THE MINISTRY OF ECOLOGY AND NATURAL RESOURCES OF THE REPUBLIC OF KAZAKHSTAN

REPUBLICAN STATE ENTERPRISE KAZHYDROMET

SCIENTIFIC RESEARCH CENTER

ANNUAL BULLETIN OF SNOW COVER MONITORING ON THE TERRITORY OF THE REPUBLIC OF KAZAKHSTAN FOR 2024

ANNUAL BULLETIN OF SNOW COVER

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ASTANA, 2025

CONTENT

BRIEF SUMMARY

The winter of 2023-2024 in Kazakhstan was unusual in terms of snowfall timing and characteristics.

In most parts of the country, **the first snowfall occurred later than the climate norm**, 10 to 20 days later, which delayed the start of the winter season. However, in the western part of the country, the snowfall occurred 4 to 21 days earlier than usual.

The formation of a stable snow cover was also delayed. This was especially noticeable in the central, northeastern, and eastern regions, where snow began to fall much later than usual. In the southeastern and southwestern regions, the snowfall was close to normal. In the Mangystau region, parts of the Atyrau region, and the far south, the snow cover did not form.

The snow cover began to melt earlier than usual across the country, but in the mountainous regions of the south, southeast, and east, the snow lasted longer than usual, lingering until spring.

The duration of snow cover was generally shorter than the climate norm, and in some areas it was record-breakingly short. The maximum negative anomalies were recorded in the west, south, and southeast of the country, as well as in parts of the Akmola, Pavlodar, and Karaganda regions.

However, the maximum snow cover surprised us — in the northern, central, and eastern regions, as well as in the mountainous areas of the south, **it reached a significant height, making it one of the top 10 in the history of observations.** In the west, as well as in some areas in the center and southeast, the duration of snow cover was shorter than usual.

Overall, the winter of 2023-2024 showed a combination of regional contrasts: late snowfall and reduced snow cover duration in most parts of the country, but record-breaking heights in some regions, making this season unique for monitoring and analyzing climate trends.

INTRODUCTION

One of the tasks of the Republican State Enterprise "Kazhydromet" is providing the widest possible range of services in in the field of meteorology and climatology based on high-quality data obtained during systematic observations on the state observation network.

Significant climate changes that have occurred in recent decades and the increased dependence of various sectors of the economy on these changes have necessitated more careful monitoring of various components of the climate system.

Snow cover is a crucial parameter of the climate system: due to its high reflectivity and low thermal conductivity, it plays a significant role in the Earth's energy balance, and the water stored in snow contributes to the water balance. Snow cover characteristics are monitored in many countries. For Kazakhstan, much of which is covered with snow for extended periods, snow cover plays a key role in shaping the climate.

Information on the distribution of snow cover across Kazakhstan is necessary for solving many national economic problems, since it is a source of river nutrition and soil moisture. Snow cover protects the soil from deep freezing, prevents winter crops from freezing, and promotes soil moisture accumulation, which positively impacts crop yields. In winter, when there is little or no snow cover, significant temperature drops lead to the death of winter crops (freezing). However, winter crops are also damaged by prolonged exposure to deep snow cover, which forms in fields at the beginning of winter when the soil freezes only slightly (evaporation). Spring snowmelt is associated with floods and inundations on lowland rivers. Heavy snowfall often leads to snowdrifts and impedes the movement of vehicles and people. It disrupts road and rail services, infrastructure, and communications networks. Accumulating snow can lead to roof collapses and cause numerous problems for utility services.

This issue of the bulletin describes the characteristics of the snow cover observed during the winter. 2023-2024 , water reserves in snow cover in the basins of large rivers and reservoirs and provides historical information on trends since the 1970s . This issue of the bulletin also contains maps of snow cover distribution in Kazakhstan.

The results of the analysis of changes in snow cover characteristics will be published annually. The snow cover monitoring subsystem created in Kazakhstan identifies and studies regional patterns in changes in snow cover characteristics. This requires estimates of a wide range of snow cover characteristics, such as snow depth, snow water content, the number of days with snow cover greater than 50%, snow cover appearance and melt dates, as well as the formation and destruction dates of stable snow cover and their spatial and temporal distribution.

Calculations, mapping, and spatial-temporal analysis are carried out on the basis of reliable meteorological information obtained from the state observation network and on the basis of methodological recommendations developed taking into account international experience and standards reflected in the guidelines of the World Meteorological Organization.

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1. OVERVIEW OF THE CLIMATIC STATE OF SNOW COVER IN THE TERRITORY OF THE REPUBLIC OF KAZAKHSTAN

Kazakhstan is part of the seasonal snow cover zone, and only its high-altitude regions can be classified as a zone of eternal snow. A wide variety of local climatic and orographic conditions determines the features of the formation, occurrence and destruction of snow cover on its territory. Among them, first of all, it should be noted the unstable nature of snow deposition from year to year, especially in the southern regions of lowland Kazakhstan. In the mountainous regions of Altai and Tien Shan, snow cover is formed earlier and persists longer than in flat areas.

