# Interactive comment on “Intercomparison of snow density measurements: bias, precision and spatial resolution” by M. Proksch et al.

**Anonymous Referee #2**

Received and published: 23 September 2015

General Comments:
This paper compared the different snow density measurement methods with substantial experimental data (lab and field). It does not only clearly list the overestimation and underestimation of different results, but also explain the reasons of the difference in detail. The precise measurement of snow density is very important to understand the snow physical processes and few studies have focused on comparing the different methods before. This paper will be a very good reference to further investigate snow density measurement.
The paper is well written and is recommended to publish. Below are some minor revisions.

We highly appreciate the valuable comments by Referee #2, which will help to improve the manuscript.

Please find our answers to the comments below in blue, *and the text changed in the manuscript in green*

Specific Comments:
3583-5: Parametrization of snow properties such as…… are lined to density. Snow mechanics is significantly related to snow density, which should not be ignored [Schneebeli and Johnson, 1998; Wang and Baker, 2013]

We agree and extended the following sentence:
*P3583, l.4ff: The biological and photochemical activities of snow are related to snow density (Domine et al., 2008). Further, snow mechanical parameters are linked to density, (Schneebeli and Johnson, 1998; Wang and Baker, 2013) and the snowpack stability depends on vertical density variations (Schweizer et al., 2011).*

3585-15: A stragraphic layer is a certain stratum with similar properties in snow layer. It is better to list several properties used to define a stragraphic layer. Is there any special calibration method to define the layer in the field?

We agree and added the relevant layer properties in brackets:
*P3585, l.17ff.: A stratigraphic layer is a certain stratum with similar properties (e.g. microstructure, density, snow hardness, liquid water content, snow temperature, impurities) in the snowpack as defined in Fierz et al. (2009)*

An objective calibration method to define a layer in the field cannot exist, as the determination of layer is subject to each field observer. However, the standard procedure for observers to define a layer (which is not a calibration method) is given in Fierz, 2009.

3586-10: For Gaussian filter used in CT measurement, how to define support and sigma, how do those parameters influence the measurement?

The Gaussian filter is used to smooth the image in order to get rid of noise before segmentation. The values of support and sigma are chosen by a trained operator, and are in line with the values used in other studies, e.g. Kerbrat, 2008. These parameters were kept constant for all measurements.

However, Hagnmuller2014 showed that for sigma in the range [0, 20] µm, density varies in the range [-8, +2]% with respect to the value obtained without smoothing (sigma = 0). Details of the CT processing will be provided in separate article, see also comment below.

3589-10: Different samples size was set with different scan resolution. The different resolution will influence the measured ice volume to some extent. Could you explain how the difference of 18 um and 10 um affect or not affect the results?

The resolution was sufficiently small in both cases that no significant influence on the measured densities has to be expected. This is supported by the fact that the variation for the different CT densities is very small (see error bars in figure 2).
In this paper, we focused just on the mean of the measurements – an in-depth analysis of the CT measured parameters with respect to scan resolution, segmentation, filtering, ect is planned as separate paper, which will be presented as well within this special section.

3589-25: The field measurement has any temperature record during the sample collection? It will be good to compare with lab measurements temperature (-10 OC) and also be useful to analyze the different density results among different methods.

The temperature range of the snow in the field was [-14; 0] °C. Snow temperature has no influence on gravimetric measurements.

3610-figure2: The figure is not very straightforward. What does the length of red line and blue line represent? Could you explain more about those details of the graph?

The red and blue lines are error bars indicating +- one standard deviation for the box cutter (red) and CT (blue) measurements. This is explained in the caption of the figure: "Error bars are +- one standard deviation, resulting from the three cutter measurements (red) and the three CT samples per block (blue)."

References:

Hagenmuller, P.: Modélisation du comportement mécanique de la neige à partir d'images microtomographiques, PHD Thesis, *University of Grenoble,* **2014**

Kerbrat, M.; Pinzer, B.; Huthwelker, T.; Gäggeler, H. W.; Ammann, M. & Schneebeli, M. Measuring the specific surface area of snow with X-ray tomography and gas adsorption: comparison and implications for surface smoothness *Atmospheric Chemistry and Physics,* **2008***, 8*, 1261-1275