Atmos. Meas. Tech. Discuss., 8, C4398–C4401, 2015
www.atmos-meas-tech-discuss.net/8/C4398/2015/

Atmospheric Measurement Techniques Discussions

Interactive comment on "A sensitivity study on the retrieval of aerosol vertical profiles using the oxygen A-band" *by* S. F. Colosimo et al.

Anonymous Referee #1

Received and published: 18 December 2015

General comment

Colosimo et al. conduct a retrieval simulation study on how well the aerosol extinction vertical profile can be retrieved from solar backscatter satellite measurements of the O2A-band. The study in particular addresses the sensitivity of information content to instrument design parameters such as spectral resolution and signal-to-noise ratio. As acknowledged by the manuscript, previous assessments have covered the topic already to some extent. Nevertheless, the paper can make a genuine contribution since the findings are presented in a systematic and generically applicable way. The manuscript is generally well written and the methods appear robust.

Overall, the main comment I have is that it would be timely to assess this question with real (not just simulated) data given that solar backscatter measurements of the O2A-

band are available from various satellites (SCIAMACHY, GOSAT, OCO-2, GOME-2,...) covering a range of design parameters. Such studies are sparse and, mostly available for the low-resolution sensors indicating only limited information content for the aerosol vertical profile.

While I acknowledge that such work would be beyond the scope of the current manuscript, I would recommend considering the comments below which mostly center on a better discussion of potential real-world problems and real-world relevance.

Specific comments

1. As far as I can trace the methodology, the information content analysis is based on a "1-step" retrieval in the linear regime around the true state: the RTM is fed by the assumed atmospheric state, then it calculates the Jacobian matrix from which the averaging kernel and the DOFs are derived. This is a benign approach in several ways:

a) For the real-world problem, the retrieval would generally be initialized at a state that is not the truth and an iterative retrieval would be required. Since the forward model is probably quite non-linear, it is not a trivial task to make the algorithm converge at the true state.

b) For the real-world problem, (non-retrieved) forward model parameters such as the shape, size, composition of the aerosols, such as spectroscopic parameters (line-mixing, collision induced absorption), or such as instrument parameters (radiometric calibration) would be imperfect inducing forward model errors. In particular, imperfect knowledge of spectroscopic parameters might preclude exploiting the theoretically available DOFs for the high spectral resolution cases.

c) Is albedo part of the state vector or is at assumed known? If it is assumed known, I would consider this a particularly optimistic case of comment 1b) above since albedo is highly variable in time and space at the required level of knowledge. Thus, assuming albedo known will induce a large forward model error. Albedo has a large effect on

the lightpath e.g. by mediating the importance of single-scattering versus multiple-scattering radiances. Therefore, I would expect DOFs to be quite sensitive to whether albedo is a retrieval parameter or not.

The manuscript should be clearer in what methodology is exactly used. If the above concerns turn out to be relevant, they should be either addressed by sensitivity studies or, at least, be thoroughly discussed as potential hurdles on the way toward the real-world problem.

2. Concerning the aerosol scenarios, it would help quoting the vertically integrated aerosol optical depth (AOD) in addition to extinction for all scenarios.

Looking at figure 1, AOD seems actually quite large (Is it >0.5 at 765 nm?) for all except the Marine-Arctic scenario. How representative are the chosen AODs for the global scale and, importantly, how do DOFs depend on AOD?

Further, the choice of albedo does not seem representative for land surfaces. Albedo is assumed either 0.05, 0.1, or 0.9. Scientifically very interesting and large regions such as the tropics or mid-latitudes are covered by vegetation surfaces with albedo 0.2-0.4 (at 765 nm). The manuscript occasionally quotes results for albedo 0.3. I would recommend extending the discussion of these cases.

3. Why is only a narrow micro-window of the O2A-band used? Current algorithms exploiting real O2A-band measurements (e.g. applied to GOSAT, OCO-2) cover the entire band. As noted by the manuscript, a larger micro-window could help increase DOFs (and – covering the shortwave and longwave sides of the band – support an albedo retrieval).

4. Are the results dependent on the assumed scattering phase function, ie. is the assumed asymmetry parameter g=0.7 a critical choice?

5. The discussion of the multi-angle paper by Frankenberg et al., 2012, (P11874,L20) does not seem too applicable. Multi-angle geometry predominantly yields information

on the scattering phase function and thus, on aerosol microphysical properties with only some marginal benefits for the aerosol height retrieval.

6. Figure 7 could be misleading or too simplistic since only downward propagating lightpaths are shown. The role of albedo does not become clear. Lightpath enhancement e.g. due to multiple scattering between the aerosol layer and the surface cannot be illustrated by the current figure.

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 11853, 2015.