Response to Anonymous Referee #1

We thank you for your careful reading of the manuscript. The comments and suggestions are valuable and very helpful for revising and improving our manuscript. We have made revisions according to your comments and suggestions, as described below.

General Comment

(1) This paper presents some information on aerosol optical properties in the Himalayan region that may possibly make a useful contribution to the literature. However the authors have failed to follow the AERONET guidelines for authorship of this paper. The paper analyzes data from only three AERONET sites therefore they should have offered co-authorship to the PI's of the sites they did not establish, both Pokhara and EVK2. From the AERONET web page (copied; same for Pokhara): "The public domain data you are about to download are contributed by the International AERONET Federation. Each site has a Principal Investigator(s) (PI) , responsible for deployment, maintenance and data collection. The PI has priority use of the data collected at the site. The PI is entitled to be informed of any other use of that site data. The Principal Investigator(s) of 'EVK2-CNR' is(are): Brent Holben. If you intend to use the following data please consult with him/her/them via e-mail(s):brent@aeronet.gsfc.nasa.gov Recommended guidelines for data use and publication: Although journal paper authorship and acknowledgement is the domain of the senior author and no policy is universally applicable, the AERONET contributors ask that every practical attempt be made to honor the following general guidelines. Using AERONET data - Please consult with the PI(s) of the data to be used. Publishing AERONET data from a 'few' sites – Please consider authorship for the PI(s) and/or the following acknowledgement: We thank the (Project/PI) for (its/theirs) effort in establishing and maintaining (site name(s)) sites."

Response

Thank you very much for your comments and suggestions. We are really very sorry about the improper use of data due to my carelessness. We do our best to gain their forgiveness. We have consulted with them, Prof. Arnico Panday (Pokhara PI) and Prof. Zhiyuan Cong (QOMS_CAS PI) have agreed to be the co-authors and improve the paper quality with us. Prof. Gian Paolo Gobbi (EVK2-CNR PI) agreed us to use the data, and recommended that we only added acknowledgement. Therefore we have added 'We thank G. P. Gobbi (ISACCNR) and G. P. Verza (EVK2-CNR), for their effort in establishing and maintaining the EVK2-CNR AERONET site. We thank A. Panday and Gupta Giri for their effort in establishing and maintaining the Pokhara AERONET site. We thank Z. Y. Cong for his effort in establishing and maintaining QOMS_CAS AERONET site.' in the acknowledgement of the new revised manuscript.

(2) Another issue that is almost as equally important is that the authors have used both level 1.5 and level 2 AERONET data even though level 1.5 data are of poorer quality.

Since the AERONET data are the primary data used in this study it is strongly recommended that only Level 2 data be analyzed to maintain consistent and high data quality throughout the paper.

Response

Thank you very much for your comment and suggestion. The quality of level 1.5 data is actually poorer than level 2.0. However, level 2.0 data are not enough to provide continuous records to analyze the aerosol optical properties, especially for QOMS_CAS station. Therefore, level 1.5 data are used in the case of lacking level 2.0 data during some periods. For example, level 2.0 data at QOMS_CAS are available only during Oct., 2010 to Oct., 2011. Then level 1.5 data during Oct., 2009 to Jul., 2010 and Nov., 2011 to Dec., 2012 are used as an alternative to provide a longer time series of aerosol optical properties. Some unreliable measurements are eliminated before the statistical analysis. And the exclusion of unreliable data can improve the data quality at some extent. The median, rather than the mean is used to represent the seasonal variations. Some extreme events would not have great influence on the analysis of results. Data that within a day are less than five hours would be excluded in calculating diurnal variations, and this can also improve the data quality.

(3) Additionally it should be noted in the paper that Angstrom Exponent (AE) has large uncertainty at low AOD and also that the AOD (and AE) have some significant cloud contamination in the rainy monsoon season months, thereby decreasing the AE and increasing the AOD. This is particularly significant in the high precipitation (and high cloud fraction) months of June through September. The uncertainty in the AE parameter should be computed by the authors so that it is clear that the AE values at low AOD conditions at EVK2 and QOMS_CAS sites have very large uncertainty that increase as optical airmass decreases, thereby possibly creating erroneous diurnal variations. The authors currently present the data while ignoring these issues.

