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Disposable radiosondes for tracking Lagrangian fluctuations inside warm clouds

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Clouds remain a weak link in modelling atmospheric circulation as they depend on chemical, physical and dynamical processes ranging from small scale of the collisions of micron-sized droplets to atmospheric mesoscale motions. The uncertainty in climate modelling due to the ambiguities related to cloud representation, justifies the need for more explorative observations. Specifically, there is still a not through knowledge on the in-cloud turbulence and the consequences of spatial distribution of turbulence on humidity, mixing and temperature transport in clouds [1,2]. These are limited by the crucial description of cloud droplet nucleation and growth. In addition, turbulence experimentation relies on the estimate of statistical moments through averaging. However, this is particularly difficult in cloud environments where boundary conditions are continuously evolving. Therefore, an innovative way of tracking Lagrangian fluctuations inside warm clouds over land and alpine environments has been proposed as part of the Horizon 2020 Innovative Training Network Cloud-MicroPhysics-Turbulence-Telemetry (ITN-COMPLETE) project [3]. Part of the project aims to conceive, design, prototype and test a new kind of processor embedded, ultralight radio probes capable of floating in stratocumuli cloud altitude.

In this abstract, we present a preliminary design of expendable, low cost and light mini radio-sondes based on the use of solid state sensors for the measurement of different physical quantities such as velocity, acceleration, vorticity, pressure, temperature and humidity fluctuations. They are initially designed to float on an isopycnic level within clouds requiring them to be 20 times lighter than the NCAR drop-sondes and 100 times lighter than the NOAA smart balloons [4]. A feasibility study has been carried out using an in-house state of the art mini electronic board designed for remote sensing applications in an environmental context, shown in the figure below.

The total target weight of the probes is around 20 g or 30 g depending on the sensors included. This proceeds from preliminary work where it was determined that without weight optimisation, the mini board weighs 6.2 g (11.5 g if an omni-directional coarse antenna is included) and is smaller than 4x4 cm, see for example [5, 6]. The hydrophobic balloon must contain a supply unit, a low consumption microcontroller and, as mentioned, a configurable set of solid state sensors.

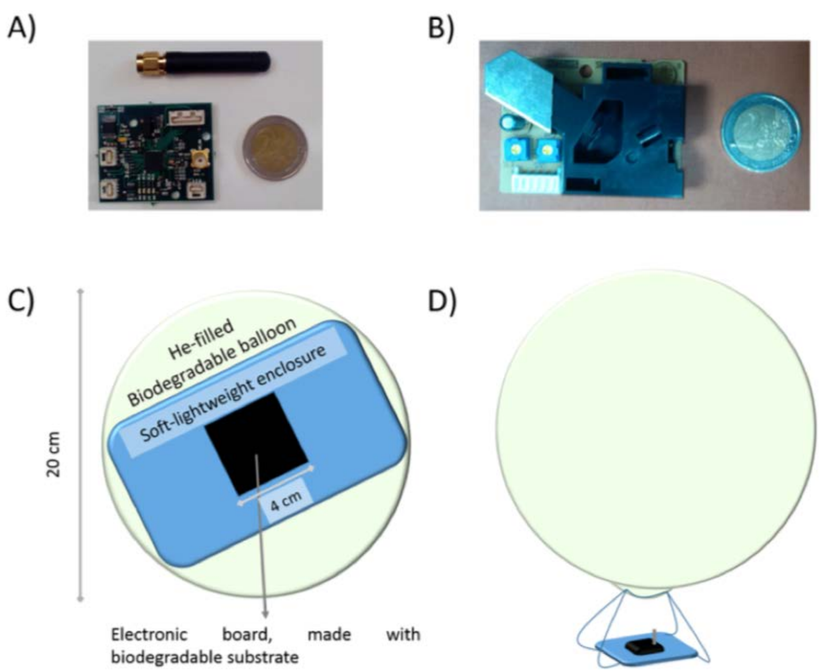

Figure 1 A) Early prototype electronic board. B) Example of the OPC (Rorato et al. Wireless Sensor Network 2013). Possible probe designs: C) ultra-lightweight model in which the electronics are comfortably placed into the He-inflated balloon and D) advanced radiosonde where the electronics hang from the balloon.

The balloon is filled with helium gas to obtain a buoyancy force equal to the weight of the system and the pressure is equal to the atmospheric pressure corresponding to the altitude at which the balloon will be released (giving a radius of roughly 12 cm at an approximate altitude of 1000 m). For the first prototype, the Printed Circuit Board (PCB) of both arrangements will be realised with a 0.3 mm thick FR4 material. However, as the probes will be disposable, they are required to be biodegradable to minimise their environmental impact. Hence, it is foreseen to use MaterBi and a biodegradable bioelastomer substrate for the electronics. Furthermore, the autonomy of the probes roughly ranges from few hours in the advanced configuration to about one day in the minimal one. The radio signals from the mini radiosondes have a frequency of about 350 MHz or 169 MHz to assure a good propagation link in the atmosphere.

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