

V.P. Yushkov¹, M.A. Kallistratova², R.D. Kouznetsov²
**SODAR APPLICATION FOR WIND VELOCITY MONITORING IN THE ECOLOGICAL
EDUCATION TASKS**

¹ Physics Faculty, Lomonosov MSU,
Leninskie Gory, 119992, Moscow, Russia

² Obukhov Institute of Atmospheric Physics of the Russian Academy of Science,
Pyzhevsky per., 3, 119017, Moscow, Russia
E-mail: yushkov@phys.msu.ru

Good background and clear understanding of the physical mechanisms of signal interaction with a researched medium is required to develop and operate the modern high-technological equipment suitable for remote meteorological measurements. Therefore, the educational programs for the graduate students, for example, in the field of meteorology and physics of the atmosphere should include the practical training of the ability to apply remote sensing devices for the measurements of atmospheric parameters. The acoustic remote sensors (sodars) are the simplest and economically accessible ones in the group. The experience of sodar operation provides a good opportunities to understand better the complexities, lacks and potential of remote sounding as a method. This paper presents a new sodar LATAN-3 which is characterized by open adjustable software control and flexible data processing techniques. The brief description of LATAN-3, mounted at two sites: in the center of Moscow (in IAPh) and in the south-west of Moscow on the roof of the Physics Faculty building of MSU are presented. The procedure of the instrument adjustment for training purposes is described.

The role of remote sensing has grown up during the last decades of geophysical measurements. Special attention in the research programs is paid to the environmental monitoring including air quality control in big cities. Involvement of geophysics in these problems is connected with a necessity of understanding of: 1) the physical principles of measured signals formation, in particular, while applying remote sensing devices and 2) connection between registered signals and environment state. However, many newly developed sophisticated instruments and details of their operation are not considered in the high school curricula, and hence the theoretical principles, for example, of remote sensing are not supported by familiarization with experimental devices. The Doppler acoustic sounding of the atmospheric boundary layer is the simplest and inexpensive method of geophysicists training [1].

Doppler acoustic sounder – sodar – measures vertical profiles of the wind speed and direction in the lowermost part of the atmospheric boundary layer (ABL). The basic principle of sodar operation is registration of the sound wave scattered by small-scale turbulent irregularities of temperature. These irregularities are dragged by the air flow, and serve as natural moving targets for Doppler measurements of wind velocity. Time delay of returned signal can be easily associated with a scattering height. Besides, sodar demonstrates a mesoscale turbulence structure and allows determining a number of parameters important for meteorology of pollution: a type of atmospheric stratification, height of a mixing layer, duration of surface and elevated inversion layers, dispersion of vertical speed [2].

The recent achievements in different scientific areas are combined in sodar: the turbulence theory, the theory of wave propagation in non-uniform medium, the Doppler technique and the methods of stochastic signals statistical processing. Therefore the use of sodar in educational process allows the students not only to master new equipment, but also to fill up and to apply the knowledge of mentioned above subjects. The relative simplicity of sodar design and its electronics makes it a convenient object for upgrading and improvement in the frames of students' scientific work. If sodar is used in a hands-on training in the meteorology and atmosphere physics, the obtained experience increases the background knowledge level of students which is necessary for modern high-technology atmosphere researches.

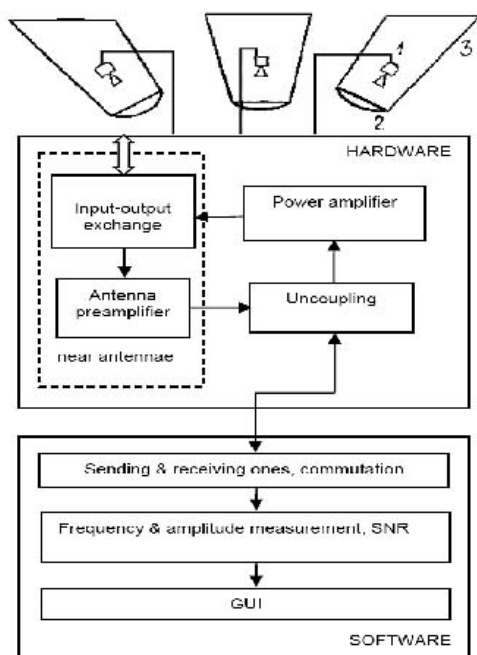
Atmosphere Physics Department of MSU Physics Faculty together with Obukhov Institute of Atmospheric Physics realizes a mutual program of geophysicist - students training as and addition to a regular environment monitoring.

