Influence of meteorological characteristics on the dynamics of VAR in Gorno-Altaisk, Russia

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Abstract. The paper presents the results of monitoring the volume activity of radon (VAR) in the premises in Gorno-Altaisk for the period 2012-2017. The influence of meteorological characteristics on the dynamics of radon volume activity is shown, and a significant decrease in the level of radon emanations in the summer period compared to the winter period, presumably connected to ground freezing, is recorded. Significant coefficients of mutual correlation of pressure and volume activity of radon were obtained.

1 Introduction

In our research, the geological environment is regarded as a space with a high level of stored energy, i.e. as an energy-containing, energy-saturated environment that has many hierarchical structural relationships [1]. At the same time, the geological environment saturated with structural stresses is seen as a thermodynamic system in which, under load and the destruction of structural bonds, there is an intensive fluid degassing of gases from the lithosphere into underground water and the atmosphere, i.e. there may be changes in the characteristics of hydrogeological, geochemical, and atmospheric characteristics of the environment [2-5].

We used the dynamics of meteorological parameters, and the dynamics of radioactive gases (radon, thoron) while transporting them to the atmosphere and groundwater as an indicator of changes. In addition, it is necessary to take into account that the level of groundwater surface depends on seismic influences, whereas this dependence leads to changes in the capillary equilibrium of moisture, which controls sorption-desorption from the surface of the massive of soil radon, proportionally changing the mode of air exchange with the surface atmosphere and the degree of saturation of groundwater with radon [6-9].

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2 Results of the analysis of the influence of meteorological characteristics on the dynamics of the VAR

To analyze the influence of meteorological characteristics on the dynamics of the VAR, we used data from the radon monitoring of Gorno-Altay State University for the period 2013-2016. At the same time, observations were made on the following parameters: the dynamics of radon, toron, as well as meteorological characteristics: temperature, humidity, pressure.

As a result of studying the dynamics of the VAR, a seasonal periodization of the dynamics of the VAR was identified. Figure 1 clearly highlights the annual dynamics of the VAR, which indicates the leading role of seasonal factors in the dynamics of the VAR, i.e. the annual dynamics of the VAR in Gorno-Altaisk is characterized by an increased value of the VAR during the winter and early spring months of December – March (VAR 400-450 Bq/ m^3). Noted that the dynamics of the toron coincides with the dynamics of radon, the correlation coefficient is 0.89 at Rcrit=0.1.

During the spring months, a decrease in the level of VAR is from 250 to 150 Bq/ m^3. From June to September there is a minimum value of VAR up to 100 Bq/ m^3. From September to mid-November there has been a dramatic increase in VAR from 150 to 220 Bq/ m^3. Since the beginning of December there is a further increase in VAR, which reaches 350-400 Bq/ m^3. These seasonal changes were accompanied by sharp peaks (enhancements VAR), in some cases, these increases were correlated for the years between them. The correlation coefficients of the VAR by year are as follows: 2013-2014-0.24, 2014-2015-0.65, 2013-2015-0.48, (significance level 0.01, Rcrit=0.14) [1]. Given that data for 3 years is shown here, we can assume that these patterns are the result of seasonal characteristics. In this case, this may be due to ground freezing (in the climate zone of Gorno-Altaisk, it is about 1.5-2 m). Frozen ground prevents the free migration of radon, which can accumulate under the cover of frozen rocks. Therefore, finding ways of migration, which can be buildings and private homes, the emanations of radon significantly increase in comparison with other seasons of the year.

