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Seismicity of the Eastern Sector of the Russian Arctic During the Instrumental Period of Observations

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Abstract: This study examines the spatio-temporal patterns of seismicity in the eastern sector of the Russian Arctic over the entire period of instrumental observations (1900–2022). Based on the most comprehensive set of instrumental data and employing a modern global velocity model together with an improved location algorithm, a consolidated, recalculated, and unified earthquake catalogue was compiled for the period 1900–1961. Its integration with the previously developed unified earthquake catalogue of the Arctic Zone of the Russian Federation for 1962–2022 made it possible to produce a generalized catalogue for the entire region, covering the full instrumental observation period. Using this catalogue, earthquake parameters were compared with the lineament–domain–focal (LDF) models of the GSZ-97 and GSZ-2016 General Seismic Zoning Maps of Russia. It was found that the LDF model of GSZ-2016 shows the best agreement with the instrumental data, whereas the GSZ-97 model requires adjustments to the maximum magnitude (M_{max}) values for several domains and lineaments. The results obtained can be used to refine the parameters of the regional seismic regime, improve the reliability of seismic hazard assessments, and ensure the safe operation of infrastructure during the development of natural resources in the Arctic.

Keywords: Russian Arctic, Laptev Sea shelf, seismicity, earthquake catalogue, seismic zoning.

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1. Introduction

In 2023, researchers from the Geophysical Center and the Institute of Earthquake Prediction Theory and Mathematical Geophysics of the Russian Academy of Sciences completed the development of the most comprehensive and unified earthquake catalogue for the Arctic Zone of the Russian Federation, covering the period from 1962 to 2022 [*Gvishiani et al.*, 2022; *Vorobieva et al.*, 2023a,b]. This catalogue integrates data from regional, national, and international seismological agencies [*GC RAS*, 2025]. Duplicate events resulting from data merging were identified and removed using an original modification of the nearest-neighbor method [*Vorobieva et al.*, 2022].

To investigate the seismicity characteristics of the eastern sector of the Russian Arctic over the entire instrumental observation period, the above-mentioned catalogue must be supplemented with data on earthquakes that occurred in this region from the early twentieth century to 1961. However, this task requires different methodological approaches from those used for the later period [*Morozov*, 2024; *Morozov et al.*, 2022]. This necessity arises from the specific conditions under which instrumental observations were carried out in the Arctic during the first half of the twentieth century: a limited number of seismic stations, their large distances from earthquake sources, and the use of incomplete data together with outdated velocity models and location algorithms. In addition, magnitudes for a number of Arctic earthquakes had not been previously determined [*Morozov et al.*, 2023a,b, 2022, 2024].

This paper presents the results of developing a consolidated, recalculated, and unified earthquake catalogue for the eastern sector of the Russian Arctic for the period 1900–1961. Combining these data with the earthquake catalogue for the Arctic Zone of the Russian Federation [*Gvishiani et al.*, 2022; *Vorobieva et al.*, 2023a,b] enabled the creation of a single unified regional catalogue covering the period from 1900 to 2022. Using this combined dataset, a comprehensive analysis of seismicity over the entire instrumental observation period was performed, and earthquake parameters were compared with the lineament-domain-focal (LDF) models of the General Seismic Zoning Maps of Russia (GSZ-97 and GSZ-2016) for the study area.

2. Data and Methods

The study area includes the shelf zones of the Kara, Laptev, and East Siberian Seas, the adjacent coastal territories, as well as the eastern part of the Eurasian sub-basin and a segment of the Gakkel Ridge (Figure 1).

Based on the information from various sources (summarized in Figure 2), preliminary data were collected for all earthquakes recorded between 1900 and 1961 whose epicenters were located within latitudes 70.0° to 90.0° N and longitudes 70.0° E–170.0° W. In addition, this analysis draws on some of the earliest syntheses of Arctic seismicity presented in [*Sykes*, 1965; *Tams*, 1922]. Using these data, a preliminary consolidated earthquake catalogue for the eastern sector of the Russian Arctic was compiled for the specified period (section A).

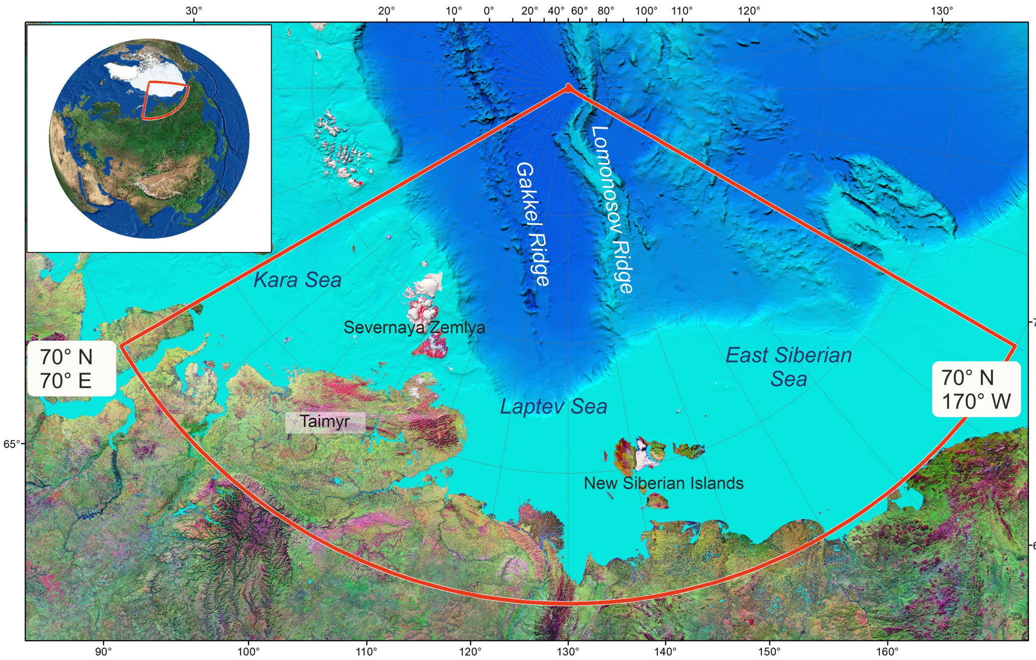

Figure 1. Map showing the boundary of the study area.

Refinement of the principal parameters of Arctic earthquakes – hypocenter locations and magnitudes – was carried out using the approach described by [*Morozov*, 2024; *Morozov et al.*, 2022]. For each event, the arrival times of seismic phases were searched for in the bulletins of seismic stations operating from the early 20th century until 1961. For this purpose, both the electronic archive of the International Seismological Centre (ISC) station bulletins [*International Seismological Centre (ISC)*, 2025b; *Storchak et al.*, 2013, 2015] and the scanned copies of the International Seismological Summary (ISS) bulletins available on the ISC website (https://storing.ingv.it/ISS/index.html) were used.

Hypocenter refinement was performed using the NAS (New Association System) program [*Asming et al.*, 2021; *Fedorov et al.*, 2019] with the global velocity model ak135 [*Kennett*, 2005; *Kennett et al.*, 1995]. Due to the limited number of seismic stations and their large distances from the sources, epicenter coordinates were computed for fixed focal depths of 10 or 15 km, depending on the minimum allowable depth ($H_{\min}$) determined according to [*Seismic…*, 1979]:

$$\mathrm{M} \leq 3.3 \log h + 3.1.$$

For several earthquakes, the final catalogue provides a range of possible depths estimated using the NAS algorithm.

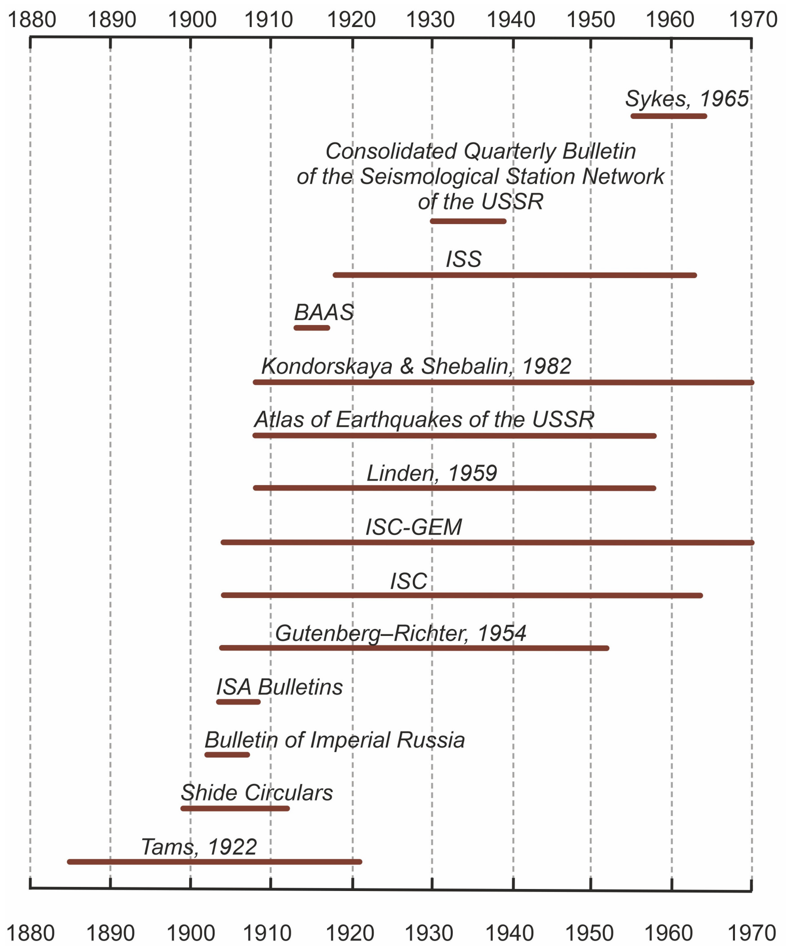

Figure 2. Sources used to search for data on earthquakes recorded in the eastern sector of the Russian Arctic from 1900 to 1961.

