Measuring carbon dioxide mole fractions in the atmosphere with RPAS

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Idea

- Paris Agreement: net anthropogenic greenhouse gas emissions to 0 by second half of 21st century
- Better tools needed to study greenhouse gas sources and sinks and improve transport modelling
- Remotely piloted aerial systems are cheap, easy to operate and flexible platforms for micro scale (<1 km) studies
- Need for small and accurate sensors (e.g. better than 5 ppm CO₂)
**COCAP**

- **Compact** carbon dioxide analyser for **airborne** platforms

- Main components: CO₂ sensor, data logger, pump/flow controller

- Other measured quantities: Ambient temperature, relative humidity and pressure

- 42x14x14 cm³, 1 kg, 8 W

- Price <10.000 €
CO2 sensor prototype based on an ethanol sensor by SenseAir AB

- Non-dispersive infrared (NDIR) sensor
- Cell volume: 50 cm³
**NDIR principle**

- Detector measures light intensity, which is influenced by absorption in the cell.
- Number of molecules in cell depends on T and p.
- Properties of filter, source and detector temperature-dependent.
Correcting the sensor output

- NDIR inherently non-linear
- Temperature and pressure correction depend on CO$_2$ concentration
- Tests in environmental chamber to establish correction formula
- Empirical model fitted to calibration data
Correcting the sensor output

![Graph showing CO₂ in µmol/mol, p in kPa, T in °C, and Signal in a.u. over time in h.]

Reference COCAP
Results of the correction have not always been so good...
New thermal management

Ambient air: 0 to 30 °C

EPP (Plastic Foam) Housing

Air inside Housing: 50 °C

Divider

LPL Sensor

Heater: >50 °C

Fan

Component block: 55.0 °C

Temperature Sensor for Fan

Heater Control: 50.00 °C

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Performance of controller

Air temperature in °C

ΔT in mK

Time in minutes

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Lannemezan

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Preliminary results

Sunrise: 5:34 UTC

Altitude above ground level in m

CO₂ dry air mole fraction in ppm

06:03 UTC

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Sunrise: 5:34 UTC
Preliminary results

Sunrise: 5:34 UTC

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Sunrise: 5:34 UTC

Temperature in °C

Temperature in °C

Altitude above ground level in m

06:03 UTC
Preliminary results

Sunrise: 5:34 UTC

Altitude above ground level in m

Temperature in °C

06:03 UTC
06:34 UTC

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Sunrise: 5:34 UTC

Altitude above ground level in m

Temperature in °C

0  10  11  12  13  14

0  50  100  150  200  250  300  350

06:03 UTC
06:34 UTC
08:17 UTC

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Next steps

- Analyse data from Lannemezan, compare to tower measurements
- Technical publication on COCAP
- New campaign in late summer:
  - Take series of profiles in the nocturnal boundary layer
  - Calculate CO\textsubscript{2} flux with a budget method
Thank you for your attention!