Reflection of Seismic and Solar Irregularities in Hydrogeological Fields of Kyrgyzstan

Jumagul Kendirbaeva[1,*]

[1] *Institute of Seismology of the National Academy of Sciences, Bishkek, Kyrgyzstan*

Abstract. The unity of exogenous and endogenous components in the regime of hydrogeological fields of Kyrgyzstan is shown on the basis of the addition of the index of solar activity as a participant in the system of «atmospheric–cosmic phenomena–groundwater–earthquakes».

The output of changes in concentration in hydrogeological fields beyond both the minimum and maximum levels is divided into a system with stable and unstable equilibria. Various effects in a water-gas mixture are associated with inhomogeneous paths of their penetration, including from solar activity. It is believed that taking this into account can serve as the basis for the integration of methods based on the theory of pulsating earth and reflection theory in the search for harbingers of natural disasters.

1 Introduction

One of the promising regions for earthquake forecasting is the Kyrgyz Tien Shan, where a deep heterogeneity is identified with which the blocks of the earth's crust are connected, differing in thickness (from 20 to 40 km), density ($2.75-2.85$ g/cm^3) and material composition. On the territory of Kyrgyzstan, which occupies a large part of the Tien Shan mountain-folded system, more than 5000 earthquakes are registered annually, of which 5–10 are noticeable on average, and strong tremors occur every 3–5 years. So, over the past 60 years, the largest Suusamyr earthquake occurred with $Ms = 7.4$ (1992), where it was not expected.

Material damage amounted to more than 50 million US dollars, 52 people were killed and part of the Bishkek-Osh road was destroyed, and the consequences are still felt. Such seismicity is natural, because there are three zones bounded by active faults: the first separates the Tien Shan from the Pamir and the Tarimmicroplate, the other the Western Tien Shan, articulating with the Talas-Fergana and South Fergana faults, and the third the Northern Tien Shan, where the series faults of the same name cover the border regions of Kyrgyzstan and Kazakhstan.In Fig. 1 shows the epicenters of the Tien Shan earthquakes with $MS \geq 5$ from historical times to 2017, which clearly shows their greatest concentration in the south, in the border region with Tajikistan and China.

Hundreds of works have been published on the effectiveness of domestic science to close and distant events, but in their responses coupled with processes occurring in both the surface and deep parts of the Earth's crust, a repeating identity from one earthquake to another has not been identified. There is no natural body that could compare with it in its influence on the course of grandiose geological

*Corresponding author: jumaevna48@gmail.com

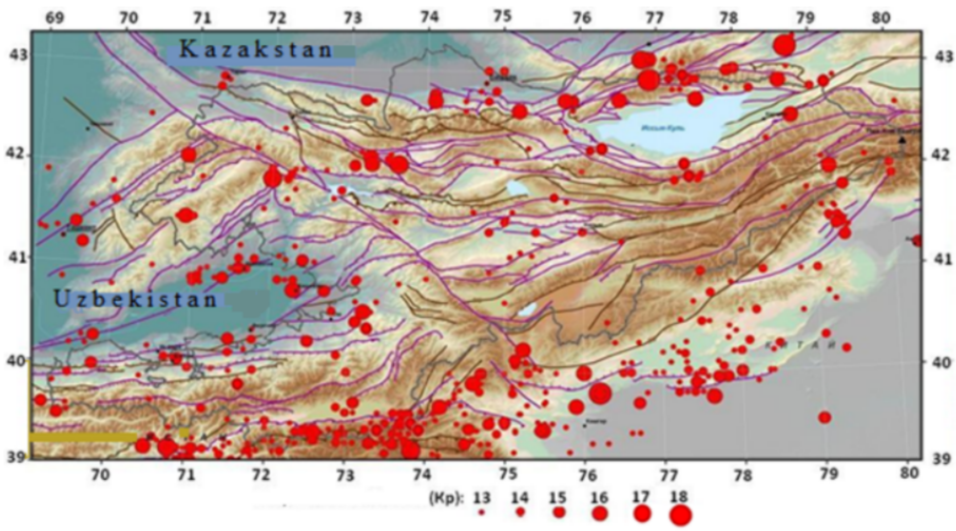

Figure 1. A copy from the Map of epicenters of earthquakes from $Kp \geq 13$ from historical times to 2017 [1].

