Supporting Information for "Passive remote sensing of aerosol layer height: The importance of near-UV multi-angle polarimetric measurements"

Lianghai Wu,[1] Otto Hasekamp,[1] Bastiaan van Diedenhoven,[2, 3] Brian Cairns,[3] John E. Yorks,[4] and Jacek Chowdhary[3,5]

Corresponding author: Lianghai Wu, SRON Netherlands Institute for Space Research, Sorbonnelaan 2, 3584 CA Utrecht, the Netherlands, (l.wu@sron.nl)

[1]SRON Netherlands Institute for Space Research, Sorbonnelaan 2, 3584 CA Utrecht, the Netherlands

[2]Columbia University, Center for Climate System Research, 2880 Broadway, New York, NY 10025, USA

[3]NASA Goddard Institute for Space Studies, 2880 Broadway, New York, NY 10025, USA

[4]NASA Goddard Space Flight Center, Greenbelt, MD, USA

Here, we provide additional information about the dependence of the height retrieval on the first guess for aerosol height(Fig. S1), geometry (Fig. S2 and Fig. S3) and aerosol optical depth (Fig. S4). The correlation between error on different aerosol parameters are also analysed(Fig. S8). Additionally, we study the effect of the assumed fixed layer width of 2 km in our retrieval (Fig. S5-Fig. S7). Table S1 lists free and fixed aerosol parameters and their ranges used in our synthetic study.

Contents of this file

1. Figures S1 to S8
2. Table S1

1. Effect of 1st guess

Figure S1 shows the performance of the retrieval of aerosol layer height when a single first guess value of 3 km has been used instead of trying 3 different first guess values and slecting the best fit. It can be seen that the retrieval performance degrades when the true (or CPL) value is far from the first guess.

[5]Department of Applied Physics and
Applied Mathematics, Columbia University,
2880 Broadway, New York, NY 10025, USA

2. Effec of Scattering Angle Range

Figure S2 shows the comparison between RSP and CPL aerosol layer height when no scattering angle filter has been applied. It can be seen that the performance is worse than in Fig. 2(a) where only cases are shown with a minimum scattering angle of 90 degrees.

Figure S3 shows the mean absolute error and correlation coefficient between the retrieved RSP center height and CPL product for RSP measurements as function of minimum scattering angle. The retrieval performance becomes gradually worse with the increase of lower limit of the scattering angle range. The sudden change from 110 to 115 degree is caused by the inclusion of a number of specic cases (cases with CPL height larger than 6 km) with larger error and this jump is not cased by sudden change in retrieval capability. Here we expect to verify the importance of information around 90 degree scattering angle in aerosol height retrieval. 90 degree scattering angle is where Rayleigh scattering signal peaks. As explained in the paper, height information mainly comes from the shielding effect by an elevated aerosol layer of the Rayleigh scattering signal below the aerosol layer.

3. Effect of AOD

In Fig. 2 of the paper we only include cases where AOD > 0.2 because the retrieved height values are less reliable for small AOD cases for both RSP and CPL. Figure S4 shows the comparison including also cases with AOD < 0.2.

4. Effect of fixed layer width

Figure S5 shows a histogram of the aerosol layer width as measured by CPL during SEAC^{4}RS campaign. The width is mostly smaller that 2 km but also sometimes higher. It seems that the assumed value of 2 km is on the high side but not unreasonable.

To investigate the effect of using a fixed layer width of 2 km in the retrieval we created synthetic measurements with a randomly varying layer width between 1.0 and 4.0 km and performed retrievals still assuming a constant width of 2 km. The results are shown in Fig. S6. It can be seen that the results are very similar to those in the paper (Fig. 1, upper left panel) which demonstrates that the retrieval is virtually insensitive to the assumed layer width.

When we try to retrieve layer width (Fig. S7) the retrieved width value varies randomly around the prior, which demonstrates that there is no information on this parameter in RSP measurements. If we try to fit it also the retrieved layer height becomes more noisy.

5. Correlation between error and aerosol parameters

We investigated the dependence of the error on aerosol height with respect to SSA and its retrieval error and other aerosol parameters in the synthetic retrieval. As shown in Fig. S8, the errors on SSA and height are slightly correlated.

