Innovative, green, floating, radiosondes to track small-scale fluctuations along isopycnic surfaces in and around warm clouds

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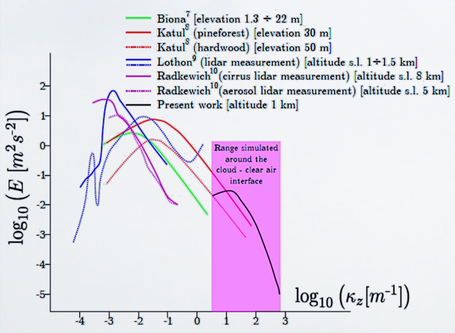
Aim

- ITN **Cl**O**u**d -**M**icro**P**hysics-turbu**LE**nce-**TE**lemetry (COMPLETE) network [1]

Field experiments + Laboratory and numerical simulations + Advanced fast temperature probes + Velocity MEMS + **Innovative atmospheric mini radiosondes**

- Probes float on an isopycnic surface in and around the cloud boundary to track small-scale fluctuations in properties such as velocity, acceleration, vorticity, temperature, pressure and humidity for several hours.
- Advanced statistical and spectral data will be used to improve prevailing numerical simulations and models (pink box below) [2-7].

Why study clouds?



- **Uncertainty in weather prediction and climate modelling.**
- **Consequences of turbulence and its spatial distribution on cloud properties unknown [8].**
- **Graph shows scarcity of high frequency measurements and simulations.**

Current measurement techniques and limitations:
- NOAA and NCAR smart balloons: heavy and large.
- High-performance satellites: measure above 16-18 km [7].
- Dropsondes: limited lifetime.

Design Principles

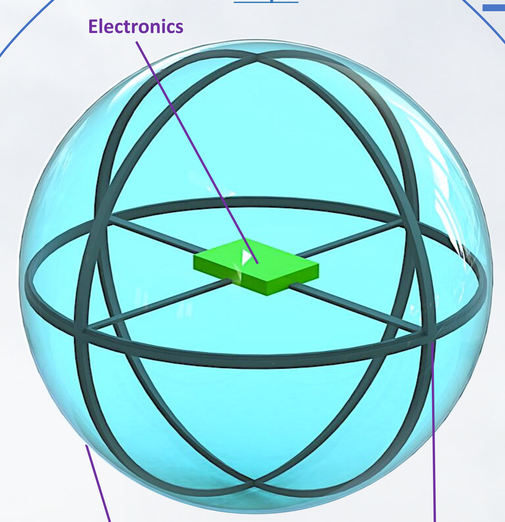
Must Be
- **Lightweight (20g)**
- **Hydrophobic**
- **Impermeable to gas and water**
- **Low cost**
- **Biodegradable**

Must contain:
- **Omnidirectional antenna**
- **Battery**
- **Low consumption microcontroller**
- **Flash memory**
- **Configurable set of sensors**

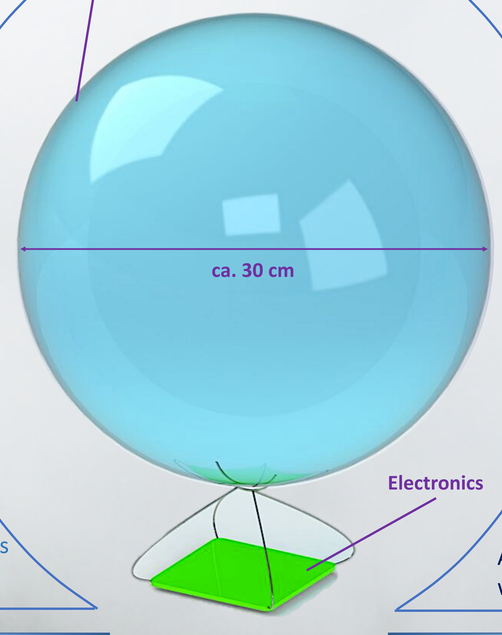
Two main configurations (shown in center):

1. **Simple:** electronics inside the balloon to measure acceleration, position, and temperature.
2. **Complex:** electronics outside balloon to measure liquid water content, pressure and in some cases particles (with an optical particle counter).

1. Simple



2. Complex



Starting with metallized balloons

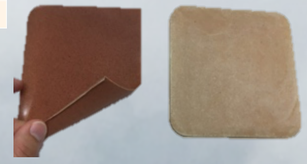
- Based on Mylar balloons
- Properties
  - **Metallized BO-PET**
  - **Good gas and water barrier properties**
  - **Inexpensive and light**
  - **Resistant to tear and wear**
- Understanding the balloon making process
- Testing for:
  - **Helium permeability**
  - **Attenuation**
  - **Mechanical strength**
  - **Hydrophobicity**
  - **Thermal stability**

Improving on metallized balloons

Material	Attenuation introduced by the material [dB]		
	370 MHz	868 MHz	2.49 GHz
Mylar Balloon	6	6	12
BO-PET	1	1	7
PET with Al	9	10	19
PET with Stainless steel (thick)	2	7	15
PET with Stainless steel (thin)	1	1	13

- An attenuation of 6-10 dB can reduce communication by a few km depending on working frequency.
- Metals are hydrophilic.

- Replace components with biodegradable materials.
- Red beetroot (left) and red beetroot with starch (right) bio-elastomers [9].



Future developments

The first prototype will be calibrated at the National Institute of Metrological Research (INRIM)

Measurement campaign on UFS where probes are released by manned and unmanned aerial vehicles

After the first measurement campaign, optimization of the sensors as well as the materials will be undertaken.

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This project has received funding from the Marie - Sklodowska Curie Actions (MSCA) under the European Union's Horizon 2020 research and innovation programme (grant agreement n°675675).