Magnitude is one of the key parameters included in earthquake catalogues. In this study, priority was given to moment magnitudes ($\mathrm{M_w}$) listed in the ISC-GEM catalogue [*Storchak et al.*, 2013, 2015] and to surface-wave magnitudes ($\mathrm{M_S}$) computed in ISC [*International Seismological Centre (ISC)*, 2025a]. Where these data were unavailable, MLH magnitudes from [*New Catalog…*, 1982] were used. Since MLH is an analogue of $\mathrm{M_S}$ employed by the Geophysical Survey RAS [*GS RAS*, 2025], it was converted to $\mathrm{M_w}$ using empirical relations proposed by [*Petrova and Gabsatarova*, 2020]. Additionally, all magnitudes in the final catalogue were standardized to $\mathrm{M_S}$(ISC) and mb(ISC) using the conversion relations described in [*Das et al.*, 2011; *Giacomo et al.*, 2015]. Whenever it was possible to refine the magnitude based on a larger number of stations, the calculation was performed using the Prague formula for $\mathrm{M_S}$ [*Kárník et al.*, 1962]:

$$\mathrm{M_S} = \log\left(\frac{A}{T}\right)_{\max} + 1.66 \log \Delta + 3.3.$$

Magnitude M_S was estimated following the procedure of [*Ambraseys and Douglas*, 2000]. In the computations, the vector sum of the maximum surface-wave amplitudes along the two horizontal components was used together with the period corresponding to the maximum amplitude. When data for one of the horizontal components were missing, the magnitude was calculated using the amplitude of the single available horizontal component. According to [*Ambraseys and Douglas*, 2000], a +0.1 correction was then added to compensate for the absence of the second component.

3. Recalculated and Unified Earthquake Catalogue for the Eastern Sector of the Russian Arctic (1900–1961)

During the refinement of the main earthquake parameters (hypocenters and magnitudes) for the eastern sector of the Russian Arctic, two catalogues were compiled (Tables 1 and 2). The first represents a consolidated and unified catalogue of earthquakes in this region for the period 1900–1961. It includes recalculated hypocenter coordinates, parameters of error ellipses, characteristics of the original datasets used, and magnitudes converted to a uniform moment magnitude scale (M_w) (Table 1).

The second catalogue (Table 2) includes events that were initially reported in the literature as belonging to the study area but were later found, after parameter refinement, to have epicenters located outside the region. It also contains earthquakes for which the phase arrival times were not found or were insufficient (fewer than three stations) to reliably determine the hypocenters. For each excluded event, the reason for exclusion is indicated in the Notes column.

Within the boundaries of the study area, 58 earthquakes were recorded between the early 20th century and 1961 according to various sources (section A). Of these, only 41 were included in the final catalogue with recalculated and unified parameters (Table 1). The recalculated epicenters of six earthquakes are located outside the study area (Table 2). For four events, phase arrival times could not be found in the available seismic station bulletins–most likely, they were recorded only by regional stations whose bulletins have not yet been discovered. In addition, for seven earthquakes, the location procedure could not be performed due to insufficient data: for these events, only one to three distant stations provided readings, typically located within a narrow azimuthal range.

For some of the earthquakes included in the final catalogue, the areas of epicentral error ellipses are relatively large. This is primarily due to the limited number of available seismic stations, their considerable distance from the sources, and the narrow azimuthal coverage. Despite these uncertainties, the computed epicenters can still be reliably associated with specific seismically active zones within the study area (Figure 3).

Of the 41 earthquakes included in the final catalogue, 35 are listed in [*New Catalog…*, 1982], 30 in the International Seismological Summary (ISS) bulletins, 12 in [*Gutenberg and Richter*, 1954], 27 in [*Linden*, 1959], and 18 in the ISC-GEM catalogue and its supplements [*Storchak et al.*, 2013, 2015]. Four events–dated August 11, 1924; August 10, 1949; April 29, 1951; and December 10, 1952–are absent from [*New Catalog…*, 1982], probably because no magnitude estimates were available at that time. During the present study, no amplitude or period data for surface waves were found for these earthquakes in the accessible seismic bulletins.

The diagrams shown in Figure 4 illustrate the data from the final catalogue of earthquakes in the eastern sector of the Russian Arctic (Table 1). The distribution of earthquakes by time and magnitude is highly non-uniform (Figure 4a, c). It reflects both the stages of development of instrumental seismic observations at global and regional scales and the temporal variations of seismic activity during the studied period. This issue is discussed in more detail in the following section.

Table 1. Recalculated and unified catalogue of earthquakes in the eastern sector of the Russian Arctic for the period 1900–1961 within the coordinates 70.0° to 90.0° N and 70.0° E–170.0° W

No	Data	Time	Hypocenter			$N_{stations}$ / N_{phases}	Gap, °	Range of epicentral distances, km	Error Ellipse			Magnitude	Unified magnitudes		
			φ, °	λ, °	h, km				Az_{major}, °	S_{minor}, km	S_{major}, km		M_w	M_S	m_b
1	10.04.1909	18:47:02.2	78.04	123.09	15f	11/18	344	3607 to 6086	30	108.9	310.3	M_w(ISC-GEM)=6.7	6.7	6.7	6.3
2	13.04.1912	02:39:45.7	85.03	95.99	10f	6/8	325	3135 to 4468	10	125.0	184.4	MLH=5.2	5.5	5.2	5.4
3	07.06.1914	16:24:02.9	73.01	116.19	10f	8/13	253	2361 to 5155	80	42.1	87.5	MLH=5.5	5.6	5.5	5.5
4	30.11.1918	06:48:44.9	70.42	130.92	15f	9/12	197	3492 to 6312	70	35.7	187.9	M_w(ISC-GEM)=6.5 M_S(ISC)=6.4	6.5	6.4	6.2
5	30.05.1923	08:30:44.6	77.37	127.27	10f	20/29	128	4737 to 6467	30	44.2	65.2	M_w(ISC-GEM)=6.0	6.0	5.9	5.9
6	30.05.1923	17:56:58.6	77.05	125.02	10f	23/36	128	3913 to 6602	50	41.9	81.0	M_w(ISC-GEM)=6.1	6.1	6.0	5.9
7	11.11.1923	14:00:08.8	84.66	104.75	10f	2/3	–	3207 to 3241	40	177.3	260.4	MLH=5.2	5.5	5.2	5.4
8	11.08.1924	02:26:00.6	81.73	119.23	10f	4/5	332	3423 to 4890	0	236.1	341.8	–			
9	19.10.1924	15:34:48.2	80.45	105.89	15f	4/6	181	3072 to 5796	90	49.9	93.6	M_S=5.6	5.7	5.6	5.6
10	09.04.1926	10:04:46.2	73.97	126.17	10f	20/24	228	2591 to 6712	80	41.9	62.0	M_w(ISC-GEM)=5.9	5.9	5.7	5.8
11	06.08.1926	05:24:00.8	85.63	85.86	13 (0 to 50)	33/51	132	3073 to 6544	130	30.7	36.6	M_w(ISC-GEM)=5.8	5.8	5.6	5.7
12	07.01.1927	10:43:04.0	81.18	122.07	10f	6/10	276	3231 to 5106	50	78.1	140.5	M_w(ISC-GEM)=5.7	5.7	5.4	5.6
13	14.11.1927	00:12:10.1	70.08	127.73	27 (0 to 60)	70/97	115	2300 to 7152	70	21.1	31.6	M_w(ISC-GEM)=6.7 M_S(ISC)=6.6	6.7	6.6	6.3
14	14.11.1927	04:56:30.4	69.99	128.31	15f	63/86	107	2320 to 7240	70	21.5	30.9	M_w(ISC-GEM)=6.9 M_S(ISC)=6.7	6.9	6.7	6.4
15	15.11.1927	21:48:47.3	70.13	127.36	10f	28/43	134	2283 to 5906	80	36.7	43.9	M_w(ISC-GEM)=6.0	6.0	5.9	5.9
16	03.02.1928	13:47:39.1	70.35	126.79	14 (0 to 50)	48/66	128	2317 to 7239	60	20.8	37.5	M_w(ISC-GEM)=6.3	6.3	6.3	6.1
17	27.03.1928	17:46:35.4	84.01	116.54	10f	4/5	278	3352 to 3691	50	100.7	263.2	MLH=5.0	5.4	5.0	5.2
18	31.05.1948	14:56:49.6	85.01	98.71	10f	17/18	173	2507 to 6572	150	26.5	58.8	MLH=4.8	5.2	4.8	4.9
19	10.08.1949	20:33:46.3	86.33	75.26	10f	22/23	179	3246 to 6522	120	19.2	57.2	–			
20	09.01.1951	16:00:22.6	80.60	122.51	10f	65/82	98	2597 to 8274	150	14.5	24.6	M_w(ISC-GEM)=5.8 M_S(ISC)=5.6	5.8	5.6	5.7
21	29.04.1951	07:35:44.5	80.51	123.27	8 (0 to 42)	52/68	111	2595 to 7478	120	21.7	25.5	M_w(ISC-GEM)=5.7 M_S(ISC)=5.3	5.7	5.3	5.6

Continued on next page

Table 1. Recalculated and unified catalogue of earthquakes in the eastern sector of the Russian Arctic for the period 1900–1961 within the coordinates 70.0° to 90.0° N and 70.0° E–170.0° W (Continued)

