P2.02

How rain forms: an in situ experiment

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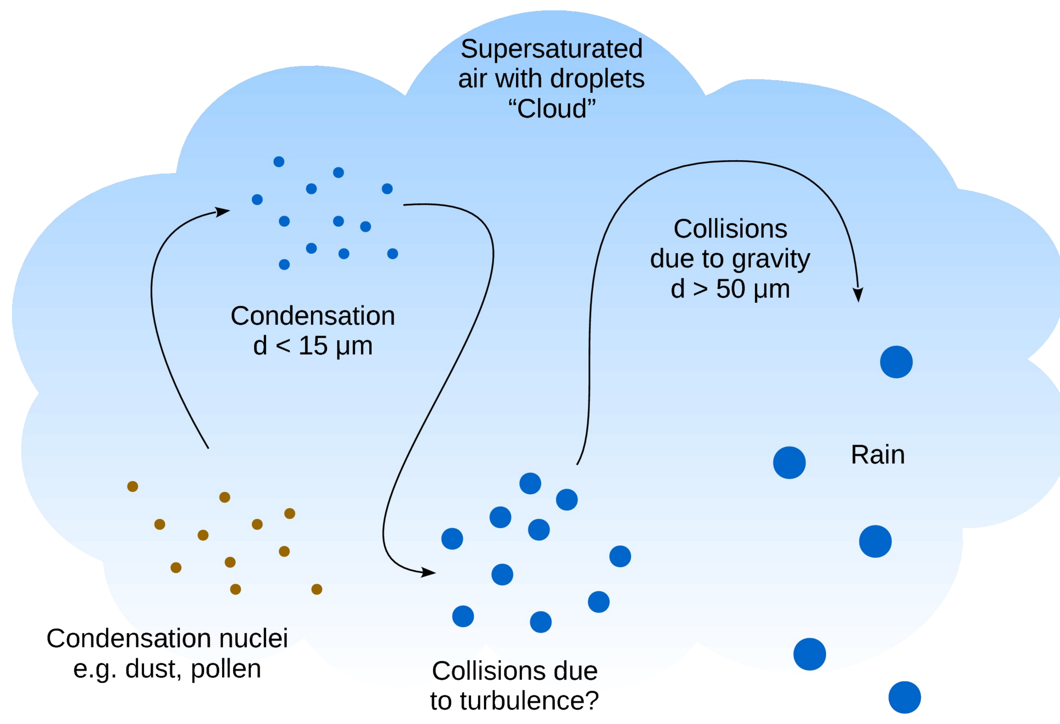
Introduction

Clouds play an important role in the weather and in climate systems. Not only do they cause precipitation, they also block sunlight from reaching the Earth's surface, and thereby greatly affect the climate's energy balance. However, they are not well understood. To illustrate this, consider that a process as ubiquitous as rain formation cannot be described based on first principles.

Rain formation

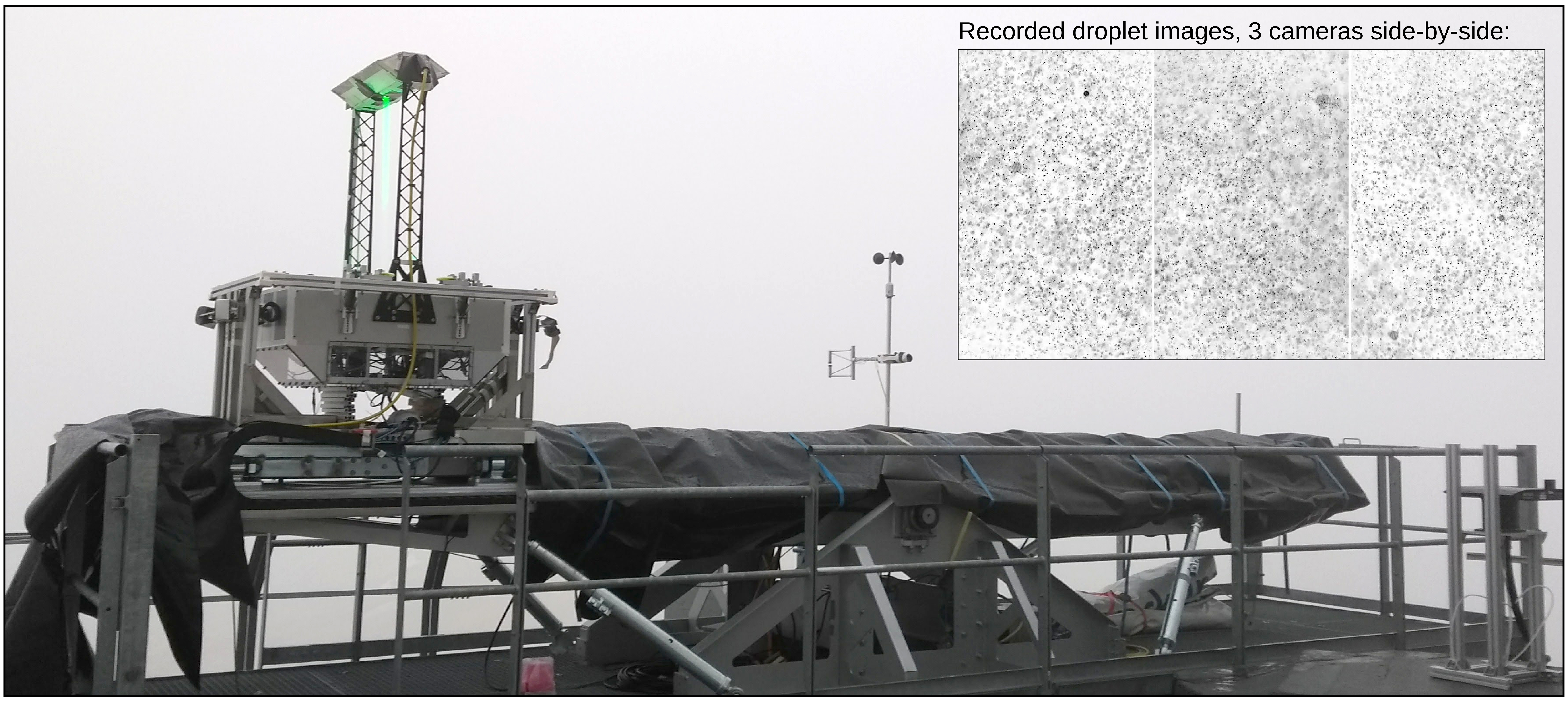
In order to form rain, small cloud droplets must grow to at least 50 um, at which point they are large enough to start falling. Condensation, which initially forms small cloud droplets, is only effective up to about 15 um, so turbulence must be responsible for bridging the gap between 15 and 50 um. Exactly how turbulence does this, is not known, but several theories exist [1]. Two popular ones are prefential concentration [2], and the sling effect [3].



