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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Carbonaceous aerosols on the south edge of the Tibetan Plateau: concentrations, seasonality and sources" *by* Z. Cong et al.

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We would like to thank the referee for the interest in our work and the helpful comments and suggestions to improve our manuscript. We have carefully considered all comments and the replies are listed below.

1. Abstract (P25052, L15-20): The authors state that "This phenomenon indicates that both slopes of Himalayas share a common atmospheric environment regime." How is an area of the southern slope defined by altitude? Does this statement apply only to an altitude of the same order of magnitude as that of Langtang and NCO-P, or it can also

apply to lower altitudes as well? The altitude values of Langtang and NCO-P should be provided here. The sentence "While OC, EC and other ionic species. . .. . ., such as Langtang and NCO-P" needs to be rephrased. My suggestion is to remove "While" and to rewrite the phrase as ". . .. . .in the monsoon season, similar to the trends of aerosol composition reported previously. . .. . .".

Response: Yes, here the southern slope area refers to the comparable high altitude area with elevation more than 3000 meters, such as Langtang and NCO-P, which are relative far away from the populated area of Nepal. The exact altitude of Langtang and NCO-P can be found in Table 2 (the second column). The sentence mentioned above has been modified.

2. The second last paragraph of Sect. 3.1 (P25059, L4-10): In addition to the radiation forcing of organic carbon aerosols, the cause(s) of high OC/EC ratios observed on the Tibetan Plateau is suggested to be discussed.

Response: Now more explanations on this point were presented. There are two potential reasons for the higher OC/EC ratios in this study (i.e. QOMS). The first possible explanation is a strong solar radiation over the TP, more secondary organic carbon (SOC) may be formed through photochemical reaction. Because of its high elevation, solar radiation on the TP exceeds 7500 MJ m-2, only next to the Sahara Desert. The strong solar radiation could enhance the yield of secondary aerosol from their precursors. Another possible reason is the influence of biomass burning. Usually, the aerosols emitted from biomass burning have higher OC/EC ratio. For example, Watson et al. (2001) have reported an OC/EC ratio of 14.5 for forest fires. Cao et al. (2005) reported the OC/EC ratio of 12.0 for coal combustion, 4.1 for vehicle exhaust, and 60.3 for biomass burning. Considering the specific condition of this study, we think the second explanation is more likely, i. e. the strong influence of biomass-burning emissions. However, the exact reason is beyond the scope of the current study and needs a detailed study in the future.

3. The first paragraph of Sect. 3.2 (P25060, L1-7): In the summer monsoon season, the observed OC and EC concentrations are very low with high variability for EC, as can be seen in Fig. 4b. What is the detection limit for EC in micro gram per cubic meter? In addition, in spite of high temperature and humidity, photochemistry might not be so intensive due to reduced solar radiation associate with rains during the summer monsoon season. Moreover, WSOC was observed to be low in the summer monsoon season as shown in Fig. 3. Therefore, linking a high OC/EC ratio to substantial SOC formation in the monsoon seasons needs to be reconsidered.

Response: The detection limit for EC was estimated as 0.02 μg m-3 according to the real sampling air volume. For the cause of high OC/EC ratio in the summer monsoon season, we agree with the reviewer's comments. Not only the absolute concentration levels of WSOC are quite low in summer (Fig. 3) as the reviewer mentioned, but also the relative abundance of WSOC to the total OC (WSOC/OC) is not high, compared with other seasons (Table 1). Therefore, we modified this sentence. The relative importance of different sources merits a further study.

4. What are the time intervals of the data presented in Fig. 3 and Fig. 6? How about the regression result if the data point with the largest EC value (which seems to be abnormal) is skipped in Fig. 4 for the post-monsoon season?

Response: The temporal resolution of the sampling is every week. So we added "(weekly)" into the figure legends. If we exclude that data point with the lowest OC/EC ratio in Fig. 4c (for post-monsoon season), definitely, the regression result will become better. However, it does not change the main claim of this discussion part, i.e., during the pre-monsoon season, the high abundance of OC and EC have common emission sources and transport processes, which is clearly suggested by the significant correlation. Therefore, we intend to keep that data point in Fig. 4c.

5. Sect. 3.5: This section discusses about the transport mechanism of aerosols. However, not so much information on aerosol variations with transport at QOMS is pro-

vided. Specifically, the authors performed backward trajectory analysis, but variations in aerosols concentrations with different clusters are not discussed; they propose that local mountain wind system may play an important role in the transport of pollutants, but neither observed pollution tracer nor meteorological data is provided to support their viewpoint. Moreover, as they mentioned, carbonaceous aerosols observed at QOMS might be originated from northern India and Nepal, instead of Langtang and NCO-P areas, and thus other processes, such as wet removal during the summer monsoon season, should be considered for discussion.

