Response to comments of referee #2

General Comments:

Reviewer: *This paper proposed the new algorithm to estimate the mixing state of black carbon (BC) using the hemispheric backscattering fractions (HBF) obtained by a TSI nephelometer and adopted the algorithm to the observation conducted in a regional site in the North China Plane. Detail understanding of the mixing state of BC is essential to estimate the contribution of aerosol particles on the earth's radiation balance. Although there are large uncertainties in the estimation of the mixing state as mentioned in the manuscript, the algorithm is simple and needs only size distribution and mass concentration data in addition to TSI nephelometer data. I therefore recommend publication in ACP once the comments and questions below are addressed.*

Response: Thanks for the comments.

Major Comments:

Reviewer:

In eq.(5), the volume fraction of LAC to all aerosols is calculated. I think density for LAC in eq.(5) should be replaced by density for average of all aerosol particles.

Response:

The density used in eq. (5) should be the density of LAC. The volume fraction of LAC can be calculated as (eq. 5):

$$f_{LAC} = \frac{M_{LAC,measure}}{\rho_{LAC} \cdot \sum_{D_p} N\left(\log D_p\right)_{measure} \cdot \left(\frac{\pi}{6} \cdot D_p^3\right)}$$

where, $M_{LAC,measure}$ is the LAC mass concentration measured by MAAP. ρ_{LAC} is the density of LAC. $N(\log D_p)_{measure}$ is the PNSD measured by TDMPS and APS. The volume concentration of LAC is:

$$V_{LAC} = \frac{M_{LAC,measure}}{\rho_{LAC}}$$

The aerosol total volume concentration can be calculated as:

$$V_{total} = \sum_{D_p} N\left(\log D_p\right)_{measure} \cdot \left(\frac{\pi}{6} \cdot D_p^3\right)$$

So the volume fraction of LAC is:

$$f_{LAC} = \frac{V_{LAC}}{V_{total}} = \frac{M_{LAC,measure}}{\rho_{LAC} \cdot \sum_{D_p} N\left(\log D_p\right)_{measure} \cdot \left(\frac{\pi}{6} \cdot D_p^3\right)}$$

Therefore, the density of LAC should be used here. If the average density for all particles is used here, eq. (5) will equal to the mass fraction of LAC, but not the volume fraction.

Minor Comments:

Reviewer:

**page 27488 lines 9-10, Does "the average aerosol effective radius" mean number based mobility* *radius?*

Response:

The average aerosol effective radius does not stand for the number based mobility radius in this study. The effective radius is used under the definition of:

$$r_{eff} = \int_{r_{\min}}^{r_{\max}} n(r) r^3 dr \Big/ \int_{r_{\min}}^{r_{\max}} n(r) r^2 dr$$

where, n(r) is the aerosol number size distribution. r_{max} and r_{min} is the upper and lower limits of the size range of the size distribution (Mishchenko et al., 2006). "The average aerosol effective radius" is the temporal average of effective radii for the whole period. To clarify this, page 27488 lines 9-11 have been revised as "The average aerosol effective radius, defined as $r_{eff} = \int_{r_{\min}}^{r_{\max}} n(r) r^3 dr \Big/ \int_{r_{\min}}^{r_{\max}} n(r) r^2 dr$, is 185.15 nm, with a 5th percentage value of…".

Reviewer:

**page 27493 line 26 - page 27494 line 2, It would be nice to add some information on comparison between the obtained size dependence of the rext-LAS,model and those obtained with HHTDMA data.*

Response:

Thanks for this suggestion. A paper on the results of HHTDMA measurements has been published on the ACP HaChi special issue (Liu et al., 2011). There were already some discussion on the comparison between the HHTDMA measurements and the aerosol modeling results in that paper. In current manuscript, we focus on the methodology estimating the LAC mixing state from aerosol optical properties, and the method was applied to retrieve the LAC mixing state during the HaChi summer campaign. Therefore, we decided not to provide such information in the current manuscript.

