Reviewer #2:

1. (Line 29) What kinds of "local gas pollutants"?

Thanks for your comment. Analysis of satellite and ground-based measurements reveals a reduction in the concentrations of NO_x, SO_2, and VOCs during the lockdown period. However, the concept of local gas pollutants is imprecise, and the analysis of satellite measurements is not the primary focus of this study. Therefore, we have decided to remove this sentence.

2. (Line 28-36) These sentences are organized in a little messy. Need to be rewritten more clearly.

We apologize for the language problems in the original manuscript. We have simplified the text, and the revised version is as follows:

Line 29~33: "*Single particle aerosol mass spectrometer (SPA-MS) analysis revealed a notable decrease in the proportion of freshly emitted BCc during the lockdown period (LD). However, we did observe a concurrent 7% increase in* $PM_{2.5}$ *concentration during LD, with a higher proportion of aged BCc compared to the period before the lockdown (BLD).* "

3. (Line 46~50) These highlights do not match the title and the major objects of this paper. The author should provide some guidance for BCc, rather than a general $PM_{2.5}$**.**

We agree with the comment and re-wrote the sentence in the revised manuscript as the follows:

Line 38~43: "*Our research highlights that short-term, strict local emission controls may not effectively reduce PM pollution due to the complex generation and transmission characteristics of BCc and the non-linear responses of* $PM_{2.5}$ *to its*

precursors. Achieving further effective $PM_{2.5}$ reduction mandates a focus on nuanced control of BCc particles and necessitates a comprehensive and extensive approach with a regionally coordinated and balanced control strategy through joint regulation."

4. (Line 75-76) References for "Due to the complex emissions and feedback with the East Asian monsoon".

Thanks for the comment. We have incorporated your suggestion by adding the reference (Ding et al., 2019) in Line 98.

5. (Line 122) Any previous results about BCc, as BCc is the topic of your study.

We appreciate the insightful comment and have incorporated a review of previous studies on BCc into the revised manuscript as the follows:

Line 61~83: " *The atmospheric aging of BCc involves intricate chemical and physical transformations that influence their mixing state, morphology, hygroscopicity, and optical properties, all of which have profound implications for climate and human health (Bond et al., 2013; Ramanathan et al., 2008). For example, freshly emitted BC particles are initially hydrophobic but possess a porous surface structure that facilitates the internal or external mixing with co-emitted primary organic/inorganic and secondary materials that are associated with BC (Cheng et al., 2012; Li et al., 2020). On the other hand, BCc undergoes continually aging processes, including the condensation of low-volatility vapors (Li et al., 2022), coagulation with preexisting aerosols (Kondo et al., 2011), and heterogeneous oxidation with gaseous pollutants (Zhang et al., 2024). This alteration may affect the coating thickness, morphology, size distribution, and hygroscopicity of BCc, thereby impacting their climate forcing as well as atmospheric lifetime (Luo et al., 2022; Taylor et al., 2014). High loading of atmospheric BCc could also depress the development of the planetary boundary layer and exacerbate PM pollution episodes (Huang et al., 2018). BCc characteristics are influenced by various combustion sources and emission conditions, including local*

industrial burning, vehicle exhausts, residential coal burning, and biomass burning (Li et al., 2020; Sedlacek et al., 2022; Zhang et al., 2018), as well as long-range transport from other regions (Adachi et al., 2014; Zhang et al., 2021). Those diverse conditions complicate the development of parameterizations of BCc properties, the insufficient understanding of complex emission sources, aging processes, and physical properties of BCc, hampering the effectiveness of air quality remediation (Cappa et al., 2019; Kahnert, 2010; Sun et al., 2021). "

6. (Line 125) You do not conduct satellite measurements. Change to "combine".

We agree with the comment and re-wrote the sentence in the revised manuscript as the following:

Line 148: "*Our investigation involved a combination of ground measurements, spaceborne observations, and mass spectrometric analysis conducted during the COVID-19 lockdown in the summer of 2021 in Yangzhou.*"

7. (Line 48) What is the flow rate and cut size for your cyclone? More detailed information is needed.

We are grateful for the suggestion. As suggested by the reviewer, we have added more details of the experiment equipment, as outlined below:

Line 153~155: "*A cyclone with 2.5 μm cutpoint (Model URG-2000-30ED) and a Nafion dryer is equipped in front of the sampling inlet. Individual particles are introduced into the SPA-MS through a critical orifice at a flow rate of 3 L* min^{-1}*.*"

8. (Line 168) Figure 1. Remove (b) and the right corner Chinese map is not very clear. Also the author should add some cities mentioned in the text.

