Reply to RC1 (Author Comment on essd-2021-68)

Thank you very much for the very valuable review of our manuscript. We address the questions, issues, suggestions, and remarks in the following point by point (response in blue).

Anonymous Referee #1

Referee comment on "Operational and experimental snow observation systems in the upper Rofental: data from 2017–2020" by Michael Warscher et al., Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2021-68-RC1, 2021

Review

The current manuscript draft on « Operational and experimental snow observation systems in the upper Rofental: data from 2017 - 2020" describes new weather and snow sensors installed and corresponding data collected in the Rofental catchment.

General comments:

Unfortunately, with the exception of the snow drift sensor, the authors miss the opportunity to introduce the new sensors in detail and to describe the applied data curation.

We added more technical specifications of the other new sensors, specifically the SPA, as this sensor is not as commonly used as the others. The unique double station setup at Bella Vista is extensively explained together with the snow drift sensor.

Moreover, the available data are sometimes carelessly interpreted without any critical plausibility assessment or references to other studies. The possibility of wrong measurements, especially regarding SPA and SGG, was not considered. If really no manual control measurements were performed during the three years, it should at least be mentioned and explained.

We significantly improved our data analyses in two cases, including the clarification of an issue that was brought up by Reviewer 2. For this we included an explanation for the source of error (snow bridging of the SSG). We now point to potential measurement errors and added a respective discussion (see below). On top of this we will add a respective remark to the respective PANGAEA data set.

Nevertheless, the new measurement infrastructure and the corresponding data are worth to be published as soon as the following points have been addressed:

- An overview is missing about what has already been documented in Paper I and what is now newly documented in this paper. Has anything been abandoned?

  We added an explanation in the revised manuscript. Besides the technical updates at the three stations presented here, the observation network exactly operates in the state described by Strasser et al. 2018. No monitoring devices or stations have been abandoned except the documented replacements.

- There is no information about any quality assurance or quality control procedures applied to the data. There is no information about the frequency data are downloaded and screened, if at all?

  All raw data are transferred via GSM network every 10 minutes to operational servers with automated backups. Screening is manual, but continuous. From the server, the data is annually downloaded, quality checked and corrected and then uploaded to the PANGAEA open access repository. We decided to perform only basic error filtering. We updated the manuscript accordingly and we will add an additional remark to the PANGAEA repository for the respective data sets.

- The snow drift sensor is explained and referenced in detail. In contrast, e.g. information and literature about the SPA and its measured quantities is missing entirely. For example, the difference in data series S1 and S2 listed in the data set is not explained at all.

  We added the lacking information about the data series S1 and S2, as well as existing literature on the device and a respective discussion about the SPA.

- Several times snow fall or snow accumulation is mentioned (e.g. L198-199) without including information of the concurrent precip data. For example, the case mentioned in L198-199 is contradicting the precip signal!

  While the signal is not contradicting (precipitation at Latschbloder is higher in Dec. 2019 and Feb. 2020 and more or less equal to the one at Proviantdepot in Nov. 2019 and Jan. 2020), we agree that this cannot explain the difference in SD alone, particularly in Nov. 2019. We also checked temperatures during the period (rain/snow) but it is well below 0 °C for both stations. We removed this misleading interpretation from the manuscript.

  Additionally, the case in L228-229 can't be true because the clearly negative temperatures demonstrate that the reason for the SWE increase can't be rain!

  While the temperatures are not constantly negative during the period we refer to, there is very little precipitation during that time, and a closer look indeed revealed that this cannot be the reason for SWE increase. As pointed out by you and Reviewer 2 the cause most probably is a measurement error by the SSG (building and later weakening of snow bridges). We added explanation to the manuscript.

- Finally, what was the precip for the case explained in L316-317?

  There was no precipitation during the presented time, and hence we added the sentence: "There was no precipitation recorded in that period (last precipitation measured on December 25) and air temperatures were constantly well below 0 °C."

- There are several situations where the pressure measured SWE is wrong. For example, see the described case in the paragraph above or the SWE increase and concurrent stable snow depth during the second half of March in Fig. 8. Please elaborate. I suggest to also check the plausibility of the calculated density as provided in 9b. The reason of the difference described in L246-247 is probably also a such wrong SWE measurement and not the difference in measurement location.

  This issue could also be explained by building and weakening of snow bridges when the isothermal front reaches the snow-ground boundary. We also agree that this could be a problem for the calculated density in Fig. 9b. However, we are pretty

sure that also the location of the device plays a role: please see the webcam images from June 1st and June 13th 2020 below (SPA and SSG in the background). The SSG measures 100 mm to 25 mm SWE during that time while the ground below the USH-9 (not visible here) is already snow-free. That said, we added a respective discussion and description about both these error sources to the manuscript and we also will add a remark to the data documentation in the PANGAEA repository.

Specific comments:

L34: Matiu et al. 2021

We corrected the reference year to 2021.

L55: Since the paper will not been published before summer 2021 I'd recommend to also include the winter season 2020/21.

Thank you for the suggestion. While this would be technically possible, we decided together with the data curators of PANGAEA to upload the data in annual chunks (calendar year) to keep the structure consistent, specifically for the continuation of the time series which will be uploaded to PANGAEA annually.

