Review of Yu et al "Heavy air pollution with the unique "non-stagnant" atmospheric boundary layer in the Yangtze River Middle Basin aggravated by regional transport of $PM_{2.5}$ over China"

Yu et al investigated the impacts of regional transport to the heavy haze pollution in January 2016 over Wuhan, a city located over the Yangtze River Middle Basin in the central part of China. This study characterized unique "non-stagnant" conditions (e.g., high winds, no inversion layers) associated with extreme high levels of $PM_{2.5}$ concentrations (e.g., strong correlation between $PM_{2.5}$ concentrations greater 150 $\mu g\ m^{-3}$ and wind speed), which differed significantly from traditional haze pollutions with low near-surface winds and inversion layers found in the literatures. The authors employed both observational and modeling analyses to prove the importance of the contribution of regional transport to the excessive $PM_{2.5}$ concentrations over Wuhan. This is an interesting study to demonstrate the complexity and challenge of the severe haze pollution over central-eastern China during wintertime, with research scope aligned with topics suitable for ACP. However, the current format of the manuscript is not accepted, due to ambiguous structure of the manuscript, lack of detailed descriptions of observational and modeling methods, concerns of technical methodology as well as numerous grammar errors and typos over the entire manuscript. A major revision is needed for this manuscript before further consideration of publication in ACP. My comments for the manuscript are shown as follows.

Major Comments

1. Research Methodology and Results/Discussions for the paper are not clear

I have difficulty in following the paper's research methodology/results. The authors mix the research methodology and results in the same section. I highly recommend

that the authors should re-organize the structure of the paper. The descriptions of observational data from various sites and FLEXTPART-WRF (Sect. 3.2.1 and Sect. 3.2.2) should be placed in Section 2. And Results and Discussions, including the analysis of the observational data and modeling study, should be placed in Section 3.

2. The descriptions of the data used in this study are not adequate and needed to be expanded to provide a more detailed and rigorous documentation.

We don't know the spatial locations of the observational sites for $PM_{2.5}$ measurements, especially ten sites over Wuhan, which need to be presented. A spatial map of WRF modeling domain, with $PM_{2.5}$ measurement sites inserted, will be very helpful. Moreover, what is the measurement technique used for $PM_{2.5}$? What is the measured frequency/quality data control method, and measurement uncertainty associated with $PM_{2.5}$ concentrations and other meteorological parameters for each site? How do you represent Wuhan's hourly $PM_{2.5}$ concentrations out of the ten measurement sites? And how do you calculate the correlation coefficients between $PM_{2.5}$ concentrations and wind speed/temperature over Wuhan in January 2016 out of ten measured sites?

3. In terms of quantification of regional transport contributions for $PM_{2.5}$ over Wuhan, the authors have utilized FLEXPART-WRF model. However, I have concerns about the convolution of FLEXPART-WRF residence time with the $PM_{2.5}$ bottom-up emission fluxes from MEIC. Firstly, what is the definition of residence time here? Is it the $PM_{2.5}$ lifetime? With Lagrangian method, it will result in a Jacobian matrix (footprint), in unit of mass per volume per unit flux. It is helpful for the authors to mathematically derive the residence time for particles out of FLEXPART, the product of the residence time and the bottom-up emission flux, and ultimately the regional transport contribution rate in the "Research Methodology" Section. The authors should insert the unit for each variable out of FLEXPART modeling. Meanwhile, please help the readers about the purpose of the WRF model here. Further, FLEXPART does not

consider chemistry and deposition in the model, the only part it accounts for is the transport, driven by reanalysis data. $PM_{2.5}$ contains a significant portion of secondary organic and inorganic aerosols, which come from important and complex physiochemical processes in the atmosphere. How this methodology (FLEXPART-WRF) is proven robustness to quantify the regional transport contribution? What is the uncertainty range here?

