

Data description

Data description of the snow isotopic composition measurements from samples collected on the Weissfluhjoch between December 2017 and April 2021.

Contact: Yoann Sadowski (Data from 2020-2021) and Jürg Trachsel (data from 2017-2020)

yoann.sadowski@slf.ch

juerg.trachsel@slf.ch

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2 Weissfluhjoch measurement site

All the snow samples presented here have been collected at the Weissfluhjoch test site (WFJ). The test site is situated on a flat area at 2536 m. a. s. l. (46°49'47"N 9°48'33"E) (Marty and Meister, 2012). Mountain ridges approximately 100 m higher are situated on three sides of the WFJ. The remaining South-East aspect is part of the slope of the Weissfluhjoch peak, hereafter, Weissfluhjoch or WFJ refers to the test site and not the peak. A small hill situated in the South-East makes the site relatively wind-sheltered from all directions (Figure 1).

Long-term measurements have been conducted on the WFJ (Marty and Meister, 2012) and meteorological data are provided by (Weber, 2017; SLF, 2020). Among them, air temperature, snow surface temperature, snow height, and relative humidity are measured continuously by automatic stations. In addition, new snow and a second snow height measurement are taken manually every morning by an observer. Two sub-sites about 50 m apart were defined to account for variations due to different wind expositions. The wind-

sheltered site (WS) is protected from the wind due to the local topography. The wind-exposed site (WE) is situated on the small hill in the South-East and is more exposed to the wind (Doorschot et al., 2004). Figure 1 shows the position of the WE and WS sites.

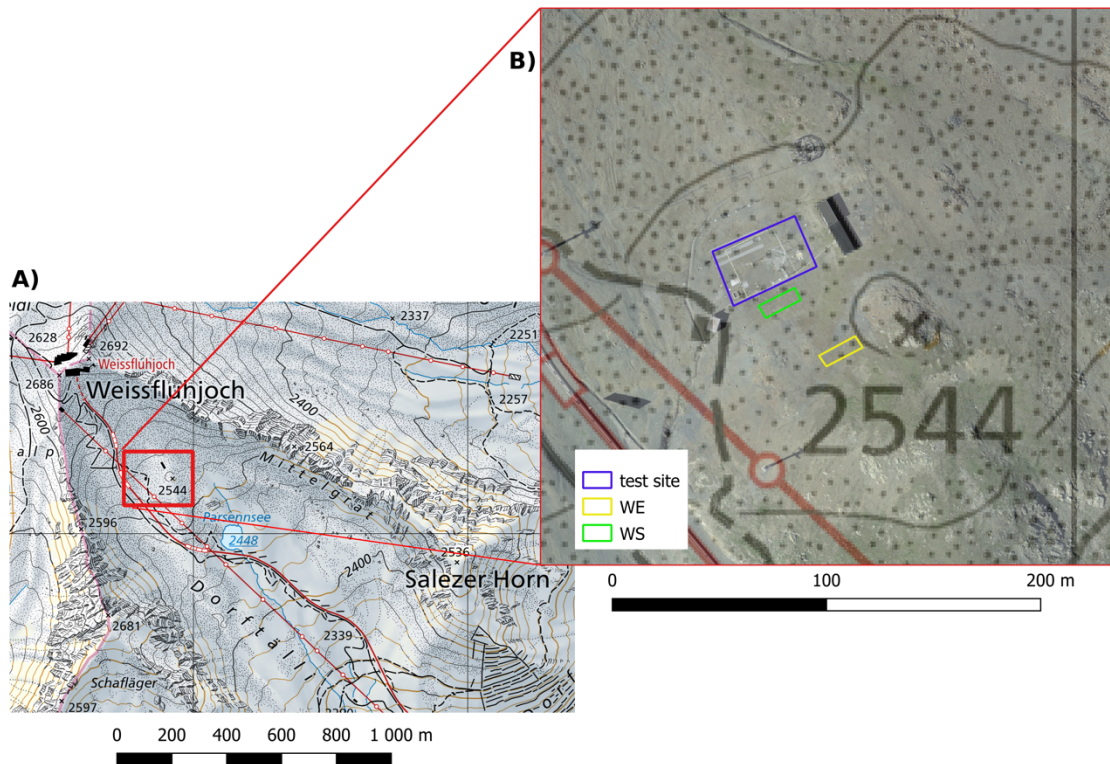


Figure 1: Location of the Weissfluhjoch (WJF) test site. A) Map of the Weissfluhjoch region above Davos, Switzerland. B) Inset, showing the WJF and the positions of the *wind-sheltered* (WS) and *wind-exposed* (WE) sites. Map and orthophoto from the Swiss Federal Office of Topography, Swisstopo (<http://map.geo.admin.ch/>)

3 Field campaigns

The different field campaigns are presented in this chapter. Different types of samples were collected during each campaign (the different types of samples are described in the section 4 of this document) and a summary is given in Table 1.

