A UAV-based active AirCore system for accurate measurements of greenhouse gases

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We developed a UAV-based active AirCore and field-tested it for atmospheric concentration measurements of CO_2, CH_4, and CO. The system is based on the AirCore technique invented by NOAA. As opposed to the conventional concept of passively sampling air using the atmospheric pressure gradient during descent, the active AirCore samples atmospheric air using a micropump to pull the air through the tube. This inclusion of the micropump opens up the possibility of sampling atmospheric air in both vertical and horizontal planes. The active AirCore used for this study weighs ~1.2 kg. It consists of a 49.1 m long 1/8” stainless steel tube with a 0.005” wall thickness, a 7.5 cm 1/4” stainless steel tube filled with magnesium perchlorate, a small KNF micropump and a 45 μm orifice working together to form a critical flow of dried atmospheric air through the active AirCore.
Shortly after collection, we analyze the air sample on site using a gas analyzer (Picarro CRDS model G2401) for mole fraction measurements of CO_2, CH_4, CO and H_2O.

We conducted an experiment with a prototype active AirCore mounted on a UAV near Lutjewad, an atmospheric measurement station hosting a 60 m high monitoring tower located next to the Wadden sea dike northwest of the city of Groningen in the Netherlands. Five consecutive flights took place over a five-hour period in the same morning, starting at sunrise to obtain vertical profile measurements during the collapse of the nocturnal boundary layer and the establishment of the mixed layer. We compared measured concentrations to continuous greenhouse gas mole fraction measurements at the nearby atmospheric tower. The results show a good agreement between the active AirCore sample and the continuous measurements obtained from the atmospheric station (N = 121, R^2_{CO2}: 0.97 and R^2_{CH4}: 0.94, and mean differences: Δ_{CO2}: 0.14 ppm; Δ_{CH4}: 5.56 ppb). The nocturnal boundary layer height was clearly observed in two out of three vertical profile measurements, and seen to increase as the boundary layer stabilized as the morning progressed. By flying in a horizontal plane perpendicular to the dike we furthermore detected a CH_4 hotspot in the coastal wetlands, which demonstrates the potential of this new active AirCore method to measure at locations where other platforms have no practical access.