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Interactive comment on "Evaluating continuous and autonomous snow water equivalent measurements by a cosmic ray sensor on a Swiss glacier" *by* Rebecca Gugerli et al.

Anonymous Referee #2

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This paper evaluates the snow accumulation on the Plaine Morte glacier by means of a buried cosmic-ray neutron probe (CRNS) and an approach based on the scaling of the precipitation records of nearby meteorological stations. The accuracy of the field data is assessed by the propagation of possible error sources. Together with the combined approach using different types of field data, this gives important insights into the evolution of the snow pack on the glacier.

The language of the paper is appropiate, as are the figures and tables. Partly, the paper would benefit from considering a geographically broader view on the state-of-the-art as many references focus on Switzerland.

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In principle, the paper is suitable for publication in this journal. In particular, the added value of the paper lies in applying a buried CRNS together with other measurements for continuously monitoring the snow accumulation of a mountain glacier. However, prior to further consideration for publication, the following two major concerns need to be addressed carefully:

(1) The story line of the paper needs to be clarified. The title and the final conclusions do not match well with the analysis made. Furthermore, the second part of the analysis is not (yet) connected to the rest of the paper. One could think of some logical links between the two parts, but it is important to state this more clearly, and to frame the rest of the paper accordingly. In addition, it would help the reader if the novelity would be more prounced in the abstract and the conclusions. (2) While the error propagation of the snow depth, snow density and the meteorological measurements is reasonable and covers all important sources of uncertainty, this is not the case for the CRNS data. Most notably, the instrument's precision is most likely largely overestimated. Furthermore, a decrease of the error with increasing SWE is highly unlikely with mostl likely the opposite behaviour being the case. Currently, only the uncertainty of the neutron count rate is considered, and a constant error is added despite the high non-linearity of the signal. The latter is probably the reason why the relative accuracy seems to increase with higher snow accumulation values. The statistical error of neutron count rate itself is an important element of measurement uncertainty, but it refers to uncorrected variations only. The uncorrected count rate includes variations not only of the accumulated SWE but also variations of incoming neutrons, atmospheric pressure, and in amtospheric moisture. An error propagation should thus include the uncertainty of (1) the neutron count uncertainty as already done, (2) the uncertainty of the measurements used for the corrections (Jungfraujoch neutron monitor data, atmospheric pressure, atmospheric moisture), (3) the uncertainty in the parameterisation of the correction functions (e.g., the value for the attenuation lenght, which may vary in space and time), and (4) the uncertainty in the (not well documented) empirical function relating neutron counts to SWE. In total, from figure 2 the error seems to be rather in the

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range of 10 to 20 % (and thus around ten times larger than estimated in the paper!), with an increasing trend for high SWE values. Also the comparison with the manual measurements (figure 3) shows that the SWE from CRNS is mostly only toughing the uncertainty bands of the manual measurements, while is partly entirely off. With the current focus of the paper the lack of a proper error propagation of the CRNS data constitutes a severe issue, as the evaluation and the precision of the CRNS are stated prominently in the title and conclusions.

Still, it is interesting to see the application of CRNS for glacier monitoring and I agree with the authors that it constitutes a very promising technique for continuous accumulation meaurements on glaciers. Existing uncertainties should, however, be kept in mind instead of propagating an unrealistically high precision of the SWE estimate.

I believe there are two equally legitimate strategies on how the authors could address this. One is a true and rigerous error propagation with regard to all relevant uncertainty sources of the CRNS SWE estimate. Another could lie in drawing the readers's attention to the fact, that the uncertainty range could be substantially (up to ten times) larger, combinded with reframing the paper towards the application rather than the error propagation.

Minor specific remarks:

Page 3 / Line 33-34: Check the sentence ("..define three different scaling factors, one for...“?).

Page 4/ Line 2: It would be helpful when the elevation of the glacier and the sourrounding mountain peaks would be added here.

Page 5/ Line 18: Can you add a few key facts on how the gridded products is produced. Does it contain station data? If so, how reliable is it when the nearby stations have data gaps?

Page 6/ Table 2: Think of readers that are not familar with the Swiss coordinate system.

I'd recommend converting the station coordinates into a globally used system like UTM or WGS84 (lat/lon). In any case, add also the EPSG-code of the coordinate system.

Page 7 / Line 1: The reliability of the CRNS is one of the objectives, thus could cannot be claimed beforehand.

Page 23 / Line 2: the effect is related to SWE not to density.

Page 23 / Line 8: Here, too much confidence is set into CRNS.

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