L63: (same special issue)?

We removed the statement, as we have no information yet if the manuscript could be added to the special issue of the preceding publication (Strasser et al. 2018).

L67: The Rofenache river

We added "river".

Fig. 1: Very bad map. Not even valleys or ridges are easy recognizable. Many geographical locations described in the text are missing in the map.

Thank you for the comment. We completely redesigned the map and added all relevant geographical locations.

L95: "..the existing weather stations..." how many? L96: "..at several locations.." What do you want to say?

We added the number of stations and changed the sentence which now reads: „ Since the reported state of the technical instruments in the catchment in Strasser et al. 2018, three of the eight existing weather stations have been extended and modified."

L113: 1.5 m does not make sense for high alpine AWS? What is the reason. Add the exact height above ground for each sensor Table 1-3. This is important for many applications. Moreover, it is in contradiction to the min/max height of 2 m written e.g. here: https://doi.pangaea.de/10.1594/PANGAEA.918096

Thank you for the comment and our apologies, this is a mistake. The instruments are all at +-2m height above the ground. 1.5 m is the height of the Pluvio constructions at the Bella Vista and Latschbloder sites which both sit on top of heavy rock boulders to be more elevated (see Fig. 2, top picture on the left and Fig. 3 in the background). We corrected the statement in the manuscript.

L123: 10 min mean values?

Depending on the variable, the logger writes 10 min. mean, max, or instantaneous values and transmits the data via GSM.

L124; I suggest to use HS instead of SD, because it is the official abbreviation.

Thanks for pointing this out, we now use HS instead of SD in the manuscript.

L126: ...by two European Avalanche...

We changed it to "… two…"

L134: Why do you mention Sommer SSG-2 and not also accordingly the same for the snow depth and snow temperature sensors?

Thank you, we removed „Sommer SSG-2" here to be consistent.

L136: The new instruments complement...

Corrected.

L142: .. installed at the main station

Added.

Fig2: The red arrow marks the main "exposed" AWSS. The blue...

Corrected.

L155: Why Sommer is mentioned for the SIR sensor, but not the SCA and the SPA-2 sensors? Be consistent!

We removed the manufacturer name "Sommer" in the text and only keep it in the Tables 1 – 3.

L163: time resolution, raw data , quality controlled?

We added the information about time resolution and quality control.

L164: I'd recommend to provide PDFs about the instruments used instead of manufacturer URLs, which can change any time.

Thank you for this suggestion! We already collected the PDFs about the instruments and will ask PANGAEA to provide them within the repository.

L171: time zone?

We added information about the time zone (UTC+1) to the manuscript.

L180: How do you manage to have enough power for heating?

The Bella Vista station has power supply from the "Schöne Aussicht Schutzhütte". At the Proviantdepot, there are four solar panels and two 72 Ah rechargeable battery packs installed. The heating device is only activated if air temperatures drop below 4 degrees C and if the signal of the USH-9 snow depth sensor is disturbed by falling precipitation. We added information to the manuscript (table captions). We also corrected an error in the manuscript text about this (Bella Vista and Proviantdepot have heated Pluviometers, Latschbloder is unheated).

L190: In 4.2.1, there is only snow depth described despite the SWE mentioned in the title.

We added a description of the presented SWE data.

Fig 7: Please provide the same figure for SWE.

We now provide the same figure for SWE in a panel plot.

L323: the technical details of the instruments are not all described!

We rephrased the sentence.

L324: It's hard to believe that no manual measurements were performed during the three years to check the plausibility and representativity of the automatic snow measurements?

We agree that manual measurements specifically for SWE would have been very desirable. However, as these stations – and particularly Proviantdepot - are only accessible via a helicopter during most of the winter time (access is limited due to avalanche risk), we did not perform them. Following your argumentation above, a series of manual SWE measurement would be necessary to get measurements of the critical moments in SWE development. Theoretically this would have been possible for Bella Vista, as this is the most accessible station, and we will consider this for the next winter season. However, there will still be no evidence for these critical cases at the other stations.

L335: Can you tell anything about funding?

Funding is a collective effort and already mentioned in the acknowledgements.

Table 1: EE08 instead of E08.

Corrected.

Is the air temperature ventilated?

Yes, air temperature is ventilated, and we added this to the manuscript.

Is the radiation sensor ventilated?

Yes, the radiation sensor is ventilated, and we added this to the manuscript.

What is the source of the given accuracy? It should rather be given in percentage.

The given accuracies are the ones provided by the sensor manufacturers as stated in the table caption.

Table4: The calculated snow drift values are wrong!

This seems to be a misunderstanding: the snow drift values were not calculated from the snow depth or SWE differences but measured by the snow drift sensor and converted to snow depth equivalents using an assumed density of 100 kg/m^3 (as explained in the manuscript). This was done to facilitate a comparison to the difference values for precipitation, snow depth, and SWE during that time period. The equivalent calculation was done for all measurements (italic numbers show equivalent values using the density assumption). This table, however, seems to be misleading, hence we replaced it with an explanation of the values in the text.