The first autumn cold snap with snowfall and short-term formation of snow cover is observed first of all in the far north and north-east of Kazakhstan, mainly in late October-early November. In the central part of Kazakhstan, these phenomena are observed on average in the first decade of November with fluctuations in some years from October 10-12 to the end of November. In the high-altitude regions of Kazakhstan, the first snowfalls with temporary snow cover formation are possible at high altitudes even in summer. In the conditions of the far north of Kazakhstan, pre-winter is almost absent. Here, the first snow cover formed in most cases does not melt and persists until spring, gradually increasing in thickness due to new snowfalls. In the extreme south-west of Kazakhstan, where winter is very mild and short, with frequent and significant thaws of both advective and radiative order, the pre-winter period stretches almost all winter, i.e. it is practically not traced. In the southwestern part of Kazakhstan, adjacent to the Caspian Sea, it is not possible to determine the pre-winter period, since the snow cover here is unstable from year to year throughout the winter.

The duration of stable snow cover on the territory of Kazakhstan varies within quite large limits. Thus, over the average long-term period in the northern forest-steppe and steppe regions of Kazakhstan, the duration varies from 135 to 167 days, in the west of Kazakhstan from 73 (Atyrau) to 140 (Aktobe), in the south-east (Almaty and Zhetysu regions) from 59 to 140, and in the extreme south of the republic (Syrdarya river region). from 50 to 80 days.

The process of destruction of stable snow cover on the territory of Kazakhstan in the far south in the long-term average falls on the first decade of February. In the central regions, this process occurs in the last decade of March, and in the far north in the first decade of April. In the high-altitude regions of the south-east and east of the republic, the height of the terrain has a great influence on the time of snow cover destruction. In the Ili Alatau, the stable snow cover collapses on February 21, at an altitude of 1750-2500 m – on March 17-22, and in the high-altitude zone of the Ile Alatau (3000 m above sea level or more) May 21 and later.

The final descent of snow cover in Kazakhstan is very uneven both in terms of thermal conditions and terrain conditions. The manes and hillsides of the southern expositions are the first to be exposed. Snow drifts in the ridges near forest belts and in depressions melt much later.

Due to climatic conditions, the first final snowfall is observed in the south of Kazakhstan. In the spring, after the snow cover disappears, the cold may return, accompanied by snowfalls with a short-term snow cover establishment. Thus, in the northern and central regions of Kazakhstan,

the probability of temporary occurrence of snow cover after its complete disappearance is 20-30 %. In the southern regions of the republic, this probability increases to 50 % and even 80 %, which is associated with earlier snowfall here and frequent cold returns during spring.

The average of the highest decadal snow cover heights in the northern regions of Kazakhstan is 20-25cm. In the area of the Kokshetau upland, it increases to 30 cm or more. In the central regions of the republic, the maximum snow height decreases to 15-20 cm, with the exception of the uplands area (south of Kokshetau and north of Karaganda regions), where the snow cover height increases to 30 cm, due to an increase in precipitation and terrain height. In the south of Kazakhstan, the snow height is reduced to 5-10cm and on average does not exceed 10 cm. Only in very rare years does the snow cover reach an average of 20-25cm per decade. In the foothill regions in the south and south-east of Kazakhstan, the average of the highest decadal snow heights before the beginning of spring snowmelt increases again to 20-30cm (Ile Alatau) and to 40-60cm in Zhetysu Alatau. The height of snow cover in the mountains naturally increases with increasing terrain height. Thus, in the Ile Alatau, the average maximum decadal snow cover height increases from 30 cm (Almaty, 848 m above sea level) to 59 cm (Medeu, 1529 m above sea level) and 89 cm in the Mynzhilki tract (3130 m above sea level).

The highest snow densities are observed in the central zone of Kazakhstan-from 0.30 to 0.36, which is mainly due to local strong wind speeds. In the south of the republic, average snow densities are the lowest in Kazakhstan and are equal to 0.25-0.27.

In the north of Kazakhstan, water reserves in snow in the pre-spring period average 60-70mm, with fluctuations in some years from 20-45 to 80-150 mm. The exception in this case is the part of the Pavlodar region located between the spurs of the Altai, Salair and Kazakh uplands, where they are somewhat underestimated relative to neighboring areas and average 60 mm or less, and in some years 20-30mm.

