Exploring global aerosol optical properties: Validation of EarthCARE ATLID with CAMS

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Introduction

Aerosols contribute to one of the greatest uncertainties in global radiative forcing of the changing climate. It is important to obtain a thorough understanding of the global aerosol distribution and population to better predict climate change.

Aerosol optical depth (AOD) and extinction coefficients are useful parameters to evaluate the aerosol properties and quantify the influence of aerosol on radiation. The ATmospheric LIDar (ATLID) lidar onboard EarthCARE efficiently measures aerosol profiles at a 355 nm wavelength, while the Target Classification (TC) product provides valuable information about cloud and aerosol (sub-)types per layer. Their combination may potentially reveal how aerosol of different compositions vary with altitude globally. Figure 1 shows a schematic diagram of target classification.

Method

We compare the AOD derived from ATLID with CAMS (Copernicus Atmosphere Monitoring Service) forecast. The CAMS forecast provides high-quality data by incorporating observations, which enhances the accuracy of atmospheric estimates. The co-located comparisons will help us better understand the satellite retrievals and the vertical distribution of aerosols globally.

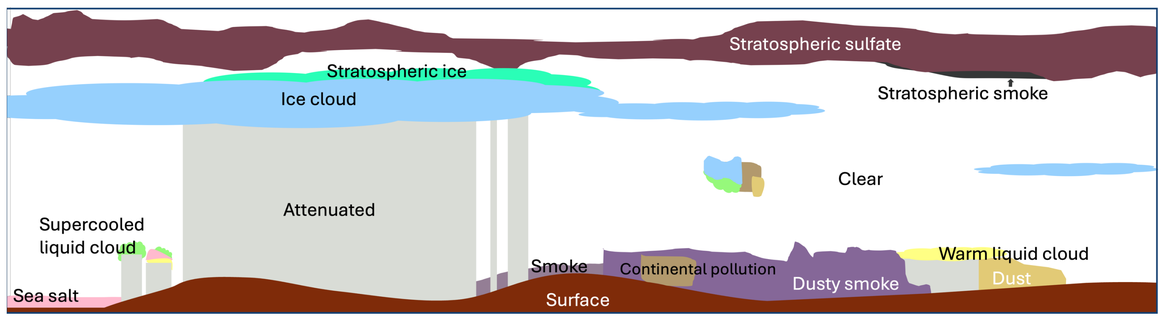

Fig. 1 A schematic diagram illustrating the target classification

Results: Comparisons between ATLID and CAMS forecast - global

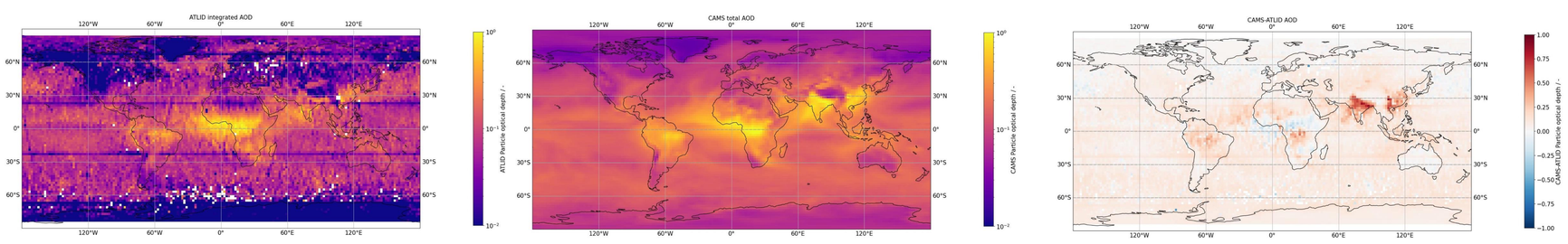

Fig. 2 Global AOD integrated from the extinction coefficient measured by ATLID, global AOD at 355 nm from CAMS forecast, and the differences of AOD between monthly mean CAMS and ATLID in December 2024. ATLID data has been filtered using TC products so that only aerosols particles are included, and both datasets have been regridded to 2° resolution.