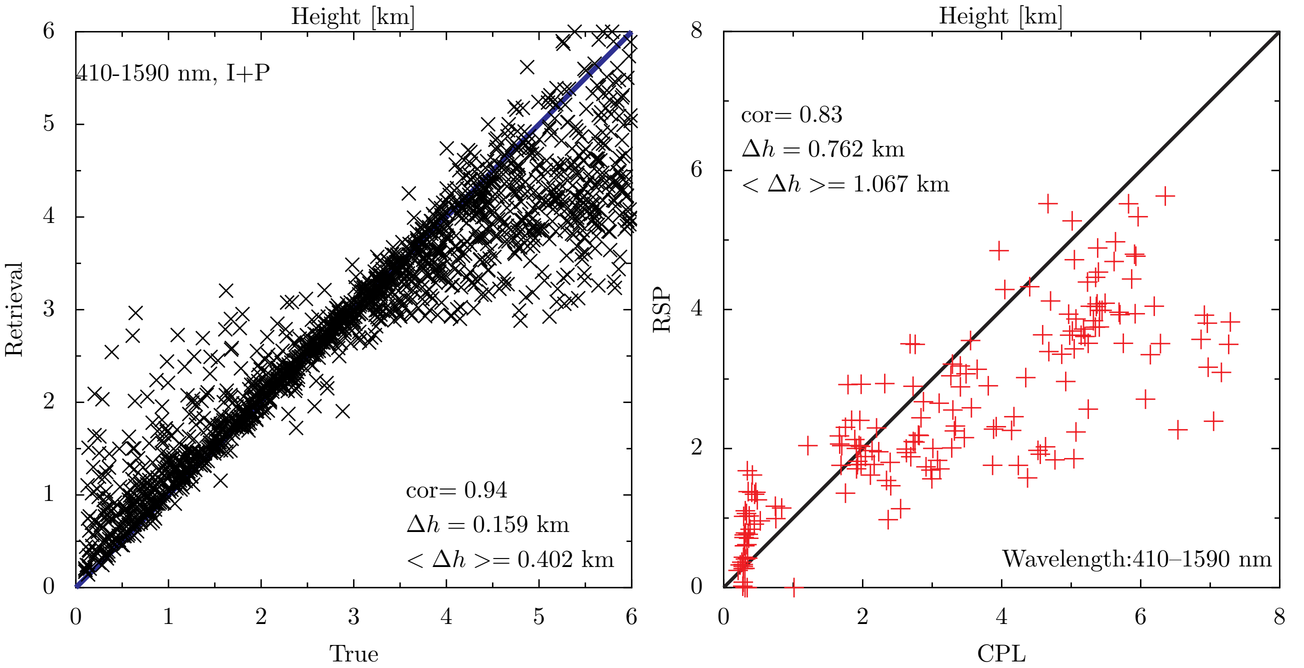

Figure S1. Retrieval performance for synthetic measurements (left) and real measurements when a fixed 1st guess for aerosol layer height of 3 km has been used instead of trying 3 different values for the first guess and selecting the best fit.

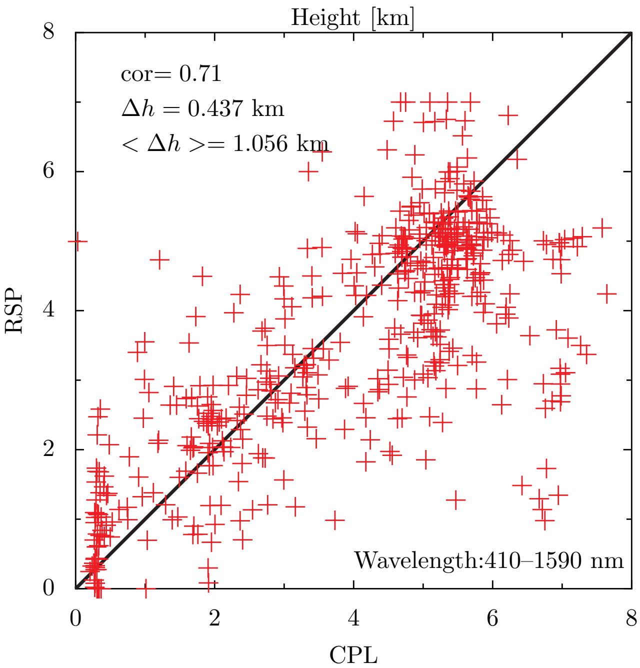

Figure S2. Same as Fig. 2(a) in the paper, but for retrievals without scattering angle range filtering.