No	Data	Time	Hypocenter			$N_{stations}$ / N_{phases}	Gap, °	Range of epicentral distances, km	Error Ellipse			Magnitude	Unified magnitudes		
			φ, °	λ, °	h, km				Az_{major}, °	S_{minor}, km	S_{major}, km		M_w	M_S	m_b
22	29.04.1951	21:59:26.8	79.69	125.10	10f	11/12	245	2629 to 7495	160	39.9	103.4	–			
23	10.12.1952	12:47:53.5	85.17	98.84	10f	21/21	212	2220 to 7087	160	25.1	74.0	–			
24	10.12.1952	14:06:43.9	84.06	101.42	10f	23/24	217	2417 to 7108	170	22.4	57.8	MLH=5.2	5.5	5.2	5.4
25	28.06.1955	04:28:06.4	86.61	70.68	10f	111/169	51	2063 to 6492	130	11.2	17.1	M_w(ISC-GEM)=5.9 M_S(ISC)=5.7	5.9	5.7	5.8
26	04.03.1956	03:18:11.9	83.49	109.68	10f	7/7	313	2678 to 7206	120	89.5	170.4	MLH=5.0	5.4	5.0	5.2
27	13.05.1956	04:27:22.4	84.91	83.17	10f	5/5	316	2375 to 4434	80	80.0	353.0	MLH=5.0	5.4	5.0	5.2
28	13.05.1956	08:56:30.7	84.67	93.57	10f	7/7	310	2314 to 4491	100	63.4	228.8	MLH=5.0	5.4	5.0	5.2
29	13.05.1956	14:34:00.2	85.12	96.35	10f	36/38	113	2228 to 6571	120	14.9	25.1	MLH=5.1	5.4	5.1	5.2
30	08.09.1957	01:21:28.3	77.14	128.20	10f	3/4	293	629 to 2913	20	54.4	105.1	MLH=4.5	5.1	4.5	4.7
31	16.09.1957	01:34:32.3	81.79	119.90	10f	5/7	344	2561 to 3599	20	108.4	385.2	M=4.9 M_S=4.5	5.3	4.9	5.1
32	30.11.1957	17:41:16.6	83.80	114.20	10f	37/38	89	1395 to 7241	150	14.5	20.8	MLH=4.1	4.8	4.1	4.2
33	16.03.1958	10:09:09.8	73.08	116.59	10f	4/6	160	442 to 2388	170	22.6	36.1	MLH=4.0	4.7	4.0	3.2
34	23.09.1959	10:38:58.7	83.56	114.27	10f	43/49	140	2217 to 7260	140	15.4	20.2	M_S(ISC)=4.6	5.2	4.6	4.9
35	24.09.1959	05:43:36.1	83.66	113.00	10f	59/64	66	1374 to 7243	110	12.5	13.7	M_w(ISC-GEM)=5.5	5.5	5.1	5.4
36	05.10.1959	17:56:23.1	83.45	114.33	10f	46/50	66	888 to 8198	150	13.1	15.9	M_w(ISC-GEM)=5.7 M_S(ISC)=5.6	5.7	5.6	5.6
37	05.10.1959	18:11:17.8	83.65	115.40	10f	15/17	193	898 to 5172	40	20.6	51.7	MLH=5.0	5.4	5.0	5.2
38	05.10.1959	18:27:17.8	83.52	114.21	10f	125/166	56	880 65– 8689	30	10.5	13.1	M_w(ISC-GEM)=5.7 M_S(ISC)=5.4	5.7	5.4	5.6
39	05.10.1959	20:28:04.7	83.11	115.95	10f	3/4	228	909 to 2627	40	16.5	76.3	M=4.4	5.0	4.4	4.5
40	03.12.1960	20:21:00.0	76.64	131.08	10f	69/69	108	565 to 8339	150	12.1	18.4	MLH=5.1	5.4	5.1	5.2
41	29.06.1961	22:01:21.8	84.91	99.65	15 (0 to 45)	62/78	69	1566 to 6572	10	14.8	17.6	MLH=4.8	5.2	4.8	4.9

Table 2. Catalogue of seismic events excluded from the final version of the recalculated and unified catalogue of earthquakes in the eastern sector of the Russian Arctic (see Table 1)

No	Data	Time	Hypocenter			$N_{stations}$ / N_{phases}	Gap, °	Range of epicentral distances, km	Error Ellipse			Magnitude	Note
			φ, °	λ, °	h, km				Az_{major}, °	S_{minor}, km	S_{major}, km		
1	26.03.1927	18:32:40	85.0	85.0	–	–	–	–	–	–	–	–	Location procedure cannot be performed with the available data
2	24.05.1927	11:52:44.3	80.30	-162.93	10f	3/4	320	4310 to 5955	150	169.4	193.3	–	Recalculated epicenter lies outside the study area
3	24.05.1927	12:07:00.0	79.15	-132.65	10f	2/2	–	6258 to 6289	–	–	–	–	Recalculated epicenter lies outside the study area
4	02.06.1928	20:13:07.3	83.03	68.33	10f	3/5	292	2772 to 3975	30	90.5	179.5	MLH=4.7	Recalculated epicenter lies outside the study area
5	16.08.1928	07:36:37.3	69.81	124.94	10f	8/12	263	2174 to 5559	90	46.7	118.9	M_w(ISC)=5.9	Recalculated epicenter lies outside the study area
6	20.06.1931	15:05:21.9	86.86	64.71	5 (0–50)	22/30	130	2160 to 6282	110	26.2	34.4	M_w(ISC)=5.5	Recalculated epicenter lies outside the study area
7	26.09.1948	05:51:14.1	82.31	41.28	10f	11/12	174	2887 to 6790	80	27.1	68.4	MLH=5.0	Recalculated epicenter lies outside the study area
8	12.09.1953	14:33:40.0	86.0	83.0	–	–	–	–	–	–	–	–	Location procedure cannot be performed with the available data; only one phase arrival detected at a station (STR tp=14:41:32)
9	28.08.1954	02:41:52.0	86.0	85.0	–	–	–	–	–	–	–	–	Location procedure cannot be performed with the available data; only one phase arrival detected at a station (TAM tp=02:52:35)
10	14.09.1955	17:32:10.0	82.0	110.0	20 (10–40)	–	–	–	–	–	–	MLH=5.0	No phase arrival times found in available station bulletins. Marked as “Unreliable data” in [*New Catalog…*, 1982]
11	11.04.1956	14:45:06.0	71.6	126.7	–	–	–	–	–	–	–	–	Location procedure cannot be performed with the available data
12	15.05.1956	02:19:22.0	72.4	130.5	–	–	–	–	–	–	–	–	No phase arrival times found in available station bulletins
13	08.06.1956	03:26:25.0	72.8	125.5	–	–	–	–	–	–	–	–	No phase arrival times found in available station bulletins
14	17.06.1956	01:21:17.0	73.0	126.0	–	–	–	–	–	–	–	–	No phase arrival times found in available station bulletins
15	04.10.1959	16:27:20.0	83.23	112.40	10f	3/3	227	1333 to 2578	–	–	–	M=4.4	Unreliable solution
16	27.10.1960	14:38:38.0	84.45	81.29	10f	3/3	342	2118 to 6935	–	–	–	–	Unreliable solution
17	01.01.1961	18:46:04.9	84.55	64.30	10f	3/3	344	1954 to 2018	–	–	–	–	Unreliable solution; recalculated epicenter lies outside the study area

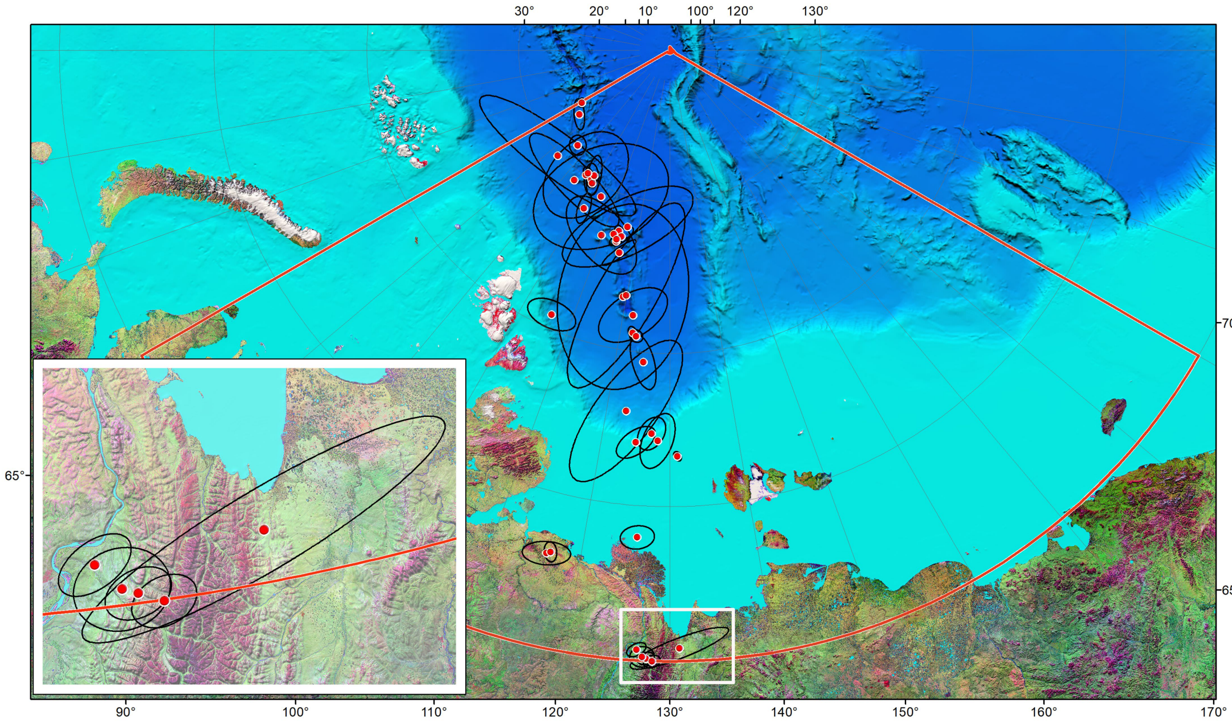

Figure 3. Map showing recalculated earthquake epicenters and their error ellipses in the eastern sector of the Russian Arctic for 1900–1961. Red circles indicate recalculated earthquake epicenters from Table 1. Black ellipses represent location uncertainties. The red line outlines the study area.