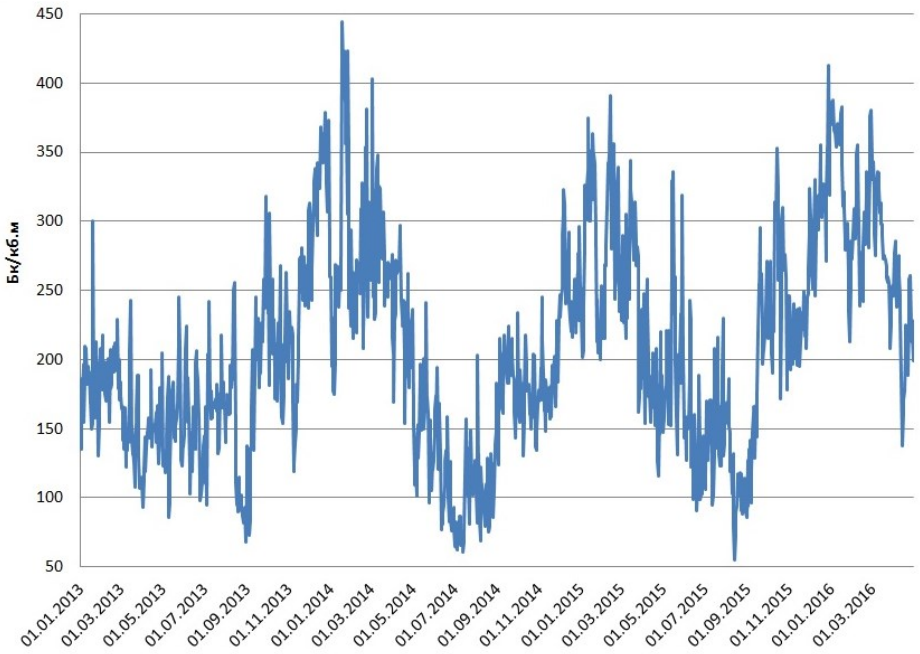

Figure 1. Dynamics of VAR in Gorno-Altaisk for 2013-2016

For a detailed study of the effect of changes in atmospheric pressure on the dynamics of the VAR, consider the change in the VAR and atmospheric pressure in 2017 in Gorno-Altaisk (Fig. 2-3).

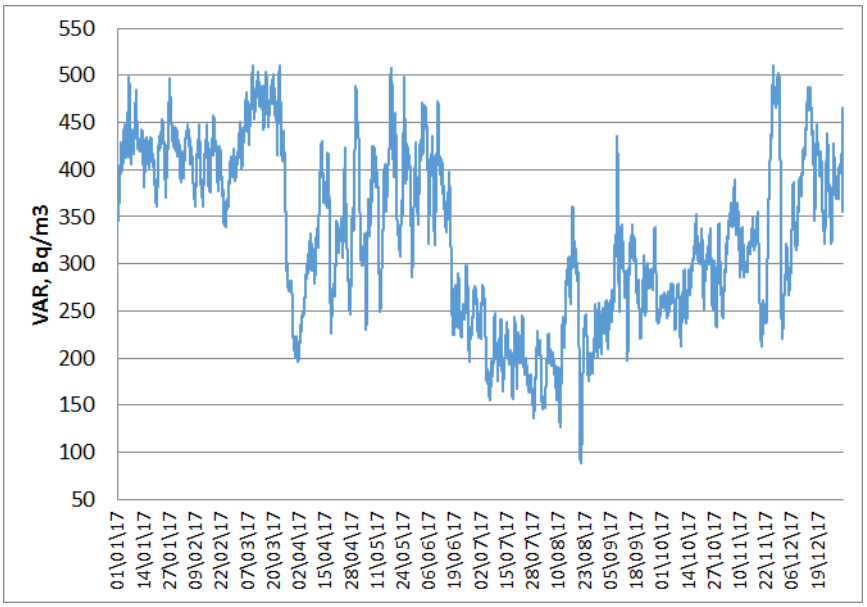

Figure 2. Dynamics of average daily values of radon volume activity in Gorno-Altaisk in 2017 (Bq / m^3)

