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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Orographic cirrus in the future climate" *by* H. Joos et al.

Anonymous Referee #1

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General comment:

This is an interesting and thoughtful study that addresses the effect of a range of basic state changes on the properties of cirrus clouds produced by orographically generated gravity waves. The goal is to shed some light on how the overall optical depths of such clouds might change in a future climate. The study is thorough in its treatment of the variety of inputs that could affect the results (temperature, wind, moisture, mountain amplitude, position of the supersaturated layer). The authors bring out their most important points (e.g., the tendency for the increase in IWP associated with warmer and moister conditions to drive the optical depth) without any overstatements about future climate effects. In fact, a little more speculation at the end might be OK (subject to good judgment). Subject to addressing the following points, the paper is largely publishable.

My only major complaint is that there needs to be some clarification of the effect of

moisture on vertical wavelengths in the model simulations. The impression given in the paper is that moisture affects the vertical wavelength at all altitudes (based on using the equivalent potential temperature instead of the potential temperature to calculate stability). In fact, the stability changes only at altitudes where condensation occurs. At most altitudes there is no condensation, and the atmosphere should behave like a dry atmosphere (excepting the "virtual temperature" effect – not included here). It is not clear what assumptions the authors have made on this.

This is of little importance for the discussion of the Southern Hemisphere. However, it appears to matter quite a bit for the Northern Hemisphere discussion. How much of the instability problem at low altitudes in summer in NH is due to using equivalent potential temperature instead of potential temperature?

If, indeed, the authors are assuming that condensation occurs everywhere, there needs to be some justification of this assumption.

The authors use "mean" profiles to do their calculations. This is reasonable, since it puts some bounds on the problem. However, there is enormous variance (day-to-day) in the conditions that generate mountain waves. Since the process generating the clouds (and even, in some cases, the waves) is horrendously nonlinear, it is possible that some systematic behavior in the variance might be comparable to changes due to the means. Obviously, there is a difference between: (1) the change (from current to future climate) in the mean optical depth of all orographic waves and (2) the change in the optical depth of orographic clouds generated by the mean flows.

An example of this might be the summer case (SH), where there is almost no cloud for the "current" climate. Essentially there is a cutoff for the mean situation because temperatures are too cold and wave amplitudes too weak. The results presented overstate the climate effect, since if variance in the meteorology is taken into account there will be plenty of cases (in the current climate in summer) where the nucleation threshold is reached and ice crystals form. Note that for the non-linear case, summer optical depths are larger than in winter, again showing the large effect of changing dynamics.

The sensitivity to the wave phase is an interesting point. I think it demonstrates the large variance in cloud properties that can be expected. One wonders whether systematic behavior in these variances can swamp the signal from the changes in clouds from changes in mean dynamics, temperature, and moisture.

I am confused by the full paragraph on page 8954. I don't see any evidence of a reduction of optical depth with increasing temperature for the 130% supersaturation case. The authors say that "This example points out, that if the increase in temperature is strong enough and the initial ice supersaturation is high, the increase in in tau due to more IWP is not the dominant effect anymore as the cloud ice is reduced due to sedimnetation and the optical depth is reduced." Only at the lowest supersaturation do we see a decrease in optical depth with temperature in Figure 6. Please clarify. The typo on line 13 (T=20K) helped throw me off.

Minor comments:

In Figure 9 and 8, label A1B9 and A1B0.

In a number of cases "extend" (verb) is mistakenly used instead of "extent." (noun).

Figure 11 and 9 have the positions of the A1B0 and A1B9 plots switched. There are a lot of cases. Consistency between figures will help.

Grammatical/typographical issues:

Section 4, page 8950 line 17: occurs.

Page 8954 line 8: "..(T-230K) does sedimentation become.." line 13: What is T=20K? line 19: delete the word "much"

page 8959, line 8: "supersaturated layer are only.."

Page 8961, line29: "..lower than winter."

Page 8962, line 2: "For the summer months.." line 26: "However, since in our case.."

Page 8963, line 25: "..that are described in this section are seen, and are therefore.."

Page 8966, line 12: "..and nearly offset the thermodynamical changes."

Page 8968, line 7: "simulations"

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 8943, 2009.