3.1 March 2021

The March 2021 field campaign ran for 10 days (23.03.2021 - 01.04.2021). This campaign aimed to observe the evolution of the snow during a fair-weather period and assess the effect of latent heat exchanges. Only a small snowfall (1 cm) occurred on 27.03.2021. The air temperature was below 0°C until 30.03.2021, but some melt (without percolation of water) occurred because of the strong short-wave radiation of that period. Samples were collected on the two sites: wind-exposed, and wind-sheltered as described above. The list below is valid for both sites.

- 2 cm surface samples were collected twice a day for 10 days (20 collection times, 60 samples per site).
- Mini-profiles were collected every 2 to 3 days (total of 5 profiles, 35 samples per site). The WE mini-profile from the 26.03.2021 was discarded because of an error during the analysis.

- Adaptative profiles were collected approximately every 3 days, at the same time as mini-profiles, except on the 28.03.2021 (total of 4 adaptative profiles on each site, 36 samples per site).
- Density was measured using a 100 cm³ snow density cutter at the same time as the sample collection. Density was measured 3 times at the surface, every 3.5 cm (snow density cutter height) for the mini-profile thickness (21 cm) and every 5 cm below and down to the bottom of the adaptative profile.
- New snow was collected once in the middle of the campaign on the morning following a snowfall of 1 cm (27.03.2021).
- As an additional note, a laser scanner was set on the WFJ and spanned the area between the two sites (WS and WE). This device allows to observe the spatio-temporal evolution of the snow surface and assess the differences between the 2 sites. (Please ask Dr. Benjamin Walter or Loïc Brouet from the SLF for scanner data and details)

3.2 December 2020

The December 2020 field campaign ran for 9 days (14.12.2020 - 22.12.2020). This campaign aimed at observing the evolution of the snow during a fair-weather period and assessing the effect of latent heat exchanges. No precipitation occurred until 21.12.2020 and snow temperature remained clearly below 0°C during that period. Samples were collected on two sites: wind-exposed, and wind-sheltered. The list below is valid for both sites.

- 2 cm surface samples were collected twice a day for 8.5 days (17 collection times, 51 samples per site).
- 1 cm surface samples were collected twice a day for 8 days (16 collection times, 48 samples per site).
- Mini profiles were collected every 2 days (total of 5 profiles, 35 samples per site).
- New snow was measured 7 times before the start of the campaign, on each morning following a visible snowfall (at least 1 cm) on the new-snow board. New snow was again collected on the last day of the campaign (22.12.2020).
- A camera was set on the WS site during part of the campaign. Due to technical problems, a long gap occurred in the middle of the campaign. This still allows observing important changes occurring at the surface.

3.3 January 2020

The January 2020 field campaign ran for 11 days (18.01.2020 - 29.01.2020). This campaign aimed at observing the evolution of the snow during a fair-weather period and assessing the effect of latent heat exchanges. Unfortunately, small snowfalls occurred at the beginning and end of the campaign. Those data can still be used as a representation of new snow. Samples were only collected on the wind-sheltered site.

- 2 cm surface samples were collected once a day for 12 days (12 collection times, 36 samples).
- One mini profile was collected at the start of the campaign (on the 18.01.2020, 7 samples).
- Vapour isotopic composition was measured, but the Picarro could not be calibrated. Only the post-processing correction to account for varying vapor mixing ratios can be

done. Details on the vapor isotopic composition measurement are given in (Trachsel, 2019).

3.4 Winter 2017

Samples were collected between December 2016 and June 2017 (at the test site). This was part of a larger field campaign. One of the main goals was to record frontal passages with the isotopic signal of an alpine snowpack and how post-depositional processes alter the precipitation signal (Aemisegger et al.). Details on this campaign are available in (Trachsel, 2019).

- 2 cm surface samples were collected approximately weekly (19 collection times, 57 samples between the 08.02.2017 and the 19.04.2017).
- Mini profiles collected approximately weekly (18 mini-profiles, 3 cm resolution, 143 samples between the 09.12.2017 and the 19.04.2017).
- Full profiles collected monthly (5 profiles collected between the 21.01.2017 and the 01.06.2017). Each full profile provide the isotopic profile of the entire snowpack, in total 108 samples with a resolution of 6 cm, and a manually observed snow profile (grain type, grain size, snow temperature, hand hardness).
- Density was measured together with each full profile (6 cm resolution)
- Vapour isotopic composition was measured from 03.02.2017 (with an interruption between 03.03.2017 and 12.03.2017. The Picarro was calibrated, and the signal was corrected for the variation in vapor mixing ratio. Details on the vapor isotopic composition measurement are given in (Trachsel, 2019).

