In collaboration with:

A new UAS System for Airborne Eddy Covariance Measurements of Heat and Carbon Fluxes

Torsten Sachs and Mathias Zöllner
GFZ German Research Centre for Geosciences, Potsdam, Germany

Motivation

Fully understanding greenhouse gas emissions from highly complex landscapes such as wetlands and permafrost-affected ground can benefit from measurements on a variety of scales. Particularly in the high latitudes where only few sites dot a vast area, combining long-term, continuous records from individual sites with larger scale surveys of the spatial variability could help to reduce biases and uncertainties in bottom-up flux estimates. Several recent projects included aircraft measurements of GHG concentrations or fluxes and succeeded in mapping permafrost GHG fluxes over large regions at resolutions down to 100 m. However, the cost and complexity of such operations allows for few temporal snapshots only.

Within the infrastructure project "Modular Observation Solutions for Earth Systems" (MOSES), we developed a new UAS system suitable for frequent airborne eddy covariance flux measurements of latent and sensible heat as well as CO_2 (CH_4 to come) on a spatial scale between tower footprints and aircraft.

Platform Requirements

- Able to integrate modular sensor pod with 3-5 kg science payload
- Fast GHG and 3D wind measurement along flight tracks, suitable for eddy covariance → fixed-wing flight mode
- Range of ~1 hour at ~20 m/s
- Operable without runway → vertical take-off and landing capability

→ Selection of VTOL Wingcopter HeavyLift 178

Platform specifications

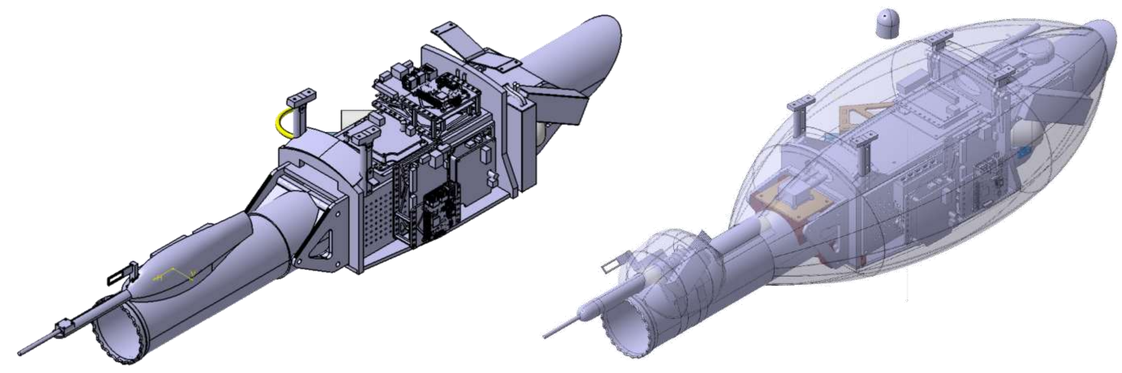
- Wingspan: 1.78 m
- Empty mass: 7 kg
- Maximum take-off mass (MTOM): 18 kg
- Material: Fiberglass and carbon fiber composite shell
- Propulsion: 4 x 2000 W brushless direct current (BLDC) motors
- Total battery capacity: 3x 16,000 mAh
- Top speed: 130 km/h
- Endurance: 45 minutes
- Nominal cruise speed: 80 km/h
- Maximum wind limitations: 15 m/s

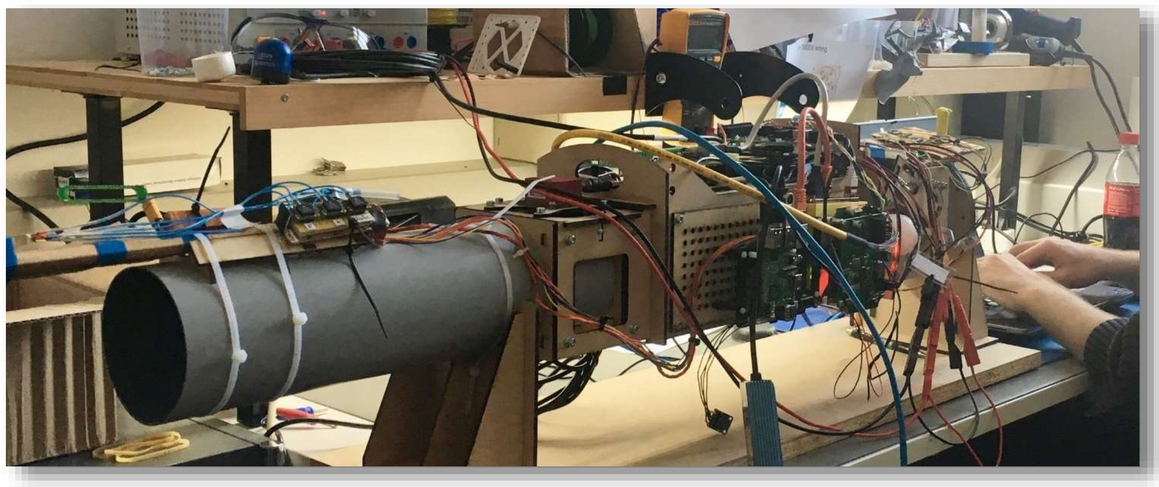
Sensor Components

Meteorology	5-hole probe for 3D wind air temperature humidity global radiation (CS320) surface temperature
Greenhouse gases	CO_2 and H_2O (LI-7500 DSI)
Attitude and position	IMU, GPS, laser altimeter
Sensor power supply	Separate LiPo battery
Data acquisition and telemetry	Data logger, data link

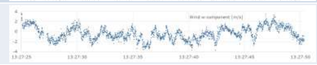
Sensor Pod

- Mass: 4 kg
- Tube design to protect LI-7500 from prop compression shocks





Data Stream

Variable	Frequency	Example
CO_2 and H_2O concentration	20 Hz	
Wind, position, attitude	100 Hz	
Surface temperature	10 Hz	
Global radiation	1 Hz	
System data (flight guidance)	variable	

Initial Testing

- Pod affected aerodynamics and stability → solved with stabilizers
- All raw data recorded as planned, no EMV problems
- Current frequency resolution 3 Hz
  → 5-hole probe likely too close to props
  → Ultimate solution: switch to pusher-configuration

Next Steps

- Integration of a light-weight OPLS CH_4 sensor
- Finalize processing workflow, evaluate covariances
- Increase frequency resolution, pusher-configuration if needed
- Test campaigns and iterations to fully characterize data quality
- Overcome regulatory challenges

www.gfz-potsdam.de
Contact: Torsten.Sachs@gfz-potsdam.de

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