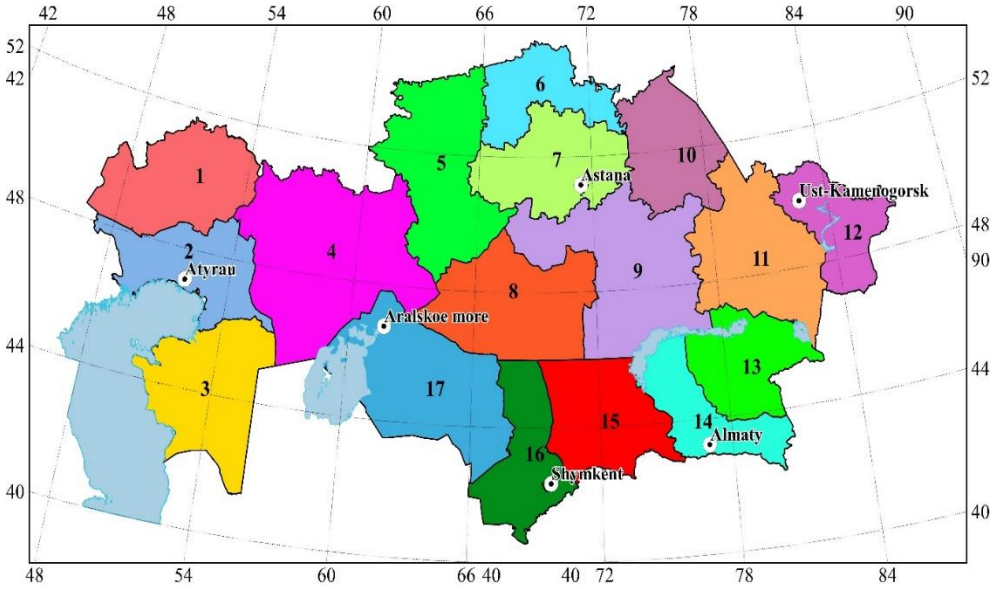
In the central regions of Kazakhstan, with the exception of the uplands region, water reserves in snow are on average 30-40mm, decreasing to 10-20mm or less in the south of the Balkhash region and the Caspian lowland. In these areas, in some years, water reserves can vary significantly – from 30 to 100 mm..[1]

[1] Usteshev A. S. (Ed.). Climate Of Kazakhstan. - L.: Hydrometeoizdat, 1959. - 360 p

2. MATERIALS AND METHODS OF RESEARCH

The analysis of changes in snow cover characteristics was carried out on the basis of data obtained at 211 meteorological stations and 47 agro - and hydro-posts of the state observation network of RSE «Kazhydromet». Data from 182 meteorological stations of the Republican Data Fund of RSE "Kazhydromet" were used to prepare a ***review of climate change***. The time series of anomalies of the considered values are averaged over the territory of Kazakhstan for 17 administrative-territorial regions and for the basins of large rivers and reservoirs. The borders of the regions of Kazakhstan are shown on the map-scheme below.

The analysis of the state of snow cover in each winter season is based on data from July 1 of the previous year to June 30 of the current year.



1	West Kazakhstan region	10	Pavlodar region
2	Atyrau region	11	Abai region
3	Mangystau region	12	East Kazakhstan region
4	Aktobe region	13	Almaty region
5	Kostanay region	14	Zhetysu region
6	North Kazakhstan region	15	Zhambyl region
7	Akmola region	16	Turkestan region
8	Ulytau region	17	Kyzylorda region
9	Karaganda region		

The number of days with snow covering more than 50 % of the territory around the weather station is determined based on daily observations (to estimate the duration of snow cover). The number of days with snow cover is calculated as a whole for the cold period from the appearance of snow cover at the end of the previous calendar year to the disappearance of snow

cover at the beginning of the current calendar year. A day with snow cover is considered a case when the degree of snow cover in the surrounding area was more than 5 points.

The date of occurrence of snow cover in the second half of the first calendar year of the study period is considered to be the first day when the degree of snow cover in the vicinity was 6 points or more.

The date of snow cover removal is considered to be the date following the day on which the presence of snow cover with a degree of coverage of 6 points or more was last noted in the first half of the next calendar year.

The dates of formation (for the second half of the current calendar year) **and destruction** (for the first half of the next calendar year) **of a stable snow cover** are determined from observations of the degree of snow cover in the visible vicinity of the station or post (Lo). In this case, the date of formation is considered to be the first day of a period with stable snow cover when the Lo value exceeded 5 points, and the date of destruction is considered to be the first day after the end of the period when the Lo value became less than 6 points.

A period with stable snow cover is considered to be a time interval of at least 30 consecutive days, in which the number of cases with Lo values of less than 6 points is no more than 3 consecutive days or separately. However, at the beginning of winter, a break of 1 day (one case with Lo less than 6 points) is ignored if it was preceded by at least 5 days with snow cover (Lo more than 5 points), and a break of 2-3 consecutive days if it was preceded by at least 10 days with snow cover. At the end of winter, breaks of 1 day or 2-3 consecutive days are ignored if they were observed continuously for at least 5 or 10 days, respectively.[2][3]

Climate norms of variables were calculated as a long-term average value for-the period 1991-2020.[4]

An anomaly of a climate variable (the maximum snow cover height in winter, the number of days with snow, the maximum snow water reserve in winter, the date of first snowfall, and the date of stable snow cover formation) is defined as a deviation from the climate norm and is calculated using the formula:

$$\Delta Xy = Xy - Xn$$

Here ΔXy is the value of the desired anomaly in year; Xy – value of the climate variable X in year y; Xn – norm of the climate variable (long-term average value over a thirty-year period).

