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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Correlation among cirrus ice content, water vapor and temperature in the TTL as observed by CALIPSO and Aura/MLS" *by* T. Flury et al.

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The authors thank the referees for their work and constructive comments on the article. Please find our answers to major comments in the beginning followed by minor comments at the end.

Answers to the major comments of referee 2:

Comment 1: Page 25040, lines 24-25: The vertical averaging methodology is an important aspect of the analysis; more detail should be provided

Answer: The initial very high vertical resolution of CALIOP is interpolated on a coarser

vertical grid which contains the levels of MLS which were listed in the text. However we added additional levels in between to give CALIOP twice as many levels than MLS in the TTL. We will add the additional details of the vertical axis to the text. The vertical resolution in the TTL is thus about 1.7 km.

Comment 2: Discussion of data product precisions and accuracies should be provided.

Answer: MLS and Calipso accuracies at 100 hPa will be added to the text. MLS has a precision of 10% and accuracy of 8% according to Read et al. JGR 07. The Calipso IWC is based on a parameterization of cirrus extinction which has an accuracy of about 10%. However the precision is not documented at that time because there are no independent measurements to compare with. (Dr. Dave Winker,Calipso PI, personal communication).

Comment 3: Page 25041: The cold point temperature should correlate with stratospheric H2O even better than the 100 hPa temperature. The cold point can be well above 100 hPa, particularly during Boreal winter.

Answer: MLS profiles are retrieved on the levels 100 hPa and 82 hPa amongst others. The cold point tropopause lies mostly in between the two levels. We studied the changes resulting in taking either the 82 hPa temperature or the average of 100 hPa and 82 hPa T to correlate with H2O. We observed only slight differences in the correlation. Positive changes at certain altitudes and negative at others. Nevertheless the changes in the correlation are not significant and do not change the bottom line of the article that TTL temperatures determine UT/LS temperatures over a wide latitudinal range. In order to be coherent to former studies of temperature and water vapor in the TTL we will leave the chosen levels as is.

Comment 4: Figure 2: With 3-4 km vertical averaging, you are probably getting mostly convective (anvil) cirrus in your sample, which is apparent from the spatial patterns in the Figure. The manuscript suggests the TWP is where dehydration is dominant. This issue is confused by the approximate co-location of low tropopause temperatures and

deep convection. Further discussion should be provided.

Answer: The seasonal cycle of CALIOP cirrus measurements is quite different to the one measured by MLS and CloudSat. This is due to CALIOP's higher sensitivity of thin cirrus. Thus we are less susceptible to convective cirrus since the cirrus data we use has a higher vertical resolution than MLS. We added 1 vertical level between every MLS level for the interpolation of Calipso data in the TTL. We chose the following set of levels [121,110,100,90,83] hPa (additional levels: 110 hPa and 90 hPa). With the corresponding vertical resolution of 1.5-2 km at 100 hPa we should not be influenced by the outflow levels of convection.

Water vapor is lowest in DJF over the tropical west Pacific (TWP) where also temperatures are reported to be lowest at 100 hPa. We agree that in the vicinity of convection water vapor and ice are positively correlated. The detrainment of convection occurs mostly at pressures p>150 hPa. Since the MLS measurement at 100 hPa is smeared with values from below we would expect a tendency of the correlation coefficient towards positive values. We are thus somewhat in a worst case scenario with influence from below but the result is still fairly high negative correlation of IWC and H2O.

Comment 5: Page 25043, lines 20-23: The tropopause is also elevated well above 100 hPa during Boreal winter over much of the tropics [Seidel et al., 2001].

Answer: It is true that the altitude of the tropopause is higher than 100hPa. There must be another explanation than the tropopause altitude (compare answer to Referee #1). We studied MLS temperature, water vapor and relative humidity over ice as well as the CALIOP IWC data to find differences between the regions inside the 8S-8N band and the regions left out, where correlation of H2O and IWC is positive. The seasonal cycle of IWC and relative humidity over the South Asian Monsoon region is opposite to the one closer to the equator over Indonesia and the TWP. This leads to the positive correlation with water vapor. This stems from the clear seasonal cycle of convection over the monsoon regions where significant amounts of ice are only found during boreal

summer and autumn when water vapor and relative humidity is high. Inside the 8S-8N band convection has no strong seasonal cycle. In this region relative humidity (Rhi) and ice are anticorrelated with water vapor.

Comment 8: Page 25044, lines 22-24: I do not really understand this statement. Why does an elevated tropopause cause a positive correlation between H2O and IWC?

Answer: If we conduct the study at 200 hPa the correlation is positive in all the regions of interest since this level is clearly inside convection and near the level of neutral buoyancy. If we go higher up to 100 hPa the level is well above the level of neutral buoyancy over Indonesia which is less true for the Indian monsoon region. Hence we do not get the same relationship between water vapor and ice. So to say similar processes occur at smaller pressure over India than over Indonesia. Similarly the cold point tropopause is higher over India (85 hPa) than Indonesia (95 hPa). The TTL is characterized by the transition from convective - to stratospheric temperature control. One would see more convective control near the ITCZ and the other elsewhere.(Please note our answer to a similar comment of referee #1)

Comment 14: Figures 6 and 7, and discussion: Following the comments above, it seems likely that in convective regions, the 3–4 km CALIPSO cloud frequency average is strongly influenced by convectively generated anvil cirrus, in which case one would not expect an anticorrelation with temperature in these regions. This seems like a clearer, more plausible explanation than the one given in the manuscript.

Answer: Cirrus from deep convection are found over smaller regions. The vast regions are controlled by temperature, where cirrus are away from convection. But your suggestion adds to the understanding of our observations.

Answers to minor comments. Please find the referee comments in the corresponding file.

6. Sentence will be changed

7. Good idea for further studies.

9. We will adapt the sentence

10. Good idea, units will be adapted in the revision.

11. The highest negative correlation of IWC and H2O is found outside of maximum cirrus occurrence. The vast regions of our study are over ocean and away from convection hence temperature controlled.

12. That is true. Other atmospheric phenomena influence the 100 hPa T as well but have also an influence on the Brewer-Dobson circulation which in turn can be said to influence the temperature.

13. The anticorrelation is strongest in the dashed boxes. But in general inside the tropical latitude band 8S-8N the correlation is clearly negative with r<-0.4. North of 10 N correlation becomes positive since the seasonal cycle of IWC and RHi is opposite to the one inside the tropical band 8S-8N.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 25037, 2011.