

Summary of Manual Snow-On-Ground Measurements for WMO-SPICE

Col de Porte

Col de Porte performs a manual snow ruler and snow pit measurement on a weekly basis during the winter measurement period. Snow depth measurements are made with a metal ruler. These measurements are made approximately 17m from the mast where the automated measurements are made (Snowpit Field in attached site diagram). The automated measurements are marked SDJEN, SDDIM, SDAPI, SDUS1, SDUS2 and are located in the NE corner of the diagram.

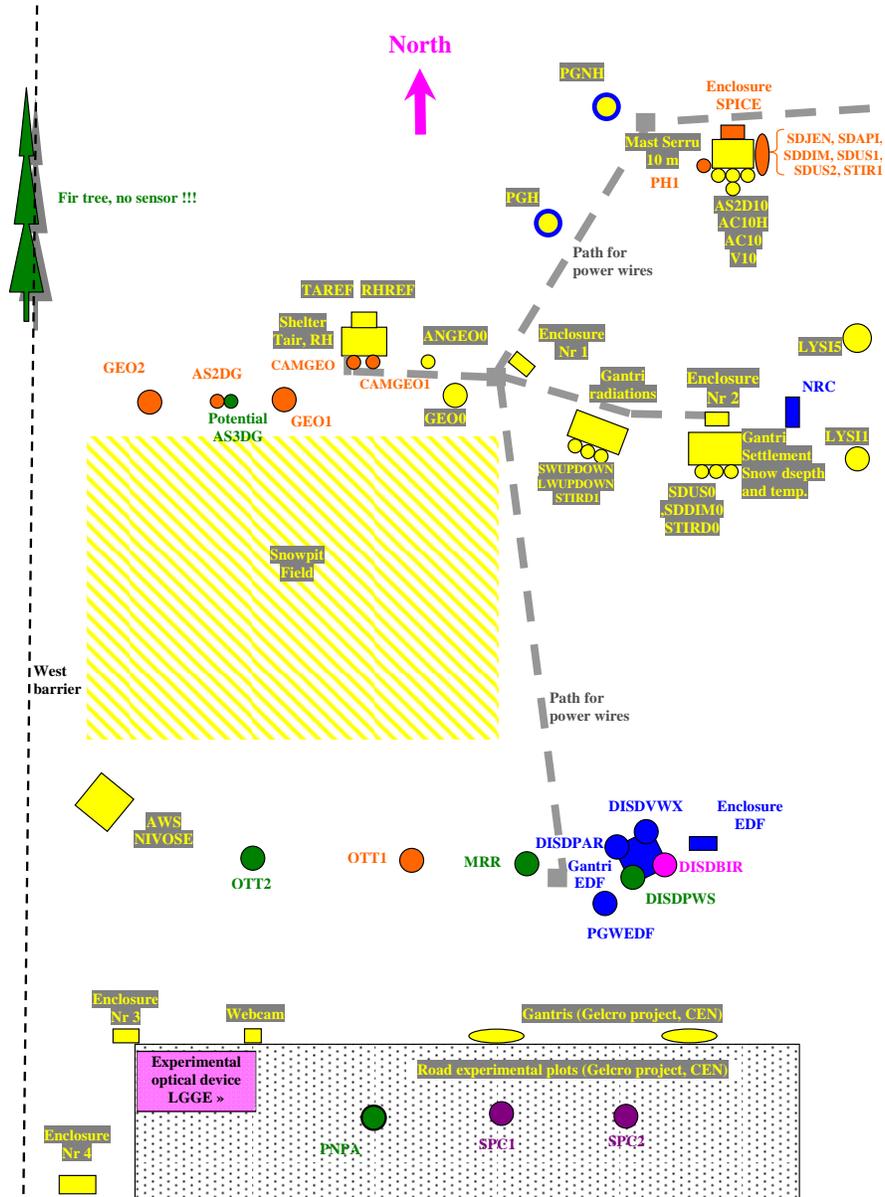


Figure 1: Site layout of the Col de Porte intercomparison site



Figure 2: Snow pit observations at Col de Porte

The manual snow observations are made around local noon and the data is archived at the site via Excel files. For the 2014/2015 season, manual snow depth stakes will be moved closer to the automatic measurements and will be photographed on a regular basis.

