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SOME RESULTS OF ATMOSPHERIC CURRENTS AND ACOUSTIC-GRAVITATIONAL WAVES MEASUREMENTS IN APATITY

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Abstract
The preliminary results carried out at the atmospheric range of PGI in Apatity of complex measurements of atmospheric current, acoustic-gravitational waves and meteorological parameters are provided. The brief description of an atmospheric pressure gauge developed on the basis of small-size liquid microbarograph and its electronic circuit is given. Such two gauges are established with spatial spacing of about three kilometers. Presented are also a system of registration of atmospheric electrical current and a block diagram of the system of data connecting. It is shown, that there are intervals, where on frequencies of about 0,001 Hz time periods are observed, when the forms of signals from both microbarograph and antenna of atmospheric currents practically coincide. Thus, in conditions of weak wind (~ 1m/sec) the length of the interconnected signals can reach 2,5 hours, whereas in windy weather only 30-40 minutes.

1. Introduction
Atmospheric electricity studies have been carried out for a long time. There are many papers and monographs related to this field of research [2,5]. However, still many questions are remaining open. Particularly there is a long standing problem on the relationship between heterogeneities in the atmospheric layer in the vicinity of the Earth surface and its influence on the fine spatial structure of the atmospheric current. Moreover, the interconnection between atmospheric current and some other atmospheric parameters (such as atmospheric pressure, wind velocity and direction) is still remaining incompletely studied.
This paper presents a measuring system built to measure atmospheric current variations and atmospheric pressure micro-pulsations. Moreover, we hope that this system will let us separate atmospheric currents concerned with atmospheric heterogeneities and global electric circuit currents. Analyses of some statistical characteristics of atmospheric current signals are discussed and the interconnection between the atmospheric pressure and atmospheric current in the frequence range of 0.001-0.005 Hz is presented.

2. The measuring system
The measuring system consists of two data acquisition systems which are connected with a local time server. This time server supports Network Time Protocol (NTP) widely used over Internet. The source of accurate time is a GPS receiver. All computers in the measuring system have LINUX operational system. Data acquisition stations have a real time kernel and it allows time shifts to be of the order of tens of microseconds.
Atmospheric currents antenna consists of two identical parts as shown in Figure 1. Each part is a long wire line which is placed 4 meters above the earth surface. The distance between the parts is about 20 meters.
The long wire line can collect atmospheric current from the region with width *L*. This width may be calculated by equation:

$$L \approx 2\pi(h-d)/\ln(2h/d) \qquad (1)$$

where *h* is height from earth surface and *d* is the wire diameter [4]. The effective square of antenna may be calculated by using equation (1) and wire line length.

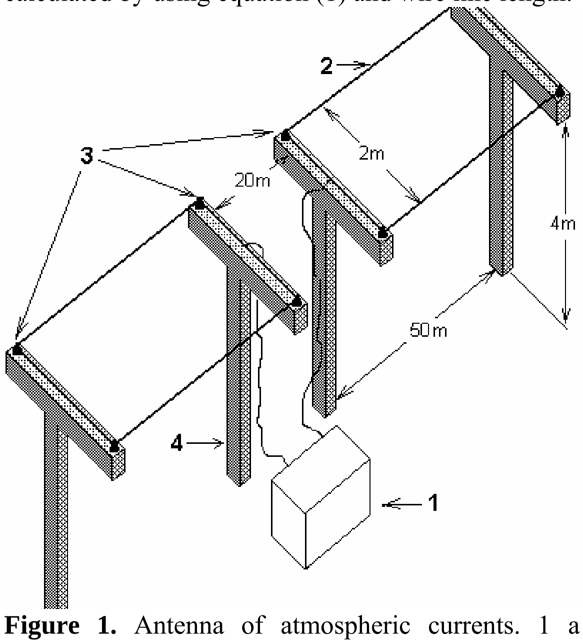

Figure 1. Antenna of atmospheric currents. 1 a geophysical data logger. 2 wire line. 3 insulators. 4 a support post.

