Use of a Motor-Deltaplane as a Platform for Placing of Sensors Measuring Optical and Meteorological Atmospheric Characteristics

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Introduction

Global climate change forecasted by a number of scientists, at the expense of change in the radiation balance of the earth, which is caused by the increased discharge of gases into the atmosphere, requires the detailed study of the interaction between electromagnetic radiation and air at the transfer from the sun to the underlying surface of the earth. It is rather expedient that such research should be four-dimensional in nature (space + time).

Basically, the system for monitoring the propagation of solar radiation in the earth's atmosphere—beginning with ground posts and stations and finalizing with space apparatuses—has been created. However, researchers are not always satisfied with data from this system on space or time resolution. Therefore, to obtain results necessary in our experiments, we resort to use of various platforms on which the sensors are established and which move in space (sondes, aerostats, aeroplanes, rockets, etc.).

From this list, the aeroplane-laboratories are the most informative and responsive to a wide array of requirements (Belan 1993). The defects one may attribute to this method are only that it is rather expensive and requires a specific infrastructure. Therefore, a search for new kinds of platforms for sensors on them is in progress. The present work describes our use of a motor-deltaplane for such purpose.

Equipment

A model motor-deltaplane MD-2, a product of the Taganrog aircraft factory, was used as a base for siting the following optical and meteorological sensors: the gauge of a radiance of clouds on the basis of photoresistance, an M-10M balance-meter, an M-115M pyrometer for measuring downward and upward summary radiation, temperature and humidity of air gauges, pressure gauge for reference of data for height, a nephelometer, and a filter. Figure 1 shows the arrangement of the equipment on the deltaplane.

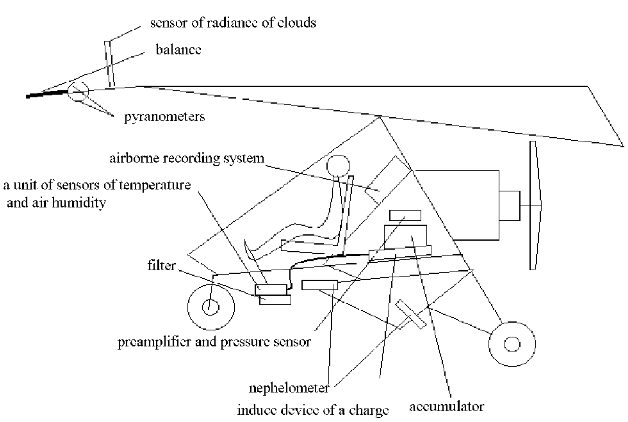

Figure 1. The arrangement of scientific equipment on the deltaplane.

The power of the whole system was supplied by an automobile accumulator. A vacuum cleaner was used to induce the charge. The gauges were connected to the airborne recording system by head amplifiers. The external volume nephelometer was fastened to a special frame, which was joined to the rigid part of the pendent design on the left side of the pilot. The accumulator, head amplifiers, pressure gauge, and recording system were placed in place of a passenger, behind the pilot, in the special demountable container, but ahead of a screw. Because of the danger of equipment hitting and damaging the propeller blades, we took specific safety measures, namely, the exclusion of easily moving units, unfastened conductors, etc. The data obtained in the air were recorded with the help of a specially developed recording system (Zuev et al. 1992, Mirmovich et al. 1979).

The requirements for the system were stringent: it must be easy to use, portable, and capable of automatically recording as many as nine various parameters in strong vibrations. It was also necessary to take account of the influence of electromagnetic fields from the ignition system and airborne radio station. Including the above, at development it was decided to reject the storage of information, incorporating any mechanisms, and to apply the storing devices of semiconductor memory. A one-crystal i80196KB microcontroller from the Intel firm served as the base of the complex.

System specifications are presented below:

Repetition frequency of processor, MHZ	10
RAM volume, Kilobyte	512
ROM volume, Kilobyte	8
Number of recording parameters	9
Dynamic ranges of source signals for	
Analogy inputs, dB	60
nephelometer, dB	80
Particle size counter, dB	90
Time of running record, hr	3
Time of running work from internal energy source, hr	10
Operating temperature, C	-40 - + 60
Weight, kg	Not more 2
The dimensions, mm	300 X 200 X 40
Model	vibration-resistant, noise-proof

To record and read data, a 512-kilobyte SRAM-512 PC-card (old name was PCMCIA-card) from Mitsubishi was applied. An interface of the PC-card has been organized by hardware and by software. A built-in nickel-manganese accumulator with a voltage of 12 V and a capacity of 2.5 A/hr supplies power to the system.

