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Dust in the Upper Stratosphere Tracking Experiment and Retrieval: Exploring the Dust Reservoir of the Upper Stratosphere through Balloons

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Dust in the Upper Stratosphere Tracking Experiment and Retrieval (DUSTER) aims to collect and characterize uncontaminated particles (<30µm) from the Earth stratosphere (30–40km). The upper stratosphere is populated by both terrestrial and extraterrestrial particles. However, it is richer in the extraterrestrial ones compared to lower altitudes [1]. The stratosphere is a reservoir for Interplanetary Dust Particles (IDPs) [2]: a selection effect would facilitate fragile materials that could not reach the ground [3].

In addition to DUSTER, only a few other attempts have been made for the collection of particles through balloons at altitude >30km [4,5]. The innovations brought by DUSTER include: (i) does not require sample manipulation after collection; (ii) guarantees low impact velocities between particles and the collector's substrate; and (iii) a key factor, adopts a strict control protocol for the minimization of contamination [3,6]. On the collector (a holder with 13 TEM grids), directly exposed to the airflow, the particles remain stuck without the use of adhesive materials (dry collection). High-resolution images of the collector and the blank (similar to the collector but not exposed to the airflow) are acquired before and after the flight, to exclude from the count pre-existing particles [6,7].

Five DUSTER launch campaigns successfully collected stratospheric particles. The most recent ones took place at the ESRANGE, Kiruna (Sweden), in 2019 and 2021. DUSTER sampled the stratosphere at an altitude of ~33km for ~5 hours over Lapland, and its collector and blank are currently under analysis. Up to now, the identified particles range from 0.1 to 150µm (latest data to be published). Morphologically, they can be classified as mineral fragments and aggregates, spherules, fungal spores [10], and a type-I cosmic spherule. EDX analyses have shown the occurrence of minerals like plagioclase, silica, fassaite, but also carbonates, CaO – all mineralogic phases present in CI and CM carbonaceous chondrites, unequilibrated ordinary chondrites, and comets [8]. The occurrence of CaO and carbon nanoparticles has been suggested to be a result of condensation after disaggregation of carbonates of extraterrestrial origin [11].

The ambitious goal of DUSTER is to become a reference collection for uncontaminated extraterrestrial particles available for scientific research – a unique and barely explored reservoir complementary to (micro)meteorites and IDPs available at the Earth's surface.

In general, the properties of solid and condensed dust in the upper stratosphere remain poorly known. Complete morphological and chemical characterization of particles collected at altitudes >30 km remains incidental with few exceptions, DUSTER will provide a record of the amount of solid aerosols, their size, shapes and chemical properties in the upper stratosphere, including particles less than 3 microns in size.

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