We are grateful for the comment. We have implemented your suggestion by removing the label (b) and updating Figure 1 with a clearer Chinese map. Additionally, we have

added the names of provinces and cities mentioned in the text to Figure1, as follows:

Line 193~196: “

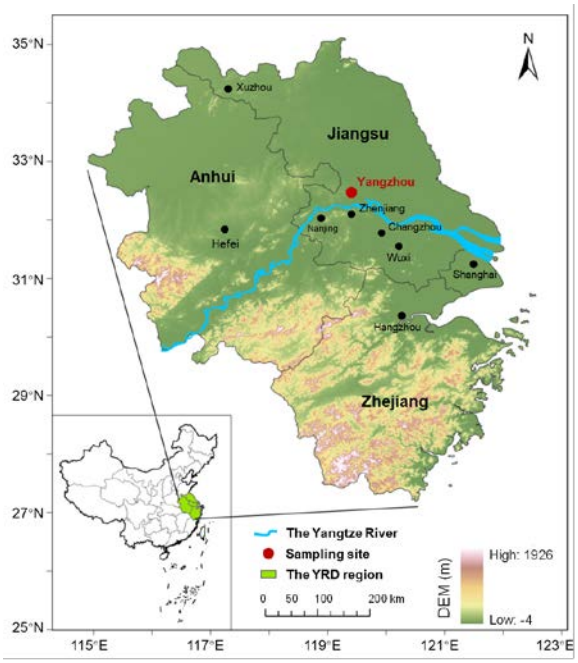

Figure 1. *Geographical overview of the Yangtze River Delta (YRD) Region in China, depicting the major cities within the YRD and the sampling site located in Yangzhou. The color gradient from green to white indicates varying altitudes across the region (Maps were generated by using Arcgis Pro).*”

9. (Line 178~182) It is very unclear here. Do you mean that you used the MERRA-2 data to replace the dataset from background SO2 from TROPOMI? Also, please provide the link for your data source and change SO2 mass concentration to SO2 column concentration, as satellite only provides column concentration.

We apologize for the unclear statement in the original manuscript. We acknowledge that the bands in TROPOMI and MERRA-2 have different spatial resolutions and units, making it challenging to compare remote sensing results from two different sensors. Therefore, we have updated the remote sensing data source to the Copernicus Atmosphere Monitoring Service (CAMS) Global Near-Real-Time dataset for analyzing the distribution of NO_2, SO_2 and $PM_{2.5}$. Section 2.2.1 has been refined accordingly, as

follows:

Line 177~291: "*In this study, we utilized the Copernicus Atmosphere Monitoring Service (CAMS) Global Near-Real-Time dataset (available at https://developers.google.com/earth-engine/datasets/catalog/ECMWF_CAMS_NRT), acquired from the European Centre for Medium-Range Weather Forecasts (ECMWF), to analyze the distribution of total surface column concentrations of NO_2, SO_2 and surface $PM_{2.5}$ mass concentration. CAMS offers the capacity to continuously monitor the composition of the Earth's atmosphere at global and regional scales since 2016, with a spatial resolution of 44528 meters (Benedetti et al., 2009; Morcrette et al., 2009). The details of the bands of the dataset used in this study are shown in Table 1. We calculated and plotted the averaged 2-dimensional data of ECMWF/CAMS/NRT NO_2, SO_2 and $PM_{2.5}$ during BLD and LD over the region of interest (17.93~54.74 ºN, 71.21~142.23 ºE) using Google Earth Engine (Gorelick et al., 2017). The integration of remote sensing measurements has provided a more comprehensive understanding of the sources and distributions of particle matter and gaseous pollutants facilitating the evaluation of the impact of human activities on air quality.*

Table S2 *Bands of $PM_{2.5}$, SO_2 and NO_2 in Copernicus Atmosphere Monitoring Service (CAMS) Global Near-Real-Time dataset SP*

Band Names	***Units***	***Description***
particulate_matter_d_less_than_25_um_surface	*kg m^{-3}*	*Surface mass concentration of $PM_{2.5}$*
total_column_nitrogen_dioxide_surface	*kg m^{-2}*	*Total surface column concentration of NO_2*
total_column_sulphur_dioxide_surface	*kg m^{-2}*	*Total surface column concentration of SO_2*

"

10. (Line 242) Remove "Further".

Thanks for the comment. The word "Further" has been removed as requested.

11. (Line 254) Please provide the meaning about the marked region.

We are grateful for the suggestion. We have added more details in the caption of Figure 2, as follows:

Line 295~296: "*The grey, blue, and red arrow ranges denote the periods before lockdown (BLD), during lockdown (LD), and after lockdown (ALD).*"

12. (Line 259) The resolution of Figure 3 is too low.

