

AC:

- The title could be specified by using the expression "weather radar". This manuscript exclusively addresses weather radar measurements, but volcanic clouds are also measured using other non-weather radar systems. The latter systems not necessarily produce the radar observables listed here. This distinction between weather (scanning) radars and other non-weather (profiling) radars should be clear also throughout the introduction. A good review on the observation of volcanic ash clouds using (any) radar system is given by Hort and Scharff (Hort, M. & Scharff, L.; Detection of Airborne Volcanic Ash Using Radar; In Book: Volcanic Ash; 2016; doi: 10.1016/b978-0-08-100405-0.00013-6)
- We have edited title and abstract to include 'weather' radars. The distinction is also made now in multiple places in the introduction and conclusions.
- L12: higher frequency microwave radars (K-band and higher) that observe volcanic activity do already exist. However, they may not operate in scanning mode. Please specify again: weather radar
- The following line has been added: 'Even though higher frequency microwave weather radars (K-band and higher) have been used to observe volcanic activity, they may not operate in scanning mode.' (L12-13).
- L22-25: again this describes scanning radars. Profiling radars will have a much better temporal and even spatial resolution, but only in one single direction.

This has been corrected to specify that we are talking about scanning weather radars. (L27)

- L38: Another observation of volcanic activity using dual-polarization weather radar was done in New Zealand (Crouch, J. F.; Pardo, N. & Miller, C. A.; Dual polarisation C-band weather radar imagery of the 6 August 2012 Te Maari Eruption, Mount Tongariro, New Zealand; 2014; doi: 10.1016/j.jvolgeores.2014.05.003)
- The eruption details have been added. (L44-45).
- L42: volcanic particles can have any size near the vent. Their size will decrease with the distance from the vent. The formulation used in the manuscript is correct ("particle sizes are smaller than raindrops especially far from the vent"), but it must also be clear that this assumption becomes invalid near the vent.
- The following lines have been added: 'Volcanic particles can have any size near the vent, but the ash particle sizes far away from the vent are smaller than raindrops. This means that frequencies higher than those used in weather radars have possible benefits while monitoring and measuring volcanic ash concentrations.' L48-51.
- L62-63: the listing could be extended by the paper by Scharff et al (2012) mentioned above. With this reference you would acknowledge the old model without explicitly mentioning it.
- The paper has been added. L71.

- L115-119: neglecting attenuation due to water vapor in the atmosphere might be feasible, but water vapor is highly abundant in the eruption cloud. Is it considered there? Effects of volcanic SO₂ can be neglected at common radar-relevant frequencies but may become more important in higher frequency radars. Please mention up to what frequency this assumption is valid.
- We haven't considered water vapour within the cloud. We agree that it is highly abundant in the eruption cloud. The reason behind not including water vapour was because we envisage the attenuation within the eruption cloud especially early in the eruption to be dominated by the larger ash particles. SynRad is to be complemented with a new stand-alone package/module which includes attenuation due to all gases (in the atmosphere and within the cloud) but the result of this work is reserved for a follow-on paper.
- We haven't done a quantification of the attenuation due to SO₂ currently. But with the new package we should be able to quantify this. Currently we agree that water vapour will have the dominant effect with respect to attenuation and SO₂ can be neglected at least up to the W-band.

- L125: When polarization is included in the future, do you also reevaluate assumption 1 on the sphericity on particles?
- Yes, the assumptions would need to be re-evaluated. We would need to do a sensitivity study to investigate the importance of the different individual parameters for the polarimetric variables. Hopefully this might reveal dependencies that could be used to simplify relations or validate assumptions. We would need to look at the variability in density, shape and settling properties, especially of ice.

- L168-179: This paragraph does not make clear whether a one-way or two-way attenuation is calculated. From the formulation it appears as if only the attenuation from the radar to each cell is calculated.
- This was an error in the manuscript but done correctly in the code. The exponential in equation 8 has been corrected to $\exp(2 \int_0^r \kappa dr)$. Additionally, a line has been added after equation 6 to clarify that L^2 is two-way path attenuation. (L155)

- L214: what is "m"? This parameter appears before its explanation in line 219.
- The explanation has been moved forward to L224.

- L337-339: Please elaborate more on the way the ATHAM VMIs are calculated. To me the difference in calculation to SynRad did not become clear enough. This leads to follow-up questions in paragraphs that include comparisons between the two VMIs (e.g. in L427). What do you expect to see from ATHAM VMIs in comparison to SynRad VMIs. Is it simply the inclusion/absence of attenuation?
- Exactly. The difference is simply the attenuation. This has been clarified with the following sentences: 'The ATHAM VMIs are calculated at each grid point and hence do not include any effects of attenuation. In essence, the difference between the

ATHAM and SynRad values for both VMI and echotops will be due to the attenuation experienced by the radar signal in SynRad.' (L352-354).

- L407-408: I do not understand this sentence. Could you please rewrite it. I suggest at least exchanging "at odds" with the more common "in contradiction to".

Changed to 'in contradiction to'.L423.

- L410: Isn't it a combination of range, particle size and concentration that lead to a return signal lower than the MDS?
- Indeed. I have changed this to 'due to the range and the fact that we tend to have lesser concentrations of fine (smaller in size) ash at these distances'. L426.

- L430-431: This application is not shown here. Please rephrase.
- Rephrased to highlight that this is the work of a follow-up paper. L448-449.

Other notable technical corrections:

L380: the color bar does not include white (no attenuation due to absence of cloud). see also Figure 8

All non-cloudy grid points are set as NaN which is why color bar does not include white to denote absence of clouds.

Figure 8: please indicate the vertical exaggeration in the caption.

I am not sure I understand what this comment means, especially 'the vertical exaggeration'. Could you please clarify?

L401-403: Something appears wrong with this sentence. You may split this into two sentences for easier reading.

Edited. L415-417.