Pilot project of measuring and computing system for mesoscale monitoring of atmospheric boundary layer.

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ABSTRACT

Conception of design of measuring and computing system for monitoring atmospheric boundary layer is proposed. The system includes: stationary measuring complex consisting of four multiple-elevation ultrasonic weather stations and mobile measuring complex consisting of transportable weather station, touch probing system of weather data profile based on unmanned aerial vehicle and also Raman scattering gas analyzer, and new modification mercury gas analyzer.

Measuring and computing system, mesoscale monitoring, atmospheric boundary layer

1. INTRODUCTION

Condition of atmospheric boundary layer influences on different sides of human activity. Meteorological factors mostly determine an efficiency and safety of operation transport and power system, system of communication, the majority of industries and other. Earth biosphere directly depends on ecological state of atmosphere boundary layer (ABL), particularly life and heath of human. In this regard, urgent (actual это не актуально, а фактически) task is to organize complex, permanent and operating control for meteorological and ecological state of aerial environment.

For mesoscale meteorological and ecological monitoring tasks automatic measuring devices and technology of data processing and interpretation are being developed[1,2]. Such complexes and systems can make continuous measuring of aerial environment properties and information processing in real-time.

In of Monitoring of Climatic and Ecological Systems, Siberian Branch of the Russian the automatic meteorological system was realized. It used algorithms of spatial and time weather prediction based on parametric dynamic-stochastic type model and Kalman filtering algorithm[3,4]. It was shown that the system can be applied for meteorological support to resolve task of atmospheric optics and ecology. However this system didn't have its own hardware and aerological station data was used as the input data, which had a long period of measuring. Further development of such systems requires its own hardware which can provide necessary set of parameters in real-time.

2. DESCRIPTION OF CONCEPTION OF THE MEASURING AND COMPUTING SYSTEM

Authors' experience in the field of production and exploitation of weather measuring system[5,6] allows us to offer composition of prototype experimental sample measuring and computing system for mesoscale monitoring ABL (MCS) (fig. 1). System include**s** measuring network which consist**s** of stationary measuring complex (SMC) and mobile measuring

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21st International Symposium on Atmospheric and Ocean Optics: Atmospheric Physics,
edited by G. G. Matvienko, O. A. Romanovskii, Proc. of SPIE Vol. 9680, 96805Z
 · doi: 10.1117/12.2205475

Table 1. Specification of ultrasonic weather station AMK-03

Measuring value	Range	Error
Temperature of Air T, °C	-50…+55	±0.3, at T ≤ +30 °C ±0.5, at T > +30 °C
Horizontal wind velocity V, m/s	0…40	±(0.1 + 0,02 V)
Wind direction D, grad	0…360	± 2
Vertical wind velocity w, m/s	–15…+15	±(0.1 + 0.02 w)
Humidity r, %	5…100	±2.5, at T > 0 °C; ±5, at T ≤ 0 °C
Atmospheric pressure P, mm Hg.	523…800	±0.25
Measurement temperature air	Ultrasonic	
Frequency sampling	80 Hz	

