Atmos. Chem. Phys. Discuss., 13, C1242–C1247, 2013
www.atmos-chem-phys-discuss.net/13/C1242/2013/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Modeling upper tropospheric and lower stratospheric water vapor anomalies" *by* M. R. Schoeberl et al.

Anonymous Referee #2

Received and published: 13 April 2013

This is a focused concise study of origins of air parcels that enter into the stratosphere and exactly where dehydration occurs. Please note the editorial type suggestions given below. There are also a few questions given below as well. After a bit of cleanup, the paper is perfectly suitable for publication in ACP.

Note: quoted text is from the manuscript. . .questions, comments or suggested corrections follow.

Abstract

Page 9654 line 9/10 "This is due to the convergence of rising air as a result of the stronger diabatic heating near the tropopause relative to levels above and below." . . .Convergence where? In the tropical Pacific? And is diabatic heating the cause

of the convergence or is wave driving above the region of convergence the ultimate forcing?

Page 9654 Line 15/16 "We find that the driest air parcels that originate below the TWP, moving upward to dehydrate in the TWP cold upper troposphere." . . .Delete the second "that" in the sentence.

Page 9654 Line 17/18 "The wettest air parcels originate at the edges of the TWP as well as the summer American and Asian monsoons." . . .change to: as well as "in" the summer American and Asian monsoon circulations.

Introduction

Page 9654 Line 25/26 "Brewer noted that air must have been entering the stratosphere through the coldest part of the tropopause, found in the tropics." . . . Change "must have been entering" to "must have entered".

Page 9654 Line 26 page 9655 Line 1 "Mass conservation requires that this tropical upward circulation would have descending branches in the extra-tropics.". . . Remove "would" from sentence.

Page 9655 Line 2 "Newell and Gold-Stewart [1981], again using stratospheric water vapor and tropopause temperature observations, suggested that most of the air reaching the stratosphere was moving upward through the very coldest part of the tropical tropopause, the winter Tropical West Pacific (TWP), a region they termed the 'stratospheric fountain.'" . . . .Note: the second author is Gould-Stewart, the paper referenced only used temperature observations and referenced water vapor observations discussed by others.

Page 9655 Line 11 "Sherwood and Dessler [2000] defined the Tropical Tropopause Layer (TTL), a transition layer between the troposphere and stratosphere to extend from the level of zero net-radiative heating (∼13-14 km, 355-360 K potential temperature) to the highest level that convection reaches (∼18- 19 km, 380-400 K).". . .change

"to extend" to "extending"

Page 9655 Line 21 "From a Lagrangian perspective, once air parcels reach the TTL, they move upward due to positive net radiative heating rates encountering colder temperature." Wouldn't a parcel experiencing positive net radiative hearing rates move upward irrespective of the temperate it encounters? Sentence needs rewriting.

Page 9656 Line 1-3 "As found by Schoeberl and Dessler [2010, here after SD2010], maps of the FDP distribution show that most parcels complete the dehydration process in the Tropical West Pacific (TWP) as originally theorized by Newell and Gold-Stewart [1981]."...change Gold-Stewart to Gould-Stewart.

Page 9656 Line 4-6 "In fact, the dehydration process and the process of entering the stratosphere are different processes that may occur at different locations as we will show below." There are too many "processes" in this sentence.

Page 9656 Line 10-12 "The sample age and water vapor amount is the ensemble average of parcel age and water vapor concentration, respectively." Change to "is the ensemble average" to "are the ensemble averages".

2. Model and Observations

Page 9657 Line 10/11 "The diabatic heating rates includes the radiative effects of gases, clouds, turbulent heating, etc." ... change "includes" to "include"

Page 9658 line 8/9 "In a diabatic trajectory model, the net heating rates controls vertical transport." Either change "rates" to "rate" or "controls" to "control".

Figure 1: Titles are messed up. It's very hard to see the winter "thin orange lines".

Page 9568 Lines 9-11 "Figure 1 shows the time mean Boreal winter (DJF) and summer (JJA) upper tropical troposphere temperatures and heating rate fields at a log-pressure height of 17 km ($\sim$90 hPa)." Are you using model levels in pressure (so this is really at 90 hPa) or some hybrid model level?

