

Interactive comment on “Concentration, temporal variation and sources of black carbon in the Mount Everest region retrieved by real-time observation and simulation” by Xintong Chen et al.

Xintong Chen et al.

shichang.kang@lzb.ac.cn

Received and published: 13 June 2018

We greatly appreciate the reviewers' valuable and constructive suggestions concerning our manuscript (ID: acp-2018-183). The point-by-point reply to the comments are as follow:

Response to Referee's Comments 2

The authors conducted a detailed analysis of the BC concentration measurements at the Qomolangma station. The measurement, with a high temporal resolution and a relatively long period, provides very valuable information for the understanding of BC

Printer-friendly version

Discussion paper



sources and transport to the Himalayas. The authors further combined observations with model simulations to investigate the BC transport mechanism. The analysis is comprehensive and the manuscript is generally well written. Before it can be considered for publication, I have a few comments and suggestions.

1. Section 2.2: Since different measurement methods may lead to quite different BC or EC concentrations, I suggest adding some discussions in this section on the possible difference in measured BC concentrations between the AE-33 used in this study and some widely-used methods from previous studies (e.g., thermal-optics method, SP2, etc.).

Author response: Thanks for reviewer's suggestion. We have added some discussions about the three commonly used methods as follow: There are several available methods capable of measuring BC concentrations, and these methods can be classified into three categories. First is the thermal/optical method, which uses a quartz filter to collect aerosols, and they are thermally volatilized in several temperature steps (Schauer et al., 2003). The signals of evolving carbon measured by thermal/optical transmission (TOT) or thermal/optical reflectance (TOR) can be converted to the concentration of BC (Chow et al., 1993; Chow et al., 2001). However, the time difference between sampling and detection, the impact of mineral dust, and the determination of the split between organic carbon (OC) and elemental carbon (EC, the same as BC) can cause deviations (Li et al., 2017a; Schauer et al., 2003). The second category is the technique of the single particle soot photometer (SP2), which can quantify BC by laser-induced incandescence because BC is the predominant refractory absorbing aerosol, which can be heated by an intense laser beam and emit significant thermal radiation (Stephens et al., 2003). This method measures the mass of BC in individual particles, but the accuracy depends on the selected calibration material (Schwarz et al., 2010; Laborde et al., 2012). Finally, the optical method measures the reduction in light intensity induced by BC aerosols collected on the sampling medium (Hansen et al., 1984; Petzold and Schonlinner, 2004). The Aethalometer is a widely used instrument based on the optical

method that can provide real-time BC concentration measurements, but all filter-based optical methods exhibit loading effects that can lead to the underestimation of BC concentrations (Bond et al., 1999; Virkkula et al., 2007; Park et al., 2010; Hyvarinen et al., 2013; Drinovec et al., 2015). However, the newly developed Aethalometer model AE-33 uses a real-time loading effect compensation algorithm that can provide high-quality data, which is very helpful for the accurate determination of BC concentrations and source apportionment (Drinovec et al., 2015) (Lines 95-111).

2. Section 3.4: The authors did a detailed analysis on possible BC sources and transport mechanisms for four pollution events, which is great. However, the evaluation of WRF-Chem model simulation seems missing here. Without knowing the model performance, it is difficult to be convinced by the source and transport analysis of model results. At least, the authors could compare modeled BC concentrations at this site with their observations. If possible, the modeled wind and precipitation can be also evaluated against some reanalysis or satellite products. If this takes too much time, the authors could also cite and discuss some previous studies where the WRF-Chem simulations have been evaluated in the TP and surrounding regions.