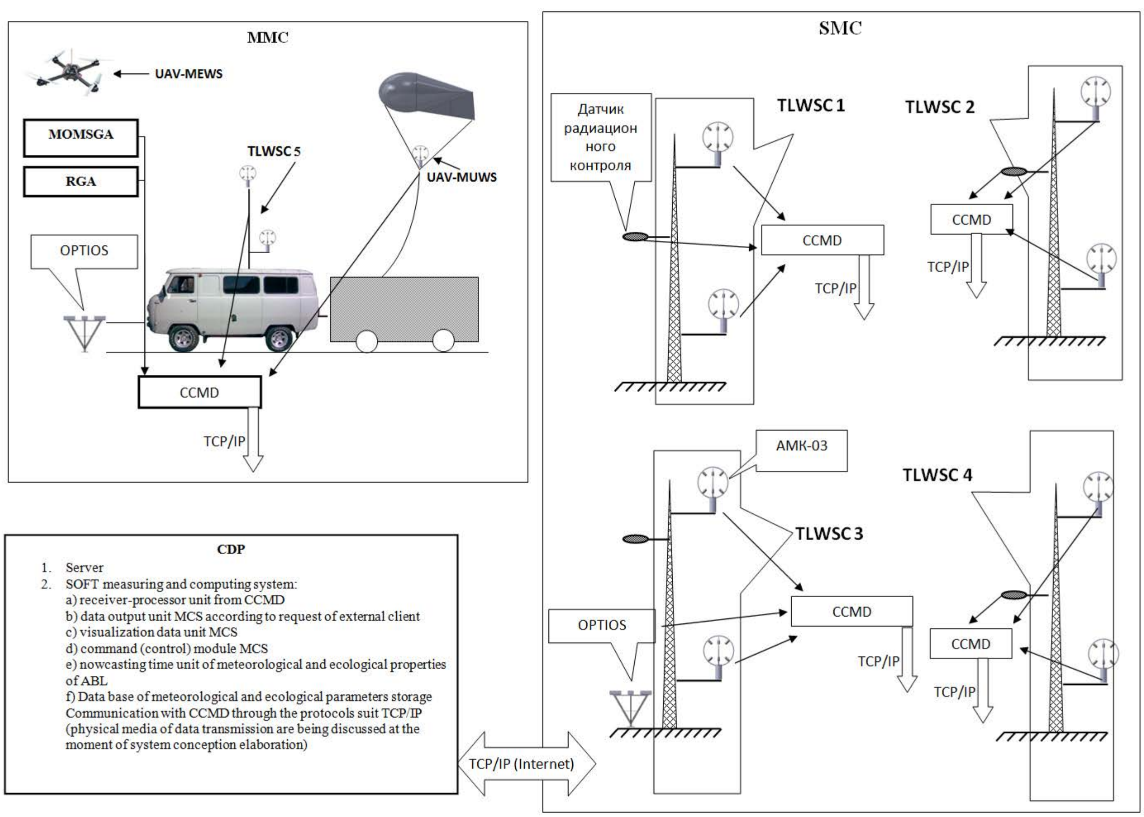

Figure 1. Composition of experimental sample measuring and computing system.

complex (MMC). SMC includes four spatially placed in the controlled area three level weather station complexes (TLWSC) made on the basis of ultrasonic weather station AMK-03 which are placed on 2, 10 and 30 meters. AMK-03 allows one to measure general meteorological data with frequency sampling 80 Hz. It will enable to compute energy and spectrum of turbulent in ABL, which is necessary for determination of atmospheric stratification type and recovery vertical profile.
Farness from each other and quantity of TLWSC on the one hand is defined by the scale of territory and on the other hand is limited by the correlation of station together.

Moreover sensors of radiation and optical device for precipitations measuring (OPTIOS) is planned to be included in composition of the stationary complex. OPTIOS is based on the method of shadowgraph for precipitations measuring [7]. OPTIOS makes multi-section scan of each spot which hits the test site. Form, size and volume of spot is recovered according to the scanned cross section. This method has high sensitivity to measure quantitative adjectives of precipitations. It allows us to determine their structural properties. Major properties of optical device for precipitations measuring are given in the Table 2.

Table 2. Specification of OPTIOS

Measuring value	Value
Size particles error	10^{-1} mm
Relative error of particle size measure	no more than 5%
Range of particle size	0,3-10 mm
Relative error of velocity particles	No more than ±3 %
Sensitivity of precipitation quantity	No less than $2 \cdot 10^{-4}$
Size of test site	50 mm^2
Regime of measuring	real-time regime

Except TLWSC and OPTIOS, MMC has touch probing device for measuring profile weather data and gas pollution in the atmosphere. Unmanned air vehicles of a hexacopter type and tethered balloon are used in order to raise the meteorological probe high in the sky. On hexacopter there will be installed mobile electronic weather station (MEWS) with resistance and capacitance gages which will measure temperature, humidity and atmospheric pressure. On the tethered balloon there will be installed mobile ultrasonic weather station (MUWS) which will measure turbulent properties of ABL. The height of balloon fly is 1500 m. Data from mobile electronic weather station and mobile ultrasonic weather station will be transmitted via radio channel.

System of ecological monitoring includes: mobile optical multicomponent system of gas analyses (MOMSGA) consisting of gas analyzer based on Raman scattering (RS). Gas analyzer based on transverse Zeeman Effect is used to measure mercury vapor in atmosphere. MUWS will measure concentration of next gases: CO_2, CO, NO, NO_2, CH_4, CH_3OH, SO_2, NH_3, formalin, benzol, toluol. The list of gases can be expanded without hardware change by addition etalon spectra in database.

All components of the system are equipped with controller of collection and manipulation of data (CCMD) which is based on industrial computers. CCMD receive data from TLWSC, OPTIOS, MEWS, MUWS, MOMSGA, it makes their preprocessing and transition processed data to receiving and preparation unit of center of data processing (CDP). The usage of standard industrial PC will enable one to supplement the system easily with new sensors and alter or supplement algorithms of preliminary data processing.

CDP except from store and processing provides their visualization. CDP makes store, processing and visualization of data. Hardware of CDP MCS allows us to use not only statistic method but hydrodynamic model of prediction (forecasting). Software includes unit of receive and preprocessing weather data from CCMD, unit of data output to the client software, unit of MCS visualization data, unit of very short-range temporal forecasting of , the data base storing meteorological and ecological parameters ABL.

CONCLUSIONS

This conception of measuring and computing system based on exists algorithm data processing of continued measurements can provide control of the field of meteorological parameters on the space limited by the points of located stations and its recovery (extrapolation) on the space which is outside of the net - on the external, “meteorologically lightless” territory in any given direction. The extrapolation deep of outside field of meteorological parameters is defined by step of measuring network and relief and it can achieve several dozens and several thousand of kilometers. Existing in monitoring system the mobile measuring complex allows us to change configuration measure network, it is adapted to real environment, and it is made to control measurements for approbation and testing the forecasting method.

In mobile version this monitoring system can be used to resolve a special task which requires using mobile measuring network. For example monitoring area is not covered by measuring network, on which natural or technological disasters have happened.

ACKNOWLEDGMENTS

This work was supported by the Agreement No. 14.607.21.0030 (unique identifier is RFMEFI60714X0030) within the Federal Target Program "Research and Development on Priority Directions of Development of Scientific-Technological Complex of Russia for 2014–2020".

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