Response

Thank you very much for your comment and suggestion. AE actually has large uncertainty at low AOD. However, we believe uncertainty in AE has no significant impact on the results. We appreciate your recommended literatures in Special comment (16), and we make a simple calculation about uncertainty in AE using the method in your recommended literatures. If uncertainty in AOD is about 0.02, uncertainty in AE is about 0.04. Even if uncertainty in AOD is about 0.05, uncertainty in AE is about 0.10. The seasonal median of AE from January to December is 0.71, 0.88, 0.91, 1.08, 0.90, 0.89, 0.47, 0.52, 0.69, 0.76, 0.75 and 1.17, respectively. Compared with the seasonal medians, the uncertainty in AE is low enough. If we assume large uncertainty in AE exists at some extent, the uncertainty should be presented as a random distribution. And the diurnal variation pattern of AE cannot be consistent across years as a result. However, the diurnal variation of AE shows a consistent pattern among years in this study. Therefore, we deduced that uncertainty in AE cannot create erroneous diurnal variations.

In the new revised manuscript, we added the estimation of AE uncertainty in Section

2.2 in the revised manuscript. The sentences are 'The equation $\Delta AE = \left(\varepsilon_{\lambda_1}^2 + \varepsilon_{\lambda_2}^2\right)^{\frac{1}{2}} / \ln\left(\frac{\lambda_1}{\lambda_2}\right)$ can be used to estimate the uncertainty in AE where ε_{λ_1} and ε_{λ_1} are the uncertainties in AOD at two different wavelengths (Hamonou et al., 1999). If the uncertainties in AOD at different wavelength are set to the same value, the uncertainty in AE can be estimated by a simple calculation. When the uncertainty value of AOD is 0.01, the uncertainty in AE at 440-840nm is about 0.02. When the uncertainty value of AOD is 0.02, the uncertainty in AE at 440-840nm is about 0.04. Even if uncertainty in AOD is about 0.05, uncertainty in AE is about 0.10. Compared to the value of AE, uncertainty is low enough and has no significant effect on the results in this study.' .

Cloud contamination is inevitable in the observations, and may have an effect on the observations at some extent. However, we think that parts of possible origins of these particles are long-range transported dust or wind erosion. Chatterjee et al. (2010) collected aerosol samples directly over a high altitude station at Northeastern Himalayas, and found that fine mode aerosol dominated during dry seasons and coarse mode aerosol dominated during monsoon. The result of direct sampling observations is consistent with this study. Therefore, we think the phenomenon is not an illusion caused by high precipitation or high cloud fraction. And we added some discussions to be more precise 'It is possible that during monsoon season, higher total AOD at QOMS_CAS and EVK2-CNR may be partly caused by cloud contamination, as low AE and high precipitation occur during this period. However, higher total AOD during monsoon season may also be a natural phenomenon: dust transported to these sites or wind erosion taking place nearby can be seen during monsoon season. Direct sampling observations over Northeastern Himalayas have found fine mode aerosol dominating during dry seasons and coarse mode aerosol dominating during monsoon (Chatterjee et al., 2010), which is consistent with the result of this study.' (please see Page 15 line 23-28 and Page 16 line 1-2 in the revised manuscript). We also have changed the expression in parts of abstract in Page 2 line 12-14 'Dust transported to these sites, wind erosion and hydrated/cloud-processed aerosols lead to an increase in coarse mode AOD during the monsoon season at QOMS_CAS and EVK2-CNR.' and in parts of conclusion in Page 24 line 17-19 'During monsoon season, dust, wind erosion and hydrated/cloud-processed aerosols may lead to high aerosol loads at QOMS_CAS and EVK2-CNR.'.

Chatterjee, A., Adak, A., Singh, A. K., Srivastava, M. K., Ghosh, S. K., Tiwari, S., Devara, P. C., and Raha, S.: Aerosol chemistry over a high altitude station at northeastern Himalayas, India, PloS one, 5, e11122, doi:10.1371/journal.pone.0011122, 2010.

(4) Figure 3 is one of the most important in the paper yet the large number of small panels makes it very difficult to read. I suggest breaking it up into 2 different figures, the first one for AOD and the second for Fine Mode AOD. More importantly, it is unusual to plot AOD figures with a logarithmic y-axis, and this makes these AOD

plots very difficult to interpret. All other Figures in the paper have linear y-axis scales and are therefore much easier to interpret. I strongly suggest plotting the AOD data with linear y-axis and also removing the 99% and 1% values in the plots (these can be listed in a table if you feel they are valuable).

Response

Thank you very much for your comment and suggestion. We followed your suggestion, and broke Figure 3 into 2 different figures in the revised manuscript (please see Figure 3 and Figure 4).

