The Lille Ice Nucleation Chamber (LINC). Progress toward the definition of an experimental protocol and results of early measurements.

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Aircraft jet engines release in the high troposphere soot aerosols that potentially act as condensation nuclei for either water or ice. The nucleated ice particles and water droplets that form the so called condensation trails (*contrails*) may evolve in persistent cirrus–like clouds when the conditions are favorable, and therefore impact the local albedo hence the radiative balance of the atmosphere especially in high density air traffic regions. Within this project we developed a dedicated facility, the *Lille ice nucleation chamber* (LINC), for a better understanding of the indirect role of soot aerosols on persistent cloud formation.

The LINC is a continuous flow diffusion chamber based on the system first developed at the Colorado State University (CSU-CFDC)[1] which then evolved in the *Zurich ice nucleation chamber* (ZINC) built at the Swiss Federal Institute of Technology[2]. The LINC was developed as a tool to obtain information on the dynamic of heterogeneous ice nucleation in deposition mode and in condensation freezing mode with soot particles as ice nuclei. Indeed, we believe that the heterogeneous nucleation of ice particles in the troposphere can be reproduced in laboratory conditions once the physical and chemical properties of the seeding aerosols are well characterized. Hence, some critical properties of nucleated ice like the particle size distribution and the complex refractive index can be related to those of the seeding aerosols.

The main goal of this work is to validate the experimental protocol to operate the LINC and eventually nucleate ice particles under controlled and reproducible conditions. Since the measurements on the efficiency of soot particles as ice nuclei are still subject to large uncertainties, it is our opinion that any experiment aiming to reproduce ice nucleation at laboratory scale should detail the experimental conditions as thoroughly as possible. In this work, we take a step in this direction and we present a first complete characterization of the onset of conditions in which ice particles are nucleated inside the LINC chamber. Such characterization is especially important whenever any comparison of the data obtained in different ice nucleation chambers is to be made. Since the methodology behind the operation of ice nucleation chambers is not yet fully validated, this approach will help in creating a common measurement protocol, possibly at international level. The investigated variables include the ice layer thickness, the iced walls temperature map, the reactor flow conditions and a detailed characterization of the seeding aerosols for instance.

At this stage of the project, particular attention is devoted to aircraft engine exhausts. Soot aerosols are generated in laboratory flames and have morphology close to that of aeronautics soot[3]. In a typical experiment, soot aerosols are sampled by means of a quartz microprobe, diluted with a cold, inert gas to prevent post-sampling coagulation, size selected, dried and finally injected into the LINC main nucleation chamber at controlled temperature, pressure and ice supersaturation. The seeding aerosols are injected from the top inlet of the nucleation chamber, while ice particles are detected by optical counting at the bottom outlet after a permanence time in the supersaturated region of about 10 s. Temperature as low as –50°C and ice supersaturation as high as 140% can be reached. A short timescale, up to 10 s, is chosen in order to simulate the early steps of the formation of contrails. The onset of thermodynamic conditions at which heterogeneous nucleation occurs and the nucleation rates are then investigated as a function of the size distribution, morphology and surface chemical composition of the seeding soot aerosol.

The experimental data are expected to provide useful information on the heterogeneous ice nucleation mechanisms, and to help validating theoretical models representative of the ice formation dynamic in the high troposphere. The comparison of the data obtained from different measurements is expected to provide original and useful information on the interaction between soot aerosols and water.

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[1] D.C. Rogers, *Atmos. Res.* **22** (1988) 149-181.
[2] O. Stetzer, B. Baschek, F. Lüönd, U. Lohmann, *Aerosol Sci. Technol.* **42** (2008) 64-74.
[3] C. Irimiea, Y. Carpentier, I.K. Ortega, M. Ziskind, A. Faccinetto, F.X. Ouf, F. Salm, D. Delhaye, D. Gaffié, A. Bescond, J. Yon, E. Therssen, C. Focsa, *Proceedings of the European Combustion Meeting 2015*, P5-04.