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Laboratory studies with cloud-derived Bacterial Cells acting as Ice Nuclei in the Immersion and Deposition Mode

C. Oehm (1,2), C. Chou (3), P. Amato (4), E. Attard (4), A.-M. Delort (4), C. Morris (5), A. Kiselev (1), O. Stetzer (3), O. Möhler (1), T. Leisner (1,2)

(1) Institute for Meteorology and Climate Research, Atmospheric Aerosol Research (IMK-AAF), Karlsruhe Institute of Technology, Germany, (2) Institute for Environmental Physics (IUP), Ruprecht-Karls-Universität Heidelberg, Germany, (3) Institute for Atmospheric and Climate Science, ETH Zurich Switzerland, (4) Institut de Chimie de Clermont-Ferrand (ICCF), CNRS - Clermont Université, France, (5) Plant Pathology Research Unit, INRA-Avignon Research Center, France

Atmospheric aerosol particles play an important role in cloud microphysics. Aerosols of biological origin are a subgroup, and some of them are able to act as heterogeneous ice nuclei and thus influence cloud life cycles and the climate. Some bacteria species have been found to act as ice nuclei at relatively high temperatures up to -2 degree Celsius and are therefore of particular importance as "high temperature" ice nuclei.

Recently, ice nucleation experiments with bacterial cells from different sources were performed at the aerosol and cloud simulation chamber AIDA at the Karlsruhe Institute of Technology. At the AIDA facility, microphysical cloud processes can be simulated and investigated in laboratory at realistic atmospheric cloud conditions.

Different ice nucleation active (INA) bacteria strains were isolated from cloud water, glacier melt water and phyllosphere and examined in AIDA experiments. The living cells were suspended in nanopure or artificial cloud water and injected into the cloud chamber through a dispersion nozzle. The injected droplets evaporated in the chamber and the bacterial cells were transformed into the aerosol phase. After the spraying, the cloud formation was started by expansion cooling.

Experiments were performed in the temperature range from -2 down to -20 degree Celsius. Detailed measurements of the number concentration and size distribution of the aerosol particles as well as of the droplets and ice particles were carried out during the AIDA experiments. A minor fraction of the bacteria cells was observed to act as ice nuclei in the immersion nucleation mode at higher temperatures as well as in the deposition nucleation mode at lower temperatures. The ice activity started at -6 degree Celsius. The most efficient INA bacteria species were Pseudomonas syringae 32b74 and Pseudomonas fluorescens Antarctica1. The ice active number fraction with respect to the cells varied from 0,01 to 0,1, and it does not change at different temperatures. Aging of the bacteria cells in the AIDA chamber didn't have an effect on the activated fraction.

Ice nucleation measurements of size-selected particles were achieved by combining an extended differential mobility analyser (DMA) from the IfT in Leibzig with the PINC (Portable Ice Nucleation Chamber) from the ETH in Zurich. With this setup, it was possible to distinguish the ice active fraction of both the smaller residual particles and the intact cells. Additionally, their efficiency as cloud condensation nuclei (CCN) was measured with a cloud condensation nuclei counter (CCNC) from Droplet Measurement Technologies. The cells are slightly better ice nuclei than the residuals, and their activated fractions don't vary with temperature. The bacteria cells and the residuals act as CCN, whereas the hygroscopicity of the residuals is higher than the hygroscopicity of the cells.

We present first results from the ice nucleation experiments at the AIDA cloud chamber including results from the PINC and CCNC instruments.