The AOD plots in logarithmic y-axis are actually unusual and difficult to interpret. We followed your suggestion and plotted AOD figures with linear y-axis scales. We maintained the 99% and 1% values. Removing the 99% and 1% values can reduce the effect of potential extreme values. However, some real values may be also removed at the same time (For example, on March 23 2010, total AOD is 1.89 and fine mode AOD is 1.80 in level 2.0 data at Pokhara, which is removed using the 99% and 1% values. We think this measurement is reliable.). And then some true phenomena may be lost. To interpret AOD and show seasonal variations clearly, we plot AOD figures with both linear y-axis scales and logarithmic y-axis scales (please see Figure 3 and Figure 4). If we only plot the AOD data with linear y-axis, the seasonal variations cannot be shown clearly in the sites with small ranges. For example, if the total AOD y-axis limit is set to 2.5, AOD at both QOMS_CAS and EVK2-CNR (seasonal medians of total AOD <0.10 at both sites) appears to be very close to x-axis. Logarithmic y-axis doesn't change the seasonal variations, but shows the seasonal variations clearer in the figures. In the revised manuscript, we added some sentences 'Total AOD and fine mode AOD are plotted with both linear y-axis scales and logarithmic y-axis scales, because AOD values can be interpreted easily and seasonal variations of AOD can be shown clearly.'(please see Page 9 line 1-4 in the revised manuscript). Although plotting with both linear y-axis scales and logarithmic y-axis scales makes panels small, we think both these two scales are necessary to show seasonal variations clearly.

Special Comment

(1) Page 20966, lines 20-21: This sentence is awkward, and does not specify whether the uncertainty you are discussing refers to the retrieval parameters or to the AOD.

Response

Thank you for your comment and suggestion. The previous expression is actually confusing. We indicated that the uncertainty in AOD is larger at low AOD. To express more precisely, we changed the sentence into 'Uncertainty in AOD increases with decreasing aerosol load (Dubovik and King, 2000).'(please see page 6, line 23 in the revised manuscript).

(2) Page 20968, lines 9-11: Please specify that the fine mode AOD you are utilizing is from the Dubovik retrievals and that the radius cutoff for fine versus coarse is defined as the minimum between the two modes for each individual almucantar retrieval, and

that this cutoff radius varies from 0.44 to 0.99 microns radius.

Response

Thank you for your suggestion. The fine mode AOD and total AOD we have used are SDA retrievals. The previous description of the data is vague. We have added this sentence 'Total AOD and fine mode AOD data are based on the Spectral Deconvolution Algorithm (SDA) retrievals (O'Neill et al., 2003).' (please see Page 8, line 19-21 in the revised manuscript).

O'Neill, N. T., Eck, T. F., Smirnov, A., Holben, B. N., and Thulasiraman, S.: Spectral discrimination of coarse and fine mode optical depth, J. Geophys. Res.-Atmos., 108, doi:4559, 10.1029/2002JD002975, 2003.

(3) Page 20968, line 26: ' <0.44' should be ' < 0.40'

Response

Thank you for your suggestion. We followed your suggestion, and changed '<0.44' to '< 0.40'.

(4) Page 20969 lines 3-7: The English here is awkward and confusing. Additionally it would be much better to use the Spectral Deconvolution Algorithm (SDA; also available from the AERONET web page) retrievals of fine and coarse mode AOD rather than the Dubovik retrievals since these are made for every AOD measurement rather than only a few times per day.

Response

Thank you for your comment and suggestion. The data we have used are SDA retrievals of fine and coarse mode AOD. SDA retrievals of fine and coarse mode AOD are much less than the direct sun products of AOD and AE. Therefore, we use the direct sun products of AOD and AE for the calculation of diurnal variations. Maybe the previous description of the data is confusing. We changed the description into 'The direct sun products of AOD and AE are used in our examination of diurnal variations. The direct sun products of AOD data have a much longer time series because total AOD and fine mode AOD are calculated by SDA. Thus the diurnal variations of total AOD and fine mode AOD cannot be calculated due to sparse data and poor continuity.' (please see Page 9, line 17-21 in the revised manuscript).

(5) Page 20969 lines 10: Do you mean 'all hourly average observations in a day' here?

Response

Thank you for your comment. We actually express this meaning. To be more precise, we changed the expression into 'All hourly average observations in a day are expressed as a departure percentage from the daily mean' (please see Page 9, line 23-24 in the revised manuscript).

(6) Page 20969 lines 27: Please replace 'rare' with 'sparse' here and at all other places in the paper.

Response

Thank you for your suggestion. We replaced all the expressions of 'rare' with 'sparse' in the revised manuscript.

(7) Page 20971 lines 17-18: Please mention here that since AE is low in August and precipitation is high that it is likely that the higher AOD here is partly due to cloud contamination.

