IN-CLOUD MEASUREMENTS OF DROP DYNAMICS

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Abstract We here present the results of a measurement campaign at the Umweltforschungsstation Schneefernerhaus (UFS) research station at an elevation of 2650 m, on the mountain top of Zugspitze, Germany. We measured the three-dimensional motion of the water droplets inside a turbulent cloud using three high-speed stationary cameras. We show the statistics of droplet acceleration and velocities, and their dependence on the flow parameters.

INTRODUCTION

Interaction between turbulence and inertial particles has long been a very active area of research as many natural and technological processes involve dispersed additives carried by turbulent flows (see e.g. the collection of papers in [1, 8]). Warm clouds in the atmosphere, which consist of water droplets suspended in turbulent air, are beautiful examples. A good understanding of the cloud-droplet interaction is, among other applications, a key requirement for developing more accurate models describing cloud droplet growth and the onset of rain, since these phenomena are highly sensitive to the distribution of relative velocities between droplets, which are strongly influenced by turbulence [7, 2]. These models, in turn, could lead to better short-term forecast on the one hand, and a better understanding of the long-term effects of the changing environmental factors (temperature, humidity, atmospheric particulates) on the global and local climate.

Cloud dynamics cover a very broad range of scales, ranging from the Kolmogorov scale, which is usually on the order of millimeter, up to the largest cloud structures that are hundreds of meters long. At present, it remains very challenging for direct numerical simulations [3, 9] or laboratory experiments [10, 11] to mimic the real in-cloud conditions despite recent progresses. It is therefore crucial to perform in-situ measurements of real clouds in order to gauge the accuracy of the current numerical and theoretical models and to guide their future development.

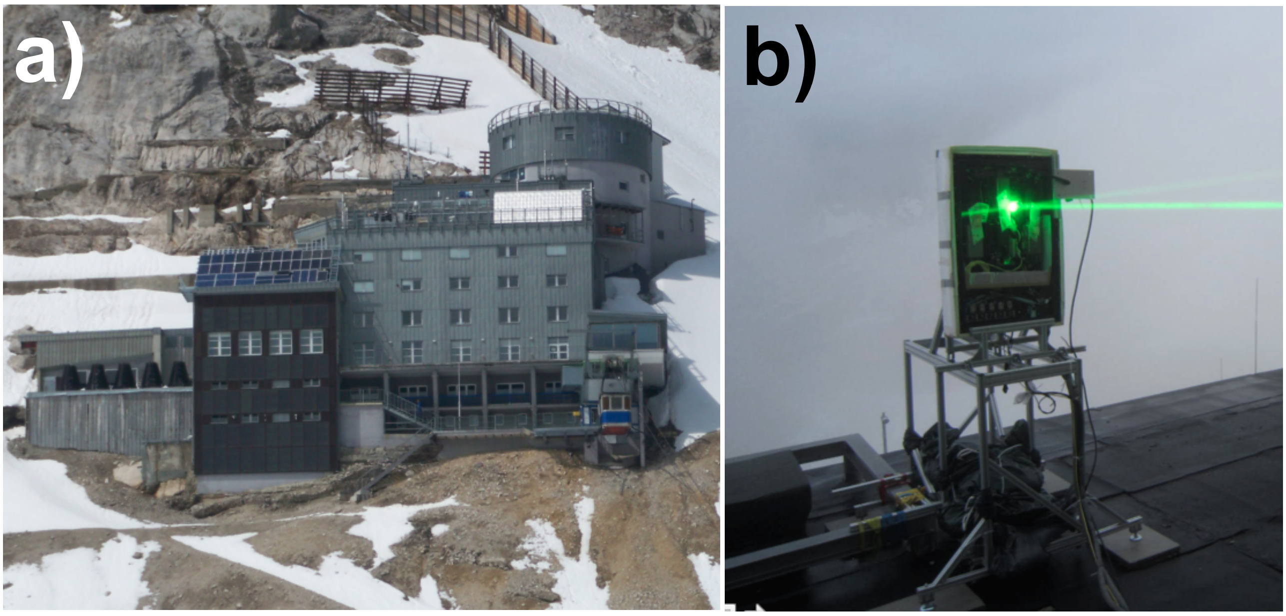

Figure 1. **a)**: The environmental research station Umweltforschungsstation Schneefernerhaus, where the data were collected. **b)**: The experimental setup - laser beam illuminates water droplets inside the passing cloud, their motion is recorded by three stationary high-speed cameras inside the box.

EXPERIMENTAL SETUP

We here present experimental data collected over a two-week measurement campaign in August 2010 at the Environmental Research Station Umweltforschungsstation Schneefernerhaus (see Fig. 1a), located at an elevation of 2650 m, on the

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mountain top of Zugspitze, the highest mountain in Germany. UFS is frequently covered in clouds, especially during the summer months [6]. The wind direction at UFS is prevailingly in the west-east direction along the mountain, which facilitates the experimental setup as the instrument, shown in Fig. 1b, can be installed in the fixed direction that aligns with the wind direction. During the measurement, the water droplets were illuminated with a laser beam from a frequency doubled Nd:YAG laser. The motion of the water droplets was recorded by three high-speed cameras Phantom V7.0 (Vision Research Inc.) at 10,000 fps and 512x512 pixel resolution housed in a weather resistant transparent box (see Fig.1b). After post-processing, images from the three cameras are combined to yield the three-dimensional droplet positions, which are then further connected to form the three-dimensional trajectories of the droplets [5, 12]. Droplet velocities and accelerations are then obtained by repeated differentiation [12, 4].

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