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Corrigendum to:

"Studies of heterogeneous freezing by three different desert dust samples", Atmos. Chem. Phys., 9, 2805–2824, 2009

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Connolly et al. (2009) presented a model of ice nucleation based on the ideas of a "singular" process (Vali, 1994), where the ice formation rate on a specific dust sample surrounded by supercooled water is approximated by a formulation that depends only on aerosol properties and the temperature. Connolly et al. developed a parameterisation to describe the rate of change of the number concentration of ice crystals, N_{ice} with respect to temperature, T:

$$\frac{dN_{\text{ice}}}{dT} = -k(T)\Sigma_j^M N_{\text{drop},j} A_j \,, \tag{1}$$

where $k(T)$ is the number of active sites per unit area per temperature interval, $N_{\text{drop},j}$ is the number concentration of liquid drops in size bin j, of which there are M and A_j is the surface area of the dust particle in a drop.

In our paper (Connolly et al., 2009) we showed that the above model could be fitted satisfactory to data obtained from the Aerosol Interactions and Dynamics in the Atmosphere (AIDA) chamber. That is we were able to derive parametric fits for the function:

$$n_{\text{s}}(T_{\text{min}}) = -\int_{0\,^\circ\text{C}}^{T_{\text{min}}} k(T)dT \tag{2}$$

for three different dust samples, which were labelled Arizona test Dust (ATD), Asia Dust-1 (AD1) 5 and Sahara Dust-2 (SD2).

Niemand et al. (2012) revisited the experimental results presented in Connolly et al. (2009) and presented a more thorough parametric fit to $n_{\text{s}}(T)$ for different dusts. They found $n_{\text{s}}(T)$ to have an exponential dependence on the temperature below the melting point of ice. The values presented by Niemand et al. (2012) were an order of magnitude lower than our original estimates in the paper by Connolly et al. (2009). This turns out to be due to an error in the analysis of Connolly et al. (2009), as will now be described.

The paper by Connolly et al. (2009) divided the ice crystal number concentration by the total available aerosol surface area to calculate $k(t)$ [$\#m^{-2}K^{-1}$].

$$k(t)\frac{dT}{dt} = -\sum_j^M \frac{dN_{i,j}}{dt} / \sum_j^M (N_{d,j} \times A_j,) \tag{3}$$

where the j subscript refers to each of the M size bins, the subscript i refers to 'ice', d refers to the 'drops' and A is the surface area of a dust particle.

For each experiment analysed Connolly et al. (2009) used Eq. (3) to generate a time series of $k(t)$ and then integrated the time series with respect to time to find $n_{\text{s}}(T_{\text{min}})$, where T_{min} was the minimum temperature achieved in the experiment. The number of drops/aerosols decreases throughout the experiment as ice is nucleated in them. Therefore, to avoid underestimation of $k(T)$, it was important to take in to account the reduction in drop/aerosol concentration in the calculation.

There were two errors in the original paper, which were made as follows:

– The first was that when dividing by the aerosol surface area we in fact divided by $A = \pi r^2$ (where r is the

aerosol particles radius) instead of the correct equation for surface area, $A = 4\pi r^2$; hence we underestimated the surface area in Eq. (3) by a factor of 4. This alone would result in our estimates of $n_s(T)$ being a factor of 4 too high.

– The second error came from the assumptions of lognormal aerosol size distributions. Two parameters described the shape of the aerosol size distributions, the median diameter, $\bar{D}$, and the geometric standard deviation, $\ln\sigma$. These values were communicated via email after the experiments took place. However, when mapping the aerosol size distribution to the bin-grid used in the model, to calculate $k(T)$ in Eq. (3), it was assumed that the lognormal distribution was defined as being number per decadal logarithm, rather than natural logarithm. This resulted in an underestimate of the aerosol number in each size bin by a factor of $\ln 10 \sim 2.3$ and therefore an overestimate in the calculated value of n_s, which if taken alone would a result in the calculated n_s being a factor of ~ 2.3 too high.

Together the two errors result in the original values of n_s calculated by Connolly et al. (2009) being a factor of $\sim 4 \times 2.3 \cong 9.2$ too high.

Connolly et al. (2009) then used the parameterised n_s to perform a simulation of the experiments and showed that the correct ice crystal number was modelled, which resulted in the drops evaporating, via the Bergeron–Findeisen (B–F) process, at the same time as in the experiments. It should be noted that the reason the model calculated the correct ice crystal number concentration was because the biases described above were applied in reverse in our model, resulting in the factor of 9.2 being cancelled out. That is, the correct value of n_s was used in our model, but for the wrong reason.

The values of n_s reported by (Connolly et al., 2009) may still be used, with the proviso that they are divided by ~ 10. Alternatively, the results of Niemand et al. (2012) may also be used.

It is also noted that the Connolly et al. (2009) study used a Cloud Particle Imager (CPI) to determine ice crystal number concentration, whereas the Niemand et al. (2012) study used a white-light aerosol spectrometer (WELAS). The estimates of ice crystal number concentration were found to not be significantly different between the two probes.

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