

SEISMIC MONITORING AND ITS ANALYSIS IN KYRGYZSTAN

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Kyrgyzstan has signed the Comprehensive Nuclear-Test-Ban Treaty (CTBT) in 1996, and in 2003 it had been ratified by the Kyrgyz Parliament. In 2002 on the basis of Data Center of the Institute of seismology of National Academy of sciences of Kyrgyz Republic (IS NAS KR) the National Data Center NDC-093 (NDC-KG) was established. Creation of the National Data Center with access to the International Data Center in Vienna opens for Kyrgyzstan the additional capabilities in solving both scientific and practical problems in the seismic monitoring field, so far as geographically Kyrgyzstan is located in the limits of the Tien-Shan orogen, the modern tectonic activity of which defines a high seismicity of this territory. Very strong earthquakes with magnitude up to 8 and a lot of weaker events occur here. In average, we process nearly eight thousand earthquakes per year, occurred on Kyrgyz territory, and about 200 events of which are classified as felt (Figure 1). Every 10 to 15 years strong destructive events take place here. The occurrence of large earthquakes makes the Kyrgyzstan the region with one of the highest seismic hazard in the world. That is why a seismic monitoring was and remains one of most actual problems for our republic.

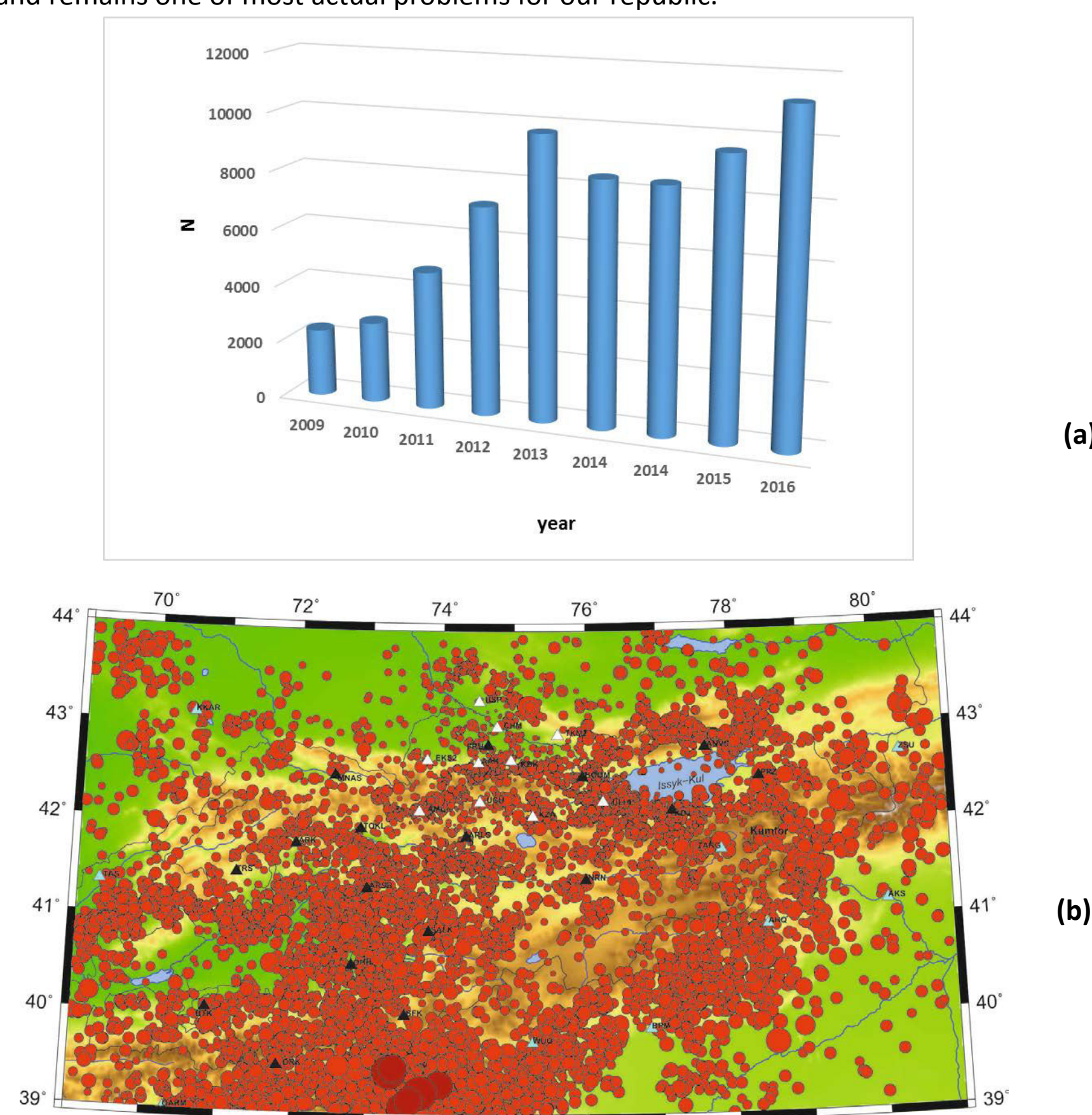


Figure 1. (a). Diagram of earthquakes number which occurred in the territory of Kyrgyzstan from 2012 to 2016. (b). Map of seismicity of Kyrgyz territory for 2016 (M ≥ 0.5, N=12687).

One of the major components of any National Data Center operation is improvement of the quality of data processing and its analysis. From four types of the International Monitoring System (IMS CTBTO) Kyrgyzstan participates in the seismic monitoring. The 3-C auxiliary seismic station AS060, located in the "Ala-Archa" gorge, operates on its territory. However, for adequate analysis of seismic regime and seismic catalog creation it is necessary to use the data of National Monitoring System of Kyrgyzstan in addition to the IMS data. At present, it includes 26 digital broadband seismic stations, 10 stations of the KNET network (RS RAS) and 16 stations of the KRNET network (IS NAS KR) (Figure 2), the real time data practically of all KRNET stations are openly accessible at the IRIS-DMC website (www.iris.edu) (Figure 3). As result of processing of all this data, seismic bulletins and different catalogues of seismic events (earthquakes and explosions) are created. All bulletins are sent to the ISC (International Seismological Centre, UK, www.isc.ac.uk) with open access status.

