SAMURAI – Making sonic anemometers fly

Development, test and validation of a drone-based turbulence measurement system for wind energy meteorology and basic boundary layer research

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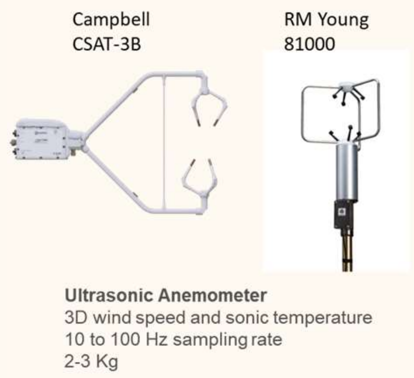
BACKGROUND

Sonic anemometers have during the last decades become the golden standard for in-situ measurements of atmospheric flow and turbulence characteristics with high temporal resolution.



The required mounting structures, typically meteorological masts and towers, are often logistically demanding, expensive and once installed at one site rather immobile and unflexible.

This limits the applicability of those accurate and well-established wind measurement technology for a wide range of applications in basic boundary-layer meteorology (e.g. air-sea interaction or stable boundary layers) and wind energy meteorology (e.g. flow phenomena in the vicinity of wind turbines and wind farms, as induction zone or wakes).

The continuous and fast development in the field of drones now provides the opportunity to use those uncrewed aerial vehicles (UAS) as convenient sensor carrier.

FoxTech D130-X8

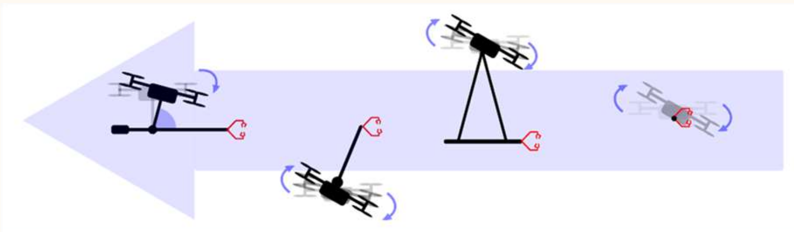
- 15 Kg (~5kg of batteries)
- 40-45' flight time (no payload)

D ≈ 74 cm

SAMURAI – Sonic Anemometer on a MUlti-Rotor drone for Atmospheric turbulence Investigations

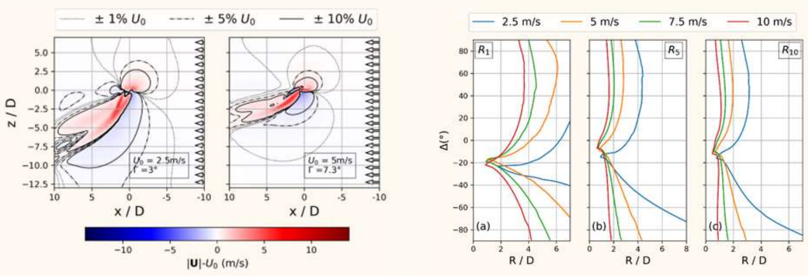
General design considerations are guided by two main criteria:

1) The sonic anemometer should not be affected by the propeller induced flow (PIF)
2) The mounting should not compromise the flight stability of the airframe (e.g. by large mass outside the centre of gravity)
3) We need appropriate attitude information for a successful motion correction



Step 1: CFD simulations of PIF

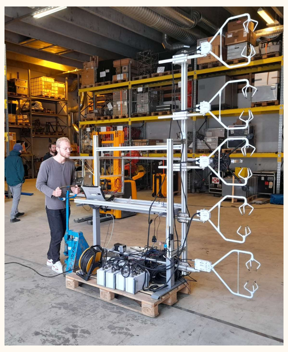
The simulations have been performed with ANSYS-fluent for different wind speeds ond drone weights