The distribution of the number of earthquakes by magnitude is shown in Figure 4b. If the methods for determining the magnitude of completeness (MAXC – Maximum Curvature [*Wyss et al.*, 1999]; GFT – Goodness-of-Fit Test [*Wiemer and Wyss*, 2000]; and LLS – Lower end of Linear Segment [*Smirnov*, 1998]) are applied, they yield M_w values of 5.3 to 5.4. The LLS method, which was recommended for use in [*Pavlenko and Zavyalov*, 2022] after comparison of different approaches, gave a representative magnitude value of $M_w = 5.4$. However, this value varied significantly depending on the time period considered.

In general, when refining earthquake hypocenters, the seismic stations used were located at considerable distances from the sources (Figure 4d). The number of recording stations varied (Figure 4e), and they were often distributed within a narrow azimuthal sector (Figure 4f). This situation primarily reflects the developmental features of the early 20th-century instrumental seismic observation network [*Morozov and Vaganova*, 2024].

4. Comprehensive Earthquake Catalogue for the Eastern Sector of the Russian Arctic During the Instrumental Observation Period

The combination of the catalogue compiled in this study with the unified catalogue of earthquakes in the Arctic Zone of the Russian Federation for the period 1962–2022 [*Gvishiani et al.*, 2022; *Vorobieva et al.*, 2023a,b] made it possible to create a comprehensive earthquake catalogue for the eastern sector of the Russian Arctic, covering the entire period from 1900 to 2022 (Figure 5).

The first earthquake within the study area was recorded on April 10, 1909, with a magnitude of $M_w = 6.7$. It occurred in the eastern part of the Gakkel Ridge, near the continental slope of the Laptev Sea shelf. Between 1923 and 1928, the highest number of earthquakes ($N = 13$) was recorded for the entire first half of the 20th century (Figure 5). This increase may be attributed to a lower detection threshold due to the gradual restoration of the seismic observation network in the USSR after the Civil War and the expansion of seismic networks in neighboring countries [*Ponomarev et al.*, 2025]. However, it is also possible that this period represents a genuine episode of increased seismic activity in the region.

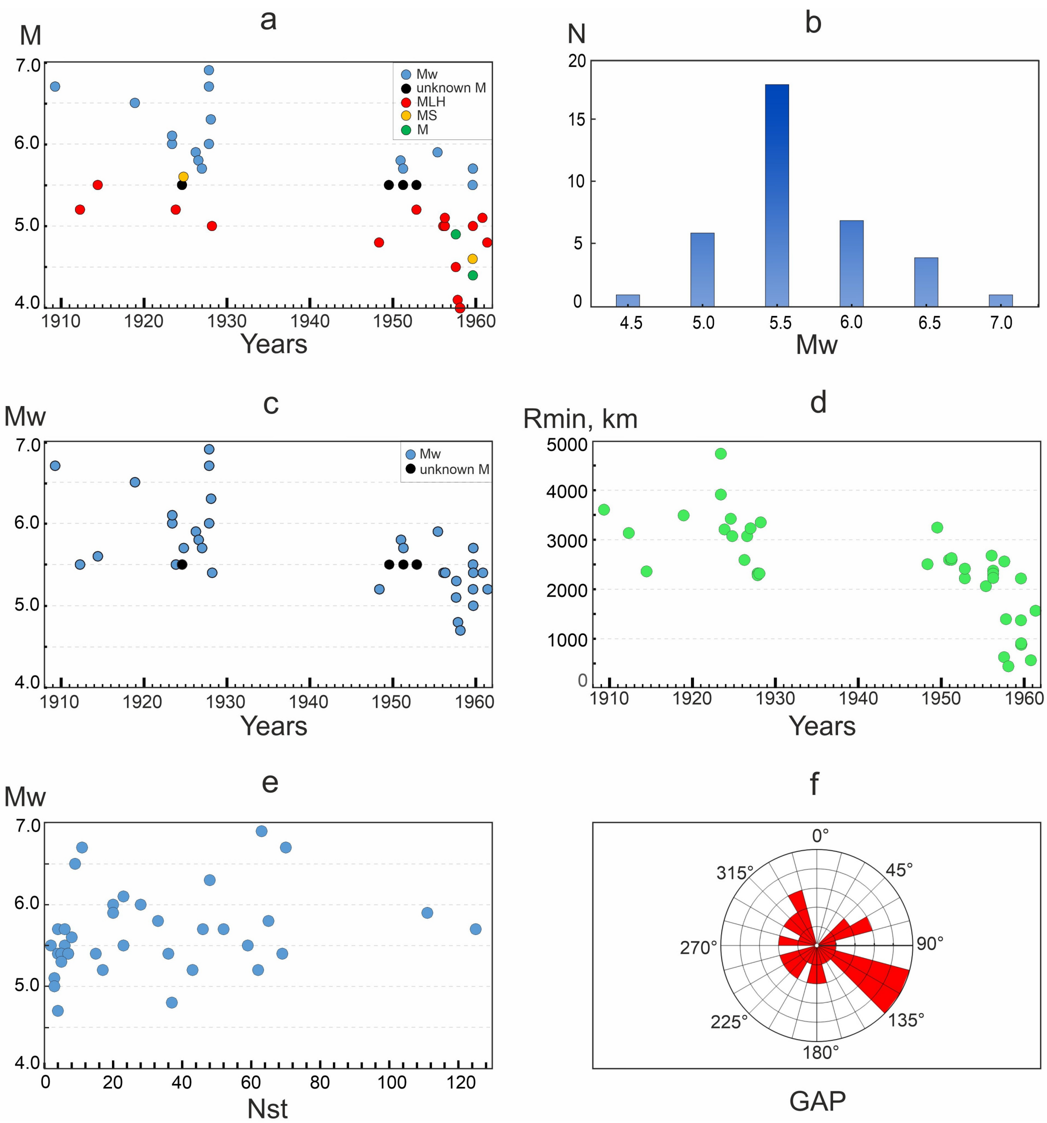

Figure 4. Characteristics of the data from the final catalogue of earthquakes in the eastern sector of the Russian Arctic for 1900–1961: (a) distribution of earthquakes by year and magnitude type; (b) histogram of earthquake counts versus unified magnitude M_W; (c) temporal distribution of earthquakes with unified magnitude M_W; (d) distribution of minimum epicentral distances versus year; (e) dependence of the number of recording seismic stations on earthquake magnitude; (f) shadow-zone diagram of station–epicenter azimuthal distribution.

After 1928 and until 1948, there was a complete absence of recorded earthquakes (Figure 5). While the lack of data between 1939 and 1945 can reasonably be explained by World War II and the associated reduction in the number of operating seismic stations across Europe and Asia, the gap between 1929 and 1939 is more difficult to interpret. A similar situation is observed in the western sector of the Russian Arctic [*Morozov et al.*, 2023b]. It is possible that this interval reflects a regional decrease in seismic activity following the episode of intensification during the 1920s.

In the subsequent decades, the temporal and magnitude distribution of recorded earthquakes clearly reflects the major stages in the development of instrumental seismology in the USSR.

From the 1950s onward, earthquake recordings within the study area resumed, corresponding to a new stage in the advancement of seismic observations in the Soviet Union. In 1949, a special government decree, “On the strengthening of seismological research and

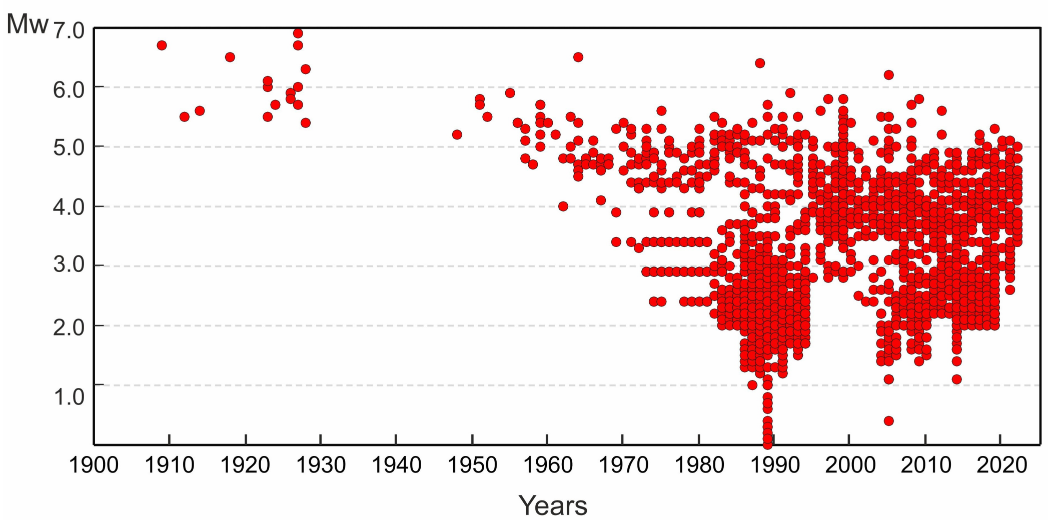

Figure 5. Temporal distribution of earthquakes from the comprehensive catalogue for the eastern sector of the Russian Arctic (1900–2022).

earthquake forecasting in the USSR", recognized the necessity of reorganizing, expanding, and institutionalizing seismic and earthquake-resistant construction efforts. Between 1949 and 1951, a large-scale effort led by E. F. Savarensky, D. P. Kirnos, D. A. Kharin, and I. L. Nersesov established a broad seismic monitoring network across the country, primarily in seismically active regions. Over 40 new seismic stations were opened, and most existing and newly established stations were equipped with improved instruments capable of recording both distant and local earthquakes. The parameters of the new seismographs were standardized, allowing for the collection of consistent and comparable datasets [*Ponomarev et al.*, 2025; *Starovoit*, 2005].

After 1965, the detection threshold for earthquakes decreased, and the number of recorded events in the Arctic region increased markedly (Figure 5). On January 15, 1965, a landmark event occurred in the history of Soviet seismology – the official establishment of the Unified System of Seismic Observations (USSO) in the USSR. Following extensive preparatory work led by the Council on Seismology of the USSR Academy of Sciences, the Schmidt Institute of Physics of the Earth, and regional seismological institutions, the Presidium of the Academy of Sciences adopted the official resolution founding the national network [*Ponomarev et al.*, 2025].

