

The paper “A black carbon peak in the free troposphere of Beijing induced by cyclone lifting and transport from Central China”, based on the Weather Research and Forecasting model coupled with chemistry (WRF-Chem) and focusing on BC, investigates the formation mechanism and regional sources of a BC peak in the free troposphere observed by aircraft flight in Beijing (BJ) on May 5th, 2018. The study falls within the scope of ACP. The manuscript is well-written/structured, the presentation clear, the language fluent. I would recommend publishing in ACP following major revision in specific aspects.

Comments:

Section “Model configuration” – please provide more references and extended description on the model and approach selected. In parts of the manuscript, previous studies are mentioned, without briefly providing discussion on the corresponding outputs of the studies, how do the outputs are different or beneficial or support the present study (e.g. “Previous studies have used a similar technique to study the source of air pollutants, such as PM_{2.5} and O₃ (Gao et al., 2016; Zhang et al., 2017b; Gao et al., 2020)”). Please elaborate on the introduction also.

Section “Tracking observed BC from the surface to the free troposphere” – The study implements airborne Black Carbon measurements as the main observational reference for the validation of the model, while at the same time the observed case corresponds to the study-case related to the scientific question. Therefore, the authors should provide more information on the flight and the performed measurements. Was the flight performed under a collaborative field campaign, which were the objectives, how many flights were performed, which instruments were mounted on the airplane, passive, active, or in-situ, algorithms used, and most important, how large were the uncertainties errors of the performed measurements? Please include references when and where necessary.

Section “Tracking BC sources at the surface” – More information needed on the PM_{2.5} measurements (instruments used - network, uncertainties/errors, density of sensors, references). Moreover, upon spatial and temporal comparison of model BC and PM_{2.5}, in which way spatially and temporarily the presented datasets were pre-processed, in order to be able to compare SIM and OBS. Please add a comparison between SIM and OBS including discussion on the relative differences and the uncertainties, including references when and where necessary.

Section “Tracking BC sources vertically” – Regarding the validation of the model, BC model outputs and Observations seems relatively in agreement. However, more information needed. The authors should include uncertainties in the observations, according to the airborne errors of the performed measurements, discuss possible errors/uncertainties in the model outputs and provide a more in-depth analysis. For instance, the authors could provide the relative difference between SIM and OBS, for each of the presented parameter. Moreover, although similarities are evidence, so are disagreements between SIM and OBS (e.g. BC at 500m, WS below 2km, WD at 1.25km), not discussed at all in the section. Please quantify and address the comparison results, including discussion, justification, and references when and where necessary. Phrases such “model grasped the key features”, should be followed by quantitative estimation of the envelope of the uncertainties (e.g. within # SD, ± error).

Section “Air mass trajectory analysis” - HYSPLIT computes the air parcel’s transport and dispersion from a source region and describes where the air parcel will go. In the framework of the study, trajectories reaching below the PBL are provided. Please provide trajectories of air masses reaching at different altitudes above BJ,

corresponding to the altitudes/measurements provided by the flight. Moreover, based on CALIPSO CALIOP observation, the 5th of May 2018 is a day of extended cloud coverage over E. China. Have the authors made any analysis on possible removal of BC through wet-deposition prior the air-masses reach the flight region? The authors could implement observations on the presence of aerosol to the central-eastern China (i.e. AERONET and AE, MODIS AOD and AE over ocean/ CALIOP volume/particle depolarization ratio).

The title needs elaboration to reflect better the scientific content of the performed study, to be more accurate.

The authors should use error-bars in the figures as a metric of the uncertainty (e.g. Figures 5 and 6).

Sections “Physical process analysis” could be merged with the work performed to provide Figure 4 results, towards higher cohesion and continuity in the manuscript.

It would be beneficial for the manuscript to include a flowchart showing the instruments, datasets, methodologies and key references for the comparison followed by the authors. The entire process can be summarized there along with the methodology requirements followed e.g. the spatial - temporal constraints, screening requirements. In sections where the information exists in the manuscript, it is scattered among the sections. Furthermore, I suggest the authors to provide the collocation criteria (both spatial and temporal), since the SIM, flight obs, and PM_{2.5} datasets are very different.