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Cloudkite: an airborne platform for resolving clouds

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The earth's atmosphere is largely covered with clouds, which significantly influence incoming and outgoing radiations, and hence, the earth's energy balance. Clouds are sources of a substantial uncertainty in both weather and climate models. They span a wide range of scales from sub-millimetre, where cloud microphysics are important, up to hundreds of kilometres, where they affect weather and climate. It is the complex coupling of cloud and turbulent fluid dynamics across those scales that makes understating of clouds challenging. Furthermore, various long-standing important riddles, such as existence and/or ubiquity of cloud holes (regions free of droplets) and sharpness of cloud boundaries, are yet to be answered. Given the high values of Reynolds numbers encountered in atmospheric clouds (Re$\sim 10^6$-10^9), laboratory-produced flows (with a few exceptions) and direct numerical simulations are not yet capable of reaching flow dynamics similar to clouds. As a result, field investigations and, in particular, airborne measurements carried out far away from earth's topographical effects can approach the correct region of parameter space relevant to naturally occurring clouds.

We are planning to carry out airborne measurements based on a novel multi-technique approaches in order to resolve cloud microphysics and cloud-turbulence interactions at an unprecedented level of accuracy. Our airborne platform, called Cloudkite, is a tethered 250m3 helium-filled balloon-kite combination aerostat (i.e. Helikite: 15m long, 10m wide/high) carrying a scientific payload designed for simultaneous measurements of cloud-microphysics and cloud-turbulence. Cloudkite is a self-contained platform capable of sampling the atmospheric boundary layer and low-level clouds within 0.5-1 km above launching altitudes (i.e. from sea-level up to 4000m above sea-level) in any location on the globe. The scientific payload includes instruments to detect cloud particle size, shape, and three-dimensional spatial distributions, and the atmospheric state (velocity, temperature, and humidity). On-board instruments are Particle Image/Tracking Velocimetry (PIV/PTV), inline holographic particle imaging, Fast Cloud Droplet Probe (FCDP), Laser Doppler Velocimetry unit, hot-/cold- wires, standard, multi-hole Pitot tubes, and humidity, temperature and pressure sensors. The main improvements of Cloudkite with respect to existing airborne platforms are i) total or partial overlapping of measurement volume of most instruments, which provide a unique picture of cloud microphysics and turbulence at a given sampling instance and ii) significantly faster sampling of cloud microphysics and turbulence (e.g. sampling rates of 1.6L/s and 1.7L/s for PIV/PTV and holographic instruments, respectively), which provides the possibility of answering old riddles of cloud-holes and cloud-boundary-sharpness. As a whole, results will improve our understanding of cloud evolution and spatial structure and, thus, potentially lead to better weather forecasts and global climate predictions. Furthermore, outcomes are also applicable to numerous fields of engineering and science dealing with particle-turbulence interactions.