Comment on amt-2021-225

Anonymous Referee #1

Referee comment on "Analytic characterization of random errors in spectral dual-polarized cloud radar observations" by Alexander Myagkov and Davide Ori, Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-225-RC1, 2021

Variational radar retrieval methods are becoming popular for solving inverse problems in cloud physics using multiparameter observations that combine multi-frequency and polarimetric radar measurements. The methods are computationally expensive and critically dependent on the adequate description of the covariance matrices characterizing the errors attributed to the imperfections in the forward operators and the statistical errors of the radar measurements. The parameters of the covariance matrices are often selected subjectively while ignoring the fact that some commonly used radar variables such as dual-wavelength ratio DWR or differential reflectivity Z_{DR} (and their spectral representations) are essentially nonlinear and their measurement errors can be considered gaussian only if they are quite small.

The authors address this problem by constructing a different set of variables (labeled as the vector **b** as opposed to the traditional vector **c**) that allows "for a proper analytic treatment of their error covariance matrix". They also make generalization to the case of the covariance error matrices with nonzero nondiagonal elements. It is shown that the theoretical expressions for the error covariance matrix with respect to the vector **b** are in better agreement with their estimations from the real radar data than the ones with respect to the vector **c** as demonstrated by the comparison of Figs. 8 and 9 in the manuscript.

I do believe that this study raises an important issue and is a step in the right direction although I personally do not foresee wide utilization of the variational retrieval methods for practical applications in the near future due to their complexity. I do not have any specific comments and suggestions mainly because the manuscript contains plenty of mathematical derivations that are quite difficult to follow and check, and a reader has to trust the authors regarding their validity. I am not even sure that the paper is a good fit for the AMT journal. It may be more suitable for Journal of the Atmospheric Sciences but this is, of course, for the editor to decide.