Reply to RC2 (Author Comment on essd-2021-68)

First of all, we would like to thank you for your thoughtful review of our manuscript and your very valuable suggestions and comments. We answer your questions and address your remarks in the following (response in blue).

Anonymous Referee #2

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-RC2, 2021

1 General comments

Warscher et al. present a data set of non-standard measurements of snow properties together with meteorological variables at three alpine stations in the Austrian Alps.

However, the unique part (i.e. non-standard measurements at three sites) of the dataset is only available for the beginning of this year and partially for the 2019/2020 snow season. I do not see that this short period is particularly useful compared to other published multi-year datasets (e.g., Morin et al., 2012; Ménard et al., 2019). Therefore, I suggest rejecting the manuscript at this stage and waiting a few more years until more data are available.

We agree that the three years (and in some parts even less) of data are still a comparably short period of time and do not represent a long-term climatological or snow-hydrological dataset. The aim of the manuscript, however, is to follow the principles of the ESSD 'living data process' (https://www.earth-system-science-data.net/living_data_process.html) of continuous data documentation and to describe and document the state of the measurement network including the new and innovative sensor techniques. Furthermore, the newly installed sensors allow for addressing research questions intensely discussed at present (e.g., the quantification of snow drift using the innovative snow drift sensor at Station Bella Vista; this process representing the origin of massive lee-side snow loads which triggered a deathly avalanche in December 2019). Hence, our intention is to present our techniques, data and results to the scientific community as soon as possible. The station network in its current state will be maintained and further continue to record data in the described setting and we will continue to upload the data to the Pangaea repository.

In addition to the short time frame, I also agree with the first reviewer that the data quality checking is unclear and that conclusions from the data are sometimes incorrect (which I will show in the next section).

(we will address these issues below)

In addition, I would like to point out that data gaps are a major problem with this dataset. These three issues should be considered before submitting a new manuscript in a few years.

Thank you for this comment. It is true that there are gaps in the dataset. The presented stations are located at very remote and exposed high-alpine locations, two of them only accessible by helicopter during most of the winter time. We permanently do our best to maintain the systems and keep everything running, however logger failures can occur and cannot always be fixed immediately. We decided not to apply gap filling methods, but provide the raw data with only some basic error filtering. If and how the gaps should and can be filled is depending on the application and should be decided by the respective user. Users report us that the measurements are still very valuable despite the existing data gaps.

2 Specific comments

2.1 Short time period

I can identify useful and unique parts of this data set, but in too short a time period. These are the spatial distribution (three measurements) in a high alpine environment, with non-standard snow measurements such as SWE from different gauges, liquid and solid fractions of snow, snow temperatures, and snowdrift sensors combined with standard measurements such as snow depth, precipitation, and meteorological variables. However, there is only one complete snow season (2019/20) in which more than one SWE measurement is available, but at leasot one of those is exposed to wind erosion, and the usefulness of this location will not become apparent until the start of the 2020/21 winter season, when a nearby wind-sheltered station was established. Similarly, the non-standard drift sensor and Snow Pack Analyzer (SPA) measurements are not available before early 2020. Therefore, I don't see much use for this data set described here. However, I can very well imagine one developing in a few years.

While we agree that the data presented here does not represent a long time series by now, we still think it is useful to publish the sensor and station setups including first time series now as the dataset is growing at the Pangaea repository (please see comment above). On the long run, the presented dataset will be part of a long and continuous period of snow and climate observations in the Rofental, following the 'living data process' (https://www.earth-system-science-data.net/living_data_process.html) of ESSD.

2.2 Data quality example and quality checks

Since this dataset is not standard and prone to errors, I propose to address typical measurement errors and possible automatic quality check routines in a next manuscript version.

We generally agree that automatic quality checks are useful, however, we decided to screen the data for obvious logger or sensor failures (and automatically correct them) and leave the remaining data as raw as possible (e.g., no data gap filling, no aggregation, no correction of unclear errors, etc.). This approach allows the scientific community to use and correct the data using methods fitting the respective purpose. Concerning the SWE measurements we now point to the possible errors you address below. A comprehensive comparison of the various automatic quality check routines to be applied to our Rofental data will be content of a dedicated scientific paper.