CARE

Manual observations of snow depth at CARE employ a network of 62 graduated snow stakes placed at various locations on the site for the purpose of assessing spatial variability. The placement of stakes generally corresponds with the locations of gauge bases on-site, with three or four stakes located at different locations around each base. It is important that stakes are placed outside the field of view of automatic snow depth sensors (Campbell Scientific SR50A, Jenoptik, GMON) to avoid disturbing the snow in areas interrogated by these gauges, and hence producing erroneous snow depth readings. Stakes are presently located just outside the field of view (FOV) of each automatic snow depth sensor location at CARE for comparison with the automatic measurements (three or four stakes outside the FOV of each SR50; two stakes outside the FOV of all other automatic sensors).

Daily snow depth measurements are obtained as follows:

- The start time is recorded (varies from 10-15 UTC)
- The snow depth is measured at each snow stake to the nearest 0.5 cm, typically starting at the southeast corner of the site
- The end time is recorded (duration of measurements is approximately 25 minutes)

All measurements are recorded on a designated sheet (hard copy), along with the observer's name and any notes. This information should also be input into an online database via a web interface.

Some stakes may be photographed each hour by the web camera while some stakes are photographed by the observer during interesting events.

No SWE measurements were obtained during the 2013/2014 season but are planned for 2014/2015.

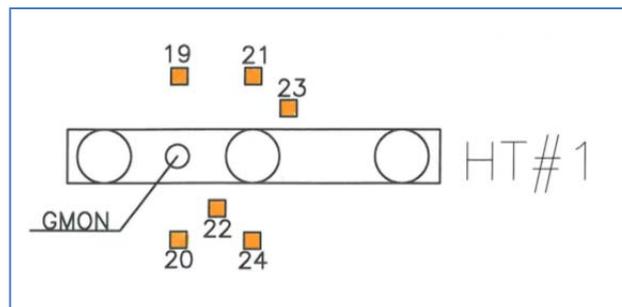
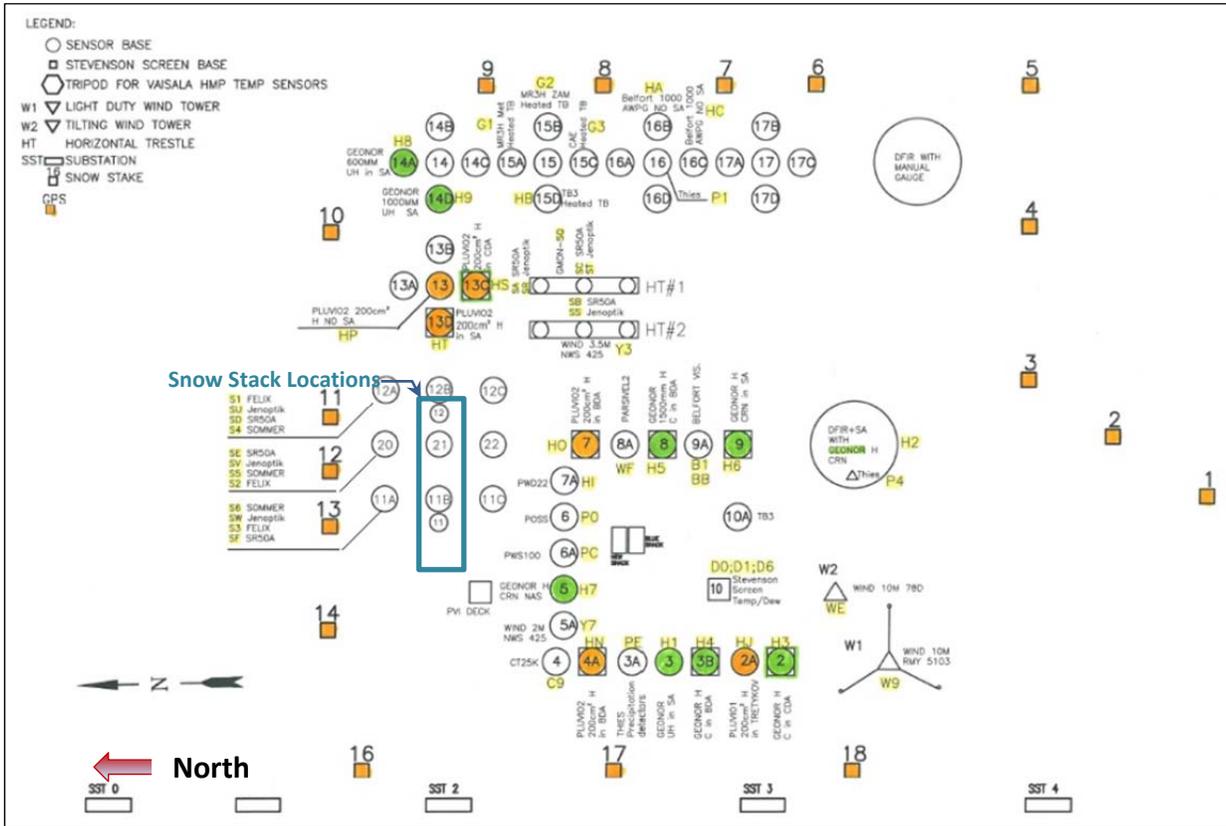


