EMS Annual Meeting Abstracts
Vol. 15, EMS2018-838, 2018
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Quad-copter as a tool for meteorological measurements in atmospheric boundary layer

Mikhail Varentsov (1,2), Arseniy Artamonov (2), Artem Pashkin (2), Irina Repina (1,2), and Vladimir Alexeev (3)

(1) Lomonosov Moscow State University, Moscow, Russia, (2) A.M.Obukhov Institute of Atmospheric Physics RAS, Moscow, Russia, (3) University of Alaska Fairbanks, International Arctic Research Center

Monitoring of meteorological conditions (temperature and humidity stratification, wind speed and direction, etc.) inside the atmospheric boundary layer (ABL) is important for investigation of the processes of surface atmosphere interaction, which are studied in many experimental campaigns. However meteorological measurements higher than few meters above the ground requires construction of the expensive and low mobility masts or organizing expensive aerological sounding with application, while the possibilities of remote sensing methods (e.g. SODARs, LIDARs or temperature profilers) or are limited by accuracy, frequency and number of measured variables.

Recent rapid development of unmanned aerial vehicles (UAVs) opens wide opportunities of the application of such UAVs for meteorological measurements in the ABL. Partially, they could be used for investigation of the vertical and horizontal variability of meteorological parameters over inhomogeneous landscapes (e.g. near land-water, ice-water, field-forest and urban-rural boundaries). Due to small weight and relatively low price (in comparison to remote sensing instruments) UAVs are an especially prospective tool for non permanent measurements during experimental campaigns.

In current study we consider the experience of boundary-layer measurements with application of mass-market quad-copter DJI Phantom 4 Pro. Its vertical flight range is limited by 500 m, horizontal range – by 1-2 km, flight time is about 25 minutes. In our study the drone was equipped with iMet-XF sensor pack, including air temperature and humidity sensor EE03 (produced by E+E Electronic), air temperature sensor InterMet Bead Thermistor (Shibaura PSB-S5), infra-red brightness temperature sensor MLX90614, integrated air pressure sensor and GPS. Data was collected to central chip and stored to MicroSD card through data logger Logomatic v2 (produced by SparkFun Electronics), whole system was powered by independent rechargeable battery.

Quad-copter equipped with listed sensors was used for several types of measurements: 1) hovering at one point near automatic weather station for verification purposes; 2) acceding and descending flights in order to obtain vertical profiles of meteorological parameters and compare then with contact and remote sensing measurements (at the coast of White Sea in winter conditions and in Obninsk town, near Obninsk Meteorological Tower); 3) horizontal flights over unfreezing polynya in the White Sea in order to investigate horizontal variability of the temperature and humidity.

Listed experiments have shown that quad-copter-based measuring complex is a promising and usable system. However, some methodological problems have been revealed, including the systematical difference between ascending and deciding vertical profiles due to the inertia of the sensors and sensitivity to the method of mounting sensors.

In additional to temperature and humidity measurements, the experience of wind speed and direction recovery from the angles of inclination of the quad-copter is also considered.

The research was supported by Russian Foundation for Basic Research, projects no. 17-05-01221 and 17 05-41095.