processes. Vernadsky V.I. already pointed out similar in 1961 as follows: «All earthly matter is the influence of the forces inherent in water and its omnipresence, it penetrates and envelops to the very heart of the Earth». To date, the hydrogeoseismological network of Kyrgyzstan, consisting of 8 points (Fig. 2), according to the structural location and types of water points, to some extent optimally covers both hydrogeological massifs and artesian basins, and the time series of each point selected taking into account the features morphotectonics of structures identified by the depth of circulation (400-1500m)of belonging to host medium-granite intrusions, Paleozoic metamorphic rocks and Cenozoic terrigenous deposits. So mineral water «Karakol» and «Kaji-Sai» are located in the East-Issyk-Kul flexural-discontinuous zone, and «Dzhety-Oguz» are located in the fissures of the Pre-Teskey fault.

This deep gap with an average width of 30–50 km and a length of 500 km is represented by tectonic blocks characterized by moderate seismicity. Each of them develops independently and in different directions. Within it, during 1988–2017, two strong and four tangible tremors occurred. These include Sary-Kamyshskoye (1970), Jalanash-Tyupskoye (1978) and Kaji-Sayskoye, Sary-Zhazskoye (2013) and Kaji-Sayskoye (2016) earthquakes, which are associated with different forms, contrasts and durations of hydroelectric effects (Fig. 3). The largest amplitudes of their fluctuations were from 20 to 50%: signals in temperature reached up to 30^o C, level (N) from 0.5 to 2 m, and flow rates from 20 to 80%. At the same time, TMV «Dzhety-Oguz» and «Kara-Oy» drew attention to changes in the content of Cl–, HCO3–, CO32–, pH and Ca+2, as well as data on Q, H, P and TS; nitrogen (N2), CO2 and helium, complete indifference was shown by the gas factor in the Alamedin thermal water [2-4].This trend, existing in Kyrgyzstan, is no exception. A similar level of all approaches aimed at predicting earthquakes dominates around the world, if you do not take into account the increase in the number of parameters proposed as precursors [5]. In I. Vernadsky already pointed out similar things in 1961 as follows: «Water in the history of our planet stands apart.There is not a single natural body that could compare with it in its influence on the course of grandiose geological processes. All earthly matter is the influence of the forces inherent in water and its omnipresence; it penetrates and encompasses even the heart of the Earth».

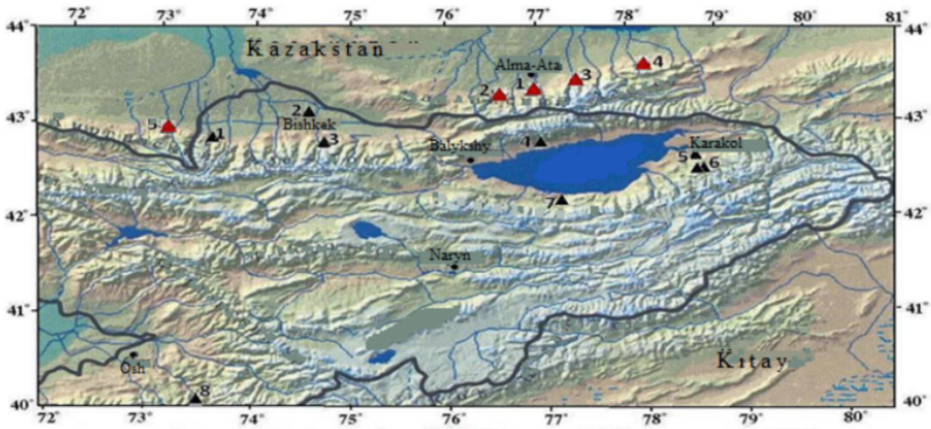

Figure 2. Seismic-hydrogeological monitoring of Kyrgyzstan and Kazakhstan. IP Network of NAS KR: 1 – Erkin-Sai; 2 – Bishkek; 3 – Alamedin-Issyk-Ata; 4 – Kara-Oi; 5 – Karakol; 6 – Jeti-Oguz; 7 – Kaji-Sai; 8 – Sopu Korgon. Network of Kazakhstan: 1 – Alma-Arasan; 2 – Lower Kamenka; 3 – Tau-Turgen; 4 – Kuram; 5 – Merke.

