

We would like to thank the referee for the thoughtful and insightful comments. Actually, we have received these comments and made some modifications in the manuscripts accordingly before its publication in ACPD. Our responses are as following in blue

Title: Climatological perspectives of air transport from atmospheric boundary layer to tropopause layer over Asian monsoon regions during boreal summer inferred from Lagrangian approach (MS No: acp-2011-962)

Comments by Referee Xu, Jianming

This paper presents a climatological trajectory study for the air transport from atmospheric boundary into tropopause layer over Asian monsoon regions on the basis of a Lagrangian data set. Main results focused on the distribution of boundary layer sources and their relative contributions, as well as transport time-scales. The paper is well structured and provides a valuable set of quantitative analysis, together with a careful consideration of the uncertainties involved. The results can possibly facilitate the evaluation of the impacts of Asian air pollutions on the global stratosphere. However, the writing of the paper could be improved and the authors ought to be more careful with their discussion at some points. I therefore recommend publication of the paper in ACP after the following major and minor comments have been addressed.

Major comments:

1) Some aspects of the method may however deserve to be addressed or clarified. Firstly, the definition of PBL height in modeling (Pg. 9, L35) and determination of the altitude of tropopause is ambiguous, since there are many definitions from the aspects of dynamical, thermal or atmospheric compositions. I think the references might be needed. Secondly, the trajectories methodology has to be clear and unambiguous. For example, what are the time steps for the FLEXPART model integration? Also, the time period of modeling for every summer (15, May to 31, Aug) does not seem to be consistent with the analysis time period as claimed in the paper (the whole boreal summer season).

Reply: The PBL heights are calculated according to Vogegezang and Holtslag (1996) using the critical Richardson number concept. The PBL height is set to the height of the first model level for which the Richardson number exceeds the critical value of 0.25. As to the tropopause definition, the dynamical tropopause is used in middle and high latitude, while thermal one in tropical region. In subtropics, linear interpolation method is adopted to get the hybrid tropopause.

The dynamical tropopause refers to the potential vortices surface of 2 PVU (1 PVU= $1.0 \times 10^{-6} \text{ m}^2 \text{ s}^{-1} \text{ K kg}^{-1}$), and the thermal tropopause follows the definition of WMO (the height apart from ground more than 500 hPa, and with temperature lapse rate less

than or equal to 2°C/km. More details could be found in Technical note by Stohl A et al. (2005).

The time steps for the FLEXPART model integration is 600s. The time period of modeling for every summer season is from 15, May to 31, Aug. However, the analyses are based on the model output from 1, Jun to 31, Aug (JJA), as claimed in the paper. More descriptions have been added accordingly in update paper.

2) In the general sense, the period of modeling is too short to make any conclusions on the representativeness of the results for climate. Author should be tentative to draw the conclusion on the point of climate. Judging from your conclusions, the impact of using a different year is not significant, however, the Fig 10 show that the source distribution is sensitive to inter-annual variability. Could you explain this discrepancy?

Reply: Thanks. We have added a remark mentioning some limitations on explanation the results of this work, particularly on the point of climatology.

As to the inter-annual variability of source distribution, we thought that several factor could cause this variability, such as sea surface temperature, deep convection, and so on. The topic of inter-annual variability and associated causes is a very important one for climate, but it is a subject that we are trying to work on at present and beyond the scope of the current manuscript.

3) Another issue relates to the choice of input data. The FLEXPART used NCEP/NCAR GFS as input data in this study. Are the results sensitive to the choice of other input data (for example, ERA - Interim or GMAO MERRA)? I do not expect the authors to repeat all the simulations with different input data but I think they should be clearly mentioned and at least comment on.

Reply: Yes. The comments on this point is added accordingly.

4) The writing of the paper needs some improvement. Some sentences are unnecessarily complicated and redundant. This paper also can be shortened by eliminating some details especially in section 1and the cited references.

Reply: We checked thorough the manuscript again and make some modifications in writing, and the copy-editing is conducted by the native speaker. The manuscript is shortened where necessary.

Specific comments:

Pg. 1, L21: What meaning the word “firstly”? Do you mean “for the first time”?

Reply: Added accordingly.

In the abstract (Pg.2, L 4) and many times in the text, the definite Article “the” is omitted.

Reply: Added accordingly.

Pg. 2, L7: misspelling word ‘form’

Reply: Revised.

Pg. 2, L49: ‘datasets’ might be ‘data sets’.

Reply: Yes, changed.

Pg. 2, L49: change the reference “Enhanced Water Vapor Transport to the Stratosphere by Pollutants in Asia”, as it might have been published. For whole paper: “timescales” seems better to replace “time scales” or “time - scales”.

Reply: The reference and the word ““timescales” has been changed accordingly.

Pg. 2, L14: I would like the words “on a timescales of 1 - 2 days” to be replaced by “within 1 - 2 days”, because parts of convection transport may be transport into stratosphere in several hours.

Reply: Yes, changed.

Pg. 4, L13: word by might omitted before TST.

Reply: Added accordingly.

I would think the figure(s) describing the patterns of atmospheric circulation might be useful to illustrate and confirm the transport pathways.

Reply: Indeed. Brief descriptions now added.

Pg. 11, L8: I would prefer to change “height” to “altitude”

Reply: Changed accordingly.

Pg. 13, L1 - 2: This sentence seems to needs some revisions.

Reply: revised.

Pg. 19, L12: the first ‘summer’ should be deleted.

Reply: Deleted accordingly.

Pg. 19, L23 - 24: some redundant existed in the sentence.

Reply: revised.

Pg. 20, L17: there should be a space after word ‘2’. The specific grammatical and writing issues listed above is given for illustration. It is not exhaustive.

Reply: Yes. Changed.

References:

Vogelezang, D. H. P. and Holtslag, A. A. M.: Evaluation and model impacts of alternative boundary-layer height formulations, *Bound.-Layer Met.*, 1996, 81, 245–269, 1996.

Hoinka K P. The tropopause: Discovery, definition and demarcation, *Meteorol. Z.*, 1997, 6, 281~303.

Stohl A., Forster C., Frank A., Seibert P., Wotawa G. Technical note: The Lagrangian particle dispersion model FLEXPART version 6.2. *Atmospheric Chemistry and Physics*. 2005, 5:2461-2474.