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Compositional studies of mineral dust ice nuclei at the AIDA chamber

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It is known that aerosols affect climate indirectly via their interaction with clouds. Aerosols can thus significantly influence the life cycle of clouds. For example, a change in aerosols can shift the formation of ice clouds to lower water supersaturations and warmer temperatures. The influence of aerosols on the formation of ice clouds is a complex phenomenon. It can proceed via different pathways commonly termed deposition, condensation, immersion and contact nucleation. Each depends on the humidity, temperature and the physico-chemical properties of the aerosol particles. The knowledge of these processes is necessary to better describe and evaluate the effect of cirrus and mixed-phase clouds on climate.

It is well known that particle size plays an important role, and that mineral- and metal-containing dusts are major contributors to the formation of ice crystals in the atmosphere. The role of the chemical composition and the particle size of mineral dusts found in the atmosphere in ice nucleation has not been extensively investigated. Experimental laboratory studies were conducted in November 2005 and September 2007 at the AIDA chamber at the National German Research Center in Karlsruhe in Germany to investigate these issues. The AIDA chamber consists of a large vessel in which the formation of an ice cloud can be simulated. An adiabatic expansion in the chamber cools the air, induces water vapour supersaturation with respect to ice, and therefore induces the formation of ice crystals. A typical experiment consists of injecting a known test aerosol and inducing ice crystals during the expansion. The properties of the aerosols, resulting ice crystals and ice nuclei are monitored over the course of the experiment by a wealth of instruments sensitive to the particle size, concentration, composition, water phase and ice crystal shape. After inertial separation from the interstitial aerosol, ice particles are sampled and melted. The resulting residue consists of the ice nuclei plus scavenged material. The residue is then sized and chemically analyzed on a single particle basis with the Particle Analysis by Laser Mass Spectrometry instrument (PALMS). In these studies, mineral dusts such as illite and hematite, Israel dust, Arizona test dust, Sahara dust and Canary island dust were investigated.

It was found that iron oxides, such as hematite, were much better ice nuclei than clays, such as illite. Calcium species were found to play a role in the ice nucleation ability of Israel and Sahara dusts. It was also found that bare mineral particles acted as more efficient ice initiators than the same particles coated with sulfates or nitrates.