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Interactive Comment

Interactive comment on "Water vapor transport in the lower mesosphere of the subtropics: a trajectory analysis" *by* T. Flury et al.

T. Flury et al.

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General Response to Referee's comments

The authors thank the reviewers for their work on this paper.

We intend to adapt the article in the following way. Trajectories are now all calculated for the 2700 K isentropic surface for 3 days backward. The treated water vapor phenomena are compared to Aura MLS version 2.2 maps for the 2700 K surface. The explanation for the occurrence of the depletion and increase in water vapor remains the same and is still supported by the trajectory analysis and the corresponding MLS maps. Further we change the overview figure for all measured profiles and plot them as a function of latitude and the binning grid for the difference plot is taken smaller as suggested by Artem Feofilov. The CIRA86 zonal mean zonal wind figure is substituted by a ECMWF wind field at 60 km for the encountered situation on November 15. Finally some more details are given for the trajectory model.

Reply to A. Feofilov

a) The instrument was operated once a year in 1998-2006. However, the extended analysis is performed only for 2005. It would be interesting to perform a more systematic analysis and to compare the atmospheric dynamics behavior in 2005 with that in other years using the same trajectory tracing approach.

Reply:

The 2005 measurement campaign was the most important and longest mission among all AMSOS campaigns. The other campaigns mainly led on a single meridian from the North Pole to the tropics and the disadvantage for the same kind of analysis is that the narrow band FFT spectrometer was only used in the 2005 campaign. Only this new spectrometer allowed accurate retrieval of mesospheric water vapor.

b) Since the measurements are limited in time and space they cannot be used in longterm trend analysis. However, this kind of measurements is invaluable for the validation of other instruments. If properly coordinated with space-borne missions, these measurements can serve as an independent source of information for validating the models used for radiation inversion.

Reply:

We agree. AMSOS data have been used by Müller and Feist for cross-validations. The purpose of the present article is different. We want to use the data and study atmospheric processes. There are no further measurement campaigns planned because the Learjet used for the measurements is no longer available. We are thinking about transforming the instrument for ground based retrieval of mesospheric winds (Reference Flury et al. GRL 2008)

Page 13776, lines 25, 26: comparing the Volume Mixing Ratios is not representative in

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respect to the text given in the line 1 on page 13777. The feasibility of measurements of this kind is linked with real concentrations and optical thicknesses along the line-ofsight. In some cases the emitters can be blanketed by the optically thick layer.

Reply:

We would like to show the reader that there is no single instrument capable to determine the whole vertical distribution of water vapor. In situ measurements show also difficulties to sensor 6 orders of magnitude in number density. But we agree that this does not have to be only explained by the huge differences between the troposphere and middle atmosphere.

Page 13777, line 5: "typical" profile mentioned here and presented on Fig. 1 lacks the parameters of the scan, namely latitude, longitude, season, date, and time. These are required due to strong seasonal variability of water vapor VMR, especially in the polar regions.

Reply:

The information about the measurement location and time will be added to the figure. This profile is from November 16 2005 at 35 N latitude and 30 E longitude.

Page 13778, lines 16-21 and page 13779, line 11: the description of a water vapor VMR profile obtaining is not clear. The instrument flies and measures continuously with a fixed line of sight perpendicular to the flight direction. The vertical and horizontal fields of view are also given. However, the integration time and, as a result, the spatial and temporal averaging parameters cannot be estimated from the text. I would also suggest moving all instrumental parameters description to the "Instrument" section.

Reply:

An atmospheric spectrum is obtained by the use of a hot- and a cold load, which in our case are ambient temperature and liquid nitrogen. A calibration cycle for 1 spectrum takes about 10 seconds, for the retrieval of 1 water vapor profile 30 spectra

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are integrated to reduce the measurement noise. Further the spectra should have been recorded at similar flight altitudes and airplane roll angles in order to be integrated. The time of flight for 1 profile is thus about 5-7 minutes which corresponds to a horizontal resolution of about 70-90 km (speed of the plane about 800 km/h). This information is added to the instrument section.

