Mobile Aerial CO_2 Sensing

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CONCEPT.

Monitoring large areas to detect small CO_2 leaks is challenging. Sensor networks are a common approach to deal with this problem. But the deployment of a large amount of sensor nodes can be costly with each node requiring at least a CO_2 sensor, a power source and a communication module. Such expenses are only justifiable in populated areas where the safety of the people has to be ensured and part of the infrastructure is already available.

To cover large unpopulated areas and to ensure the detection of CO_2 leakages in an early stage, we propose the usage of an unmanned small helicopter equipped with a high accuracy CO_2 sensor, a GPS and a communication module. Depending on the aspired time interval between consecutive measurements one or multiple of these unmanned aerial vehicles (UAVs) can be deployed.

The experiments presented in this poster are part of an ongoing feasibility study trying to determine if and how rotor-craft UAVs can be used for aerial gas measurements.

PLATFORM.

The main challenge of aerial CO_2 measurements is the trade-off between accuracy and coverage. For accurate readings, currently available CO_2 sensors need about multiple seconds to deliver one measurement. If such a sensor is deployed on an UAV, the measurement represents the average CO_2 concentration of the covered area in that time interval. If the aerial platform is moving too fast, CO_2 leakages might remain undetected (CO_2 spikes are averaged out). On the other hand, slower UAVs need more time to cover the same area.

To be able to reliably detect CO_2 leakages, we chose a rotor-craft UAV which allows slower velocities compared to a fixed wing UAV. Our customized T-Rex 700E is driven by an electric motor and flies about 12 minutes in its current configuration. A Vaisala GMP343 CO_2 sensor is used for the CO_2 measurements delivering one CO_2 measurement every two seconds with an accuracy of ±(3 ppm + 1 % of reading).

EXPERIMENTS AND THEIR RESULTS.

Figure 1: Experimental set-up (Photography by Ben Coughlan)

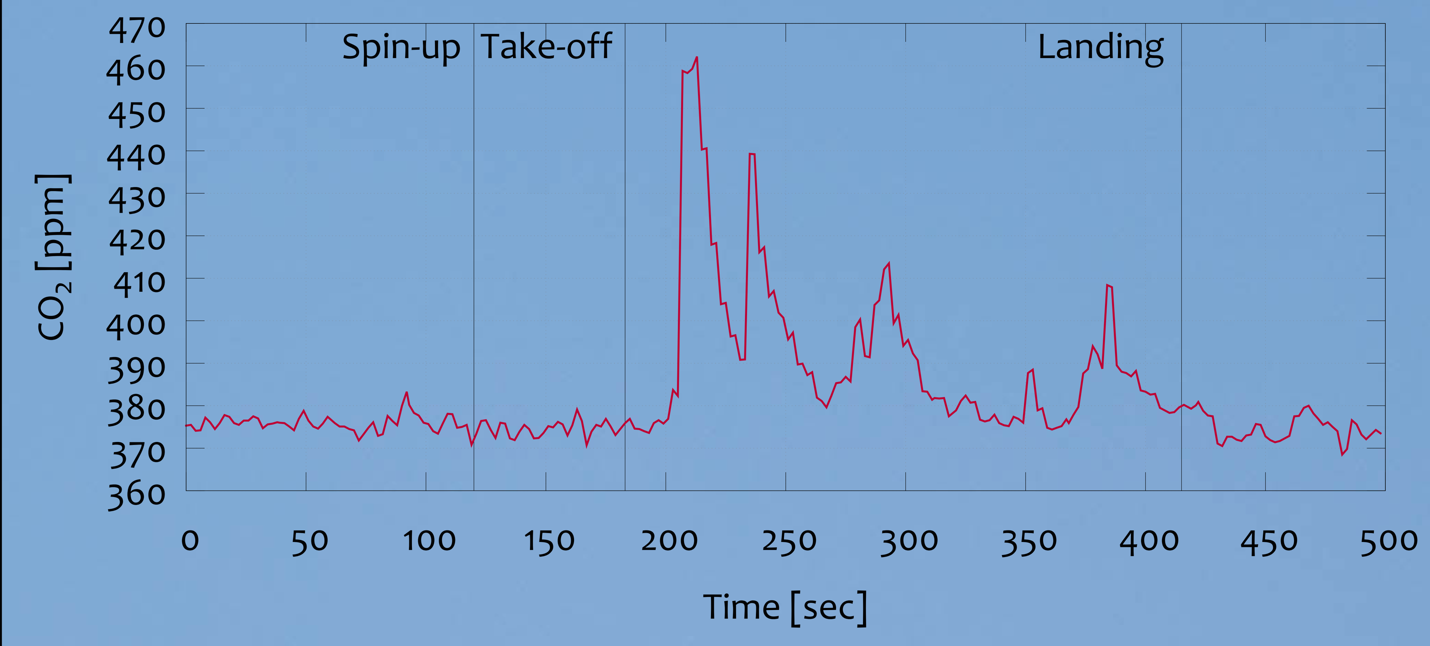

Figure 2: Measured CO_2 concentration

A diffuse CO_2 source with a flow rate of 100kg of fluid CO_2 per day was set up in the middle of a field (Figure 1) on a calm day. The UAV was flown repeatedly over the CO_2 source in about two meters height. The down-wash of the main rotor mixes up the air-CO_2-mixture and pushes it through the CO_2 sensor mounted in the front of the UAV. The experiment was conducted to determine if this mixing denies meaningful CO_2 readings in midair.

Figure 2 shows the CO_2 concentration measured by the Vaisala GMP343 during the experiment. A relative constant CO_2 concentration of around 375 ppm was measured before the start of the helicopter. Spinning up the rotor blades did not negatively influence the measurements. A clear jump can be seen when the helicopter was flown over the CO_2 source. The pilot was then flying back and forth over the release point which is reflected in the repeating CO_2 spikes. The ongoing dilution of the air-CO_2-mixture through the helicopter rotor blades resulted in each consecutive CO_2 spike having a smaller CO_2 concentration than the preceding one.

The results suggest, that a rotor-craft UAV can be used for CO2 measurements in midair.

ACKNOWLEDGEMENTS.

The authors greatly appreciate the extraordinary efforts of the following organizations which made the CO_2 trial possible:

- Geoscience Australia (http://www.ga.gov.au/)
- CO2CRC (http://www.co2crc.com.au/)
- CSIRO (http://www.csiro.au/)