Author response: According to the reviewer's advice, we compared the simulated BC concentrations with the observations at QOMS during the four heavy pollution episodes, please find in Lines 284-287 and Figure S3. The WRF-Chem model could capture the variation trends of BC concentrations at this sampling site, with correlation coefficients all above 0.8 for the four pollution episodes. We also compared the WRF-Chem simulated 500 hPa wind and 500 hPa relative humidity with the ERA-Interim reanalysis data during the non-monsoon season. As shown in Figure S4, the simulated results had a good agreement with the reanalysis data in spatial distribution. Additionally, compared with the observations from 73 national meteorological stations, the WRF-Chem simulation results represented well the monthly variation of precipitation (Figure S5). Moreover, the simulation setup and selection of parameterization schemes in this study were according to Yang et al. (2018)'s study, which pointed

[Printer-friendly version](#)[Discussion paper](#)

out that the WRF-Chem model can capture key spatiotemporal variations of wind and precipitation over the TP and its adjacent regions, compared with independent observations and reanalysis data. We have added these comparisons in Lines 287-289.

3. Line 15: "... concentrations were significantly greater from mid-night to noon. ..." This sentence is a little confusing. Do you mean "concentrations increased from mid-night to noon"?

Author response: The meaning of this sentence is that the BC concentrations remained significantly high from midnight to noon in the pre-monsoon season, compared with other times of a day. We have corrected this sentence in Lines 14-15.

4. Line 16: "... , implying the potential contribution from the long-range transport." It is not very straightforward for readers to understand why such diurnal variation implies the contribution from the long-range transport. Could you please rephrase the sentence and clarify the point?

Author response: The BC concentrations remained significantly high from midnight to noon in the pre-monsoon season. Meanwhile, the westerly winds prevailing during this period provided the potential possibility for pollutants to be transported across the Himalayas from long-distance sources to QOMS along the valley. We have rephrased this sentence in Lines 14-17.

5. Line 40: For the authors' information, a recent study (Lee et al., 2017) investigated BC deposition effects on reducing snow albedo over the Tibetan plateau based on satellite observation analysis. This study can be cited here.

Author response: Lee et al. (2017) revealed the impact of absorbing aerosol deposition on snow albedo reduction over the TP, which can support our statement that BC is an important contributor to rapid shrinking of glaciers over the TP and we have cited this study in Line 42.

6. Line 57: For the authors' information, a recent study (He et al., 2014b) has also

[Printer-friendly version](#)[Discussion paper](#)

used a global CTM to investigate the sources of BC over the Tibetan Plateau based on a tag-tracer technique, which can be cited here.

Author response: Considering the reviewer's suggestion, we have cited the study of He et al. (2014b) in Lines 59-60 to support our statement.

7. Lines 102–112: It would be more informative if the authors could provide the uncertainty/accuracy associated with this algorithm for BC concentration calculation.

Author response: Previous studies demonstrated that more accurate BC concentration could be obtained by the new real-time compensation algorithm of AE-33, which is based on the dual-spot technology and allows extrapolation to zero loading (Drinovec et al., 2015; Crenn et al., 2015; Zhu et al., 2017). Furthermore, the comparison between AE-33 and earlier Aethalometer models and other filter-based absorption photometers showed the well performance of this new algorithm (Drinovec et al., 2015; Rajesh and Ramachandran, 2018). We have added these discussions in Lines 132-137.

8. Section 2.3 “Model simulation”: A number of studies (e.g., Flanner et al., 2007; Liou et al., 2014; He et al., 2017) have shown significant effects from BC in snow on albedo simulations. This albedo effect and feedback may exert an important impact on model simulations. Did the authors include such “dirty snow” effect in the WRF-Chem simulations? I suggest adding a brief discussion on this issue. .

Author response: Thank for the reviewer's inspiring suggestion. Previous studies (e.g., Flanner et al., 2007; Liou et al., 2014; He et al., 2017) have shown significant effects from BC in snow on albedo simulations, and this albedo effect and feedback may exert an important impact on model simulations. But the WRF-Chem model used in this study cannot simulate the radiative effect of absorbing aerosols, because the SNICAR (snow, ice, and aerosol radiative) model is not fully coupled into the WRF-Chem. In the future, we will try our best to connect the WRF-Chem atmospheric aerosol deposition with the SNICAR model to analyze the radiative effect of BC in the snow. Additionally, we compared our results with reanalysis data and in-situ observations (Figure S3,

Figure S4, and Figure S5). The comparison suggested that the WRF-Chem can capture the key spatiotemporal characteristics of meteorological elements and surface BC concentrations in this study area.

