Atmos. Chem. Phys. Discuss., 10, C3720–C3728, 2010
www.atmos-chem-phys-discuss.net/10/C3720/2010/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Water vapor budget associated to overshoots in the tropical stratosphere: mesoscale modelling study of 4–5 August 2006 during SCOUT-AMMA" *by* X. M. Liu et al.

X. M. Liu et al.

xiaoman.liu@univ-reims.fr

Received and published: 8 June 2010

Answer to Referee#2

Preliminary remarks: We have chosen in the revised manuscript to use colored text each time a change has been made, so that the reviewer can notice immediately where revisions are.

Main changes due to referee#1 and D. Grosvenor's comments: Referee#1 wish we used microphysical measurements from Corti et al. (2008) to validate our simulation.

This has been done and comments on this are included at the end of section 4.1 and in section 5.1 after the discussion of Fig 13. Referee#1 proposes to follow the hydrated plume as far as possible to clearly validate the hydrated layer measured above Niamey by the balloon-borne hygrometers. Since our simulation ends before the overshooted airmass can reach Niamey, this was not possible to do that with our simulation. However, we have checked the hydrated signal (in Grid#1) when the simulation ends. The signal is still identifiable but is relatively low. This is discussed in the text at the end of section 5.1.

Following the recommendation of D. Grosvenor's comment, each time mixing ratios from other studies are given, the sizes of the domain have been added. We have also added in Table 3 the lower and the upper limit of the water mass that remains in the stratosphere for both cases. It is compared to mass budget estimation given in D. Grosvenor's comment and in the recent publication of Iwasaki et al. (2010) based on satellite observations, a new reference in the manuscript. The stratospheric water mass change is now given in a new Fig. 15 (see below for details). These new findings are now mentioned in the abstract and in the conclusion.

Many (small) changes in the figures have been done, mostly due to color scales (Figs 7,9, 10, 12), name of the countries or latitude/longitude labels (Fig 2, 4, 5). Important change has been done in Fig. 1: Referee#1 highlighted an altitude shift between the FLASH and the micro-SDLA profile. This was due to the use of the geopotential height for FLASH rather than the GPS altitude. This has been corrected and a much better fit in altitude is reached for the main pattern of the profiles.

Now we answer point by point to referee#2

General comments:

The main point of Referee#2 concerns the calculation of the upward total water flux across isentropic surface rather than a net flux:

ACPD

10, C3720–C3728, 2010

Though we are aware that these fluxes are not an indication of the amount water that remains in the stratosphere, the reason for this choice is twofold: 1) The main aim was to compare the impact of an overshoot in Africa with other cases from other regions of the globe. Thus we have chosen to use a similar approach as in Chaboureau et al. (2007), hereafter CH2007, so that we can compare our results with this study. We agree with referee#2 that we have presented total water in our flux calculation whereas CH2007 have shown only water vapor fluxes. In order to directly compare our result with CH2007, we have added the water vapor upward flux for the 380 K and the 390 K levels in Fig. 14. It shows that our result is significantly lower than CH2007. However the difference of the size of the domain in which the calculation is made must be accounted for. Having saying that, differences still exist but are much lower than they are apparently. This effect is now discussed in section 5.1. Possible reasons for the above mentioned differences between our study and CH2007 are examined such as the vertical velocities, as proposed by referee#2. In the core of the convective system the maximum vertical velocity is typically half of less the one of CH2007. These numbers are given in the text after the comment of Fig. 14. One other possible reason is the microphysical scheme (see unchanged text for this point). Finally the time resolution for the isentropic calculation (10 minutes for CH2007 and 5 minutes in our study) is a possible source of difference. We have performed the same calculation using a 10 minute time-step, and the results does not differ very much. This cannot be the major explanation. This is also mentioned in the text. Thus the vertical velocity and the microphysical scheme should explain the difference. Note also that the case of CH2007 is from another continent.

2) Computing a net flux is not unambiguous because the downward flux would hide an indirect contribution of the sedimentation of ice particles (which must to be taken into account in an explicit way by an online calculation for a precise estimation). Ice particles that fall from high above the tropopause can enrich the layers just above the tropopause. In such a case, a downward relative vertical wind at the tropopause would take into account the transport of water that would be already partially taken into

ACPD

10, C3720–C3728, 2010

account in a calculation of loss by sedimentation. Keeping in mind that what remains in the stratosphere, is the sum of the upward contribution, the downward contribution, and the sedimentation contribution, a calculation with net fluxes would be biased. Instead, and following recommendation from the comment of D. Grosvenor, we have prefer to compute a stratospheric mass change from the overshoot time in order to tentatively infer the amount of water that remains in the stratosphere. The results are shown in the new Fig 15 of the revised version and is commented in section 5.1. We reach the conclusion that the Chad case has hydrated the stratosphere irreversibly by 330 to 507 tons. The addition of these new results has induced changes at the end of the abstract, and in the conclusion. Now we insist more on this amount of water that remains in the stratosphere, though we still mention the results on the upward water fluxes to make the comparison with CH2007 possible.

