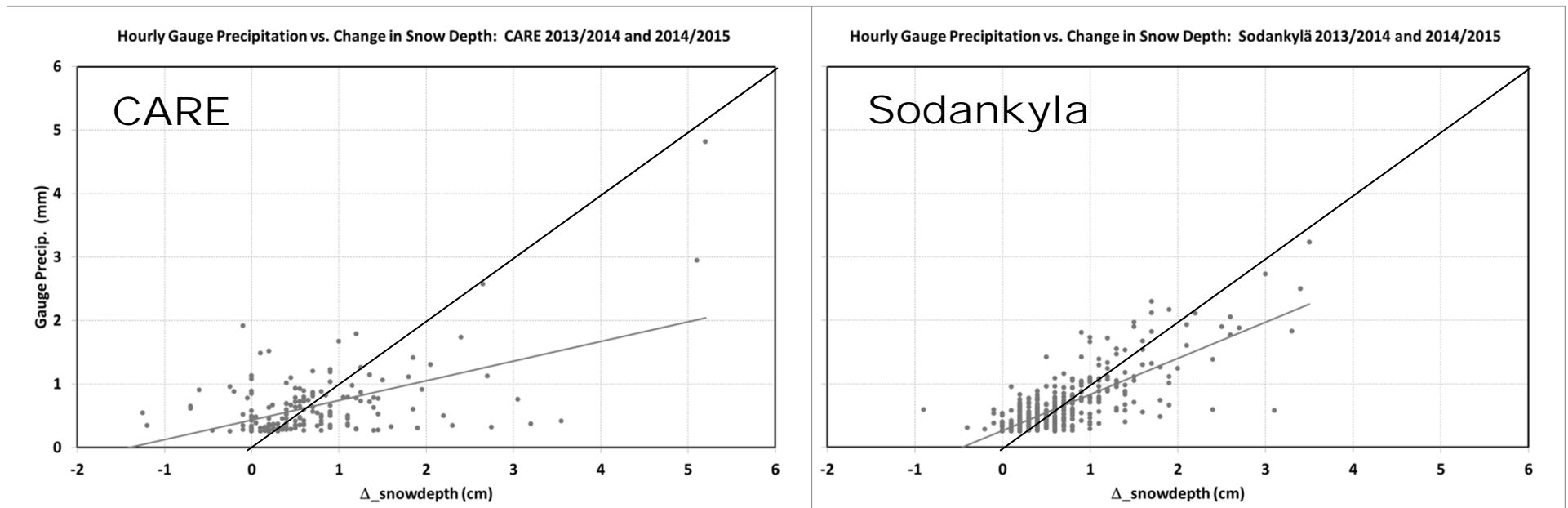


Unheated sensor, heated angled boom

Linkages between SoG and Snowfall

Can we use a snow depth sensor to estimate precipitation?

Hourly precipitation (mm) vs. change in snow depth (cm)



Site	Slope	Intercept	r^2	N
CARE	0.31	0.44	0.28	165
Sodankylä	0.57	0.26	0.58	442

Conclusions and Recommendations

- **Generally, all SoG sensors behaved according to the manufacturer's specifications**
 - Intercomparisons impacted by spatial variability (point measurements)
 - Recommendation: an assessment of spatial variability should be a key component to any point measurement of SoG
 - SWE sensors had different biases related to the measurement principle
 - Using the mean of several (4 to 6) automated sensors worked well for a high frequency measurement reference for snow depth
 - Recommendation: reference methods for SoG intercomparisons should be standardized across all sites
- **Surface target selection (snow depth) considerations:**
 - Flat, stable target more important for sonic sensors
 - Texture impacts measurement of first snow; radiation balance impacts melting
 - Colour of target alters the behaviour of the signal strength output from optical sensors
 - Recommendation: assess all targets for zero drift (settling or frost heave) after each season
- **Other infrastructure considerations**
 - Recommendation: heat snow depth sensors and mounting booms (high snow, low wind)
 - Minimize temperature errors used for sonic corrections; Recommendation: aspiration(?)
- **Issues with using snow depth sensors for estimating total precipitation are complex**

