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Can we define an asymptotic value for the ice active surface site density for heterogeneous ice nucleation?

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The formation of ice in atmospheric clouds has a substantial influence on the radiative properties of clouds as well as on the formation of precipitation. Therefore much effort has been made to understand and quantify the major ice formation processes in clouds. Immersion freezing has been suggested to be a dominant primary ice formation process in low and mid-level clouds (mixed-phase cloud conditions). It also has been shown that mineral dust particles are the most abundant ice nucleating particles in the atmosphere and thus may play an important role for atmospheric ice nucleation (Murray et al., 2012). Additionally, biological particles like bacteria and pollen are suggested to be potentially involved in atmospheric ice formation, at least on a regional scale (Murray et al., 2012).

In recent studies for biological particles (SNOMAX and birch pollen), it has been demonstrated that freezing is induced by ice nucleating macromolecules and that an asymptotic value for the mass density of these ice nucleating macromolecules can be determined (Hartmann et al., 2013; Augustin et al., 2013, Wex et al., 2014). The question arises whether such an asymptotic value can also be determined for the ice active surface site density n_s, a parameter which is commonly used to describe the ice nucleation activity of e.g., mineral dust. Such an asymptotic value for n_s could be an important input parameter for atmospheric modeling applications.

In the presented study, we therefore investigated the immersion freezing behavior of droplets containing size-segregated, monodisperse feldspar particles utilizing the Leipzig Aerosol Cloud Interaction Simulator (LACIS). For all particle sizes considered in the experiments, we observed a leveling off of the frozen droplet fraction reaching a plateau within the heterogeneous freezing temperature regime (T > -38°C) which was proportional to the particle surface area. Based on these findings, we could determine an asymptotic value for the ice active surface site density, which we named $n_\mathrm{s}^\star$, for the investigated feldspar sample. The comparison of these results with those of other studies elucidates the general feasibility of determining such an asymptotic value and also show that the value of $n_\mathrm{s}^\star$ strongly depends on the method of the particle surface area determination.

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