Other comments

We have changed all the “vapor” to “vapour” P3975, L1: We have changed the title as proposed by referee#2 but mentioning the modeling approach and the SCOUT-AMMA context. “Stratospheric water vapour budget and convection overshooting the tropopause: modeling study from SCOUT-AMMA”

P3977, L4: We have changed “entry of water vapor amount” to “water vapour mixing ratio”

P3977, L6: We have changed “two overshooting cases” to “two cases of overshooting convection” P3977, L14: We have corrected “thought” to “though”

P3977, L16: We have added “displacement” after typically 1°” P3978, L5: “when exiting the highest resolution grid”: this sentence has been removed due to a comment from referee#1. P3978, L22: Combining the first two sentences. . .: We have rephrased the two sentences into “Until recently, the most accepted mechanism driving the water vapour mixing ratio in the lower stratosphere is dehydration by freezing.”, followed by a shorter sentence than in the ACPD version. P3979, L2: We have changed “This

ACPD

10, C3720–C3728, 2010

process is called the cold trap hypothesis" to "This is often referred to as the cold trap hypothesis" P3979, L3: "In contrast to this hypothesis" : we have decided to rephrase the sentence by using "Concurently" instead of "In contrast to this hypothesis". P3979, L4: We have changed "show" to "shown"

P3979, L12: We have added "a" before "too short duration" P3979, L13: We have changed "for being" to "to be" P3979, L14: We have changed "impact" to "representation" P3979, L23: We did not change "from Niamey" since the balloon measurements are not strictly above Niamey: the balloons are travelling west while flying, sometimes crossing the border with Burkina Faso.

P3979, L29: We have changed "However, the modelling approach, validated by this set of measurements . . ." to "Conversely, a modelling approach, evaluated by such a set of measurements" P3980, L14: We have added "the" before "local scale"

P3980, L28: We have deleted "different" P3980, L29: We have added "and" before "the second one is . . ." P3981, L7: We have changed "at a local scale" to "at the local scale" P3981, L12: No change of "from Niamey" to "in Niamey" P3982, L2: We did not change "Balloon borne water vapor measurements" to "Water vapour measurements using a balloon-borne system" since we think the first sentence is clearer. "of 5 August 2006" to "on 5 August 2006", and "from Niamey' to 'from the Niamey military airport"

P3982, L18: We have changed "We suspect this artifact could be due to" to "We suspect that this bias could be due to"

P3984, L12: We have changed "for the 12:15 UT to 19:15 UT with a 15 min timestep period" to "from 12:15 UT to 19:15 UT with a 15-min time resolution"

P3984, L16: We have changed "in the North of" to "north of"

P3985, L1: We have added "of" in the title 2.2 "Description of the Aïr case"

P3985, L4: We have added "the" before "Aïr mountain area" P3986, L15: We have changed "mother or son grid" to "parent or child grid" P3986, L22: We have changed

ACPD

10, C3720–C3728, 2010

"two moment scheme (Meyers et al., 1997)" to "two moment scheme developed by Meyers et al. (1997)" P3986, L25: We have added "number" after "hydrometeor"

P3986, L26: We have added "a" before "gamma function"

P3987, L15: We did not change "nudging" to "forcing" since nudging is the appropriate word for this simple data assimilation technique. P3987, L21: We have added "convective" before "system formation"

P3988, L17: We have changed "three" to "triply"

P3988, L19: We have changed "fraction" to "part"

P3988, L24: We have changed "under the scope of our study" to "of interest" P3988, L26: We have changed "is located at the South of" to "is located south of"

P3989, L5: We have changed "Validation" to "Evaluation"

P3989, L9: We have deleted "first"

P3989, L15: I We have changed "Secondly, we compare" to "We also compare"

P3990, L2: We have deleted "Thus", and change "rainrates" to "Rainrates"

P3990, L9: We have changed "on MSG observations" to "to using MSG observations"

P3991, L2: We have changed "both for" to "for both"

P3991, L8: We have changed "computed" to "visible"

P3991, L9: We have changed "validate" to "evaluate"

P3991, L11: Usually the 380 K is used to characterise the tropopause. The reference Holton et al., (1995) has been added in the text here.