The USSO framework included a network of reference (teleseismic) stations, as well as regional networks in each seismically active zone of the country, independent of administrative boundaries. Among them were the Arctic regional network, managed by the Central Seismic Station "Pulkovo" of the Schmidt Institute of Physics of the Earth, and the Siberian regional network, managed by the Institute of the Earth's Crust of the Siberian Branch of the USSR Academy of Sciences.

In the following decades, the development of seismic observations mainly involved expanding the number of stations while maintaining the organizational structure established in 1965. The increasing number of seismic stations and the improvement of their instrumentation significantly affected the number of recorded earthquakes in the study area.

The temporal and magnitude distribution of epicenters (Figure 5) also clearly reflects the period following the collapse of the USSR in 1991, when the USSO effectively ceased to function in its original form. Due to limited state funding, many seismic expeditions and field parties faced severe difficulties, leading to the closure of dozens of stations and an almost complete halt in data transmission to processing centers. Only in the early 2000s did a gradual restoration and modernization of the national seismic network begin, which also affected high-latitude and Arctic regions, resulting in a renewed increase in the number of recorded earthquakes.

The spatial distribution of earthquake epicenters is shown in Figure 6. Within the oceanic part of the study area, most instrumentally recorded earthquakes are concentrated along the Gakkel Ridge – an ultra-slow spreading center – and its continuation on the Laptev Sea shelf, which coincides with the boundary between the Eurasian and North American lithospheric plates. The Gakkel Ridge has a sub-meridional orientation and merges into the continental slope of Eurasia near the central part of the Laptev Sea. To the east, it is nearly parallel to the Lomonosov Ridge, which bounds the Amundsen Basin from the east and merges into the continental slope in the northeastern Laptev Sea [*Avetisov*, 1996].

The spatial pattern of epicenters highlights the unique tectonic position of the Laptev Sea shelf, which represents a transitional zone between the continental margin of Eurasia and the Central Arctic seismic belt – effectively its continental extension. This makes the Laptev shelf one of the most distinctive and least explored regions on Earth due to its remoteness and difficult accessibility [*Avetisov*, 1996].

The distribution of earthquakes recorded in the Laptev Sea shelf region during the 20th century has been previously summarized in [*Avetisov*, 1996]. The analysis of epicenters from the comprehensive catalogue for 1900–2022 refines several of these previously noted features (Figure 6). The linear Arctic Seismic Belt remains continuous across the continental slope for approximately 50 km on the northern shelf, extending southward to 76.8° N. Farther south, the line of epicenters shifts 50–70 km eastward, trending southeastward west of the New Siberian Islands. About 50–100 km northwest of Belkovsky Island, the zone widens and extends toward the Yana Bay, gradually fading south of Stolbovoy Island. In the southeastern shelf, earthquake density decreases, and the distribution becomes more scattered. In the article [*Avetisov*, 1996] hypothesized the presence of an aseismic lithospheric block encompassing Belkovsky, Kotelny, Faddeyevsky, and Maly Lyakhovsky islands. However, data from the present catalogue do not confirm this hypothesis.

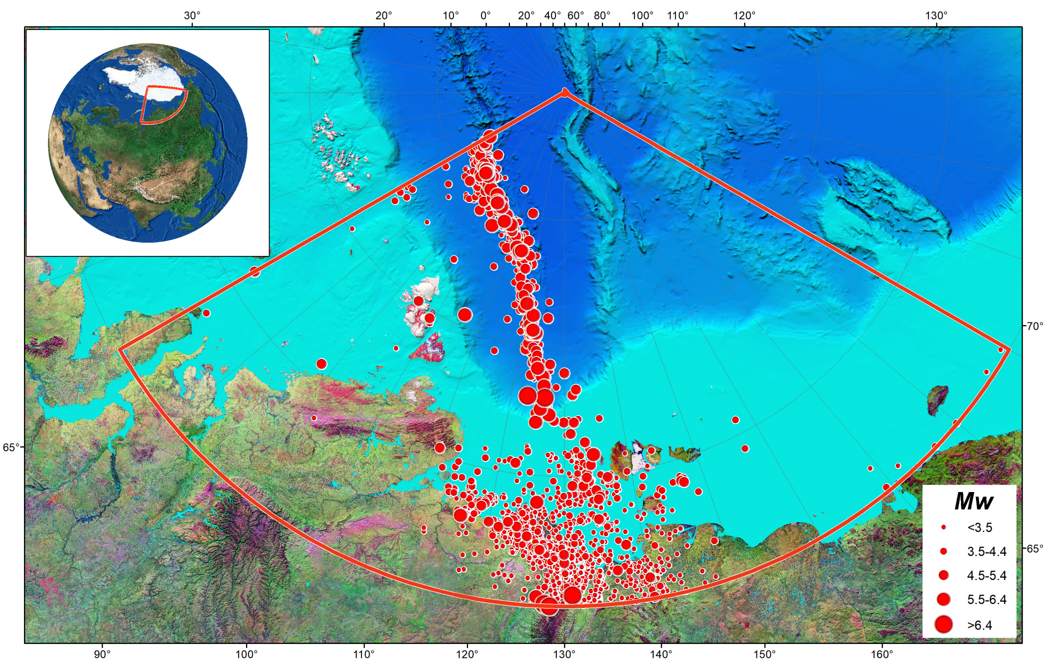

Figure 6. Spatial distribution of earthquake epicenters from the comprehensive catalogue for the eastern sector of the Russian Arctic (1900–2022).

West of 130° E, the epicenter distribution changes markedly. Here, a sub-linear zone extends from the Buor-Khaya Gulf northwestward, crossing the Lena Delta and continuing, with some interruptions, through the Olenyok and Khatanga Bays to the eastern coast of Taimyr. Earthquakes with magnitudes up to 5.5 have been recorded along this zone, some of which have available macroseismic data [*Avetisov*, 1996]. Two additional, though less well-defined, epicentral zones can also be recognized due to the limited number of events. The first extends nearly east–west from Belkovsky Island toward the eastern Taimyr coast near the Khatanga Bay. The second trends northwestward from the Yana Bay to the central Laptev shelf, where it fades near 123° E, north of 76° N.

According to [*Krylov et al.*, 2023], the modern extensional zone, representing the continuation of the Gakkel Ridge axis onto the Laptev Sea shelf, is associated with an area of normal faulting along the eastern boundary of the Anisin, Zarya, and Belkovsky–Svyatonossky rift chains. An older extensional axis, corresponding to the fault systems bounding the Ust-Lena and Omoloy rifts and continuing the Gakkel Ridge axis, shows significantly lower present-day activity. This older axis primarily accommodates residual stresses near the intersections with the Khatanga–Lomonosov fault zone in the northwestern shelf and the Lena–Taimyr uplift zone in the southwest.

Focusing on the Lena Delta region, [*Krylov et al.*, 2023] show that the extensional axes are oriented mainly along the Olenyok and Bykov channels and along the margin of the Siberian Platform. These observations indicate that this tectonic setting produces an extensional regime in the eastern part of the region and strike-slip deformation in the western part. Enhanced seismic activity in the area is associated with the Lena–Anabar marginal suture, marking the boundary of the Precambrian Siberian Platform, and with the Chersky Range, corresponding to the modern boundary between the Eurasian and North American plates. A notable series of strong earthquakes occurred in 1927–1928 in northern Yakutia, within the Verkhoyansk Range, reflecting this tectonic complexity. Overall, the data from [*Krylov et al.*, 2023] provide a comprehensive framework for understanding the spatial distribution and kinematics of seismic deformation in the Lena Delta region.

No earthquakes have been recorded on the shelf of the East Siberian and Chukchi Seas, or on the adjacent continental territories, including the Taimyr Peninsula. Within the continental slope, only a single event was recorded – the earthquake of October 19, 1924, near the Severnaya Zemlya archipelago.

5. Seismic Zonation of the Eastern Sector of the Russian Arctic

This section presents a comparison of earthquake parameters recorded throughout the instrumental period with the LDF models of the GSZ-97 [*Ulomov and Shumilina*, 1999] and GSZ-2016 [*Ulomov et al.*, 2016] seismic zonation maps for the eastern Russian Arctic. One of the earliest seismic zonations of the Laptev Sea shelf was conducted by [*Kuzin*, 1989], who identified seismically hazardous zones with estimates of M_{max}, recurrence intervals, and maximum intensity (Imax). Kuzin noted, however, that this scheme was preliminary due to the limited and sparse seismic dataset.

GSZ-97 LDF Model

The LDF model of the general seismic zonation map GSZ-97 [*Ulomov and Shumilina*, 1999] was compared with instrumental data from the consolidated earthquake catalogue of the eastern Russian Arctic for 1900–2022 (Figure 7a). The model fragment covering the study area comprises multiple domains with MLH ranging from 3.5 to 7.0, including lineaments with MLH of 6.0 to 7.0. The highest MLH values occur in the Gakkel Ridge and along shelf and coastal lineaments.

From this comparison, the following observations can be made:

- Only for domain No. 7RUD0406, in the region of the New Siberian Islands archipelago, did the M_{max} value fall below the magnitude of the strongest recorded earthquake. For all other domains and lineaments, M_{max} values are not less than the magnitudes of the strongest earthquakes.
- For most domains and lineaments, M_{max} values exceed the magnitudes of the strongest recorded earthquakes by more than 0.5 units.
- The boundaries of domain No. 7RUD0374 in the Gakkel Ridge are slightly shifted relative to the epicenters of earthquakes recorded within the ridge.