9. Line 183: "... , which might be owing to the surrounding local emissions." Is there any reference/observation showing surrounding emissions? Is there any populated city or town around the observational site? More information would better convince readers.

Author response: There are several villages located north (approximately 5 km away) of the observational site (QOMS), and the uplifted valley wind from the north in the morning could bring the short-distance emissions from local cooking or heating to QOMS. We have added this information in Lines 210-211.

Please also note the supplement to this comment:

<https://www.atmos-chem-phys-discuss.net/acp-2018-183/acp-2018-183-AC2-supplement.pdf>

Interactive comment on Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2018-183>, 2018.

Printer-friendly version

Discussion paper



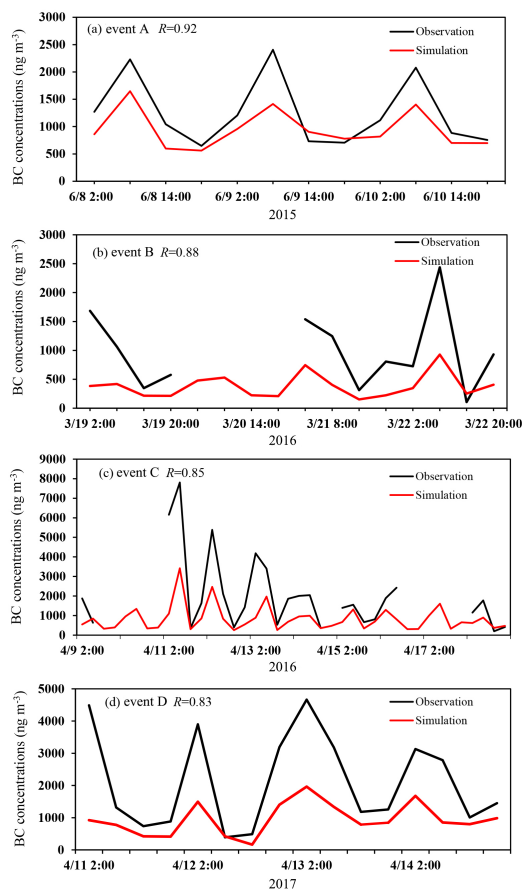


Fig. 1. Comparisons between simulated BC concentrations and the observation at QOMS during the four pollution episodes: (a) event A, (b) event B, (c) event C, and (d) event D.

[Printer-friendly version](#)[Discussion paper](#)

