Atmos. Meas. Tech. Discuss., 6, C2839–C2843, 2013
www.atmos-meas-tech-discuss.net/6/C2839/2013/

Atmospheric Measurement Techniques
Discussions

Interactive comment on “Characterization of disdrometer uncertainties and impacts on estimates of snowfall rate and radar reflectivity” *by* N. B. Wood et al.

N. B. Wood et al.

norman.wood@ssec.wisc.edu

Received and published: 9 October 2013

Thank you for the comments and suggestions. Below, we’ve reproduced those comments and provided our responses.

General) I am (weakly) disappointed with one fact: every time when I thought that it now becomes really interesting I was consoled with a potential forthcoming work. This criticism applies to the investigation of the uncertainity of the mass density relationship ... and the errors that are induced with the assumption of Rayleigh scattering.... I acknowledge that you might want to treat those errors in a forthcoming article, but then

I do not really understand how relevant that your results are in terms of the uncertainty of the radar reflectivity, since, from my feeling and my experience, these two error sources will significantly change the uncertainty values that are published in the current study.

Thanks, we appreciate this comment but had to omit this other material for several reasons. Regarding the uncertainties in the mass density relationship, the work presented here prepares for a retrieval that estimates the mass-dimension relationship parameters using observations including the near-Rayleigh radar reflectivity and snowfall rate. The retrieval results also provide the estimates of the uncertainties in the parameters. The assessments presented here of forward model uncertainties are required a priori for that retrieval. Although in the Introduction, we describe the use of these observations to estimate snow microphysical properties, we would clarify this in the passage you referenced. For the uncertainties due to the Rayleigh scattering assumption, including the methods and results for that work would have substantially increased the length of this paper, and departed from the focus on disdrometer uncertainties.

1. (page 6334, line 18): through instrument -> through the instrument

Thanks. this will be corrected.

2. (page 6341, line 3-5): "Since the models use solid ice and liquid water densities and dielectric parameters, these are not expected to be significant sources of uncertainty and are neglected..." -> I do not fully agree with this statement, at least not without further justification. The dielectric constant of ice is not that well known, and a wealth of models exist that try to empirically describe it. Depending on the model you use, the error you incorporate might be quite large. In addition, the dielectric constant exhibits a temperature dependence. Can you simply ignore it?

At microwave frequencies, the value of |K_i|ˆ2 is driven by the real part of the refractive index. Warren and Brandt (2009) provide estimates of the uncertainties in ice refractive index at 266 K (their figures 8 and 9), based on comparisons between two earlier studies (see refs in Warren and Brandt). From their graphical presentation, the discrepancy in the real part of the refractive index between the two studies appears to be no larger than about one part in 200 at X-band. The temperature dependence of the real part is also weak at X-band. A formula provided by Mätzler (2006) suggests that the real part varies by less than one part in 200 from 243 K to 273 K. These uncertainties would contribute negligibly to uncertainties in Ze, given the assumption of Rayleigh scattering by spheres used in this work.

We'd suggest inserting a statement justifying our neglect of ice dielectric parameter uncertainties in the first paragraph of section 4.1.

3. (page 6340, line 9): "These errors may consist of both systematic biases and random components. Once recognized biases have been corrected, the residual uncertainties are characterized by a covariance matrix S_e." -> I have not fully understood how you deal with biases. Where and how do you correct these recognized biases?

Referring to equation (14), there are two types of forward-model error, the model formulation error (delta F), and the forward model parameter error. For the forward model formulation errors (delta F), errors arise from the discretized and truncated size distributions reported by the SVI (and by any other disdrometer with finite sampling limits that reports discrete PSDs). To evaluate these errors, we compute synthetic observations of reflectivity and snowfall rate using more complete size distributions (from the 2DVD), then compare those against synthetic observations computed using the discrete, truncated 2DVD size distributions. Bias is evaluated simply as the mean difference between these two sets of synthetic observations. We evaluate the biases for different values of the parameter “b”, then correct the discrete-truncated observations for the biases and compute the error variances and covariances to obtain the values shown in Tables 2 and 3.

We'd suggest that we add a statement briefly explaining the bias evaluation at the end of the second paragraph of section 4.2.

For the forward model parameter errors, we have included uncertainties in the measured size distributions arising from analytic and sampling errors, in the measured fallspeeds, and in phi. For the fallspeeds, an apparent bias is corrected by applying a filter consistent with a prior study, as described on pages 6345 and 6346. For the size distribution parameters, the analytic and sampling error are expected to be unbiased, and the discretization-truncation bias is handled as a forward model formulation error. For phi, lacking higher quality assessments of its value, we treat it as unbiased.

4.: I have also not fully understood if your errors need to fulfill certain criteria: Do they need to be Gaussian distributed or is this irrelevant?

No, definitions of expectation and variance/covariance and the methods used for error propagation in the Appendix do not require assumptions that the errors be distributed as Gaussians. Some applications that use these results may require that the errors be distributed in a particular form (i.e., solution techniques for inverse problems may assume Gaussian error statistics), but that assumption is not needed for these uncertainty assessments. The Gaussian assumption is applied only in the construction of Figure 3, which is used to compare these forward model uncertainties against estimates of observational uncertainties.

We would add a comment near the beginning of the second paragraph of section 5 explaining that, while the uncertainty estimates do not require assumptions about the shape of their distributions, we have applied a Gaussian assumption here in order to illustrate and compare the uncertainties.

References:

Mätzler, C., 2006, Microwave dielectric properties of ice, in Thermal Microwave Radiation: Applications for Remote Sensing, edited by C. Mätzler, P. W. Rosenkranz, A. Battaglia, and J. P. Wigneron. IET Electromagnetic Waves Series, 52, Institute of Engineering and Technology, Stevenage, UK.

Warren, S. G., and R. E. Brandt, 2009, Optical constants of ice from the ultraviolet to the microwave: A revised compilation. J. Geophys. Res., 113, D14220, doi:10.1029/2007JD009744.

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 6329, 2013.