As additional characteristics of anomalies, indicators based on the distribution function are used (the probability of not exceeding, which characterizes the frequency (in %) of occurrence of the corresponding anomaly value in the observation series), ordinal statistics (ranks, i.e. ordinal numbers in an ordered series of values relative to other numbers in the data set).[5]

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[2] Guidelines for preparing for printing materials on snow cover (snow surveys and snowmelt) // Hydrometeoizdat, Leningrad - 1963

[3] Methodological guidelines. On critical review of snow cover materials (daily observations and snow surveys) // RSE Kazhydromet, Almaty - 2006

[4] WMO-1203. Guidelines for the calculation of climate norms. 2017

[5] Methodological guidelines for statistical processing of meteorological series. Leningrad, Gidrometizdat, 1990

As an estimate of changes in snow cover characteristics for-the period 1970-2024, we use **the coefficients of linear trends** determined by the method of least squares and measures of trend significance – the coefficient of determination, which characterizes the contribution of the trend component to the total variance of the climate variable for the considered time period (in %). It is generally considered that the trend estimate is statistically significant if the critical level a is 0<=5%.

3. FEATURES OF THE STATE OF SNOW COVER IN WINTER 2023-2024

3.1 The formation and destruction regime of stable snow cover

In the 2023–2024 season, the first snow fell 10–20 days later than normal across most of Kazakhstan. This deviation is particularly noticeable at some stations in the northern and central regions, where the first snow traditionally appears earlier. This shift in the timing of the first snowfalls is due to the abnormally warm autumn and the prolonged influence of anticyclone weather conditions. In the western regions of the republic, on the contrary, the first snow fell 4–21 days earlier than usual. This is due to the passage of cold fronts, which brought lower temperatures and snowfall earlier than usual for this time of year (Figure 3.1).

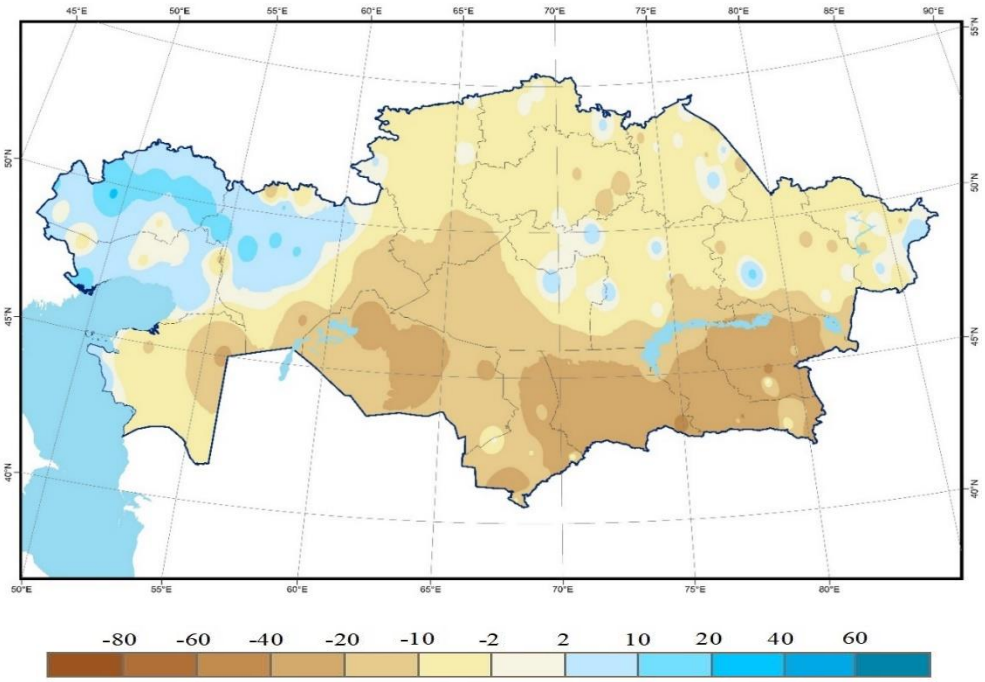

Figure 3.1 – Anomalies in the dates of the first snow (positive anomalies correspond to earlier dates) in Kazakhstan in the winter period of 2023-2024 (from the norms of 1991-2020)

Across most of Kazakhstan, stable snow cover formed 4-18 days later than the climatic norm. Only in some areas of the southeast, southwest, and certain parts of the east and center did snow cover form around the climatic norm or 2-8 days earlier. A significant delay in the onset of snow cover was observed in the center, northeast, and east of Kazakhstan, as well as in certain areas of the west and northwest, where it was observed 22-40 days later than the climatic norm (Figure 3.2). In a number of regions, frequent heat waves prevented snow cover from forming completely. In the Mangystau region, in some districts of the Atyrau region, and in the far south of the country, stable snow cover did not establish, with the exception of mountainous areas.

