

Interactive comment on “Ultrathin Tropical Tropopause Clouds (UTTCS): II. Stabilization mechanisms” by B. P. Luo et al.

Anonymous Referee #1

Received and published: 26 March 2003

General comments:

This paper highlights some puzzling properties of the recently discovered cloud class of ultrathin tropical tropopause clouds (UTTCS) and tries to solve these puzzles. A model is presented that explains UTTCS as remnants of thicker cirrus (SVC or Cb outflow), stabilised by the combined action of a slow uplift (with velocity decreasing with altitude) and an upward increasing supersaturation profile. The paper is certainly suited for publication in ACP. However, to my view the possibility that these clouds could be formed in situ by some suitable IN is underestimated in the paper; at least the author's argument against this possibility does not convince me (see below). Furthermore, both the presented models need a bit more thorough discussion. Hence, I would like to have some minor modifications of the paper before publication.

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Special comments:

p. 1582, par. 1, and p. 1585, par. 2:

Have a look on Fig. 9–29 in Pruppacher and Klett (1978). The active fraction of aerosol particles increases strongly with decreasing temperature. In particular for the AgI mentioned by the authors the active fraction increases between -8 and -15°C by 5 orders of magnitude. I think that this dramatic change renders extrapolations from about -10°C to an almost 75K lower temperature impossible. Thus, the argument against heterogeneous nucleation is a bit weak. Furthermore, there could be other solid substances that become thermodynamically stable just at these cold temperatures. These could serve as good IN — who knows? I wonder whether the existence, homogeneity, large horizontal extension vs. small thickness of UTTCs would still be such a surprise if such good IN capable of nucleation at 1–5% supersaturation would be around.

p. 1587, par. 1:

The authors present one solution of their single particle model for a certain choice of uplift speed and supersaturation profile. When reading it, my first impression was that there is a need of a delicate balance between the S_{ice} -profile and the v_{air} -profile, which would be at least as difficult to explain for a wide region as the question how nature would maintain a slight supersaturation over that region. However, playing around with a numerical solution, I found that the details of the profiles are not as important as my first impression suggested. It would be good for the paper if the conditions the profiles must fulfil for a suitable solution would be discussed in more depth.

p. 1588, last par. :

In the column model the UTTC is the remnant from an evaporating SVC. The evaporation of the SVC is triggered by a slight warming over 8h. How exact must the warming be in order to produce the UTTC at the observed vertical thickness. What happens, if there is less or more warming? I believe that the resulting UTTC thickness and lifetime is sensitive to the assumed initial warming, although it is stable then against 0.5K temperature fluctuations. How probable is it that just the right warming appears, and

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how probable is it that this is the case over tenths of square kilometres? Are the fluctuations anyhow in phase or correlated with the oscillations we saw in the single particle model, or is it just white noise?

p. 1590, end of par. 1:

Slow uplift and sufficiently humid air are essential conditions for UTTCs anyway, may they be remnants from thicker clouds or formed in situ by suitable IN.

p. 1590, last par. :

In the column model the UTTC vanished by a forced cooling after 25h. This leads to dehydration. However, this is not the only possibility. A forced warming would probably lead to evaporation of the UTTC without dehydration of this layer. It is not clear which mechanism dominates.

Other comments:

eq. 3: Tell the reader that n is number, not number density, as one would expect.

Sentence after eq. 4: Something is missing around "and".

Figure 4, panel E: Can you explain the sudden jumps by almost 1 km of the lower saturation level during the UTTC lifetime?

Interactive comment on Atmos. Chem. Phys. Discuss., 3, 1579, 2003.

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