Experiment

Here we present an experiment that allows us to do in situ measurements of cloud droplets dynamics. In particular we are able to track individual cloud droplets in 3D, which allows us to compute several statistics such as droplet acceleration and clustering. The experiment is currently being developed, and first results are expected this year.

The experimental setup is shown in the image below. At the heart of the setup is a box with three fast cameras, that all look at the same (3 cm)³ volume from below. The cameras record images at 10 kHz. The volume is illuminated using a 150 W laser, that comes in from the top so that we observe forward-scattering. In order to keep droplets in view for longer periods of time the camerabox is mounted on a 6.5 m long rail system, that allows it to move with the mean wind speed.

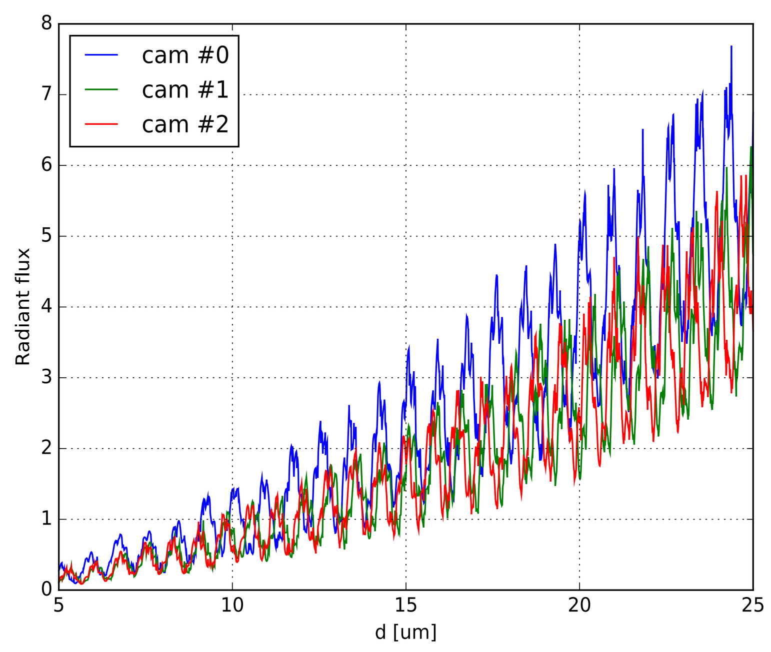


Recorded droplet images, 3 cameras side-by-side:

Outlook

The aim of the experiment is to see how turbulence affects droplet collision and coalescence. We are soon able to obtain droplet tracks, and will then advance to computing several statistics related to e.g. droplet clustering.

The dynamic properties of droplets depend heavily on their size, but the experimental setup is currently not able to measure droplet sizes. Due to the short coherence length of our laser, we cannot use experimental techniques that rely on interference, such as IPI or GPD. Instead we want to make use of the recorded droplet intensities and post-process our data using an algorithm that inverts the Mie-scattering.



References

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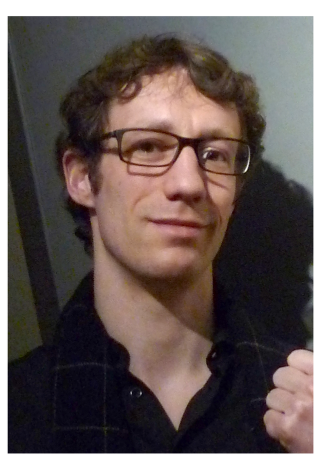
Acknowledgements

This project has received funding from the European Union Horizon 2020 Research and Innovation Programme under the Marie Sklodowska-Curie Actions, Grant Agreement No. 675675.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