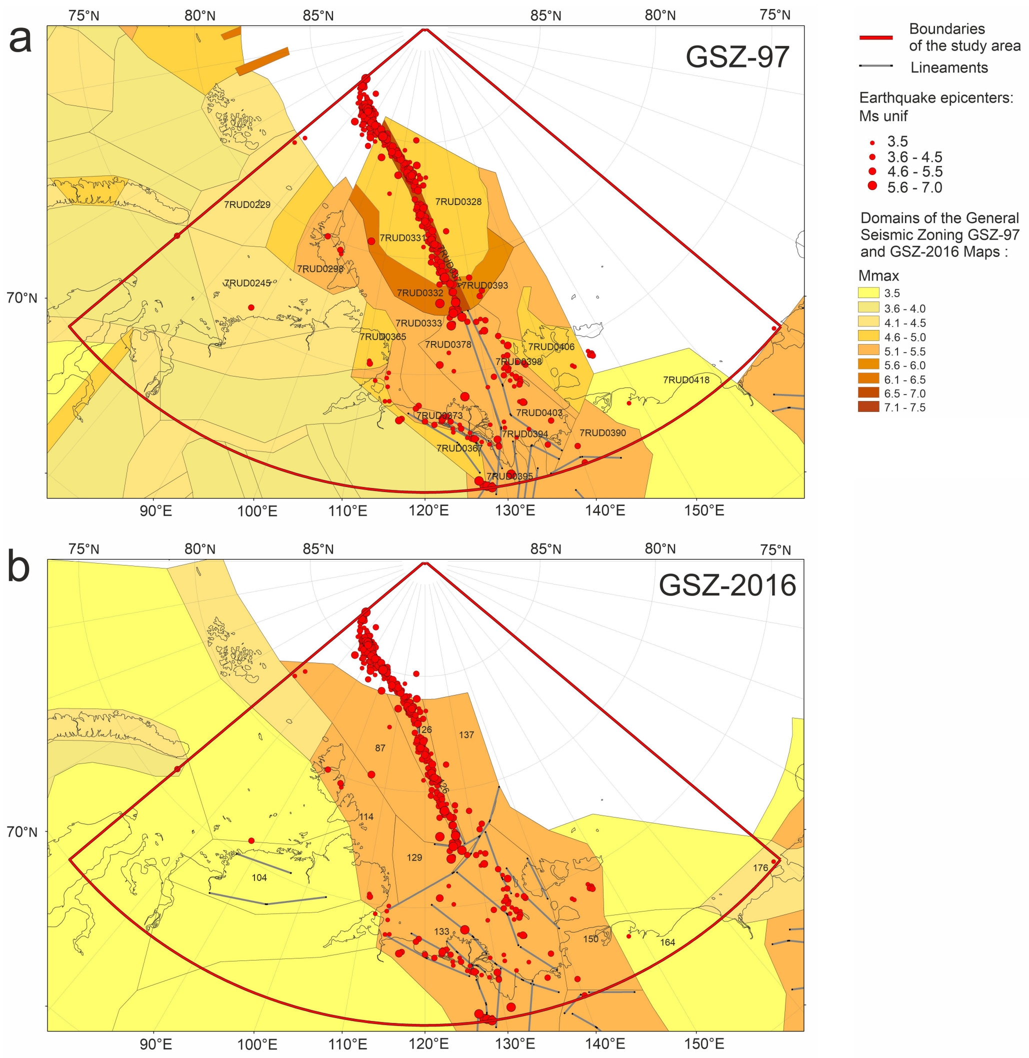

Figure 7. Fragments of the LDF models from the GSZ-97 [*Ulomov and Shumilina*, 1999] (a) and GSZ-2016 [*Ulomov et al.*, 2016] (b) maps with overlaid earthquake epicenters with unified M_S magnitudes from the consolidated catalog of earthquakes in the eastern sector of the Russian Arctic for the period 1900–2022.

- The LDF model in the New Siberian Islands region does not cover areas where earthquakes occurred, including the December 15, 1973 earthquake ($M_S = 4.7$).
- Lineaments Nos. L-0813, L-0818, and L-0847, which are extensions of the Gakkel Ridge onto the Laptev Sea shelf, are not reflected in the distribution of recorded earthquake epicenters.
- Earthquake depths are the least reliably determined parameter in this region. Therefore, it is not possible to confidently characterize the depth distribution of earthquake hypocenters or compare them with domain depths.

Based solely on instrumental data, the following recommendations for improving the LDF model of the GSZ-97 map are suggested:

- Slightly shift the boundaries of domain No. 7RUD0374 in the Gakkel Ridge region to better match the distribution of recorded epicenters.
- Expand domain No. 7RUD0406 eastward to include the entire New Siberian Islands archipelago and increase M_{max} to 5.5.
- Consider lowering M_{max} to 4.5 for domains Nos. 7RUD0328 and 7RUD0331 in the Nansen and Amundsen Basin areas.

- Reduce M_{max} for domains in the "continent–ocean" transition zone: domain No. 7RUD0393 to 4.5 and domain No. 7RUD0411 to 3.5, where no earthquakes with magnitudes above 3.0 were recorded.
- For the Laptev Sea shelf, several lineaments and domains have overestimated M_{max} values. Specifically: L-0818 to 5.5; L-0847 and L-0849 to 5.5; L-0813 to 6.5; 7RUD0394 to 4.5; 7RUD0401 to 3.5; and 7RUD0333 to 4.5.
- Some coastal lineaments and domains also exhibit overestimated M_{max} values: L-0861 and L-0862 to 5.5; L-0791 to 6.0; 7RUD0365 and 7RUD0402 to 4.5.
- Within domain No. 7RUD0366, east of the Taimyr Peninsula, north of the Khatanga Gulf, no earthquakes with magnitudes ≥ 3.0 have been recorded. It may be necessary either to merge this domain with adjacent ones or reduce its M_{max} to 3.5.

GSZ-2016 LDF Model

The GSZ-2016 represents a further development and improvement of the earlier LDF model GSZ-1997. A comparison of its parameters with instrumental data from the consolidated earthquake catalogue of the eastern sector of the Russian Arctic for 1900–2022 was conducted (Figure 7b). In the studied fragment of the LDF model, a relatively small number of large domains and lineaments are identified, with maximum possible magnitudes (MLH) reaching 5.5 for domains and 6.0–7.0 for lineaments.

From this comparison, the following conclusions can be drawn:

- The locations of domains and lineaments, as well as their M_{max} values, generally correspond to the actual distribution of earthquake epicenters and magnitudes.
- In domain No. 105, an earthquake on May 26, 2015 (M_S = 3.7) slightly exceeded the domain's M_{max} value of 3.5.
- In domain No. 87, near the "continent–ocean" transition zone by the Severnaya Zemlya archipelago, an earthquake on October 19, 1924 (M_S = 5.6) slightly exceeded the M_{max} value of 5.5 for the domain.
- In the Amundsen Basin area, domain No. 137 and lineaments Nos. 671, 672, and 673 have M_{max} values that significantly exceed the magnitudes of the strongest recorded earthquakes.
- Earthquake depths are the least reliably determined parameter in this region. Therefore, it is not possible to confidently characterize the depth distribution of earthquake hypocenters or compare them with domain depths.

The following recommendations for improving the LDF model of the GSZ-2016 map, based solely on instrumental data analysis, are proposed:

- Reassess the maximum magnitude values, reducing M_{max} for domain No. 137 to 4.0, and for lineaments Nos. 671, 672, and 673 to 5.5–6.0, all located in the Amundsen Basin area.
- Increase M_{max} for domain No. 105 to 4.0, located in the Khatanga Gulf region.
- Consider lowering M_{max} for domain No. 150 to 5.0, located in the New Siberian Islands archipelago.

6. Conclusion

This study presents a comprehensive analysis of seismicity in the eastern sector of the Russian Arctic throughout the entire instrumental observation period. A consolidated, recalculated, and unified earthquake catalogue for 1900–1961 was compiled based on the most complete set of instrumental data available, the modern global velocity model ak135 [*Kennett*, 2005; *Kennett et al.*, 1995], and an improved location algorithm implemented in the NAS (New Association System) program [*Asming et al.*, 2021; *Fedorov et al.*, 2019]. Integration of this catalogue with the dataset of earthquakes in the Arctic Zone of the Russian Federation for 1962–2022 [*Gvishiani et al.*, 2022; *Vorobieva et al.*, 2023a,b] allowed the creation of a single, comprehensive catalogue of earthquakes in the eastern sector of the Russian Arctic covering the entire period from 1900 to 2022.

The temporal and magnitude distributions of earthquakes recorded within the study area are highly non-uniform, reflecting the major stages in the development of instrumental seismic observations in the country. A peak in recorded seismic activity was observed in the 1920s, which can be attributed both to the restoration of seismic stations in the USSR and, likely, to a genuine increase in regional seismicity. Between 1929 and 1948, a gap in earthquake records is observed, partly explained by the events of World War II (1939–1945) and the consequent reduction in the number of operational seismic stations across Europe and Asia. However, for the period 1929–1939, this explanation is insufficient, and it is possible that a regional decrease in seismic activity occurred following the intensification in the 1920s.

From the late 1960s, with the establishment of the Unified System of Seismic Observations (USSO) in the USSR in 1965, the number of recorded events significantly increased, and the magnitude threshold for detection decreased. In the 1990s, a reduction in available data is observed due to the disruption of the observation system in the post-Soviet period, followed by gradual restoration beginning in the early 2000s.

The main earthquake epicenters are concentrated in the area of the Gakkel mid-ocean ridge and its extension onto the Laptev Sea shelf, as well as in the continental part of northeastern Yakutia. On the Laptev Sea shelf, linear and diffuse seismic zones correspond to modern geodynamic structures.

Using the consolidated earthquake catalogue of the eastern sector of the Russian Arctic for 1900–2022, a comparison was performed between the LDF models of the GSZ-97 and GSZ-2016 maps [*Ulomov et al.*, 2016; *Ulomov and Shumilina*, 1999] and actual instrumental data. The boundaries and M_{max} values of the LDF models correspond to the observed distribution of earthquakes and their magnitudes to varying degrees:

- The GSZ-97 LDF model generally reproduces the geometry of seismically active zones but overestimates M_{max} for most domains and lineaments;
- The GSZ-2016 LDF model demonstrates the best agreement with both the spatial positions of domains and lineaments and the M_{max} values, although some elements require local adjustments.

