

***Interactive comment on* “The accuracy of weather radar in heavy rain: a comparative study for Denmark, the Netherlands, Finland and Sweden” by Marc Schleiss et al.**

Anonymous Referee #2

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This paper compares the accuracy of weather radar rainfall using data from different countries (Denmark, Netherlands, Finland and Sweden). The study focuses on the top 50 heavy rainfall events which are more relevant for urban hydrology. The results showed that 1) radar underestimates rainfall rates; 2) radar products with higher spatial/temporal resolutions agree better with observations; 3) the combination of radar measurements from overlapping radars can improve rainfall rates. Although the results are interesting for the scientific community, there are a number of issues that the authors need to address before the paper is accepted for publication:

1) Raingauge data quality. The raingauge measurements used to validate the radar

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observations come from different operational agencies. It is obvious that the quality of the gauge measurements is not going to be the same among the different agencies and therefore this could impact your results. There is no discussion about this in the paper.

2) Raingauge network density (Fig 1). It seems that the gauge network density is playing an important role in your results and there is little discussion on this. For Denmark the gauges are mainly clustered in a particular area (around 40-60km from radar site), for Finland the gauges are further away (beyond 50km) and cover different radars, for Sweden I can only see 4-5 gauges, whereas for the Netherlands all the gauges are more or less evenly distributed between 0-100km in range from the radar sites. This again will have important consequences in your results. For instance, VPR corrections will be important at far ranges. Attenuation due to heavy rain will also play a role. I will expect the radar rainfall error to increase with range and so the results will be better (or worse) depending on the location of the raingauge network.

3) Radar data quality. Every operational agency applies different corrections to the radar data. These corrections are extremely important and can help to explain some of the results. However, there is very little detail in the paper on the actual processing steps performed by each operational agency. Some corrections are discussed, but what about corrections for attenuation, VPR, partial beam blockage, etc for some of the countries. How do you ensure that the radar data have good data quality in both rain/no rain conditions? How does the operational agencies monitor the calibration of their radars (I do not mean comparisons with raingauge observations)? Do the bias corrections include the same (or some) of the gauges that you used for your validation? If so, what are the implications? I think this section deserves a more detailed summary.

4) The radars have different spatial/temporal resolutions. This is obviously a challenge when comparing the accuracy across different operational agencies. Would not be better to accumulate to the same spatial/temporal resolution (e.g. 2x2km, 15min) in order to have a fair assessment of the results? It seems to me that the different spatial

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resolutions have important implications in your comparisons.

5) The use of ARF can help to explain the discrepancies, but I suggest to compare with the method proposed by Ciach and Krajewski (1999) which actually uses the spatial correlation of the rainfall field within the radar grid resolution to separate (or explain) the variance due to the fact that gauges represent a point whereas radar rainfall is an areal measurement from the total variance (see also Bringi et al, 2011).

6) Although the focus of heavy rainfall is important, what about the accuracy of radar rainfall for more conventional events (implications of the different corrections for radar errors) or in no rain conditions (e.g. implications of using robust clutter schemes, etc)? Are the results still consistent with those observed during heavy rainfall?

Other comments:

Fig 1. x/y labels? is that lat/lon?

Line 80. There is a reference that it is worth to look at related to the impact of spatial/temporal resolution in hydrodynamic modelling (Ochoa-Rodriguez et al, 2015).

Line 155. A lot of statements not justified: "Erroneous echoes and non-meteorological targets are removed using four different techniques. The algorithm used for correcting the vertical profile of reflectivity (VPR) is the same as in the operational product."

Line 160. "BRDC"?

Fig 5. did you accumulate to 1h? or it is 5min,15min ...and so on?

Table 2. can you include more radar specs? e.g. beamwidth, scanning rate, radome type, pulse width, etc that can affect the measurements.

Line 420. "The total accumulated rainfall amounts per event (i.e., 10-30 mm) were lower though, suggesting that the events sampled by the X-band system were rather short and localized." For x-band radars, sometimes the radar signal might be lost due to attenuation in heavy rain and without signal there is no way to apply any correction. Is

this the reason for the lower rainfall amounts? i think signal lost due to rain attenuation at X-band has to be carefully taken in to account.

References

Bringi, et al., 2011. Rainfall estimation with an operational polarimetric C-band radar in the United Kingdom: comparison with a gauge network and error analysis. *Journal of Hydrometeorology*, 12(5), pp.935-954.

Ciach, G. J., and W. F. Krajewski, 1999: On the estimation of radar rainfall error variance. *Adv. Water Resour.*, 22, 585–595.

Ochoa-Rodriguez, S., et al. 2015. Impact of spatial and temporal resolution of rainfall inputs on urban hydrodynamic modelling outputs: A multi-catchment investigation. *Journal of Hydrology*, 531, pp.389-407.

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