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## Comment on amt-2022-104

Feng Xu (Referee)

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Referee comment on "Estimates of remote sensing retrieval errors by the GRASP algorithm: application to ground-based observations, concept and validation" by Milagros E. Herrera et al., Atmos. Meas. Tech. Discuss.,  
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By performing truth-in-truth-out simulations, the paper by Herrera et al. did a careful work on assessing GRASP retrieval errors. The topic of study is important and technical routine was well presented. Following an introduction of the error estimate model, examples of error estimate for ground based observation including AERONET and elastic lidar were demonstrated through 40 figures and in-depth analyses in the paper. The main conclusion matches their numerical results and technical approach is well displayed and explained. I have the following comments for the authors to consider:

1. The imposition of a priori constraints (e.g. the smoothness constraints) in GRASP algorithm can very effectively mitigate the subjection of optimization towards locally optimized solutions. However, such a possibility of getting locally optimized solutions still exist when the parameter space gets large and/or the measurement uncertainties increase. In addition, the some modeling assumption of aerosol microphysics (e.g. type, shape, aerosol size components, ...) and atmosphere structure (e.g. plane-parallel atmosphere) behind the retrieval can bring in certain levels of errors as well. If I understand correctly the authors' paper, these error sources are not attempted to be analyzed in the present work. So the authors might want add some caveat information to this regard either in the introduction or summary of the paper.

2. As illustrated via the box plots (Figs.6 and 13-19), the comparison of GRASP estimate errors of various aerosol properties against the actual errors indicated general agreement, which is impressive ! Interestingly, there are some systematic differences. It is quite commendable that the authors are looking into the impact of correlation of retrieval errors. I'm curious whether there are other possible causes behind these systematic differences. For example: the authors made an interesting observation - "The results of the statistical tests with randomly generated noise showed that GRASP error estimates in most cases are comparable or exceed the actual errors by the 20 to 30% and therefore can be safely used for assuring uncertainties of actual retrieval products." Could the overestimate of the error due to the chance of double counting the effect of random error

in both " $C_{\{\delta_a_{ran}\}}$ " and " $a_{\{bias\}}*a_{\{bias\}}$ " terms via Eq.(22) ?

3. As described by the authors in Table 1, the authors assume almuquantar geometry in their simulation. I wonder whether there is any dependence of the accuracy of GRASP error estimate model on other observation geometries (e.g. principal-plane scan) ?

4. The abstract and the conclusion of the paper may be shortened by summarizing the main work and finding. For example, the first two paragraphs can be moved to the introduction part of the paper.