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BOU: Development of a low-cost tethered balloon sensing system for monitoring the lower atmosphere

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The study of the atmospheric boundary layer, the lowest part of the atmosphere, and the processes that occur therein often requires the observation of vertical profiles of the main meteorological variables, i.e. air temperature and humidity, wind vector and barometric pressure. In particular, when the interest is focused on the air-surface interactions, a high vertical resolution over the first 500 m is required for the observations to describe the physical processes that occur immediately above the surface. Typically, these needs are covered with the use of captive balloons, which are helium-filled balloons tethered to a winch on the ground and a sensor package suspended a short distance below the balloon. Since the commercial version of such instrumental platforms are scarce and expensive, a new low-cost device has been developed in the last years: BOU (tethered Balloon sonde OWL-UIB).
In this paper, we focus on the sensor package and data acquisition system part, that is able to fulfill the low-cost requirements. The system uses a low-cost Arduino Mega board as the processor, and stores all the data in a SD card, though an RF connection is also possible but more unreliable. The system has been configured to sample temperature, humidity, air pressure, wind speed, having also a magnetometer and an accelerometer. Sampling time was 1 second, though it was possible to set it faster. It is worth mentioning that the system is easily reconfigurable, and more sensors can be added. The system is powered by a Polymer battery of 1800mA , allowing the system to run continously for more than 6 hours.
The temperature is acquired using three different sensors (a HYT 271 calibrated sensor with an accuracy of ± 0.2 °C, plus the internal temperature sensors of the wind and pressure sensors, with accuracies around ± 0.5 °C). The humidity is also sensed using the calibrated HYT 271 sensor, which features an accuracy of $\pm 1.8\%$. Air pressure is sensed using a BMP080 sensor, which also provides a reading of the temperature (less accurate than the HYT 271 but useful as a complement). Wind speed is measured using a low-cost hot-wire sensor, bought from a commercial source (Wind Sensor Rev. P, from Modern Device), that has also been calibrated against a WindSonic. This sensor also provides a reading of the temperature, with the same characteristics than the BMP080. Finally, the magnetometer and the accelerometer are used as a mean of tracking the position of the balloon, allowing us to additionally estimate the wind direction from the lateral acceleration.
This system has been used successfully in different campaigns, comparing favorably the obtained values against data obtained using an unmanned aerial vehicle (UAV) and a WindRass.
Possible additions to the system are a GPS tracker, a RF link to the base station, and different kinds of sensors. The current configuration of the system includes RS232, I2C, and purely analog input ports, giving it a wide flexibility to add different sensors.