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Observing mean profiles and turbulence in the atmospheric boundary layer with an instrumented unmanned aerial system

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In recent years, owing to the miniaturization of sensors and acquisition systems, several unmanned aerial systems (UASs) were developed all over the world notably for atmospheric research to characterize the atmospheric boundary layer (ABL). These technological advances make it possible to carry out measurements at very low altitudes in areas that are unreachable by piloted airplanes, and thus to cover a wider airspace for gathering meteorological data.

In Toulouse (France) we developed a small UAS called OVLI-TA designed for ABL observations, and allowing us to investigate turbulence in a complementary way to other existing measurement systems, such as instrumented towers/masts, radiosondes and piloted airplanes. OVLI-TA has a wing span of 2.60 m, weighs 3.5 kg payload included and has at least one hour of flight autonomy. The instrumental package of OVLI-TA includes a 3D printed 5-hole probe replacing the nose of the airplane to measure attack and sideslip angles, a Pitot probe to measure static and dynamic pressure, a fast inertial measurement unit, a GPS receiver, a Pixhawk autopilot used for autonomous flights, as well as temperature and moisture sensors situated in specific housings. OVLI-TA is an affordable system able to fly at low altitudes, easy to deploy, and it is capable of profiling wind speed, wind direction, temperature and humidity up to 1 km of altitude, in addition to measuring turbulence within the ABL.

We will present OVLI-TA design and instrumentation. Indeed, after wind tunnel calibrations, flight tests were conducted in March 2016 in Lannemezan (France) where there is a 60-m tower equipped with meteorological sensors considered as a reference to our measurements. The observations of turbulence on the tower and with the UAV are compared through a time-space conversion based on the Taylor's hypothesis applied to the two platforms. We found a good agreement for the mean values of wind, as well as for turbulence parameters. The capacity of the drone to sample wind fluctuations up to a frequency of around 10 Hz, which corresponds to a spatial resolution of the order of 1 m, was thus validated. Then, in July 2016, OVLI-TA participated in the international project DACCIWA (Dynamics-Aerosol-Chemistry-Clouds Interactions In West Africa), in Benin. The comparison of the OVLI-TA observations with the radiosonde profiles allowed us to characterize the in-flight time response of the sensors.

Eventually, we will also give some perspective insights of the future work related to the on-going development of a larger size UAS.