

A point to point response to the reviewers' comments

Thank you for the reviewers' comments on our manuscript entitled "Land-surface forcing and anthropogenic heat modulate ozone by meteorology: A perspective from the Yangtze River Delta region" (acp-2021-619). Those constructive comments are all valuable for revising and improving our manuscript, as well as the important guiding significance to our researches. We have studied those comments carefully and have made corrections which we hope to meet with approval. Here are point to point responses (in blue colored). Accordingly, we also revised the manuscript (in red colored). The line numbers in response are obtained from the unmarked manuscript, in which all revisions have been accepted.

Anonymous Referee #2:

This paper describes the general characteristics of regional O₃ pollution in the Yangtze River Delta (YRD) region, a highly urbanized place with complex geography. The impacts of land-surface forcing and anthropogenic heat (AH) on meteorological factors, local circulations and O₃ are investigated by using the WRF-Chem model. This is an interesting topic to diagnose the changes in local circulations affected by land-surface forcing/AH and their effects on O₃ because these elements are usually at different scales. From this paper, the interactions of these multi-scale local circulations seem to play an important role in O₃ pollution, and this may be an important supplement to current research on related topics. Thus, the manuscript can be considered to be published in ACP after making revisions as follows:

Response: We would like to thank the referee for the valuable and affirmative comments of our manuscript. We carefully revise our manuscript based on the following comments.

General comments

1. I suggest replacing the "land-surface forcing" in the title as well as the corresponding place in the text with "land use".

Response: Thanks for the constructive comment. We agree that "land use" is more accurate and common than "land-surface forcing", which is more in line with our topic. We have replaced the phrase "land-surface forcing" with "land use" in the full text.

2. Section 3.2.1, since the subsequent results are based on this case, I believe that a more detailed description is needed to make sure the case is in a calm weather. This is an important prerequisite for the formation of local circulations. In fact, plenty of materials, like the time series of meteorological factors, have been given in the section of model evaluation, but should be condensed here.

Response: Thanks for the constructive comment. We take your suggestion and deeply reorganize this section. In the revised manuscript, we add a table containing detailed information about ozone concentrations and meteorological variables (2-m air temperature, relative humidity, 10-m wind speed and cloud cover) during this ozone pollution episode. These contents are also described in the corresponding text. Please see lines 267-281 in the revised manuscript.

During this ozone pollution episode, the means of MDA8 O₃, 2-m air temperature, relative humidity, 10-m wind speed and cloud cover in the Yangtze River Delta region were 182.1 $\mu\text{g m}^{-3}$, 26.4 °C, 58.6%, 2.8 m s^{-1} and 4.2 okta, respectively. The values of these meteorological variables meet the general standard that the temperature exceeds 20 °C, the relative humidity is less than 80%, the wind speed is less than 3 m s^{-1} and the cloud cover is less than 5 okta (Sect. 3.1). Furthermore, the weather pattern was dominated by high pressure/uniform pressure field (Table S1) during this smog episode. Therefore, this case is in a calm weather, which is conducive to the formation of ozone pollution and local circulations.

Specific comments

1. Lines 359-361. The titration of NO does not terminate, and surface O₃ seems to be lowest in the early morning (Figure 6).

Response: Thanks for the constructive comment. We are deeply sorry for the confusing sentence “The loss of O₃ caused by NO titration almost ceased around 2:00 LT when O₃ was at its lowest level of the day” here. This sentence is revised as “surface O₃ concentration generally decreased due to nitrogen oxide titration, and reached its minimum in the early morning” in the new manuscript (lines 356-358), hoping this statement is accurate.

2. Lines 395-397. "... the sea-breeze front lifted the boundary layer ...", the development of the boundary layer mainly depends on solar radiation, although some factors do affect the boundary layer height.

Response: Thanks for the constructive comment. The sentence "The intensified sea-breeze penetrated inland for a distance of 20-30 km, and the sea-breeze front lifted the boundary layer top over Shanghai up to ~ 2 km." is a clerical error. The original intention should be that "The sea breeze front moved inland for a distance of 20-30 km, and was elevated to ~ 2 km". We have corrected this in the new manuscript, please see lines 391-392. Thanks again for your reminder.

3. Figure 7 and 9. O₃ concentration on the lake is higher than that in the city during the day. Why? Will this affect the lakeside cities?

Response: Thanks for the constructive comment. Figure R2 shows the distribution of different processes to O₃ concentration in the control simulation (MODIS_noAH). Although stronger photochemical reactions are found on the land (Figure R2a and b), the amount of O₃ deposition on the lake is much smaller than that on the land (Figure R2d and e). The small dry deposition velocity on the water is also mentioned in Park et al. (2014), an important literature recommended by referee #1. In addition, the southeast wind continuously transports high O₃ from coastal to inland areas (from east to west) during this period (Figure 7a-d). But the lake breeze (from west to east) can hinder this process since they are in opposite direction (Figure R2g and h). The differences in deposition and transport processes finally lead to higher O₃ on the lake.

The high concentration of O₃ on the lake is like a reservoir because the onshore flow (from lake to land) of the lake breeze can transport the O₃ to the lakeside cities (Figure 9e and h). This is also the reason why O₃ concentration in lakeside cities will increase after the lake breeze is established.

