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Atmospheric Chemistry and Physics Discussions

Interactive comment on “Properties of subvisible cirrus clouds formed by homogeneous freezing” *by* B. Kärcher

Anonymous Referee #1

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This paper presents analytic model calculations of subvisible cirrus (SVC) properties. The scaling laws generated may be useful for large-scale model parameterizations, and the calculations lead to interesting conclusions about SVC lifetime sensitivity to temperature and vertical wind speed. I think the paper will be suitable for publication after the authors address the comments below. These comments primarily concern the discussion in the paper and references to previous work.

Specific Comments:

1. The authors are using an analytic parcel model, so fallout of ice crystals is clearly not included. Some discussion of the implications of omitting sedimentation should be included. For example, sedimentation of ice crystals is clearly important for relatively weak updrafts (w less than about 0.5 cm/s). Under these conditions, fallout of ice

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crystals limits the SVC lifetime, prevents the cloud from reducing the saturation ratio to unity, and probably also limits the maximum size reached by ice crystals. On the other hand, fallout probably does not significantly affect the number density of ice crystals nucleated.

2. Several approximations are required to allow development of the analytic model. It would be helpful if some quantitative estimates were given for how much these assumptions affect the calculated quantities such as ice number density, growth time, etc. For example, how do the ice number densities calculated as described in section 2.2 differ from ice number densities calculated with a detailed cloud model? How much does the extinction efficiency given by the approximate expression (equation 17) differ from what a full Mie code would give?

3. What is the wavelength at which the extinction is calculated (corresponding to index of refraction = 1.31)?

4. I see no point in including equation 20 here. The extinction ratio is clearly irrelevant since it is just used for distinguishing clouds from aerosols, and you are only discussing the cloud extinction here.

5. Bottom of page 9: It would be helpful to give the zenith optical depth corresponding to the threshold extinctions for a typical cloud depth (say 500 meters).

6. How much different would the growth timescale and equilibrium radius be if you assumed the parcel kept rising even after nucleation ceased?

7. Section 3.3: You should compare your ice number density versus w calculations to other recent modeling studies [Lin et al. 2002; Jensen et al., JGR, 106, 17237, 2001; DeMott et al., JGR, 102, 19575, 1997]. If there are significant differences, you should discuss them.

8. It seems to me that the most interesting result of this study is that long-lived SVC are only possible at low temperatures and for a narrow window of updraft velocities.

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This result should be emphasized in the abstract and summary. In fact perhaps this conclusion provides an explanation for why SVC are much more common in the very cold tropical tropopause region than in the relatively warmer mid-latitude tropopause region.

9. The conclusion that long-lived SVC can't be formed even at low temperatures if the updraft velocity is above 1-2 cm/s is particularly surprising. I suspect SVC are also often residuals of clouds that were visible at some stage of their lifetime. For example, a visible cloud could become subvisible after larger ice crystals fall out and sublimate leaving behind only the smaller crystals.

Interactive comment on Atmos. Chem. Phys. Discuss., 2, 357, 2002.

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