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Atmospheric Measurement Techniques Discussions

Interactive comment on "Error analyses of a multistatic meteor radar system to obtain a 3-dimensional spatial resolution distribution" *by* Wei Zhong et al.

Anonymous Referee #1

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Error analyses of a multistatic meteor radar system to obtain a 3-dimensional spatial resolution distribution

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The manuscript presents a theoretical error analysis for statistical multistatic radar systems. Such radars have been known and have been used since decades, but are fairly new for scientific data of meteors and mesosphere/lower thermosphere winds. The basic concept and the related technical details are well-described in textbooks about radar theory. The manuscript shows the algebraic solution of the error propagation considering the uncertainties of the angle of arrival and the sampling or pulse width.

This study is entirely driven by the theoretical aspect on these errors, which might affect the wind retrievals. The authors don't show observations or data. The content of the paper is suitable for a publication at AMT. A proper error propagation is of high relevance and should always been part of a scientific analysis. However, these details presented in the manuscript are often not described in publications.

The reviewer has a few comments that are worth to be included in a revised version.

Major concern:

The reviewer had difficulties to follow some part of the error propagation due to the various introduced coordinate systems denoted as prime without prime and so forth. This made the manuscript very hard to read and one gets easily lost. Although there are some schematics outlining the coordinate systems the reviewer was not able to follow what actually is shown in Figure 5-7. The reviewer was not able to understand the plots reading the figure caption or the corresponding passage in the text. So please describe the color bars in the text or in the caption what they actually mean. The reviewer understands that the authors intended to keep things as general as possible, but some units or quantitative expressions are helpful. In particular, section 2 after line 140 is very hard to read and to follow. This is also partly the case as the Figures are only found at the end of manuscript and one has always to scroll forth and back.

Error budget:

Another important point that should be discussed is that the algebraic errors are just one source that plays a role. The authors should mention in the discussion that there are other error sources as well, originating from the scattering itself or from the experimental set up due to a potential mutual antenna coupling or other obstacles in the surrounding. The later one introduces further biases in the measurements as the angle of arrivals can be significantly altered. Usually HFSS simulation are required to investigate actually the limits of trustworthiness for the interferometry. Furthermore, the authors should mention in the discussion that the scattering occurs not really at a singular point. The radio wave is bounced back from at least a few Fresnel zones of several kilometer length along the trajectory, which is actually most relevant for the altitude resolution as the radar signal is scattered from an extended volume (1D) and, thus, probes a volume.

Error budget spatial sampling and wind retrieval aspects:

It is also worth to mention and discuss the issues of the sampling volume in the context of the trustworthiness of the interferometry. The schematic in Figure 2 provides a nice example of a multistatic geometry resulting in a less good measurement response compared to a monostatic radar of the same measurement volume, although the set up appears to have a multistatic geometry. The measurement response provides a measure of how well a bragg vector can be inverted to still derive reliable wind speeds (u,v,w). Ideally, all three variables can be estimated with similar measurement response, otherwise biases in one of the wind components are not avoidable. The receiver array in Figure 2 defines the sampling volume. Meteors below a certain elevation angle have to be excluded from the analysis due to the mutual antenna coupling or other ground obstacles causing issues in the interferometry. Further, it is obvious that the angular diversity of the three links inside the remaining sampling volume is less diverse (all are located in a certain sector relative to the receiver) than a monostatic radar and could systematic bias the wind retrievals. This is the nature of the forward scatter ellipse. As all three forward scatter ellipses have the receiver site in the one of their foci points and the bragg vectors always points towards a point along the distance vector between Rx and Tx. It is further obvious that the longer the total path Rt+Rx becomes the less spatial diversity these vectors have, or with other words – all three links start to see the same geometry as it would be the case for a monostatic radar. However, building three receiver sites and using one transmitter would increase the sampling volume and if well-distributed compensates some of this sampling effect on the wind analysis (at least partially), but still has a less good measurement response compared to a monostatic system. I suggest that they add in Figure 5-8 a line or

shading area indicating the angular limit of the receiver/transmitter array by using a truncation elevation angle of about maybe 30°. The actual limit depends on the array set up.

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