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Interactive comment on "Annual Greenland accumulation rates (2009–2012) from airborne Snow Radar" *by* L. S. Koenig et al.

Anonymous Referee #1

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Note: I am writing to clarify my comments regarding the uncertainty calculation detailed in my review (Anonymous Referee #1, 16 Jan 2016).

The description of the uncertainty calculation in my initial review was too simplified because I did not account for the fact that the depth errors are dependent on density in an inverse sense. Essentially, if the density is too high, the depth measured will be less, partly reducing the error from the $\pm$12% density error, which means the minimum error of 15% that I originally stated is too large.

That being said, after properly accounting for the depth's dependence on density and including the other independent sources of error, a minimum error of around 12% is found. This value is still larger than the maximum error of 11% stated in the text. Therefore, either some details are missing that should be clarified or the uncertainties

should be re-calculated. See below for my approximation of the measurement errors.

First, a simple density model was generated to visibly match the profile displayed in Figure 2 using the Herron and Langway steady state densification model, which is shown in this comment as Figure C1. To estimate errors, the bin size (in two-way travel time) for the 2012 Greenland survey was determined by downloading one of the files from the NSIDC and was found to be 1.70200113552302e-10s; I was not sure how much this changed in different survey years, so if they are different, it should be discussed in the text or just noted. Using that bin size and the density model, the depth-density error in the accumulation rate measurement can be determined for a density uncertainty of $\pm$12%. The plot below shows the error from the depth-density, age, and layer picking under various accumulation scenarios (0 – 2.5 m w.e.). Because the accumulation uncertainty from density is minimized by an inverse change in depth, the uncertainty from density –depth is reduced to $\sim$9% (blue line, Figure C2).

The uncertainty from age is constant for every accumulation scenario, and is $\sim$8.3% (1 mo / 12 mo; red line, Figure C2). Finally, the layer picking scheme was assigned an uncertainty of $\pm$ 3 bins, which means the percent error will largely change based on the accumulation rate (green line, Figure C2). More accumulation means the error is largely reduced < 1%, but the error grows rapidly as the accumulation rates decrease, and it becomes the dominant error at accumulations less than 0.25 m w.e.. Assuming these three sources of error are independent, the combined uncertainty is shown in black, suggesting the minimum error is $\sim$12%, but at low accumulation rates it can become quite large. The radar-measured accumulation rates appear in the paper as low (or even lower than) 0.18 m w.e., which based on the errors shown in the plot below corresponds to an error of $\sim$17%.

The calculations presented are based on my understanding of the error analysis, so it is entirely possible that I might have misunderstood the text as presented. Therefore, if that is the case, please try to clarify the error analysis, so it can be reproduced by others. A plot like Figure 2C would be a welcome addition.

Interactive comment on The Cryosphere Discuss., 9, 6697, 2015.

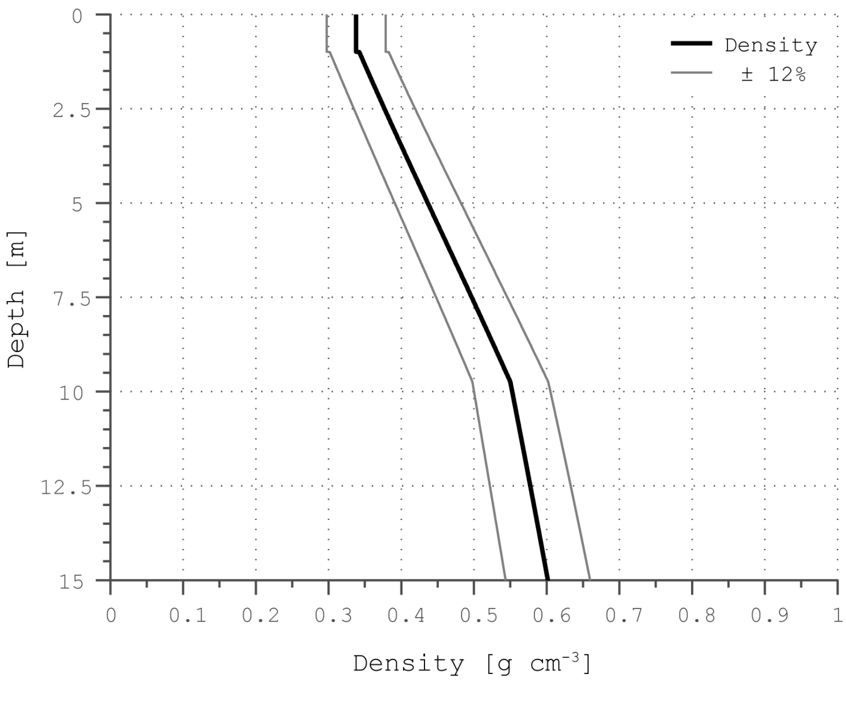

Fig. 1. Figure C1. Approximation of the density profile shown in Figure 2 of Koenig et al. (2016), based on the Herron and Langway (1980) empirical model of densification. The upper 1 m was set 0.338 g cm-3

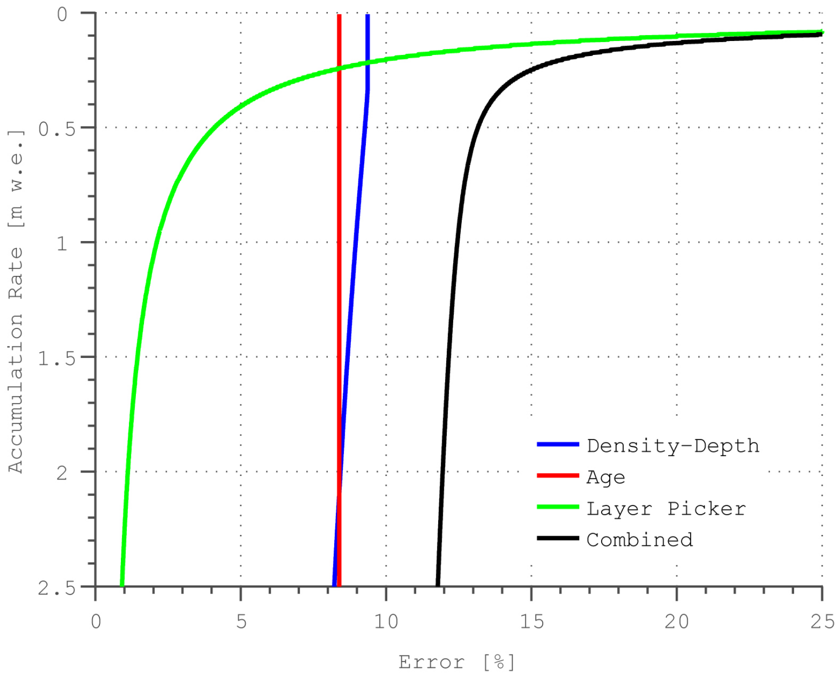

Fig. 2. Figure C2. Independent sources of error and their combination in accumulation measurements for a range of accumulation rates based on the density model presented above in Figure 1C.