In this regard [6], applying the theory of catastrophes to spasmodic changes, they predicted throughout Russia the general features of groundwater regimes and seismicity with $M \geq 6$. In addition, to study changes in hydrogeological fields and seismic process parameters, structural factors are evaluated.

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Therefore, to increase the reliability of the earthquake forecast, we used variations of the solar activity index of a participant in the «atmospheric–cosmic phenomena–groundwater–earthquake» system. This is due to the fact that groundwater not only reacts to processes of seismic activation and soil displacement with a frequency of up to 0.01 Hz, but also is actively affected by gravitational fields, as well as lunar-solar tides.

2 Initial data and research methodology

The structure of the work performed, presented in Fig. 4, combines the primary data, using which time series are created and graphs are constructed, and are also combined with seismicity information.

In monitoring, the dynamics of the situation is studied by the nature, amplitudes and duration of oscillations associated with the intensity and epicentral distance, if any. It is believed that the monthly mean values and deviations of the confidence interval ($\pm 2\sigma$), as well as variance (D), information entropy (S) and spectral-temporal representation ($SWAN$) in the manifestations of previously unknown signs, act as a direct participant. The maximum amplitude of fluctuations in the parameters of hydrogeological fields that arise due to atmospheric pressure and tidal forces is determined using barometric and tidal efficiency coefficients: if tidal coefficients exceed barometric efficiency, the former are calculated separately for the periods of the new moon and full moon, and in the second

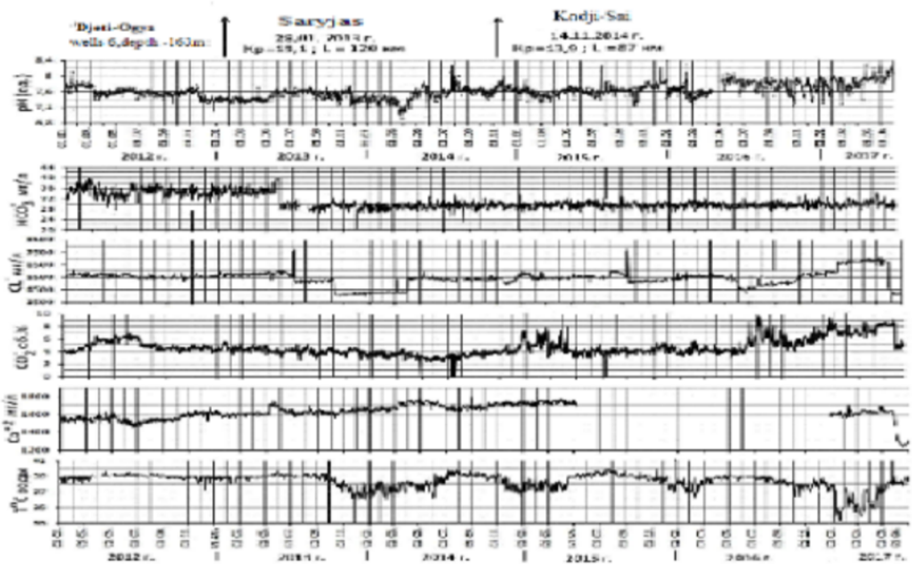

Figure 3. Temporary variations in the parameters of the TMV «Jet-Oguz» for 2012–2017.

case, for maximum groundwater level or pressure. The nature of the relationship between the parameters is revealed through the correlation coefficient, for example, of chlorine, calcium, magnesium, hydrocarbonates, carbonates, carbon dioxide, and also each of them with pH and TMB temperature.

The quantitative exit of the parameter beyond the confidence interval $\pm 2\sigma$ is considered the approximation of the discharge of seismicity, the intensity of which leads, irrespective of the distance of the source, to an excess of two orders of magnitude from the average level. Such temporary leaps, highlighted retrospectively, recall the precursor signs.

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3 The results obtained and their analysis

In general, time series on all variation graphs form repeating curves connected by dashed lines, which do not always reflect the role of tectonic disturbances. For this, «tectonic traces» in hydrogeological fields, captured by phenomena of a similar nature, were first identified.