The results obtained in this study provide a foundation for further research aimed at assessing potential natural and technological risks and seismic hazards in the Arctic and adjacent regions. Moreover, these results can be used to develop measures for the safe operation of industrial facilities and systems during the development of major deposits in the eastern sector of the Russian Arctic.

Acknowledgments. The work was supported by the Russian Science Foundation Grant 21-77-30010-P “System analysis of geophysical process dynamics in the Russian Arctic and their impact on the development and operation of the railway infrastructure”. The authors express their gratitude to the staff members of the GS RAS Archive for their help in the search for the bulletins of the Russian seismic stations.

Appendix A

Table A1. Recalculated and unified catalogue of earthquakes in the eastern sector of the Russian Arctic for the period 1900–1961 within the coordinates 70.0° to 90.0° N and 70.0° E–170.0° W

No	Data	Time	Hypocenter			Magnitude*	Source*
			φ, °	λ, °	h, km		
1	10.04.1909	18:46:54.0	77.5	128.0	35	M(GUTE)=6.6 M_S(PAS)=6.6 M=6.5 MLH=6.8 M_w(ISC-GEM)=6.7	[*Gutenberg and Richter*, 1954]
		18:46:58.0	78.0	128.0	–		[*Linden*, 1959]
		18:46:58.0	78.0	128.0	20 (10 to 40)		[*New Catalog…*, 1982]
		18:46:54.3	78.54	129.16	10f		ISC-GEM
2	13.04.1912	02:40:00.0	86.4	94.6	–	M_S(PAS)=5.6 M=5.0 MLH=5.2	[*Tams*, 1922]
		02:39:42.0	80.0	100.0	35		[*Gutenberg and Richter*, 1954]
		02:39:36.0	78.9	107.9	–		[*Linden*, 1959]
		02:39:36.0	78.9	108.0	20		[*New Catalog…*, 1982]
3	07.06.1914	16:24:00.0	73.0	119.0	–	M=5.3 MLH=5.5	[*Linden*, 1959]
		16:24:00.0	73.0	119.0	15		[*New Catalog…*, 1982]
4	30.11.1918	06:48:31.0	70.1	132.0	–	M_S(PAS)=6.2 M=6.0 M_S(ISC)=6.4 MLH=6.2 M_w(ISC-GEM)=6.5	ISS
		06:48:40.0	71.0	132.0	35		[*Gutenberg and Richter*, 1954]
		06:48:38.0	71.2	134.0	–		[*Linden*, 1959]
		06:48:40.0	71.2	134.0	20 (10 to 40)		[*New Catalog…*, 1982]
		06:48:46.9	70.54	130.51	15f		ISC
		06:48:47.0	70.56	130.44	15f		ISC-GEM
5	30.05.1923	08:30:30	76.5	127.0	–	M_S(PAS)=6.0 M=5.5 MLH=5.8 M_w(ISC-GEM)=6.0	ISS
		08:30:46	77.0	127.0	35		[*Gutenberg and Richter*, 1954]
		08:30:40	77.5	128.4	–		[*Linden*, 1959]
		08:30:40	77.0	127.0	20 (10 to 40)		[*New Catalog…*, 1982]
		08:30:41.9	76.76	127.07	10f		ISC-GEM
6	30.05.1923	17:56:42	76.5	127.0	–	M_S(PAS)=6.0 M=5.3 MLH=5.8 M_w(ISC-GEM)=6.1	ISS
		17:56:42	77.0	127.0	35		[*Gutenberg and Richter*, 1954]
		17:56:55	76.0	129.0	–		[*Linden*, 1959]
		17:56:55	76.0	129.0	20 (10 to 40)		[*New Catalog…*, 1982]
		17:56:58.4	77.06	126.14	10f		ISC-GEM
7	11.11.1923	14:00:24	84.0	100.0	–	MLH=5.2	ISS
		14:00:27	85.0	102.0	20 (10 to 40)		[*New Catalog…*, 1982]
8	11.08.1924	02:25:42	82.0	120.0	–	–	ISS
9	19.10.1924	15:34:45	79.0	110.0	–	M=4.3 MLH=4.5	ISS
		15:35:11	78.2	107.5	–		[*Linden*, 1959]
		15:35:11	78.2	107.5	20 (10 to 40)		[*New Catalog…*, 1982]
10	09.04.1926	10:04:35	73.5	127.0	–	M_S(PAS)=5.8 M=5.5 MLH=5.8 M_w(ISC-GEM)=5.9	ISS
		10:04:50	74.0	125.0	35		[*Gutenberg and Richter*, 1954]
		10:04:47	74.0	127.4	–		[*Linden*, 1959]
		10:04:50	74.0	127.4	20 (10 to 40)		[*New Catalog…*, 1982]
		10:04:44.2	74.18	128.02	10f		ISC-GEM

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Table A1. Recalculated and unified catalogue of earthquakes in the eastern sector of the Russian Arctic for the period 1900–1961 within the coordinates 70.0° to 90.0° N and 70.0° E–170.0° W (Continued)

No	Data	Time	Hypocenter			Magnitude*	Source*
			φ, °	λ, °	h, km		
11	06.08.1926	05:23:48	85.0	85.0		M_S(PAS)=5.6 M=5.3 MLH=5.6	ISS
		05:23:58	86.0	85.0	35		[*Gutenberg and Richter*, 1954]
		05:23:54	85.5	100.0	–		[*Linden*, 1959]
		05:23:54	85.5	100.0	20 (10 to 40)		[*New Catalog...*, 1982]
12	07.01.1927	10:43:00	80.5	113.0		M_S(PAS)=5.6 M=5.0 MLH=5.1	ISS
		10:43:12	80.0	117.0	35		[*Gutenberg and Richter*, 1954]
		10:43:00	82.0	126.5	–		[*Linden*, 1959]
		10:43:00	82.0	126.0	20 (10 to 40)		[*New Catalog...*, 1982]
13	26.03.1927	18:32:40	85.0	85.0	–	–	ISS
14	24.05.1927	11:52:24	74.0	-173.0	–	–	ISS
15	24.05.1927	12:08:00	74.0	-173.0	–	–	ISS
16	14.11.1927	00:12:00	70.0	128.0	–	M_S(PAS)=6.5 M=6.5 MLH=6.8 M_S(ISC)=6.6 M_w(ISC-GEM)=6.7	ISS
		00:12:05	70.5	128.0	35		[*Gutenberg and Richter*, 1954]
		00:12:07	70.0	129.7	–		[*Linden*, 1959]
		00:12:07	69.9	129.9	20 (10 to 40)		[*New Catalog...*, 1982]
		00:12:08.5	70.22	128.94	15f		ISC
		00:12:08.6	70.32	129.00	15f		ISC-GEM
17	14.11.1927	04:56:24	70.0	128.0	–	M_S(PAS)=6.8 M=6.5 MLH=6.8 M_S(ISC)=6.7 M_w(ISC-GEM)=6.9	ISS
		04:56:24	70.0	128.0	35		[*Gutenberg and Richter*, 1954]
		04:56:28	70.0	131.5	–		[*Linden*, 1959]
		04:56:28	70.1	129.2	20 (10 to 40)		[*New Catalog...*, 1982]
		04:56:33.3	70.09	128.73	15f		ISC
		04:56:33.2	70.09	128.78	15f		ISC-GEM
18	15.11.1927	21:48:36	70.0	128.0	–	M_S(PAS)=6.0 M=5.5 MLH=5.8 M_w(ISC-GEM)=6.0	ISS
		21:48:46	70.5	128.0	–		[*Gutenberg and Richter*, 1954]
		21:48:48	70.0	128.5	–		[*Linden*, 1959]
		21:48:46	70.5	128.5	16 (8 to 32)		[*New Catalog...*, 1982]
		21:48:46.3	70.30	128.59	10		ISC-GEM
19	03.02.1928	13:47:28	70.0	128.0	–	M_S(PAS)=6.2 M=6.0 MLH =6.2	ISS
		13:47:35	70.5	128.0	–		[*Gutenberg and Richter*, 1954]
		13:47:38	70.6	128.8	–		[*Linden*, 1959]
		13:47:38	70.5	128.8	16 (8 to 32)		[*New Catalog...*, 1982]
20	27.03.1928	17:46:20	84.0	100.0	–	M=4.5 MLH=5.0	ISS
		17:47:04	82.7	87.8	–		[*Linden*, 1959]
		17:47:04	82.7	88.0	20 (10 to 40)		[*New Catalog...*, 1982]
21	02.06.1928	20:12:54	83.0	70.0	–	M=4.5 MLH=4.7	ISS
		20:13:00	83.4	81.6	–		[*Linden*, 1959]
		20:13:00	83.4	82.0	20 (10 to 40)		[*New Catalog...*, 1982]

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Table A1. Recalculated and unified catalogue of earthquakes in the eastern sector of the Russian Arctic for the period 1900–1961 within the coordinates 70.0° to 90.0° N and 70.0° E–170.0° W (Continued)

