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Atmospheric Measurement Techniques Discussions

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Interactive comment on "New In Situ Aerosol Hyperspectral Optical Measurements over 300–700 nm, Part 1: Spectral Aerosol Extinction (SpEx) Instrument Field Validation during the KORUS-OC cruise" *by* Carolyn E. Jordan et al.

Anonymous Referee #3

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This manuscript describes spectrally resolved aerosol extinction measurements taken with a White-type optical cell during KORUS-OC campaign during the summer of 2016. The performance of the system was evaluated by comparison to the sum of scattering and absorption measurements done with commercially available instruments. Perhaps the most significant issue discussed in this manuscript is the pitfall in using the extinction Angstrom exponent (EAE) to describe the spectral dependence of optical properties. The authors compare and discuss the advantages of alternatively using a 2D parameter space (namely, the two first fitting parameters of a 2nd order polynomial fit).

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I recommend this manuscript be published after addressing the following comments. General comments: 1) The title of the manuscript does not seem to describe the main topic I understood it. From the title, it would seem that the field validation is the main topic while to me it seemed almost the trivial part. There is no mention in the title of the fact that the instrument was used to compare and discuss the advantages of an alternative to the EAE. 2) I believe that the manuscript could be much better organized. The text often refer the reader to plots not in the order of their appearance and to several plots at the same line. This makes it a bit less readable and difficult to follow the story. 3) The use of the 2D parameter space as an alternative to EAE (i.e. to derive information on the aerosol size distribution) is discussed only in the context of the data presented here. I believe it would strengthen the manuscript to add a more general discussion, perhaps with the aid of simulated data. 4) The reason for the large errors in fitting an EAE to spectral data, namely "larger" particles is not mentioned (aside from one sentence towards the end of the manuscript, line 417-418). The curvature aspect of the log-log data can be easily explained in terms of Mie theory for light extinction by spherical particles. The classical Qext Vs size parameter curve shows smooth increase behavior for "small" size parameters while it wiggles over "larger" size parameters due to Mie resonances. "larger" size parameters mean larger particles and/or shorter wavelengths. It is these wiggles (due to Mie resonances) that cause the apparent deviation from power law behavior. The larger the particles (and/or shorter the wavelength) the more wiggles fit into the measured spectral window and more orders are needed for a reasonable fit using a polynomial. This means that the smaller the mode diameter and the smaller the sd of the aerosols size distribution the more likely the measured log-log spectrum will be adequately represented with a linear (1st order polynomial) fit. 5) My impression was that there is a fair amount of text and some figures that are not essential to deliver the main message. removing them (maybe to the supplementary material) would some room for more needed discussion. 6) A few simple simulations that I did showed inverse (almost) linear relationship between a2 and a1. This manuscript shows a positive (almost) linear relationship (note the inverted x-axis in figures 9 and 10. I could be mistaken but I suggest the authors take a second look to check this issue. Specific comments: Line 28: I suggest using the convention of EAE (Extinction Angstrom Exponent) rather than α which can be easily confused with the symbol often used to describe extinction coefficient. Line 33-35: after reading the final part of the abstract several times I still don't understand what is exactly the message here. The characteristic wavelength is not a well-known property of aerosol population and is not explained in the abstract. Therefore, to me it sounds like one would need to read the whole paper to understand this part. This is surly not something you would want for the abstract. Additionally, (1) "such that …aerosol size distributions with the same α…" how can different size distribution of aerosols have the same α? Isn't it true that α is heavily dependent on the size distribution? (2) is the slope related to λch or is it the λch? Line 81: it is not clear to me what the authors meant by "2 nm resolution in intensity" Line 117: TAP is not defined. Line 135: sampling off (from/by/using?) the same inlet line? Line 141-142: "as the ship… at that time". It is not clear to me what do you mean by "restarting the system". I also feel this sentence does not contribute to the manuscript. Line 148-149: the internet links are not needed and in my opinion reduce readability. Line 165: here, the reader is asked to compare figure S3 and figure 2 but there is no explanation as to what is the difference between the two figures. It should also be made clear that this data was acquired by using the TAP and IN. Line 174: a discussion about the errors generated from the wavelength adjustment is needed. Line 263-265: how were local ship emissions distinguished from emissions of the research vessel? Line 272: the plot referring to the 632nm channel shows that all fitted lines consistently show 5-9% over estimation of extinction from sum of scattering and absorption compared with measured extinction. What could be the cause? How accurate are the absorption measurements in this wavelength? Is it possible that these have a positive bios? Line 280-281: it is not clear to me what is meant here by "10 s scat and 1 s abs measurement for every ext spectrum. Please explain. Line 303: it would be beneficial to choose one unit system (wavelength in nm or um) and b consistent throughout the manuscript. Line 350-355: this is an important paragraph which

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I strongly feel that is not explained properly. (1) “The two expressions used here to fit the relationship between σext and λ are related by their negative derivative, defined as α in Eq. (2)”. Eq. 2 applies by definition only to the linear fit so how does it relate the linear fit to the 2nd order poly' fit? (2) “the derivative of the linear fit (y=a+bx; dy/dx = b) equals the derivative of the 2nd order polynomial fit (y = a0 +a1x+a2x2; dy/dx = a1 +2a2x) such that. . .” this statement seems wrong to me. It implies that for every λ the expression (a1+2a2*ln(λ)) has the same value. Did you mean to write that Eq 5 is only valid for one λ? That is λch? Line 357: “The wavelength dependence of Eq. (5)” if I understand correctly, Eq. 5 is not dependent on wavelength (i.e. the spectra of the measured data, 300-700 nm). It is dependent on the characteristic wavelength (λch) as it is defined in the lines above. Line 360: did you mean figure 9? Not sure how figure 10 is related here. Line 360-362: it is clear that when a2 = 0 the 2nd order poly' fit is actually a line fit. What is the physical interpretation of λch = 1 um? Line 364: what does it mean? Line 369: to the right and left of which distribution? Lines 376-378: “but as discussed. . .space”. This section is realy not clear. If the intension here was to link the information about the sampled aerosols that is available in other publications and that is presented in section 3.1 to the fitted parameter space, this is was not made clear. Please rephrase. Figure 4 top: the gray trace is not visible. Figure 6: it would be more intuitive for me to plot these data sets with the EAE calculated from the full range on x axis because this represents the optimal case and demonstrates the variances is most of the spectra to that case. Figure 7: what information is presented or made clearer in the top two figures that is not presented or is not clear in the middle two figures? In my opinion there is no add value to the top two and therefore should be removed. Additionally, the residual could be presented in relative terms (i.e. % error). This would be more intuitive to understand and reduce the text needed to describe the fit errors. Figure 8: here I would also suggest showing the x-axis in terms of relative error. Figure 9: in this figure all x-axis are inverted. This makes the figure less intuitive and harder to understand. Is there a reason for this choice? If yes I believe it should be explain in the text or at least in the figure caption. What is the purpose of the rectangle

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inset in the bottom panel of figure 9? Figure S2: it is not clear what this data set is based on. Is it simulation or measurements? If data is from another reference which is it? Figure S3: the full range of the right axis is not needed. Values range from 0 to 2. Figure S4: what do the authors mean by hour set of intensity spectra? Is it a one hour average?

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