4 Sample types

Details on the various types of samples collected during the different field campaigns and the isotopic analysis of the snow samples are given in this section.

4.1 Samples analysis

After collection, all the snow samples were rapidly transported in their closed container (50 ml pre-cleaned polypropylene tubes) to a -20°C cold room at the SLF (WSL-Institut für Schnee- und Lawinenforschung SLF, Davos, Switzerland). To prevent melt during transport, additional snow was put around the sample's bag in the backpack.

Before the isotopic analysis, the samples were completely melted in their closed 50 ml tubes. The resulting water was then mixed and transferred to vials suitable for isotopic composition analysis (1.5 ml glass vial closed by a cap with a septum). This procedure was done within 3 hours following the melt of the samples. The transfer was done using a micro-pipette, a facemask, and gloves to avoid contamination. The time when the water was in contact with the air was reduced as much as possible (less than 1 minute).

The isotopic composition measurements were done with two different analyzers: a Picarro WS-CRDS, L2130-I for the winter 2017 and part of the December 2020 samples, and an LGR Off-Axis Integrated Cavity Output Liquid Water Isotope Analyzer (LGR) for January 2020, March 2021, and part of the December 2020 samples.

4.2 Two centimeters surface samples

Two centimeters surface samples were collected in the 50 ml tubes (diameter of 3 cm). Due to the round shape of the tubes about 60% of the collected snow comes from the first cm of the

snowpack (28.8 % of the volume of the tube is empty, 28.8 % filled with snow between 1 and 2 cm and the remaining 42.4 % comes from the first centimeter). Three samples were collected each time and the distance between each replicate was about 50 cm.

4.3 One centimeter surface samples:

Collection of the uppermost cm of snow using a spatula with ledges (see Figure 2). The snow on the spatula was then transferred in 50 ml plastic tubes. Three samples were collected each time and the distance between each replicate was about 50 cm.



Figure 2: 1 cm surface snow collection with the spatula with ledges.

4.4 Mini profiles

Mini profiles of 20 cm thickness with a 3 cm resolution (7 samples) were collected. The top samples are corresponding to the 2 uppermost cm of the snowpack (same as the 2 cm surface samples). The collection was done using the 50 ml plastic tubes and a template allowing to place each tube relatively precisely (± 0.5 cm). The procedure is shown in Figure 3.

