Electronic design of innovative mini ultralight radioprobes aimed at tracking lagrangian turbulence fluctuations within warm clouds

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Clouds are a natural challenging element of Earth that play active role in climate change and climate sensitivity; and their evolution involves multi dynamical, radiative, and microphysical process on a vast range of temporal and spatial scales.

Turbulence plays an important role in the development and dynamics of clouds, spanning from the microphysics level (fraction of millimetres) to the weather and global climate scale (tens of kilometers) since, it leads entrainment, stirring and mixing processes. Specifically, at the smallest scales, turbulence affects the cloud's efficiency to produce rain since it enormously favours the motion and growth of rain droplets through collisions and coalescence, thus reducing significatively the time required for warm rain initiation. Nevertheless, turbulence mechanisms associated to particle dynamics are not yet fully understood partly due to the complexity in measuring clouds at such scales and the poor/lack of explicit representation of turbulence processes in general circulation models hence leaving open questions in atmospheric physics.

In an attempt to address these knowledge gaps, this work presents a novel in-situ experimental method for measuring the influence of small-scale turbulence in cloud formation and producing an in-field cloud Lagrangian dataset by means of an innovative ultra-light and expendable radioprobe. With a maximum target weight of 20 grams and a diameter of 30 cm, this radioprobe is designed to passively track small-scale turbulence fluctuations, such as air velocity, water vapor, pressure, and temperature inside warm clouds and neighboring ambient air according to the Lagrangian description.

This research work focuses on the electronic design of the complete radioprobe system (ultra-light radioprobes and ground stations) and presents the most significant results derived from laboratory and field experiments. The fully customized radioprobe board featuring small dimensions (5 cm x 5 cm), embeds a set of compact size microprocessors, controllers, and sensors aimed to measure local inner cloud fluctuations in acceleration, trajectory, pressure, humidity, and temperature. For the duration of the flight, it acquires, partially processes, stores, organizes, and transmits in nearly real time the collected information to various ground stations spatially distributed on land. Due to the radioprobes' physical constrains and the environmental conditions that can be found inside warm clouds, the communication between the flying instrumented balloons and the ground stations is achieved thanks to the use of a dedicated long-range and power-saving wireless communication link. At the ground level, the ground

stations are designed to capture, store, manage, process, and display the data coming from the floating devices.

The tests performed to validate the system design, both in the lab and in open air, confirm that the newly developed radioprobes together with the ground stations perform well, providing accurate information about small scale atmospheric turbulence variables, referenced in space. The combination of multiple mini radioprobes will consent systematic and accurate observations into small scale turbulence fluctuations inside warm clouds specifically over land and alpine environments. These unique in situ measurements are essential to enhance the current understanding of turbulence-related microphysical processes in warm clouds thus, improving actual studies of cloud formation.