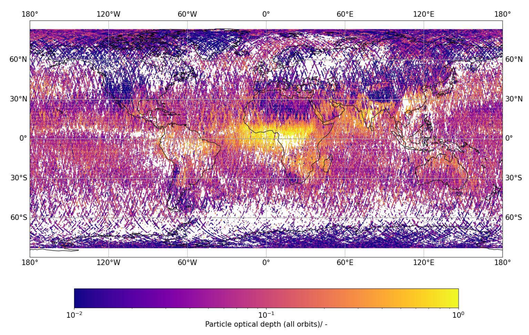

Fig. 4 A map of AOD from all the orbits from ATLID in December 2024

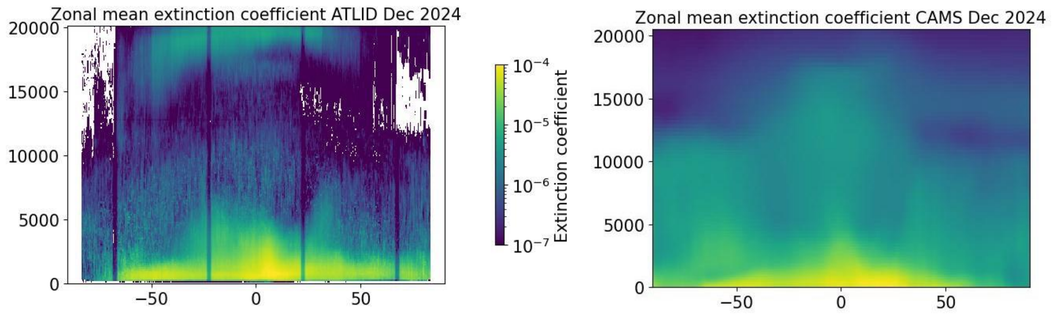

Fig. 3 The zonal mean extinction coefficient from ATLID, CAMS forecast and the differences between the two products in December 2024. ATLID data has been vertically interpolated according to CAMS altitude.

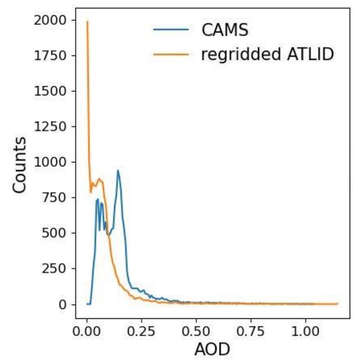

Fig. 5 Histograms of AOD from ATLID and monthly mean AOD at 355 nm in CAMS in December 2024.

AOD from ATLID and CAMS show similar global spatial patterns, although ATLID has in general lower AOD than CAMS (Fig. 2). The global mean AOD in ATLID is 0.08 and is 0.15 in CAMS. The histograms in Fig. 5 indicate that AOD from both ATLID and CAMS peaks around 0.05, and CAMS has another peak around 0.15 which is not found in ATLID observations.

Zonal mean extinction profiles (Fig. 3) have the largest differences below 2.5 km altitude between ATLID and CAMS. The differences are partly caused by inconsistent height coordinates. It will be investigated in future analysis.

Comparisons in several regions

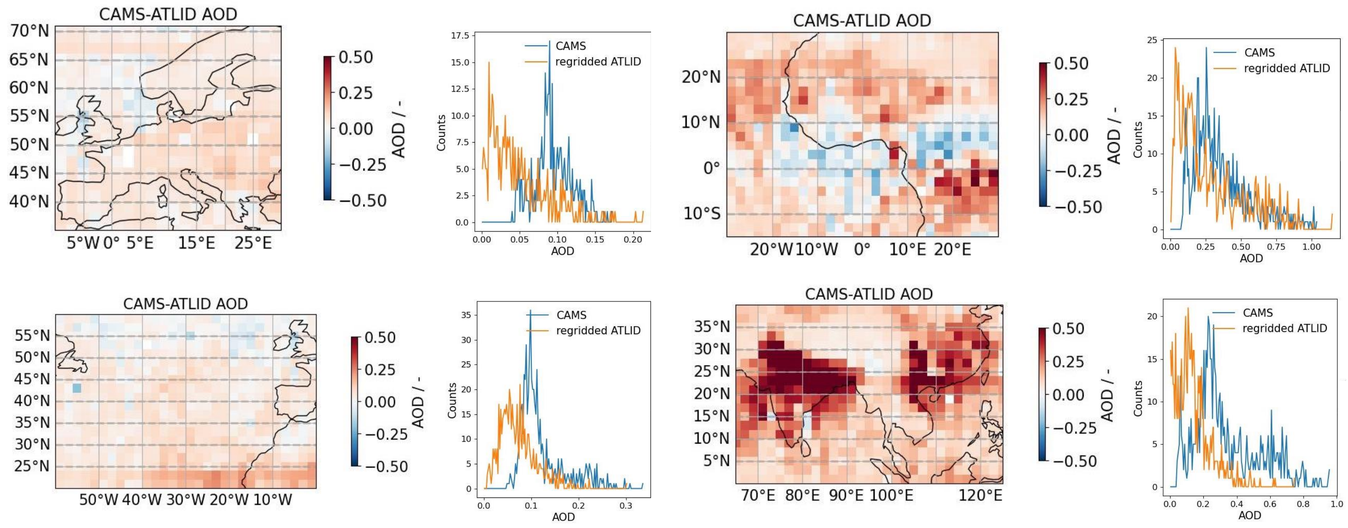

Fig. 6 Differences in AOD between ATLID and CAMS in Europe, Africa, North Atlatic and Asia and the corresponding histograms of AOD from both datasets.

We zoom into 4 regions to observe the AOD distributions. Regions with higher AOD (Africa and Asia) tend to present larger bias than regions with smaller AOD (Europe and North Atlantic). Differences in modes between ATLID and CAMS are also larger in high-AOD regions.

Conclusions and future analysis

1. ATLID has lower AOD than CAMS globally.
2. The zonal mean extinction coefficient profiles show the greatest differences close to the surface.
3. The vertical coordinates should be matched in future analysis to compare the extinction coefficient profiles.
4. Bias in individual regions between ATLID and CAMS is larger where AOD is high, but it may be attributed to missing data due to frequent cloudy conditions.
5. Results may be improved with a newer version of the ATLID products produced in later months.
6. Future analysis will also distinguish different aerosol compositions.

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