The basis of the analysis and interpretation of the obtained data is the theory of pulsating earth and the theory of reflection, as well as the multifactorial nature of the formation of hydrogeological fields. The fact is that, according to [7, 8], medium-sized earthquakes represent the influence of deformation waves on the destroyed zones of the lithosphere when calculating the interval between seismic processes in real time. But this is instantaneous with respect to the geological evolution of structures.In [9], the relationships between the physicochemical parameters of the sources with the nature and intensity of neotectonic movements are shown using the example of the «Teskey hydrothermal line». So, in the eastern part of the Teskeysky massif, where the greatest extension is dominated by a

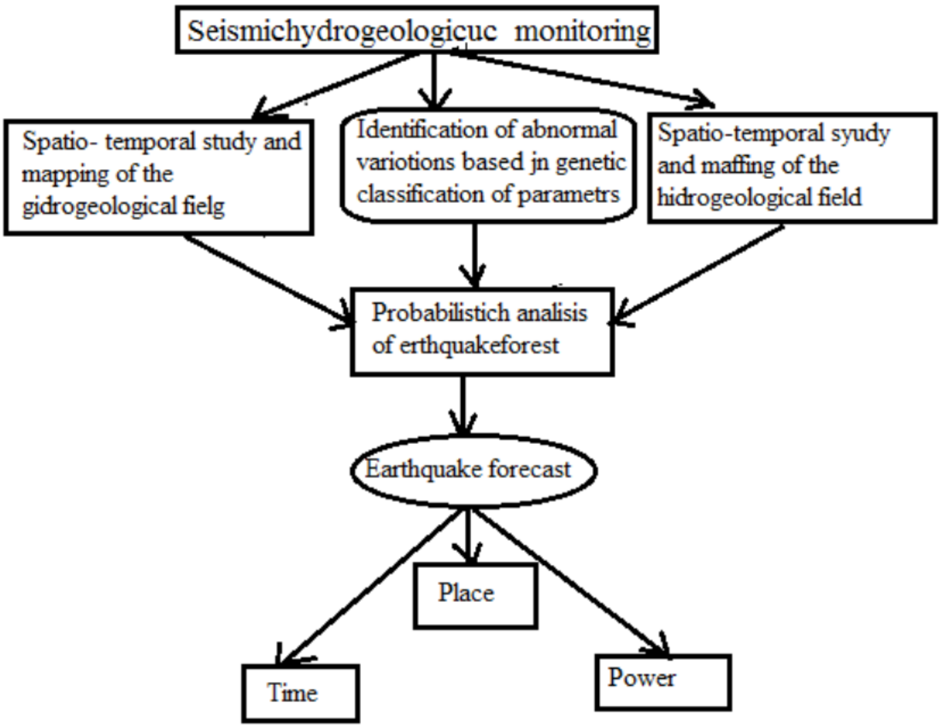

Figure 4. Transmission and analysis of seismic hydrogeological information.

long geological time, both the epicenters of most tremors with $K \geq 12 - 16$ and the natural outputs of low-mineralized terms (≥ +500 C) with high concentrations of helium, argon and deuterium are concentrated Aksu, Altyn-Arashan), whereas in its west, where at a small vertical displacement compression forces prevail, as a result, weak earthquakes occur, and microcomponents in carbonic waters with a mineralization of 0.8 – 1.2 g/l and a temperature of +36 – 37 to +200 C are absent (Ulakhol, Tuura-Suu).

These facts allow us to recognize, on the one hand, the presence of selective circulation of fluid systems along the deep faults of the Kyrgyz Tien Shan, and on the other hand, they can be centers of ancient tremors along which energy exchange takes place and substances in the form of HMW continue. The objectivity of such a statement was confirmed for wells drilled in the Ferghana, Chui and Issyk-Kul depressions to a depth of 5 – 6 km for oil, gas and thermal waters. In them, as evidenced by the results of hydrogeochemical tests, they have similar situations. So, against the background of broken curves shown in Fig. 5, the common roots of the variability of temperature, pH, and Eh and the concentration of ions in groundwater clearly coincide with certain geological periods. These are peaks deviated from the average values of parameters, as along the «Teskey hydrothermal line», gravitating to the maxima of tectonic activation of geological sections. According to well data, in the structure of Mailuu-Suu in East Fergana, the largest inflows of mineralization and components of the ion-salt composition of groundwater are in the contacts of neogene and paleogene-neogene rocks, when in this region, indeed, tectonic activation led to the renewal of the ancient and the appearance of new faults, accompanied by the opening and closing of cracks in the rocks.In the first case, there is an observation

 https://doi.org/10.1051/e3sconf/201912702022

post of the same name based on a well with a depth of 1500 m (Fig. 6), which randomly throws out chloride-hydrocarbonate-sulfate sodium thermal waters of low salinity (53 – 540 C) from the upper Neogene (≤ 0.3 g/l).