Figure 3: CARE Site Layout Snow Stack Positions at HT#1 (see Figure 4)



Snow stacks layout details

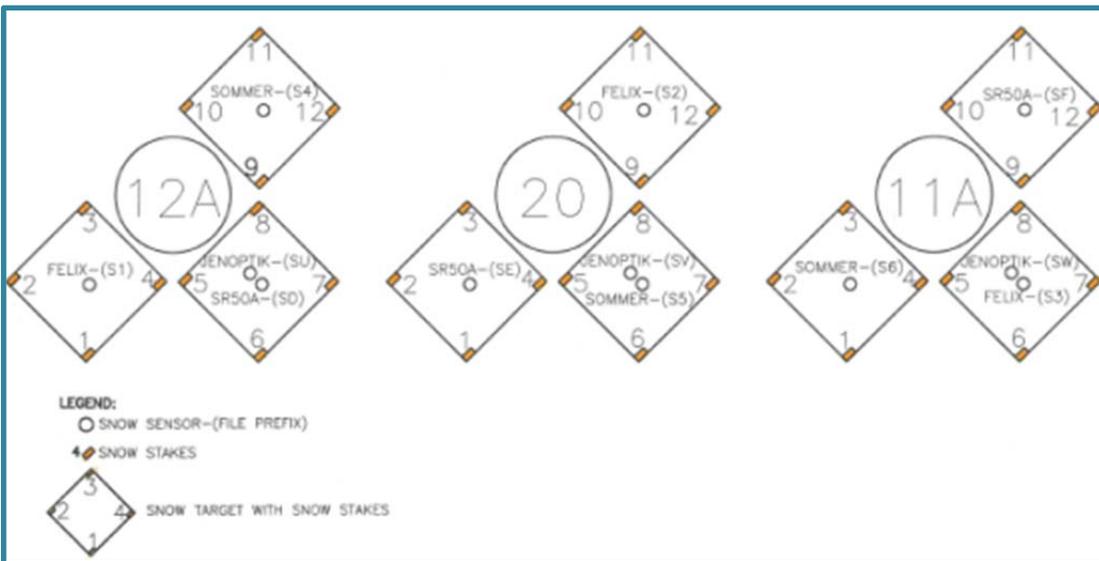


Figure 4: CARE Site Layout and SPICE Snow Stack Positions



Figure 5: Site Installation for the SPICE Snow Stacks



Figure 6: A Close-Up of a Snow Target

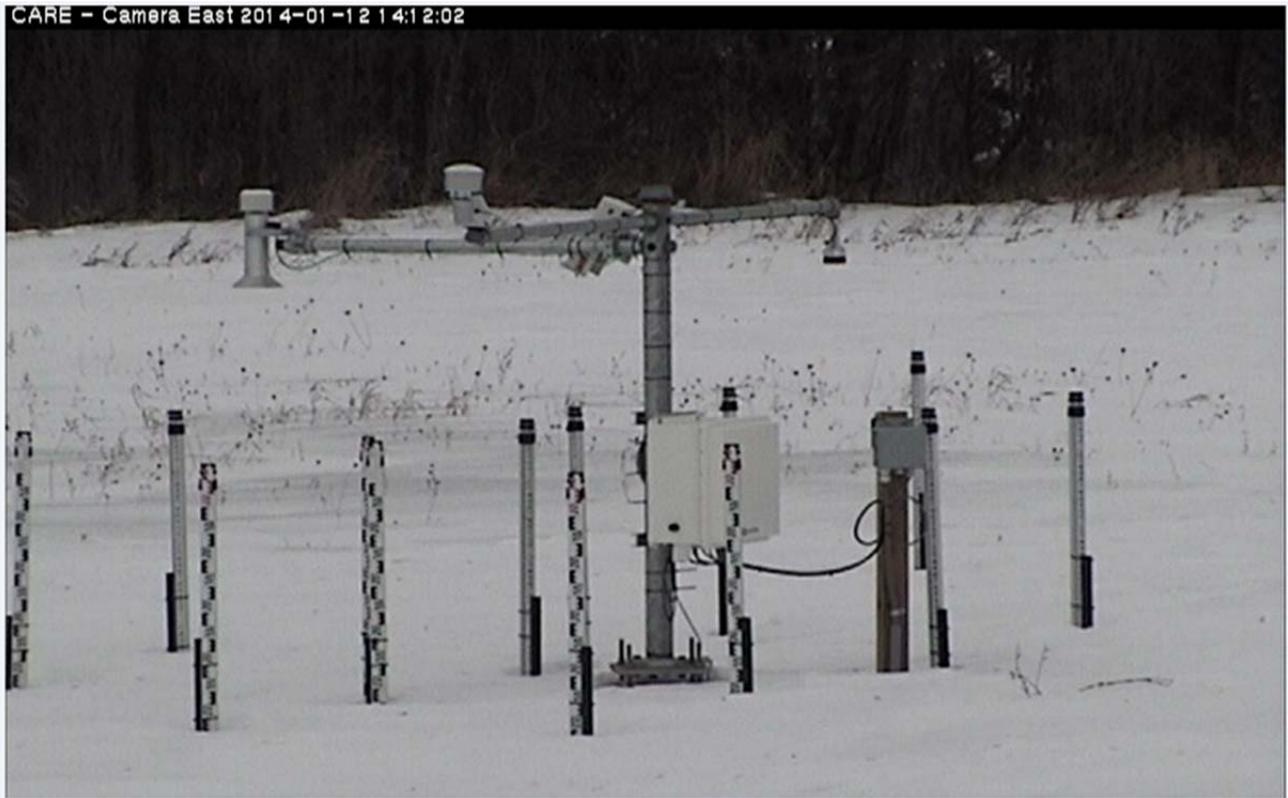


Figure 7: Snow Stacks at Base 12A: after a snow event on 11-Jan-2014 and the observation

Table 1: Data from 11-Jan-2014

Input Date UTC	Site	Stake	Obs Start Time UTC	Obs End Time UTC	Inputter	Depth (cm)
16/01/2014 20:55	CAR	12a01	12/01/2014 14:31	12/01/2014 14:59	PSR	10
16/01/2014 20:55	CAR	12a02	12/01/2014 14:31	12/01/2014 14:59	PSR	14.5
16/01/2014 20:55	CAR	12a03	12/01/2014 14:31	12/01/2014 14:59	PSR	14
16/01/2014 20:55	CAR	12a04	12/01/2014 14:31	12/01/2014 14:59	PSR	10
16/01/2014 20:55	CAR	12a05	12/01/2014 14:31	12/01/2014 14:59	PSR	11