Minor Comments

Line 48: The order of the references is messed up, which should follow the order of the first letter of the first author for each reference alphabetically, and should be "An et al., 2019; Fuzzi et al., 2015; Nel, 2005" for this case. Please check the entire manuscript.

Line 50: The definition of $PM_{2.5}$ "particulate matter with an aerodynamical diameter equal to or less than 2.5 micrometers".

Line 99: change "humid environment. (see Fig. 1b)" to "humid environment (see Fig. 1b)". There are so many similar typos across the entire manuscript. Please CHECK!

Line 101: The associated temporal variations of $PM_{2.5}$ concentrations for the study period out of ten sites in Wuhan are strongly recommended to be plotted and placed in the Supplemental.

Line 107: Change "obviously" to "obvious".

Line 124: "heavy $PM_{2.5}$ pollution the over central-eastern China" should be revised as "heavy $PM_{2.5}$ pollution over the central-eastern China".

Line 128: The number and unit should be separated (75 $\mu g\ m^{-3}$). Similar changes should be applied for the entire manuscript.

Line 146: "at same day." should be changed to 'at the same day,".

Lines 147-Line 149: The authors use “am” and “a.m.” interchangeable. Please be consistent for the entire manuscript. Similar for “pm” and “p.m.”.

Lines 161-165: Grammar error here. Please re-write this sentence. And what is the logical relationship between this sentence and the previous one? Do you try to demonstrate the reasons for this result? If so, probably it is better to begin the sentence with “There are several reasons associated with this result. Firstly, ……”.

Line 165: what is “CEC” here?

Lines 165-170: There are many typos and grammar errors in this sentence. And I am confused by this sentence as well, which looks very odd to me. Is this your statement or conclusion? Several references to support your statement will be necessary.

Lines 184-185: There should be spaces between references, which should be “(Miao et al., 2018; Xu et al., 2016b). There are many cases (e.g., Line 187, 254, 263 and etc) like this. Please check over the entire manuscript.

Line 210: “the stagnation meteorological conditions” should be revised as “meteorological conditions of the stagnation”.

Lines 233-234: References relevant to secondary organic and inorganic aerosols study over Wuhan?

Line 276: Change “relatively” to “relative”.

Lines 296-299: First of all, there are grammar errors in this sentence (e.g., …by winter monsoonal winds the from Tongling and Hefei to Wuhan (…). Second of all, the site numbers of Tongling and Hefei are 6 and 5 respectively, as indicated by legend of Figure 6a?

Lines 311-313: It seems that this sentence belongs to the beginning of Section 3.2.

Lines 331-333: I recommend that the authors make a plot associated with the modeling domains, which demonstrates the regions with the coarse and finer horizontal resolutions (refer to my major comment #2).

Lines 341-342: I have concerns about the release of the number of particles in FLEXPART-WRF. Firstly, for particles from FLEXPART, it is not PM2.5 particles, it is just particles to represent the air parcels. Secondly, can you double check that the model release 50,000 particles per hour? From my understanding, for each hourly mean $PM_{2.5}$ observation at the receptor list, the release of particles in the 48-h backward trajectory simulation in FLEXTPART just happens in the first hour, with the rest of the time tracking the routes/transport of the particles over the simulation domain?

Line 374: Change "Eq (1)" to "Eq. (1)".

Lines 634-637: For "K km-1", it should be "K km^{-1}".

Lines 640-645: There are many typos for Figure 1. For Y-axis title in Figure 1a, it should be "Latitude". Moreover, both units of X-axis and Y-axis in Figure 1a are missing. In Line 643, "YPD" is a typo. And where is the description of PRD here?

Lines 663-664: The solid line for heavy $PM_{2.5}$ pollution and the dash line for clean air period are missing in the caption for Figure 5.

Lines 679-680: Why there are no "comma" among "P1 P2 and P3". I suggest changing the caption of the last part of the caption of Figure 7 as "….pollution periods of P1 (upper panel), P2 (middle panel) and P3 (lower panel), respectively, in January 2016".