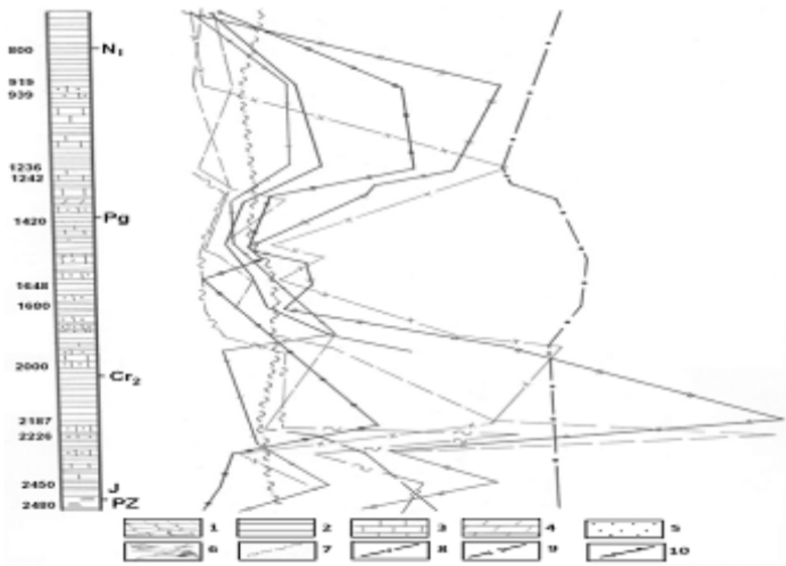

Figure 5. Geological and hydrochemical section of the Mailuu-Suu well 1 – conglomerates; 2 – clay; 3 – limestones; 4 – marls; 5 – sandstones; 6 – folds; 7 – sulfates; 8 – chlorides; 9 – temperature; 10 – nitrogen.

What is the situation in modern conditions? In 2015, a series of earthquakes with energy classes from 9.1 to 12 and a focal depth of 19 – 70 km occurred in the South Issyk-Kul region (Fig. 6).

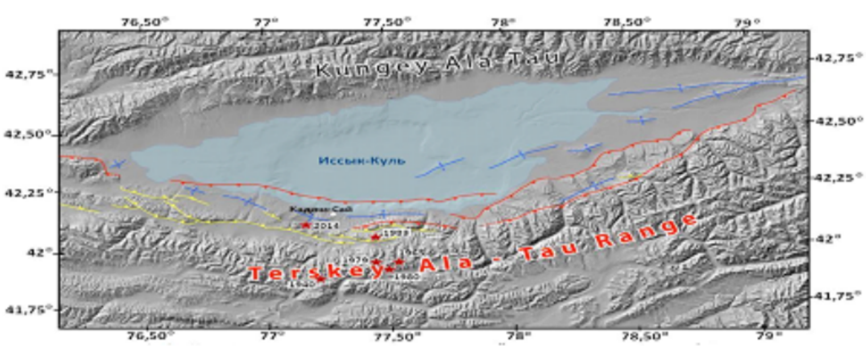

Figure 6. A copy of the active structures of the South Issyk-Kul from the Map with the epicenters of the Kadzhi-Sai and Barskaun earthquakes and water termals [10].

Their epicentral regions are located in the Jumgalo-Teskeyseismic zone, enclosed between the Predterskey and Central Terskey faults with a block structure. As a result of this seismic event in the village numerous buildings were destroyed by Kaji-Sai and Korgon, significant cracks formed, plaster fell off and power lines were partially cut off(Fig. 7).