Response

Thank you for your suggestion. We followed your suggestion and made some discussions to be more precise 'It is possible that during monsoon season, higher total AOD at QOMS_CAS and EVK2-CNR may be partly caused by cloud contamination, as low AE and high precipitation occur during this period. However, higher total AOD during monsoon season may also be a natural phenomenon: dust transported to these sites or wind erosion taking place nearby can be seen during monsoon season. Direct sampling observations over Northeastern Himalayas have found fine mode aerosol dominating during dry seasons and coarse mode aerosol dominating during monsoon (Chatterjee et al., 2010), which is consistent with the result of this study.' (please see Page 15 line 23-28 and Page 16 line 1-2 in the revised manuscript).

Chatterjee, A., Adak, A., Singh, A. K., Srivastava, M. K., Ghosh, S. K., Tiwari, S., Devara, P. C., and Raha, S.: Aerosol chemistry over a high altitude station at northeastern Himalayas, India, PloS one, 5, e11122, doi:10.1371/journal.pone.0011122, 2010.

(8) Page 20972 line 25: 'shown' should be 'show'

Response

Thank you for your suggestion. We replaced 'shown' with 'show' in the revised manuscript.

(9) Page 20973 lines 12-16: This sentence does not make much sense since you say seasonal yet are discussing monthly means that are not the seasonal 3-month intervals that were previously defined.

Response

Thank you very much for your comment. We are grateful that you point out this problem. This expression 'seasonal' is not accurate. Therefore, we changed 'seasonal' into 'monthly' in Section 3.2. We think that monthly means can show these effects clearer than 3-month intervals, such as fire emissions or dust. Diurnal variations using the seasonal 3-month intervals can better compare diurnal variation pattern with others' results.

(10) Page 20975 lines 4-5: This sentence does not really make much sense, so please clarify here.

Response

Thank you for your comment and suggestion. The previous expression is wordy. We changed it into 'The diurnal variations of precipitation show a consistent pattern in each season across the years.' (please see Page 16 line 6-7 in the revised manuscript), and deleted the next sentence 'And only diurnal variations of the average PR are displayed.'.

(11) Page 20976 both line 9 and line 24: Please note that ~15 to 20% range in daytime AOD variation is quite significant. By plotting all three sites on one plot the scaling makes it difficult to see the diurnal AOD trends in the sites with the lower ranges.

Response

Thank you for your suggestions. We followed your suggestion and re-plotted this figure on two plot scaling. QOMS_CAS and Pokhara with the lower ranges are on one plot scaling, and EVK2-CNR is on the other plot scaling. Please see Figure 9 in the revised manuscript. We add the sentence to describe the plot scaling 'In Figure 9, QOMS_CAS and Pokhara are shown on the left scale, and EVK2-CNR is shown on the right scale, which make it easier to see the diurnal AOD trends at QOMS_CAS and Pokhara with the lower ranges.' (please see Page 17 line 10-13 in the revised manuscript)

(12) Page 20976, Section 3.3.2: Please make sure that you have enough observations at hour 18 to be representative versus the other hours of the day.

Response

Thank you for your comment and suggestion. We have checked the original data and intermediate results. There are adequate observations for the AOD decrease from 15:00 to 17:00 at QOMS_CAS. But there are no adequate observations at hour 18 versus the other hours of the day in summer at QOMS_CAS and in spring at Pokhara. To be more precise, we have deleted the sentences 'which can result in a decrease of the average aerosol size in a fixed time. For example, the diurnal peak value of rainfall exists in spring at Pokhara. AOD decreases, but AE increases slightly. The same phenomenon happens in autumn at QOMS_CAS.' in Page 20 in Section 3.3.4 in the revised manuscript.

(13) Page 20977, Lines 12-17: Please give the % diurnal range for the Pokhara site, similar as you did for the EVK2 site in the previous paragraph.

Response

Thank you for your suggestion. We followed your suggestion, and changed the sentence 'The relative daytime variation range in summer is about 10 %, and much smaller than other seasons' into 'The relative daytime variation range is about 28% in MAM, 10% in JJA, 27% in SON and 23% in DJF.' (please see Page 19 line 2-3 in the revised manuscript).

(14) Page 20977, Lines 18: Make sure that you have enough observations at hour 18 to be representative versus the other hours of the day.

Response

Thank you very much for your comment and suggestion. And we appreciate that you point out the problem which we have ignored before. We have checked the original data and intermediate results. There are no adequate observations versus the other hours of the day. We changed the expression into 'In MAM, AOD at 18:00 decreases quickly, likely due to wet deposition by precipitation during the frequent pre-monsoon evening rainfalls experienced in Pokhara. Unfortunately, whether decreasing AOD is caused by precipitation is not confirmed due to inadequate observations of AOD versus the other hours of the day.' (please see Page 18 line 25-28 and Page 19 line 1 in the revised manuscript).

