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A new parameterisation for the deposition mode ice nucleation on mineral dust particles

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It is known from numerous field and model studies that both homogeneous freezing of solution droplets and heterogeneous ice nucleation on the surface of insoluble aerosol particles contribute to the formation of ice crystals in cirrus clouds. Specific surface properties of the heterogeneous ice nuclei can markedly lower the ice saturation threshold for heterogeneous ice nucleation compared to homogeneous freezing, thereby changing not only the frequency of occurrence but also the microphysical and optical properties of cirrus clouds. Mineral surfaces are known to effectively initiate ice formation both in the immersion freezing and deposition nucleation mode.

In three series of AIDA cloud chamber experiments at cirrus temperatures between 196 K and 223 K we investigated the deposition mode ice nucleation efficiency of so-called Arizona Test Dust as reference aerosol and two desert dust samples from Asia (AD1) and the Sahara (SD2). The latter two may be more typical for dust particles found in the atmosphere. In 12 experiments with different initial temperatures and aerosol number concentrations the fraction f_i of ice particles, i.e. ice activated aerosol particles, to the total particle (aerosol plus ice) number concentration was measured as a function of the increasing ice saturation ratio. All three mineral dust aerosol samples contained significant numbers of very efficient deposition ice nuclei. Heterogeneous ice nucleation already started at ice saturation ratios S_i below 1.2, in most cases below 1.1.

In contrast to homogeneous freezing rates of solution droplets which can be parame-

terised in numerical models mainly as function of the temperature, relative humidity, and aerosol parameters, microphysical-based parameterisations for heterogeneous ice nucleation processes are more difficult to assess. Our experimental results indicate that for a given aerosol sample and initial temperature the ice activation spectrum, i.e. the relation between f_i and S_i, is almost independent of the cooling rate and the total aerosol number concentration. We therefore suggest an exponential equation as function of S_i to calculate the fraction of mineral particles acting as deposition nuclei. Our limited data set already shows that both the onset ice saturation and the exponential factor a, that mainly determines the formation rate of ice particles with increasing S_i, depend on temperature and the type of the dust aerosol. Further experiments and process modelling studies are needed to assess the influence of temperature and particle properties on the respective ice activation spectra.