We apologize for the unclear figures in the original manuscript. We have refined Figure 3 to ensure high resolution and clarity.

Line 298~303: "

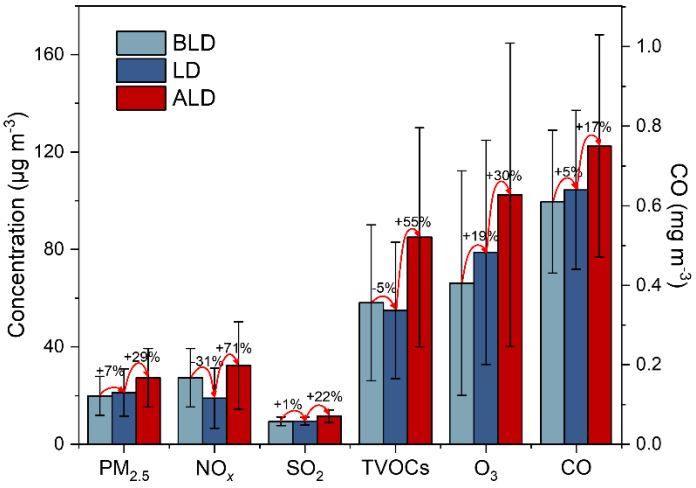

Figure 3. *Ground-based observations of $PM_{2.5}$, NO_x, SO_2, O_3, CO, and TVOC concentrations in Yangzhou. The figure compares the averages during the BLD (blue-grey), LD (dark-blue), and ALD (crimson) periods. Error bars indicate SDs over different lockdown periods.*"

13. (Line 262) Which satellite produce of $PM_{2.5}$ was used? The related information should be provided in section "2.2.1 Satellite Product".

We apologize for the missing information in the original manuscript. In order to unify the data source, we have updated the remote sensing data to the Copernicus Atmosphere

Monitoring Service (CAMS) Global Near-Real-Time dataset for analyzing the distribution of NO_2, SO_2, and $PM_{2.5}$. Section 2.2.1 has been refined accordingly.

14. (Line 430) Figure 7. It is hard to see the Log-normal distribution.

We apologize for the unclear figures in the original manuscript. We have revised Figure 7 to enhance clarity and legibility by improving resolution and enlarging the font size

Line 489~496: “

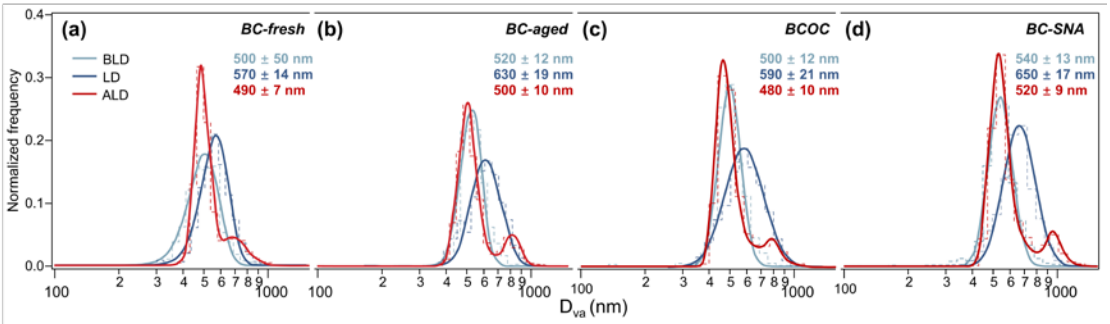

Figure 1. *Size distribution of different types of BCc particles during different lockdown in Yangzhou.* ***(a)*** *BC-fresh particles,* ***(b)*** *BC-aged particles,* ***(c)*** *BCOC particles, and* ***(d)*** *BC-SNA particles. The Log-normal distribution was used to fit the unimodal size distribution, and the Lorentz distribution was used to fit the bimodal size distribution. The corresponding mode sizes (with the standard deviations) are also shown.*”

15. (Line 525) The resolution of Figure 10 is too low.

We apologize for the unclear figures in the original manuscript. We have refined Figure 10 to ensure high resolution and clarity.