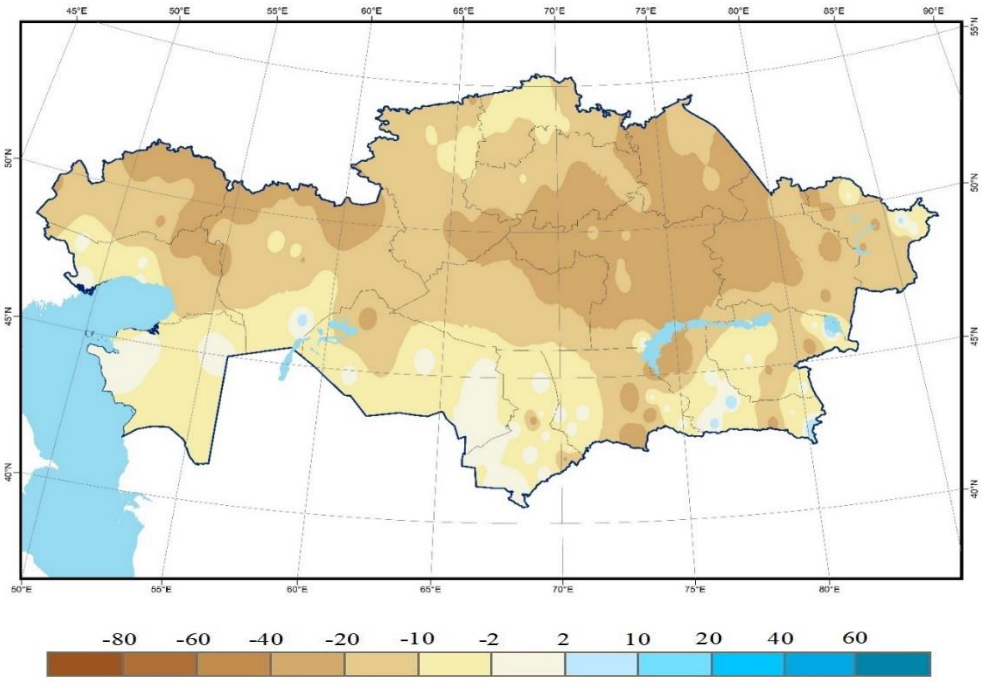

Figure 3.2 – Anomalies in the dates of establishment of stable snow cover (positive anomalies correspond to earlier dates) on the territory of Kazakhstan in the winter period of 2023-2024 (from the norms of 1991-2020).

Across most of the country, the breakup of stable snow cover began 4-10 days earlier. However, it nevertheless lingered beyond the climatic norm in the mountainous south, southeast, and east of the country, and in some areas of the Almaty and Abay regions, for up to 26-33 days. This was due to heavy snowfalls in these areas in February-March, which delayed the snowmelt process. In the west and southwest of the country, breakup of stable snow cover was observed 22-35 days earlier than the climatic norm (Figure 3.3).

In the northern regions of Kazakhstan, where the climate is characterized by colder winters, the final melting of the snowpack occurred earlier, 8-12 days earlier than normal. This accelerated melting is due to rising temperatures in March, which led to faster snowmelt. In the central regions of the country, snowmelt was less pronounced than in the north. Here, snowmelt occurred 2-6 days earlier than normal. In eastern Kazakhstan, in the mountainous and foothill areas, the greatest change in snowmelt time was observed. Here, the process began 10-22 days earlier than normal. This is due to topographic features and climate changes, such as faster air warming in spring, which accelerates snowmelt in eastern Kazakhstan (Figure 3.4).

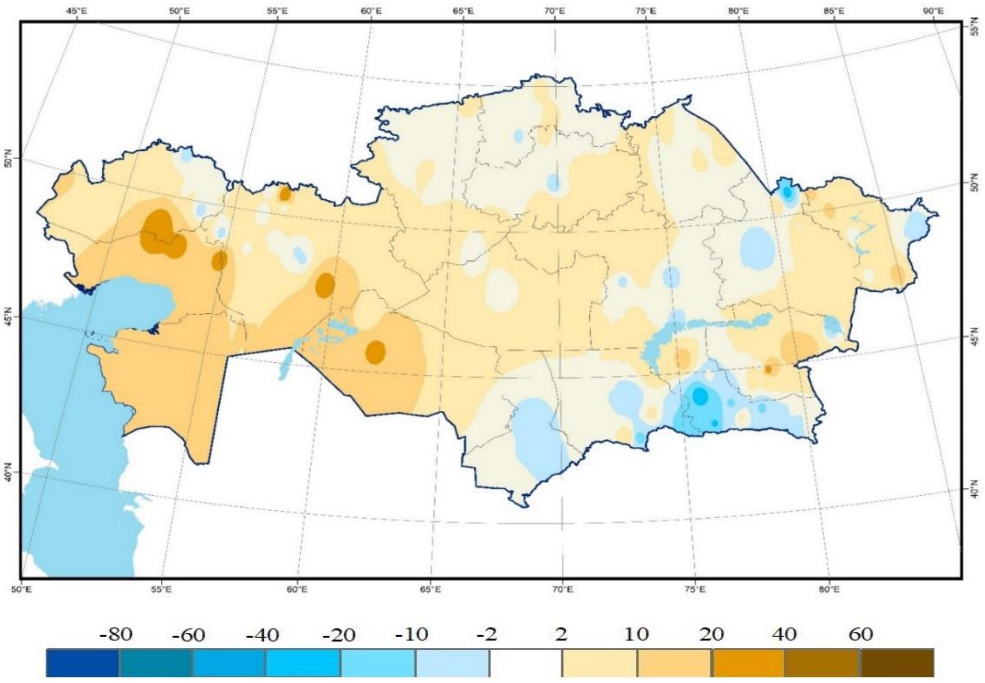

Figure 3.3 – Anomalies in the dates of destruction of stable snow cover (negative anomalies correspond to later dates) on the territory of Kazakhstan in the winter period of 2023-2024 (from the norms of 1991-2020).

