EGU22-5278, updated on 09 Aug 2022
https://doi.org/10.5194/egusphere-egu22-5278
EGU General Assembly 2022

Improvements of a low-cost CO_2 commercial NDIR sensor for UAV atmospheric mapping applications

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Unmanned Aerial Vehicles (UAVs) have provided a cost-effective way to fill in gaps between in-situ (ground-based) and remote-sensing observations. In this study, a lightweight CO_2 sensor system suitable for operations on board small UAVs has been developed and validated. The CO_2 system autonomously performs in situ measurements, allowing for its integration into various platforms. It is based on a low-cost commercial nondispersive near-infrared (NDIR) CO_2 sensor (Senseair AB, Sweden), with a total weight of 1058 g, including batteries. A series of accuracy and linearity tests showed that the precision is within ±1 ppm for 1σ at 1 Hz. Variability due to temperature and pressure changes was derived from environmental chamber experiments. Additionally, the system has been validated onboard a manned aircraft against a reference instrument (Picarro, USA), revealing an accuracy of ±2 ppm (1σ) at 1 Hz and ±1 ppm (1σ) at 1 min (0.02 Hz). Integration on a quad-copter led to improvements in the calibration strategy for practical applications. The developed system has been deployed in an intensive flight campaign (a total of 16 flights per day), with horizontal flights performed at a low altitude (100 m AGL). The designed system highlights the capacity to detect CO_2 concentration changes at 1 Hz and spatial gradients and to provide accurate plume dispersion maps. It proved to be a good complementary measurement tool to the ground-based co-located observations performed by the Picarro G2401. This study gives a practical example of the process to be followed for the integration of a lightweight atmospheric sensor into a mobile (UAV) platform. Details of the measurement system and field implementations are described in this study to support future UAV platform applications for atmospheric trace gas measurements and closing the gaps in the monitoring of the current carbon cycle.