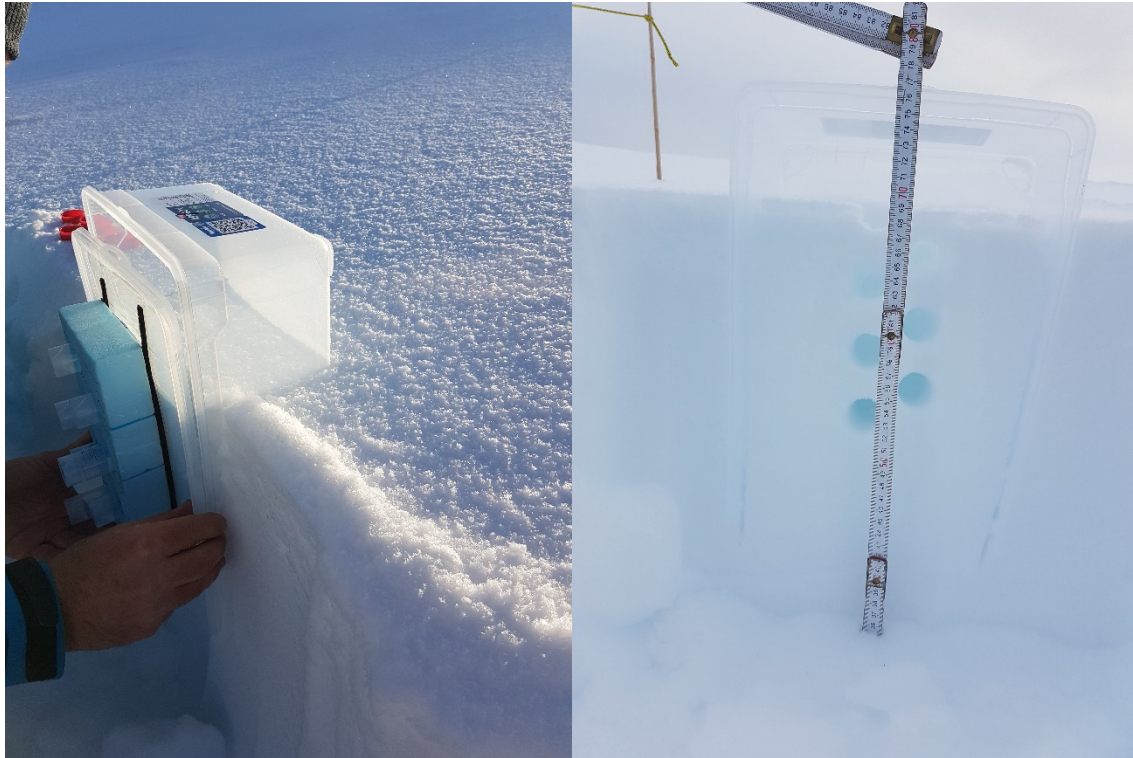


Figure 3: Pictures of the mini-profile template (left) and of the mini-profile after removal of the tubes (right).

4.5 Adaptive profiles

Adaptive profiles were collected in March 2021. They cover a larger depth and were collected with a different technique than the mini-profile. This sampling was done top-down by inserting a spatula at the targeted depth and pushing the tube vertically from above until the spatula was reached. Each adaptive profile was collected in 9 samples of the same thicknesses covering the snowpack between the surface and a recognizable layer, which could be identified throughout the whole March 2021 field campaign. On the WS site, this recognizable layer consisted of snow with very poor cohesion. It was located below the new snow, which was deposited between 14.03.2021 and 23.02.2021. Initially, this recognizable layer was located 80 cm below the snow surface, such that on 23.03.2021, the adaptive profile was conducted by sampling the upper 80 cm in 8 samples, hence each sample had a thickness of 10 cm. The ninth sample was collected below and contained the recognizable layer. Due to settling and compaction, the adaptive profiles thereafter were less thick. For example, on 26.03.2021, the thickness was 64 cm, which was collected in 8 samples of 8 cm thickness. On the WE site, we chose a very hard snow layer as a recognizable layer since the wind removed most of the snow with lower density. This hard layer was older than the one of the WS site and was initially located 60 cm below the snow surface.

4.6 Complete profiles

Five full profiles were collected in 2017 as part of a larger measurement campaign, including trace elements in snow measurements (Avak et al., 2019; Trachsel, 2019) and snow cover on the WFJ description (Calonne et al., 2020). Snow samples of 6 cm were collected vertically along the whole snow depth.

4.7 Vapour isotopic composition

Air vapor isotopic composition was measured on the WFJ between 03.02.2017 and 30.04.2020 with a Picarro. During winter 2017 (between 03.02.2017 and 05.07.2017) only, the Picarro was calibrated daily and corrected for the vapor mixing ratio. Details on the correction procedure can be found in (Aemisegger et al., 2012). Only raw data are available after 05.07.2017, and since no calibration was performed, only a correction for the vapor mixing ratio can be considered. The scripts for data processing and the correction (specific to this Picarro) of the vapor mixing ratio are provided in the dataset. However, for periods without calibrations, the usefulness of these data is very limited. The authors are happy to provide the raw data for periods after July 2017 upon request. Details on the vapor isotopic composition measurement set-up are given in (Trachsel, 2019).

4.8 New Snow

New snow was collected in December 2020 before the start of the December 2020 field campaign on each morning following a snowfall of at least 1 cm. The snow was collected directly on the new-snow board allowing to capture only fresh snow (less than 24 hours old). For relatively small snowfalls (<10 cm), the snow was directly collected in 50 ml plastic tubes that were pushed vertically until reaching the board. For large snowfalls (>10 cm), the snow was transferred to a sealed plastic bag using a metallic cylinder with a 6 cm diameter.

Table 1: Summary of the different campaigns

	2017 (January-June)	2020 January	2020 December	2021 March
Mini Profile	Test site, weekly	WS once at the start	WS + WE, every 2 days	WS + WE, every 2-3 days
Full profile	Test site, Monthly (5x)	-	-	-
Adaptative profile	-	-	-	WS + WE, every 3 days
2 cm Surface sample	Test site, weekly	WS, daily	WS + WE, 2x per day	WS + WE, 2x per day
1 cm surface profile	-	-	WS + WE, 2x per day	-
Vapour isotopic composition	Calibrated	Non-calibrated	-	-
Analysis	Picarro (PSI)	LGR (WSL central lab)	LGR (WSL central lab) and Picarro (SLF) (1)	LGR (WSL central lab)
(1) LGR (WSL central lab) for the WS mini profiles and surface samples between the 14.12.2020 and the 20.12.2020 and Picarro (SLF) for all the other samples.				

5 Reference

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