Page 13779, line 17: the latitudinal gradient described here needs better explaining. Lines 14 and 15 refer to the mesospheric gradient above 65 km. Aura MLS water vapor data presented in Fig. 10, 11, 14, and 15 do not show water vapor distribution at 70 km. However, even 60 km distribution shows the features typical for this season. H2O VMR decreases from the summer to winter hemispheres at the mesospheric altitudes. Partially this is explained by the strong pressure decrease at high latitudes in the winter hemisphere that is linked with the lower temperatures below 70 km altitude. The second reason for the summer to winter H2O decrease is the behavior of the vertical wind in different seasons (Körner and Sonnemann, JGR 106(9), 2001). As their Fig. 5a shows, the upward transport in the summertime changes to downward transport in the wintertime. However, Fig. 4 of the reviewed paper demonstrates the opposite behavior. Taking into account the above mentioned facts the explanation given in lines 16-18 looks speculative.

Reply:

The MLS maps at 60 km show the highest water vapor values between around 25 N and 20 S. The gradient we measured occurred above the Arabian Emirates, which is around 25 N. The tropical pipe explains differences in trace gas concentrations between the tropics and mid latitudes. But there is also other proof for our measured gradient: There was a 4 day-stop of the campaign in Dubai and the MLS map of November 4 when we flew to Dubai shows values around 7 ppm above the Emirates. On November 8, when the campaign resumed the light green color of the MLS map changed to dark green above Dubai which corresponds to 6-6.2 ppm. So the barrier moved a bit and MLS confirms our measurements . In the text we will emphasize that the tropical

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pipe is an uncertain interpretation.

Page 13779, lines 12-21 and references to Fig. 4, page 13788: Fig. 4 shows that there are two parameters that were varied during the flight, namely, latitude and longitude. One can see that these parameters were in counter phase with each other that complicates the "single-parameter" conclusions. Water vapor distributions measured by Aura MLS shown in the paper demonstrate the complexity of the atmospheric dynamics. The only way to understand the instant measurement in this case is to use an additional source of information like trajectories calculations and models. The paper shows that it’s really doable and I would put more stress to it from the beginning.

Reply:

We thank you for your comment on that and try to put more weight on this point in the text.

Page 13780, lines 7-14: the model used for trajectories calculations is not described either in the text or elsewhere (reference). It is not clear from the text how accurately the model predicts the trajectories and what are its limitations. The ECMWF acronym is not defined in the text.

Reply:

TomTOM is a trajectory model, which interpolates the ECMWF wind field to the current location of an air parcel. Isentropic motion is assumed and we use a one hour time step before we change and calculate a new velocity vector. Comparison to the HYSPLIT (NOAA) model and Goddard Automailer showed an agreement of better than 200 km for 3 day trajectories at 20 km. No comparison could be made for mesospheric altitudes. But it seems that TomTOM trajectories confirm MLS and AMSOS measurements and are usable for short time periods even at mesospheric altitudes.

Page 13788, Fig. 4: the figure requires modifying. The non-linearity of the horizontal axis leads to puzzling the reader. I would suggest latitude binning instead of profile number binning. Using more natural geographic grid would also help to avoid using different rectangle sizes in the upper half of the picture.

Reply:

We agree that the different number of profiles recorded on same flight tracks are misleading. Two figures have now been made instead of the old one. The figures show the profiles on outward and return flight as a function of latitude. The exact profile location can be found in combination with figure 3, where the flight track is shown.

Page 13789, Fig. 5 and page 13790, Fig. 6: the grids used here are very coarse. Fig. 4 shows that the changes were gradual and one could use a smaller bin size. There is also an inconsistency in figure titles. Fig. 5 shows the same relative difference in H2O VMR as Fig. 6 but has a different title.

Reply:

The titles and binning have been changed for the difference plots.

Page 13779, line 5: "focusses" -> "focuses" Page 13782, line 16: "prooven" -> "proven"

Reply:

Errors have been corrected.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 13775, 2008.