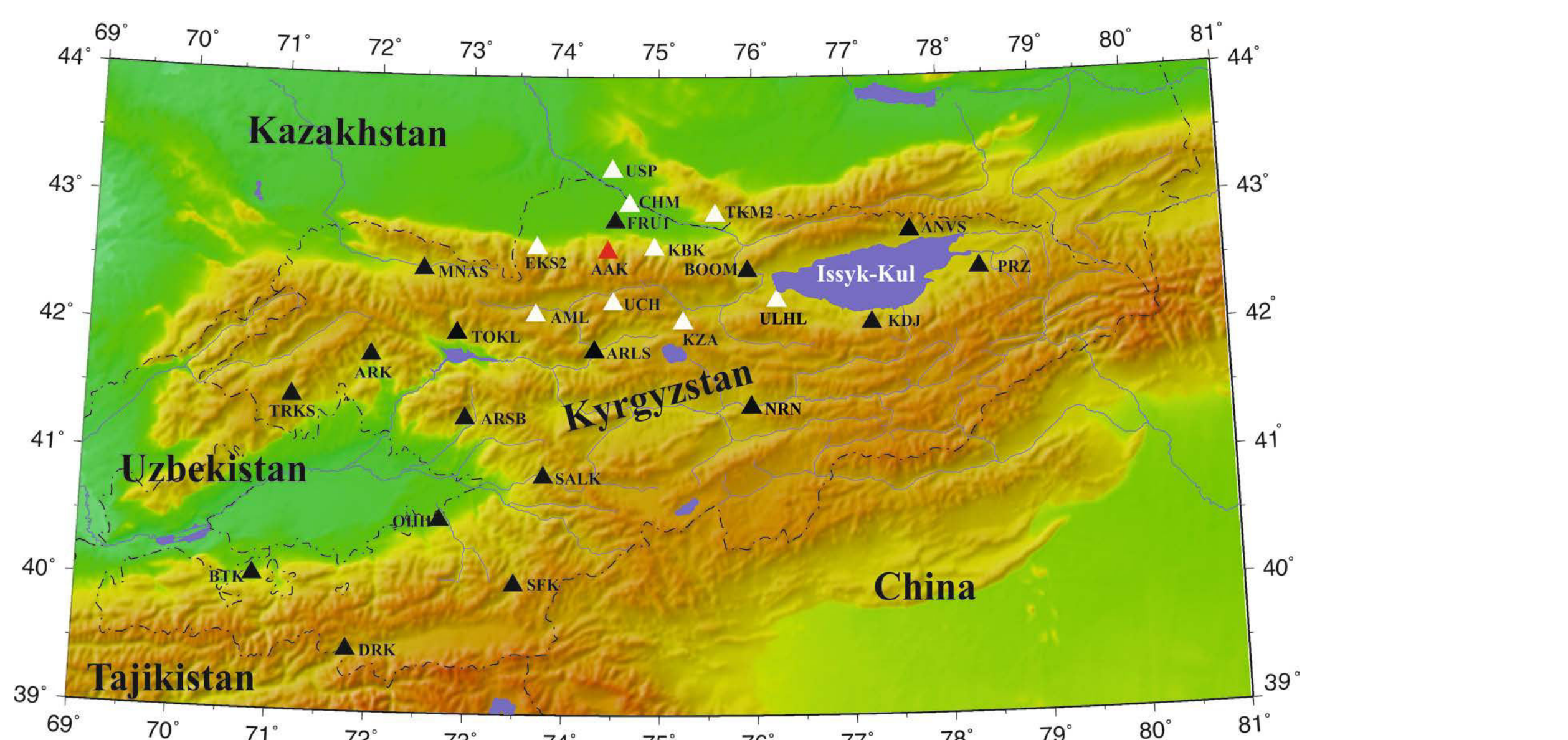


Figure 2. Map of Kyrgyz system of seismic monitoring. By black triangles the KRNET stations (IS NAS KR) and white triangles the KNET stations (RS RAS) are indicated. The red