Here I would like to describe an erroneous SWE measurement that has already been identified by reviewer 1 as a misinterpretation by the authors. In lines 225ff, the authors described the stage at which the snowpack at Latschbloder becomes isothermal (Figure 8) and explained the subsequent SWE values. This is a typical time when pressure sensors measuring SWE exhibit errors (Johnson and Schaefer, 2002). I do not claim to provide the correct interpretation, but the authors certainly missed something.

This description should serve as an example of how future quality control can be designed or how errors in the data set can be described in a future manuscript, especially when more instances of redundant SWE measurements will be available (SPA and snow scale).

The authors claim snowmelt starting at midnight on 11 April 2020, explaining the loss of SWE of ~110 mm in less than 18 hours. It is questionable whether this is melt, as air temperatures were well below 0 °C and the snow depth sensor only indicated a constant decrease similar to the days before and after.

It appears to be more a measurement error which is typical when the isothermal front reaches the snow-ground boundary as described by Johnson and Schaefer (2002), which was detected based on the snow temperature measurements two days earlier. A decrease in SWE could be explained by snow shear strength being able to bridge the sensor (Johnson and Marks, 2004), which could happen when meltwater near the ground refreezes. The authors describe the later increase in SWE as rain percolating into the snow. However, reviewer 1 correctly pointed out the negative air temperatures during this time (colder than -5 °C). In addition, the rain gauge measured only <3 mm of precipitation, while the SWE sensor increases by more than 150 mm during the same period through April 18. This discrepancy cannot be explained by undercatch of the rain gauge, especially since the snow depth sensor shows the same continuous decrease as in the days before, without any indication of a major snowfall. Thus, it seems more likely that the previously mentioned snow bridges have been continuously weakened as snow temperatures are around the melting temperature. Future availability of redundant SWE data, snow depths, air and snow temperatures will provide more examples in a few years from which the authors can select examples of faulty and good situations. The methods of Johnson and Marks (2004) or others may be included to tag poor quality data.

Thank you very much for revealing our misinterpretation here and please see also our answer to Reviewer 1 regarding this issue. We fully agree with your findings and the most probable explanation for the erroneous measurements (formation and weakening of snow bridges). We removed our interpretation attempt from the manuscript and added the suggested literature (Johnson and Schaefer 2002, Johnson and Marks 2004, as well as Egli et al. 2009) to the manuscript and discuss the sources of measurement errors and the reliability of the instrument in general. We will additionally tag the data and add a respective remark to the PANGAEA repository.

2.3 Data gaps

The use of this dataset is also limited due to data gaps, which is partially visible in Figure 5. For example, for Bella Vista in 2018, over 33% of all data are missing with gap sizes of 49, 27, 20, ... days. Precipitation is missing 75% of the time, with another gap of 199 days. In 2019, this station typically has 7% data gaps, wind over 11%, with gap sizes of 12, 7, 3, <1 days. Such multi-day data gaps are difficult to fill.

Yes, there was a major problem with the logger at the Bella Vista in 2018 (and 2017). However, this holds true for Bella Vista only, not at all for the other two stations. The problem at Bella Vista station is fixed, as you can see in the data from 2019. We are not sure what you mean by the statement "typically 7%" data gaps: depending on your calculation or variable or something else? You are right, these data gaps are difficult to fill, however, unfortunately they are to be expected at hard to access alpine stations at nearly 3000 m a.s.l. (e.g., our snow pillow at Bella Vista is the highest one all over the European Alps to our knowledge). We still think these time series are very useful for many scientific applications (see also comment above on data gaps), and we are confirmed by many of our data users.

2.4 Other

- A measurement height of 1.50 m does not seem sufficient in alpine terrain. Please provide the exact height for each sensor in the tables. Please provide time periods when a sensor is buried or consider larger masts (if possible).

Unfortunately, this was a mistake (see also answer to Reviewer 1): 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 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. The sensors were not buried within the presented time period.

- Literature describing the quality of the snow pack analyzer should be added. For example, Staehli et al. (2004) and Egli et al. (2009).

Thank you for the suggestion, we added the references to the respective section. We additionally added a section in the text about the performance of the SPA.

- The fact that each year and station is in individual files makes it difficult to use the data. Please consider consolidating the data into one or a few file(s) as much as possible.

We considered this option as well as other different consolidation and/or splitting strategies (hydrological, glaciological, etc. year). We also discussed this issue with the data curators at PANGAEA. We followed the advice of PANGAEA and decided on one file per station per year. This way we can continuously add data to PANGAEA without having to “override” the unique DOIs of a data set.

References

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