CONSTRUCTION OF A LOW-BUDGET QUADROCOPTER AND DESIGN OF A SIMPLE MEASURING MODULE APPLICABLE FOR ATMOSPHERIC MEASUREMENTS

Á. Bordás
Bolyai High School, Senta, Serbia, bordas.arpad@gmail.com

ABSTRACT

During the past school-year a low-budget quadrocopter was constructed at the Bolyai High School. After successful test flights the quadrocopter was equipped with a simple onboard measuring module which contains air pressure, temperature, and humidity sensors, a GNSS module and a data logger. Vertical profile measurements were done in rural and urban areas with the aim of understanding land-atmosphere interactions during different stability conditions, as well as to extend our knowledge about the climate modification effects of cities, which is useful for urban planning strategies.

INTRODUCTION

UAVs (Unmanned Aerial Vehicles) are useful tools in a number of different engineering and scientific disciplines. Through their use, it is possible to test and evaluate new ideas in the fields of navigation, real-time systems, flight control, robotics, as well as environmental monitoring and measuring. A quadrocopter is a type of UAV that is lifted and propelled by four rotors. It uses two pairs of identical fixed pitch propellers, two clockwise and two counter-clockwise. By the independent variation of the speed of each rotor it is possible to control the flight of the UAV.

During the past (2014-2015) school-year the group of Bolyai High School (BHS) students constructed a low-budget quadrocopter and developed an onboard measuring module suitable for atmospheric measurements. The aim of this paper is to the describe characteristics of the BHS quadrocopter and to introduce the measuring module designed by our students. Results of the low altitude profile measurements done during the PABLS 15 (Pannonian Atmospheric Boundary Layer Studies) campaign [1], as well as Urban-Path project [2,3] are also presented.

THE QUADROCOPTER AND THE MEASURING MODULE

Due to limited budget, our aim was to build a multicopter suitable for atmospheric measurements that was as cheap as possible. The frame was made of an aluminium rod, the legs were superflat. The constructed quadrocopter operates using medium-priced hardware (ArduPilot flight controller, 30 A rotation speed controllers, 1000 kv brushless motors and GPS compass). An old radio controller designed for model airplanes was modified; the kHz band radio was replaced with a 2.4 GHz radio system. After tens of hours of practicing on a simulator, the first test flights were performed on the local football field (see Fig.1.). During the test flights we revealed that the quadrocopter can fly up to 20 minutes with a 5000 mAh battery.

Fig.1. Test flight, February 2015

After the successful test flights the students designed a simple measuring module. The module includes Sparkfun's air pressure (MPL3115A2), temperature (TMP102) and humidity (HTU21D) sensors, MicroElektronica's GNSS (Global Navigation Satellite System) click, as well as a simple data logger including a micro SD card. The measuring module was housed in a plastic box and attached to the copter's frame. The measuring module is shown in Fig.2.

Fig.2. The measuring module housed in a plastic box -
data logger with GNSS click (left) and the set of sensors (right)

THE PABLS 15 CAMPAIGN AND THE URBTA-PATH PROJECT

The PABLS 15 campaign [1] was organized at the Szeged Airport (Hungary) in July, 2015. During the campaign the group of students worked with the team for the direct sounding devices. Beside the multicopter soundings [4] the students got an insight into tethered (see Fig.3.) and free balloon soundings. Vertical profile measurements were done with the idea to understand land-atmosphere interactions during different stability conditions. Fig.4. shows characteristic daytime and nighttime temperature profiles obtained using the BHS quadrocopter close to the grassy runway.

Fig.3. Students are performing the tethered balloon measurements during the PABLS 15 campaign (Szeged Airport, July 2015)

