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Interactive comment on "Tropical tropopause ice clouds: a dynamic approach to the mystery of low crystal numbers" *by* P. Spichtinger and M. Krämer

Anonymous Referee #2

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The manuscript is based on the hypothesis that the concentration of crystals in tropical cirrus does not require non standard microphysics but can be entirely explained by the coupling between dynamics and microphysics. More specifically, the manuscript investigates the role of fast oscillations of the temperature on the nucleation and growth of ice crystals. The manuscript is well written (in spite of a few critics I am drawing below), the results are substantial and there is a interesting and stimulating discussion of the hypothesis and the results. The paper should be published in ACP after taking into account the more or less minor comments that follow.

Comments are listed in order of appearance in the text

1. p.28113, l.27: spontaneously

2. p.28114, l.4-5: repetition of the sentence in l.1-2
3. p.28115: Using an adiabatic motion for the fast waves make sense but it is much less justified to assume that the slow large scale motion is adiabatic. As a matter of fact, the authors mention on p.28122 that the "ascents compensates diabatic heating" and on p.28123 that the stratification of the TTL is very high. Using a more realistic lapse would have perhaps a limited impact but this should be mentioned.
4. The authors should clarify how they characterize the amplitude of the wave. In the first part of the paper, they use vertical velocity but what an air box feels is not velocity or acceleration but pressure and temperature variations. The temperature variation is proportional to the ascent for stationary motion but the temperature range depends also on the frequency for a wave. Hence, the conclusion made at the end of section 5.2 that the vertical velocity does not matter to estimate ice crystal number concentrations is a somewhat straightforward consequence of the setup. In section 5 and the sequel, the amplitude of the wave is characterized by its temperature range. I would recommend to do it from the beginning.
5. p.28119: The amplitude of the wave can also be given in terms of vertical excursion which is near 100m for the set of chosen parameters.
6. p.28119: The choice of the pressure initial level in the idealized simulation is 100 hPa which is not the level above which most cirrus are generated in the TTL. Is it because the effect of the wave would be less spectacular at lower levels?
7. p.28120 and fig.4: I do not understand why the red curve does not oscillate around the blue curve in the upper panels before the onset of nucleation as it does after the system has relaxed to saturation. The relative humidity of the stationary case rather looks like the envelop of the case with superimposed wave.

8. p.28122: The authors might add the recent work of Flury et al. (2012) in support of the link between temperature and cirrus.

9. p.28127: It would be useful to summarize how many cases have been investigated. By taking into account the level (5 values), the large-scale velocity (7 values), the wave amplitude (5 values) and its frequency (7 values), I find 1225 cases multiplied per 2 if heterogeneous nucleation is accounted. Is that correct and is each case given an equal weight in the mean curves shown on figs. 8, 10 and 11?

10. p.28127: It is unclear in which way the simplified case considered in section 3 differs from one of the "realistic" cases. If not, I would suggest to move all the discussion leading to (8) and this equation to an earlier position in the text.

11. p.28128: Is fig. 9 showing something else than the superposition of sinusoidal pdf for waves defined by (8) and a set of amplitudes and frequencies given on p.2826 and p.2827. If not, this figure is useless and it is enough to mention that the largest encountered velocity is 3 m/s. In addition, I do not see the point to focus on the velocity if the next section 5.2 concludes that this quantity is not correlated with the number concentration. See above.

12. p.28129, l.25-26: Repetition of l.9-10 in the same page.

13. p.28131: There are many cases (2400?) which are first grouped into 4 families, with a more or less arbitrary separation of fast versus slow mean ascent and then combined to reconstruct the observed spectrum. The weighting within each family is not indicated but it does not seem to be related to any observation derived distribution of the parameters. Hence, it is unclear whether the combination shown as the black curve in fig.11 is optimal or even unique. The robust result seems, however, that combined heterogeneous end homogeneous nucleation with small mean ascent is required to explain the small and mid number

concentrations.

14. p.28132: The explanation of the large number concentrations by fast ascent (with either homogeneous nucleation alone or combined with heterogeneous nucleation) is puzzling. This contribution is necessary to fit the observations but the proportion a4 is very small. This is possibly the less robust result of this work as we do not know how the simplifications made in the model are influencing the large concentration tail. If the result was true, the large concentration tail should exhibit considerable temporal and spatial variability in the observations. Is there any hint of that feature in the recent data of the ATTREX campaigns (Jensen et al., 2013)?

15. p.28133-28134: Although there is a relation between wavelength and frequency for gravity waves, there is no spatial structure involved in this study. The discussion should be in terms of frequency and avoid the word "wavelength".

References

Flury, T., Wu, D. L., and Read, W. G.: Correlation among cirrus ice content, water vapor and temperature in the TTL as observed by CALIPSO and Aura/MLS, Atmospheric Chemistry and Physics, 12, 683–691, doi:10.5194/acp-12-683-2012, http://www.atmos-chem-phys.net/12/683/2012/, 2012.

Jensen, E. J., Diskin, G., Lawson, R. P., Lance, S., Bui, T. P., Hlavka, D., McGill, M., Pfister, L., Toon, O. B., and Gao, R.: Ice nucleation and dehydration in the Tropical Tropopause Layer., Proceedings of the National Academy of Sciences of the United States of America, 110, 2041–6, doi:10.1073/pnas.1217104110, http://www.ncbi.nlm.nih.gov/pubmed/23341619, 2013.

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