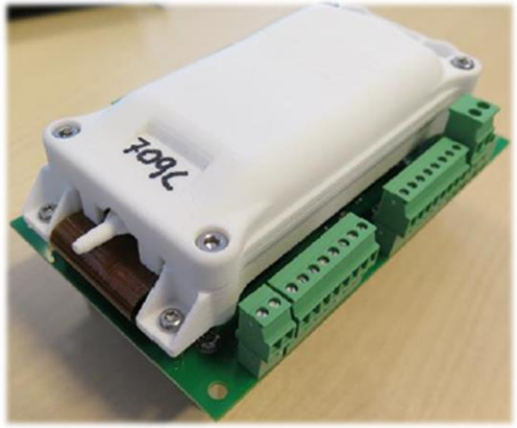
UAV atmospheric mapping applications using an improved low-cost NDIR sensor

Yunsong Liu [1,2], Jean-Daniel Paris [1,2], Mihalis Vrekoussis [1,3], Panayiota Antoniou [1], Christos Constantinides [1], Maximilien Desservettaz[1], Christos Keleshis [1], Olivier Laurent [2], Andreas Leonidou [1], Carole Philippon [2], Panagiotis Vouterakos [1], Pierre-Yves Quehe [1], Philippe Bousquet [2], Jean Sciare [1]

[1] The Cyprus Institute, Climate and Atmosphere Research Center (CARE-C), Nicosia, Cyprus

[2] Laboratoire des Sciences du Climat et de l'Environnement, 91191 Gif sur Yvette, France

[3] University of Bremen, Institute of Environmental Physics and Remote Sensing (IUP) & Center of Marine Environmental Sciences (MARUM), D-28359 Bremen, Germany

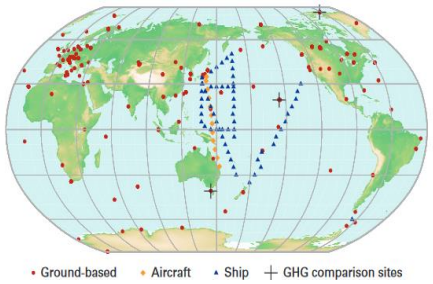


CO_2 sensor (Senseair AB, Sweden)

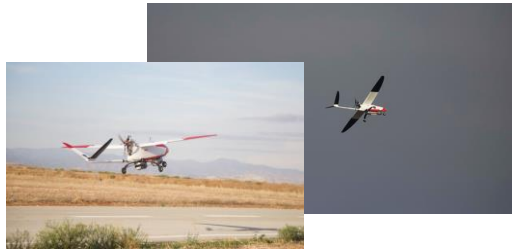
Measuring CO_2 through UAVs ?

WHY ?

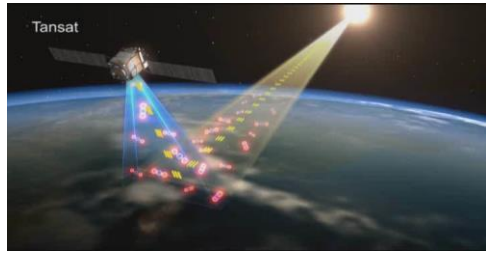
- To better document the sustained CO_2 increase in the atmosphhere
- To fill the gap between in-situ observations and remote sensing approaches
- To focus on point emissions (e.g. industry and urban region)



GAW global network



Unmanned System Research Laboratory, CyI



TanSat launched in 2016

Advantages of UAVs:

- Cost-effective solution for routine observations
- Operation at low altitudes and slow speeds (e.g. higher resolution data)
- Documentation of the spatial distribution of CO_2 around fixed points

Challenges:

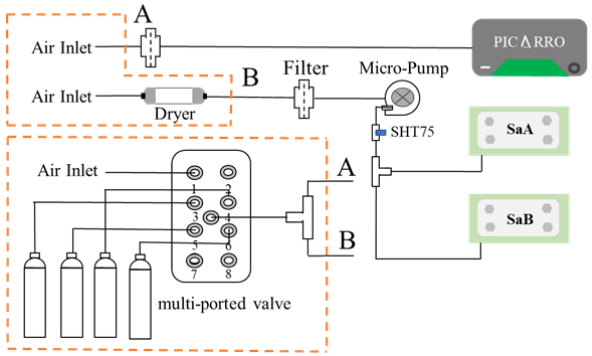
- To obtain stable and acquisition frequency measurements against rapid changes in pressure and temperature
- To obtain sufficient precision measurements (<2ppm) with light payload (<2 kg) on board UAVs

How to have this qualified UAV-CO_2 system?

❖ **Goal: to develop a low-cost, light weight and high precision UAV-CO_2 system for various applications**

Step One

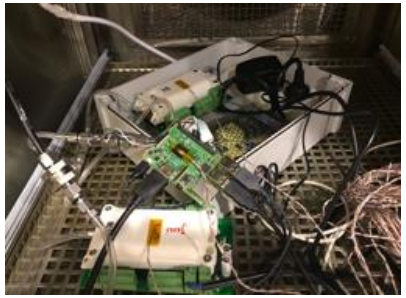
Accuracy and linearity tests in the lab



Calibration follows the WMO X2004 scale
Precision: ±1 ppm (1σ) at 1 Hz

Step two

Assessment of the impact of T/P changes



Necessary before any measurements (ICOS-ATC Mlab: https://icos-atc.lsce.ipsl.fr/mlab)

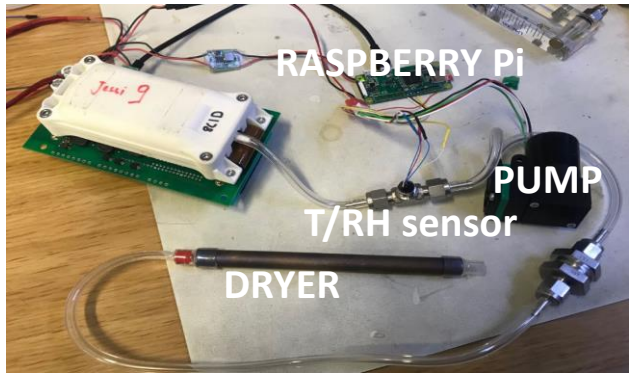
Step three

Assessment of meas. accuracy onboard

The manned aircraft Beechcraft Baron 58
Precision: ± 2 ppm (1σ) at 1 Hz and ±1 ppm (1σ) at 1 min time resolution

