Response to 1st Referee's Comments on

What controls the stable isotope composition of precipitation in the Asian monsoon region?

by Le Duy Nguyen et al

General Comments:

In recent years, a number of empirical, theoretical, and modeling studies have attempted to identify, characterize, and quantify the dominant controls of the stable isotopic composition of rainfall in tropics, particularly in the Asian monsoon domain. Duy et al manuscript, which at a first glance, seems like yet another manuscript along this line, indeed dives much deeper than the previous studies and attempts to provide more rigorous and quantitative assessments of various climatic factors that control stable isotope composition of rainfall in the Asian monsoon domain. Authors present a robust body of observational precipitation isotope data (weekly to bi-weekly samples over ~1.5 years) collected from Vietnamese Mekong Delta region. This observational isotope data has been examined in the context of both local-and-regional-scale station-based climate data (temperature, precipitation amount, humidity), GNIP data, and finally climate data extracted from GDAS gridded dataset, the latter being used to drive the NOAA's HYSPLIT models. Authors conclude that the influence of the different factors on the isotopic condition is best quantified by multiple linear regressions (MLR) of all factor combinations and that explains up to 80% of the variation of δ18O of precipitation. This study, like many previous studies, shows that local rainfall amount and temperature play a minor role in controlling the isotopic composition of the rainfall with upstream precipitation amount emerging as the dominant regional control again a result consistent with previous studies, but the author's conclusion is backed by solid quantitative analysis. The manuscript is well-written, free of excessive jargon, logically structured with high-quality figures and graphics that are instructive and easy to understand. In sum, I did not find any major issues with this manuscript and I highly recommend its publication. I have provided here a few comments, which authors may find useful in further improving their manuscript.

We thank the first anonymous referee for the positive and constructive comments, and the recommendation of publication of this paper. We are also grateful for the constructive comments, to which we reply below (in blue). Our answers will be included in a revised version of the manuscript.

Specific Comments:

1. Are results of this manuscript sensitive to the choice of gridded dataset (for example, R1/R2) vs GDAS, which was used to drive the HYSPLIT model?

Yes, we acknowledge that the results of this manuscript might be sensitive to the choice of the climate dataset driving the HYSPLIT model. Harris et al. (2005) studied the sensitivity of the trajectories to the meteorological input data (focusing on ERA-40 and NCEP/NCAR reanalysis data) and pointed out that the horizontal trajectory deviations summarized as a percentage of average distance traveled could be around 30-40% depending on the used data set. However, it is difficult to prove that in all situations a single meteorological data set was superior to another (Gebhart et al., 2005;Harris et al., 2005). Moreover, the backward-trajectory simulations by HYSPLIT are also influenced by other parameters to be defined for running HYSPLIT, such as starting time and height of the trajectories, trajectory duration, vertical motion options, and number of trajectories. Studying the sensitivity of HYSPLIT backward-trajectory simulations would be an interesting topic, but exceeds the scope of this study. More details about the uncertainty of trajectories, and a review of the types and uses for back

trajectories and the associated errors and probabilities within them has been provided by Stohl (1998), later by Fleming et al. (2012) and references therein.

With regard to the particular dataset mentioned by the reviewer (we assume that the R1/R2 dataset mentioned the 'NCEP/NCAR Reanalysis (1948 - present)' in http://ready.arl.noaa.gov/archives.php), we argue that the GDAS dataset used is more suitable for the purpose of our study. GDAS offers higher horizontal and vertical resolutions of the meteorological data (1-degree), compared to NCEP/NCAR Reanalysis (2.5 degree). Hence the HYSPLIT trajectories calculated on GDAS are supposed to be more detailed and reliable.

2. Figure 5 shows backtracking trajectories (only those which produced rainfall). Perhaps I missed reading about it but can authors more clearly elaborate on the criteria they applied to establish when a certain air parcel was considered to produce rainfall?

Because there is no daily precipitation data recorded at An Long, we used daily precipitation data at Cao Lanh instead. This is the closest national meteorological station to An Long, which is approximately 37 km SouthEast of An Long. Backtracking trajectories are plotted for the days when rainfall was recorded at Cao Lanh. This is based on assumption that days with precipitation at Cao Lanh and An Long are the same.

3. Additionally, I think it will be useful to have another figure that shows major cluster tracks (instead of trajectories) and their relative weights. For example, what percentage of trajectories originate from the Indian Ocean vs continental sources during the rainy season?

Thank you very much for this constructive suggestion. We will add the following figure to the manuscript.

