

Interactive comment on “A Lagrangian description on the troposphere-to-stratosphere transport changes associated with the stratospheric water drop around the year 2000” by F. Hasebe and T. Noguchi

Anonymous Referee #1

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General comments:

This manuscript describes the change of pathways of backward kinematic trajectories initialized at 400 K height level from a period before and after the stratospheric water vapour (SWV) drop in the year 2000. The authors discuss the cause of the stepwise drop in SWV by an analysis of the water vapour entry values to the stratosphere. They focus on the month of September in the period 1998–2002, because the drop in H₂O entry values first occurred at that month. The authors' conclusions are that the low

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H₂O entry values to the stratosphere in September 2000 and the sustained low values thereafter can be interpreted as being driven by changes in thermal forcing from the earth's surface.

I recommend major revisions before a potential publication of the manuscript in ACP.

Specific comments:

Two former publications of 1. by Bonazzola and Haynes (2004), who performed a trajectory analysis on the basis of ECMWF operational analysis data for the period prior to the drop (1997–1999) and 2. by Fueglistaler, Wernli and Peter (2004), who analysed the troposphere-to-stratosphere transport in the time period January/February and July/August for the year 2001 (i.e. posterior to the drop), and probably relevant to this study, are considered neither in the introduction nor in the results. The authors should compare their results with those of these older ones. In particular I would like to see what is new in the current manuscript.

In Section 2.1 you state that your method is similar to that of Fueglistaler et al., 2005. I suggest that you describe at least the main aspects of your method (e.g. in an Appendix), so that the reader can understand what you did without reading the aforementioned paper. Please provide as well more information on the calculation of the trajectories. For instance: which time interval of ERA-interim data was available for interpolation? As ERA-interim has 6 hours output interval, do you consider this sufficient for temporal interpolation? Also, how many trajectories do you analyse in total? Is this sufficient for robust results?

In sections 3.4/3.5 you show that the horizontal distribution of LCP-event probability (Fig. 5) shifts from Bay of Bengal and the Western Pacific area to the Central Pacific. Fig. 7 shows that the contribution of the region from which the water vapour enters the stratosphere shifts in the same way. However, this effect is accompanied by a general decrease in H₂O entry values over most of the tropical area (Fig. 6(b)) and a strong temperature decrease at 100 hPa (Fig. 9), which is most prominent in the Central

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Pacific. I wonder whether it is not this cooling at 100 hPa which is the dominant process for the water vapour drop instead of the shift of trajectories entering the stratosphere. Thus I would like to see more evidence for your suggestion that it is the shift of the trajectories rather than the strong cooling at 100 hPa that leads to the water vapour drop. My feeling is that it is not possible to disentangle these two influences with your analysis.

Page: 28040, line 10: what do mean by occasional value? line 20: however, it will...what is meant by "it"? line 21: "the advantages" . Please specify the advantages or omit the "the"

Page 28041, line 12: what is meant by " those on pressure levels". Which variables are on pressure levels?

Page 28042, line 19: if you use ERA-interim data for the calculation of backward trajectories, how is a time step of 30 minutes possible? Please provide some information why 0.2 K in potential temperature within one time step defines a fast ascending air parcel. line 24: "rapidly decays" is probably the wrong expression. Do you mean the proportion of fast air parcel go to zero?

Page 28045, line 2: The reference to figure 4 of Randel and Jensen is misleading. It shows the intrusion of ozone-rich air, which I expect to be of stratospheric origin and thus dry air.

Page 28046, line 10: Please provide information about the statistics ("significance") including the respective formulas you used. I do not understand how the t-test is applied for your samples. I expect to see arguments why you think your applied statistics method is suitable. You might do this in an appendix. line 8: "leading to a reversal of the zonal gradient of SMR_min over the equator"... I do not understand this sentence. Page 28048, line 21: How can the contribution from the Tibetan high and the thermal forcing from the ocean to the SWV drop be quantified by a "projection of the H2O entry values onto bins in the tropics"? I don't understand this sentence.

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Page 28049, line 5: "without taking the average". I do not understand what you intended to calculate. Page 28049, lines 23-29: I cannot follow your description of Figure 10.

Page 28050, lines 1-3: I doubt your conclusion drawn from Fig. 7, namely that the TTL temperature in the Central Pacific is not the cause of the water vapour drop. I think that this interpretation is not supported by the results of Figure 7. Please consider that the cooling in 2001/2002 is distributed over the whole tropical belt, as Figure 9 shows.

Discussion section: As far as I understand the following two sentences contradict each other:

Page 28050 line 1ff: "The important point in our analysis is that the drop of H2O does not come from the decrease of TTL temperature in the Central Pacific but that from the the water transport by way of the Bay of Bengal and the Western tropical Pacific."

and

Page 28052 line 6: "The correspondence to the change in the SST distribution... suggests that the drop and the subsequent low values of H2O are brought about by the eastward expansion of warm SST region to the central Pacific through reduced water entry to the stratosphere."

Could you please clarify?

Figure 5: The caption of this figure is not at all comprehensible from the beginning of "The difference of probabilities...". Please give details of the computational method either in the main text or in an appendix. For instance, describe what is considered in the Binomial distributions and how you determined their parameters. What do you mean with Gauss transformation? Is it simply the fact that the Binomial approaches a Gaussian for a large number of data?

Technical corrections:

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Figures 5/6/7: please describe the respective month and year on top of the figures, then it is easier to follow the description in the text.

Figure 9/10: color bar is missing.

Figure 12: select a more appropriate color bar to display the results for the upper and middle figure.

References:

Bonazzola M, Haynes PH (2004), A trajectory-based study of the tropical tropopause region. *J Geophys Res* 109:D20112 doi:10.1029/2003JD004356.

Fueglistaler, S., H. Wernli, and T. Peter (2004), Tropical troposphere-to-stratosphere transport inferred from trajectory calculations, *J. Geophys. Res.*, 109, D03108, doi:10.1029/2003JD004069.

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