Estimating Error in Drone-Based Measurements Using Computational Fluid Dynamics

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Abstract

Unmanned Aerial Vehicles, also referred to as drones, have become a popular platform for air quality measurements. Many previous studies have used rotary-wing drones for vertical measurements to study atmospheric composition and pollution, but there is a lack of consensus on how to minimize the disturbance and error caused by the rotors during flight. Specifically, there are a variety of proposed flight procedures (the speed and path of the drone), and multiple recommended sensor or intake locations within the literature. Most of these recommendations are based on observations or simulations during hover conditions rather than flight conditions. The focus of this work was to use computational fluid dynamics to simulate vertical flight (ascent and descent) and investigate the influence of the rotors on measurements from an onboard ozonesonde. We simulate flight through a constant vertical ozone gradient and compare the concentrations observed during ascent and descent to the expected gradient. Our results show that during ascent, the error caused by the rotors is minimal ($< 10\%$) regardless of sensor location. During descent, however, the error caused by the mixing from the rotors can reach values up to ~60% around the drone. This is largely due to the fact that during descent, the drone flies through its own wake where there is significant mixing and potential for recirculation. Our simulations are in good agreement with trends observed in experimental data. These results provide guidelines for the optimal flight pattern and sensor location to reduce error during vertical measurements.