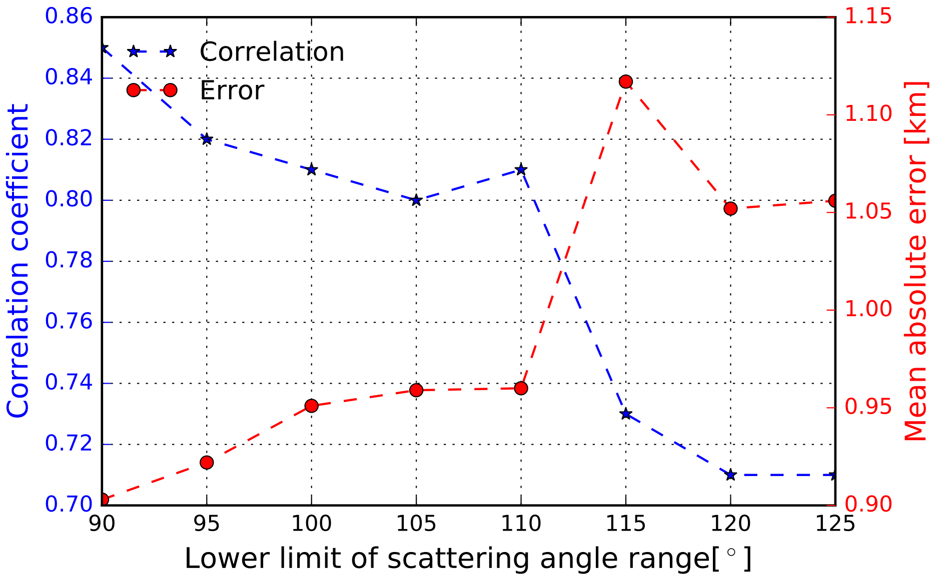

Figure S3. The results of mean absolute error and correlation coefficient between the retrieved RSP center height and CPL product for RSP measurements with different lower limit of scattering angle range.

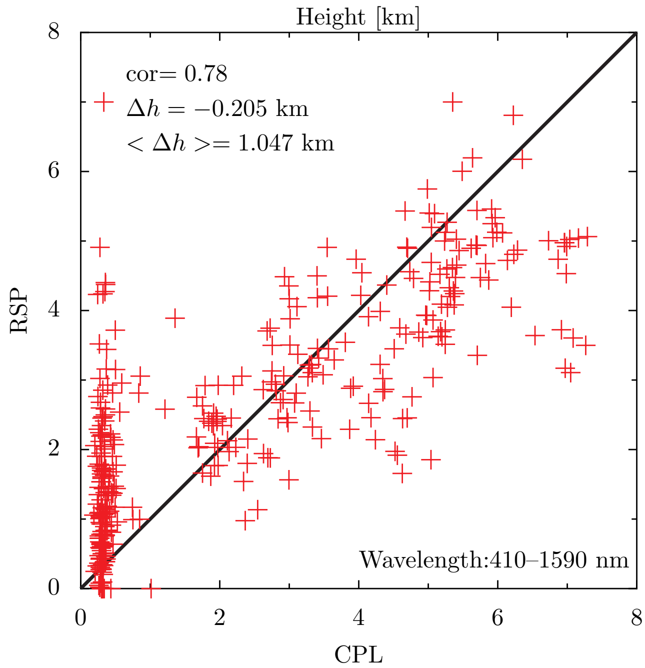

Figure S4. Same as Fig. 3(a) in the paper, but for cases without optical depth filtering.

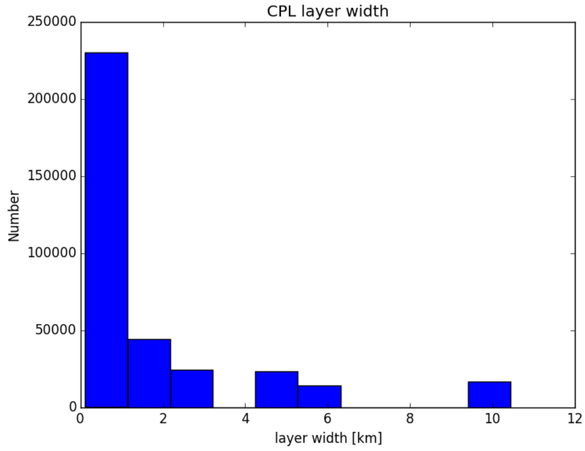

Figure S5. Layer width measured by CPL during SEAC[4]RS campaign.