Step four

Integration, validation and evaluation of the UAV-CO_2 system



Payload: 1058g including the battery *Cost: ~ 3000 euros*

A blueprint study

Step One : one month

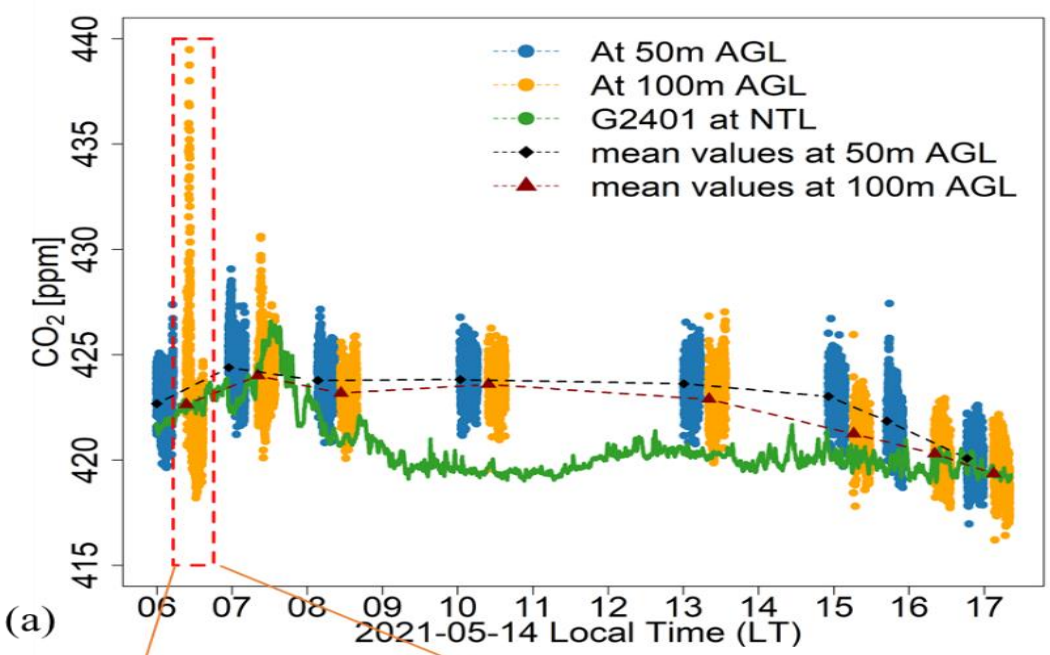
Step Two : one month

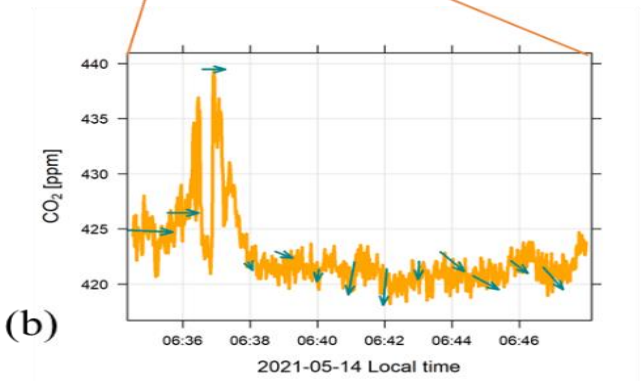
Step Three : half month

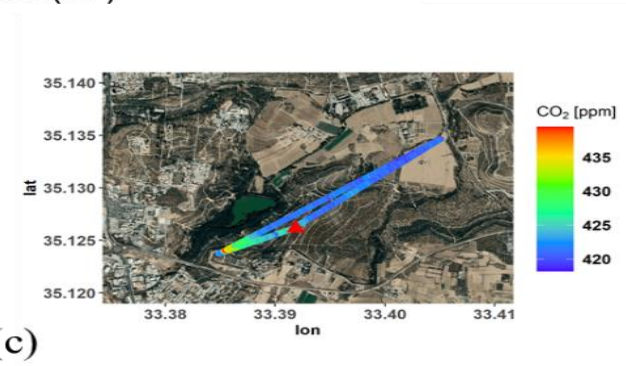
Step Four : eight months

A case study in Nicosia, Cyprus

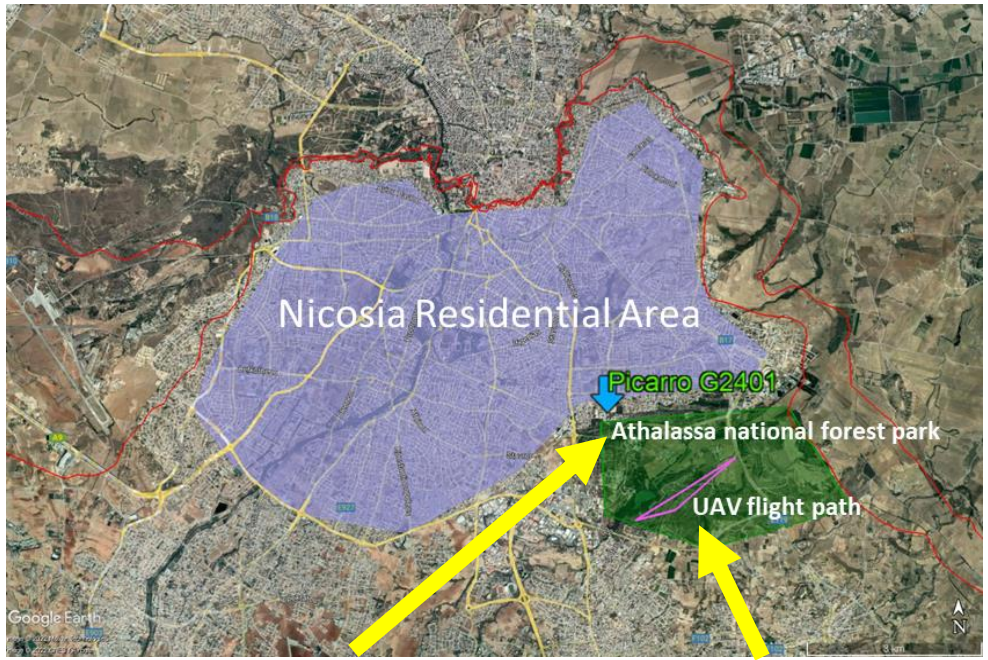
- *Location:* Athalassa National Forest Park
- *Flights:* from 0600 to 1730 on May 14 2021. 16 flights in total



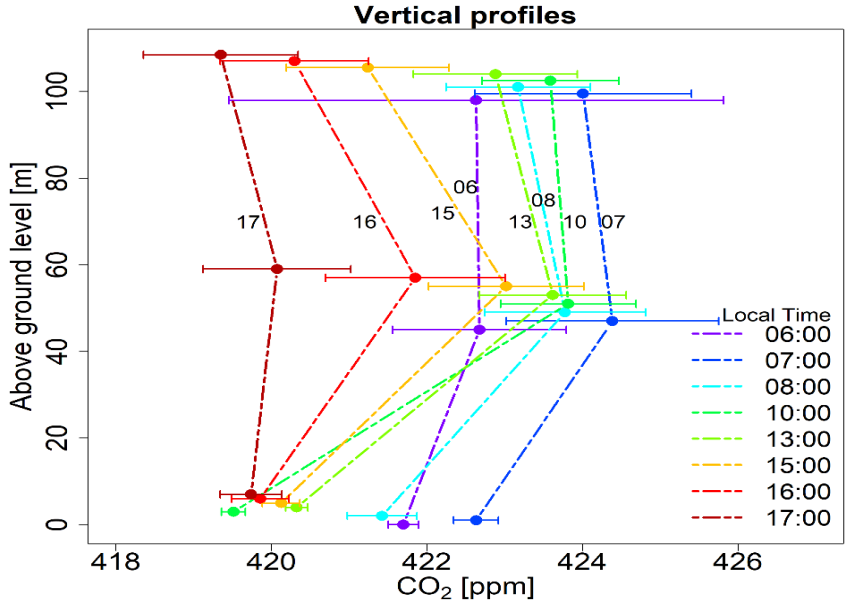




Time series of CO_2 mole fraction measured by the UAV CO_2 sensor (at 50 m in blue and 100 m AGL in orange) and by the Picarro G2401 at CyI (in green).



Locations of the Picarro G2401 at CyI, the UAV flight path and the residential area in Nicosia (© Google Earth 2022).



Vertical profiles from the eight paris of flights.

Take home messages

- Lightweight UAV-CO_2 system (1058 g) with dimensions of 15 cm×9.5 cm×11 cm.
- Developed and validated a UAV-CO_2 system under WMO scale, make it comparable between labs.
- An estimated precision of ± 2 ppm (1σ) at 1 Hz validated onboard, suitable for quantifying urban emissions.
- To investigate emission factors and fluxes by combining with other sensors on board the UAV platform.

More details: Liu, Y. et al., Improvements of a low-cost CO_2 commercial NDIR sensor for UAV atmospheric mapping applications, Atmos. Meas. Tech. https://doi.org/10.5194/amt-15-4431-2022.

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Thank you for your attention
Welcome to questions