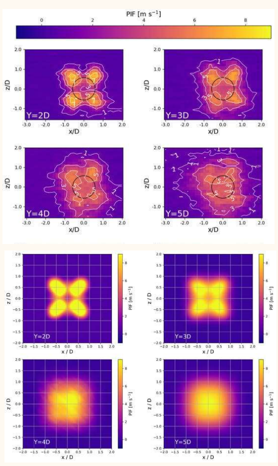


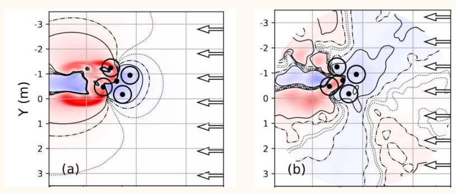
Moving the Sonic upwind on a boom slightly below the rotor plane or as sling load far below is the most efficient way to reduce the PIF!

Step 2: Measurements of PIF

Laboratory measurements Lidar measurements in flight

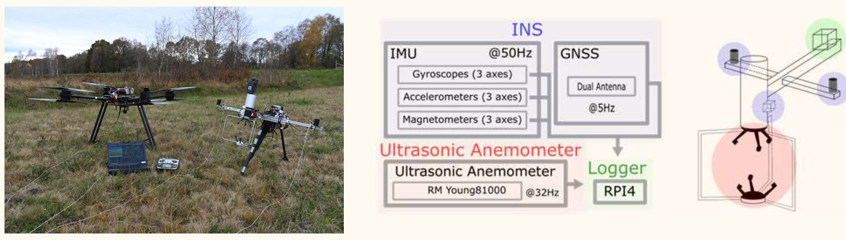






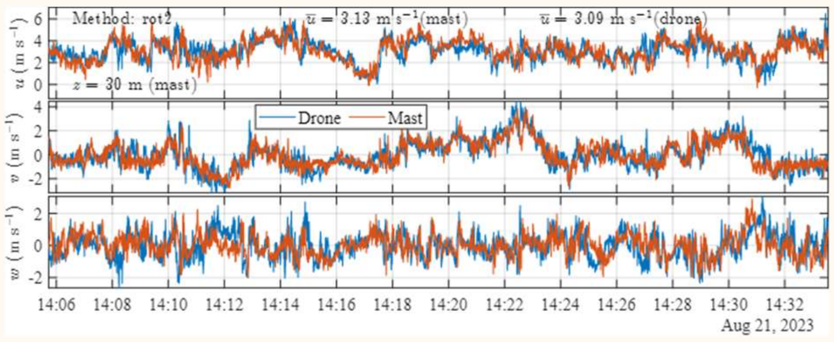
Laboratory and environmental measurements confirm that CFD simulations have a large potential for a realistic characterization of PIF

Step 3: System validation

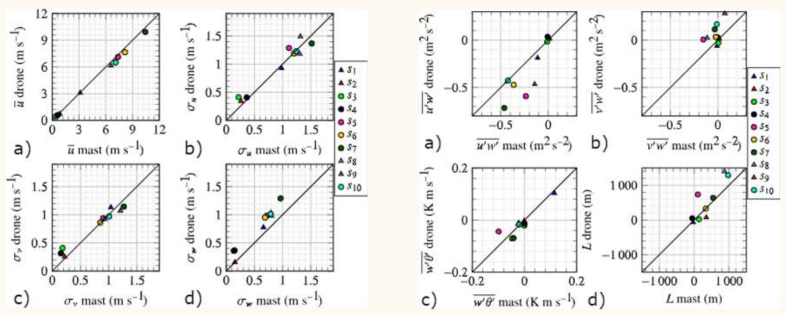


Realization of the SAMURAI-S (for sling-load configuration)

Validation of SAMURAI-S against mast mounted sonic anemometers @30 m and 60 m



Example: comparison of wind speed at 30 m



Overall comparison (10 validation flights) for the mean wind and the standard deviation of the three wind components (left) and for turbulent fluxes and Monin-Obukhov length (right)

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