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Atmospheric Measurement Techniques Discussions

Interactive comment on "Retrieving aerosol height from the oxygen A band: a fast forward operator and sensitivity study concerning spectral resolution, instrumental noise, and surface inhomogeneity" *by* A. Hollstein and J. Fischer

Anonymous Referee #2

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The authors present a study of the impact of factors like spectral resolution, instrumental noise and surface inhomogeneity on the retrieval of aerosol type, optical thickness and height. These are important considerations that should inform the development of appropriate aerosol retrieval algorithms for different hyperspectral instruments. The results obtained are thus of high interest and deserve publication.

The authors make adept use of principal component analysis to allow efficient handling of hyperspectral measurements. They provide scatter plots of Jacobians of measured

radiances with respect to retrieval parameters, which highlight the dissimilar dependence of different parts of the spectrum on the aerosol optical thickness and height, making them easy to distinguish from each other using the O_2 A-band, whereas the opposite is seen to hold for AOT and surface reflectance, indicating a high level of correlation which makes their individual effects difficult to separate.

The authors obtain the very interesting that height retrievals depend on a good SNR but are are more robust than AOT retrievals when the underlying surface reflectance and/or aerosol type are unknown. This result becomes intuitive given the above-mentioned scatter plots.

While their results and analysis are of high value, it would be advisable to improve the quality of the presentation. In the following, some suggestions are made to this effect:

Typos and Grammar:

1. page 10512, line 11: then → than
2. page 10513, line 2: ascends → ascents
3. Page 10515, line 24: as → than
4. Page 10517, line 4: consists → consist
5. Page 10517, line 17: then → than
6. Page 10517, line 21: and is by a compression factor n_λ/n_p smaller than Y → and is smaller than Y by a compression factor n_λ/n_p
7. Page 10517, line 27: computed → done (double use of "computed" in the same sentence)
8. Page 10520, line 7: sub sample → sub-sample

9. Page 10522, line 9 (and throughout the text/Figure captions): Jacobean → Jacobian

References:

1. Page 10515, Section 2: Include Sanghavi et al. 2012 (Retrieval of the optical depth and vertical distribution of particulate scatterers in the atmosphere using O_2 A- and B-band SCIAMACHY observations over Kanpur: a case study) in addition to Boesch et al. 2006 as a retrieval method with direct use of an RTM as forward model.
2. Page 10519, Section 3: Why has the log-normal parametrization been chosen? Again, cite Sanghavi et al. 2012 (Retrieval of the optical depth and vertical distribution of particulate scatterers in the atmosphere using O_2 A- and B-band SCIAMACHY observations over Kanpur: a case study) as a previous instance of the use of this parametrization.

Content:

1. Page 10515, line 23: Remove "locally" in front of nonlinear behaviour of solutions (redundant)
2. Page 10517, line 10: two instances where "orthogonal" is used instead of "orthonormal". Suggest orthogonal → orthnormal
3. Page 10519, Section 3, Eq. 2: Include a factor $1/\sqrt{2\pi}$ on the right hand side
4. Page 10520, Section 3, Eq. 3: Remind the reader that the variables on the right hand side have been discussed in Section 2. Re-describe the variables $\mathbf{y}_i$ and $\widetilde{\mathbf{y}}_i$ briefly.

5. Page 10521, line 4: Explain what is meant by a "neutral" aerosol type. Provide microphysical parameters (complex refractive indices, size distribution parameters and mode fraction of all modes considered) for all aerosol types considered, preferably in the form of a Table.
6. Page 10521, line 6: extinction → extinction cross-sections
7. Page 10521, line 7/Fig 5: It is difficult to understand why the aerosol phase functions are considered dependent on the AOT. Please clarify.
8. Page 10521, last paragraph referring to Fig. 6 and 7: It is difficult at first sight to understand that the spectral wavelength is the common parameter for the scatter plots. Please make explicit mention of this. Before Figures 6 and 7 are introduced, it is advisable to show the actual partial derivatives ($\partial\mathbf{I}/\partial\tau$, $\partial\mathbf{I}/\partial\alpha$ and $\partial\mathbf{I}/\partial h$) plotted against wavelength for at least one of the aerosol types considered.
9. Page 10522, line 9: define "Jacobian". Explain how they are calculated.
10. Page 10522, 2nd last paragraph: Simulated measurements are discussed here, but a definition of a synthetic measurement is only introduced later in Section 5. Please reorder the sequence, so that the discussion can follow the introduction.
11. Page 10522, last paragraph: These statements appear to contradict each other and may need further refinement. For example: how does the asymptotic solution described here work when the step size is large enough to cause a parameter to exceed the bounds of your lookup table by more than a factor of 2? Is it then successively divided by two until it falls within the expected bounds? If that is the case it should be mentioned explicitly. Also, the first line of the paragraph should make it clear that the lmder routine is only *nominally* implemented for an unbound problem.

12. Figures 9 and 10: Artifacts due to finite resolution of the LUT are still present. Please make mention of this when discussing the results, so that the reader is aware of potential bias due to the artifacts.

13. Figures 9 and 10: Define tp in the text making use of an appropriate equation to show its relation to individual microphysical parameters.

14. Figures 11 and 12: the green and cyan lines are almost indistinguishable. If possible, replace the color scheme with one that has more contrast.

15. Figure 13: Color scheme does not match that indicated in the caption. Again, try to use a color scheme with more contrast: violet (?) and black(?) are almost indistinguishable.