16/01/2014 20:55	CAR	12a06	12/01/2014 14:31	12/01/2014 14:59	PSR	12.5
16/01/2014 20:55	CAR	12a07	12/01/2014 14:31	12/01/2014 14:59	PSR	15
16/01/2014 20:55	CAR	12a08	12/01/2014 14:31	12/01/2014 14:59	PSR	12.5
16/01/2014 20:55	CAR	12a09	12/01/2014 14:31	12/01/2014 14:59	PSR	13
16/01/2014 20:55	CAR	12a10	12/01/2014 14:31	12/01/2014 14:59	PSR	15
16/01/2014 20:55	CAR	12a11	12/01/2014 14:31	12/01/2014 14:59	PSR	21
16/01/2014 20:55	CAR	12a12	12/01/2014 14:31	12/01/2014 14:59	PSR	21

Sodankylä

In the SPICE field, manual measurement of SWE are taken weekly near the CS725 sensor. These are a bulk density sample as shown in Figure 9.

Photographs of snow stakes near the automated snow depth instruments are taken hourly by the site webcam. Photos are archived onsite. Four manual snow depth stakes are distributed around the SPICE field at locations 22:40, 44:66, 65:57 and 65:37 (Figure 10) and are within 8.5 m of the automated snow depth instruments.

