Atmos. Chem. Phys. Discuss., 9, S1961–S1965, 2009
www.atmos-chem-phys-discuss.net/9/S1961/2009/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "A statistical analysis of the influence of deep convection on water vapor variability in the tropical upper troposphere" *by* J. S. Wright et al.

J. S. Wright et al.

Received and published: 5 May 2009

Thank you for your many constructive comments. We greatly appreciate the time and effort that you invested in reviewing our manuscript.

Responses to general comments:

1. We have included a rough quantitative estimate of the uncertainty associated with this equation (about a factor of 2), which is based on applying a range of reasonable mass-dimension relationships. Also, Deierling et al. (2008) showed a graphical analysis of ten other Z_e-IWC relationships, and Eq. 1 would fall nearly in the middle. For reference, see Fig. 6 of Deierling et al. (2008); Eq. 1 lines up very well with the curve corresponding to Atlas et al. (1995).

2. The detailed comments have been addressed in the revised text.

3. The satellite data is not interpolated to a common grid; rather, TRMM observations are used to initialize the trajectories, and AIRS observations are used to examine upper tropospheric water vapor changes at points along the trajectories. The MODIS data has been removed.

4. The number of trajectory points that meet the analysis criteria are listed in column 3 of Table 1. Although there are some differences, all months comprise between 21% and 27% of total scenes. Seasonal biases should not be an issue in the overall analysis.

5. Mixing is incorporated into the results implicitly, since we track the evolution of water vapor using observations; mixing would be a much larger issue if we were trying to simulate water vapor. In addition, any small-scale mixing of the detrained parcel with ambient air will typically be occurring within the analyzed volume, which encompasses the trajectory point, and will thus be included in the analysis.

6. We do not use the trajectory model to calculate GRD; it is based solely on daily mean gridded observations at $1^\circ \times 1^\circ$ resolution. This has been clarified in the text at the end of Subsect. 2.4.

7. Neither. The TIM distributions are binned according to the time elapsed since convection prior to the trajectory passing through the observed volume. That is, if the trajectory originated in convection 27 hours prior to passing through the volume, the ambient RH and change in water vapor are aggregated in the TIM3 distribution. The same is true of DST: if the trajectory has traveled 342 km, then the ambient RH and change in water vapor are aggregated in the DST2 distribution. 9 m s^{-1} is only the average wind speed; many of the trajectories travel faster or slower than that. Consequently, the DST and TIM distributions end up being different even though their bins are chosen based on 9 m s^{-1}. We have attempted to address this in the caption for Table 1.

ACPD

9, S1961–S1965, 2009

Interactive Comment

Responses to specific comments:

p6,l1: The exact TRMM PR frequencies are now listed.

p6,l28: An error calculation for different frequencies is relevant because the analyzed algorithms were developed using an identical functional form, with similar data, with respect to similar radar instruments, and were validated in much the same way as the equation that we use. An error analysis of the exact relationship would be preferable, but is beyond the scope of this work.

p7,l7: See response to general comment 1 above.

p7,l19: The MODIS data and related discussion have been removed from the manuscript.

p9,l13: "High quality" in an AIRS context means that the data is reliable and suitable for scientific research. Specifically, the retrieval was correctly performed with no complications.

p11,l5: We have rephrased this sentence to remove "chaotic".

p11,l11-13: Including the smoothing parameters explicitly becomes cumbersome because they vary depending on the distribution. We have included the smoothing parameters for the LNK distribution; the parameters for the other distributions are similar.

p13,eq4: Pr is the probability function. We have clarified this in the text.

p16,eq5: We apologize; our presentation of Eq. 5 clearly created quite a bit of confusion. FDC is not included in the calculation of the convective timescale (τ_{conv}): N$_{obs}$ is the number of successfully observed pixels (the denominator in FDC), not the number of convective pixels (the numerator in FDC). Thus, N$_{obs}$ scales with the length of the analyzed period τ (meaning that τ_{conv} does not get shorter when τ is longer). In fact, we have performed the same analysis at several timescales τ and ended up with the same results. Meanwhile, N$_{grid}$ is the number of TRMM PR footprints needed to

ACPD

9, S1961–S1965, 2009

Interactive Comment

cover the local grid box, and is time-invariant. The lifetime of convection (τ_{life}) is a free parameter that represents how often observations would need to take place to successfully observe part of all events (effectively the observable lifetime of a convective system). In effect, τ_{conv} is a gridded version of the convective timescale τ_{moist} as defined by Sherwood et al. (2006), which represents the mean length of time between individual convective events encountered by an average air parcel.

We continue to believe that τ_{conv} is a more relevant and intuitive measure of what is important for upper tropospheric water vapor than FDC: it represents the mean relaxation time between convective events rather than how many convective events occur. However, we feel that the introduction of this quantity deserves a more thorough treatment than we can provide in the context of this work and have removed it from this manuscript.

In the discussion paper, Fig. 4a shows FDC and Fig. 4b shows τ_{conv}. The revised caption to Fig. 4a now includes the abbreviation of FDC specifically.

p22,l1: The detrainment temperature in this context is the potential temperature at the point where the trajectory is initialized; i.e., the horizontal location and geometric height of the TRMM PR observation.

p23,l17-29: The discussion of particle size has been removed.

p24,l28 and p25,l1-4: We agree with the findings of Ryoo et al (2008) in the subtropics, which is where they performed their analysis. On p26, we are talking instead about the tropics. We have amended the text to make this distinction more clear. We have also added an additional figure and revised the manuscript to provide a more quantitative assessment of the relationships between IWC and downstream UTWV.

p26,l29 and p27,l1-4: No, it does not concretize the associated error in a quantitative way; see general comment 1 above. However, none of these errors is likely to impact the qualitative nature of our results. Regardless of the conversion used, a greater radar

ACPD

9, S1961–S1965, 2009

Interactive Comment

reflectivity translates to a greater IWC. A greater IWC is shown to be associated with enhanced moistening downstream.

p28,l16: UTH stands for upper tropospheric humidity. We apologize for using this abbreviation without defining it, and have amended the text accordingly.

Figures: Both quantities in Fig. 1a are the same as the single quantities in the other figures. We feel that this is sufficiently clear.

Tables: The quantity reported is not the total number of trajectories; it is the number of trajectory points meeting the matching and binning criteria. So some trajectories may have a successfully matched point in the TIM1 bin but not in the TIM2 bin and vice versa. In fact, it is rare for individual trajectories to have more than one point meet the matching criteria within the 48-hour analysis period.

References

Ryoo, J.-M., Waugh, D. W., and Gettelman, A.: Variability of subtropical upper tropospheric humidity, Atmos. Chem. Phys., 8, 26438211;2655, 2008.

Sherwood, S. C., Kursinski, E. R., and Read, W. R.: A distribution law for free tropospheric relative humidity. J. Climate, 19, 6267-6277, 2006.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 4035, 2009.

ACPD

9, S1961–S1965, 2009

Interactive Comment