Response: We understand the referee's concern on the aerosol transport process that proposed in this study (Section 3.5). Now we added more evidence to demonstrate that the both side of Mt. Everest do connect each other. Because both QOMS and NCO-P have sun-photometers and participated in the AERONET project, the same instrument (Cimel 318), the same data process methods and simultaneous observation between QOMS and NCO-P make it possible to compare AOD data directly between the two slopes of Himalayas. As seen in the figure below, the daily AOD (500 nm) of QOMS and NCO-P varied in highly similar pattern (The correlation significant at $p<0.001$), which is in agreement with our viewpoint that both slope share a common atmospheric environment regime. Furthermore, in the work by Lüthi, et al. (2014), the transport mechanisms of pollutants from IGP (the foothills of the Himalayas) to the TP was investigated using a high-resolution atmospheric transport model. They found some trajectories with low altitudes actually originate from the TP, flow down through valleys to the IGP during nighttime where they can mix with polluted air and are then lifted onto the TP again during daytime. For the vertical distribution of aerosols, two examples of such transport episode revealed by CALIOP satellite now were provided in the Supplementary Information (Fig. S3), which clearly showed the pollution plumes from South Asia could transport across the Himalayas. We admit that the exact description of the local transport mechanism would require more study, not only the high-resolution model but also the simultaneous observation of air pollutants (like O3, CO and BC) between the two slopes of the Himalayas, especially on the ground level. As

to the influencing factor during the aerosol transport, like wet removal, it is difficult to evaluate based on the current observation results. In this work, we emphasize that although the air mass trajectories are similar in pre-monsoon, post-monsoon and winter, the difference of the carbonaceous aerosol abundance is mainly linked to the emission strength.

6. The authors are suggested to take into account and refer to a study recently published in ACP (Xu, C., Ma, Y. M., Panday, A., Cong, Z. Y., Yang, K., Zhu, Z. K., Wang, J. M., Amatya, P. M., and Zhao, L.: Similarities and differences of aerosol optical properties between southern and northern sides of the Himalayas, Atmos. Chem. Phys., 14, 3133-3149, 10.5194/acp-14-3133-2014, 2014).

Response: This reference is now cited in the revised manuscript. As described above, we further analyzed the similarity of AOD temporal variation between QOMS and NCO-P (Fig. 11), to support our viewpoint.

References

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Interactive comment on Atmos. Chem. Phys. Discuss., 14, 25051, 2014.

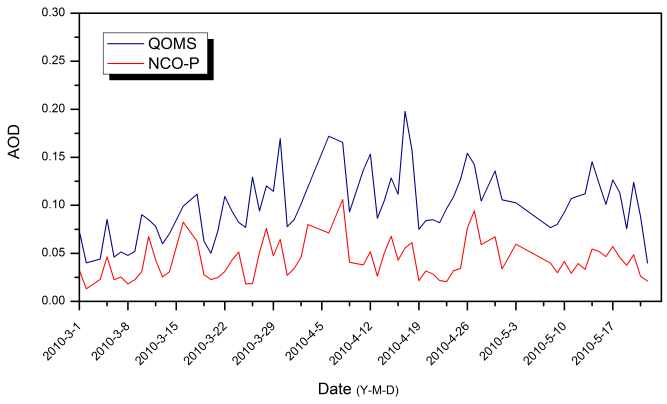
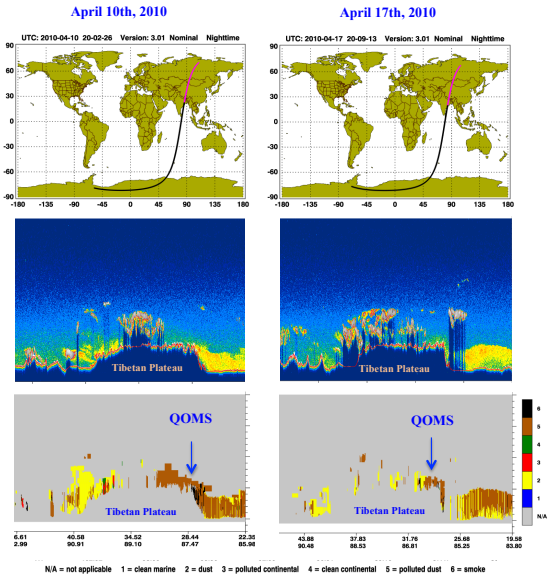


Fig. 11. The temporal variation of the daily aerosol optical depth (AOD, 500nm) at QOMS and NCO-P (n=70).

Fig. 1.



Supplement Fig S3. CALIOP lidar transects across the Himalayas and Tibetan Plateau during the pre-monsoon season (on Apr. 10th and 17th, 2010, respectively). The upper panels in the figures show the orbit tracks across the HTP and adjacent areas. The 532 nm backscatter return signals in the middle panels reveal the vertical distribution of aerosol and clouds. The bottom panels are the main aerosol types derived from the CALIOP observation, clearly showing that polluted air plumes could transport across Himalayas.

Fig. 2.