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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 #2

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General Comments

The title of this paper is “A redistribution of water due to pileus cloud formation near the tropopause”. Pileus clouds, like various wave clouds lower in the troposphere are produced when dynamical pressure gradients (caused by flow over orography, or in this case upward moving buoyant air in cumulus towers), forces air to rise sufficiently to cause condensation. Typically the resulting cloud particles are very small and sediment negligibly, so that later when the pressure forcing is gone, the air returns to its previous height and temperature, they re-evaporate leaving no net change to the atmospheric state. But as the final paragraph of the introduction of this paper points out, there are two processes that may lead to an unreversed change: first, if significant sedimentation does occur, there is a net downward transport of moisture, and second, there may be a persistent change in the temperature due to absorption and emission of radiation during the lifetime of the cloud. Unfortunately, that is the last we hear of these processes until a few comments in the discussion, where it is suggested that pileus only occurs in air that was supersaturated prior to its upward displacement, and will thus remain cloudy even after returning to its initial level. If this could be confirmed, and the resulting moisture transport quantified, it would be rather interesting. Unfortunately, the authors present no direct observations (other than a couple of photographs) of pileus clouds, and make no use of their simulations to address the two processes identified in the introduction. In fact 5 of the 13 manuscript pages are spent explaining the setup of the simulations, and only 1 on results (Figs. 6b,c are not even mentioned in the text). One almost gets the feeling that a couple of pages, namely the ones that describe "a redistribution of water due to pileus cloud formation near the tropopause", got left out. In its present form I cannot recommend the paper for publication, although Fig. 7 and the accompanying discussion giving a quantitative estimate for the prevalence of pileus cloud, and giving some indication of the environments where they are likely to form, are convincing, and would provide a very useful component of a study that estimated the transport and/or radiative effects. Based on Potter and Holton (1995) and subsequent work, it is quite plausible that transport is occuring - pileus cloud marks the first crest or two of the gravity wave pattern above a cumulus tower, but this paper does not add to the evidence.

Specific Comments

Section 2: The cloud photographs are quite impressive.

Section 3: The evidence from water isotopes that convective outflow has mixed with TTL air does not seem to provide compelling evidence that the TTL air had anything to do with pileus cloud (the total water content of detraining cumulus air can be 50 times the saturation vapour pressure at TTL levels, and can mix with large amounts of air from the environment and remain cloudy.

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Interactive Comment

Section 4: The description of the simulations is tedious. If there were any observations to compare the simulation to, than it might be worth pain-stakingly reconstructing the flight environment, but the main message that the section conveys is that the values are very uncertain, and one ought to do sensitivity tests (none are presented). As previously noted, Fig. 6 is not adequately explained. It is difficult to understand why the authors have not attempted to estimate a precipitation flux, since this seems to be the main point of the paper. It is certainly not apparent from the figures that there is any net transport, nor is it evident that the water contents found when the convective moisture source is introduced are any different from the linear sum of the no-convective source case and the applied source term (is there a significant interaction?).

Section 5: Fig. 7 is quite suggestive, and the discussion is interesting. It is unclear how the curves of isentropic lifting required for cloud formation were calculated (have I missed something - is this a result from the simulations in the precious section?). It is also unclear what the significance of mixing between pileus and convective outflow is. If the pileus air is transiently above its level of neutral buoyancy, what will happen to the water content when the air returns to that level? Unless there is some interaction affecting the size distribution of the particles and thus their sedimentation rates, the end result is the same as if the pileus cloud had not been there - the re-evaporation is just displaced in time, and the cloud water content is that expected from the convective outflow.

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