triangle represents the auxiliary seismic station AS060 (AAK) of the IMS CTBTO network.

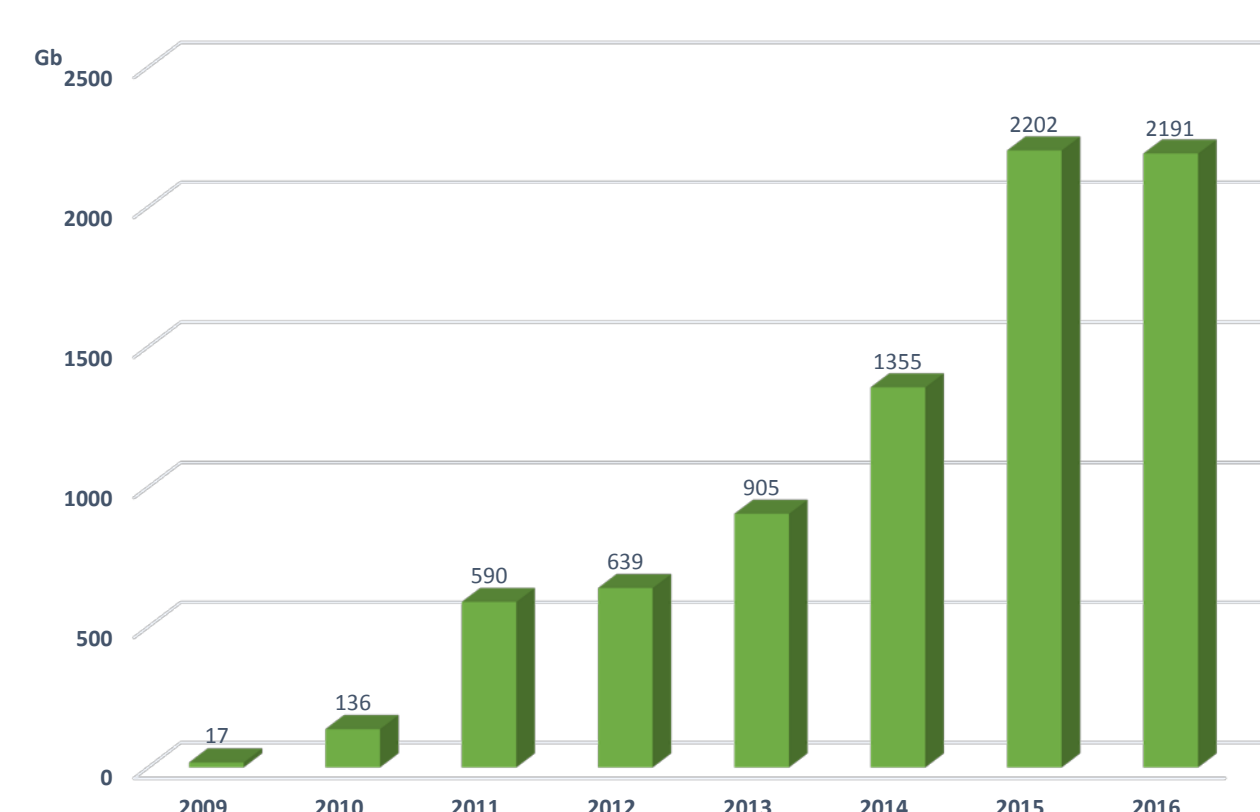


Figure 3. Diagram of KRNET data requests at the IRIS/DMC website in gigabytes (Gb).

