

Interactive
Comment

Interactive comment on “Impact of H₂SO₄/H₂O coating and ice crystal size on radiative properties of sub-visible cirrus” by P. Räisänen et al.

Anonymous Referee #3

Received and published: 1 August 2006

Recommendation: Acceptable for publication with minor revisions

Major Comments

This paper is a very worthwhile study that uses results from recent laboratory experiments to examine how a coating of H₂SO₄/H₂O on small ice crystals can affect the reflection of solar and absorption of longwave radiation by cirrus. Even though this coating has a small impact on the total cloud radiative effects (CRE) at the top of the atmosphere, the study is worthy of publication in showing that this covering does not have a large impact on the CRE which was hitherto unknown. Although I highly endorse this study for publication, there are a couple of comments I make where the presentation and/or discussion could be improved:

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1) I think the authors do not discuss how the coating might have the biggest impact on the CRE. Although the coating does not seem to have a big impact on the radiative fluxes, it could still have an impact on the radiative fluxes if the coating impacts the lifetime of the sub-visible cirrus by altering the rates at which sublimation or deposition occurred. I have no clue if there is such an effect, but if present could easily overwhelm any direct effect on the radiation. This is somewhat addressed in the last line of page 5238, but could be expanded upon.

2) Many previous observations in sub-visible cirrus show pristine particle shapes or quasi-spherical particle shapes, not spheres (e.g., the Heymsfield observations referred to of columns and trigonal plates). Hence, most studies that have examined the cloud radiative effects of sub-visible cirrus have used single-scattering properties of non-spherical ice crystals rather than the spherical ice crystals used in this paper. Thus, the radiative transfer calculations presented in this paper do not give a good absolute magnitude of the radiative effects compared to previous studies. Perhaps the difference in the CRE due to the impact of the coating is correct, but this limitation should be clearly explained (in the abstract in addition to the main body of the text). I would also recommend replacing Figure 4 with a Table similar to Table 1 to examine how the coating affects the CRE when a constant optical depth is assumed (see comments below on whether to assume constant optical depth or constant crystal number). Given that sub-visible cirrus almost certainly does not consist of spherical ice particles, it is really a comparison between simulations with and without coatings that is unique to this paper. Prior papers have done better computations with more realistic shapes on cloud radiative effects for clouds consisting of pure ice.

3) The authors state that the over-layer is thickest for young freshly formed ice particles and becomes thinner as they grow due to water vapor deposition. Given that sub-visible cirrus are nearly ubiquitous in the Tropics and persist so long, would the impact therefore expected to be reduced? I would recommend that the authors add some comments on the potential origin of sub-visible cirrus (perhaps Boehm and Verlinde

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paper) to expand upon this point a little.

Minor Comments:

Page 5233, line 19: If the effective diameter of sub-visible cirrus is 2 microns, is this still cirrus? It would seem that you would almost be looking at aerosols in this case.

Page 5234, line 13: Can you specify pressure, temperatures and dew-points that you are referring to when you say conditions resembling those found in the uppermost troposphere?

Page 5236, last line: Have you done any sensitivity studies to see how your results differ if saturated conditions are not assumed in the cloud layer?

Page 5237, line 10: In these sensitivity studies with varying diameters, I fear that almost all of the differences you will see will be due to varying the optical depth of the cirrus. Why not keep the optical depth fixed and adjust the effective diameter?

Page 5238, line 11: Note also that the cases with smaller diameters have smaller optical depths. Typically, whenever you have smaller optical depths, any adjustments will cause a larger relative change in the cloud optical properties. If you keep optical depth constant between the simulations, would you still see the largest change in CRE for the smallest particle size?

Page 5239, bottom: Can you comment or speculate on any differences you would have in the Q_e plots if you were using non-spherical rather than spherical particles?

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 5231, 2006.

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