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Atmospheric Chemistry and Physics Discussions

ACPD

12, C7866–C7870, 2012

Interactive Comment

# *Interactive comment on* "Estimation of aerosol particle number distribution with Kalman filtering – Part 2: Simultaneous use of DMPS, APS and nephelometer measurements" *by* T. Viskari et al.

**Anonymous Referee #2**

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General comments

This paper describes a brand-new method to retrieve aerosol particle size distributions using the extended Kalman filter (EKF) coupled with a box aerosol model. EKF has the ability to estimate mathematically optimal state values from multiple data so that the authors attempt a retrieval experiment simultaneously using multiple-instrument observations (DMPSs, APS, and nephelometer). EKF is one of the most advanced data assimilation schemes, which have a great advantage over the other inversion methods that cannot deal with multiple observations optimally. This paper is well written and the scientific significance to develop a new retrieval method is extremely high, but this referee thinks that a major revision is needed before publication in ACP.

In this study, validation of the EKF retrieval results was performed by comparison with the counterpart inversion results and by the increment analysis. However, although the increment analysis is interesting, both the EKF and inversion results were derived from the same observations. This paper seems to present just a conclusion: "the data assimilation result was closer to the observations that were used for the data assimilation." If other independent observations were used for the EKF validation, the validation would be more convincing.

In addition, any independent observations and analyses were not used for the EKF validation in the Part 1 of this paper series, which is not acceptable for the validation of data assimilation schemes. The status quo of the Part 1 is inappropriate as a data-assimilation-system description paper. Therefore, this referee strongly recommends that the Part 1 paper be merged with this Part 2 paper.

Specific comments

Page 18893, section 2.1: The observation error information of DMPS should be described here, not in Chapter 4.

Page 18893, section 2.2: The observation error information of APS should be described here, not in the result chapter.

Page 18895, line 1-4: The raw measurement of APS is aerodynamic diameters, isn't it? If so, why does the observation operator for APS calculate geometric diameters from aerodynamic diameters? My understanding is that geometric diameters are model variables. Is this right? The input data of the observation operator is model state vector x. What variables are included in your model state vector x?

Page 18895, eq (3): N in this equation is explained nowhere in this paper. Even if it is trivial, all of the variables in equations should be explained in the text.

Page 18895, line 20 and 25: What is Dp? Even if it is trivial, explain it in the text.

Page 18896, line 21-22: The observation error covariance is ignored in this paper, which is acceptable because this paper describes a preliminary study. However, this assumption is not realistic. I hope that the effect of the error covariance is investigated in your next study.

Page 18897, line 1-4: “The model error term is omitted, and thus the standard deviations are artificially kept at 20%.” This means that the B matrix at time k is not evolved to time k+1 at all? If so, this is not called “inflation” (it is just a fixed covariance). This description contradicts the description of B in the Part 1 paper. The B matrix was time-evolved in the Part 1 paper, wasn’t it?

Page 18897, section 3.2: Please describe clearly all of the forecast variables of UHMA model and the control variables of the data assimilation. It is very important information.

Page 18898, line 8-9: I am sorry, but I do not understand the meaning of “the increase in computational cost is even larger due to the increased number of tangent-linear model evaluations”...

Page 18898, chapter 4: My understanding is that the authors defined only the relative errors but did not define the minimum errors (standard deviations) of each instrument. This seems unrealistic. Generally, even if an instrument observes zero values, its observation error never gets close to zero.

Page 18899, line 8: Please briefly describe how “inverted particle number size distribution” was inverted from the raw measurements. Of course, Virkkula et al. (2011) might describe it in detail, but this inversion process is very important information in this paper to compare with the EKF process.

Page 18901, line 5: Is “then” the erratum of “than”?

Page 18901, line 6: “This partially leads to the discontinuity over particle size at 10 um visible.” <- “This” indicates what? Could you please explain the logic of the discontinuity more carefully.



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Page 18902, line 4-7: The large differences in the measurement values imply that both the instruments, or at least either one, have a large bias. In principle, it is impossible to assimilate biased data with non-biased data. Generally, largely biased data deteriorate the analysis, so that it is better not to use the biased data for data assimilation. Did you make consideration of the bias elimination for APS?

Page 18903, line 26-28: I do not simply agree with your conclusion "the implementation of EKF to retrieve consistent results from a combination of number size distribution measurements and light scattering could result in improvements in data quality". We can see systematic errors (= bias) between observations and the EKF analysis in Figs 5a and 5c. Biased data are often harmful to data assimilation, so that careful validation is needed.

Before a discussion about the small difference in data assimilation results induced from nephelometer data, the authors should discuss a large bias between nephelometer's and DMPS's measurements.

Page 18903, line 19: What is "from 21:00LT to 20:40LT"? That means from 20:40 to 21:00? Or, another time? Is it shown in any figure?

Page 18905, line 2: According to Page 18904 line 20-23, the reason of the acceleration is the error of nephelometer's timestamps, and the reason of the deceleration is nephelometer's response delay. In either case, the nephelometer seems inadequate to be assimilated with the status quo.

Page 18905, line 21-22: "We note that this approach will emphasize somewhat more the positive than negative increments when calculating the averages." I am sorry, but I do not understand what this sentence means. This implies the existence of a large model-bias? If so, describe it explicitly.

Page 18907, line 14-15: What made you decide definitively that DMPS II is more unreliable than APS? Based on what?



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Page 18907, line 17-18: The authors' description "due to changes in the parameters, e.g. particle density" needs further explanation and reason. What made you think so?

Figures 1a, 1b, 2a, 2b, 3, 4, 6a, 6b, 7, and 8: The unit of diameter should be unified between the text and figures as much as possible. Although nanometer or micrometer is used in the text, meter is used in figures.

Without tick marks, the visibility of logarithmic scale axes is very low. For example, it is extremely difficult to understand the location of 600-800 nm in Fig 1 at a glance. Please add the tick marks.

Caption of Fig 1a: #m-3 ?

Caption of Fig 2a: "Note that the particle number concentrations ..." is the erratum of "particle volume concentrations"?

Caption of Fig 3: "300-2000 nm" contradicts both the text description and the figure plot.

Caption of Fig 6a: "100-5000 nm" means what? Is it described in the text?

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Interactive comment on Atmos. Chem. Phys. Discuss., 12, 18889, 2012.