For data quality assessment, analysis of NDC-KG bulletins, registered in the ISC as a KRNET, relative to data of other Data centers represented in the ISC (www.isc.ac.uk), including the International Data Center (IDC CTBTO), for the investigated area within the coordinates of 39° 00' - 44° 00' N and 69° 00' - 81° 00' E, which includes all the territory of Kyrgyzstan and adjacent areas of neighboring countries (Kazakhstan, Uzbekistan, Tajikistan, China) was conducted. From Figure 4 it is clear, that representativeness of the NDC-KG (KRNET) bulletins for observed territory is very high in the ISC, which allows use this data for a wide range of problems (Figure 4).

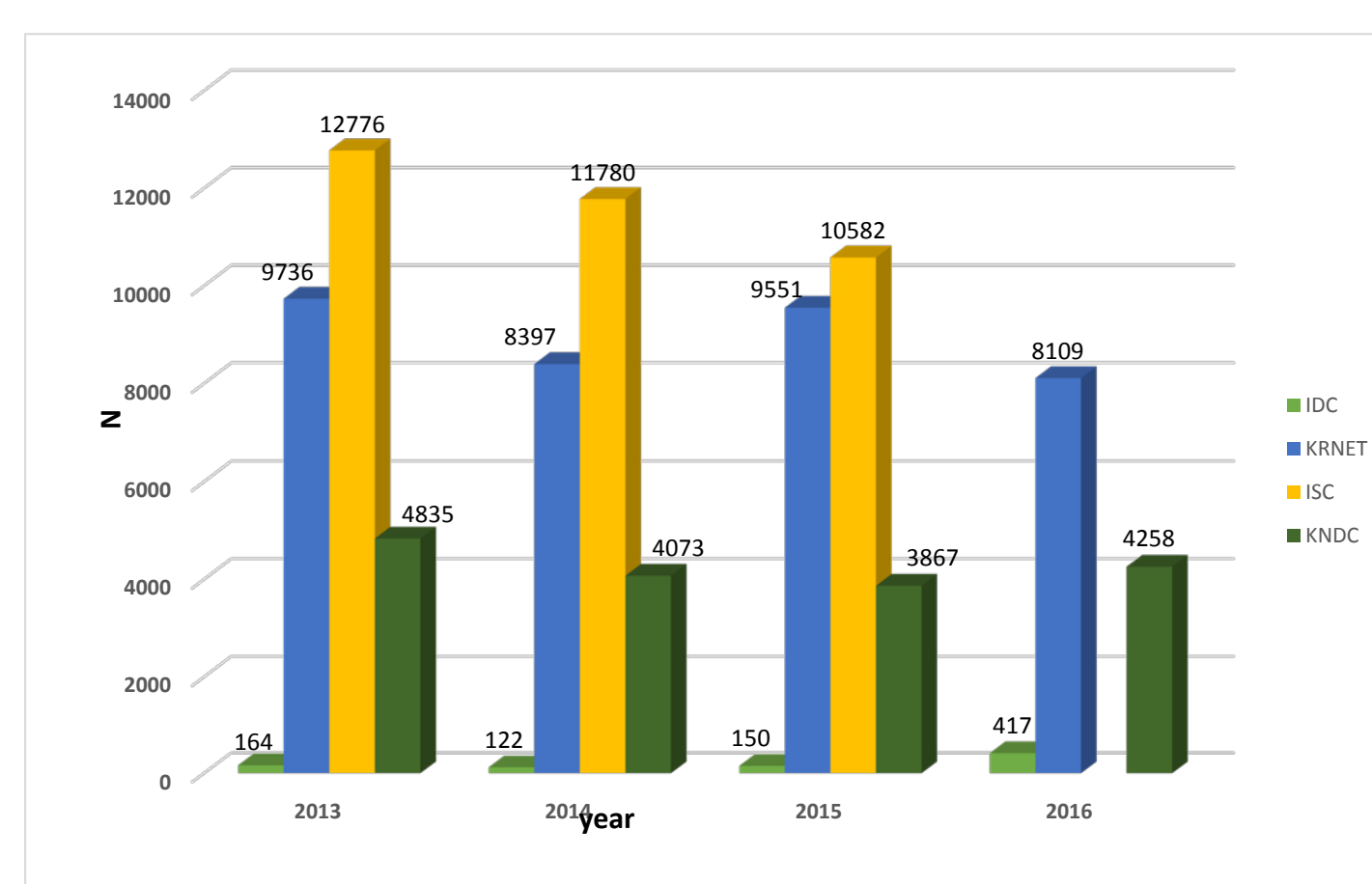


Figure 4. Diagram of earthquake bulletins for the territory of Kyrgyzstan and presented by various Data Centers in the ISC.

