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# ***Interactive comment on “Modelling of cirrus clouds – Part 1: Model description and validation” by P. Spichtinger and K. M. Gierens***

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## **1 General comment**

We have decided to follow the suggestion of reviewers 1 and 2 to split the paper into two parts. The first part includes the sections 2, 3, 4.1 and 4.2.1/4.2.2 of the discussion paper (i.e. model description, validation of the microphysics scheme against detailed boxmodel calculations and validation against literature case of arctic cirrostratus) while the second part will include sections 4.2, 5 and 6, including some new material originating from some suggestions of reviewer 2 (new figures on the basis of the existing simulations). We have rewritten the introductions and conclusions for both papers, including the existing material. The first part is now entitled as “Modelling cirrus clouds – Part 1a: Model description and validation”, the second part has now the title: “Mod-



We have attached also the reference list to which we refer for the responses to the three referees; the reply is splitted into three parts for technical reasons.

## References

- [Bailey and Hallet(2004)] Bailey, M. and J. Hallet, 2004: Growth Rates and Habits of Ice Crystals between  $-20$  and  $-70^{\circ}\text{C}$  *J. Atmos. Sci.*, 61, 514–544.
- [Birner(2006)] Birner, T., 2006: Fine-scale structure of the extratropical tropopause region, *J. Geophys. Res.*, 111, D04104, doi:10.1029/2005JD006301.
- [Comstock et al.(2004)] Comstock, J., T. P. Ackerman, D. D. Turner, 2004: Evidence of high ice supersaturation in cirrus clouds using ARM Raman lidar measurements. *Geophys. Res. Lett.*, 31, L11106.
- [Dürbeck and Gerz(1996)] Dürbeck, T., and T. Gerz (1996), Dispersion of aircraft exhausts in the free atmosphere, *J. Geophys. Res.*, 101(D20), 26,007-26,015.
- [Gayet et al.(2006)] Gayet, J.F., V. Shcherbakov, H. Mannstein, A. Minikin, U. Schumann, J. Ström, J. Ovarlez, F. Immler, 2006: Microphysical and optical properties of midlatitude cirrus clouds observed in the southern hemisphere during INCA. *Q. J. R. Meteorol. Soc.*, 132, pp. 2719-2748
- [Gierens et al.(2007)] Gierens, K., R. Kohlhepp, N. Dotzek, H. G. Smit, 2007: Instantaneous fluctuations of temperature and moisture in the upper troposphere and tropopause region. Part 1: Probability densities and their variability. *Met. Z.*, 16, 221–231.

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[Haag et al.(2003a)] Haag, W., B. Kärcher, U. Schurath, O. Möhler, O. Stetzer, S. Schaefers, C. Schiller, M. Krämer, 2003a: Numerical simulations of homogeneous freezing processes in the aerosol chamber AIDA. *Atmos. Chem. Phys.*, 3, 195–210.

[Haag et al.(2003b)] Haag, W., B. Kärcher, J. Ström, U. Lohmann, J. Ovarlez and A. Stohl, 2003b: Freezing thresholds and cirrus cloud formation mechanisms inferred from in situ measurements of relative humidity, *Atmos. Chem. Phys.*, 3, 1791–1806.

[Hall and Pruppacher(1976)] Hall, W.D., and H.R. Pruppacher, 1976: The survival of ice particles falling from cirrus clouds in subsaturated air. *J. Atmos. Sci.*, 33, 1995–2006.

[Heymsfield and Iaquinta(2000)] Heymsfield, A. and J. Iaquinta, 2000: Cirrus crystal terminal velocities. *J. Atmos. Sci.*, 57, 916–938.

[Heymsfield and McFarquhar(2002)] Heymsfield, A. and G.M. McFarquhar, 2002: Mid-latitude and tropical cirrus: Microphysical properties. In: *Cirrus* [D.K. Lynch, K. Sassen, D. O'C. Starr, G. Stephens (Eds.)]. Oxford University Press, Oxford, U.K., pp. 78–101.

[Heymsfield and Sabin(1989)] Heymsfield, A. J. and Sabin, R. M., 1989: Cirrus crystal nucleation by homogeneous freezing of solution droplets, *J. Atmos. Sci.*, 46, 2252–2264.

[Jensen and Pfister(2004)] Jensen, E., and L. Pfister, 2004: Transport and freeze-drying in the tropical tropopause layer, *J. Geophys. Res.*, 109, D02207, doi:10.1029/2003JD004022.

[Kajikawa and Heymsfield(1989)] Kajikawa, M. and A. Heymsfield, 1989: Aggregation of ice crystals. *J. Atmos. Sci.*, 46, 3108–3121.

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Comment

[Kärcher and Lohmann(2002a)] Kärcher, B., U. Lohmann, 2002a: A Parameterization of cirrus cloud formation: Homogeneous freezing of supercooled aerosols. *J. Geophys. Res.* 107, (D2), 4010, doi:10.1029/2001JD000470.

[Kärcher(2005)] Kärcher, B., 2005: Supersaturation, dehydration, and denitrification in Arctic cirrus. *Atmos. Chem. Phys.*, 5, 1757–1772.

[Kay and Wood(2008)] Kay, J. and R. Wood, 2008: Timescale analysis of aerosol sensitivity during homogeneous freezing and implications for upper tropospheric water vapor budgets, *Geophys. Res. Lett.*, 35, L10809, doi:10.1029/2007GL032628.