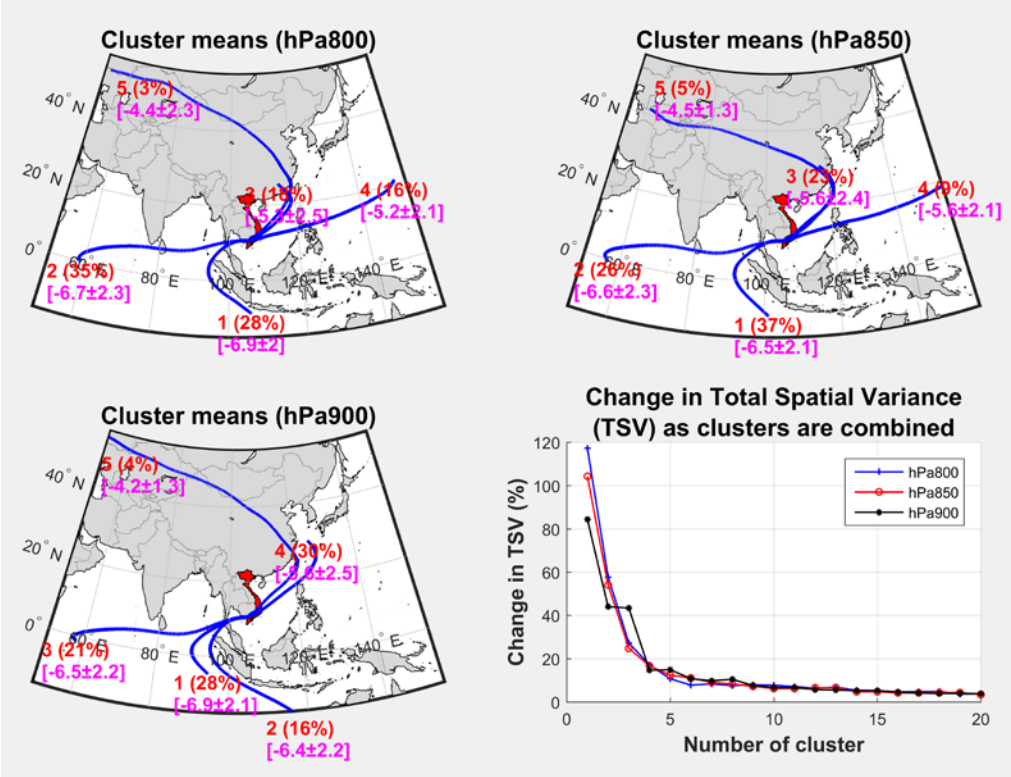

Figure 6: Spatial distribution of vapor trajectories (cluster means) for precipitation days at An Long for 3 barometric surfaces (800, 850, 900 hPa) between June 2014 and December 2015, and change in total spatial variance (TVS) for different cluster numbers. The TSV was used to identify the optimum number of clusters. Red texts indicate the cluster number (1-5) and the percent of all trajectories assigned to each of the five clusters. Magenta texts indicate the mean $\delta^{18}O$ values for each cluster plus/minus the standard deviation of each cluster.

The trajectory cluster analysis conducted by the HYSPLIT model groups similar trajectories. The cluster analysis merges trajectories that are near to each other and represent those clusters by their mean trajectory. Differences between trajectories within a cluster are minimized while differences between clusters are maximized. Computationally, trajectories are combined to decreasing number of clusters until the Total Spatial Variance starts to increase significantly. This occurs when disparate clusters are combined. This number of clusters is then selected as the optimal cluster number sorting similar trajectories. More information about the HYSPLIT cluster analysis can be found at: https://ready.arl.noaa.gov/documents/Tutorial/html/

Furthermore, can these tracks be fingerprinted with their typical d18O values? I suppose this should not be too difficult given that authors have access to the d18O values of precipitation.
The mean $\delta^{18}O$ values for the 5 clusters are plotted in the added figure (see above- magenta texts). The mean cluster values are similar for the three pressure levels. Also the mean values of the two clusters form the Indian Ocean, as well as the two clusters from the Pacific are similar. For a fingerprinting one also has to consider the variation of the values within the clusters, which partly overlap. This means that the $\delta^{18}O$ values of precipitation in the Mekong Delta cannot be used to uniquely identify the origin of the trajectory. However, they provide a coarse indication of the origin.

4. I think the authors need to be more specific (as opposed to providing generic comments) in suggesting how their conclusions need to be considered in paleoclimate studies. It would be helpful if they can cite some paleoclimate studies where proxy data may have been misinterpreted in light of the results obtained from this study.

We conclude that the isotopic variation of precipitation in the Asian monsoon region should not be regarded solely as being influenced by either local factors (e.g. local rainfall effect or temperature effect) or regional factors (e.g. circulation effect). Instead, it should be regarded a combination of both (Johnson and Ingram, 2004). However, to our best knowledge, there has been no study quantitatively investigates the interplay of local and regional factors in controlling isotopic composition in precipitation, which has been pointed out in this study. We will elaborate these findings in the conclusion in final version of the paper.

The suggestion of citing paleoclimate studies where our findings could have made a difference seems to be appealing, but we have to admit that paleoclimate is not our research focus and that we don't have an encompassing picture about all the past and ongoing research in this field. We thus don't feel qualified to criticize published studies in this field. We rather hope that the paleoclimate community will become aware of our results and methods, and that they might be considered in their future research.

References

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