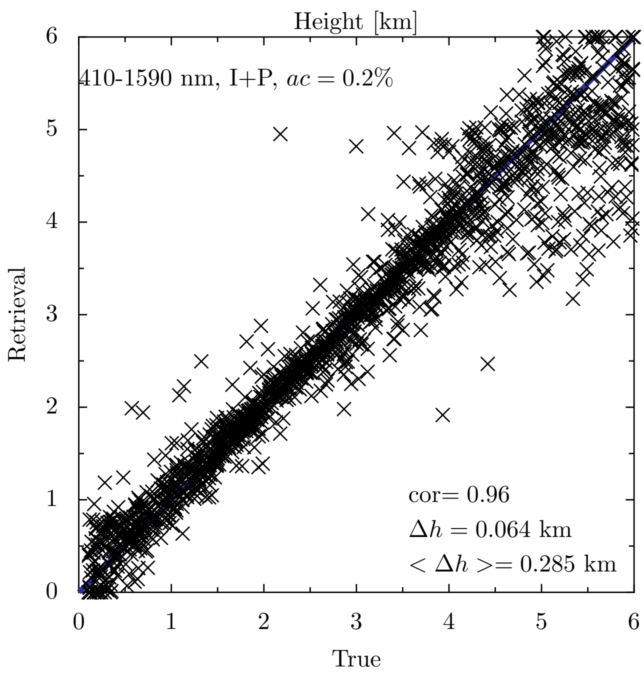

Figure S6. Retrieved versus true layer height for synthetic retrievals from synthetic measurements with varying layer width between 1.0 and 4.0 km, but a fixed layer width of 2.0 km assumed in the retrieval.

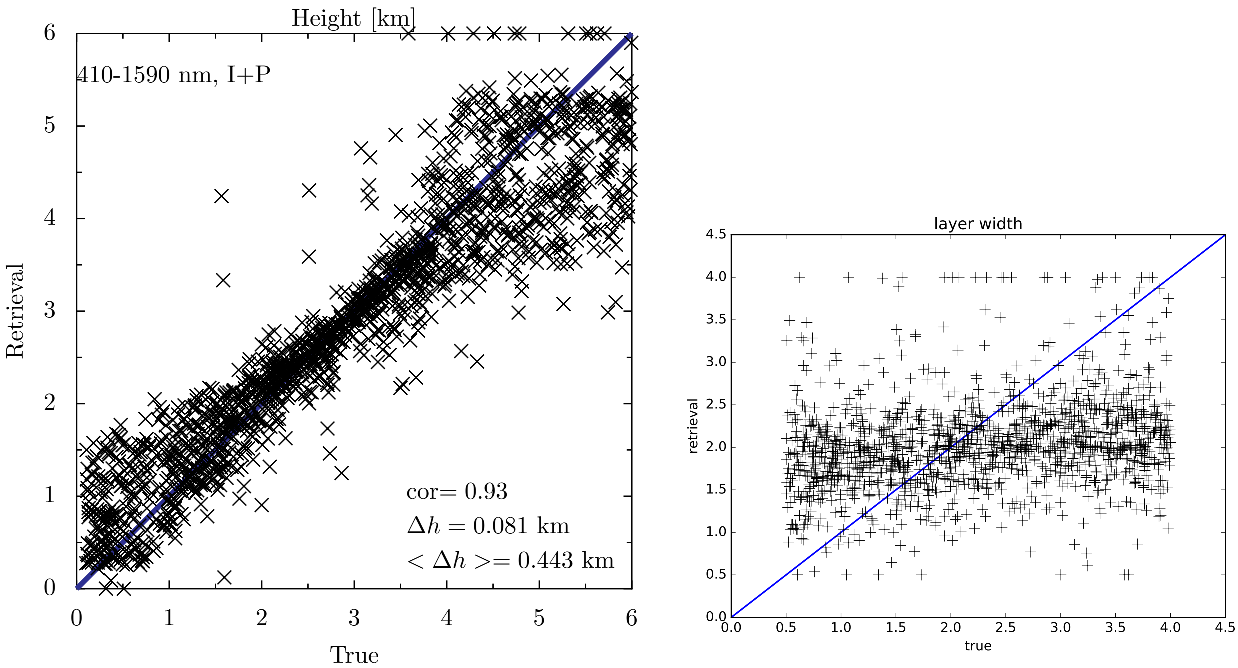

Figure S7. Same as Fig. S6, but when also width is included as unknown parameter in the retrieval (left), and (right) the retrieved values versus true width.

