Development and testing of innovative, mini, biodegradable radiosondes to track small-scale fluctuations in warm cloud and clear air environments

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Modelling clouds has been a challenge for decades as they depend on a variety of chemical and physical processes ranging from the nanometre scale, where nucleation, coalescence and rain formation take place, to airflow dynamics which can range up to kilometres. Specifically, turbulence plays an important role in the behaviour of these processes and can be noted on different scales. However, how turbulence influences processes on small scales is difficult to model and reproduce in laboratory experiments mostly due to a lack of in-situ measurements of small-scale fluctuations in velocity, temperature, pressure, humidity, etc. [1]. It is this gap that the innovative, ultralight radiosondes presented here are aimed at addressing [2]. They are designed to passively track fluctuations of temperature, humidity, pressure and velocity for several hours on isopycnic surfaces in cloud and clear air environments at altitudes between 1-3 km.

To float on an isopycnic surface, the density of the sonde must match the density of air at the desired altitude of flight. Hence, by the Archimedes principle, the volume of the spherical sonde with a target weight of 20 g can be calculated at various altitudes [3]. To equalize the buoyancy force to the weight of the system, the balloon is filled with a mixture of helium gas and air. The spectral and statistical data obtained will be sent to receivers on Earth via transmitters that will transmit per the LoRa wireless protocol, the advantages of which are low power properties across longer distances [4]. Each radiosonde will be equipped with a specific set of solid state sensors to measure a chosen type of data, be it humidity and temperature, acceleration, temperature and pressure, and, for more specialised versions of the balloons, a difference optical absorber spectroscope to obtain a particle count. In this way, a more Lagrangian set of data can be obtained, which is a key ingredient for the development of stochastic models for turbulent formation in processes such as cloud formation [5]. Furthermore, to minimise their environmental impact, the design of the disposable balloons is made with biodegradable materials tailored to have specific properties, such as hydrophobicity and flexibility. The development and specialisation of these materials is presented along with the first tests of the radiosonde in climate chambers where fluctuations in temperature, pressure and wind velocity can be manually applied.

These hydrophobic, lightweight balloons will fill in the existing gap between transoceanic NOAA smart balloons [6] and high resolution research aircrafts, as the CIRPAS Twin Otter [7], with the aim of providing an insight into the unsteady life cycle of warm clouds over land, ocean and alpine environments. These explorative observations are essential for the contribution and development of the current understanding of microphysical processes in and around clouds to ultimately improve weather prediction and climate models.

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