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Interactive comment on "A redistribution of water due to pileus cloud formation near the tropopause" *by* T. J. Garrett et al.

Anonymous Referee #3

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In general this is an interesting paper and should be suitable for publication in ACP with major revisions. Mostly I think the authors need to do a better job of discussing the measurements, and clearly indicating what they can show and what they are inferring. There are too many unsupported inferences in this paper. This pretty much starts with the title, and runs right through to the conclusions. I think that if these are modified, and I provide detailed comments below, that this paper could be acceptable for publication.

My problem with the tone of the manuscript is summed up by a line in the conclusions (p 8222, l11-12) "... pileus clouds may influence how both ice and water are distributed and partitioned in the TTL." It seems to me that pileus clouds are indicators of saturated air in the TTL, and their persistence may indicate mixing, but the authors have not

shown that the clouds themselves affect humidity distributions (e.g. a radiative effect or some microphysics), except by inference in one of their model runs. This is difficult to evalutate, since the key figure (figure 5) is difficult to interpret, and I don't think it is properly disussed in the conclusions (it took me a while to figure out this was the implicaiton of the model runs).

Nor do I think the title is representative of what is discussed: pileus clouds do not redistribute water. They indicate that convection can redistribute water, but this is not properly discussed. The clouds appear to dissolve as soon as they form (being wave clouds). There are some interesting comments here on mixing of convective turrets and cirrus: but one example does not make an important process.

I also think that the distinction between pileus and cirrus has been blurred here. Are there any observations within pileus clouds? Or are all these observations in anvil or cirrus clouds? I do not see a clear example of a pileus cloud turning into cirrus: the one example in figure 2 has them clearly separate.

I think with more appropriate caveats and a slightly different tone, as well as corrections based on some of the detailed comments below, that this paper will be suitable for publication in ACP.

Also, in general there is too much description in the figure captions that should appear in the regular text of the paper.

Specific comments:

Title: as noted, I think the title needs to be changed. You really have not shown that a pileus cloud can redistribute water vapor. The paper really seems to be more about mixing of convection and cirrus, or pileus/cirrus as an indicator of supersaturated air, or convective effects on cirrus clouds.

p8210,l8: not a great TTL description: you might mention that the major issue is that this is a region with a character intermediate between the troposphere and strato-

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sphere, in which most air enters the stratosphere, but we are not certain how. A reference might help.

p8211,l10: How do these indicators of lightning and a gust front correlate with cloud tops reaching the tropopause? Can you estimate from the photo how high this cloud is? There is way too much speculation here: where is the anvil in the photo?

p8211,l17: Again, 'suggests' that the pileus was in the lower stratosphere, 2km above the tropopause? How do you know the altitude from this picture or another one? I think this is pure speculation.

p8211, l19+: Once again: where is the tropopause here? Also, in figure 2, I see a clear separation between 'cirrus' (TTC) and a pileus cloud. What are you really talking about in this paper? It seems to me that the former is of more importance and the latter is tightly tied to local convective turrets.

p8212,l25: This paragraph is not quantitative enough. What does 'commonly' mean? What fraction of the time are you implying? Is this information contained in Garrett 2004? I couldn't find it. How many 'cases' are examined?

p8213,l8: 'much of the TTL cirrus ... originated as pileus'. The statement is not supported by Garrett 2004. Garrett 2004 concludes that such a hypothesis is 'highly spectulative'. I think this needs to be phrased differently.

p8213,l9: I think the 'fractional contribution' statement needs a reference. How do you know this? It is not in Garrett 2004.

p8213, l27-28: This paragraph needs a significant rewrite.

Pure speculation 'the implication is...'. Do you have any evidence for this? Keep in mind that this is not a pure profile, but that the WB57 is flying at nearly 200m/s, so that if the aircraft climbs or descends 1.5km we are likely looking at air separated by 30-60km (based on a quick look at WB57 flight tracks and the climb rates). Are pileus clouds this big? Seems to me that these air masses could be totally unrelated and from different

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convective events entirely. I do not thing that words like 'could' are appropriate here.

In particular, it is entirely possible (and probable) that convective air with the total water characteristics noted in figure 3 at 13km could lose its condensate and end up looking like the air at 14.5km with no mixing involved. I do not see any mixing with TTL cirrus necessary. Recall we are looking at total water and isotopes here, which makes interpretation more difficult.

p8214, l4: Couldn't the 3K temperature difference be due to gravity waves and not convective mixing? Which is what you imply the aircraft measurements show later.

p8214, l10: Where does this equation come from? The units work, but why is there no timescale on delta T?

p8216, l21: I was unclear about what the model is doing from the description. Maybe a simple schematic is warranted: you create a trajectory from an assumed wave and assume some mixing at the crest of the wave.

p8216, l26: particle –> particles

p8217,l13: What is 'wave-like'? There are lots of variations here, and I am not sure I know what you are talking about.

p8217,l16: Why is there no temperature drop for the first plume intersect at 67300?

p8217,l18: When do these fluctuations occur.

p8217,l20: Wait a second: you just said the cold temperatures within the plume were because the air was above its LNB. This is not a gravity wave induced fluctuation then. It might be the source.

p8218, l5: How is the 'pressure weighted mean wind' related to what the aircraft measures for wind?

p8218,l24: You might want to also to simply discuss the signal in figure 4 in water vapor.

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There appears to be less H2O in cloud and more in vapor when the temperatures are warmer at 67900 and 68000. It kind of looks like total water might be constant though (no dehyrdarion)?

p8219:,l5: Fig 5 is hard to interpret. Please label the panels and label them in the caption as well.

p8220, l1: There are no observaions in figure 5. Do you mean figure 4? Also, 2um seems pretty small for clouds which are not really that cold. I suppose this is a whole other can of worms.

p8220,l3: Please put the discussion in the paper, not in the figure caption.

p8220,l6: Why should mixing be any different with a pileus cloud or without? All the pileus indicates is a layer of humid air.

When have you shown any of these pileus clouds are larger than the size of the turret? My thinking is that you are just looking at thin cirrus above convection, possibly forced by convection.

p8220,l11: Define 'thin' cirrus: subvisible?

p8220,l16-17: Please rewrite this sentance: how can updrafts be 'higher' in the 'lower' TTL I assume you mean that updraft velocities are larger.

p8221, l20: To me this statement means that no mixing is necessary to explain these clouds: they form in air which is supersaturated, and the convection (or gravity waves from the convection) triggers temperature fluctuations that raise Sice until clouds form, and then because the air was supersaturated to begin with, the clouds persist. The model assumes some sedimentation, and I suppose a change in water vapor, but this is not well discussed (and figure 5 is very confusing). The pileus to me is just a transitory indicator of what is happening, and it depends on the background humidity.

p8222, l11: See my general comment on this statement and the comment above. I

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don't think the clouds 'influence' anything: they are an 'indicator' of what the convection is doing and the background humidity.

Also: your figure captions are often two descriptive and not informative: please limit them to a complete discussion of what is in the figure, but save the commentary and description for the text.

Figure 4: not enough information on which intstruments, even a date.

Figure 5: I cannot understand this figure. Please label the panels (a-d) and describe each. Does the thickness of the dark gray lines with black borders mean anything different between the top panels and bottom left. I do not understand the lower right panel at all from the caption. What is shaded? Light or dark gray? isn't that 2 different runs?

Figure 6: this discussion need to be in the text, not the caption.

Figure 7: again, some of the last few sentences should be in the text, not the caption.

Interactive comment on Atmos. Chem. Phys. Discuss., 5, 8209, 2005.