Using ultra-light (flying wing) for regular tropospheric profiling

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OUTLINE

1. Boundary layer gap of measurements
2. RPAS and instruments
3. Field Experience
4. Some results
1. Boundary layer gap of measurements

... filling the gap of in-situ measurement with UAV

- Boundary layer gap of measurements
  - Tropopause: 10 - 15 km
  - Boundary layer top: 1 - 2 km

1. CNRM UAVs

- Max 11 km
- Max 7.5 km
- Max 5 km
- Max 4 km
- Max 1 km

- CNRM
- METEO FRANCE
- CNRS

- 25 kg
- 2.6 kg
- 800 g

- www.safire.fr

- Sébastien Laflorencie
1. Boundary layer gap of measurements

... USE OF UAS an international perspective

Boundary Layer Late Afternoon and Sunset Turbulence (BLLAST)

http://bllast.sedoo.fr/ – Lannemezan, summer 2011; PI: M. LOTHON

Observation of boundary layer turbulence at the end of the day.

Coordinated UAS and piloted aircraft operations

Research groups in COST-ES0802 (PI: J. Reuder).
2. RPAS and instruments

RPAS Fleet at CNRM

**Ultralight RPAS**
(< 1 kg / payload ~ 300 g)

Electric motor
Endurance: 30 mn / 25 km
Altitude max: 1 km
Airspeed: 40 – 54 km/h

**Lightweight RPAS**
(< 2.6 kg / payload ~ 0.8 kg)

Electric motor
Endurance: 1.5 h / 75 km
Altitude max: 4 km
Airspeed: 50 - 90 km/h

**Mid-size RPAS**
(< 25 kg / payload ~ 5 kg)

Gas engine
Endurance: 10 h /1000 km
Altitude max: 5 km
Airspeed: 60-130 km/h

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2. RPAS and instruments

Ultra-light vector for P, T, U

Autopilot card
Paparazzi Apogee
Sensor acquisition included

Sensor conditioning
Meteostick

Humidity
Temperature

Screen

EPP cell
Multiplex Xeno
2. RPAS and instruments

Humidity calibration
In lab and fields

Calibration coefficients stored in Meteostick
Precision measurement board (ENAC Paparazzi)
T, R.H., absolute and differential P
3. Field Experience
Summary of UAS Flights at CNRM

- 10 different types of platforms (all fixed-wing)
- Weather conditions: winds up to 17 m/s, snow, ice, rain, fog; up to 3350 m.agl

700+ flights / ~250 hours (2012 – 2019)
3. Field Experience

BACC+: toward operational activities

- Long term measurements in Landes for boundary layer and fog studies => step toward operational activities
- Boundary layer evolution
- Around 100 flight at the end of 2017
- 1 operator alone

Acknowledgements: S. Defoy
3. Field Experience
Cerdanya-2017: mountain boundary layer (cold air pool)

Intercomparison: T from UAV, MWR, WindRASS, RS
3. Field Experience
Cerdanya-2017: mountain boundary layer (cold air pool)

- Flights up to 1000 m AGL (every 20 min)
- Boundary layer evolution

Morning

Evening

Temperature
Humidity

Temperature
Humidity
3. Field Experience
BURE : FOG CAMPAIGN

- 1 operator + 1 car
- 2 to 3 soundings per hour
- T and RH measurement, wind estimation during spirals ascents
3. Some results – Fog in Bure

Temperature / humidity comparison with mast

Relative Humidity [%]

Temperature [K]

=> Very good agreements UAV/tower temperature at 50m and 120m
3. Some results – Fog in Bure
Temp comparison with radiometer, tower, RS, AROME model

=> Good agreement of all systems for temperature vertical structure
3. Some results – Fog in Bure
Humidity comparison with tower, RS, AROME model

AROME model

Sensors limits close to saturation

=> Not as good as for temperature. Classical difficulties for humidity ...
SUMMARY

Advantages of CNRM ultra-lights system

→ 1 operator + 1 car
→ 2 to 3 soundings (0-1 km) per hour
→ T and RH measurement, wind estimation during spirals ascents
→ Paparazzi and EPP cell => cost effective and home-made

Needs

→ Time for operators training
→ Deal with regulation (airspace, security on the ground…)
→ Easy calibration for sensors (even during campaigns)
acknowledgements

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