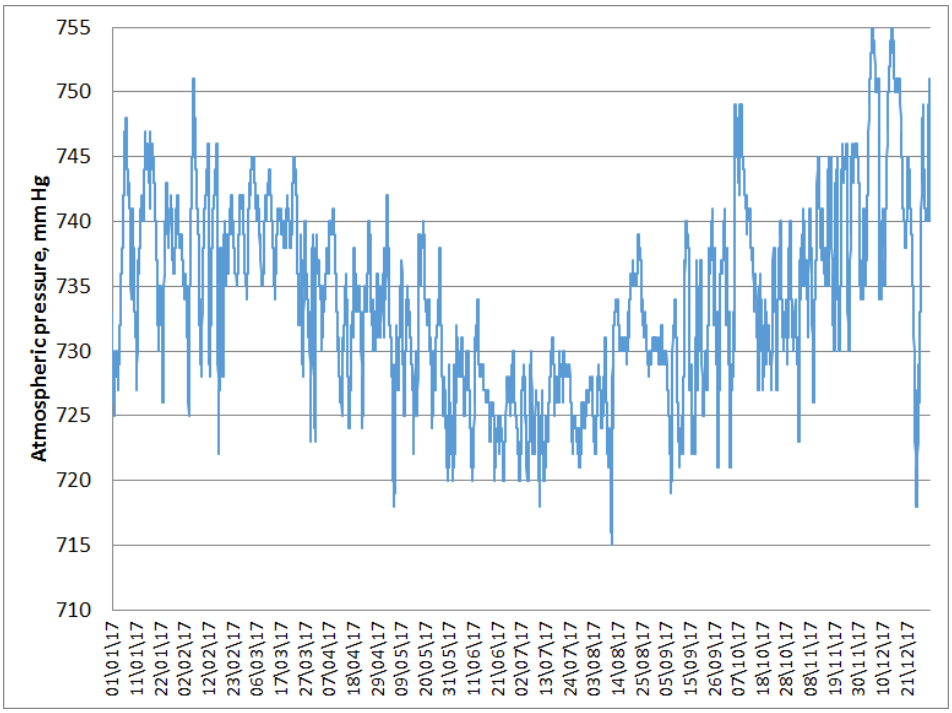

Figure 3. Dynamics of atmospheric pressure in Gorno-Altaisk in 2017 (mmHg)

Correlation coefficient of the dynamics of the VAR and atmospheric pressure R=0.45, (significance level 0.01, Rkrit=0.14). Note that the literature shows a negative coefficient (R=-0.4 P=0.006), which may be due to different climatic characteristics of the regions [8-9].

Comparing the average daily course of atmospheric pressure and radon activity, it should be noted that their anomalies do not coincide in time. It follows that in this case, most of the radon activity anomalies are not directly related to the baric field disturbances, or the influence affects after a while.

Given that the influence of atmospheric pressure on the dynamics of the VAR may affect later, we used the method of sliding correlation. The number of counts per day is 65, the sliding window is 7.7 days, and the confidence correlation is 0.01 Rcrit=0.1.

3 Conclusions

As can be seen from the course of the curve, the mutual correlation of the VAR and atmospheric pressure is significantly heterogeneous, and is probably related to the cyclonic activity of the region. This determines the short curve of increased levels of correlation of the studied characteristics.

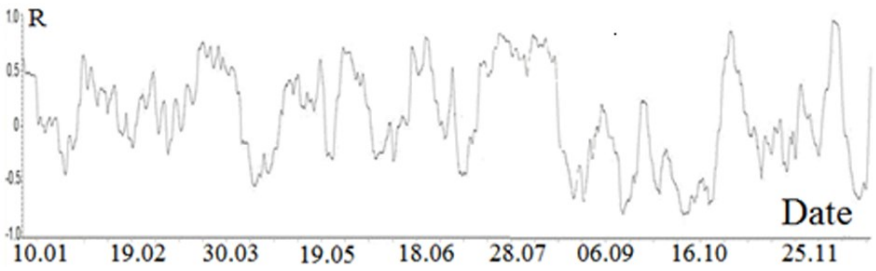

Figure 4. Sliding coefficient of correlation between the VAR series and atmospheric pressure in 2017

As a result of the analysis of monitoring data of radon volume activity in Gorno-Altaisk for the period 2012-2017, the following seasonal patterns were identified:

1. The Volume of radon activity in the premises of a private house has clearly expressed seasonal patterns, namely, an increase in the level of VAR in the winter months, starting from the end of September to the beginning of April.

2. This pattern is associated with the freezing of the ground and the inability to migrate radon from the interior to the surface of the earth and the movement of radon emanation in areas where the ground does not freeze – the location of heated houses.

3. Shows the General relationship of atmospheric pressure and VAR in Gorno-Altaisk.

4. While using the sliding correlation coefficient of the VAR and atmospheric pressure, short sections of a sharp increase in the R value of these characteristics were identified, apparently associated with cyclonic activity in the Altai region.

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