2.2 Observations

Page 9569 Lines 9-12 "While the model can include simple parameterization for the effects of gravity waves and convection, as well as allowing for super-saturation (see SD2010), for these experiments we turn off all the parameterizations and assume that water is instantly removed at 100% saturation. Including these additional processes does not affect our results." Have you tested the impacts of not assuming water is instantly removed, but instead falls and re-evaporates?

3.0 Water Vapor Simulations

Figure 2, caption does not mention 83 mb included in the plot? I assume it should come before (e-h). And, what does "the zonal mean water vapor fields are normalized to the zonal mean MLS field" mean? Is it multiplicative or a linear offset? Please explain more either in the caption or the text.

Page 9660 lines 9-15 "The good agreement between the MLS water vapor features and the model features give us confidence that the models can be used to further understand water vapor anomalies in the upper troposphere. It is also somewhat surprising. Dessler and Sherwood [2004] argued that the monsoonal high water vapor features are related to convection. Our model, however, does not include convective moistening, so this indicates that a model including only slow radiative ascent can also accurately simulate these features." For stratospheric water vapor, isn't the key actually having accurate temperatures at the cold point? Convective moistening is not in the reanalysis explicitly, but its impact on temperature is. Hence, I'm not sure you've demonstrated that a model including only slow radiative ascent is all that is needed.

3.1 Parcel displacement in the TTL

Page 9661 Lines 1-3: "For winter the plots (Fig. 3a,b) show that very little displacement of parcels from 360 -> 370 K over a region stretching from the Africa to the TWP, and South America." Change to "...that there is very little displacement..."

Page 9661 Lines 17-20 “Bergman et al. [2013] has noted the almost complete isolation of the air within the Asian monsoon high pressure system; their back trajectories initiated within the upper troposphere anticyclone descend almost vertically to the surface.” This is a bit awkward. . .maybe instead. . .”their back trajectories initiated within the upper troposphere anticyclone originate virtually directly from the surface below”?

3.2 Water vapor spectrum

Figure 4: I’ve assumed the spectrum is from all parcels at all latitudes in the stratosphere. . .but what altitude region do you define the stratosphere as? The text states that it is all parcels above 380K. Does your trajectory calculation fill the stratosphere up to 1 mb, or are most parcels included between 100 and 10 mb? And, can you include MLS on the plot?

Page 9662 Lines 18/19: “Figure 6 shows the distribution of parcel initialization locations vs. water vapor amount in the stratosphere for all seasons.” I’d just like clarified exactly what’s plotted here....x axis is origination latitude, y axis is water vapor (without methane) at any location in the stratosphere, and the color scale gives a sense of the likelihood of that combination..but what does the numerical value (the color bar; 0-215 at top and 0-53 at the bottom) mean?

Page 9662 Line 25 “These source regions are generally of higher heating rates (Fig. 1).” I’d suggest changing this to “These source regions have generally higher heating rates in the TTL (Fig. 1).”

3.3 Transport Patterns*

Page 9663 Lines 7-9 “We agree with F2004 that most of the air moving into the stratosphere is from the TWP, we find that South America and Africa are significant source regions.”..change to “Although we agree. . ..we also find that. . ..”

Page 9663 Lines 18-21“Antarctic dehydration yields significantly lower water vapor concentrations than Arctic dehydration; however, neither region has a strong impact on the

overall dryness of the stratosphere except that the southern hemisphere is slightly drier than the northern hemisphere as observed by the MLS (SD2010).” . . . Note that Rosenlof et al. 1997 (JGR, Hemispheric asymmetries in water vapor and inferences about transport in the lower stratosphere) discusses this issue in detail, and attributes the reason to both Antarctic dehydration and phasing of the tropical dry phase of the tape recorder and transport/mixing into the summer hemisphere and differences in hemispheric downwelling.

3.4 Sources of wet and dry parcels*

Page 9664 Lines 20-23 “From Figures 6a and 7c and as noted above, the wettest parcels appear to originate at the edge of the tropics and in the low displacement zones associated with the monsoon (Fig. 3) while the driest parcels arise near winter TWP.” Just something to think about: when it was proposed that trends in water vapor not explained by methane could be due to tropical expansion, Zhou et al, (2001, JGR, Cooling trend of the tropical cold point tropopause temperatures and its implications) actually tested that out in model world. Is there any way you can use the long-term runs done in this study to look at that issue as well?

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 9653, 2013.