(15) Page 20977, Lines 27-28: The diurnal pattern of AE at QOMS_CAS could be due to greater uncertainty in AE at smaller solar zenith angles (minimum SZA at solar noon).

Response

Thank you for your comment. In the special comment (16), we estimated the uncertainty in AE. The uncertainty in AE is usually about 0.04. Comparing with the seasonal medians of AE, the uncertainty in AE is low enough. If we assume greater uncertainty in AE at smaller solar zenith angles at some extent, the uncertainty should be presented as a random distribution. And the diurnal variation pattern of AE cannot be consistent across years. Therefore, we think uncertainty in AE cannot create erroneous diurnal variations.

(16) Page 20978 lines 9-12: Please put these ranges of AE into the context of the computed uncertainty in AE, see Hamonou et al. (1999) and Kato et al. (2000) both in JGR for equations to compute uncertainties for both AOD and AE.

Response

Thank you for your suggestion. We appreciate for your recommended literatures. Both the literatures have mentioned the method to compute the uncertainties in AE. We used the equation in Hamonou et al. (1999) to estimate the uncertainty. The equation is $\Delta\alpha = \left(\varepsilon_{\lambda_1}^2 + \varepsilon_{\lambda_2}^2\right)^{\frac{1}{2}} / \ln\left(\frac{\lambda_1}{\lambda_2}\right)$. ε_{λ_1} and ε_{λ_1} mean the uncertainty in AOD at different wavelengths. Uncertainty in the optical thickness will evidently result in uncertainty in AE. We have known the general uncertainty in AOD is about 0.01 to 0.02. If the uncertainties of AOD at two different wavelengths are set to same value, we can use the general uncertainty at two wavelengths to do a simple calculation. When the uncertainty value of AOD is 0.01, the uncertainty in AE at 440-840nm is about 0.02. When the uncertainty value of AOD is 0.02, the uncertainty in AE at 440-840nm is about 0.04. When the uncertainty value of AOD is 0.03, the uncertainty in AE at 440-840nm is about 0.06. When the uncertainty value of AOD is 0.04, the uncertainty in AE at 440-840nm is about 0.08. When the uncertainty value of AOD is 0.05, the uncertainty in AE at 440-840nm is about 0.10.

To be more precise, we added the estimation of AE uncertainty in Section 2.2 in the revised manuscript. The sentences are 'The equation $\Delta AE = \left(\varepsilon_{\lambda_1}^2 + \varepsilon_{\lambda_2}^2\right)^{\frac{1}{2}} / \ln\left(\frac{\lambda_1}{\lambda_2}\right)$ can be used to estimate the uncertainty in AE where ε_{λ_1} and ε_{λ_1} are the uncertainties in AOD at two different wavelengths (Hamonou et al., 1999). If the uncertainties in AOD at different wavelength are set to the same value, the uncertainty in AE can be estimated by a simple calculation. When the uncertainty value of AOD is 0.01, the uncertainty in AE at 440-840nm is about 0.02. When the uncertainty value of AOD is 0.02, the uncertainty in AE at 440-840nm is about 0.04. Even if uncertainty in AOD is about 0.05, uncertainty in AE is about 0.10. Compared to the value of AE, uncertainty is low enough and has no significant effect on the results in this study.' (please see Page 6 line 26-28 and Page 7 line 1-6).

From the above simple calculation, we can know that the uncertainty in AE has no significant effect on the results. And the results are reliable in this study.

Hamonou, E., Chazette, P., Balis, D., Dulac, F., Schneider, X., Galani, E., Ancellet, G., and Papayannis, A.: Characterization of the vertical structure of Saharan dust export to the Mediterranean basin, J. Geophys. Res.-Atmos., 104, 22257-22270, doi:10.1029/1999JD900257, 1999.

(17) Page 20979 lines 9-10 & lines 14-15: Please explain the physical mechanism that results in wet deposition selectively removing more fine versus coarse mode particles (or vice versa) and give references for this.

Response

Thank you for your comment and suggestion. Our previous expression is not quite accurate. To be more precise, we added some references 'A previous study reported that larger aerosol particles consisting of more internally mixed hygroscopic compounds could be more likely removed via nucleation scavenging (Moteki et al., 2012). Another study proposed that precipitation would tend to remove the larger particles first and then smaller particles after the larger ones have been removed (Tunved et al., 2013). This assumption indicates that precipitation can also affect the average particle size.' (please see Page 20 line 20-26 in the revised manuscript). This reference showed the mechanism of the precipitation removal, and indicated that precipitation selectively removed the particles.

