Atmospheric
Chemistry
and Physics
Discussions

Open Access

EGU

# *Interactive comment on* "Wintertime Aerosol Optical and Radiative Properties in the Kathmandu Valley during the SusKat-ABC Field Campaign" *by* Chaeyoon Cho et al.

**Chaeyoon Cho et al.**

sangwookim@snu.ac.kr

Reply to Reviewer # 1 comments:

We appreciate your thoughtful and helpful comments. Our 'Reply' is embedded below. We hope we provide the appropriate answers, and if there are more questions, please let us know.

Best Regards, Authors

# Page 1, Line 26: Author should indicate the mass scattering efficiency is based on PM2.5 or PM10 measurements.

Thanks for a good suggestion. As we mentioned in Section 3.3, the aerosol mass scattering efficiency is calculated from PM10 measurements. We will clarify this in the revised manuscript.

# Page 1, Line 28: Author should clarify the 11 m2/g is based on PM10 or PM2.5. How about 7.5 m2/g.

As we replied above, the aerosol mass absorption efficiency (Qa) is also estimated from PM10 measurements (see Line 5-6, Page 7 of Section. 3.3). We also will clarify this in the revised manuscript. Many previous studies also showed Qa for BC from lab-generated aerosols, ambient aerosols, diesel engines and theoretical calculations (e.g., Mie scattering theory). Bond and Bergstrom (2006) reviewed all these published papers and suggested Qa of 7.5 m2/g for fresh BC. This value has been popularly used for simulating BC's radiative effect. Therefore we cited Qa of Bond and Bergstrom (2006) to explain why we observed higher Qa at Kathmandu.

# Page 2, Line 1: How do we estimate the values in different heights?

As we mentioned in the Methods (Section 2), in this study, aerosol direct radiative forcing (ADRF) was estimated by the column radiative transfer model, which calculates the net fluxes (i.e., up- and down-welling radiative fluxes) at 54 altitude levels, including the top of the atmosphere (TOA) and bottom of the atmosphere (BOA) with and without aerosols. Therefore, we can easily calculate ADRFs both TOA and BOA. Details are given in Won et al. (2004), which is also cited in this paper.

# Page 2, Line 3: How do we know this? performed the experiments?

Thanks for your comments. The EC to sulphate ratio given in this study was directly calculated from sulphate and EC concentrations, which were extracted from 24-h PM10 filter measurements (see Section 2; line 29 Page 3 – line 5 Page 4).

# Page 2, Line 13: Why dry season?

Air quality in the Kathmandu Valley during dry season is the worst in all year round

due to the combined effects of increased emissions, a build-up of pollutants under high pressure system, reduced wet scavenging, and a bowl-shape topography. Especially, as we mentioned in the manuscript (Sections 3.1 and 3.2), there are distinct increased combustions for house heating, and from a brick-baking factories during the dry season.

# Page 2, Line 23: considering very high values

Thanks for a good comment. BC mass concentrations observed in the Kathmandu Valley by Sharma et al. (2012) are similar to those measured at the polluted cities in India (Apte et al., 2011), but are much higher than other urban (Wang et al., 2005, Kedia et al., 2012)sites in East and South Asia.

Apte, J. S., Kirchstetter, T. W., Reich, A. H., Deshpande, S. J., Kaushik, G., Chel, A., Marchall, J. D., Nazaroff, W. W. (2011) Concentration of fine, ultrafine, and black carbon particles in auto-rickshaws in New Delhi, India, Atmospheric Environment, 45(26), pp. 4470-4480. Kedia, S., Ramachandran, S., Rajesh, T. A. and Srivastava, R. (2012) Aerosol absorption over Bay of Bengal during winter: Variability and sources, Atmospheric Environment, 54, pp. 738-745. Wang G., Bai, J., Kong, Q., Alexander, E. (2005) Black Carbon Particles in the Urban Atmosphere in Beijing, Advances in Atmospheric Science, 22(5), pp. 640-646.

# Page 3, Line 19: The discussion does not include g!!!

The asymmetric parameter showed small variations ($0.60 - 0.68$) at the Kathmandu Valley during the study period. So, we did not discussed in the manuscript. However, this asymmetric parameter was only used for the column radiative transfer model as an input.

# Page 3, Line 20: multiple points regression?

In this study, Angstrom exponent was calculated from aerosol optical depths at 5 wavelengths by linear regression.

# Page 3, Line 29: Why all use PM10?

Unfortunately, PM filter samples were only obtained in 10 ïA■m size-cut during the SusKat campaign.

# Page 4, Line 22: However, based on the Fig. 1d, during the pre-monsoon season it is not dominated by fine-mode particles.

We've already mentioned that coarse soil dust particles, mainly emitted from unpaved roads and farmland in the Kathmandu Valley, also exist, especially during dry winter and pre-monsoon periods. Please see the related sentences in line 23 - 24, page 4 of submitted manuscript.

# Page 5, Line 13: Why can the author be so sure to conclude that the main source is biogenic emission? Should summarize some evidence demonstrated in Sarkar et al. (2016).

Sarkar et al. (2016) reported high mixing ratios of isoprene (> 3 ppb) emitted from biogenic sources and low mixing ratios of acetonitrile, benzene and isocyanic acid emitted from biomass burning during period ÎŹ. In addition, brick kilns, which are major contributor for anthropogenic aerosols, were not operational at that period. Because detailed discussion on biogenic emission is given in Sarkar et al. (2016), we have not repeated in this paper.

