Atmos. Chem. Phys. Discuss., 12, C7578–C7581, 2012
www.atmos-chem-phys-discuss.net/12/C7578/2012/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Estimation of aerosol particle distributions with Kalman Filtering – Part 1: Theory, general aspects and statistical validity" *by* T. Viskari et al.

Anonymous Referee #2

Received and published: 28 September 2012

General comments

The authors describe a new method to retrieve aerosol particle size distributions from multiple instrument measurements in this paper. The method is based on an advanced data assimilation scheme, extended Kalman filter (EKF), which is coupled with a box aerosol model. Validation of the EKF retrieval method was performed by comparison with a regular inversion method. I am doubtful whether the EKF retrieval result is always more accurate than the inversion result, but the EKF retrieval method has a great advantage over the inversion method due to the simultaneous utilization of multiple instruments. Generally, it has been hard to retrieve the data from multiple instruments

and observations. This paper is well written and its scientific significance is very high. However, in my opinion, the critical issue of the scientific quality of this paper has to be solved before publication in ACP.

In this paper, independent observations/analyses are not used for EKF validation at all. This is never acceptable for the validation of data assimilation schemes. The authors compared the EKF results with not only the raw data but also the inversion results, but both the results were based on the same observations. Furthermore, this comparison seemed to be unfairly performed because the inversion results were not noise-canceled using a time-filter. In any case, the referee recommends more careful verification of data assimilation results.

Specific comments

Title: The title of this paper is different from the authors' Part 2 paper. The term "aerosol particle distributions" is vague. "aerosol particle number distributions" or "aerosol particle size number size distributions" should be used.

P 18855, line 26: Liu et al. is the error of Lin et al.?

P 18857, eqs (1) and (2): Why do you include the error term Q in eq (2) but not include an error term in eq (1)? Standardization is recommended. Plus, Q represents not only system noise but also the model "imperfection" error.

P 18859, line 24: What is "transfer function peak diameter"?

P 18860, section 3.2: Please describe the model initialization in this section, not in section 4.2.

Is R in Eq (7) supposed to be the same as R in Eq (6)?

P 18861, line 22: Please describe the more detailed validation process of "a mathematical inversion" method, or draw references.

P 18864, line 9-12: This sentence is very vague. Don't you mean that the smallest

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particles and the largest particles are correlated?

P 18864, line 20: “a large innovation can only affect the size distribution to a maximum distance of 15 size bins.” This method is called “variable localization”, which is sometimes used for ensemble Kalman filters.

P 18865, line 15: The phrase “in Fig. 2” appears twice in this sentence.

P 18865, line 18: Xekf is smoothed, and Xinv is apparently noisy. But it is not clear that Xekf is less erratic than Xinv.

P 18865, line 21: “which makes it difficult to limit Xekf to the same diameter range than Xinv” I do not understand what this sentence means. . .

P 18866, line 5: The observations could have biases. Otherwise, the observation overlap must improve the data assimilation result even if the observations have random noises.

P 18866, line 7 and Fig 3: The x-axis is expressed by the unit of m, but the text is described by the unit of nm. This discrepancy is not reader-friendly. Standardization is recommended.

P 18866, line 13: The phrase “broadly equally large” is vague. What is equally?

P 18866, line 13: I have no idea that the standard deviation is large or not, because the values of raw measurements are not shown in this section.

P 18867, line 11: If you think that large random errors in observations are excluded in the EKF result but included in the inversion result, why did not you use a time-filter to smooth the observations or the inversion result?

P 18867-18868, section 5.2.1: Generally, Kalman filters are not good with sudden changes in the system state. However, Kalman smoothers are good at following such sudden state changes because they can use the future observations. If you are not going to use this EKF system in real time in the field, using extended Kalman smoothers

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is a good choice.

P 18869, line 4: If a noise filter was used for the raw measurements or the inversion results, you could prove your story.

Captions of Figs 2a and 3a: “1” before the unit is unnecessary in the International System of Units (SI). For example; “1m-3” -> “m-3”; “[1cm-3]” -> “[cm-3]”

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 18853, 2012.