Manuscript: Water Vapour Exchange between Atmospheric Boundary Layer and Free Troposphere over eastern China: Seasonal Characteristics and ENSO Anomaly (egusphere-2023-1639)

Response to Reviewer #2:

Summary

The manuscript discusses the water vapour exchange between the atmospheric boundary layer (ABL) and free troposphere (FT). The water vapour exchange between the ABL and FT is an important phenomenon related to e.g. precipitation, clouds, tropical cyclone formation etc. Therefore, it is quite important to improve the understanding of the water vapour exchange. The authors are using WRF simulations for seven years to study the phenomena. The model and the parameterization schemes used are well evaluated against meteorological observations. The manuscript is very well written and structured and, in my opinion, it is quite easy for the reader to follow. The structure and results are already quite good, and the methods used are well evaluated, the results are discussed and compared well to existing literature and also the uncertainties of the results are discussed well. Therefore, I have only minor suggestions before I can suggest the publishing of the paper.

Response: We thank the reviewer for the positive evaluation of this manuscript. The response to each comment is listed below. The original comments are in *blue and italic*, our replies are in normal font. Bracketed numbers are used for referee comments (e.g., ***[R2.1]***).

Minor comments

[R2.1] *Figure 2: Do you have an explanation why the model seems to be underestimating the ABLH in winter months, but overestimating during the summer months?*

Response: We infer that the model biases of ABLH are linked to the simulated temperature, which is underestimated in wintertime and overestimated during summertime (Table S1 and S2), thus leading to the lower winter boundary layer and the higher summer boundary layer. The simulation of these two variables (ABLH and temperature) involves many factors such as surface-atmosphere exchange, boundary layer turbulence, long and short wave radiation, cloud process and their interaction. Previous studies have pointed out that even with the same set of parameterization schemes, various model performances may be given in different seasons (Vautard et al.,

2012; Brunner et al., 2015). In the present study, there is insufficient observational data to verify these processes, and the analysis of the specific causes of model errors is beyond the research scope. Though for these biases in ABLH and other meteorological variables, major results and conclusions in this paper should not be altered.

[R2.2] *Figure 2 (+others): It would be good for the reader to point out in the caption, that the winter panel and the summer panels have different scales in y-axes.*

Response: Thanks for this suggestion. The scale differences have been pointed out in the captions of Fig. 2, Fig. 5, and Fig. 7.

[R2.3] *P8 L239: Please give proper citation for the ECMWF data used in the study.*

Response: Accepted. We have standardized the citation format for this dataset according to the journal requirements in the revised manuscript at L249-250, and provided the creators, title, repository, DOI and publication year in the references section.

[R2.4] *P9 L273: Do you mean Sect 3.2 instead of Sect. 3b?*

Response: Yes. This mistake has been corrected in the revised manuscript at L290.

[R2.5] *Figure 8: Is the map showing only statistically significant grids? If not what percentage of the grids were significant? Were there any spatial variation of the significancy?*

Response: Figure 8 shows all grids, not only statistically significant ones. In the whole research domain (20-42°N, 108-122°E), approximately 64% of grids are significantly correlated, with a confidence level of 95%. In terms of spatial variation, a positive-negative-positive triple distribution is presented in the correlation map. The proportion of significant grids is highest (~70%) in the central region (28-35°N, 108-122°E), followed by the southern area (~65%) and the northern area (~55%). This means that the central region has the most sensitive response to ENSO.

In the revised manuscript, the significant grids are indicated by black dots in new Fig. 8, and their percentage and spatial variation are supplemented at L457-464. These revisions are displayed below.

"The statistical result shows that there is a significant correlation between the two factors, with about 65% of the grids meeting the 95% confidence level. A positive-negative-positive triple distribution is presented in the correlation map (Fig. 8). On this basis, the sensitive areas are identified, in which the water vapour exchange fluxes are further analysed. The central region (28-35°N, 108-122°E) has the most obvious significance, where the proportion of significant grids is as high as 70%. This area shows a negative correlation, i.e., the mean vertical output flux of water vapour is enhanced by about 57.6~151.2 g m^{-2} h^{-1} in cold phase La Niña years, and vice versa in

warm phase El Niño years. In south (20-28°N, 108-122°E) and north (35-42°N, 108-122°E) areas with positive correlation coefficients, the trend is reversed. That is, the ABL moisture ventilation flux weakens 79.2~140.4 g m^{-2} h^{-1} in La Niña years and increases 108~194 g m^{-2} h^{-1} in El Niño years."

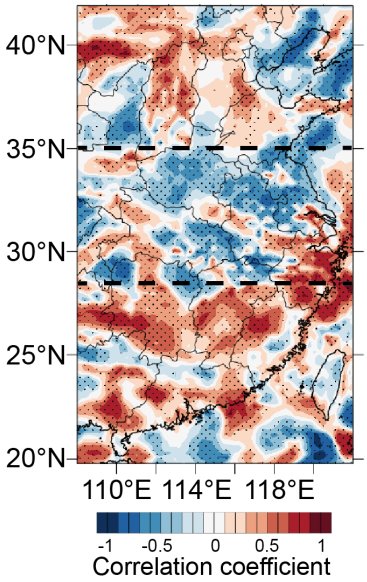

Figure R1. Spatial distribution of correlation coefficient between the water vapour exchange flux anomalies and Niño-3.4 index in July for 7 years. The dots indicate statistically significant grids and the black dashed lines indicate the triple distribution.

[R2.6] *P16 L458–459: Which section do you refer to with Sect. 3a?*

Response: It refers to Sect. 3.1.2. We are sorry for this mistake, and it has been corrected in the revised manuscript at L472.

[R2.7] *Summary: Even if it is good to have some sort of summary of the results, I would prefer (also or instead of summary) a short conclusions section that would also point out the most important findings of this study. In addition, it should be also clearly pointed out in the abstract.*

Response: Thanks for this suggestion. Reviewer #1 also gives a similar comment. In the revised manuscript, we have removed the detailed summary statements, replacing them with brief conclusions. This section is renamed as Conclusions and highlights the most important findings of this study. The abstract is also rephrased.

References

Brunner, D., Savage, N., Jorba, O., Eder, B., Giordano, L., Badia, A., Balzarini, A., Baró, R., Bianconi, R., Chemel, C., Curci, G., Forkel, R., Jiménez-Guerrero, P., Hirtl, M., Hodzic, A., Honzak, L., Im, U., Knote, C., Makar, P., Manders-Groot, A., van Meijgaard, E., Neal, L., Pérez, J. L., Pirovano, G., San Jose, R., Schröder,

W., Sokhi, R. S., Syrakov, D., Torian, A., Tuccella, P., Werhahn, J., Wolke, R., Yahya, K., Zabkar, R., Zhang, Y., Hogrefe, C., and Galmarini, S.: Comparative analysis of meteorological performance of coupled chemistry-meteorology models in the context of AQMEII phase 2, Atmospheric Environment, 115, 470-498, doi: 10.1016/j.atmosenv.2014.12.032, 2015.

Vautard, R., Moran, M. D., Solazzo, E., Gilliam, R. C., Matthias, V., Bianconi, R., Chemel, C., Ferreira, J., Geyer, B., Hansen, A. B., Jericevic, A., Prank, M., Segers, A., Silver, J. D., Werhahn, J., Wolke, R., Rao, S. T., and Galmarini, S.: Evaluation of the meteorological forcing used for the Air Quality Model Evaluation International Initiative (AQMEII) air quality simulations, Atmospheric Environment, 53, 15-37, doi: 10.1016/j.atmosenv.2011.10.065, 2012.