

Development of ultra-light radio probes for atmospheric monitoring inside clouds Miryam Elizabeth Paredes Quintanilla Supervisor: Prof. Flavio Canavero

### **Research context and motivation**

- Representation of clouds remains a latent ambiguity for weather forecasting and climate models since their characteristics depends on multidisciplinary processes in a wide range of natural scales, from the collision of micron-sized droplets and particles to the thousandof-meters scale of airflow dynamics.
- Within the Horizon 2020 Innovative Training Network Cloud-MicroPhysics-Turbulence-Telemetry (ITN-COMPLETE), the development of ultra-small light disposable radio probes for fluctuation-inside-clouds monitoring is promoted and financed. Being light-weighted (less than 20 grams), the probes will have a fluid-dynamic behavior to allow them to "float" inside warm clouds after been released by an aircraft or an Unmanned Aerial Vehicle



# **Novel contributions**

- Optimization of the first prototypes of both, the radio probes and the ground stations.
- Selection and tests of the different sensor stages of the radio probes (temperature, pressure, humidity, velocity and position estimation).
- Integration of the radio probe systems.
- Design of the first compact-size PCB radio probe prototype.







#### Adopted methodologies

- Code development and improvement
- Experimental tests and measurements in field and laboratory



















## **Future work**

Position estimation tests and optimization combining data from an Inertial Measurement

- network in an urban noisy environment, Journal of Electromagnetic Waves and Applications", Vol. 33, No.15, pp. 2022-2036, 2019.
- Bertoldo, S., Paredes, M., Carosso, Allegretti, M and Savi, P., "Empirical indoor propagation models for LoRa radio link in an office environment", 13th European Conference of Antennas and Propagation (EuCAP), Krakow (Poland), 2019, pp. 1-5.
- Bertoldo, S., Carosso, L., Marchetta, E., Paredes, M., Allegretti, "Feasibility Analysis of LoRa-based WSN using public transport", Applied System Innovation, Vol. 1, No. 4, 49, 2018.
- Bertoldo, S., Allegretti, M., Paredes, M., Carosso, L., and Savi, P., "Feasibility study of LoRa ad-hoc network in an urban noisy environment", Mediterranean Microwave Symposium, Istanbul (Turkey), 2018, pp. 357-360.
- Bertoldo, S., Paredes, M., Carosso, L., Lucianaz, C., and Allegretti, M., Canavero, F., and Perona, G., "Progress on the realization of a LoRa® based communication system for atmospheric monitoring probes", XXII Riunione Nazionale di Elettromagnetismo, Cagliari (Italy), 2018, pp. 129-132.
- Paredes, M., Bertoldo, S., Lucianaz, C., and Allegretti, M., "Ultra-light disposable radio probes for atmospheric monitoring", European Geosciences Union General Assembly 2018, Vienna (Austria), 2018, Geophysical Research Abstracts, Vol. 20.

2020

Unit and a GNSS receiver module

- Tuning of the radio probe antennas using an RF anechoic chamber
- PCB tests and optimization
- Size and weight optimization of the radio probes
- Design of the PCB board using flexible materials
- Evaluation of materials to achieve as much as possible green radiosondes
- Evaluation of soldering techniques on bioplastic surfaces

## List of attended classes

- 01SDJRS Earth climate and climate change (29/1/2018, 20)
- 01RPQIW Turbolenza atmosferica (23/02/2018, 15)
- 01SIIRV Introduction to Phased Array Antennas (26/02/2018, 12)
- 02NQUBG Radio planning (06/03/2018, 60)
- 01QEZRV Sviluppo e gestione di sistemi di acquisizione dati (19/06/2018, 25)
- 01QRPRV Satellite Navigation signal exploitation for atmospheric and environmental monitoring (21/06/2018, 15)
- External Training Activity Joint ICTP-IAEA School on LoRa Enabled Radiation and Environmental Monitoring Sensors. Trieste - Italy (23/4/2018, 88)
- External Training Activity Spring School on Cloud Dynamics and Modeling. Paris France (28/05/2018)
- External Training Activity 2nd Summer School on Microphysics and Dynamics of Clouds. Umweltforschungsstation Schneefernerhaus, Mt. Zugspitze, Germany. (09/07/2018)
- 01RISRV Public Speaking (28/2/2019, 5)
- External Training Activity 3rd COMPLETE Workshop. Warsaw Poland (04/02/2019)
- 01QORRV Writing Scientific Papers in English (6/6/2019, 15)
- 01PJHRV Cloud computing per applicazioni e-science (10/06/2019)
- External Training Activity 3rd Summer School on Small-Scale Turbulence in Clouds. Göttingen, Germany (24/6/2019)
- 01SWPRV Time Management (9/9/2019, 2)