Here we show a figure to provide some information on this issue. HHTDMA cannot provide direct information on how many LAC particles are externally mixed ($r_{ext\text{-}LAC}$). However, it can measure the number fraction of nearly-hydrophobic particles (hf_{NH}), as shown in the lower panel in figure 1. Assuming nearly-hydrophobic particles are mainly externally mixed LAC, these two parameters can be hence compared. It can be seen that there is no big difference between the measured hf_{NH} at 50, 100, 200 and 250 nm. However, large differences can be found between the $r_{ext\text{-}LAC,model}$ at different size ranges, as shown in the upper panel in figure 1. The $r_{ext\text{-}LAC,model}$ for large particles are much lower than that for small ones. The reason is that in the model, the initial aerosol for all size range is assumed to consist of LAC as 5% in mass. And the freshly emitted LAC particles are assumed to be distributed as a log-normal distribution with a geometric average diameter of 50 nm. Therefore, the fraction of externally mixed LAC decreases with the increase of particle size.

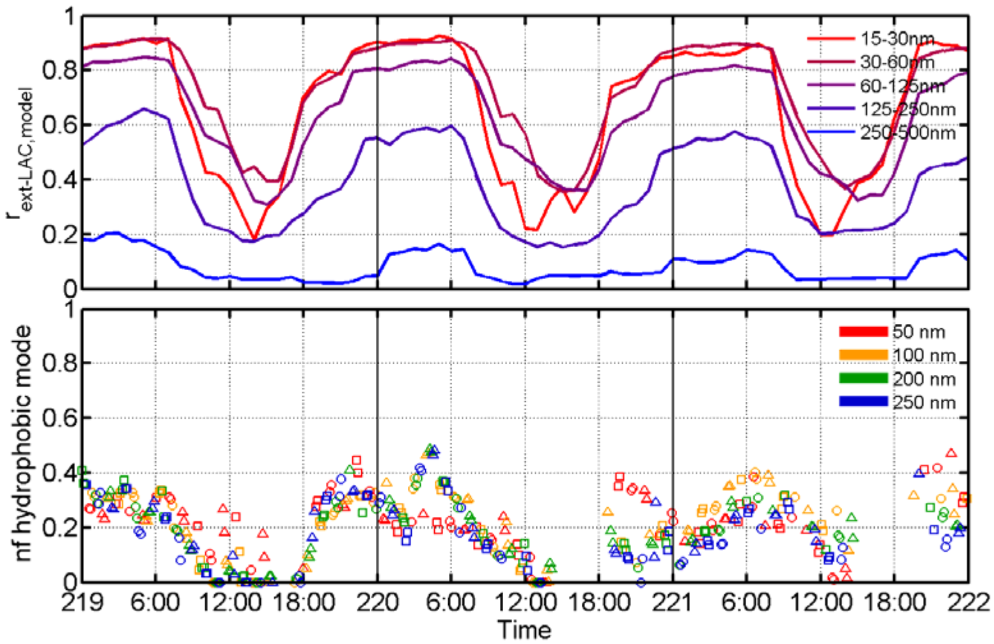

Fig. 1. Time series of the fraction of externally mixed LAC at different size ranges yielded from the PartMC-MOSAIC model (upper panel), and the number fraction of nearly-hydrophobic particles with diameter of 50, 100, 200 and 250 nm (lower panel). The marker of triangles, squares and circles respectively stand for the data measured as RH of 90%, 95% and 98.5.

References:

Liu, P. F., Zhao, C. S., Göbel, T., Hallbauer, E., Nowak, A., Ran, L., Xu, W. Y., Deng, Z. Z., Ma, N., Mildenberger, K., Henning, S., Stratmann, F., and Wiedensohler, A.: Hygroscopic properties of aerosol particles at high relative humidity and their diurnal variations in the North China Plain, Atmos. Chem. Phys., 11, 3479–3494, doi:10.5194/acp-11-3479-2011, 2011.

Mishchenko, M. I., Travis, L. D. and Lacis, A. A.: Multiple scattering of light by particles: radiative transfer and coherent backscattering, Cambridge Univ. Press, New York, 129-130, 2006