Review of manuscript 'Cancellation of cloud shadow effects in the absorbing aerosol index retrieval algorithm of TROPOMI' by Trees et al submitted for publication in AMT

Summary

In this paper the authors discuss the effect of cloud shadows in the magnitude of the qualitative Absorbing Aerosol Index (AAI) parameter derived from TROPOMI near UV observations and verify their findings with 3D radiative transfer (RT) calculations. The reported RT results are a good validation of their developed 3-D RT tool application to UV observations. They conclude that the effect on the AAI is quite small and that, therefore, a correction is not necessary.

General Comments

The detection of cloud shadows signal in the AAI is not a new finding. Cloud shadows in equivalent AAI definitions have been previously identified in satellite observations by sensors with UV observational capability at sub-kilometer spatial resolution [Fukuda et al., 2013; Tanada et al., 2023; Gogoi et al, 2023]. As in the previously published analyses, this manuscript concludes that the cloud shadow effect on the AAI is quite small and does not warrant a correction. This conclusion can be further justified by the fact that the AAI is not a physically meaningful parameter. Thus, in its current form, the manuscript's main contribution is the validation of the MONKI UV radiative transfer scheme and could, perhaps, be submitted to an RT specialized journal.

The authors could advantageously use the documented AAI-cloud shadow detection capability to develop corrections to radiance measurements at relevant channels in the UV-VIS-near-IR range that are used in the retrieval of important geophysical parameters. Although corrections would not be necessary for DOAS (Differential Optical Absorption Spectroscopy) based applications, they would be needed for cloud and aerosol algorithms and other inversion schemes based on the interpretation of discrete channel observations. One such AAI-based reflectance correction was developed and applied to GOSAT/TANSO CAI observations at 672 nm (Fukuda et al., 2013). Similar applications to TROPOMI measured radiances would be an important contribution to improve the accuracy of retrieved physical parameters and contribute towards the error budget analyses of TROPOMI retrieved parameters. I encourage the authors to pursue this goal.

Specific Comments

Line 19: Suggest replacing *spectrometer* with *hyperspectral instrument.*

Line 22: Suggest adding *hyperspectral* before *predecessors*.

Line 24: It can be said that TROPOMI's 3.6X5.6 km spatial resolution is indeed unprecedented in hyperspectral sensors. However, that is not the case for multi-wavelength sensors. Near UV channels at sub-kilometer resolution have been added to several sensors over the last decade. In 2009, the Cloud Aerosol Imager (CAI) sensor on the Japanese GOSAT TANSO satellite made 380 nm radiance measurement at 0.25 km resolution (Fukuda et al., 2013). Similar measurements were carried out by the Second-generation Global Imager (SGLI) launched in 2017 (Tanada et al, 2023). Measurements at 339 and 377 nm at 0.46 km resolution have been made by CAI-2 since its launch in 2018 (Gogoi et al., 2023). The recently deployed PACE-OCI instrument measures UV radiances at 1 km spatial resolution (Werdell et al., 2019).

Lines 34-35: Another important non-aerosol related effect on measured near UV radiances is pure water absorption over the remote oceans. Suggest adding '*as well as pure water absorption effects over the remote oceans (Fry, 2000)*' after (Kooreman et al., 2020).

Line 39: Suggest adding *hyperspectral* before *predecessors*.

Line 40: A brief discussion on earlier studies on cloud shadows in the near UV applied to observations by other high spatial resolution multi-wavelength instruments (JAXA's CAI, SGLI and CAI-2) should be included here.

Line 99. Suggest qualifying or removing the statement '*In the absence of aerosols and clouds, the AAI is, in theory, ideally equal to zero'*. Actually, there are multiple non-aerosol related effects such as land surface reflectance spectral effects (deserts in particular) and ocean signal associated with sunglint and clear water absorption (both yielding positive AAI values) as well as chlorophyll absorption that yields negative AAI values. An explanation of how these non-aerosol related effects are detected and flagged should be included.

Line 100 Elaborate on the reasons for such a large negative offset. Is the reported AAI adjusted for this offset? If so, how? Provide references on this issue.

Line 101 On the detectability of aerosols above clouds suggest adding the Torres et al (2012) reference.

References

Fry, E.S., Visible and near ultraviolet absorption spectrum of liquid water. Appl. Opt. 2000, 39, 2743–274

Fukuda, S., T. Nakajima, H. Takenaka, A. Higurashi, N. Kikuchi, T. Y. Nakajima, and H. Ishida (2013), New approaches to removing cloud shadows and evaluating the 380nm surface reflectance for improved aerosol optical thickness retrievals from the GOSAT/TANSO-Cloud and Aerosol Imager, J. Geophys. Res. Atmos., 118, 13,520–13,531, doi:10.1002/2013JD020090.

Gogoi, M. M., Babu, S. S., Imasu, R., and Hashimoto, M.: Satellite (GOSAT-2 CAI-2) retrieval and surface (ARFINET) observations of aerosol black carbon over India, Atmos. Chem. Phys., 23, 8059–8079, https://doi.org/10.5194/acp-23-8059-2023, 2023.

Tanada, K., Murakami, H., Hayasaka, T., & Yoshida, M. (2023). Aerosol optical properties of extreme global wildfires and estimated radiative forcing with GCOM-C SGLI. *Journal of Geophysical Research: Atmospheres*, 128, e2022JD037914. https://doi.org/10.1029/2022JD037914

Torres, O, H. Jethva, and P.K. Bhartia, Retrieval of Aerosol Optical Depth above Clouds from OMI Sensitivity Analysis and Case Studies, Journal. Atm. Sci., 69, 1037-1053 Observations: Sensitivity Analysis and Case Studies, Journal. Atm. Sci., 69, 1037-1053, doi:10.1175/JAS-D-11-0130.1, 2012

Werdell, P.J., Behrenfeld, M.J., Bontempi, P.S., Boss, E., Cairns, B., Davis, G.T., Franz, B.A., Gliese, U.B., Gorman, E.T., Hasekamp, O., Knobelspiesse, K.D., Mannino, A., Martins, J.V., McClain, C.R., Meister, G., and Remer, L.A. (2019). The Plankton, Aerosol, Cloud, Ocean Ecosystem Mission: Status, Science, Advances, Bull. Am. Meteorol. Soc., 100(9), doi: 10.1175/BAMS-D-18-0056.