As a result of conducted analysis, negligible differences within the limits of mathematical error, in coordinates, magnitude and time of events ($\Delta\phi=0.05^\circ$, $\Delta\lambda=0.1^\circ$, $\Delta M = 0.36$) were defined. At the same time, the largest convergence of the solutions is observed in regional data centers (NDC-KG, KNDC) which can be explained by the same approach to the solution definition. As for depth definition, the considerable differences observed between all Data centers (Figure 5 (a, b, c)).

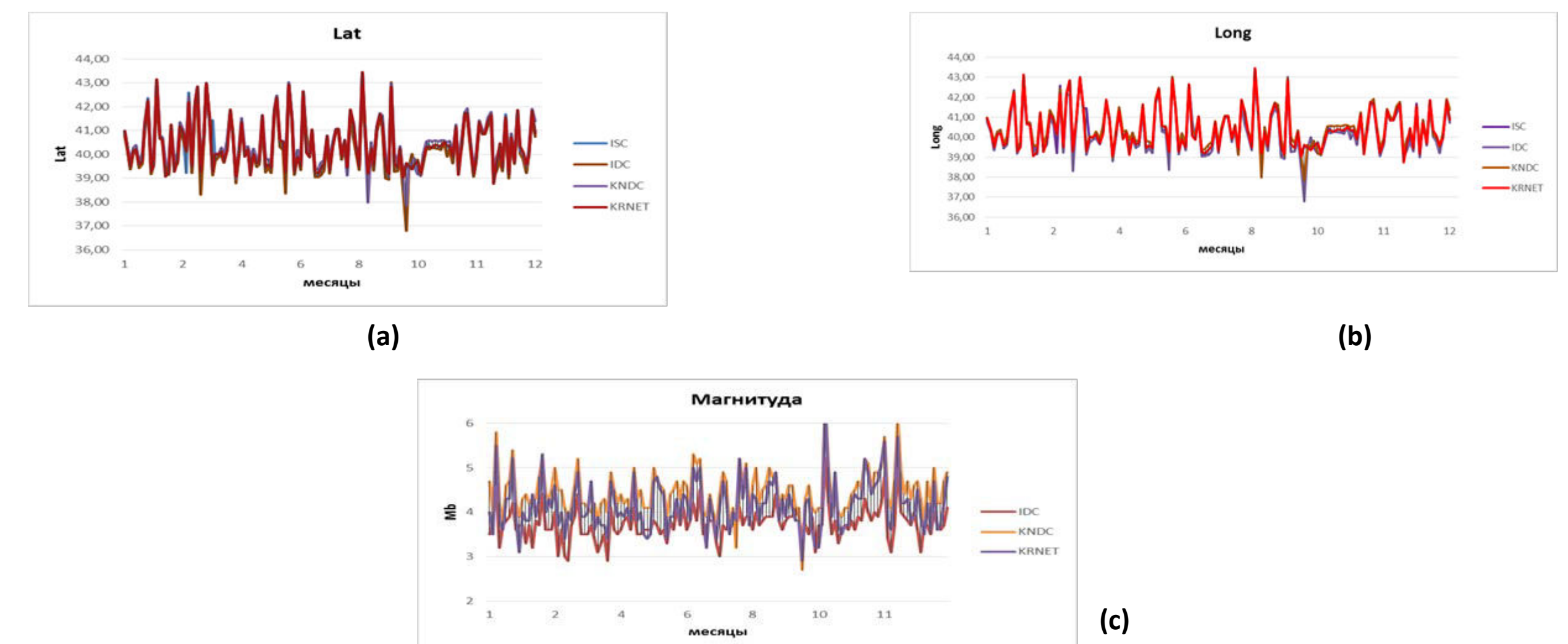


Figure 5. Diagram of parameters "latitude" (a), "longitude" (b) and "magnitude" (c), determined by the NDC-KG, KNDC, IDC CTBTO and ISC.

It should be noted that for the analysis of seismic monitoring data and correct assessment of seismic hazard of observed territory is very important to determine the intensity (I) of seismic shocks in various settlements. Up to date the definition of this parameter was conducted manually by the corresponding models using (Figure 6), which were built with the use of regional values of the attenuation coefficients ν and c [Djanuzakov K.] in the Shebalin N. equation for the macroseismic field:

$$I_i = bM - \nu \lg \sqrt{r^{-2} + h^2} + c$$

where I_i - the intensity of the shock, caused by an earthquake with a magnitude M_{LH} (Ms), with a source at the h (km) depth and at a distance of r (km) from the observation point. For processing improvement and more operative preliminary assessment of the seismic intensity the program «SEISMIC INTENSITY» and the appropriate database (DB) with corresponding models of attenuation were created and tested (Figure 6). This program allows during short limits of time to receive the approximate value of the seismic intensity parameter in the different places of Kyrgyzstan. It's very important, so far as the rapid preliminary definition of this parameter gives an opportunity for local authorities, such as Ministry of Emergency Situations, for more adequate and operative reaction to the occurred seismic catastrophes, and, that is why to preserve the human lives and increase the level of damages.

