Dear editor and referees,

Thank you for giving us an opportunity to revise our manuscript (acp-2021-339). We appreciate your constructive comments and suggestions. We have studied these comments and suggestions carefully and made revisions to the manuscript. These comments and the corresponding replies are listed below. In the revised manuscript, we invited one new coauthor, Jinhui Gao, to help describe the BC tagging technique and process analysis.

The referees' comments are highlighted in grey. Following the comments are our responses (normal text) and revised text in the manuscript (**led by line number**). Revisions in the manuscript are coloured in red. The revised manuscript with tracked changes is attached at the end of this file.

With regards,

Zhenbin Wang, Bin Zhu*, and all coauthors.

Replies to Referee #1

1. Meteorological and chemical observations in Beijing was used to evaluate the model performance. It is not enough for evaluation on regional transport. More observations in North China are needed, particulaly, HN, SX (source regions).

Thank you for this valuable suggestion. We agree with your opinion that more observations in North China are needed. We have added model validation in North China to the supplement, particularly in the HN and SX regions, and as the study was mainly conducted in BJ, model validation in HN and SX was not included in the manuscript. As shown in Tables S1 and S2 and Figures S2 and S3, the model effectively reproduced the numerical magnitude and variation characteristics of $PM_{2.5}$, BC and meteorological factors (temperature, relative humidity, wind speed and wind direction) in the HN and SX, which could provide a good basis for the analysis of BC regional transport. The specific modifications are shown below:

Lines 156–157 in the revised manuscript (Model validation)

The model validation in North China, particularly in HN and SX (source regions), is presented in Figures S2 and S3 and Tables S1 and S2 in the supplement, and the modelling profiles of BC and meteorological factors are also presented in Fig. 6 in Section 3.2.2.

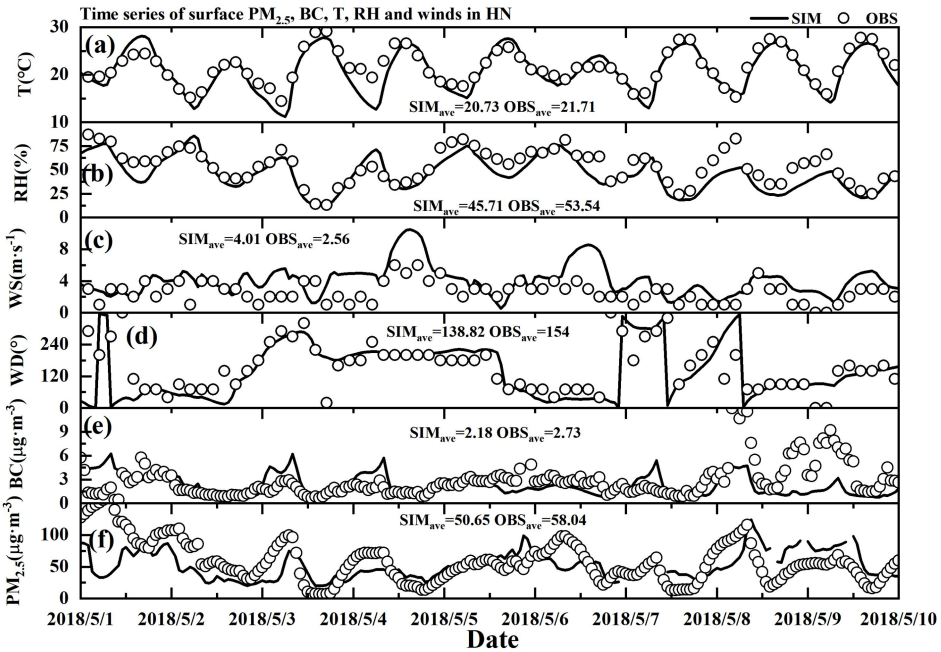

Figure S2. Model validation in HN.

Table S1. Statistical indicators for evaluating the simulation results in HN.

Variables	IOA	MB	RMSE	MNB	MFB	TE
T (°C)	0.98	-0.24 ([-0.5, 0.5])	2 (≤ 2.0)	-0.04 ([-0.15, 0.15])	-0.03 ([-0.6, 0.6])	1.58 (≤ 2.0)
RH	0.99	-8.05	**11.62**	-0.15 ([-0.15, 0.15])	-0.11 ([-0.6, 0.6])	9.43
WS ($m \cdot s^{-1}$)	0.55	1.45	**2.17**	**0.57**	0.38 ([-0.6, 0.6])	1.73
WD ($m \cdot s^{-1}$)	0.92	-14.8	93.54	-0.1 ([-0.15, 0.15])	-0.4 ([-0.6, 0.6])	**54.11**
BC ($\mu g \cdot m^{-3}$)	0.64	0.52	2.2	0.24	0.18	1.49
$PM_{2.5}$ ($\mu g \cdot m^{-3}$)	0.71	9.72	33.84	0.2	0.15	26.26

Values that do not meet the threshold criteria are shown in bold.