No	Data	Time	Hypocenter φ, °	Hypocenter λ, °	Hypocenter h, km	Magnitude*	Source*
22	16.08.1928	07:36:12	70.0	128.0	–	M_S(PAS)=5.6 M=5.5 MLH=5.6 M_w(ISC-GEM)=5.9	ISS
		07:36:37	70.0	126.0	35		[*Gutenberg and Richter*, 1954]
		07:36:42	73.9	130.2	–		[*Linden*, 1959]
		07:36:42	70.0	126.0	16		[*New Catalog...*, 1982]
		07:36:40.7	69.41	125.17	15f		ISC-GEM
23	20.06.1931	15:05:22	86.3	79.0	–	M_S(PAS)=5.6 M=4.8 MLH=5.3 M_w(ISC-GEM)=5.5	ISS
		15:05:15	86.25	79.0	35		[*Gutenberg and Richter*, 1954]
		15:05:17	87.0	86.0	–		[*Linden*, 1959]
		15:05:17	87.0	86.0	20 (10 to 40)		[*New Catalog...*, 1982]
		15:05:24.8	87.01	64.33	10f		ISC-GEM
24	31.05.1948	14:56:44	84.5	100.0	–	MLH=4.8	ISS
		14:56:44	84.3	123.8	–		[*Linden*, 1959]
		14:56:44	84.3	124.0	20 (10 to 40)		[*New Catalog...*, 1982]
		14:56:51.2	85.01	99.52	15f		ISC-GEM (supplement)
25	26.09.1948	05:51:15	80.7	99.6	–	MLH=5.0	[*Linden*, 1959]
		05:51:15	80.7	99.6	20 (10 to 40)		[*New Catalog...*, 1982]
26	10.08.1949	20:33:42	86.0	82.0	–	–	ISS
27	09.01.1951	16:00:21.0	80.0	125.0	–	M=4.8 MLH=5.3 MS(ISC)=5.6 M_w(ISC-GEM)=5.8	ISS
		16:00:21.0	81.0	126.4	–		[*Linden*, 1959]
		16:00:21.0	81.0	126.5	20 (10 to 40)		[*New Catalog...*, 1982]
		16:00:26.2	80.60	122.59	10		ISC-GEM
28	29.04.1951	07:35:42.0	80.0	125.0	–	M=4.8 MLH=5.2 MS(ISC)=5.3 M_w(ISC-GEM)=5.7	ISS
		07:35:38.0	81.5	131.0	20		[*Linden*, 1959]
		07:35:37.0	81.5	131.0	20 (10 to 40)		[*New Catalog...*, 1982]
		07:35:49.4	80.56	123.39	15		ISC-GEM
29	29.04.1951	21:59:28.0	80.0	125.0	–	–	ISS
		21:59:29.0	79.34	124.35	15		ISC-GEM (supplement)
30	10.12.1952	12:47:48.0	84.5	100.0	–	–	ISS
31	10.12.1952	14:06:44.0	84.5	100.0	–	M=5.0 MLH=5.2	ISS
		14:06:29.0	87.0	140.0	–		[*Linden*, 1959]
		14:06:40.0	84.5	100.0	20 (10 to 40)		[*New Catalog...*, 1982]
32	12.09.1953	14:33:40.0	86.0	83.0	–	–	PDE
33	28.08.1954	02:41:52.0	86.0	85.0	–	–	CGS
34	28.06.1955	04:28:05.0	86.6	70.2	–	M=5.5 MLH=5.2 MS(ISC)=5.7 M_w(ISC-GEM)=5.9	ISS
		04:28:02.0	88.0	70.0	–		[*Linden*, 1959]
		04:28:09.0	87.0	69.0	20 (10 to 40)		[*New Catalog...*, 1982]
		04:28:10.7	86.63	69.92	15		ISC-GEM

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Table A1. Recalculated and unified catalogue of earthquakes in the eastern sector of the Russian Arctic for the period 1900–1961 within the coordinates 70.0° to 90.0° N and 70.0° E–170.0° W (Continued)

No	Data	Time	Hypocenter			Magnitude*	Source*
			φ, °	λ, °	h, km		
35	14.09.1955	17:32:08.7	80.74	119.91	–	MLH=5.0	SYKES
		17:32:10.0	82.0	110.0	20 (10 to 40)		[*New Catalog...*, 1982]
36	04.03.1956	03:18:10.0	83.0	116.0	–	MLH=5.0	[*Linden*, 1959]
		03:18:10.0	83.5	112.0	–		CGS
		03:18:09.2	83.69	112.32	–		SYKES
		03:18:10.0	83.0	112.5	20 (10 to 40)		[*New Catalog...*, 1982]
37	11.04.1956	14:45:06.0	71.6	126.7	–	–	[*Linden*, 1959]
38	13.05.1956	04:27:14.0	86.0	86.0	–	MLH=5.0	[*Linden*, 1959]
		04:27:10.9	84.96	95.04	–		SYKES
		04:27:15.0	87.0	85.0	–		BCIS
		04:27:15.0	85.5	96.0	20 (10 to 40)		[*New Catalog...*, 1982]
39	13.05.1956	08:56:36.0	85.0	85.4	–	MLH=5.0	[*Linden*, 1959]
		08:56:34.0	85.17	94.24	–		SYKES
		08:56:38.0	87.0	85.0	–		BCIS
		08:56:36.0	85.0	85.4	20 (10 to 40)		[*New Catalog...*, 1982]
40	13.05.1956	14:33:59.0	85.3	85.7	–	MLH=5.1 M=5.0	ISS
		14:33:56.0	84.5	106.0	–		[*Linden*, 1959]
		14:33:59.7	85.26	95.35	–		SYKES
		14:34:01.0	85.5	96.0	12		[*New Catalog...*, 1982]
		14:34:02.6	85.24	91.16	15		ISC-GEM (supplement)
41	15.05.1956	02:19:22.0	72.4	130.5	–	–	[*Linden*, 1959]
42	08.06.1956	03:26:25.0	72.8	125.5	–	–	[*Linden*, 1959]
43	17.06.1956	01:21:17.0	73.0	126.0	–	–	[*Linden*, 1959]
44	08.09.1957	01:21:23.0	77.8	128.4	–	MLH=4.5	[*Linden*, 1959]
		01:21:23.0	77.8	128.4	20 (6 to 24)		[*New Catalog...*, 1982]
45	16.09.1957	01:34:33.0	81.87	119.06	–	M=4.9	SYKES
		01:34:36.0	82.0	120.0	–		CGS
46	30.11.1957	17:41:16.0	84.02	112.77	0	MLH=4.1	ISS
		17:40:52.0	85.2	157.5	–		[*Linden*, 1959]
		17:40:57.0	83.8	116.5	20 (10 to 40)		[*New Catalog...*, 1982]
		17:41:18.9	83.68	113.92	15		ISC
47	16.03.1958	10:09:14.0	73.2	117.6	–	MLH=4.0 M=4.0	[*Linden*, 1959]
		10:09:06.2	73.68	117.38	–		SYKES
		10:09:14.0	73.2	117.6	12 (6 to 24)		[*New Catalog...*, 1982]
48	23.09.1959	10:38:58.0	83.53	114.02	–	MLH=4.5 M=4.5 MS(ISC)=4.6	ISS
		10:39:00.0	83.5	117.5	20 (10 to 40)		[*New Catalog...*, 1982]
		10:39:02.1	83.58	114.11	15		ISC-GEM (supplement)

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Table A1. Recalculated and unified catalogue of earthquakes in the eastern sector of the Russian Arctic for the period 1900–1961 within the coordinates 70.0° to 90.0° N and 70.0° E–170.0° W (Continued)

No	Data	Time	Hypocenter φ, °	λ, °	h, km	Magnitude*	Source*
49	24.09.1959	05:43:34.0 05:43:39.0 05:43:39.2	83.53 83.5 83.55	113.49 114.5 113.73	– 20 (10 to 40) 15	MLH=4.5 M=4.5 MS(ISC)=5.0 M_W(ISC-GEM)=5.5	ISS [*New Catalog…*, 1982] ISC-GEM
50	04.10.1959	16:27:16.3 16:27:18.0	83.35 84.0	115.05 113.0	– –	M=4.4	SYKES BCIS
51	05.10.1959	17:56:21.0 17:56:29.0 17:56:26.3	83.46 83.5 83.44	113.37 114.5 114.89	– 20 (10 to 40) 15	MLH=5.6 M=5.2 MS(ISC)=5.6 M_W(ISC-GEM)=5.7	ISS [*New Catalog…*, 1982] ISC-GEM
52	05.10.1959	18:11:19.2 18:11:17.0 18:11:25.0	83.64 84.0 83.5	114.53 113.0 114.5	– – 20 (10 to 40)	MLH=5.0	SYKES CGS [*New Catalog…*, 1982]
53	05.10.1959	18:27:45.0 18:27:47.0 18:27:50.4	83.53 83.5 83.65	112.54 114.5 113.76	– 20 (10 to 40) 15	MLH=5.7 M=5.7 MS(ISC)=5.4 M_W(ISC-GEM)=5.7	ISS [*New Catalog…*, 1982] ISC-GEM
54	05.10.1959	20:28:00.4	83.49	115.65	–	M=4.4	SYKES
55	27.10.1960	14:38:23.9 14:38:29.2	85.26 85.90	89.92 80.40	– 25	–	SYKES CGS
56	03.12.1960	20:20:59.0 20:20:58.9 20:21:01.3 20:21:10.0	76.64 76.61 76.80 76.6	131.24 131.17 131.10 131.1	0 – 28 20 (10 to 40)	MLH=5.1 M=5.1	ISS SYKES CGS [*New Catalog…*, 1982]
57	01.01.1961	18:45:45.4	86.44	70.06	–	–	SYKES
58	29.06.1961	22:01:19.0 22:01:19.8 22:01:19.0	85.00 84.99 85.0	100.42 98.38 99.5	0 – 20 (10 to 40)	MLH=4.8 M=4.8	ISS SYKES [*New Catalog…*, 1982]

*Notes: GUTE – The data from [*Gutenberg and Richter*, 1954];
ISS – International Seismological Summary bulletins https://storing.ingv.it/ISS/index.html;
PAS – California Institute of Technology (https://www.isc.ac.uk/cgi-bin/agency-get?agency=PAS);
PDE – Preliminary Determination of Epicentres (https://www.isc.ac.uk/cgi-bin/agency-get?agency=PDE);
CGS – Coast and Geodetic Survey of the United States (https://www.isc.ac.uk/cgi-bin/agency-get?agency=CGS);
SYKES – Sykes Catalogue of earthquakes 1950 onwards [*Sykes*, 1965] (https://www.isc.ac.uk/cgi-bin/agency-get?agency=SYKES);
BCIS – Bureau Central International de Sismologie (https://www.isc.ac.uk/cgi-bin/agency-get?agency=BCIS);
ISC-GEM – The data from ISC-GEM Catalogue and its supplement ISC-GEM (supplement) [*Storchak et al.*, 2013, 2015]

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