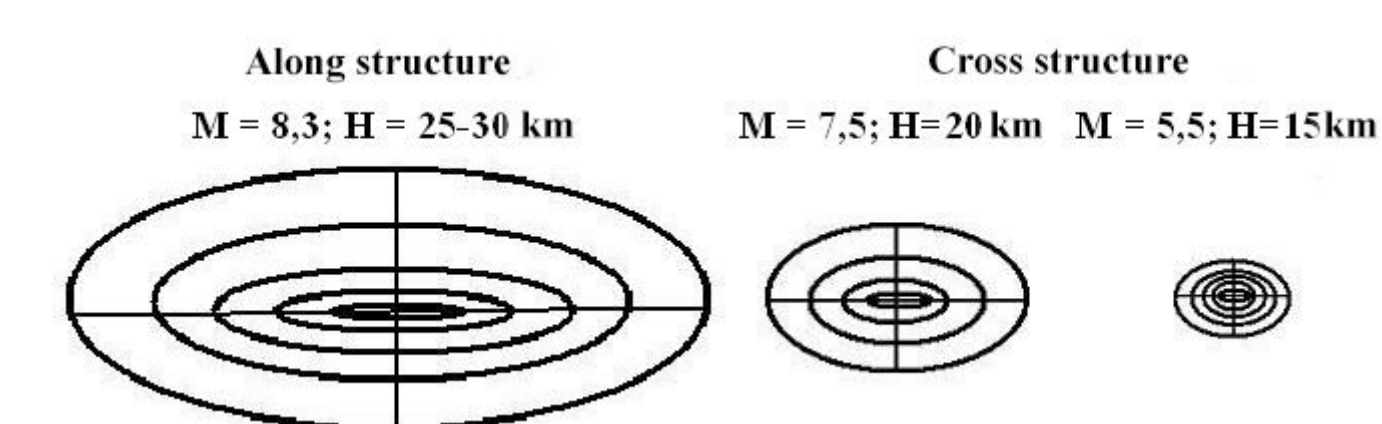


Figure 6. Examples of computational models of the macroseismic field of earthquakes with different magnitude and depth of the focus according to local data (Dzhanuzakov K.).

Figure 7 (a) illustrates the work of this program, and in Table 1 (a), also as an example, the results of comparing the determination of the intensity of the Kochkor-Ata earthquake (May, 15, 1992, $M_s = 6.3$) on macroseismic data [1] and under the program «SEISMIC INTENSITY». The result of the analysis showed quite good convergence within the mathematical error, on the average $\Delta I = \pm 0.5$ (Table 1 (a)). Figure 7 (b) and Table 1 (b) show the result of determination of the intensity for the strongest earthquake in 2015 (17.11.2015) under the program «SEISMIC INTENSITY» (Grebennikova V., Mirkin E.), and according to the Template (Dzhanuzakov K.), which was used early. The analysis of the obtained results showed good convergence, $\Delta I = \pm 0.37$ (Table 1(b)).