Our antenna has an effective square which measures approximately 500 square meters. The wire antenna was chosen because it is less affected by the charge transfer currents (these are currents which are generated by air flow charge transfer) in comparison with solid plate antenna. [3] This antenna is connected to the geophysical data logger.
Geophysical data logger has 4 channels. One channel can digitize the analog signal with sampling rate 584 Hz and it has a dynamic range of 105 dB. Channels

have an accuracy of the order of 1 microvolt (used 22-bit ADC AD7716 that is produced by Analog Devices). The sampled signals are transmitted to the computer by RS-232 interface. The geophysical data logger may be separated from the data acquisition system by the distance of the order of several kilometers. In this case the sampled data can be transmitted by RS-485 interface.

The enhanced dynamic range of the geophysical data logger is provided by the complete galvanic separation between the analog and digital parts. This separation allows to exclude noisy digital circuit influence to the sensitive input of the first amplifier.

Two channels of our geophysical data logger are connected to antenna and two channels are connected to antenna equivalent circuit in order to control the internal noise of the geophysical data logger.

In order to reduce data size and to adjust it with GPS time samples it is filtered by low-frequency numerical filter and interpolated.

Microbarograph consists of two volumes as shown in Figure 2. The volumes are connected. They are filled with polymeric liquid by half. Each volume has a plate capacitor inside. The capacitor permittance depends on the liquid level in volumes.

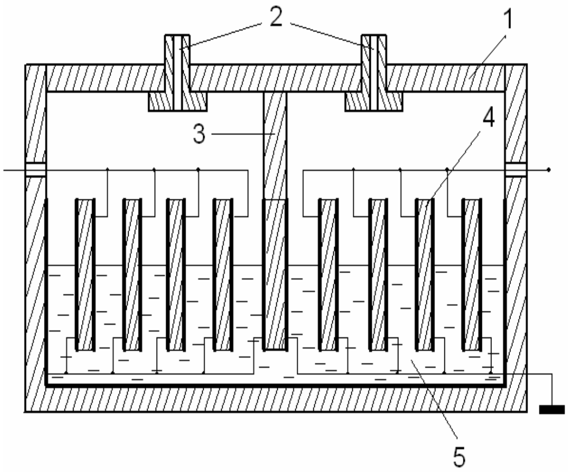

Figure 2. Microbarograph. 1 microbarograph body. 2 pipe sockets. 3 barrier. 4 the measuring capacitor plate. 5 polymer liquid.

This probe is connected to an electronic device, which converts the permittance value into digital signal and transmits this signal to the computer by RS-232 interface. The final data have a sampling rate of 5 Hz.

3. Observations and discussion

The measuring system, which we have described above, was used for the atmospheric current and atmospheric pressure micro pulsations at the atmospheric range of PGI in Apatity. Observations were carried out from October to December in 2005.

Analyses of some statistical characteristics atmospheric current signals are given for both fine and bad weather conditions. The fine weather conditions are slow wind velocity (less than 2 m/s) and the absence of precipitations. In order to show the meteorological conditions influence on the atmospheric currents signals statistical features, we chose two days in December (December 19 and 20), when the weather conditions changed from bad to fine. It is shown in Figure 3.

Figure 3 displays correlation coefficients between atmospheric currents signals recorded from two antenna's parts in the frequency range of 0.01-14 Hz (right panel) and wind velocity (left panel). It is obvious, that correlations coefficients depend on meteorological conditions and frequency. This dependence on meteorological conditions is caused by aero ionic flows, generated by wind [1]. The dependence on frequency is caused by the existence of natural sources (Shuman resonance frequencies) and atmospheric heterogeneities typical dimensions.

Correlation coefficients are steadily high and they depend on meteorological conditions very weakly at the frequencies lower 0.025 Hz. Probably, high correlations coefficients between signals from antenna's parts are caused by strong global electrical circuit influence on these frequencies and/or big atmospheric heterogeneities, which have typical dimensions greater of typical antenna sizes. In the frequency range of 0.025-1 Hz wind velocity influence is very strong. In frequency range of 1-7 Hz the correlation coefficients are steadily low and they depend on meteorological conditions very weakly. Probably, the low correlations coefficients between signals from antenna's parts are caused by small atmospheric heterogeneities influence, which have typical dimensions much less of typical antenna sizes. On frequencies of 8 and 13 Hz there are registered obvious first and second Shuman resonance influence in all whether conditions.