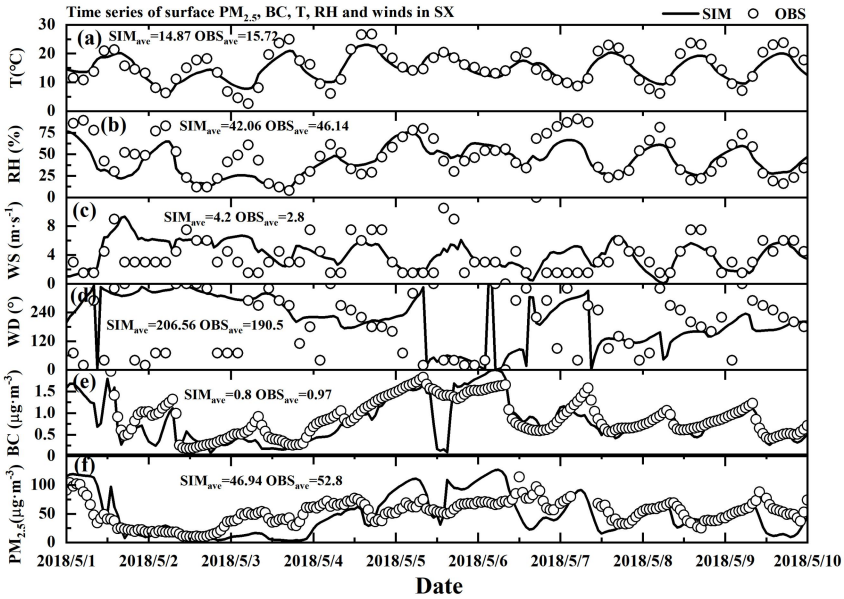

Figure S3. Model validation in SX.

Table S2. Statistical indicators for evaluating the simulation results in SX.

Variables	IOA	MB	RMSE	MNB	MFB	TE
T (°C)	0.99	-0.25 ([-0.5, 0.5])	1.89 (≤ 2.0)	-0.05 ([-0.15, 0.15])	0.01 ([-0.6, 0.6])	2.55 (≤ 2.0)
RH	0.97	-4.26	**14.54**	-0.09 ([-0.15, 0.15])	-0.01 ([-0.6, 0.6])	11.52
WS ($m \cdot s^{-1}$)	0.54	1.44	**2.43**	**0.52**	0.37 ([-0.6, 0.6])	1.83 (≤ 2.0)
WD ($m \cdot s^{-1}$)	0.75	16.09	140.23	0.08 ([-0.15, 0.15])	0.2 ([-0.6, 0.6])	**98.91**
BC ($\mu g \cdot m^{-3}$)	0.77	0.17	0.46	0.22	0.16	0.28
$PM_{2.5}$ ($\mu g \cdot m^{-3}$)	0.69	3.66	32.29	0.08	0.24	25.82

Values that do not meet the threshold criteria are shown in bold.

2. Usually, high BC is related to impact of biomass burning because these emissions are easilly lifted to high altitudes in high temperature without atmospheric dynamic uplifting. I suggested that authores investigate the impact of biomass burning in this study. At least, fire counts from satellites.

Thank you for this valuable suggestion. Following your advice, we have used MODIS satellite products to research the distribution of fire points during the study period (4th–6th May). The MODIS Fire and Thermal Anomalies product is available from the combined Terra and Aqua (MCD14) satellite product. The spatial and temporal resolutions are 1 km daily. The thermal anomalies are represented as red points. **We found that the fire points were mainly concentrated in Jiangsu and Liaoning Provinces on May 4th and mainly in Liaoning Province on May 6th, with almost no fire points on May 5th. There were few fire points in and around Beijing during these three days, especially on the air mass pathway to Beijing (Fig. 8 in the manuscript). In addition, the busy agricultural season in North China is generally from late May to early June (Deng et al., 2006).** Therefore, we concluded that biomass burning made a minor contribution to the BC over Beijing in this study period.

Figure S5. Fire maps on (a) May 4th, (b) May 5th and May 6th.

3. Section 3.2.1 more dynamic conditions are suggested to conduct. For example, the convergence of BC/PM2.5 at different altitudes in each phase of this episode. It's better to provide a comprehensive dynamic driving forces of regional transport.

Thank you for this valuable suggestion. The divergence field is indeed more helpful to reflect the dynamic driving forces of BC lifting and regional transport, so we have added divergence fields in the near surface (Fig. 4e, f and g) and the free troposphere (Fig. 4h, i and j). **Figure 4 shows that the near-surface convergence area was mainly in SX from May 4th to 5th, corresponding to the position where the cyclone appeared, indicating that convergent uplift of surface BC existed in SX, which was consistent with the cross-sectional analysis in Section 3.3.2. The convergence area is not obvious in the free troposphere, and BC is transported by westerly winds.** In addition, the integral results from the surface to the free troposphere are shown in Figure S6 of the supplement, and the main convergence regions are also over SX and HN. The specific modifications are shown below:

Lines 180–183 in the revised manuscript (Tracking BC sources at the surface)

At the same time, it can be seen that the near-surface convergence areas were mainly in SX from May 4th to 5th (Fig. 4d and e), corresponding to the position where the cyclone appeared, indicating that convergence uplift of surface BC existed in SX, which was consistent with the cross-section analysis in Section 3.3.2.

