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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Review and uncertainty assessment of size-resolved scavenging coefficient formulations for snow scavenging of atmospheric aerosols" *by* L. Zhang et al.

Anonymous Referee #1

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The paper describes the mathematical formulations for size resolved aerosol impaction scavenging by snow and ice crystals, which are applicable for large-scale modelling.

The uncertainties for this process description are associated to the diversity of existing parameterisations for four key factors, i.e. collection efficiency, cross-sectional area, snow/ice crystal distributions and terminal velocity, which are commonly used to determine the scavenging efficiency. For each of the key quantities, a few parameterisations are described and then sensitivity tests, exchanging the individual factors have been performed and analysed.

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Interactive Discussion
Discussion Paper

The paper is well written and I recommend publication after consideration of a few remarks.

Major comments:

1)
The paper discusses a lot the mathematical effects of the parameterisations, but does not go into detail which physical concepts are accurately captured by the individual approaches, e.g., it is not obvious why the formulas for E result in differences of more than one order of magnitude. The only aspect which is elucidated are differences resulting from particle types and corresponding terminal velocities, but they cannot explain the differences between the three formulations for E, but only the differences among the individual E values for each respective scheme.

Also it is not obvious, why the differences are larger for the lower snow intensities than for stronger solid precipitation.

This is similarly true for the individual parameterisations for Vd and A; the effects are well described and the subsequent influence on the scavenging efficiency is obvious, but the physical (not the mathematical) reasons of the different formulations for the parameters remains unclear.

2)
In the paper the terminology for snow / ice crystals and solid hydrometeors in precipitation is not always clear. To certain degree the different snow crystal types are explicitely considered in the formulations, but in Fig.10 it is not clear if the shape is still considered.

However, typical regional to global scale models do not provide the information about the crystal type and shape, but only total solid precipitation flux, which then can be used for the scavenging calculations either with additional assumptions on crystal type distributions or by using generalised crystal types/shapes. This should be discussed in

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some detail if the applicability of the parameterisations is suggested.

3)
As the empicirally fitted formula of Paramonov et al. includes all processes like the electric charges, thermophoresis, etc. it is reasonable that the obtained values for Λ are larger than in the conceptual approaches, in which those processes are neglected. Even though they are assumed to have small influences only, close to the mininum values they will potentially have the largest importance. This becomes most obvious in Fig. 7, where theoretical approaches underestimate the observed fit.

Furthermore, the turbulence during the snow events can likely cause a completely different spectrum of terminal velocity especially for dendrite snow flakes, such that the effective scavenging can be much larger than theoretically assumed. This should be considered in the comparisons.

However, it should be taken into account, that the observations are an empirical fit to a multitude of individual events and do not represent the prescribed settings as for the theoretical approaches.

4)
Would the diversity even increase if also the terminal velocity is calculated with a different scheme than the Mitchell and Heymsfield approach? This is not discussed in the manuscript, but as this quantity alone can influence the values for one E by up to one order of magnitude (Fig. 7), I am surprised that the overall diversity remains smaller than 2.5 orders of magnitude, especially if the combined uncertainty is stated to be larger than the sum of individual uncertainties (Page 14840, line 22).

On the other hand, to which degree do these effects cancel out, since for increased snow rate the differences from E are reduced, but from N(d_p) are growing?

5)
How is the integral over the collector sizes in the respective size distribution discretised

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for the numerical calculations? This should be mentioned in the manuscript, as the impact of the collector size distribution will be larger for a highly resolved discretisation in solid hydrometeor size, but on the other hand, this will make the calculations computationally more expensive and less suitable for large-scale, long-term simulations.

Similarly, it is not described how the aerosol spectrum in Sect. 4.3 is discretised to calculate the loss in mass and number concentrations due to the scavenging. Are the 100 size bins (Page 14842, line 19) assumed for the aerosol or the precipitation distribution (or both or are they overlapping)?

Minor comments:

1) Please correct the unit in the caption of Fig.2: "m" should be "mm"

2) Abstract last sentence: This does not become obvious from the manuscript in its current form. Consequently, this sentence should be reformulated less strongly.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 14823, 2013.