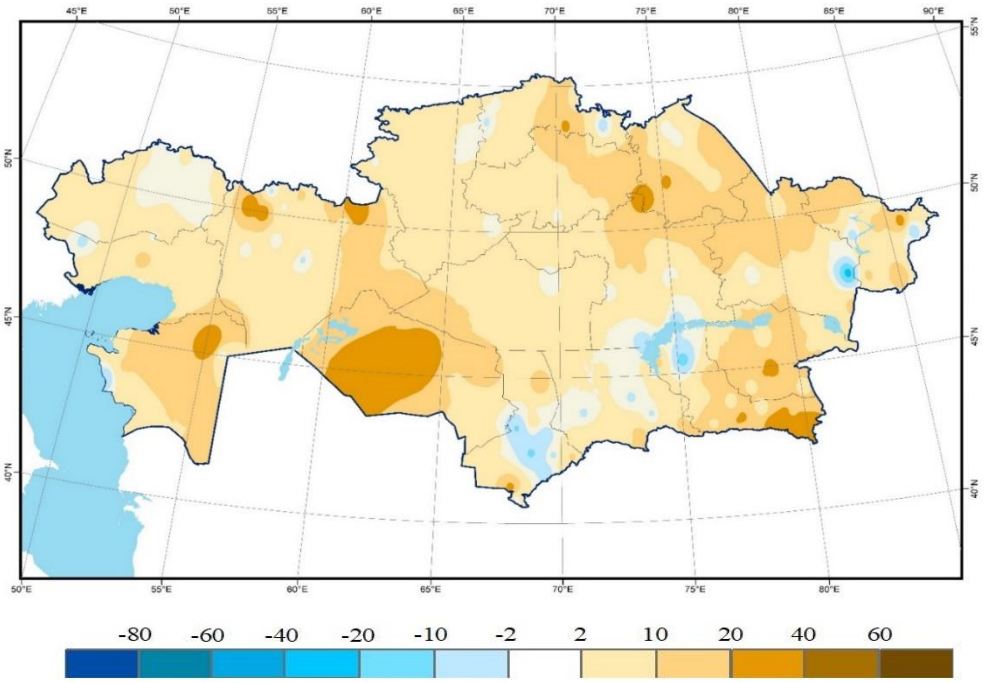

Figure 3.4 – Anomalies in snow melt dates (positive anomalies correspond to earlier dates) in Kazakhstan in the winter period of 2023-2024.
(from the standards of 1991-2020).

3.2 Duration of stable snow cover

Negative snow cover duration anomalies were observed throughout virtually the entire territory of Kazakhstan, which is explained by the abnormally high air temperatures during the cold period under consideration. The maximum negative snow cover duration anomalies were recorded in the west, south, and southeast of the country, as well as in some areas of the Akmola, Pavlodar, and Karaganda regions (Figure 3.5). These negative anomalies were record-breaking for these regions. (Table 3.1) Positive snow cover duration anomalies were observed in some areas of the Almaty region and in the extreme east of the Zhetisu region and the East Kazakhstan region.

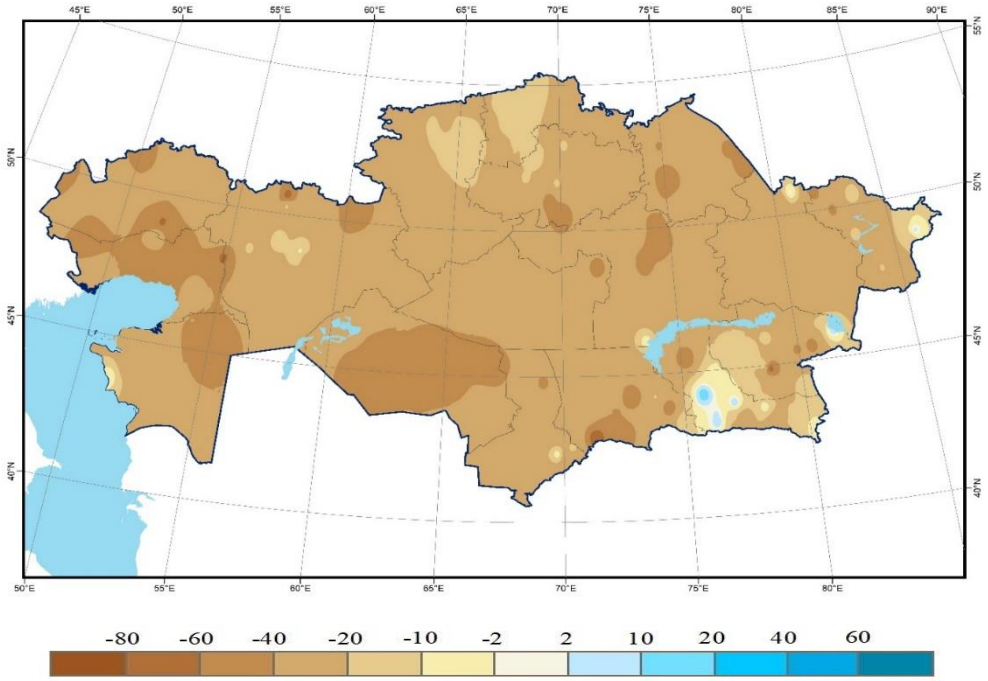

Figure 3.5 – Anomalies in the number of days with snow coverage of more than 50% of the territory around the meteorological station stations in the winter of 2023-2024 (from the standards of 1991-2020);

