Dear Reviewers,

Thank you very much for your valuable comments on our paper amt-2012-97 “A new method for estimating aerosol mass flux in the urban surface layer by LAS”. Below we present the detailed replies to your comments.

Please find also the revised manuscript with all changes marked.

Yours sincerely

On behalf of all co-authors,

Renmin Yuan

Interactive comment on “A new method for estimating aerosol mass flux in the urban surface layer by LAS” by R. M. Yuan et al.

Anonymous Referee #2

Received and published: 15 February 2016

The manuscript is innovative to define the Atmospheric Effective Refractive Index (AERI) and the Atmospheric Effective Refractive Index Structure Parameter (AERISP), then, use the imaginary part of AERI to derive aerosol mass concentration and, particularly, its vertical flux. This is very important for numerical simulation of air quality and for the regional climate models. The results are generally acceptable.

Revision suggestions:

1. It may not be proper to differentiate the common used LAS and the USTC one by ’gLAS’ and ’sLAS’. The so-called sLAS, except a slightly shorter IR wavelength, others (especially hardware) are basically similar. The authors stressed the bandwidth of the amplifier and a higher sampling rate, however, the effects particularly in the low frequency region, which may be important for the detection of the imaginary part of AERI, are not clear. By the way, from the theory of LAS, the effective eddies are with the size about LAS aperture (here ~ 0.18 m, which is also in the inertial part of turbulence spectra). The contributions from high frequency smaller eddies and low frequency larger eddies are actually minor. This can be easily checked by the refractive index power spectra.

Answer: Now we use the same abbreviation for the traditional LAS for sensible heat flux and our made LAS.

The aperture just smooths the high frequency components with scale less than diameter of the aperture, and has no effect on the low frequency components. Based on numerical calculation, the log-intensity variance due to the imaginary part of the refractive index does not depend on the diameter of the aperture, but the log-intensity variance due to the real part of the refractive index depends on the diameter of the aperture (Yuan et al. 2015). For our experiment with the diameter of 0.18m, the contributions from high frequency smaller eddies are smoothed, and the contributions from low frequency larger eddies can be measured.

Yuan, R., Luo, T., Sun, J., Zeng, Z., Ge, C., and Fu, Y.: A new method for measuring the imaginary part of the atmospheric refractive index structure parameter in the urban surface layer, Atmos. Chem. Phys., 15, 2521-2531, 10.5194/acp-15-2521-2015, 2015.

2. As mentioned in later parts, the observation was conducted in late December. Do you think the using of ’free convection’ approximation (Eqs. (3), (4), etc.) is proper? As we know, using ’free

convection' in the LAS calculation of sensible heat flux may induce an underestimation of 20-30%. How much the error would be induced in the estimation of aerosol concentration and flux in this method? It would be not so difficult to use directly the general similarity formulas.

Answer: We think using of 'free convection' approximation (Eqs. (3), (4), etc.) is proper. According to the surface similarity theory (ST), we have

$$F_a = -M_* u_* = -(\frac{C_M^2}{C_T^2})^{1/2} T_* u_* \tag{1}$$

When free convection (FC) approximation is assumed, then we have,

$$F_a = a \cdot (\frac{g}{T})^{1/2} (C_M^2)^{1/2} (C_T^2)^{1/4} z \tag{2}$$

where the coefficient *a* can be set 0.567 (DeBruin et al. 1995; Lagouarde et al. 2006)

Figure 2 shows the comparison of aerosol mass fluxes calculated with Eqs. (1), F_{a_ST} and (2), F_{a_FC} respectively. According to Lagouarde et al. (2006), stable, neutral, and unstable stability can be classified as z/L <-0.15, -0.15<z/L<0 and z/L>0. The comparison shows the scattering is a little large under stable and weak unstable conditions, and the relative errors are 31% and 21% respectively. Good agreement is shown under unstable condition and the relative error is about 5%. All data together give a relative error about 8%. Equation (2) for FC approximation is very attractive from a practical point of view because it allows one to compute the flux without the need for any extra meteorological measurements and with an acceptable error.