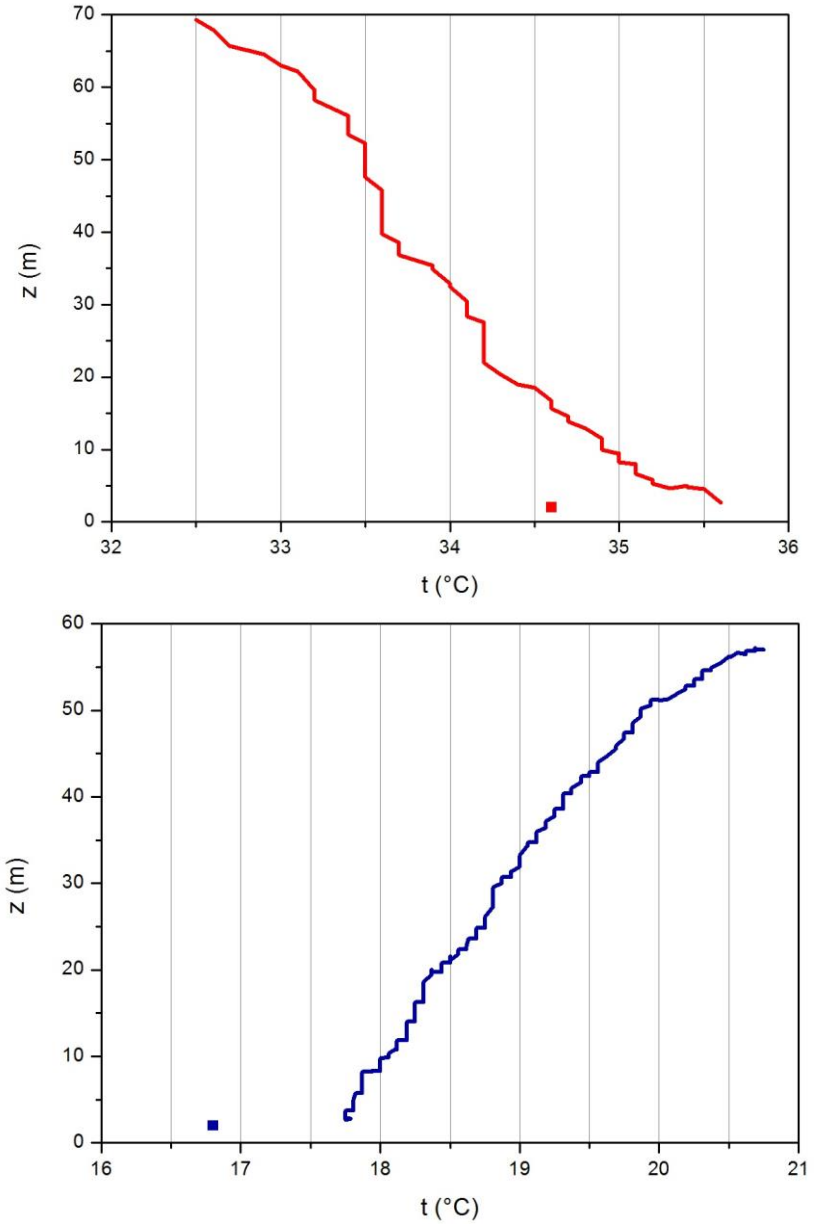

Fig.4. Daytime (red – 13.30 local time, 7th July) and night time (blue – 03.57 local time, 16th July) temperature profiles. Squares indicate temperatures measured at the ground station

Climate modification effects of the cities are very significant and affect many people. The aim of the Urban-Path project [3] was to monitor heat generated by the cities of Szeged (Hungary) and Novi Sad (Serbia) using measurement networks. In both cities more than 20 stations were installed. The spatial resolution of the stations provided high-resolution maps of the urban heat island [5]. Several high school students joined the Urban-Path project team. Vertical profile measurements were performed close to the urban meteorological stations. Differences between the day urban canyon and rural area temperature profiles are presented in Fig.5. Contrary to the rural data, the temperature increases slightly with height in the urban canyon.

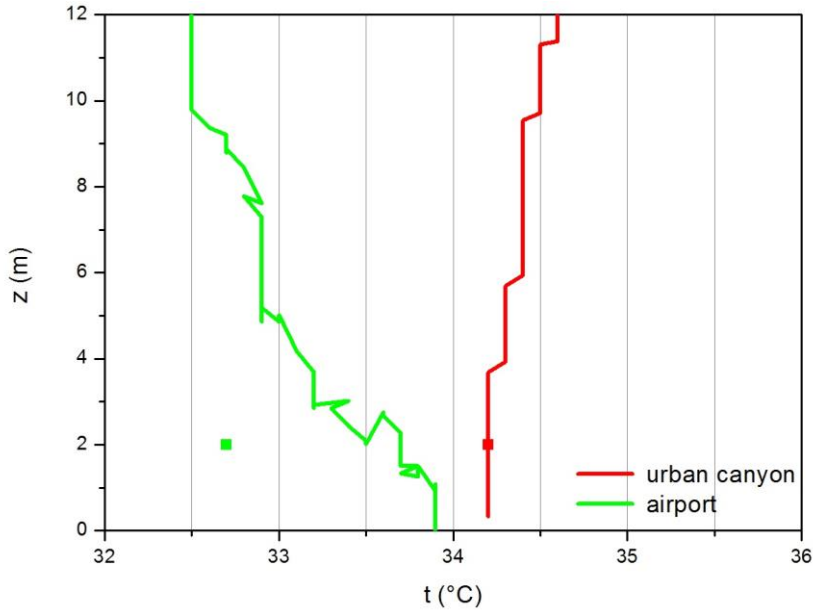

Fig.5. Raw temperature data obtained on July 6th in Szeged
urban canyon (15.37 local time), and at the Szeged Airport (17.27 local time)

FURTHER PLANS

The next step in the development of the BHS multicopter is the installation and testing of the autopilot and improved safety pilot systems. The modified version of the measuring module attached to the DJI Phantom quadrocopter will be used for profile measurements during the Dry Andes Research Program [6].

ACKNOWLEDGMENTS

The author wishes to thank Alexandra Apró, Róbert Boros, Márk Dobó and Tamás Kiss for their work, as well as Burkhard Wrenger (OWL University of Applied Sciences, Germany) and Zoltán Istenes (Eötvös Loránd University, Hungary) for discussions and their suggestions.

REFERENCES

1. J. Cuxart, T. Weidinger, G. Simó, B. Wrenger, A.Z. Gyöngyösi, D. Tátrai, Z. Istenes, B. Matjačić, Z. Nagy, Á. Bordás, A. Kircsi, J. Józsa: Pannonian atmospheric boundary layer studies (PABLS): some findings of the 2013 and 2015 campaigns, GEWEX workshop on the climate system of the Pannonian Basin, Osijek (Croatia) 2015.
2. J. Unger, S. Savić, T. Gál, D. Milošević: *Urban climate and monitoring network system in Central European cities*, University of Novi Sad – University of Szeged, 2014.
3. http://en.urban-path.hu
4. B. Wrenger, Á. Bordás, J. Cuxart, G. Simó, T. Weidinger: Multicopter measurements in the PABLS 15 campaign, GEWEX workshop on the climate system of the Pannonian Basin, Osijek (Croatia) 2015.
5. J. Unger, T. Gál, Z. Csépe, E. Lelovics, Á. Gulyás: Development, data processing and preliminary results of an urban comfort monitoring and information system, Időjárás, **119**, 307, 2015.
6. http://atacama.expedicio.eu/en/