P3991, L18: We have changed "is well in agreement" to "is in good agreement"

P3991, L19: We have changed "This good result" to "This good agreement of the model

ACPD

10, C3720–C3728, 2010

with observations”

P3991, L24: We have changed “On the other hands” to “On the other hand” P3991, L26: We have changed “ressources” to “resources” P3992, L8: We have changed “compute” to “produce”

P3992, L14: We have changed “validate” to “evaluate” and “of August 5, 2006” to “on 5 August 2006”

P3992, L19: We have changed “are expressed in the Grid 1 resolution in . . .” to “are displayed for Grid 1 in . . .” P3993, L1: We have changed “plays” to “play” P3993, L7: We have changed “slightly propagates westward” to “propagates slightly west-ward” P3993, L19: We have changed “computes” to “shows”

P3993, L22: We have added “is” before “not taken into account”

P3994, L7: We have changed “Contrarily, to . . .” to “In contrast to”

P3994, L10: We have changed “computes” to “produces”

P3994, L11: We have added “at 19:10 UT and at 19:45 UT” after “(first at 8.35°E, and later at 8.18°E)” P3994, L12: We have changed “Grid” to “the Grid”

P3994, L17: We have deleted “Contrarily to Chad case, the displacement of the overshooting signal with time is not only due to the horizontal advection of lower stratospheric ice particle injected by overshoots since for the Aïr case, there are several stratospheric penetrations at 19:10 UT and at 19:45 UT.” P3995, L27: We have changed “grid mesh” to “all the grid meshes” P3996, L9: We have changed “This is due to the very low altitude of the 380 K at that time” to “This is due to the decrease in the altitude of the 380 K level at that time” P3996, L15: We have changed “12b” to “13b” P3997, L3: We have added “(15:10UT)” after “Grid 3”

P3998, L7: We have changed “Integrated on” to “Integrated over” and “encompassing” to “covering”

ACPD

10, C3720–C3728, 2010

P3998, L24: We have deleted “its” before “horizontal diffusion” and before “vertical diffusion”

P3998, L25: We have changed “larger” to “large” P3998, L26: We have changed “hydrated bulge” to “area of maximum hydration”

P3999, L1: We have changed “hydrated spot” to “area of maximum hydration”

P3999, L14: We have changed “mandatory” to “necessary” P4000, L4: We have added “in duration” after “shorter” P4000, L5: Referee#2 asks the following question: “Does this suggest that isolated convection transports more water to the lower stratosphere than widespread convection? It would be an interesting point to discuss in the manuscript, though the work might not be conclusive in that respect”. The question raised by referee#2 is an interesting issue to address. We are not sure that studying only 2 different cases can be conclusive to answer this question, and probably a statistical approach on a larger number of cases would be necessary. Some of the authors of the paper will lead and participate in a French funded project whose aim is to better characterize the link between deep (overshooting) convection and the cross-tropopause transport of water at different time and spatial scales. One major objective will be to characterize the variability of the overshooting convection. In the conclusion, we have added “and different type of overshooting convection” after “We propose as a first step to better estimate the variability of the impact of overshooting convection among a larger set of different cases”, since the present paper raises the question of a potential variability of the impact of overshooting convection on the stratospheric water budget.

P4000, L11: We have not changed “from Niamey” to “in Niamey”, see above.

P4000, L15: We have deleted “in order to achieve this goal”

P4000, L26: We have deleted “significantly” before “after the overshoot”

P4001, L17: This was not the same duration. This is now clarified in the text.

ACPD

10, C3720–C3728, 2010

P4001, L24: We have changed “timescale” to “time scale”

P4001, L28: We have changed “put the fore” to “pinpoint” P4001, L29: We have changed “the reasons of the differences” to “the reasons for the differences” P4002, L3: We have added “scale” before “models”

P4007, Table 1: ‘We have changed “Local time of overshoot” to “Time of overshoot (UT)”, and add “BTD: Brightness Temperature Difference.” in the caption.

P4009, Caption of Table 3: We have changed “encompassing” to “covering” and “1 h 50” to“1 h 50 min”. We have added a column in which the range of the overshooted mass which remains in the stratosphere is given. P4010, Caption of Fig. 1: “from Niamey” has been kept. See above.

P4015, Caption of Fig. 6: We have changed “for BRAMS simulation” to “for the BRAMS simulations”. We have added a closing bracket after “and 3” in the caption.

P4016, Caption of Fig. 7: We have changed “on 3 h periods” to “over 3 h periods”

P4018, Caption of Fig. 9: We have changed “Longitude/Altitude cross-section of condensed water mixing ratio (g.kg-1) around the overshoot location with iso-theta levels inside the Grid 3 at = 12°N latitude and 14:15 UT on August 4, 2006. The solid lines indicate the isentropes levels 370, 380, 390 and 400 K. “ to “Longitude/Altitude cross-section of condensed water mixing ratio (g.kg-1) around the overshoot location inside Grid 3 at 12°N latitude and 14:15 UT on August 4, 2006. The solid lines indicate the isentropes levels 370, 380, 390 and 400 K.” P4020, Caption of Fig. 11: We have changed “on” to “over” P4022, Caption of Fig. 13: We have added “for the Chad case” after “simulation”. We have added “Purple crosses highlight grid points in the overshooting plume area (latitude from 11.95°N to 12.06°N and longitude from 20.9°E to 21.1°E)".

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 3975, 2010.