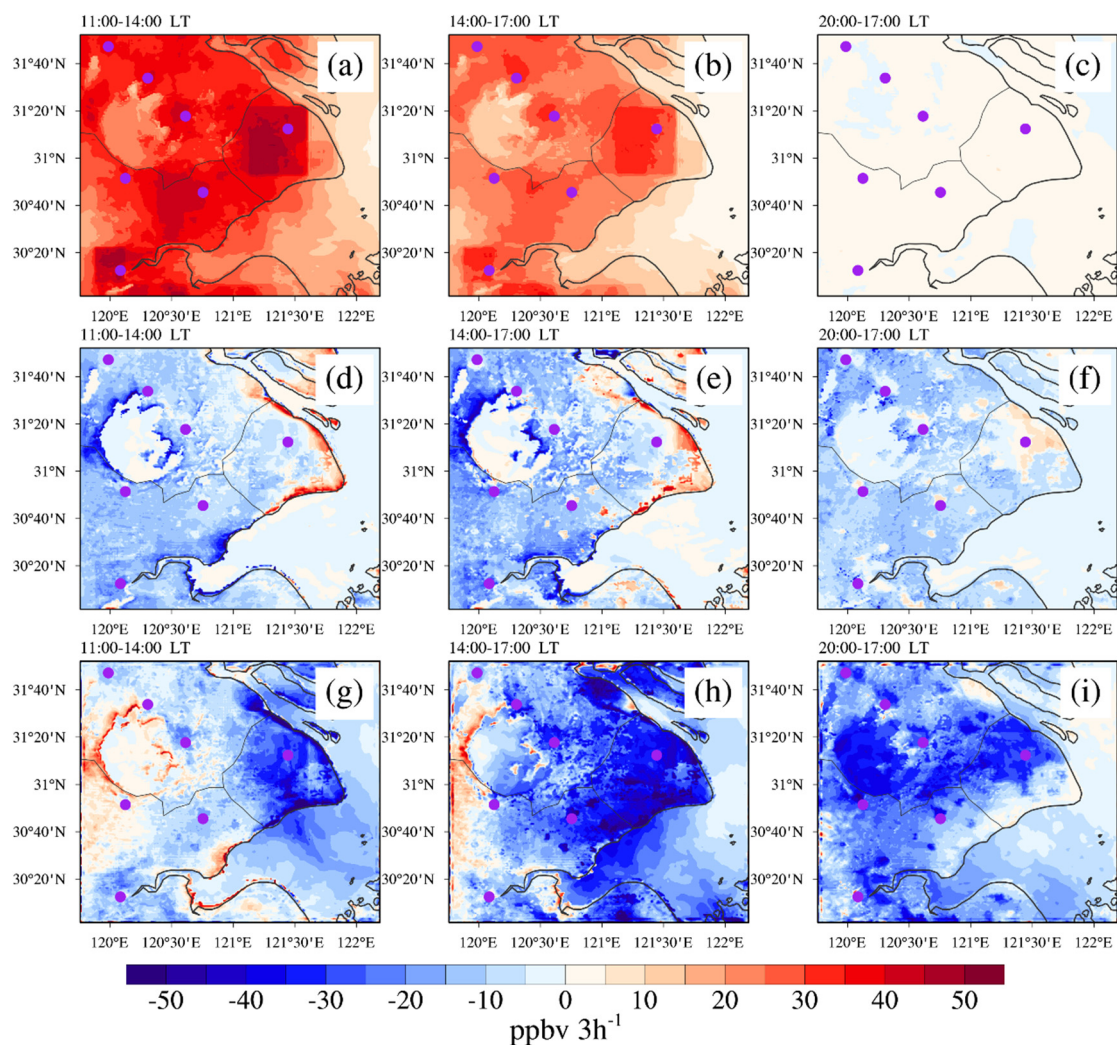


Figure R2. Horizontal distributions of (a)-(c) gas-phase chemical reactions, (d)-(f) vertical mixing and (g)-(i) advection transport process to O₃ concentration in MODIS_noAH.

Reference

Park, R. J., Hong, S. K., Kwon, H. A., Kim, S., Guenther, A., Woo, J. H., and Loughner, C. P.: An evaluation of ozone dry deposition simulations in East Asia, *Atmospheric Chemistry and Physics*, 14, 7929-7940, 10.5194/acp-14-7929-2014, 2014.

4. Section 3.4.2. Only the sea breeze was discussed in this section. However, both the offshore and onshore flows should be considered when we discuss circulations.

Response: Thanks for the constructive comment. During the daytime, the offshore flow (from land to sea) is usually not obvious due to the strong background southeast wind (Figure 9). Therefore,

we don't mention the offshore flow in Sect. 3.3.2. However, the expansion of coastal cities, like Shanghai, can enhance the offshore flow. In the Sect. 3.4.2, as shown in Figure 11c, the offshore flow transports high concentration of O₃ to the sea, which may be an important reason for the forming of O₃-rich reservoir in the nocturnal residual layer on the sea. Thanks for your suggestion. These new contents have been added to the revised manuscript. Please see line 454-457.

5. Wind arrows in Figure 11 and 14 are too small to identify. Please improve the figure presentations with better quality.

Response: Thanks for the constructive comment. We take your suggestion, and enhance the length of the wind arrows in revised figures. Please see line 464 for new Figure 11 and line 525 for new Figure 13.

In fact, we almost redraw all the figures in the manuscript and the supporting information, hoping that they can meet the standard.

Technical corrections

1. "MODIS_withAH" and "MODIS_AH" should be the same, please choose any one of them.

Response: Thanks for your reminder. In the revised manuscript, we uniformly adopt "MODIS_AH" throughout the paper.

2. Line 258, "is" -> "are".

Response: Thanks for the constructive comment. The word "is" in the original manuscript is revised to "are". Please see line 254 in our new manuscript.

3. Line 277, "provide" -> "provides".

Response: Thanks for the constructive comment. The word "provide" in the original manuscript is revised to "provides". Please see line 277 in our new manuscript.

4. A few typos, grammatical and syntactic mistakes need to be corrected.

Response: We appreciate the referee for the valuable and constructive comments on our manuscript. We have utilized an English proofreading service through our university, hoping the written English is satisfactory in this version.