Response to reviewer's comments – review 1

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We thank the reviewer for the comments, leading to an improvement of our manuscript.
We extended our manuscript by time scale analysis in order to estimate the importance of aggregation for different regimes of ice crystal number concentrations and modal masses, respectively.

1 Major points

1. Review of relevant literature:
A full review is not within the scope of this paper. However, we extended the introduction by some references on ice aggregation, giving an overview about the main processes. Additionally, we add some references to older and recent work on modelling ice aggregation with bulk schemes (Passarelli, 1978; Mitchell, 1988; Ferrier, 1994; Morrison et al., 2005); some of these are further discussed in a new section (Comparison with other model parameterisations). Obviously, there are two kind of solutions, which are described shortly. We especially concentrate on comparison with Schumann (2012), the only one which is intended for the cold temperature regime of cirrus clouds (contrails). All other parameterisations are developed for warmer temperatures, thus a comparison is not appropriate.

2. Model validation:
Unfortunately, the majority of scientists still believes that models can be validated. Since Popper's work "The logic of scientific discovery" it should be clear that science consists of hypotheses that may be falsified but that can never be verified. This is true for theories, however, for models this is even more so. One should keep in mind that models are generally incomplete in the sense of representing physical processes, as stated by Box and Draper (2007, page 63): "Remember that all models are wrong the practical question is how wrong do they have to be to not be useful".

   For aggregation we have the following situation: The prefactor E is certainly a very complicated function of temperature, pressure, supersaturation, perhaps absolute humidity, crystal shape, size, relative orientation, etc. In our paper we use an assumption on its temperature dependence that has probably been guessed by Lin and Levkov, but not derived from measurements or first principles. The other simplifications required to formulate the kernel function are descibed in the paper. They in turn are based on simple numerical fits to shot patterns of data. Other models use similar but in details different assumptions and numerical procedures. All these assumptions and simplifications are more or less justified, and the main justification is that they work and that the results are plausible. In that sense, no model of aggregation is "physically accurate". The view that models could be ranked is an illusion; the base for such a ranking, that is, an agreed on and generally accepted"truth", does not exist. If there is an instance of such a "truth" (for cold temperatures, please) we would be happy to hear from it.

   Finally, we have to accept that all we can get is that the impression of plausibility is growing, for instance when independent parameterisations yield similar results(as ours and those by Schumann, 2012), when results are more or less expected and explanations for not-so-easily-expected effects are readily found.

3. Figures:
We changed figures and their captions in order to approach consistency. However, old figure 2 (now figure 4) was not changed, because any other choice of colours did not improve the representation; however, this stems from the fact that for small modal masses, aggregation is negligible.

2 Minor points

1. "classical form" is now specified as "classical Smoluchowski form".

2. In fact, this turns out rather involved. K is actually the rate (1/s) at which the crystal concentration (m^{-3}) changes due to aggregation per unit concentration ($1/\mathrm{m}^{-3}$) of crystals of mass m and per unit concentration ($1/\mathrm{m}^{-3}$) of crystals of mass m'. Thus the units are in case of using number concentration per volume of dry air
$$[K] = \frac{\mathrm{m}^{-3}}{\mathrm{s}(\mathrm{m}^{-3})^2} = \frac{\mathrm{m}^3}{\mathrm{s}}. \quad (1)$$
If the number concentration is given per mass of dry air (kg^{-1}) the units are then given by
$$[K] = \frac{\mathrm{kg}^{-1}}{\mathrm{s}(\mathrm{kg}^{-1})^2} = \frac{\mathrm{kg}}{\mathrm{s}}. \quad (2)$$

This is corrected in the text now, however, without mentioning the different cases (per volume vs. per mass of dry air).

3. We believe it is easier for the reader to have the equations repeated here. Otherwise it would be required to browse back and forth within the paper. So this is left unchanged.

4. The whole section has been rewritten and we hope it is less cumbersome now. But we refrain from including details of the microphysical processes of ice nucleation and depositional growth. These are described in much detail in Spichtinger and Gierens (2009a) and giving more details here would lead away from the topic and be a long deviation from a straight way. The sedimentation parameterisation is described in more detail, since this process is of high importance in combination with aggregation.

5. Corrected.

3 Grammar and Wording

We implemented the suggested changes

References

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