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## **UAS measurements for the investigation of emissions of air pollutants at the Duesseldorf airport and industrial sites in the Rhine-Ruhr area, Germany**

**Konradin Weber**, Christian Fischer, Martin Lange, Tobias Pohl, Tim Kramer, Christoph Böhlke, and Detlef Amend

Duesseldorf University of Applied Sciences HSD, Duesseldorf, Germany

Instrumented UAS (unmanned aerial systems, drones) can substantially enhance the capabilities for the investigation of air pollutants, when equipped with the appropriate and customized air pollution measurement systems. Important advantages can be found in the exploration of vertical and horizontal pollutant profiles as well as in the determination of fugitive emissions. The HSD Laboratory for Environmental Measurement Techniques (UMT) has developed a series of different multicopter UAS for various measurement tasks and payloads. Additionally, different commercial UAS are used by UMT. The multicopter UAS are equipped, depending on the measurement task, with different specifically adopted lightweight measurement systems for aerosols (PM<sub>10</sub>, PM<sub>2.5</sub>, PM<sub>1</sub>, UFP, PNC, number size distributions) or gases like O<sub>3</sub>, SO<sub>2</sub>, NO<sub>x</sub>, CO<sub>2</sub> and VOCs. All measurement systems were intercompared with certified standard measurement equipment before use to assure the quality of the measurement results. Moreover, physical samples of aerosols can be taken during the flight, which enables a chemical or REM analysis after the flight.

Additionally, UMT developed an on-line data transmission system, which allows the transmission of measurement data during the flights from the UAS to the ground for continuous monitoring. In this way concentration plumes can be tracked and hotspots can be pinpointed during the flight. This online data transmission system is independent of commercial platforms, can work on different radio frequencies in a push mode (presently on 2.4 GHz) and communicates with RS232 and I<sup>2</sup>C interfaces. Within several intercomparison studies this online data transmission proved a high reliability and correctness of transmitted data.

In addition to technical details of the UAS and instrumentation we present in this contribution the results of different measurement campaigns based on our UAS measurements:

- Investigations of emissions from the Duesseldorf airport combining upwind and downwind UAS measurements. These investigations became of special interest, as due to the reduced air traffic caused by the Corona pandemic now single aircraft starts and landings could be monitored with their emissions at elevated altitudes.
- Investigations of vertical concentration profiles above the city of Duesseldorf, which could be influenced by industrial sites in the north of Duesseldorf as well as by the Duesseldorf airport.

- Investigations of vertical and horizontal pollution distributions near, at and around industrial sites in the Rhine Ruhr area, especially of metal industry plants and chemical plants.

These examples highlight the capabilities of UAS measurements, which will be further enhanced by planned simultaneous use of several UAS in parallel and joint tasks.