Atmos. Chem. Phys. Discuss., 12, C6639–C6642, 2012
www.atmos-chem-phys-discuss.net/12/C6639/2012/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Particle backscatter and relative humidity measured across cirrus clouds and comparison with state-of-the-art cirrus modelling" *by* M. Brabec et al.

M. Brabec et al.

martin.brabec@env.ethz.ch

Received and published: 5 September 2012

We thank the reviewer for his insightful comments which helped improving the manuscript significantly.

Specific comments: (arranged in order of appearance in the text)

1. Abstract line 1-2 (and Page 9568, line 7-9): ' ... determine the partitioning of atmospheric water between the gas phase and the condensed phase in and around cirrus clouds, ... ' Do you think that it is really possible to determine the condensed phase from the measurements? As far as I can see it is possible to determine the in-cloud and out-of-cloud gas phase from CFH, but deriving the condensed phase from

COBALD seems to be problematic. Please comment on that and possibly scale back the statement.

We scaled back and decided to change the word “determine” to “estimate”.

2. Abstract, Page 9554, line 22: Please define NWP.

Done.

3. Page 9555, lines 12-14: ‘At times surprisingly high supersaturations inside and around cirrus clouds have been measured, as if the nucleation of ice particles or the uptake of water onto the existing ice surfaces were hindered (Peter et al., 2006, and references therein).’References of more recent studies as e.g. Krämer et al. (2009), ACP, or Murray et al. (2010), Nature Geosciences, are missing. These studies show high supersaturations both from atmospheric and laboratory observations and give possible explanations of the related processes.

The other reviewer was also missing some newer citations. They are now included.

4. Page 9559, line 17: I am wondering that heterogeneous ice nucleation is not included in the model, nor mentioned at all in the paper, though it is known that initial heterogeneous freezing can influence the formation and microphysical properties of cirrus clouds (see e.g. Spichtinger and Cziczo, 2010, JGR). Maybe the upper cloud ‘U’ (Fig. 1, 3, 5) could have been better reproduced with the model in case heterogeneous freezing would be allow to occur?

Heterogeneous nucleation is now discussed in some detail towards the end of Section 6. However, this does not help improving the position of the upper cloud, with would require more realistic RHice from COSMO (see Fig. 5b).

5. Page 9560, line 20: Please specify the homogeneous ice nucleation parameterization implemented in the model. These parameterizations are based on Koop et al. (2000) with updated homogeneous nucleation rate coefficient for pure water (Zobrist et al., 2007). This is now better described.

ACPD

12, C6639–C6642, 2012

6. Page 9561, line 4-5: '... , in a mixed phase cloud, the water cloud droplets, the so-called Bergeron- Findeisen effect (Seinfeld and Pandis, 1998).' Are mixed phase clouds also implemented in the model? If yes, please describe how.

No, mixed phase clouds are not implemented in the model. We removed the confusing part from the manuscript.

7. Page 9562, line 26-28: 'The observed clear-sky supersaturations of 30% are not surprising; for example homogeneous ice nucleation requires more than 45% supersaturation under midlatitude upper tropospheric conditions (Koop et al., 2000).' Heterogeneously freezing ice nuclei (IN) are omnipresent in the upper troposphere and in case they are aged and coated with organics or sulfuric acid they can have freezing thresholds between 130% and the homogeneous freezing threshold. This should also be discussed here (see also comment 4.).

Done.

8. Page 9562, line 28ff: The range of RHice = 50%-130% inside the lower cirrus might be more surprising at first sight, but only detailed cloud modelling can help clarifying whether such non-equilibrium conditions are to be expected (see Sects. 5 and 6).'From earlier field, laboratory and modelling studies (see -as examples- the already mentioned papers) it is known that non-equilibrium RHice exist and are expected from theory. So please rephrase.

Well, whether RHice = 50-130 % is likely to be found inside a cirrus will depend on its ice number density and size. These in turn have not been measured, but need to be modeled for the specific circumstances. We did not rephrase the text.

9. Page 9566, line 4: ' ... peak-to-peak amplitudes of 1 K ... '. Why you choose 1K as amplitude? Maybe beased on the study of Gary (2006), ACP ? The other reviewer had similar problems. We replaced "amplitude" by variance, refer to Hoyle et al. and discuss why these are then restricting to wavelengths shorter than 30 km. We explain

ACPD

12, C6639–C6642, 2012

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

this now in more detail in the first paragraph of Section 6.

10. Page 9566, line 25ff: ' ... . the BSR maxima are located below the RHice maxima (or actually sit close to the transition point of super- to subsaturation), which is likely due to particle sedimentation.' Another possible explanation cloud be that no cloud is formed above the observed and thus RHice is still high, and that inside of the cloud RHice is already reduced, yes?

Yes, in principle this could be possible. However, we find RHice > 1 above the clouds and not below the clouds. This asymmetry suggests that sedimentation of the particles into the supersaturated regions depleted the gas phase below the clouds.

11. Page 9566, line 25-27: 'The modeled in-cloud RHice covers only the range from 80% to 105%, i.e. in the model sub- and supersaturations tend to relax too rapidly. This suggests a delicate interplay between RHice and (dT/dt)ss:...'This suggests that the model might produce too many small ice crystals, which brings me back to heterogeneous ice nucleation: in case ice formation would be initialized heterogeneously and followed by a homogeneous ice nucleation event, the ice crystal concentrations could be lower than for pure homogeneous ice formation (Spichtinger and Cziczo, 2010, JGR). I suggest to discuss that in the paper.

Heterogeneous nucleation would indeed result in fewer ice crystals, but obviously bigger in size. That would mean they sediment faster and fall into subsaturated regions (see Fig. 5b) and therefore evaporate. The connection between heterogeneous nucleation and small-scale T fluctuations is better described towards the end of Section 6.

Regards, M. Brabec et al.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 9553, 2012.

ACPD

12, C6639–C6642, 2012