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Development of a small unmanned aircraft system to derive CO_2 emissions of anthropogenic point sources

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A reduction of the anthropogenic emissions of CO_2 (carbon dioxide) is necessary to stop or slow down man-made climate change. To verify mitigation strategies, a global monitoring system such as the envisaged European Copernicus anthropogenic CO_2 monitoring mission (CO2M) is required. Those satellite data are going to be complemented and validated with airborne measurements. UAV (unmanned aerial vehicle) based measurements can provide a cost-effective way to contribute to these activities. Here we present the development of a sUAS (small unmanned aircraft system) to quantify the CO_2 emissions of a nearby point source from its downwind mass flux without the need for any ancillary data. Specifically, CO_2 is measured by an in situ NDIR (non-dispersive infrared) detector and the wind speed and direction is measured with a 2D ultrasonic acoustic resonance anemometer. In order to minimize the effect of rotor downwash, we calibrate the anemometer by analyzing wind measurements taken while following a suitable flight pattern and assuming stationary wind conditions. We quantify the quality of the CO_2 and wind measurements with an in-flight validation at the ICOS (Integrated Carbon Observation System) atmospheric station Steinkimmen (STE) near Bremen, Germany. By means of two flights downwind of the ExxonMobil natural gas processing facility in Großenkneten about 40km east of Bremen, Germany, we demonstrate how the measurements of elevated CO_2 concentrations can be used to infer mass fluxes of atmospheric CO_2 related to the emissions of the facility.