Investigation of the interconnection between the atmospheric pressure and atmospheric current is carried out in order to test two hypotheses origin of this interconnection. The first hypothesis assumes that, probably, the interconnection source is acoustical-gravitation wave influence on the electro sphere shape. Although data analyses results did not confirm this hypothesis we do not reject it once and for all. The second hypothesis assumes that local pressure gradients can make changes in the electrical structure of the surface atmospheric layer (spatial ion distribution and atmospheric heterogeneities). Obviously, these processes must be recorded with both atmospheric current antenna and microbarograph.

For frequencies less 0.005 Hz there were found record regions, where records of atmospheric current agree with atmospheric pressure. These records lengths depend on meteorological conditions (they depend on the wind velocity especially). Figure 4 presents atmospheric current and atmospheric pressure records that were obtained on 27/10/2005. The wind velocity was less than 1.5 m/s.

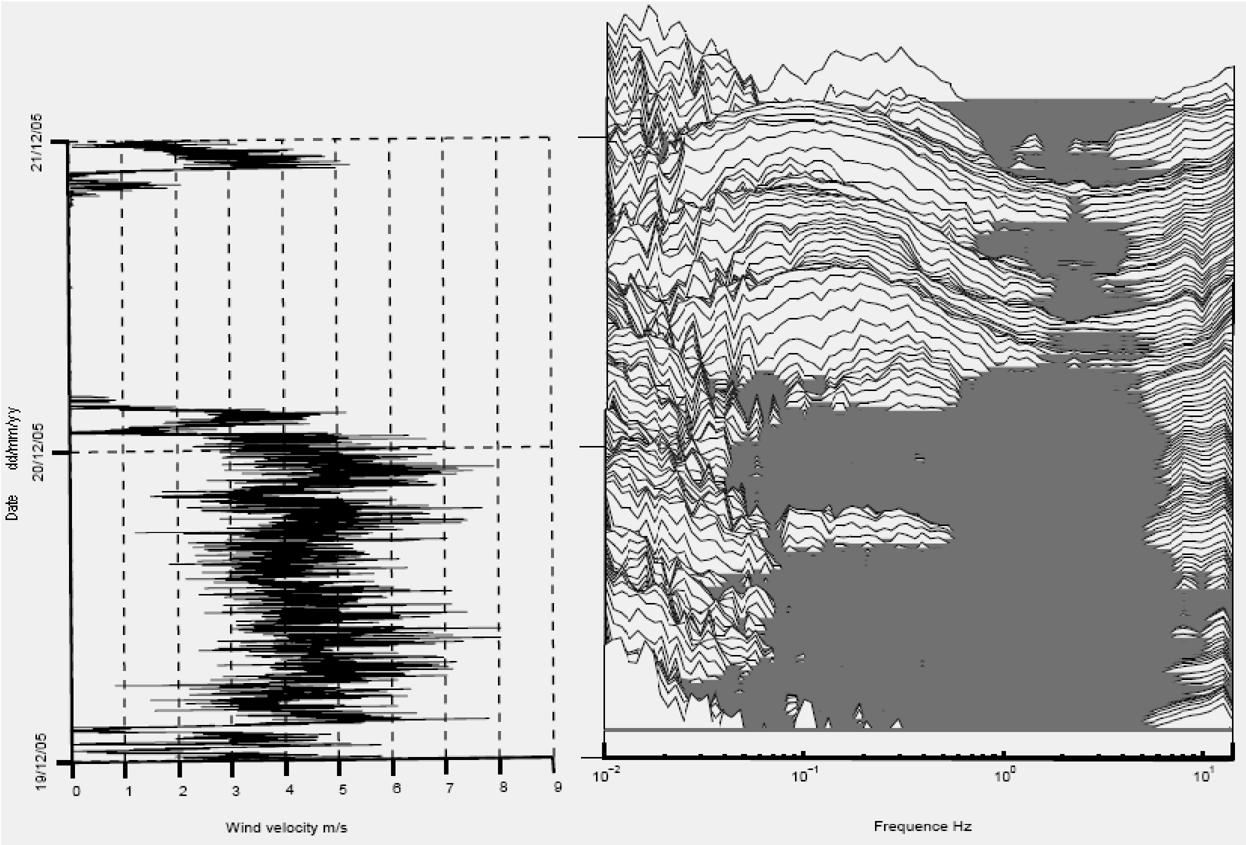

Figure 3. Correlation coefficients between atmospheric currents signals are recorded from two antenna's parts at 19-20 December 2005 in the frequency range 0.01-14 Hz (right panel) and wind velocity (left panel).

