Atmospheric Measurement Techniques Discussions

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Comment on amt-2021-84

Anonymous Referee #1

Referee comment on "GFIT3: a full physics retrieval algorithm for remote sensing of greenhouse gases in the presence of aerosols" by Zhao-Cheng Zeng et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-84-RC1, 2021

This is an informative and well-written paper on a subject which is important to understanding remote sensing of greenhouse gases, and should certainly be published after some revision. My suggestions and questions follow

First I will discuss two important points that I believe need explanation and a bit more consideration by the authors. Pages 8 and 9 of the manuscript describe the state vector and its relation to the underlying forward model. So for example a CO_2 a priori profile is assumed for the forward model and a single scale factor for the profile is retrieved in the state vector. For aerosol, values of AOD are retrieved for coarse and fine aerosols, and a single layer height value is retrieved. It is not at all clear how those 3 scalar quantities are related to the underlying quantities of albedo, phase function, and altitude distribution of the 5 aerosol types discussed in lines 205-224. Please explain. Are the values of CO_2 and CH_4 affected by the details of this assumed relationship?

My second important point concerns uncertainties in the retrieval. Namely, the discussion on p. 10-11 (lines 260-267), and conclusions on p. 18 attribute forward model error entirely to noise and to approximations in the calculations of multiple scattering. But surely, spectroscopic error and uncertainties in aerosol albedo and phase function are far larger. Or if not, that should be stated and justified. What has been done to evaluate these well-known sources of forward model error?

A related point concerns the measurement error covariance matrix. The error sources I refer to are strongly correlated between channels. It is nevertheless usual in my my experience to assume a diagonal measurement covariance matrix, for practical reasons. But that assumption should be explicitly recognised as such, and the effect of those errors evaluated post retrieval.

Aside from the two major points above, I have a few minor ones:

p. 2-3, lines 62-68: There is a very recent paper on GFIT2 which the authors will know about (it shares 1 co-author with this paper):

Roche, S., Strong, K., Wunch, D., Mendonca, J., Sweeney, C., Baier, B., Biraud, S. C., Laughner, J. L., Toon, G. C., and Connor, B. J.: Retrieval of atmospheric CO2 vertical profiles from ground-based near-infrared spectra, Atmos. Meas. Tech., 14, 3087–3118, https://doi.org/10.5194/amt-14-3087-2021, 2021.

p. 14, line 360, and Fig A4: The three reflecting points most used are also the closest to the instrument. I presume that explains why Fig A4 shows the AODs for other sites have mostly low values, in comparison to the AOD values for the 3 dominant sites. A sentence or two would be interesting to confirm and interpret that.

p. 15, line 397: CLARS-FP?

p. 17: Section 6.2 is confusing. The discussion jumps back and forth from one assumption to another about reflectance ratio, and loses this reader.