Moteki, N., Kondo, Y., Oshima, N., Takegawa, N., Koike, M., Kita, K., Matsui, H., and Kajino, M.: Size dependence of wet removal of black carbon aerosols during transport from the boundary layer to the free troposphere, Geophys. Res. Lett., 39, L13802, doi:10.1029/2012GL052034, 2012.

Tunved, P., Strom, J., and Krejci, R.: Arctic aerosol life cycle: linking aerosol size distributions observed between 2000 and 2010 with air mass transport and precipitation at Zeppelin station, Ny-Alesund, Svalbard, Atmos. Chem. Phys., 13, 3643-3660, doi: 10.5194/acp-13-3643-2013, 2013.

(18) Page 20980 lines 15-17: Note that AE is much more sensitive to small errors especially at low AOD values, therefore this large diurnal pattern of AE may be an artifact of large uncertainty that is airmass (solar zenith angle) dependent.

Response

Thank you for your comment. In the special comment (16), we computed the uncertainty in AE. The uncertainty in AE is usually about 0.04. Compared with the seasonal medians of AE, the uncertainty is low. If we assume large diurnal pattern of AE may be an artifact of large uncertainty at some extent, the uncertainty should be presented as a random distribution. The diurnal variation pattern of AE cannot be consistent among years. But this phenomenon does not exist in this study. Therefore, we think the diurnal variations of AE are reliable.

(19) Page 20980 lines 28-29: You need to provide a reference that supports your claim that the particle size is much smaller in the free troposphere than the surface layer in this region. Also define the altitude ranges in km for both layers.

Response

Thank you very much for your comment and suggestion. The previous expression is not precise. We changed this expression into 'A previous study showed that the fraction of smaller particles in aerosol was larger near the surface than at high altitudes (Sheridan et al., 2012).' (please see Page 23 line 3-5 in the revised manuscript). And this reference clearly indicated the particle size is smaller in the high altitude than low altitude. The vertical distributions of particle size should be shown in the total atmosphere, and not be only in these two layers. Thus, we don't define the altitude ranges further.

Sheridan, P. J., Andrews, E., Ogren, J. A., Tackett, J. L., and Winker, D. M.: Vertical profiles of aerosol optical properties over central Illinois and comparison with surface and satellite measurements, Atmos. Chem. Phys., 12, 11695-11721, doi: 10.5194/acp-12-11695-2012, 2012.

(20) Page 20981 lines 7-8: Give references to support your statement that the aerosol load in the upper atmosphere is similar to the lower atmosphere in this region and define upper and lower atmosphere altitudes in kilometers.

Response

Thank you for your comment and suggestion. The speculation is deduced from the diurnal variations of AOD and AE together. AOD don't have a consistent diurnal variation pattern, while AE shows a consistent pattern. The aerosol parameters are affected by both higher altitude and lower altitude aerosols. The diurnal variations of AOD reflect the random variations of higher altitude aerosols. The diurnal variations of AE reflect the impact of ABL evolution, which mainly happened at lower altitude. We added a reference which showed the vertical aerosol load in other region 'Sinha et al. (2013) revealed that aerosols within atmospheric boundary layer (ABL) over a tropical urban station Hyderabad, India dominated the column aerosol loading with ABL-AOD contributing to not less than 50% throughout the year.' (please see Page 21 line 28 and Page 22 line 1-3). Sinha et al. (2013) revealed that at a urban station the aerosols within atmospheric boundary layer (ABL) dominated the column aerosol loading. But the aerosols above ABL also affect the column aerosol loading. Urban site is heavily influenced by ground level urban air pollution, while QOMS_CAS is not. Observations at QOMS_CAS can generally be representative of a remote background atmosphere. The aerosol vertical distribution at QOMS_CAS would be different from an urban site. Then we make this speculation. We changed the previous expression into 'The aerosol load at QOMS_CAS in the upper atmosphere is possibly comparable to that in the lower atmosphere.' (please see Page 23 line 11-12 in the revised manuscript).

The vertical distributions and dynamic process of aerosols are related to ABL evolution. Thus, we define upper and lower atmosphere altitudes by ABL height. And there are seasonal and diurnal variations of ABL height. For example, the ABL height during the dry season is higher than that in the wet season on the TP. The specific heights cannot be given during different periods. And we added the division of upper and lower atmosphere by this sentence 'In this discussion, the upper atmosphere represents the atmosphere above the ABL, and the lower atmosphere represents the atmosphere condition within ABL.' (please see Page 22 line 13-15 in the revised manuscript).

