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Impact of aerosol hygroscopic growth on retrieving aerosol extinction coefficient profiles from elastic-backscatter lidar signals

Gang Zhao et al.

Correspondence to: Chunsheng Zhao (zcs@pku.edu.cn)

1 The size-resolved κ

Fig. S1 shows the size-resolved κ by combining the GF data from the HTDMA and the method of Chen et al. (2012). The mean distribution of the size-resolved κ is used to represent the aerosol hygroscopicity in the NCP. The variation of size-resolved κ are used to conduct the sensitivity studies in section 4.2.2 of the article.

2 Variations of LR with RH

As shown in section of 4.1.1 in the article, $\mathrm{LR} = \frac{4\times\pi}{SSA\times PF(180)}$.

We calculated the variations of the PF(180) and SSA with RH. The aerosol phase function can be directly calculated by the Mie scattering model, which is introduced in section 3.1 in the article. The mean measured aerosol PNSD is used as the input and the other parameters are the same as those in the article. Fig.S2 shows the variation of phase function with RH. We can conclude that when the aerosol grows, there is a larger partition of forward scattering signals with increasing RH. The aerosol phase function increases in the range of 0 to 20 degree sand decreases in the range 160 to 180 degrees with the increase of RH. The PF(180) decreases 40% from 0.27 to 0.16. When the aerosol grows, it is reasonable that SSA increases with RH (Tao et al., 2014). In our study, the SSA increases 5% from 0.93 to 0.97.

With the synthetic variations of PF(180) and SSA with RH, it is reasonable that the LR increases with RH, as shown in fig. S3.

At the same time, we analyze the relationship between aerosol PNSD and the LR. As shown in fig. S4, the LR values of single particles with different aerosol diameter are calculated. The LR values tend to increase with the diameter in the range of 100nm to 288nm. LR decreases with the diameter when the particle is larger than 288nm. At the same time, the LR value of the measured mean PNSD is 47 sr, which corresponds to the single particle LR value with a mean diameter of 236nm. When the aerosol grows, the aerosol mean diameter increases and corresponds to larger LR. At the same time, most of the particles distribute in the range of 100 and 300nm. When these particles grow larger, they tend to have larger values of LR too.

3 Details about the MPL lidar signals

The auxiliary information of retrieving the MPL lidar signals, which is used to retrieve the MPL signals, is shown in fig. S5. It is shown that the environment at 13:00 is very wet with high RH of around 92% at the top of the mixed layer. Due to the influence of RH, the variable LR varies from around 25.8 sr at the ground to 45 sr at the top of the mixed layer, which is significantly different from the column-related constant LR of 26.6 sr. At the time of 14:30, the maximum RH in the mixed layer decreased to 86%, which corresponds to relative dry conditions with a mean value of 44.5% at the ground. The LR values are 26.5 sr at the ground and 38.4 sr at the top of the mixed layer. The received MPL signals are also shown in fig.S5 (b) and (d).

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Tao, J.C., Zhao, C.S., Ma, N., Liu, P.F. (2014) The impact of aerosol hygroscopic growth on the single-scattering albedo and its application on the NO2 photolysis rate coefficient. Atmos. Chem. Phys. 14, 12055-12067.

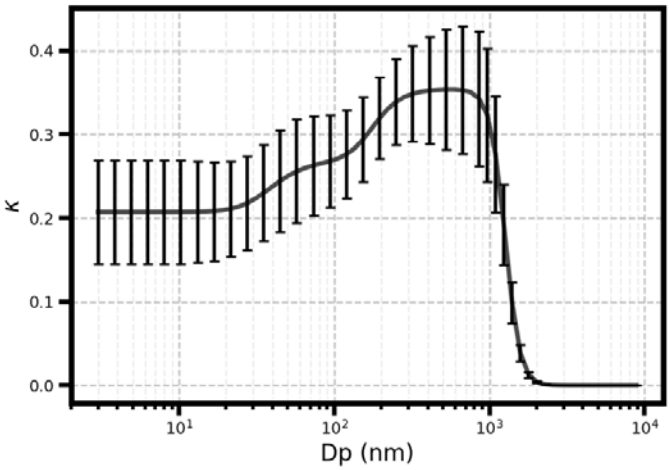

Figure S1. The κ values at different aerosol diameter. The solid line shows the mean distribution of the size-resolved κ.The error bars represent ± one standard deviation.

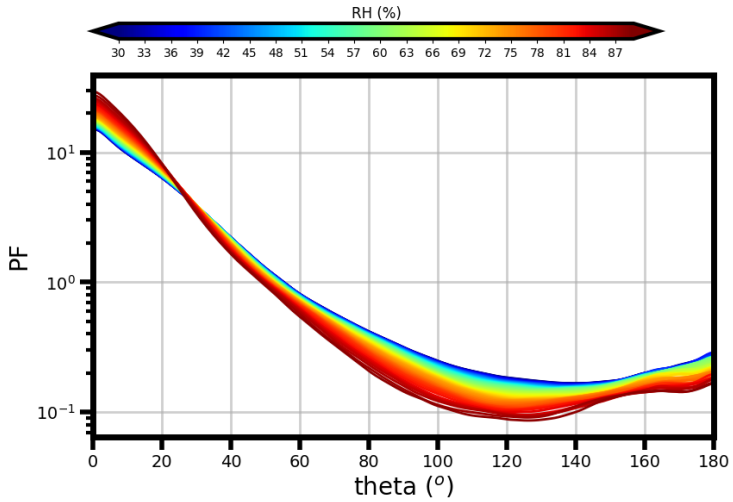

Figure S2. The aerosol phase functions under different RH conditions. Different colors represent the different RH.