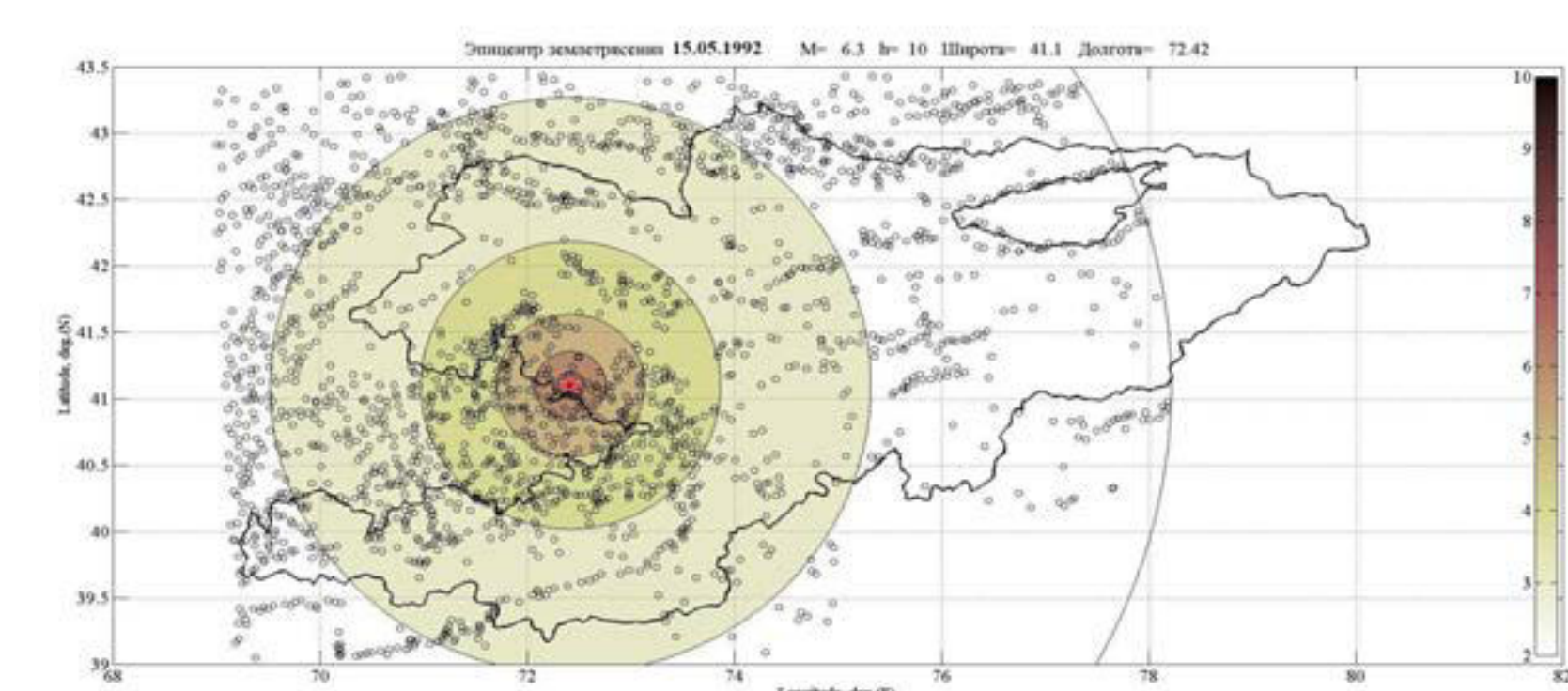


Figure 7 (a). An example of intensity determination according to the program «SEISMIC INTENSITY» for the Kochkor - Ata earthquake (May, 5, 1992, $M_s = 6.3$).

Table 1 (a). Comparison of the intensity determination for the Kochkor - Ata earthquake (May, 15, 1992, $M_s = 6.3$, $H = 10$ km, $\phi = 41.10^\circ$, $\lambda = 72.42^\circ$) according to the macroseismic observations and the work of the «SEISMIC INTENSITY» program.

No	Name of the settlement	Latitude	Longitude	Distance to the epicenter	Intensity (according to the program)	Intensity (macroseismic observation)	Difference
1.	Kochkor - Ata	41.05	72.49	8.03	7.23	7	0.23
2.	Shamaldy - Say	41.19	72.19	21.55	6.34	5	1.34
3.	Soviet	41.06	72.74	26.93	6.07	6	0.07
4.	Tash-Kumyr	41.34	72.20	32.3	5.83	5	0.83
5.	Andijan (Uzbekistan)	40.80	72.34	33.96	5.77	6	-0.23
6.	Kyzyl-Jar	41.26	72.01	38.39	5.6	5	0.6
7.	Suzak	40.90	72.9	45.61	5.37	6	-0.63
8.	Kara-Suu	40.71	72.89	58.27	5.03	6	-0.03
9.	Sultanabad (Uzbekistan)	40.77	72.97	58.53	5.02	6	-0.98
10.	Kok-Yangak	41.03	73.2	65.2	4.87	5	-0.13
11.	Uzgen	40.78	73.32	82.71	4.53	5	-0.47