For educational purposes the concept of “computer device” was realized in sodar named LATAN-3. Main sodar functions are assigned on computer: the control of parameters of transmitted impulses and received echo-signal, generation of sounding signal and echo-signal filtering, analysis of the signal/noise ratio and the Doppler shift value, visualization of turbulent structures and wind profiles, statistical processing and data transfer.

Sodar contains only four simple electronic units: power amplifier, transmit-receive commutator, microphone preamplifier, and power supply with uncoupling scheme. In contrast to the commercial “computer” sodars, LATAN-3 doesn’t contain any special microprocessor, and all manipulations are executed on inexpensive standard PC. Important attribute of this sodar is pulse-by-pulse data processing, which provides a good time resolution (about 15 sec) of wind profiles and complete set of statistical estimates.

The program control of sodar operation provides a device flexibility, i.e. allows changing a number of parameters like carrier frequency, the impulse length and signal waveshape, the duty factor and the sounding height, vertical resolution of the received signal, as well as adaptation of data processing to different geometry of sound rays and so on. All parameters are controlled by configuration files. The text format of data files enables wide application of standard UNIX commands for their sampling, sorting and processing. Synchronization of sounding cycles with the world time is performed through Internet, as well as remote monitoring of sodar work and data obtaining.

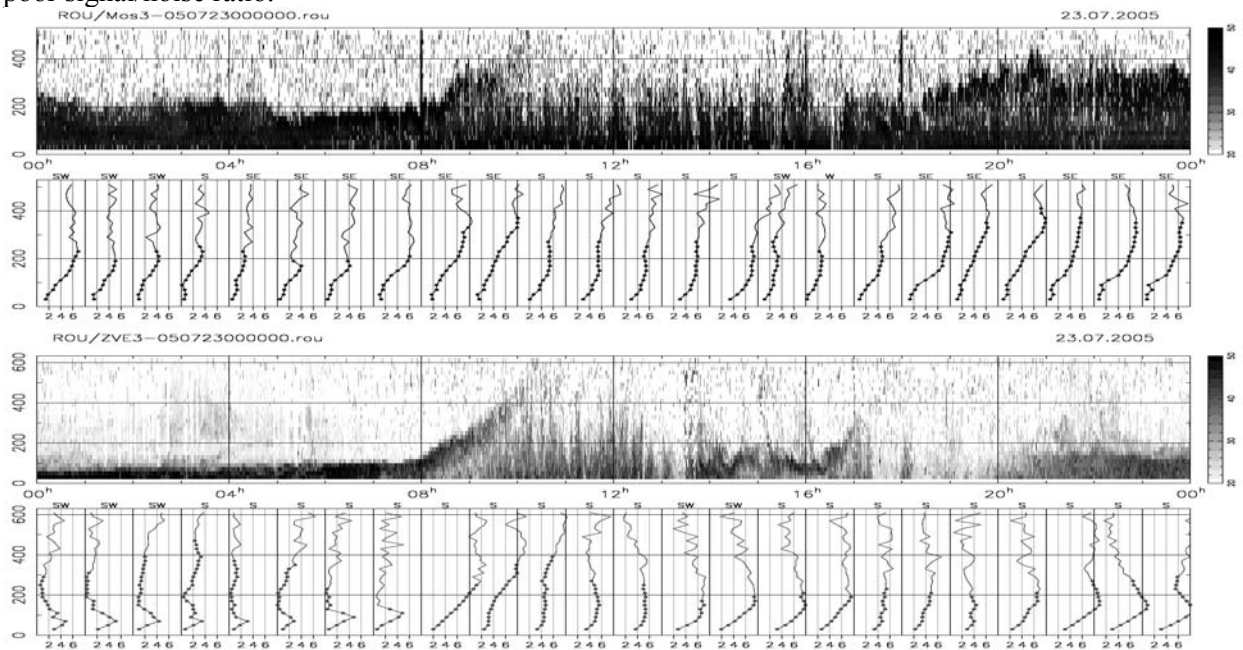
Fig. 1. shows LATAN-3 circuit and antennae in acoustic baffles on the roof of the Physics Faculty. (The main building of MSU is seen in the background)



The detailed description of the device specifications and the comparison with the results of simultaneous in-situ wind measurements can be found in [3].