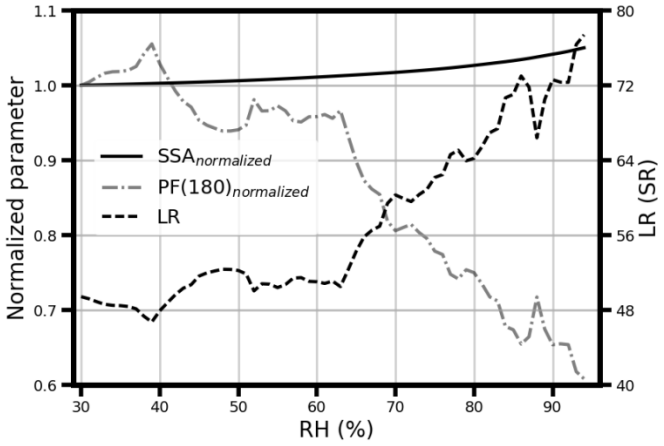

Figure S3. The variation of $SSA_{normalized}$, $PF(180)_{normalized}$ and LR with RH. The SSA and PF(180) are normalized to unity at RH=30%.

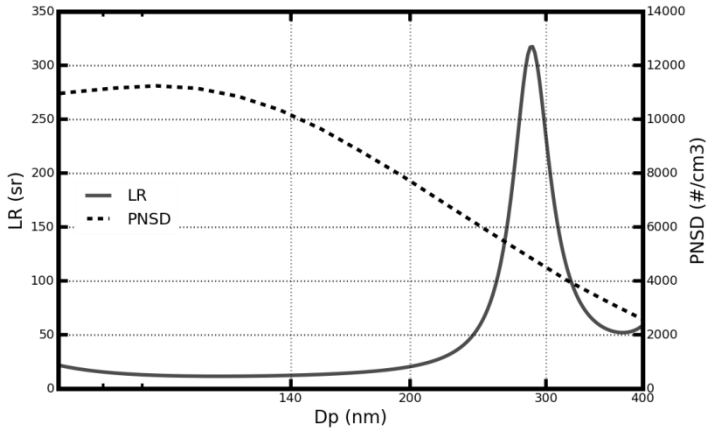

Figure S4. The solid line shows the variation of the LR values for single particles. The dashed line shows the measured mean aerosol PNSD.

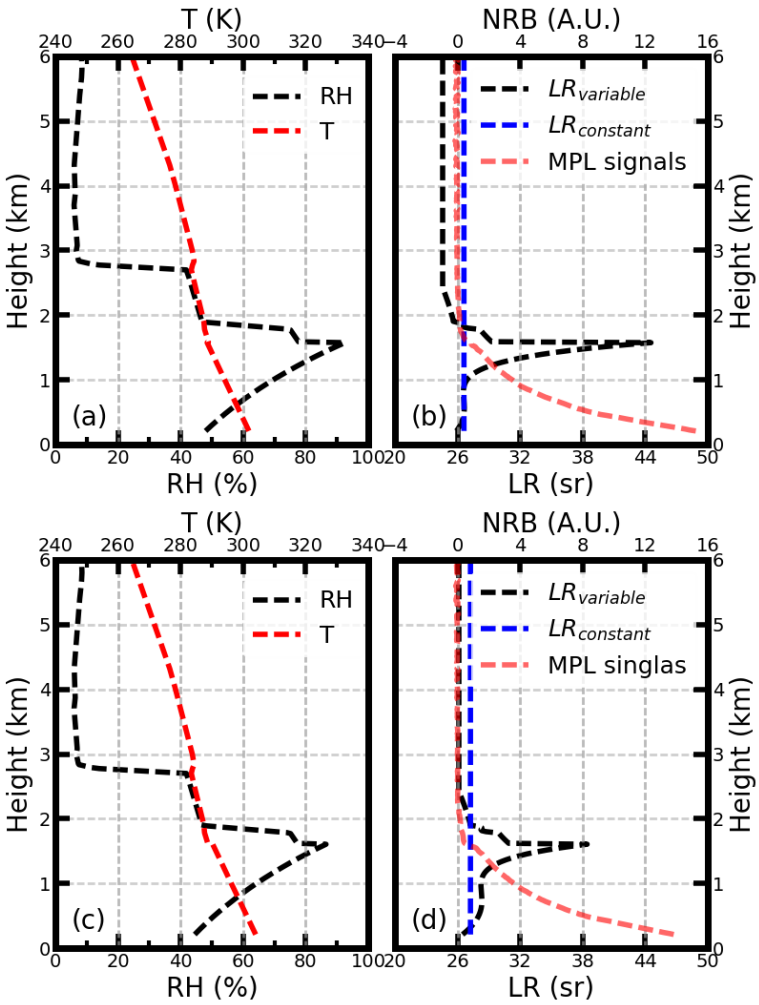

Figure S5. The auxiliary information used in retrieving the MPL signals. In panel (a), the black dashed line and red dashed line show the RH and temperature profile respectively at 13:00. The black dashed line, blue dashed line and red dashed line show the LR profile that is calculated with the LR enhancement factor, AOD determined column-related LR profile and the received MPL normalized relative backscatter signals (NRB), which is defined as $P(R) \cdot R^2$. The contents of fig. 5(c) and (d), which correspond to 14:30, are the same as those of fig. 5(a) and (b) respectively.