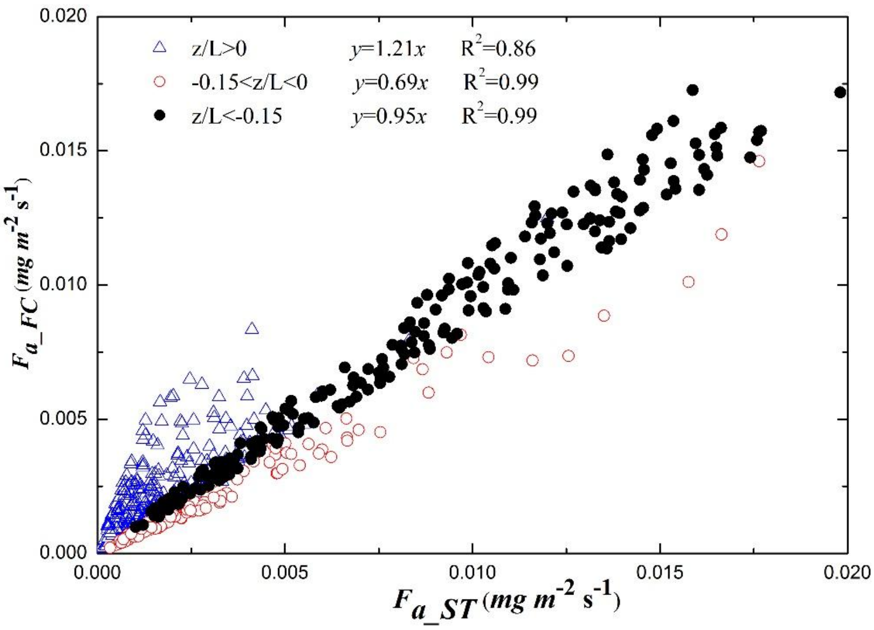

Figure 2 Comparison of aerosol mass fluxes based on the similarity theory (ST) and the free convection (FC) approximation under three different stability conditions (z/L <-0.15, -0.15<z/L<0 and z/L>0).

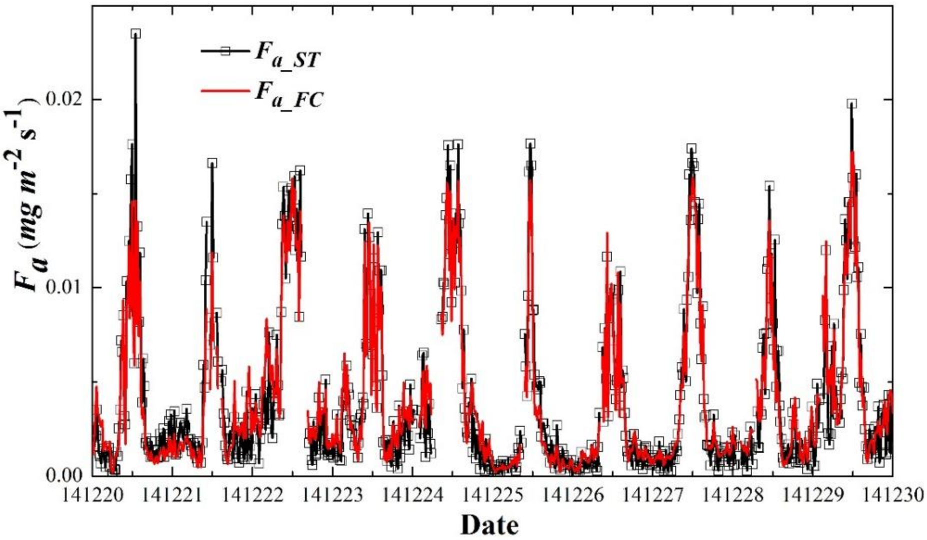

Figure 3. The time series aerosol mass flux derived from LAS measurements using the surface similarity theory (ST) (black rectangle symbol and line) and the free convection (FC) approximation (red line).

We modified the Section 2 and added Fig. 7 for comparison between applications of similarity theory and free convection approximation.

Please see Pages 4-5 and page 13 Lines 13-24.

3. It would be better to have some method used in Hefei to validate the results obtained with this new method.

Answer: We are planning to measure aerosol particle number flux with the eddy-covariance method.

4. 'Abstract' line 5-6, '...a new method for measuring atmospheric aerosol vertical transport flux is developed based on the similarity theory of surface layer'. This is in-complete. Actually, this work was also based on, especially, the observations & studies of the effective refractive index (and the theory of light propagation in turbulent atmosphere).

Answer: We modified the statement.

Please see Page 1 Line 14-16 in abstract.

Reference

DeBruin, H. A. R., vandenHurk, B., and Kohsiek, W.: The scintillation method tested over a dry vineyard area, Boundary-Layer Meteorology, 76, 25-40, 1995.

Lagouarde, J. P., Irvine, M., Bonnefond, J. M., Grimmond, C. S. B., Long, N., Oke, T. R., Salmond, J. A., and Offerle, B.: Monitoring the sensible heat flux over urban areas using large aperture scintillometry: Case study of Marseille city during the escompte experiment, Boundary-Layer Meteorology, 118, 449-476, 10.1007/s10546-005-9001-0, 2006.