Line 588~590: “

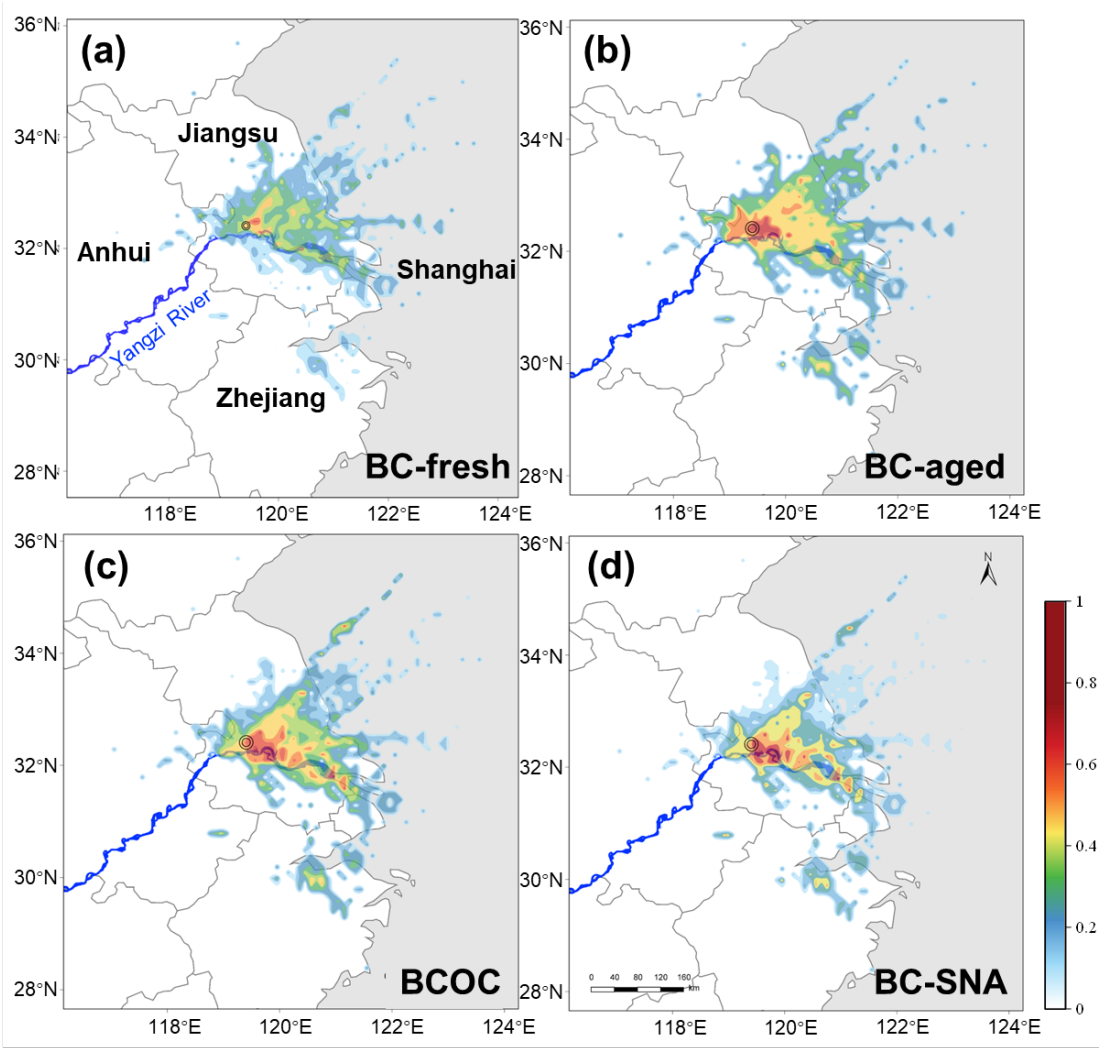

Figure 2*. The PSCF maps for different BCc particles during the LD period.* ***(a)*** *BC-fresh.* ***(b)*** *BC-aged.* ***(c)*** *BCOC.* ***(d)*** *BC-SNA.”*

16. (Line 541) Figure 11 should be removed and be used as a TOC/Abstract graphic.

We fully agree with your suggestion. Figure 11 has been removed and will be repurposed as the abstract graphic.

17. (Line 567) The resolution of Figure 12 is too low.

We apologize for the unclear figures in the original manuscript. In response to feedback from reviewer #3, we have decided to remove Section 3.5 entirely, along with Figure 12. This decision was made to streamline the manuscript and focus on the most essential findings.

18. (Line 643-651) Similar to #3, the author should highlight some discussion about BCc, rather than a general $PM_{2.5}$.

Thank you for your insightful comment. We have revised the conclusion in accordance with your suggestion. The revised sentence reads as follows:

Line 640~647: "*Our research underscores the crucial role of BCc, which constitutes a significant portion of $PM_{2.5}$, in particulate matter pollution. These particles originate from diverse combustion sources and their behavior is intricately influenced by complex chemistry, regional transport, and meteorological factors. Mere reductions in local primary emissions from traffic and manufacturing sectors exhibit limited efficacy in air quality improvement. Therefore, effective air quality remediation strategies necessitate nuanced control of BCc alongside broader emission reduction efforts.*"

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