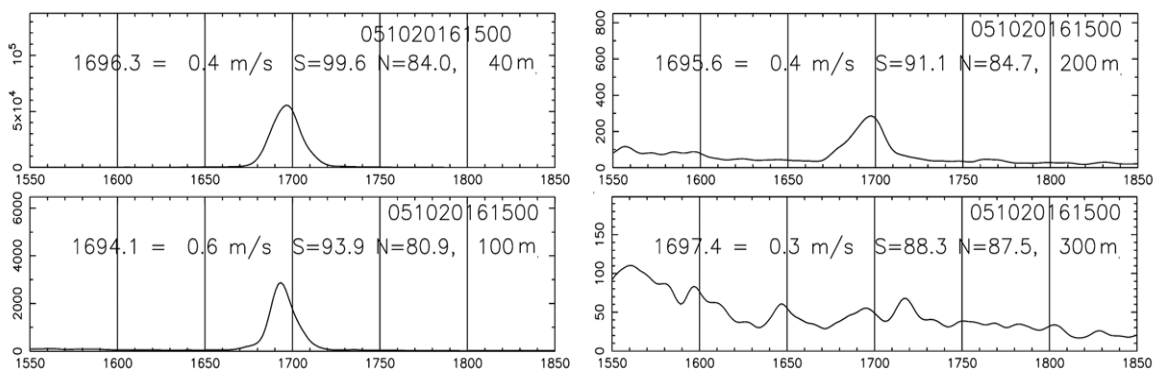
Fig. 2 shows the sodar echograms (top) and 30-min averaged profiles of the wind speed (bottom) in simultaneous measurements in Moscow (above) and suburb area (Zvenigorod, below). In the figure X-axis is Moscow time in hours, Y-axis is an altitude above the sodar antenna in meters. The blackening scale indicates the level of echo-signal in dB, which is an indicator of turbulence intensity. Profiles of the speed

are plotted by dots with lines for stable data, and by lines for unsure data. The latter case corresponds to the situation when more than 75% of the measurements results are rejected from processing because of the poor signal/noise ratio.



Due to relative sodar simplicity, student, as a part of scientific work, may replace a type of speaker set in the focus of the parabolic antenna, horn or even the reflector. A slight modification of sounding frequency or signal filtration algorithm, updating of sodar program management are also available.

The statistical generalization of data under noisy conditions can be a valuable teaching tool. Fig. 3 shows a 30-min averaged echo-spectra realizations at the different altitudes (40,100,200 and 300 m above sodar antenna). Signal (S) and noise (N) levels are presented in logarithmical scale. The influence of the urban noise at greater heights is evident.



The aim of this experimental task in a student's hands-on training is not only to extend knowledge in the field of atmospheric acoustics, but also to obtain experience in the modern technologies application in the real ABL studies.

Acoustic remote sensing of ABL gives students good opportunities to improve an understanding of both atmospheric acoustics and turbulence dynamics. Student - acoustics can better understand the principles of sound propagation in the turbulent medium, can get an idea of the ratio of acoustic to stochastic pulsations of pressure, to observe the influence of turbulence spectrum on intensity of scattered

sound wave, to evaluate the relationship between signal intensity, its attenuation and range of sounding, and the influence of wind and temperature fluctuations on sound propagation and frequency shift. Student - geophysics receive a unique chance of ABL investigation up to the heights, which are inaccessible with standard meteorological masts. Recent years of geophysics development have demonstrated an increasing enthusiasm about numerical modeling application instead of measurements. To greater extent this problem touches educational courses. Lack of funding and experimental equipment drive the students to solve "computer tasks" which connection with reality is not always clear.

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