Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC1
https://doi.org/10.5194/amt-2022-104-RC1, 2022

Comment on amt-2022-104

Anonymous Referee #1

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., https://doi.org/10.5194/amt-2022-104-RC1, 2022

Manuscript amt-2022-104 “Estimates of the remote sensing retrieval errors by GRASP algorithm: application to ground-based observations, concept and validation”

by Milagros E. Herrera, Oleg Dubovik, Benjamin Torres, et al.

Reviewer comments.

Manuscript discusses estimation of errors of aerosol and surface parameters retrieved from remote sensing observation by using covariance matrix of retrieved parameters. This approach is an alternative to more commonly used sensitivity analysis approach which is based on perturbing synthetic measurements and radiative transfer model parameters by assumed biases and then inverting perturbed measurements to observe deviation of retrieved parameters from those used in generation of synthetic observation. The advantage of sensitivity approach is its intuitive simplicity and clarity. Its disadvantage, however, is a long time of error estimation which prevents using of this approach in real time. From other hand, covariance matrix of retrieved parameters is calculated after each inversion which allows error estimation in real time. The diagonal elements of covariance matrix provide standard deviation of retrieved parameters and non-diagonal elements are proportional to correlation coefficients between them. In spite of their rare use, the non-diagonal elements of covariance matrix have a valuable information about retrieval tendencies which can be used for better understanding and improving of information

content of measurements.

The main focus of the manuscript is development, testing, validation and applying covariance matrix approach to real observations. Also, manuscript includes the first to my knowledge, analysis of full covariance matrix including non-diagonal elements. The manuscript describes in detail the inversion procedure and error estimated used by GRASP algorithm. It also presents analysis of performance of the approach by example of two types of ground-based measurements: sun photometer measurements of aerosol optical depth and sky radiances and synergy of sun photometer observation and multi wavelength lidar. This is very detailed analysis done by numerical tests using synthetic measurements and perturbing them by random noise and biases. After numerical tests, approach is applied to real observations combination of sun photometer and lidar at Aeroparque and Villa Martelli stations in Buenos Aires, Argentina. Finally, the manuscript describes GRASP error estimates applied to POLDER/GRASP retrievals. Each case considered to illustrate the approach performance is supplemented by analysis of full covariance matrix which allows fast and efficient analysis of information content of the given set of observations.

I believe that the subject of the manuscript is in scope of AMT. It can be published after the following comments will be addressed.

Major comments.

- My major comment is related to using linear approximation in errors estimation because forward model can be highly non-linear in vicinity of solution. This issue is discussed in the manuscript and named as a reason for overestimation of errors by 20 to 30%. I wandering whether any specific research was done to better understand the effect of non-linearity of forward model on error estimate? For example, how variation of increment in calculating derivatives can help diminish the effect of non-linearity? I do not require this research to be added to the current version of the manuscript but recommend doing this analysis in the future research. It would be good adding a couple

of sentences outlying doing this analysis in perspective.

- On page 11 it is stated "Indeed, this optimization makes the iterations converge from given initial guess to git the data even if the basic linear system is singular. Therefore, ones Levenberg-Marquart optimization is used there is an evident dependence on the initial guess that can bias the solution". This is true if not a priori information is used. Underdetermined linear system has multiple solution and minimized quadratic form has wide maximum. In this case there is dependence on initial guess. However, the goal of adding a priori information is to improve condition of linear system for it not being singular. In this case the dependence on initial guess will decrease or didapper. Is this somehow accounted for in including dependence on initial guess in error estimates?
- On page 21 it is stated "In this regard, while the retrieval of multi-component is not a part of the standard AERONET inversion, GRASP algorithm allows the retrieval of several aerosol components from dives remote sensing observations including the case of aerosol retrieval from radiometer measurements only". As far as I know, AERONET retrieval code has an option to retrieve several aerosol components. In particular, at the start of the AERONET project the standard product included aerosol parameters for bi-component mixture. Later it was decided to retrieve only one component. Therefore, I always was under impression that information content of sun photometer observation is not sufficient to separate different aerosol types in external mixture. Mostly because of possible correlation between aerosol parameters of different components. Could you please explain, how this separation is achieved in GRASP algorithm? At what conditions or using some additional constraints?

Monir comments.

- In Eq (30), what exactly bias proxy set means? Is it set of assumed/modeled biases?
- In EQ. (35), I wandering would it be more correct averaging standard deviations corresponding to + and – biases of the same type prior to the averaging over contribution from different sources of uncertainties? In this case the multiplier in front of sum would be 2N.