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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Intraseasonal variations of upper tropospheric water vapor in Asian monsoon region" *by* R. Zhan et al.

R. Zhan et al.

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Response to comments of reviewer ♯1

1. Zhan et al. present a study of tropical upper tropospheric water vapour (UTWV) over the Asian monsoon region based on AIRS data, and complemented with analysis data from ECMWF. They observe that UTWV is correlated with convection, and identify propagating intraseasonal anomalies. They divide the monsoon region into two distinct regions, and discuss results in terms of a 10 day and a 30–60 days oscillation. The presentation and discussion of the results for those regions and oscillation periods is often confusing, and the authors should try to find a way to present the material more clearly (perhaps it would help to

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discuss the results for each region separately, rather than switching back and forth?).

Response: As mentioned in the manuscript, it is possible that the signatures of UTWV variations in East Asia differ significantly from those in South Asia (p8071/l13), so one of the main purposes in this study is to compare the UTWV variations in East Asia with those in South Asia. Just due to this purpose, after analysing the UTWV variations in South Asia, we turned to East Asia and discussed the difference of UTWV variations in two sub-monsoon regions. We have tried to reorganize the document to better reflect the reviewers concern, and be more focused in discussing each region.

2. The paper points out differences in results to other studies (e.g. p8074/l23), without writing what the differences are. Readers less familiar with these papers are left wondering.

Response: We wrote in the manuscript, that "The peak UTWV in Fig. 1 ($\sim$40 ppmv) is in widely elongated belt stretching eastward from the Indian subcontinent to East Asia, including China and southern Japan. This is different than the peak at 100 hPa observed in HALOE data (Gettelman et al., 2004a) which is located just to the northwest of the Indian subcontinent in boreal summer (p8074/l7)". We referred to such difference in p8074/L23 just for emphasis. In order to eliminate the confusion, the difference has been made more concrete with further discussion of Gettelman et al. 2004a.

Further, a statement like 'The propagating features ...of 2003 ... are not identical ... 2004' (p8081/l10) is too vague: the paper should describe what is different, and why it is considered an aspect worth mentioning.

Response: We thank the reviewer for the comment, and we have clarified this statement. In the revised manuscript this sentence 'The propagating features ...of 2003

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... are not identical ... 2004' (p 8081,l10) has been modified as follows: 'Although the propagating features in UTWV during boreal summer of 2003 are highly similar to those for the same period of 2004, the strength and the date of wet phase of the ISOs in these two years are not identical.' It suggests that the 30–60-day oscillation of UTWV in monsoon regions has significant interannual variations. Therefore, it may be also interesting to study the interannual relationship between monsoon activity and the UTWV disturbances. This is why we mentioned the difference in two years.

Naturally, the reader begins to wonder what the statistical significance of the described features are (i.e. are they climatologically relevant, or a random observation of one particular year?). Some clarifying statements would be helpful.

Response: Clarifying statements have been added in the end of the revised manuscript: 'It should be noted that the above results are obtained just from two-year AIRS data. Further understanding of the ISOs of UTWV and its relationship with Asian summer monsoon is required. We hope that the new AIRS and other instruments provide more high-quality water vapor data to clarify this issue in much detail.'

Also, the paper has awkward sentences that should be improved (e.g. p.8076/l3/4: 'relatively single propagating signature').

Response: We carefully checked the paper again, and some sentences have been improved in the revised manuscript. For example, the sentence 'relatively single propagating signature' has been modified into 'Compared to the 30–60-day mode, the 10–20-day mode (Fig. 4c and d) exhibits a uniform direction of propagation.'

3. My main concern, however, is that the paper does not really arrive at substantial conclusions. That UTWV oscillations on various timescales do occur is hardly new, and neither is its association with deep convection.

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Response: It has to be kept in mind that the characteristics of ISOs in UTWV and its association with deep convection may be different in particular region and particular season. The UTWV oscillations have been studied recently, whereas emphasis of these studies is put on the characteristics of the boreal winter ISO in the tropics (also called the Madden-Julian Oscillation, or MJO), and less attentions are paid to the summer UTWV in Asian monsoon areas. In this work, we use a relatively new data source (AIRS) with higher quality and frequency upper tropospheric humidity to draw two distinct conclusions from previous studies in the sources and propagating signatures of the UTWV disturbances The first is to indicate two distinct propagating patterns in the UTWV disturbances over the Asian summer monsoon region, and the second is to reveal the relationship between wet/dry periods in UTWV and active/break (inactive) periods in monsoon convection. It should help further understand not only the distribution and variability of the UTWV but also the relationship between the UTWV and Asian summer monsoon. We have clarified this in the conclusions.

Sentences like 'We note that the 30–60 day wet periods are closely related to the monsoon activity.' (p8076/l2) are too vague to have meaning.

Response: This sentence has been deleted.

The authors point out that they find disturbances that propagate westward, which differs from the results of other studies that focus on eastward propagating disturbances. This may be interesting and could deserve publication, but the paper does not provide any insight as to why this different behaviour occurs, or why it may be important at all.

Response: This is an interesting question. We have added the following information to Section 3.2 of the revised manuscript: It suggests that the 30–60-day oscillation of UTWV does not always move eastward, especially in East Asian summer monsoon

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region where the preferred source of moisture over West Pacific plays an important role in UTWV over China and southeast Asia by westward propagating. It also notes a unique feature of this manuscript.

In addtion, Hovmöller plot of 850 hPa zonal wind averaged over 15°–25° N from May to September of 2004 shows that the westerly is very strong in South Asia but weak even reverse in East Aisa (not shown), so we also changed the following information in Section 3.3: 'The similarity of UTWV disturbances (Fig. 5) and the OLR convective proxy (Fig. 6) suggests that the propagation of UTWV is the result of a westward-propagating Rossby wave from convective heating in the Indian and West Pacific oceans interacting with the monsoon circulation.' We will investigate in more detail in future work.

Further, a short description as to why you observe a lag with height (e.g., p. 8078/l20, Fig. 8) between UTWV and convection would certainly help to improve the relevance of the paper (for example, one might expect convection to transport water upward on timescales of hours, and the subsequent gravitational settling of the ice crystals may also be of order hours to a day or so, and hence it is not immediately trivial to see why you observe a progressive lag with height from about 400 hPa upward).

Response: A sentence has been added to the revised manuscript: 'Such a lag correlation between UTWV and OLR can be explained largely by convection, which carries the moisture to the upper troposphere, and a strong three dimensional circulation, which occurs several days after the convective maxima (Randel and Park, 2006). The upper level circulation and response are likely due to the reaction of the large scale dynamics to convective heating anomalies which affect the regional circulation (Hoskins and Rodwell, 1995), and not the direct injection of air in convection'. This is yet another unique feature of this manuscript.

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