3.3 Height and water content in stable snow cover

In the winter period of 2023-2024, the maximum snow depth in the northern, central, eastern regions, as well as the mountainous areas of the south and southeast was significantly above the climatic norm and was among the ten highest values in the ranked series (Table 3.1) . In the west and in some areas of the center, east and southeast, the snow depth was below the norm. In the south , it was near and below the climatic norm, with the exception of mountainous areas. The maximum snow depth over the winter exceeded the norm in North Kazakhstan, Akmola, Kostanay, Karaganda, as well as in the east of Abay and East Kazakhstan regions; positive anomalies of the maximum snow depth averaged from 6 to 35 cm, and up to 40-80 cm in the north (Figure 3.6).

Table 3.1 – For the winter period (2023-2024) , anomalies in snow cover characteristics, averaged over the territory of the regions of the Republic of Kazakhstan.

Δ is *the deviation from the average for 1991–2020 , σ* is **the** standard *deviation* , **R** is the rank of current values in a series *of decreasing characteristics of the winter period for 1970–2024.*

No.	Regions	Number of days with snow			Water storage in snow			Max snow depth		
		Δ	**σ**	**R**	**Δ**	**σ**	**R**	**Δ**	**σ**	**R**
1	North Kazakhstan region	-5.3	9.0	41	58.0	52.9	2	23.4	28.4	1
2	Akmola region	-8.4	11.2	45	16.9	49.5	7	25.4	31.83	1
3	Kostanay region	-12.5	11.7	48	53.7	28.3	2	5.2	11.8	12
4	Pavlodar region	0.6	7.4	30	33.0	31.0	4	4.3	14.5	14
5	East Kazakhstan region	-11.5	27.7	42	53.4	152.2	4	10.1	45.7	7
6	Abay region	-24.7	16.2	52	-7.9	59.4	24	2.6	21.3	13
7	Karaganda region	-20.0	17.9	49	-10.6	35.9	36	4.7	14.9	8
8	Ulytau region	-18.3	14.0	47	-24.2	5.7	46	1.3	8.6	28
9	West Kazakhstan region	-4.8	14.3	36	-10.2	23.2	35	-0.7	13.9	27
10	Atyrau region	-14.7	10.5	43	-13.9	7.7	38	-6.1	2.1	42
11	Mangystau region	-12.1	6.8	40	-4.0	3.5	19	-5.3	1.4	44
12	Aktobe region	-9.2	42.0	19	-11.8	48.3	32	-3.1	23.1	25
13	Kyzylorda region	-24.3	16.3	48	-2.2	6.40	30	1.0	2.3	17
14	Turkestan region	-8.50	32.5	32	-14.0	116.6	33	3.5	27.9	16
15	Zhambyl region	-8.2	20.5	38	-6.0	18.2	26	9.4	7.4	5
16	Almaty region	1.4	48.6	24	4.3	81.4	17	1.4	48.6	24
17	Zhetisu region	-20.7	19.0	49	-44.3	77.1	50	-7.7	18.8	35

According to field snow surveys, the maximum winter snow water content exceeded the norm in the north, northeast, and east of the country. Significant excesses were observed in the North Kazakhstan, Abay, East Kazakhstan, and Pavlodar regions. Positive snow water content anomalies in these regions were record-breaking and among the top ten years with record-breaking records. Exceedances were also detected in the northern part of the West Kazakhstan, Aktobe, Kostanay, and Akmola regions, as well as in the mountainous regions of the south and southeast. In the remaining territories, snow water content was below the long-term norm (Figure 3.7).

