Review of: Intercomparison of snowfall estimates derived from the CloudSat Cloud Profiling Radar and the ground based weather radar network over Sweden

Scientific significance 3
Scientific quality 2
Presentation quality 2

General comments:

The authors compare two data sources of snowfall, a parameter notoriously difficult to measure with any instrument. The intercomparison shows encouraging agreement. In general, I am happy with the selected parameters (POD, FAR, HR, KSS and pdfs), the conclusions are based on results, and the amount of data is larger than in many other projects due to use of several years and several radars.

I see the weaknesses of this paper in description - and perhaps even preprocessing – of the data used, its uncertainties, and in setting the work in context. In my opinion this is an important weakness because the paper otherwise is lacks novelty compared to e.g Cao 2014, unless the differences in datasets are clearly defined, as the concepts, ideas and tools are largely the same.

Also I see a weakness in proofreading. With several authors from different institutions, the team has somehow forgotten to check that the different paragraphs match, that the same issues (as blind zone) is not explained over and over again and that all methods used are documented somewhere. Example of this is the weak link between Figs 3 and 4 and the describing text.

In introduction, properties of ground-based radars and CloudSat are compared to gauges. I would like to see a short paragraph about other satellite missions, especially NASA's Global Precipitation Measurement GPM, but it would not harm to comment the products of geostationary satellites either.

As you comment in conclusions (P8177 L24) major source of uncertainty in ground-based weather radar estimates is the selection of Z-S equation. <<Quote: Our preliminary comparison of snowfall distributions employing various ZS relationships shows that there exists a large room for improvements of Swerad relationship has been one of the chronic problems, often discussed widely in the scientific community.>> But I can not find in other parts of paper anything about this "preliminary comparison" You do not even mention which Z-S equation(s) you used to process the Swerad data here, and why. . The only one mentioned in the paper is Z=aR**B with a=200 and b=1.5, very near but not equal to what Marshall and Palmer (1948) used for rain (b=1.6), in context of correcting the radar data with gauges. So, please, describe what ZS equation was used, how it was selected, and speculate of effect of selection of this equation to your results.

The issue is indeed "discussed widely in scientific community", as an example there is a nice overview of these in Rasmussen et al (2003) *Snow Nowcasting Using a Real-Time Correlation of Radar Reflectivity with Snow Gauge Accumulation* in JAMC. If you have used the is Z=aR**B with a=200 and b=1.5, compare it to the values given by Rasmussen et al.

Using pixel-to-pixel comparisons and long time series has provided the authors with plenty of data points. However the allowed disparity in time (15 min) and place (2 km) are not balanced in my eyes. If a precipitation system moves 60 km/h, it moves 15 km in 15 minutes. Grouping to rings with different

radius helps somewhat, but I think the spacing of rings (15 km) is quite small. I would like to see this uncertainty discussed more than the comment P8167 L 7 “this is likely to introduce some uncertainty”.

The authors do not compare their approach or results to similar intercomparison studies, or other validation of the same instruments. An interesting reference would be the paper by Cao et al (2014), using Nexrad/NMQ as a reference. I think there should also be available some reference to the overall performance of the Swedish radar network as compared to gauges. .

Specific comments:

P859 L16: connection between timely information of snowfall and agricultural industries remains unclear to me.

P861. Please clarify “insensitive to vertical location of the precipitation system?” Do you mean that if there is overhanging precipitation (virga, snow evaporates before reaching surface) satellite considers it as real snowfall ? Or are you talking about ground-based radars overshooting shallow precipitation? You mention several times that CloudSat can also miss shallow snowfall that forms in its blind zone, so none of the data sources is insensitive to vertical location of the precipitation system in my eyes.

P8163 L16.”enhanced sensitivity of C-band” might be an useful remark to American readers. In Europe, there are no S-band radars in snow region anyways, and the benefit of sensitivity difference can be overrun by beam overshooting (at distance where it would be important, the radar beam may already be above the precipitation layer). Also note that S-band typically uses 3x as high transmit power to compensate for their lack of sensitivity. You come back to this on P8176 where the “Swerad’s decreased sensitivity for increasing distances” is “mainly” the reason for differences. It is actually possible to calculate at what distance the sensitivity becomes an issue, if you know the sensitivity (MDS) of the radar, and the used ZS equation. Different combinations which I tried quickly give values between 80 and 250 km.

P8163 L25: For clarity, add “The <u>Swedish</u> radar measure… “ – this is no universal property of all the radars in the world.

P8163 L 26: You write about “minimum reflectivity” being below -30 and its upper limit increasing. An established term is Minimum detectable signal MDS, which is defined at range of 1 km and then increasing with range. See Doviak & Zrnic p. 60 and chapter 6.

P8165 . You earlier mentioned the gauge network is not dense enough, here it is used for correction of radar data with no remarks. Is it a source of uncertainty? Can you find an estimate of how much the original radar values are changed with this adjustment?

P8165 L 10. Vertical profile or reflectivity is, in addition to partial or complete overshooting, also effected by microphysical properties of the snowfall process: hydrometeor in upper parts of cloud are smaller and grow as they fall (consuming cloud drops which are invisible in radar).

P8165 L10 You mention the height of the radar beam growing with distance, but not the width of the beam. At long distances (say 250 km) the beam may be 5- 6 km wide, so the nominal resolution of 2x2 km on Nordrad data may be artificial. I know this is an issue in edges of the network and at sea areas,

but is the Swerad network really so dense you don't need to care ? You could calculate this with the maximum distance from radar you use (>199 km) and Swedish beam width (0.9 degrees).

P8167 There is no discussion of Figure 3.

P8167 L18 / Figure 4. "In addition to the ECDF for all distances, Fig. 4 shows the corresponding functions for the various range bins defined in Sect 2.3.". I do not see the ECDF for all distances, and it is not fully clear for me how you defined several ECDFs for CloudSat. And I can't see them either, apart from first few millimeters, as the Swerad-ECDFs are drawn on top of them. To me it looks like you have 11 lines for radar and 5 lines for satellite.

P8168 L20 "This suggests that either Swerad overestimates the snowfall rate for large reflectivities" …which may be result of bright band contamination, or poorly selected ZS equation, or what do you think? Please speculate different possible reasons for such overestimation (knowing that Swerad data has been corrected with gauges).

Technical corrections:

P8163. In my understanding even the radars owned by the military are part of "Swedish radar network" (SWERAD, a collaboration between SMHI, FMV and the Swedish Armed Forces which was established in the 1980s to ensure the operation of Sweden's weather radar network). See https://www.defencetalk.com/saab-modernizes-swedish-weather-radar-network-42851/ is this old knowledge ?

P8164 Estonian EMHI is now EtEA Estonian Environment Agency (EtEA)

P8167 line 1 Range bins, would more naturally be range rings to me.

P8168 (and elsewhere) Hanssen–Kuipers skill scores are, according to Wilks' (Statistical Methods in the Atmospheric Sciences)and Jolliffe's recent textbooks, more correctly caller Peirce skill Scores. I think this is becoming a standard in meteorological world.

P8176 L26. Change order of words to make sure you do not mean the clutter is detected by ground-based radars.