Excerpt from “DESCRIPTION OF THE SNOW RELATED MEASUREMENTS IN FMI-ARC, SODANKYLÄ, FINLAND, Anna Kontu:

The longest (“the snow course”, “Tähtelä snow course”) is shown on map in Figure 1. This snow course is 4 km long and is measured twice a month (around the 1st and 15th of each month). Snow depth is measured every 100 m and snow water equivalent every 800 m (2 times per side of the square track). Every 5th SD measurement site is marked on the field, the rest are estimated at equal spaces. The snow course covers varying land cover types typical to the area to give a good representation of the snow conditions. The snow course has 1 measurement on open area, 5 on forest openings, 33 in pine dominated forest, 4 in deciduous dominated forest, and 37 on open bog.

The second course (“the snow depth variability course” or “Snow depth variability 2 (forest)”) has 21 fixed snow depth sticks at 1 m intervals. These are also measured twice a month (about 10th and 25th day, since the measurement staff has so many other duties always on 1st and 15th day), except in January and March every 5th day (due to other measurements performed at the same site on these days). This course is located close to Sounding station (Figure 8) on a forest opening. The course is shown in Figure 48.

Third course (“IOA snow course” or “Snow depth variability course 1 (IOA)”) has 17 fixed snow depth sticks at 1 m intervals. These are measured every time during snow pit measurement on IOA.

Note: The 0 cm value of a fixed depth stick is at ground surface level. Due to uneven ground surface, the sticks are not on same horizontal level. Thus the sticks measure the actual snow depth, but there are large variations in snow depth even in small area.

Note: The fixed sticks affect the snow at their surroundings. There is always a small pit on snow surface around the stick. When the fixed sticks are measured, the recorded value is an estimate of snow depth around the stick, not the actual snow level at the stick (at the bottom of the pit).



Figure 8: Map of the FMI Arctic Research Centre area showing the most important measurement sites. The main Intensive Observation Area (IOA) is indicated in the lower left. The dotted line indicates a monthly operational snow course. The blue area in the lower left corner is Kitinen river, pale yellow is sparse pine forest and green lines mark bog area. The SPICE field is near the Sounding Station.



Figure 9: SWE measurement (left) and manual snow measurement stakes (right)

