Responses to Referee 1

The authors wish to thank the referee for his/her comments on our submitted manuscript. In our following responses, the page and line reference for each comment have been matched according to where the commented text appears on the ACP Discussion paper.

Specific comments:

Page 16980, line 26: Since sedimentation is dependent upon particle size, and the removal of ice is removed mostly through sedimentation, what are typical ice radii that are predicted by the model? Are these radii realistic? I do note that on page 16984, line 25 that the 'vapour-scavenging' and 'vapour-enrichment' effects are insensitive to variations to fallout velocity. What change in particle radius corresponds to a doubling of the fallout velocity?

Following Thompson et al. (2008), typical cloud ice diameters predicted in the model range from 4μm to 300μm. The latter, however, is rarely reached due to the transfer of cloud ice, once it exceeds 200μm, into the snow category at each time step. While these size assumptions still have uncertainties due to the bulk nature of the microphysics scheme, these modelled sizes are within the range of diameters that have been observed in both fresh thunderstorm and aged cirrus anvils during the Tropical Warm Pool International Cloud Experiment (TWPICE) – c.f. Figs. 8 and 9 of May et al. (2008).

In the study, doubling the fallout velocity of snow was an artificial approach to test the sensitivity of the results; this was done without changing the snow radii explicitly. However, using the snow mass-diameter relation given by $m(D) = 0.069D^2$ and a snow fallspeed relation given by $v(D) = 40D^{0.55}e^{-125D}$ (Eqns. (A2) and (A3), respectively, in Thompson et al. (2008)), an increase of about 4 to 5 times in particle diameter roughly corresponds to a doubling in the fallout velocity.

Page 16986, line 14: What is the total volume of cloud mass that is irreversibly injected into the stratosphere from the TTL for the two cases?

For the SUBSAT case, the total amount of water mass that is irreversibly injected into the stratosphere from the TTL (>425 K) is ∼118 tonnes. For the SUPERSAT case, this amounted to ∼28 tonnes.

We've also calculated the total amount irreversibly injected into the stratospheric overworld (>400 K) in each case. For SUBSAT, this amounted to ∼298 tonnes and for SUPERSAT, ∼143 tonnes.

Compared to a recent estimate (∼100 tonnes, Peter (2008)) based on single, observed overshooting Hector event during the SCOUT-O3/ACTIVE campaign in November 2005 in Darwin, our cases likely provide an upper limit to the permanent transport of water into the tropical lower stratosphere by individual systems.

Technical Corrections:

Page 16974, line 23: Revise the phrase "did not cater" with a phrase that is more easily understandable.

The phrase has been revised to "did not account for" in the text.

Page 16975, line 25: Revise the phrase "with a difference of almost 40% (100±20%)" in expanded form. I am not sure what is meant by the current text.

The sentence containing the phrase has been revised to "In particular, the RHI difference between the two cases is maximised at approximately 16.5 km (~365 K), with a difference of almost 40%, i.e. SUBSAT RHI is ~80% and SUPERSAT RHI is ~120% at that height."

Page 16977, line 6-7: Give units for IHGT and IQV.

The units for IHGT (km) and IQV (gkg^{-1}) have been included as requested.

Page 16978, line17-26: I needed to read this paragraph twice to understand it. On line 19, the perturbation should be -15 km. It may be helpful to indicate on line 22 the x and y range of the outer shell, on line 24 the x and y range adjacent to the outer core.

The missing negative sign has been included and the x and y ranges of the outer shell and the region adjacent to the outer core have been included as requested.

Page 16980, line 13: Change to "accounted for by an increase in water vapour"

Changed as requested.

Page 16982, line 20: Indicate verbally why TKE of 0.05 m^2s^{-2} is chosen (i.e. identify what physical threshold this TKE represents).

Initially, this threshold value was arbitrarily chosen to simply indicate non-zero mixing, but was found to best represent the mixing within and near the cloud boundary (i.e. mixing due to interfacial instabilities).

Page 16986, line 18-20: Indicate the x and z range (and/or the color in the Figure) of the plume of ice and water in the text.

Indicated in the text as requested.

Page 16987, line 20: Revise to "perturbations in the right portion of Fig. 12f"

Revised as requested.

Figure 2 caption: Indicate in the caption text that the levels of neutral buoyancy heights are 16.5 and 16.0 km for panels (a) and (b).

Indicated as requested.

Figure 4 and 5 captions: Indicate in the caption text that the 0.01 g kg^{-1} contour marks the cloud boundary.

Indicated as requested.

Figure 10 caption: Indicate what physical threshold is represented by the 0.05 m^2s^{-2} TKE value.

Indicated as requested as per the earlier reply.

Figure 11 caption: Mention in the text that potential temperature values are contoured in steps of 10 K.

Mentioned as requested.

References

May, P. T., J. H. Mather, G. Vaughan, C. Jakob, G. M. McFarquhar, K. N. Bower, and G. G. Mace, 2008: The Tropical Warm Pool International Cloud Experiment. *Bull. Amer. Meteorol. Soc.*, **89 (5)**, 629–645, doi:10.1175/BAMS-89-5-629.

Peter, T., 2008: Upscaling results from Hector measurements to global convective H2O input into the tropical stratosphere. *Presented at the SCOUT-O3/ACTIVE/TWP-ICE workshop on the tropical UTLS, University Of Manchester, 8-11 January 2008*. URL http://www.ozone-sec.ch.cam.ac.uk/scout_o3/meetings/manchester/presentations/Peter.pdf, URL http://www.ozone-sec.ch.cam.ac.uk/scout_o3/meetings/manchester/presentations/Peter.pdf.

Thompson, G., P. R. Field, R. M. Rasmussen, and W. D. Hall, 2008: Explicit forecasts of winter precipitation using an improved bulk microphysics scheme. Part II: Implementation of a new snow parameterization. *Mon. Wea. Rev.*, **136 (12)**, 5095–5115, doi:10.1175/2008MWR2387.1.