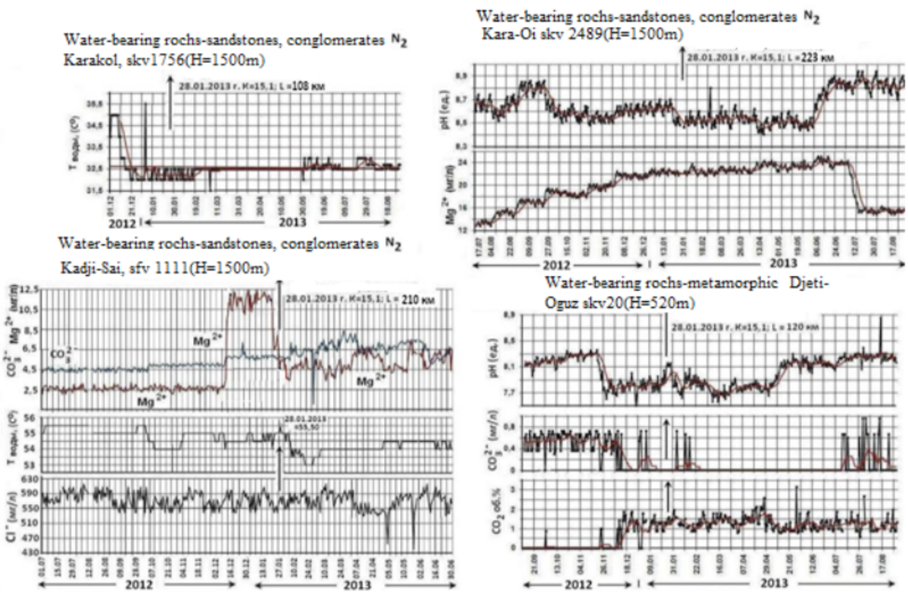

Figure 7. Variations of thermal water «Detj-Ogys», «Kara-Oi», «Karakol» and «Kaji-Sai».

As a result, pH fluctuations are represented by a scatter from 8.7 to 8.6, which gradually decreased to 7.4 – 7.5 in December, but rose to 8.2 – 8.4 in November with a decrease in chlorine concentration from 650 – 665 to 590 – 600 mg/l and weak CO outbreaks from 3.8 – 4.0 to 4.8 – 5.1. All parameters are characterized by insignificant scatter, which allows us to admit the insufficiency of the voltage force for tangible hydrogeological impacts.

Thus, in our opinion, the lack of knowledge about the specifics of the functional relationships of seismicity with the groundwater regime indicates the complexity of this problem. For completeness of the scientific analysis of the studied flows of solar activity and the average annual rainfall are given below in [12, 13].

Therefore, for the sake of completeness of the scientific analysis of hydrogeological flows, the solar activity data with the average annual precipitation were jointly considered. Indices of solar activity - the Wolf number (W), determined by the 11–year cycle, is calculated for each day according to the formula: $W = k(f + 10g)$, where: W is the Wolf number; f is the number of sunspots; g is the number of spot groups per day; k is the correction factor, usually < 1. To date, 24 cycles of solar activity have been recorded, the latter began in December 2008, and the maximum falls on 2014 (Table 1).

Authors [14] based on a comparison of the fluctuations in the annual maximum magnitudes of Mw earthquakes of the Earth for 1900–2014. According to Global CMT data, changes in Wolf numbers indicate that solar activity maxima often correspond to a decrease in earthquake activity with $Mw \geq 8$. It is believed that the higher the amplitude of the solar activity cycle, the higher the seismic and

Table 1. Minimum and maximum of 11-year cycles of solar activity

Cycle number	Min	Max	Cycle number	Min	Max	Cycle number	Min	Max
1	1755	1761	9	1843	1848	17	1933	1937
2	1766	1769	10	1856	1860	18	1944	1947
3	1775	1778	11	1867	1870	19	1954	1957
4	1784	1787	12	1878	1883	20	1964	1968
5	1798	1804	13	1889	1893	21	1976	1979
6	1810	1816	14	1901	1905	22	1986	1989
7	1823	1830	15	1913	1917	23	1996	2000
8	1833	1837	16	1923	1928	24	2008	2014

volcanic activity. An example is Chilean (1960) with Mw = 9.6, Alaskan (1964) with Mw = 9.2, Sumatra (2004) with Mw = 9.0, Maule in Chile (2010) with Mw = 8.8, Tohoku in Japan (2011) with Mw = 9.1 and about, Sumatra (2012) with Mw = 8.6 earthquake.