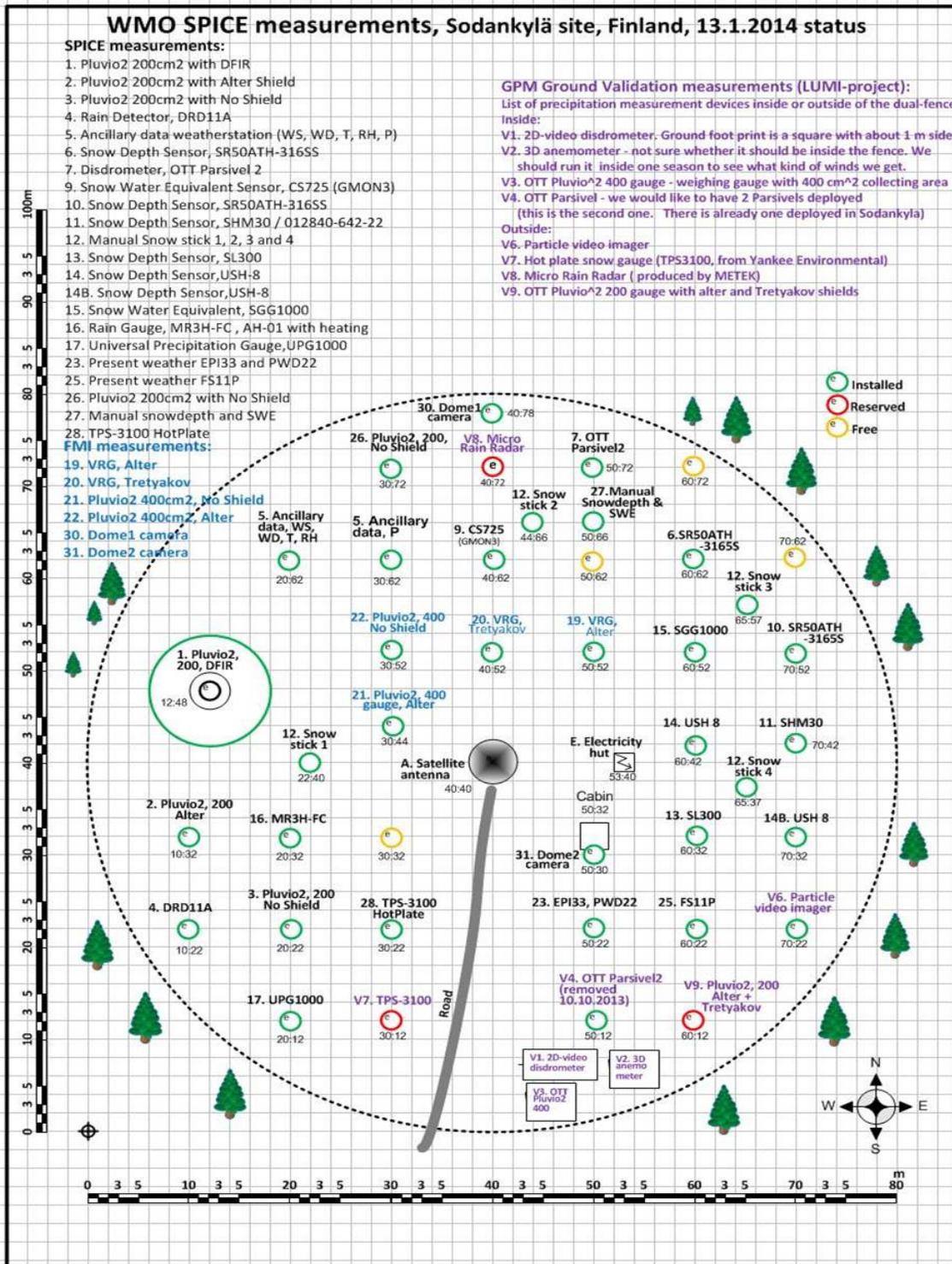


Figure 10: SPICE field at the Sodankylä ARC. Snow stakes are at locations 22:40, 44:66, 65:57 and 65:37 with automated snow depth sensors at 60:62, 70:52, 60:42, 70:32, and 60:32.

Caribou Creek

A five point snow survey transect was established (September 2013) at the SPICE Caribou Creek research site. The transect runs North-South, perpendicular to the prevailing wind direction, with 2 points in the bush south of the measurement compound, 2 points in the compound, and 1 point on the north edge of the clearing (Figure 12). Spacing between the SWE measurement points is 10 meters and additional depths are taken at 2 meter intervals along the transect.

Snow surveys are conducted approximately every two weeks during the snow season with frequency increasing during the melt season as required to assess sensor performances during this time. SWE measurements are performed using an ESC-30 snow tube. Vertical bulk samples (30 cm² surface area) are taken from the snowpack at transect points, the cores are bagged and weighed at the conclusion of the survey. Individual point SWE amounts and densities are calculated from this data as well as average SWE, density, and depth values for the transect.

The middle point of the snow survey (point 3) is in close proximity (within the FOV) of the CS725 sensor installed on pedestal C2. The marker is approximately 3m south of the sensor. An extra bulk sample was obtained on the north side of the sensor (just inside the sensor FOV) at the same time as the full snow survey. Data from the survey is archived locally and available upon request.

Because the Caribou Creek site is unmanned, daily snow depth measurements are not possible. However, a web camera has been set up at the site to take hourly photos of the instruments in the clearing. Hourly photos include at least one snow depth stake installed in the site clearing (Figure 11). Artificial lighting allows for decent quality photos over the entire day.