[Koop et al.(2000)] Koop, T., B. Luo, A. Tsias, T. Peter, 2000: Water activity as the determinant for homogeneous ice nucleation in aqueous solutions. *Nature* 406, 611–614.

[Krämer et al.(2008)] Krämer, M., C. Schiller, I. Gensch, N. Sitnikov, S. Borrmann, M. de Reus, P. Spichtinger, 2008: On Cirrus Cloud Supersaturations and Ice Crystal Numbers. *Geophysical Research Abstracts*, 10, EGU2008-A-05254.

[Lee et al.(2004)] Lee, J. C. Wilson, D. Baumgardner, R. L. Herman, E. M. Weinstock, B. G. LaFleur, G. Kok, B. Anderson, P. Lawson, B. Baker, A. Strawa, J. V. Pittman, J. M. Reeves, T. P. Bui, 2004: New particle formation observed in the tropical/subtropical cirrus clouds, *J. Geophys. Res.*, 109, D20209, doi:10.1029/2004JD005033.

[Libbrecht(2005)] Libbrecht, K.G., 2005: The physics of snow crystals. *Rep. Prog. Phys.*, 68, 855–895.

[Lin et al.(2002)] Lin, R.-F., D. Starr,1 P. DeMott, R. Cotton, K. Sassen, E. Jensen, B. Kärcher, X. LIU, 2002: Cirrus Parcel Model Comparison Project. Phase 1: The Critical Components to Simulate Cirrus Initiation Explicitly. *J. Atmos. Sci.*, 59, 2305–2329.

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Comment

[Lin et al.(2005)] Lin, R.-F., D. Starr, J. Reichardt, P. DeMott, 2005.: Nucleation in synoptically forced cirrostratus, *J. Geophys. Res.*, 110, D08208.

[Meyers et al.(1992)] Meyers M.P., P.J. DeMott, W.R. Cotton, 1992: New Primary Ice-Nucleation Parameterizations in an Explicit Cloud Model. *Jour. Appl. Met.*, 31, 708-721.

[Ovarlez et al.(2002)] Ovarlez, J., J.-F. Gayet, K. Gierens, J. Ström, H. Ovarlez, F. Auriol, R. Busen, U. Schumann, 2002: Water vapor measurements inside cirrus clouds in northern and southern hemispheres during INCA. *Geophys. Res. Lett.*, 10.1029/2001GL014440.

[Peter et al.(2006)] Peter T., Marcolli C., Spichtinger P., Corti, T., Baker M.B., Koop, T., 2006: When dry air is too humid *Science* 314 (5804), 1399-1400.

[Peter et al.(2008)] Peter, T., M. Kraemer, O.Moehler, 2008: Upper Tropospheric Humidity, SPARC/WCRP Newsletter 30, [http://www.atmosphysics.utoronto.ca/SPARC/Newsletter30Web/index\\_30.html](http://www.atmosphysics.utoronto.ca/SPARC/Newsletter30Web/index_30.html).

[Pruppacher and Klett(1997)] Pruppacher, H. and J. Klett, 1997: *Microphysics of Clouds and Precipitation*, Kluwer Acad. Pub., Dordrecht.

[Sassen and Dodd(1988)] Sassen, K. and G.C. Dodd, 1988: Homogeneous nucleation rate for highly supercooled cirrus cloud droplets. *J. Atmos. Sci.*, 45, 1357–1369.

[Spichtinger et al.(2005a)] Spichtinger P., Gierens K., Wernli H., 2005a: A case study on the formation and evolution of ice supersaturation in the vicinity of a warm conveyor belt's outflow region *Atmos. Chem. Phys.*, 5, 973-987.

[Spichtinger and Gierens(2008)] Spichtinger, P., and K.M. Gierens, 2008: Modelling cirrus clouds – Part 2: Competition of different nucleation mechanisms. *Atmos. Chem. Phys. Diss.*, 8, 9061-9098.

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[Stephens(1983)] Stephens, G., 1983: The influence of radiative transfer on the mass and heat budgets of ice crystals falling in the atmosphere. *J. Atmos. Sci.*, 40, 1729–1739.

[von Storch and Zwiers(1999)] von Storch, H. and F.W. Zwiers, 1999: Statistical Analysis in Climate Research . Cambridge University Press, 484 pp, ISBN 0521 450713.

[Wacker and Seifert(2001)] Wacker, U. and A. Seifert, 2001: Evolution of rain water profiles from pure sedimentation: Spectral vs. parameterized description. *Atmos. Res.*, 58, 19–39.

[Wendisch et al.(2005)] Wendisch, M., P. Pilewskie, J. Pommier, S. Howard, P. Yang, A. J. Heymsfield, C. G. Schmitt, D. Baumgardner, and B. Mayer, 2005: Impact of cirrus crystal shape on solar spectral irradiance: A case study for subtropical cirrus, *J. Geophys. Res.*, 110, D03202, doi:10.1029/2004JD005294.

[Wendisch et al.(2007)] Wendisch, M., P. Yang, and P. Pilewskie, 2007: Effects of ice crystal habit on thermal infrared radiative properties and forcing of cirrus, *J. Geophys. Res.*, 112, D08201, doi:10.1029/2006JD007899.

[Wernli and Davies(1997)] Wernli, H. and H. Davies, 1997: A Lagrangian-based analysis of extratropical cyclones. I: The method and some applications. *Quart. Jour. Roy. Meteorol. Soc.*, 123, 467–489.

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