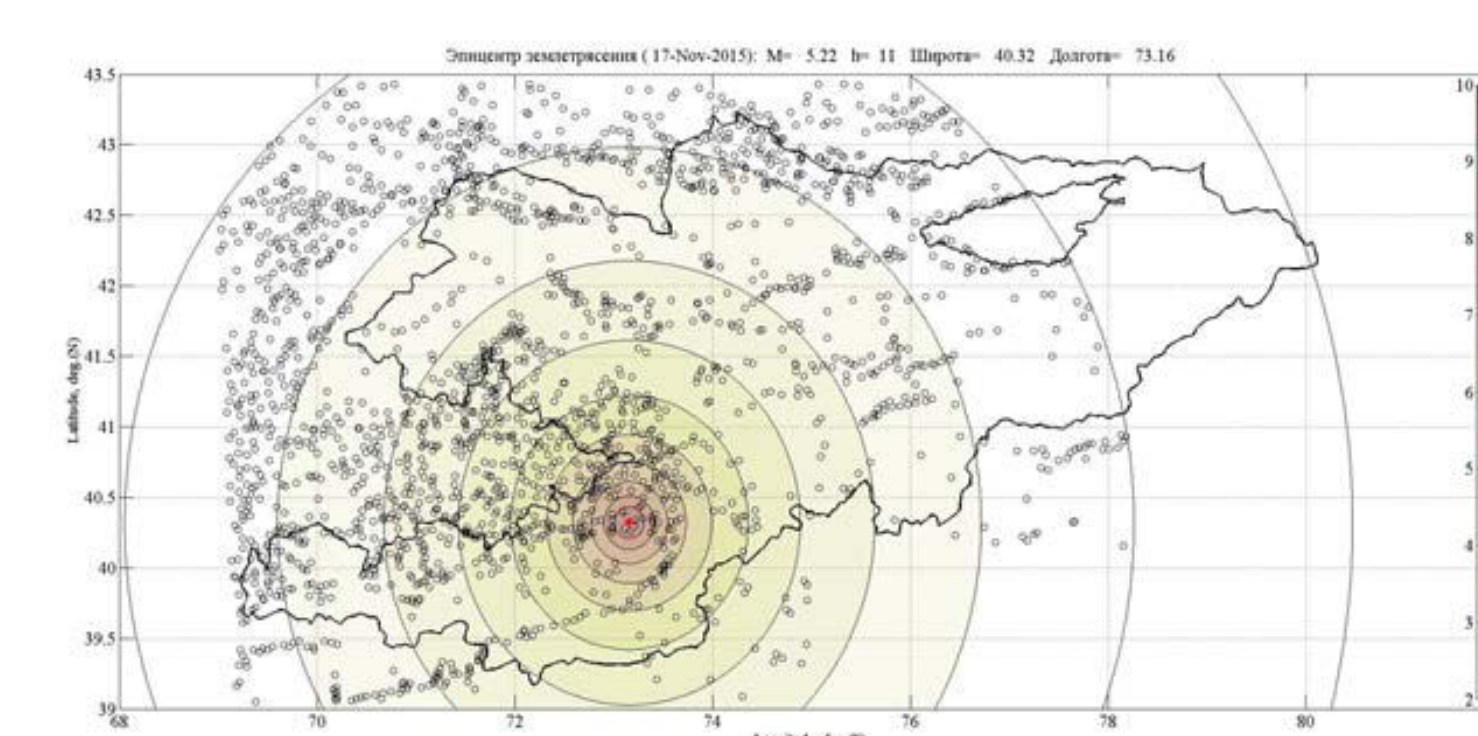


Figure 7 (b). An example of intensity determination according to the program «SEISMIC INTENSITY» for the earthquake of November 17, 2015, $M_s = 5.2$.

Table 1 (b). Comparison of the intensity determination for the earthquake of November, 17, 2015 ($M_s = 5.2$, $H = 11$ km, $\phi = 40.32^\circ$, $\lambda = 73.16^\circ$) according to the local Template and the «SEISMIC INTENSITY» program.

No	Name of the settlement	Latitude	Longitude	Distance to the epicenter	Intensity (according to the program)	According to the Template
1.	Taldyk	40.30	73.21	4.71	6.96	
2.	Alga-Bas	40.34	73.21	4.71	6.96	
3.	Be-Jar	40.36	73.13	5.09	6.94	7
4.	Laglana	40.28	73.11	6.08	6.89	
5.	Teeke	40.26	73.17	6.71	6.85	
6.	Langar	40.40	73.09	10.61	6.62	7
7.	Koblan-Kul	40.35	73.29	11.29	6.57	
8.	Chaychi	40.43	73.26	14.76	6.36	6
9.	Berul	40.34	72.98	15.1	6.34	
10.	Papan	40.29	72.98	15.31	6.33	
11.	Kyzyl-Tuu	40.27	72.98	15.94	6.29	6
12.	Kora-Sugut	40.38	72.98	16.36	6.26	7

Conclusion

Correct seismic monitoring data and its appropriate analysis have both scientific and practical importance for Kyrgyzstan, as they are the basis for its territory seismic hazard assessment. This information is necessary for the estimation of seismic risk and appropriate preventive procedures planning, especially as the most densely populated areas are located in the focal zones of strong earthquakes.