Comment on "amt-2024-198" by Martin de Graaf, Maarten Sneep, Mark ter Linden, L. Gijsbert Tilstra, and J. Pepijn Veefkind

RC2: 'Comment on amt-2024-198', Anonymous Referee #3, 12 Mar 2025

The authors present a new aerosol layer height (ALH) product from TROPOMI oxygen A-band measurements. This product employs surface albedo estimated from TROPOMI measurements (as opposed to previous versions that used GOME-based albedo data). This is an important change as it enables usage of the correct viewing geometry (TROPOMI makes measurements in the afternoon while GOME does so in the morning) and hence provides the proper directional reflectivity. Comparisons with CALIPSO measurements demonstrate significantly improved ALH retrievals over land (including bright surfaces) and decreased land-ocean contrast. This work is novel and well written and certainly publishable in AMT.
The reviewer is thanked for kind review and assesment. Below we address all the points raised and answer the questions. The changes made in the manuscript are highlighted.

I have only two major comments.

First, it is mentioned that the neural network training was done assuming fixed aerosol properties, in particular a single scattering albedo of 0.95 and a Henyey-Greenstein function with asymmetry parameter 0.7. Does this not bias the retrievals when the actual aerosols present have different properties? The authors note that "the ALH does not take different aerosol types into account, but assumes weakly absorbing aerosols, because in the O2 A-band the penetration depth is controlled by the scattering of the aerosol layer, not the absorption." I am not so sure that this is true (and even if it is, the asymmetry parameter would matter). The single scattering albedo and the phase function do affect the relative interplay between aerosol scattering and gaseous absorption. At the very least, the authors should do some sensitivity studies (varying SSA and asymmetry parameter) to prove their hypothesis that the absorption does not matter.
This is a valid point, also raised by reviewer #1. The explanation in the manuscript was too brief and neglected the considerations leading to the argument. This has been addressed in the manuscrpt, explaining the sensitivity. In short, differences between the modelled and meaured reflectances, such as introduced by differences in the real and modeled aerosol model and scattering phase function, are compensated by changing the aerosol optical thickness, from fitting the reflectances in the continuum. Therefore, the AOT from the retrieval is considered an effective AOT and not to be used as an AOT measurement. See also the reply to Reviewer #1.

The following was added to the manuscript as a clarification: "This model does not account for different aerosol types, but the ALH was shown to be robust with respect to fixed aerosol model parameters (sanders et al 2015, nanda et al 2019). The main reason is that differences between the modeled and the measured reflectances are mostly absorbed by the AOT, which is primarily controlled by the fit of the spectra in the continuum. Therefore, AOT is considered an effective quantity and not to be used as an AOT measurement. On the other hand, the ALH is optimized in the retrieval and considered the prime retrieval target. Currently, no dynamic information (daily measurements) on aerosol type is available, but this may change with missions like EarthCARE, PACE and Metop-SG A, in which case a better fit with different aerosol models may be considered for operational processing."

Second, some of the aerosol plume events have an hour or longer time difference between the Sentinel-5p and CALIPSO overpasses. What was the purpose of selecting these cases? There needs to be some text describing the rationale for the case selection.

The selection of the cases is based on several criteria, involving temporal and spatial coverage, (globally and during the entire TROPOMI mission as much as possible), different aerosol events and coverage over land and ocean surfaces. CALIPSO and Sentinel-5P have similar equator crossing times, resulting mosly in small time differences between CALIOP and TROPOMI measurements (depending on the details of the CALIPSO track in the swath of TROPOMI, which is 2600 km wide). Since we follow the validation excercise by Nanda et al (2020), time differences up to 5 hours are acceptable, also considering that aerosol plumes are generally not very dynamic and can be expected to mainly move laterally to first order. This is easily satisfied by all cases but one, (over Asia in 2020), which turned out to have a very poor coverage of CALIOP measurements during daytoime, and we decided to show the more interesting coimparison with the night time overpass. This was mentioned in the caption of Figure A5: "Note that CALIOP data were collected from the nighttime overpass in order to get a good coverage of the plume over Beijing."
For reference, the coverage with the daytime overpass is shown here in Fig. 1, to illustrate the poor selection (Calipso track is just in the low-left corner). Furthermore, it also shows that the

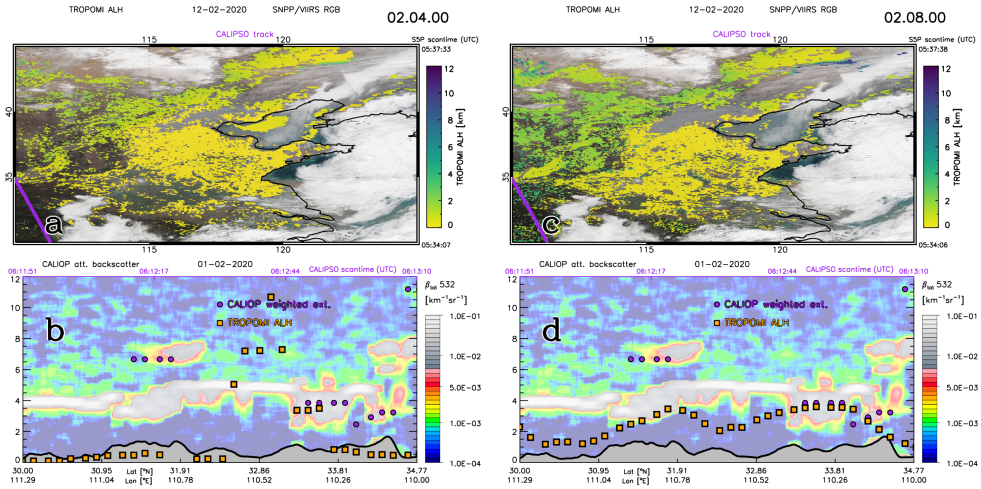

Figure 1: (a) True color (RGB) image from SNPP/VIIRS on 12 Feb. 2020 showing industrial pollution over China,, overlaid with TROPOMI ALH, version 02.04.00 from 14:37:59–14:43:35 UTC. The purple line shows the daytime CALIPSO track over the area on the same day from 06:11:51–06:13:10 UTC. (b) CALIOP L1 532 nm attenuated backscatter curtain image along the purple track in the top panels, overlaid with the CALIOP weighted extinction height (purple dots) from L2 extinction profiles at 532 nm (averaged every 0.15° latitude along the track) and the average TROPOMI ALH of collocated pixels within a 0.5° radius of the CALIOP extinction profiles along the track. (c) and (d): Same as (a) and (b), but with TROPOMI ALH version 02.08.00

comparison does not necessarily show better or worse results, so we feel it justifies to keep the figure A5 as it is, also to show comparisons are similar even after 13 hours.
The explanation of the selection of cases was extended in the manuscript (section 2.4).

Minor comments/typos:

Line 37: space-based instruments → space-based retrievals
Indeed, corrected

Line 42: extend → extent
Corrected

Line 54: remove "like"
Agreed

Line 65; Line 104: wavelengths → wavelength
Both corrected

Line 114: 20204 → 2024
Corrected

Line 123: For the ALH → For the ALH retrieval,
Agreed

Line 174: maximum likelihood → maximum likelihood estimate
Agreed

Line 185: remove "CALIOP L1 data"
Corrected

Lines 212-213: land surfaces and ocean surfaces → land and ocean surfaces
Corrected

Line 303: weakly scatterers → weak scatterers
Corrected