Interactive comment on "Bulk density and its connection to other microphysical properties of snow as observed in Southern Finland" *by* Jussi Tiira et al.

Anonymous Referee #1

Received and published: 26 June 2016

Overall it is an interesting and potentially useful paper. However, I feel that some significant revisions are needed.

General comments

1. I am concerned about adequacy of the discussion about the relation between snow depth and bulk density of falling snowflakes. The bulk density as given by (8) assumes some snowflake shape (a spheroidal shape in this case). Such snowflakes cannot be stored at the ground compactly (without air volumes between them. These internal air volumes would increase the snow depth on the ground. Snow compression on the ground might counteract this to a certain extent but the total effect is not known. Due to this I do not think the rho(t) in (9) and rho(t) in (10) are exactly the same quantities.

This issue needs clarification.

2. The bulk density which is sought in this study represents the whole PSD: rho=rho(Do). In many previous studies, starting probably from Magono and Nakamura (1965), the bulk density was understood as the density of an individual snowflake defined as the ratio of the individual particle mass, which has a size D, to its volume: rho=rho(D) (for example to the spheroidal volume as this is the shape used in your study too). It causes a confusion. The Brandes et al. (2007) paper, for example, compares bulk densities from two different definitions in their table 2 and Fig. 6a. However, rho(D) is not the same as rho(Do), they are different parameters. I suggest that you clearly state different definitions of bulk densities used previously to minimize confusion for potential readers.

3. What are uncertainties of estimating bulk density and the coefficients in m-D relation? Some discussion is needed here.

4. You estimated coefficients am and bm in the m-D relation assuming the exponential distribution and just one value of bv=0.217. According to the data in Figs. 5-6, bv changes relatively widely from 0.208 to 0.256. How this variability in bv would change the derived coefficients in the m-D relations? Also what is influence of variations in the mu factor?

Specific comments.

1. Section 3.1: It appears that you model particles as oblate spheroids. Please provide some discussion to justify this model.

2. Equations (4)-(7) are obtained assuming integration from 0 to infinity. In reality there is not only truncation due to particle maximum size, but also due to the smallest considered size being 0.2 mm (not zero) as shown in the last line of page 5. Can you estimate errors due to realistic integration limits?

3. Equations (8) and (9): again why the lower integration limit is 0 (not 0.2 mm)?

4. Equations (17)-(18): put the integration limits. What would be the effect of using the non-truncated integral as given by (19) instead of smaller values which the truncation and non-zero lower limit provide.

5. How changing the assumption of the aspect ratio (currently 0.6) would change your lines in Fig. 9?

Technical corrections/comments

1. I suggest indicating in the title and introduction that you are deriving the density of FALLING snow. I tend to believe that the density of falling snow and the density of snow on the ground are different (see the general comment 1.

2. Page 3, Line 11: Indicate here which "couple of days" from Table 1 were used in this study.

3. Page 11, line 6: the subscript "m" should be at the "b" level not at "D".

4. The citation to Matrosov 2007 from Table 3 and Fig. 9 is not in the reference list.

5. Page 9, line 22: Is it "all the cases" from Table 1?

6. Add units for density in Figures 7, 10 and 12.

—————————————————————