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Interactive comment on "Multi-mode retrievals for aerosol microphysical and optical properties" *by* Guangliang Fu and Otto Hasekamp

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The paper by Fu and Hasekamp provides very useful insight in the different performance of retrievals applying a parameterization of the 2-mode (fine and coarse) size distribution on the one hand (parametric mode), and retrievals utilizing more than two modes of size distribution parameters (multi-mode retrievals). I can recommend the paper for publication because it addresses a fundamental choice made by a lot of aerosol retrievals, which may have significant consequences not only for the accuracy of the retrievals (as the authors show) but potentially also for its computational cost. The paper may therefore provide some guidance for selecting an appropriate retrieval method in the context of accuracy needs, computational performance and the available information content in the measurement. Fu and Hasekamp are basing their results of the

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evaluation of the performance of the both mode-fitting approaches on the same SRON based RT and inversion algorithm using both synthetic and PARASOL measurement. The latter are then evaluated with respect to Aeronet data.

While the presented approach is solid in terms of performance differences for the SRON Algorithm, what is missing is a discussion to which extend the results are significant even for other full inversion approaches and RT models. Since there are currently not many which can perform at a global scale (as the authors state themselves) it would have been interesting to understand if these few algorithms would converge in their performance when using the same type of mode fitting. While I would guess that the authors ultimately had such a comparison in mind, a discussion of the results in this context - and maybe providing some outlook on how to apply this kind of sensitivity test also in the context of other retrieval schemes - is currently missing.

Before publication I would like to ask the authors to also address the following set of comments:

1) While one would expect that retrievals over water surfaces would reduce the parameter space and therefore may make the evaluation of the performance difference for different mode fitting scheme more robust, the study focuses on land surfaces only without further qualification. In this context I am also missing a discussion of the combination of wavelength, surface properties and scattering geometry, on the synthetic results, since some of the combinations may not be realistic and may therefore complicate the interpretation of the comparison of the synthetic results to the performance using PARASOL measurements. Ideally the synthetic retrievals could limited to the observation geometries and surface properties combination available at the Aeronet stations. This greatly would improve the interpretation of the PARASOL retrieval results in the context of the synthetic retrievals.

2) The difference of the retrieval performance between consistent and inconsistent synthetic retrievals are potentially very interesting to understand the frequent problems

when using, for example, generic pre-launch TOA test-data sets for end-to-end system performance studies and developments. However a more detailed interpretation or analysis of the results appears to be missing in the paper. The results for AOT at least seem to indicate that parametric 2 mode retrievals perform better in inconsistent cases than multi-mode retrievals. Can this be understood or explained?

3) For the PARASOL retrievals in section 5 it is stated that multi-mode retrials with more than 4 modes perform well (while at the same time mode-5 seems to have the largest bias), whereas the conclusion from the synthetic retrievals was that multi-mode retrievals perform well for n>5. Could there be a reason for this (although small) discrepancy. Overall the results are presented as if mode-5 is a kind of physical significant lower limit for multi-mode retrievals (if yes, why?), while the results seem to more indicate a general trend for decreasing RMS with higher mode numbers.

4) In Section 3.1 there is a reference missing to the actual PARASOL data and its version used. Are there references available for the expected intensity and polarisation error for PARASOL?

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