Figure 11: Snow stake #1, 2014-03-01, 17:49 (left) and 20:51 (right) LST

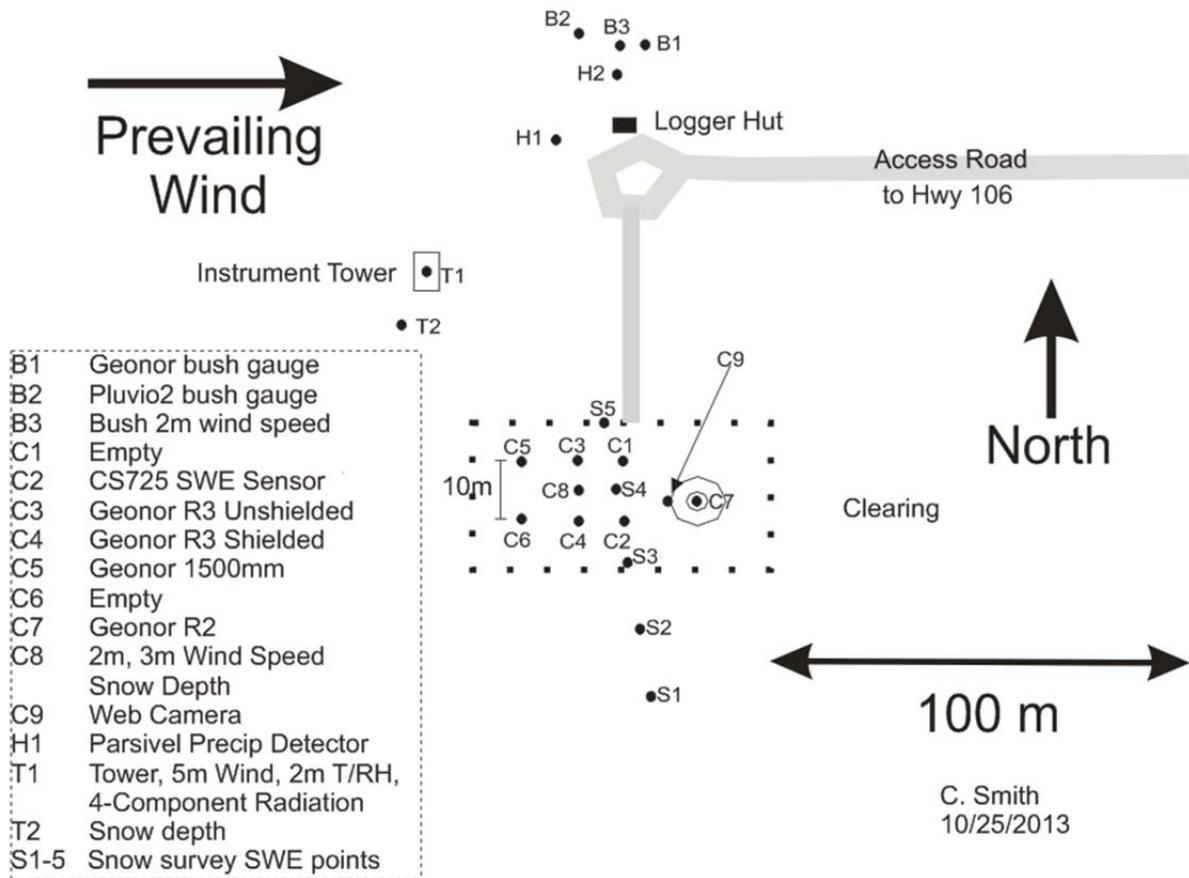


Figure 12: Site diagram for Caribou Creek. Snow survey stakes are marked S1-S5.

Weissfluhjoch

Daily manual measurements

The daily measurement program contains:

- New snow (on cm basis, also to be reported when zero). At least two measurements have to be done. The reported value corresponds to the mean value. Place the snow board on snow surface after measurement has been performed.
 - Special cases:
 - New snow on the plate is less than 0.5 cm: Report "0" and flag it with "traces"
 - No snowfall during the period, but snow accumulated on the plate: Report "0" and comment
 - Measured new snow on the plate does not correspond to the measurement on the field (automatic measurements, sticks, etc.): Report the measured value and comment (e.g. blowing snow event). For SWE, report the measured value. SoG and SWE are then corrected by SLF.
- SWE from new snow: Extract new snow from the board using a cylinder (1000 cm²) and a metal plate (see picture below).



Report the measurement in gram precision. Divide value by 100 and report it for SWE [mm]. Fill in the hole with snow after measurement. If new snow is higher than 30 cm, measure the SWE on site with a dedicated 55 cm cylinder.

- Snow height: with snow stake, reading the information from snow surface level
- Snow penetration resistance using Ram penetrometer: perform several measurements and report the mean value, do not consider outliers
- Observations:
 - Snow surface (whole measuring site)
 - Snowfall altitude range
 - Formation of cracks
 - Weather patterns/phenomena

Biweekly snow profile measurement

Two parallel profile lines are defined on the site. After profile measurement, place a stake ca. 25 cm away from the actual profile in the undisturbed direction of the profile line. Next profile will be done ca. 25 cm away from the stake in the same direction, so that the snow pack remains undisturbed over 50 cm. SWE will be done for each snow layer of the profile.