Computer working programs are executed either from a computer console or by software through the sequential communication RS-232 port. All computer software has been written in assembler language. The program has 676 lines.

The nephelometer has been developed specially for installation on the deltaplane. The device records scattered radiation, including that in clouds, with a frequency of 1 Hz. The nephelometer operates under the control of an airborne recording system. The nephelometer records the scattered radiation at an angle of 45, which was chosen because this radiation correlates to the utmost with the integrated characteristic of aerosol scattering—total scattering coefficient (Panchenko et al. 1982).

Structurally, the device has been mounted on an easy rigid frame of duraluminium. The central part of the device is open, which permits the nephelometer to operate in any position. The transmitters and receivers in the nephelometers are lenses; they are outfitted with lengthened blinds, which are also protective casings. Opposite of each receiver, the black screen is situated so as to decrease the level of ambient background illumination. The compact electronic blocks of the transmitter and receiver are anchored directly to the coil of the device.

Results and Discussion

The tests of the motor-deltaplane equipped with the above-mentioned equipment were conducted from August 26 till October 10, 1996, near Tomsk, Russia. The flights were conducted on the following program:

- switch-on of recording equipment; recording of 5-sec realizations
- start of deltaplane motor, switch-on of data recording
- taxi and take-off
- climb to 100 m, the aisle of 11-sec platform at this height over a square
- similar platforms were conducted at heights of 200, 400, 800 m and at high cloudiness at height of 1600 m
- climb to the bottom of the clouds, switch on a vacuum cleaner in 30 min for the aerosol intake on a filter
- sharp descent with speed of the order of 4 m/sec and land
- turn off data-recording mode, disconnect the recording unit from gauges without switching on power and transport it into the laboratory of the Institute
- read data from PC-card of recording unit into a computer through a sequential port
- turn off unit power
- accumulator charging of the recording unit.

A smooth field, 1500 X 1500 m on the left bank of the Tom river, was used as a take-off platform. The flights at platforms of 100, 200 and 400 m have been executed for the purposes

purposes of flight safety over this platform. More high platforms have been executed over a city and over a suburban zone.

For illustration, the vertical profiles of a number of quantities obtained in one of the flights are shown in Figure 2. One can see from this figure that with the help of the motor-deltaplane, we are able to record a rather thin structure of the vertical distribution of optical-meteorological quantities. At the same time, not all inflections on the curves coincide at a take-off and a descent of the deltaplane, especially in radiation measurements. Apparently, it has happened because the flights were executed above an inhomogeneous surface, which has a different albedo; this has had an effect on measurement results.

The tests of the deltaplane also have revealed a number of disadvantages, which require finishing. In particular, a more reliable pressure gauge for a sharp "reference" of data to height is necessary. The additional measures to overcome the effect of vibration on devices and neutralization of electromagnetic interference on scientific equipment are necessary. For radiation measurements, the selection of a platform with uniform underlying surface is desirable.

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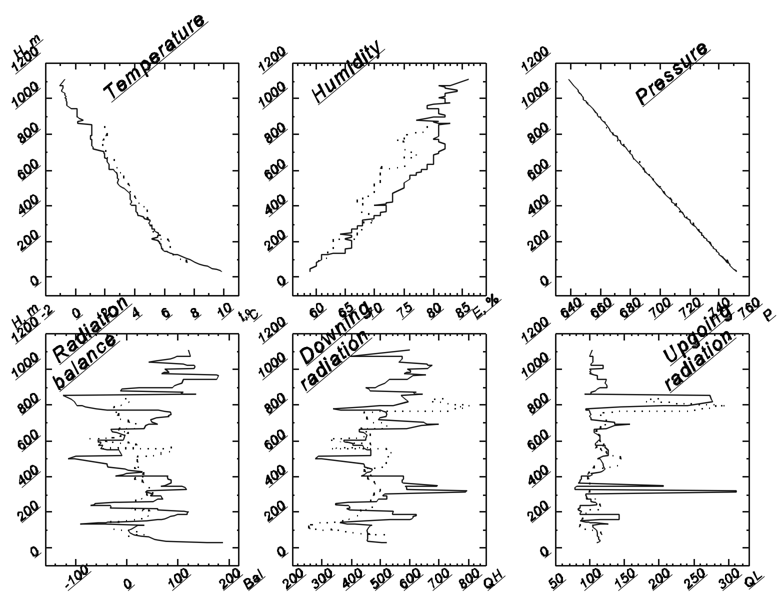

Relative units

Figure 2. Vertical profiles of optical and meteorological characteristics on September 29, 1996, beside Tomsk city: take-off of the motor-deltaplane (solid line), descent (dotted line).