# Page 5, Line 19: The collected samples are all PM10, how can the authors use the results to explain "fine scattering aerosols". The particle size distribution is another very important information for this study. Without PSD, the analysis seems incomplete.

Thank you for your comment. Because size-segregated aerosol chemical compositions and aerosol particle number size distributions were not measured during SusKat field experiment, we could not show direct evidences regarding to the reviewer's concern. Generally, it is well known that most scattering aerosols (sulphate, nitrate, ammonium, etc.) are found predominantly in the fine particles. For example, please see Figure 8.23

of 'Atmospheric chemistry and physics (by John H. Seinfeld and Spyros N. Pandis), which represent the typical urban aerosol size and composition distribution.

# Page 5, Line 26: Author should also provide PM mass concentration data. Not only TC, the analysis about EC & OC measured by Lab OC-EC Aerosol Analyzer Model 5 should be included.

It's a good suggestion. Thank you. The reason why we show only TC in here is that the temporal variation of PM10, TC, OC and EC concentration is almost identical. Daily mean EC, OC and PM10 concentrations are given in Kim et al. (2015, Atmos. Environ.), which report source apportionment of PM10 mass and particulate carbon. So, we do not show in this paper.

# Page 6, Line 8: I still do not get the explanations for this point.

Single scattering albedo ($\omega$) is defined as the ratio between scattering ($\sigma$s) and extinction ($\sigma$e = $\sigma$s + $\sigma$a). As we showed in Figure 3, aerosol scattering and absorption ($\sigma$a) coefficients observed almost same temporal variations during SusKat campaign. Thereby, $\omega$ is remained without sudden changes during the measurement period because it is calculated by $\sigma$s and $\sigma$a.

# Page 6, Line 27: The notation of mass efficiency should be unified. In the table, alpha was used.

We have corrected it. Thank you.

# Page 7, Line 3: Was this EC mass conc. determined by Lab OC-EC Aerosol Analyzer Model 5? The EC measured by TOT method usually leads to smaller values compare to TOR. Please include the discussion about the influence on the Qa estimated here.

Thanks for the good comment. According to Chow et al. (2004), EC results determined by simultaneous thermal/optical transmittance (TOT) corrections are generally 30 % lower than thermal/optical reflectance (TOR) for the same temperature protocol. This can be resulted in about 30 % difference in Qa. However, we have not mea-

sured EC mass by both TOT and TOR methods during SusKat campaign (only by TOT method), so we cannot estimate the influence of EC analysis method on Qa estimation. Therefore, we have not discussed in the manuscript.

# Page 7, Line 7: The experimental evidences provided here is not enough to make this conclusion. For example, how can we know the carbonaceous aerosols here are fresh? What is the typical value of so-called short distance? The unique topography here limited the pollutant transport (as described at beginning). Will it lead to particle aging here? These should be justified or clarified here. In addition, as mentioned previously, the EC value could be underestimated.

Thank you for the comment. About 11 m2 g-1 of Qa observed in the Kathmandu Valley was higher than that of fresh BC (7.5 m2 g-1; Bond and Bergstrom, 2006). This elevated Qa can be explained by the enhanced light absorption due to aging process during the transport over short distance (a few $\sim$ a few 10 km). To avoid the confusion, we rewrote the sentence in the revised manuscript to read:

"We can conclude that most of the carbonaceous aerosols in Bode were externally mixed with other aerosols under dry conditions during the transport of over short distance (less than a few 10 kilometers) from their sources."

# Page 7, Line 10: Since the author has performed 7-wavelenth Aeth and OC/EC measurements, more detail analysis about OC/EC was expected and could provide some insight of diurnal pattern.

We have showed the diurnal variation of BC mass from aethalometer measurements (See Figure 5 and related sentences in Section 4). Contrary to aethalometer-measured BC mass, EC/OC mass was extracted from 24-h sampling filters. So, unfortunately, we cannot discuss their diurnal variation.

# Page 7, Line 14: However, the wind direction changed a lot. It seems not likely to be emitted from the same source.

Winds observed at Bode varies in relation to topography-induced circulations in the Kathmandu Valley. As we cited in many papers (e.g., Panday and Prinn, 2009), the changes in wind direction during the day influence on the accumulation or ventilation of aerosols within the Valley. That is, the amount of light-absorbing aerosols can be changed, as indicated by the aerosol absorption coefficient (see Figure 5). However, the proportion of light-absorbing aerosols of the total aerosol composition is not much changed. This is well consistent with the variation of single scattering albedo (see aforementioned our reply for the previous comment).

# Page 18: What is wrong with the data in July?

The AERONET sun/sky radiometer generally measures columnar aerosol properties during the daytime under cloud-free conditions. However, we have not obtained valuable observation data under rainy and cloudy conditions during summer monsoon, especially in July at Kathmandu.

# Page 20: It is not fair to present the hourly variation using the contour plot. This kind of plot implicitly assumed the measured values at the same time but different dates are correlated. However, it is unnecessarily to be true.

We think that Figure 3 is an ideal plot to represent the diurnal and day-to-day variations of several parameters at a glance.

**Thank you again for your valuable comments and suggestions.