Line 185 in the revised manuscript (Tracking BC sources at the surface)

Moreover, there was almost no convergence but an obvious ‘transport channel’ from SX to BJ...

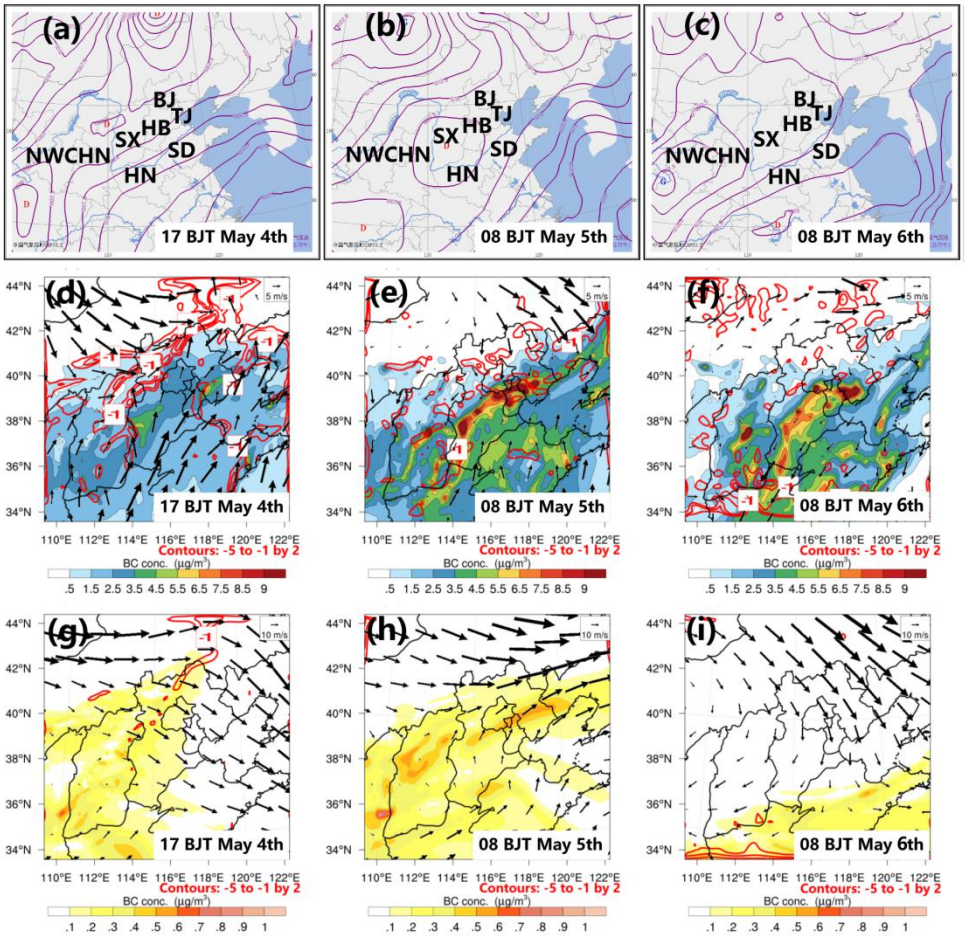

Figure 4. (a)-(c) Surface synoptic patterns, (d)-(f) BC concentration and wind vector at the surface, and (g)-(i) BC concentration and wind vector in the troposphere (~4000 m) at 17:00 BJT on May 4th, 08:00 BJT on May 5th, and 08:00 BJT on May 6th. The red line represents the convergence region (divergence < 0; unit: $\times 10^{-6}\ s^{-1}$).

4. 3.3.1 what is the input data of HYSPLIT?

Thank you for your valuable suggestion. The website of the HYSPLIT model is presented in parentheses (https://ready.arl.noaa.gov/hypub-bin/trajtype.pl?runtype=archive). We use the NCEP Global Data Assimilation System (GDAS) half-degree archive (0.5 degree, global, Sep, 2007 - June, 2019) to compute the 24 h backward trajectory, and the GDAS data can be obtained from the website links in parentheses (ftp://ftp.arl.noaa.gov/pub/archives/gdas0p5).

5. LIne 169 China central seems to be cenrtal China.

Thank you for your reminder. We have corrected this typo.

Line 225 in the revised manuscript (In this version, the original line 169 is now line 225)

During this time, the conditions in Central China (including SX, HB and HN)...

References

Deng, X. P., Shan, L., Zhang, H. and Turner, N. C.: Improving agricultural water use efficiency in arid and semiarid areas of China, Agricul. Water Manag., 80, 23-40, https://doi.org/10.1016/j.agwat.2005.07.021, 2006.