Sinha, P. R., Manchanda, R. K., Kaskaoutis, D. G., Kumar, Y. B., and Sreenivasan, S.: Seasonal variation of surface and vertical profile of aerosol properties over a tropical urban station Hyderabad, India, J. Geophys. Res.-Atmos., 118, 749-768, doi:10.1029/2012JD018039, 2013.

(21) Page 20981 lines 19-23: Again, what is the source of your information on vertical distributions and dynamics here? Please provide references.

Response

Thank you for your comment. We followed your suggestion, and added some references to indicate the vertical distributions and dynamics. We added some references to show the vertical distributions 'Previous studies have investigated the vertical distributions of aerosols. Aerosol extinction coefficients in the upper and lower layers decreased with altitude at Zhangye station, whereas the coefficient in the middle layer changed slightly, which suggested that aerosol mixing occurred in the middle layer (Zhang et al., 2012a). Sinha et al. (2013) revealed that aerosols within atmospheric boundary layer (ABL) over a tropical urban station Hyderabad, India dominated the column aerosol loading with ABL-AOD contributing to not less than 50% throughout the year. And BC mass loadings decreased approximately monotonically from the surface to an altitude of 7 km over urban locations in South India (Safai et al., 2012). Atmospheric species concentrated in the ABL are "occasionally transported to the free troposphere in 'uplifted plumes' via systematic vertical motions of air" (Moteki et al., 2012). Therefore, the vertical dynamics process of aerosols is related to ABL evolution at some extent.' (please see Page 21 line 24-28 and Page 22 line 1-8 in the revised manuscript). We also added the reference of diurnal convection variations. We also added this sentence 'The convection over the Tibetan Plateau evolves from dry shallow convection in the morning to wet deep convection in the afternoon (Ma et al., 2009).' (please see Page 22 line 11-12 in the revised manuscript).

Xia et al. (2006) analyzed the diurnal variations of aerosol optical properties at a site in urban Beijing and indicated the potential vertical dynamics. At this site, AOT steadily increased throughout the daytime and reached maximum in the late afternoon, while surface aerosol concentration in Beijing generally exhibited peak value in the morning, then steadily decreased and reached minimum in the late afternoon. This research indicated that aerosol concentration at the surface would decrease gradually along with aerosol transportation from surface to troposphere, and the column integrated aerosol concentration would increase because more aerosols are transported into the troposphere along with this process. Thus this study indicated the diurnal variation were related to the diurnal variation of boundary layer and associated dilution of aerosols in the troposphere. Similar dilution of aerosols took place at Pokhara, however, Pokhara that is a suburban site with different surrounding environment has different diurnal variations. We added this reference to indicate the potential vertical dynamics 'Similar results were reported at a urban site, which indicated the diurnal variation was related to the diurnal variation of boundary layer and to associated dilution of aerosols in the troposphere (Xia et al., 2006).' (please see Page 24 line 1-4 in the revised manuscript).

According to results of previous studies, we know the general vertical distribution patterns of aerosols. And the vertical distribution is related to ABL evolution at some extent. Thus, we can deduce the impact of ABL evolution on aerosols from our limited results reasonably.

Ma, Y., Wang, Y., Wu, R., Hu, Z., Yang, K., Li, M., Ma, W., Zhong, L., Sun, F., Chen, X., Zhu, Z., Wang, S., and Ishikawa, H.: Recent advances on the study of atmosphere-land interaction observations on the Tibetan Plateau, Hydrol. Earth Syst. Sci., 13, 1103-1111, doi:10.5194/hess-13-1103-2009, 2009.

Moteki, N., Kondo, Y., Oshima, N., Takegawa, N., Koike, M., Kita, K., Matsui, H., and Kajino, M.: Size dependence of wet removal of black carbon aerosols during transport from the boundary layer to the free troposphere, Geophys. Res. Lett., 39, L13802, doi:10.1029/2012GL052034, 2012.

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(22) Page 20983 lines 14-15: I am not convinced that rainfall selectively removes more large particles (dust) than fine mode particles. You did not present any references or physical mechanism that support this. Also your AE data shows lower values in the rainy months which suggests the opposite, or alternatively that cloud contamination lowers the measured AE.