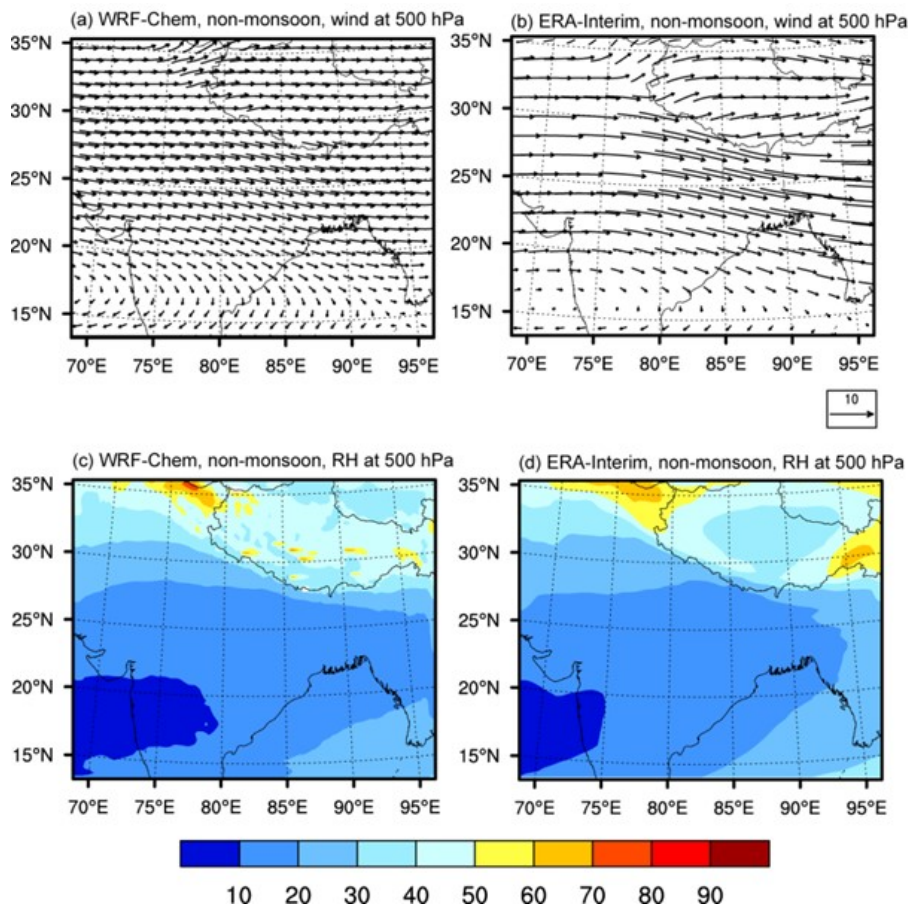


Fig. 2. Mean wind (m s⁻¹) and relative humidity (RH, %) at 500 hPa during the non-monsoon season from the WRF-Chem simulation (a, c) and the ERA-Interim (b, d), respectively.

[Printer-friendly version](#)[Discussion paper](#)

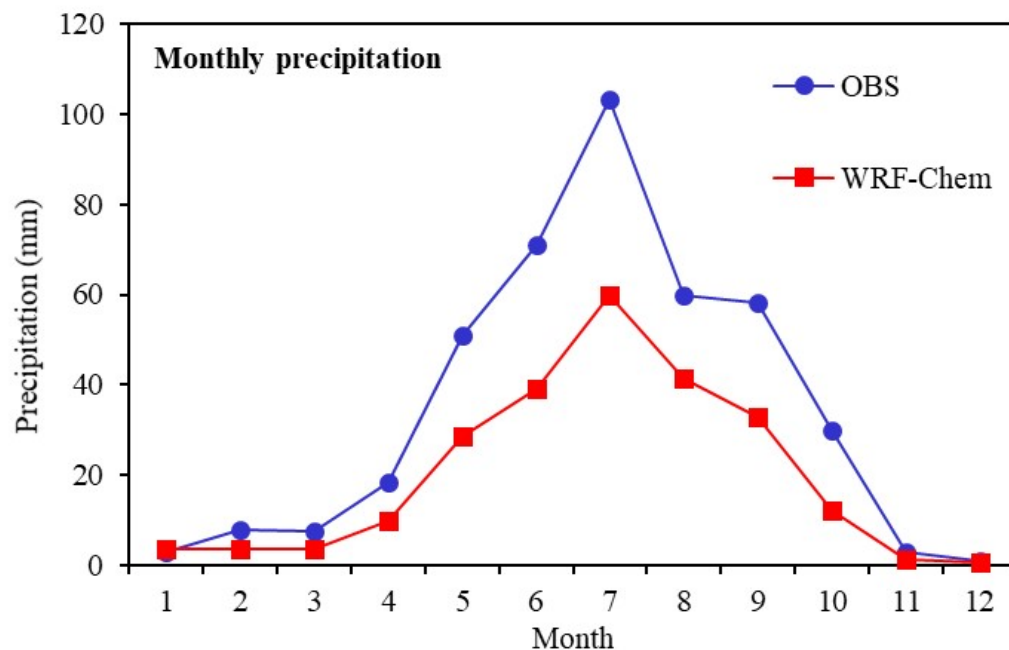


Fig. 3. Monthly mean precipitation in 2013, averaged at 73 sites over the TP. Data are from the observations at national stations (OBS) and the model simulation in this study (WRF-Chem).

[Printer-friendly version](#)[Discussion paper](#)