

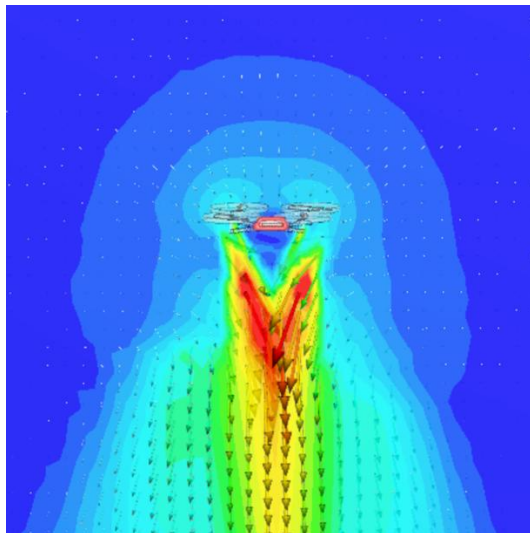
# Optimizing Gas Sensor Placement on Micro Drones via CFD and Wind Tunnel Experiments

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The challenge of optimal gas sensor placement on micro drones has become increasingly important for environmental monitoring applications. Gas detection accuracy is significantly affected by propeller airflow disturbances, making sensor positioning critical for reliable measurements. This project addresses this challenge by combining Computational Fluid Dynamics (CFD) simulations with experimental validation to identify optimal sensor placement.

Building upon previous work at DISAL that used OpenFOAM for airflow simulation, this project adds experimental validation through wind tunnel testing. The complexity of OpenFOAM led to the adoption of SimScale, a cloud-based CFD platform that provides an accessible interface while maintaining OpenFOAM's underlying capabilities.

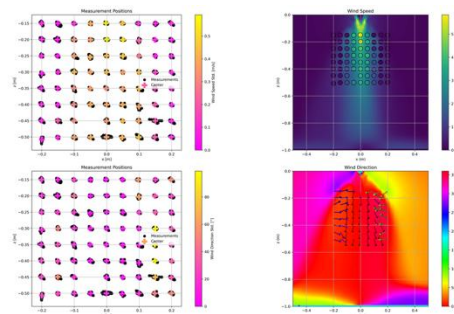


*Airflow visualization around the Crazyflie drone showing velocity field distribution*

It was done creating simplified 3D models of the Crazyflie 2.0 drone and conducting CFD simulations under various conditions. These simulations were validated with wind tunnel

experiments using ultrasonic anemometry, measuring wind speed and direction at multiple grid points beneath the drone.

Key findings were that CFD simulations can reliably predict airflow patterns, with accuracy improving at higher forward speeds (SMAPE dropping from 38% in static conditions to 12% at 1.6 m/s). The literature revealed two promising sensor placement regions: above the drone in the intake region for stable, low-noise measurements, and below the drone in the downwash zone for potentially higher detection rates but with increased signal noise.



*Comparison between Simulation and Real Experiment for a static drone*

The main limitations encountered were the precision of steady-state RANS models and time limitations that prevented gas plume simulations. The steady-state assumptions seems to have introduced some diffusion effects compared to real measurements, particularly in static conditions.

This research successfully validates the use of accessible CFD tools for drone-based gas sensing applications and provides a foundation for future work. The proposed sensor placement could not be accurately tested with plume simulation but the the airflow visualization tends to the same conclusion as the litterature, providing a good base for future work.