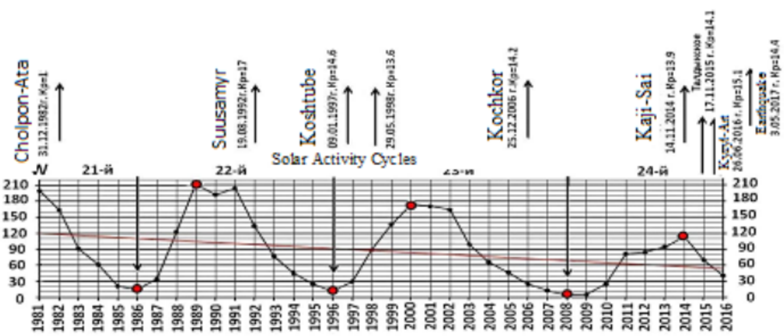

Figure 8. Graphs of Wolf numbers and earthquakes with $Kp \geq 13.6$ for 1981 – 2017 in Kyrgyzstan: red dots are minima and maxima of solar activity.

The correct application of this approach for our territory is determined by the amount of precipitation from the Gulcha weather station. As can be seen from fig. 8, global globe information is traced in Kyrgyzstan. On the participation of exogenous components in bursts in Fig. 9 also shows the correlation coefficients between the temperature and the flow rate of the Sopu-Kurgan source. They are negative (−0.3) during seismically active time (2015), and in 2016 they become positive (+0.2), in 2017 they increase to +0.4.This indicator is between their temperature and consumption in the spring, but with the index of solar activity is also high in the opposite direction: it decreases from positive 0.64 (2015) to negative −0.12 (2016), decreasing to −1.

The performed correlation analysis between the flow rate (Ql/sec) of the Sopu-Kurgan spring with solar activity - Wolf numbers from 01.01.2015 to February 2017, when seismic activation is observed, also shows the reflection in hydrogeological fields of high values, from −1 to 0.64, respectively.

4 Conclusions

Both the minimum and maximum levels of hydrogeological fields due to differences in the nature of geological development and the solar activity cycle indicate the general nature of the existence of

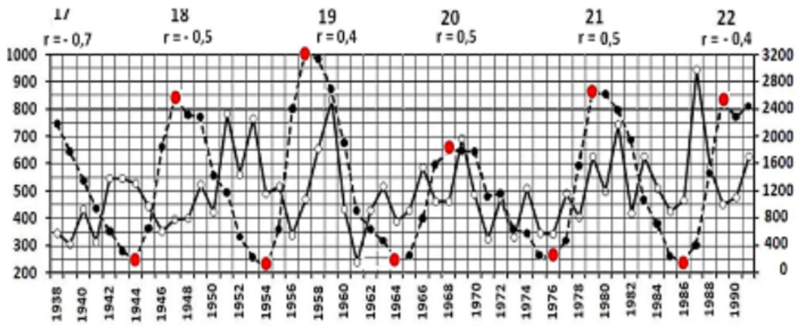

Figure 9. Fluctuations in annual precipitation and Wolf's number for 2016 – 2017.

unstable equilibrium in the system of «atmospheric-cosmic phenomena-groundwater-earthquakes». Both minimum and maximum levels of hydrogeological fields. The participation of exogenous components in these hydrobursts indicates their relationship in terms of Wolf numbers – solar activity indices identified under 11-year cycles: its maxima, often reflecting the low intensity of earthquakes with $M \geq 8$, are confirmed by correlation coefficients between temperature and water flow «Sopu Kurgan».

Hydrovariances due to their multiphase nature are different: blurred in width and insignificant in amplitude are recorded inside the tectonic block, and sharp and narrow anomalies appear in interblock zones of deep faults. Changing the stable regime to an unstable state depends on the heterogeneity of the total effect of the water-gas mixture.This can serve in the search for the forerunners of natural disasters, as well as for the integration of methods based on the theory of pulsating earth and the theory of reflection of actual materials.

The participation of exogenous components in these hydrovariations is also indicated by the situation in conjunction with Wolf numbers, the average annual indicator of solar activity detected under 11-year cyclic conditions: according to available data, the decrease in earthquakes with $Mw \geq 8$ often corresponds to its maximums.

The foregoing is also confirmed in our work on the correlation coefficients between temperature and Sopu-Kurgan water discharge, seismicity and solar activity index. So, in 2015, in a relatively seismically active period, the correlation coefficients had negative values (−0.3), in 2016 they switched to positive signs (0.2), and in 2017 increased to 0.4.

In general, the correlation coefficients are also high between each studied parameter and the solar activity index, but decreased in 2015 from a positive value of 0.64.

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