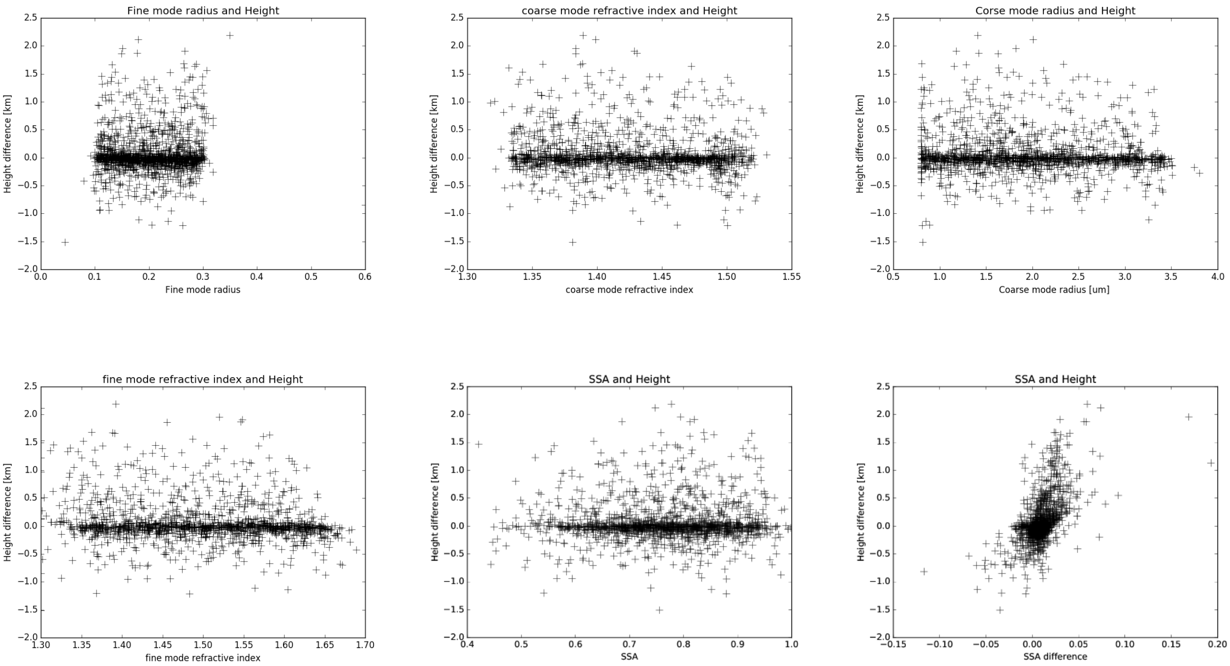

Figure S8. Correlation between height retrieval error on different aerosol parameters, including fine mode radius, coarse mode refractive index, coarse mode radius, fine mode refractive index, SSA and SSA difference.

Table S1. Free and fixed aerosol parameters used in our retrieval

Parameters	Free or fixed and range
fine mode effective radius	free, 0.1-0.3 [um]
fine mode effective variance	free, 0.1-0.3
fine mode refractive index, real part	free, 1.33-1.65
fine mode refractive index, imaginary part	free, 0.0-0.3
fine mode aerosol column	free, 0.05-0.7 (aot at 550 nm)
fine mode spherical fraction	fixed, 1.0
coarse mode effective radius	free, 0.6-3.5 [um]
coarse mode effective variance	free, 0.4-0.6
coarse mode refractive index, real part	free, 1.33-1.53
coarse mode refractive index, wavelength dependent ratio	free, 0-0.7
coarse mode refractive index, imaginary part	free, 0.0-0.008
coarse mode refractive index, wavelength dependent ratio	free, 0-0.7
coarse mode aerosol column	free, 0.05-0.7 (aot at 550 nm)
coarse mode spherical fraction	free, 0.001-1.0
center height of Gaussian height distribution	free, 100-6000 [m]
width of Gaussian height distribution	fixed, 2000
Scaling parameter for BPDF model	free
nu parameter of Maignan model	fixed
BRDF model (RPV) parameter 1	free
BRDF model (RPV) parameter 2	free
BRDF scaling parameters for wavelength band 410 nm	free
BRDF scaling parameters for wavelength band 470 nm	free
BRDF scaling parameters for wavelength band 550 nm	free
BRDF scaling parameters for wavelength band 670 nm	free
BRDF scaling parameters for wavelength band 865 nm	free
BRDF scaling parameters for wavelength band 1590 nm	free