Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2018-27-RC1, 2018

Atmospheric Measurement Techniques Discussions

Interactive comment on "Fast time response measurements of particle size distributions in the 3–60 nm size range with the Nucleation Mode Aerosol Size Spectrometer" *by* Christina Williamson et al.

Anonymous Referee #1

Received and published: 6 March 2018

This is an excellent paper. It nicely discusses the design of the NMASS in the context of prior work, as well as essential technical aspects of the NMASS design, function, calibration, and data inversion. It also compares measurements of the NMASS with those from an SMPS, which provides better resolution in size (but not time), and illustrates results that can be obtained with the NMASS when used on a research aircraft. The paper is also very well written. I feel it should be published with only minor editorial corrections and revisions.

Suggestions, to be included at the discretion of the authors (not essential):

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Discussion paper

1. p. 4, lines 3-5. The authors might consider mention of Winkler's DMA train among the fast-time response instruments for measuring nanoparticle size distributions (Pichelstorfer et al. 2018). Due to its higher sensitivity to number concentrations and lower weight and power requirements, the NMASS is more suitable for use on aircraft. However, the DMA train is a new development that has its place and might be mentioned.

2. p. 8, figure caption. The authors cite the Airmodus PSM (Vanhanen et al., 2011) as an instrument that uses a working fluid other than n-butanol (diethylene glycol) and a two-stage CPC detector. These aspects of the Airmodus instrument are based on the earlier work of Iida et al. (2009), who identified diethylene glycol as a suitable condensing fluid for sub 3 nm particles and pioneered the use of a butanol CPC "booster" as a second stage detector for the small droplets on which diethylene glycol had condensed. The authors should consider citing Iida's contributions as well. Iida et al. (2009) also experimentally studied differences in activation efficiencies for positively and negatively charged sub 3-nm particles. This may be pertinent to your discussion on p. 11.

3. p. 15: Although it may be obvious to those who have worked with CPCs, you might point out the reason that the counting efficiency for CPC5 decreases with decreasing size below 7 nm.

4. pages 19 & 21. The paper indicates that the method used in section 4.1 was used to invert both the NMASS and SMPS data. The discussion is mercifully concise, but I am still curious about several points:

-Are the data from the two NMASS instruments merged prior to inversion, or are the data merged separately and the inverted distributions merged after inversion? It is not entirely obvious to me which approach would be preferable, and the paper provides no insight. Systematic differences between the instruments that could lead to large errors in concentration differences between adjacent channels might argue in favor of separate inversions, but constraining a single inversion with more data points might argue in favor of merging the data before inversion. A sentence or two would suffice.

-Standard SMPS inversion methods (e.g., TSI's AIM software as well as software used by most aerosol scientists) would lead to accurate results for mean size and concentration for aerosols sampled from a DMA, (Figs. 9 & 10). However, the size distributions provided by those methods would be broader than the measured size distributions. This is because the distributions delivered by the DMA are broad relative to the transfer function of the DMA in the SMPS. I believe the modified Twomey technique that was used in this analysis should not suffer from that problem, but too few details are given for me to be certain. Nevertheless, if the DMA in Fig. 9 was operating properly, the size distribution of the sampled aerosol would be exactly equal to the DMA transfer function times the size distribution of the aerosol from the atomiser. It would be interesting to see this theoretical size distribution on Fig. 10 as well. If it agreed well with the blue dashed line, it would provide further support for the validity of your inversion algorithm. (Most aerosol scientists who have worked extensively with data inversion -I am certainly among them- are skeptical about the results.)

Minor Editorial Changes:

p. 7 line 14: missing ")." following Hanson et al., 2002) p. 11, line 9: and mostly limited to the smallest... p. 13 line 14: Should this be Fig. 5, not Fig. 6? p. 16, caption to Fig 7: "smallest cut-off sizes by." ??? p. 27, line 9: "for all but one channel"

Iida, K., M. R. Stolzenburg and P. H. McMurry (2009). "Effect of Working Fluid on Sub-2 nm Particle Detection with a Laminar Flow Ultrafine Condensation Particle Counter." Aerosol Science and Technology 43(1): 81-96. Pichelstorfer, L., D. Stolzenburg, J. Ortega, T. Karl, H. Kokkola, A. Laakso, K. Lehtinen, J. N. Smith, P. H. McMurry and P. M. Winkler (2018). "Resolving nanoparticle growth mechanisms from size and time dependent growth rate analysis." Atmospheric Chemistry & Physics 18: 1307-1323. doi: 10.5194/acp-18-1307-2018.

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