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A global climatology of ice nucleating particles derived from model simulations with EMAC-MADE3

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Atmospheric aerosols can act as ice nucleating particles (INPs) and thereby influence the formation and the microphysical properties of cirrus clouds, resulting in distinct climate modifications. From laboratory experiments several types of aerosol particles have been identified as effective INPs at cirrus conditions. However, the understanding of the global atmospheric distribution of INPs in the cirrus regime is still highly uncertain as in situ observations are scarce and limited in space and time.

We perform global model simulations with the ECHAM/MESSy Atmospheric Chemistry (EMAC) general circulation model including the aerosol microphysics submodel MADE3 (Modal Aerosol Dynamics model for Europe, adapted for global applications, third generation) coupled to a two-moment cloud microphysical scheme and a parametrization of aerosol-induced ice formation in cirrus clouds. We present a global climatology of INPs in the cirrus regime, that includes, besides mineral dust and soot, also crystalline ammonium sulfate and glassy organics as INPs at cirrus conditions. The model representation of ammonium sulfate and organic ice nucleating particles includes a formulation of the particle phase state, as recent laboratory measurements suggest that only crystalline ammonium sulfate and glassy organics initiate ice nucleation.

After implementing the different INP types into the microphysical cirrus cloud scheme, their ice nucleation potential at cirrus conditions is analysed, considering the possible competition mechanisms between different INPs. The simulated INP concentrations in the range of about 1 to 100 L^{-1} agree well with in situ observations and other global model studies. Our model results suggest that glassy organic particles probably have only minor influences, as ambient conditions often inhibit the glassy phase. On the other hand, crystalline ammonium sulfate often shows large INP concentrations, has the potential to influence ice nucleation, and should therefore be taken into account in future model applications.