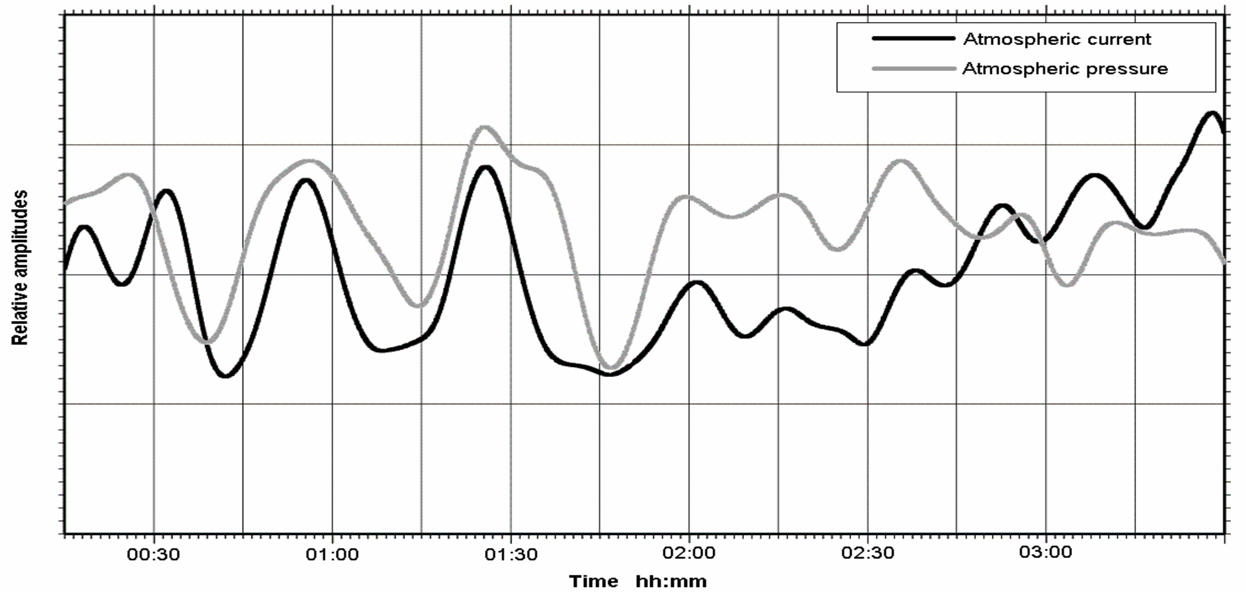

Figure 4. Atmospheric current and atmospheric pressure records were obtained on 27/10/2005 at the atmospheric range of PGI in Apatity. The records were filtered by low frequency Butterworth filter for frequency 0.001Hz. The wind velocity was less than 1.5 m/s.

4. Conclusions

The measuring system to measure atmospheric current variations and atmospheric pressure micro-pulsations is built and tested.

Some statistical features of atmospheric current antenna signals are analyzed and discussed. The influence of meteorological conditions on these features are studied.

Interconnection between atmospheric current and atmospheric pressure on frequency 0.001 Hz is found.

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5. References

Aspinall W.P., 1972: Mechanical-Transfer Currents of Atmospheric Electricity. JGR v.77, №18. (3196-3203).

Chalmers, J.A., 1967: Atmospheric electricity, 2nd ed. Pergamon, 515pp.

Cobb W.E., B.B. Philips, P.A. Allee. 1697: Note on mountain-top measurements of atmospheric electricity in northwestern United States. Monthly Weather Review v.95, №12. Dec. (912-916).

Roldugin, V.C., 2002: Measurement of atmospheric electric current by mesh collector. Techniques and methods of geophysical experiments. Book of science proceedings. PGI KSC RAS, Apatity. (154-165).

Wahlin, L., 1989: Atmospheric Electrostatics, Colutron Research Corp. 125pp.