Response

Thank you for your comment. Our previous expression is not quite accurate. We added some references to support this mechanism 'A previous study reported that larger aerosol particles consisting of more internally mixed hygroscopic compounds could be more likely removed via nucleation scavenging (Moteki et al., 2012). Another study proposed that precipitation would tend to remove the larger particles first and then smaller particles after the larger ones have been removed (Tunved et al., 2013). This assumption indicates that precipitation can also affect the average particle size.' (please see Page 20 line 21-26 in the revised manuscript). The references indicated the mechanism of the precipitation removal of aerosols. And we also changed the sentence into 'Precipitation can reduce the aerosol load and affect the average particle size.' in Page 25 lines 20-21 in the revised manuscript.

Cloud contamination may have an effect on the measured AE at some extent. However, we think parts of possible origins of these particles are long-range transported dust or wind erosion. Chatterjee et al. (2010) collected aerosol samples directly over a High Altitude Station at Northeastern Himalayas, and found that fine mode aerosol dominated during dry seasons but coarse mode aerosol dominated during wet season (monsoon season). This result of direct sampling observations is consistent with this study. Therefore, we think the phenomenon is not an illusion caused by cloud contamination.

To express more accurately, we have changed parts of the abstract in Page 2 line 12-14 'Dust transported to these sites, wind erosion and hydrated/cloud-processed aerosols lead to an increase in coarse mode AOD during the monsoon season at QOMS_CAS and EVK2-CNR.' and changed parts of the conclusion in Page 24 line 17-19 'During monsoon season, dust, wind erosion and hydrated/cloud-processed aerosols may lead to high aerosol loads at QOMS_CAS and EVK2-CNR.'.

Chatterjee, A., Adak, A., Singh, A. K., Srivastava, M. K., Ghosh, S. K., Tiwari, S., Devara, P. C., and Raha, S.: Aerosol chemistry over a high altitude station at northeastern Himalayas, India, PloS one, 5, e11122, doi:10.1371/journal.pone.0011122, 2010.

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(23) Page 20984 lines 4-5 and lines 11-13: There is too much speculation in the conclusions section. There are no data on vertical profiles of aerosol presented in this paper to support these statements.

Response

Thank you for your comment. We agreed that too much speculation in the conclusions is not appropriate. We reduced the speculation of the vertical dynamics in the conclusion in the revised manuscript. We deleted the sentences 'At QOMS_CAS, aerosols in the lower atmosphere may have a clear daytime variation pattern. Nevertheless, long-range transport aerosols in the upper atmosphere are of great randomness on a daily time scale. Therefore, AOD does not have a consistent diurnal variation pattern at QOMS_CAS. The diurnal variations of convections have its inherent laws due to surface heating. Large particles are picked up from the surface into the atmosphere by strong convection. However, the particle size in the upper atmosphere is small and changes little. Thus, the aerosol particle size changes in accord with the convection during daytime at QOMS_CAS. The diurnal variations of AE in autumn and winter at EVK2-CNR are similar to QOMS_CAS, because the similar convection process happens. However, there is greater inter-annual difference in diurnal curves of AE in spring at EVK2-CNR. The surface heating and convections make the pollution transport upward so that the pollution concentration would drop at the surface at Pokhara. Nevertheless, the pollution in the upper atmosphere would increase. The strength of convection controls the vertical exchange and the diffusion rate of pollutions. AOD decreases in the morning with an enhanced convection, but increases in the afternoon with a weakened convection at Pokhara.' in the conclusion section in the revised manuscript.

In the last paragraph, we indicated that the assumption is deduced by the limited results. To prove this mechanism, we need more vertical observations on the TP. And this will be an important work, we would like to study in the future.

(24) Page 20984 lines 17-19: How did you deduce that the aerosol load in the upper and lower atmosphere were comparable? There was no data presented on vertical aerosol distribution, such as from lidar measurements. Therefore this statement is very inappropriate for the conclusions section.

Response

Thank you very much for your comment and suggestion. This speculation is deduced by the diurnal variations of AOD and AE together. AOD don't have a consistent diurnal variation pattern, but AE shows a consistent pattern. The aerosol parameters are affected by both higher altitude and lower altitude aerosols. The diurnal variations of AOD reflect the randomness of higher altitude aerosols. The diurnal variations of AE reflect the impact of ABL evolution, which mainly took place at lower altitude. Thus, we make this speculation.

This speculation is inappropriate for the conclusions section. We have deleted 'It is deduced that the aerosol load in lower atmosphere is comparable to that in the upper atmosphere at QOMS_CAS on a daily time scale. And the aerosol load in lower atmosphere is a bit more than that in the upper atmosphere at EVK2-CNR. But the aerosol load at Pokhara is nearly completely influenced by the local emissions.' in the revised manuscript.