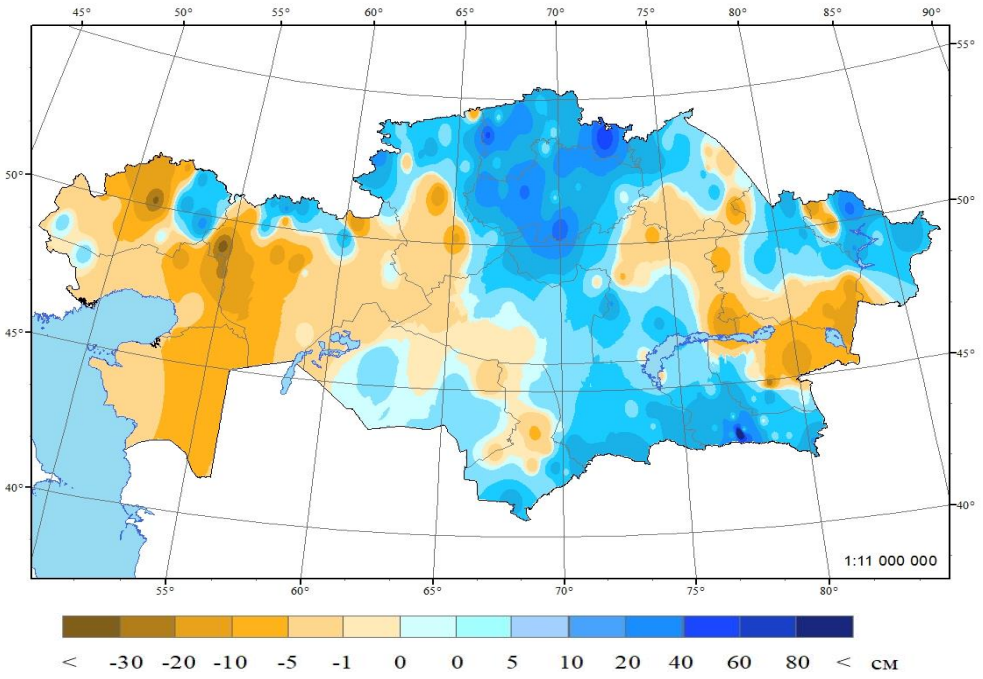

Figure 3.6 – Anomalies of maximum snow depth in winter 2023-2024. (from the standards of 1991-2020).

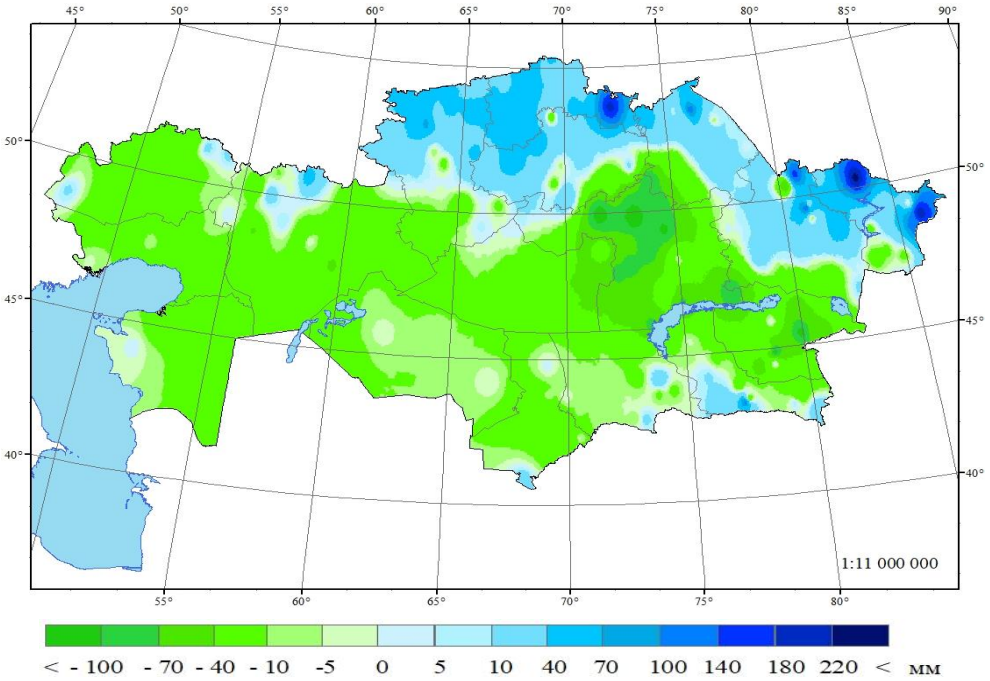

Figure 3.7 – Anomalies of maximum water content in snow (mm) in winter 2023-2024 years (from the norms of 1991-2020) in the field.

4. WATER RESERVES IN SNOW COVER IN BASINS OF LARGE RIVERS AND RESERVOIRS

Table 4.1 provides detailed data on water reserves in snow cover for the basins of large rivers and reservoirs.

In 2023-2024, winter was generally warmer than normal across most of Kazakhstan. Zones with positive air temperature anomalies occupied the western and eastern regions, as well as certain areas in the northeast and southwest. Consequently, the maximum amount of water in snow across Kazakhstan was observed almost everywhere in the second ten-day period of March, with only mountainous regions experiencing a later period. In the west, south, and southeast of the country, the maximum amount of water in snow was observed in the second ten-day period of February 2024.

During the winter, the maximum water reserve in the snow cover turned out to be higher than normal in the lowland rivers, as well as in the basins of the Yesil and Ertis rivers, as well as in individual rivers of the Zhaiyk-Caspian basin (the Toguzak river - 221% of the norm, the Or-Bogetsay river - 172% of the norm).

In the Nura-Sarysu basin, snow water levels were 44-116% of normal. At the Samarkand and Sherubaynura reservoirs, snow water levels were 40-50 mm lower than last year, reaching only 44-56% of normal.

In the Yesil and Yertis River basins, snowpack water reserves significantly exceeded normal levels. In the Shaglin and Shulbinsky reservoirs, they amounted to 151-211% of normal levels, 20-130 mm higher than last year. In the remaining rivers in these basins, snowpack reserves were either slightly higher or close to normal. Only in the Astana Reservoir was snowpack water reserves significantly lower than normal—62%, 30% lower than last year.

In the Tobyl-Torgay basin, water levels were within normal limits, as in the previous year, and even slightly above, reaching 80-166% of normal. However, in the Torgay River - Tusum sands. water levels were below normal, as in the previous year.

In the Zhaiyk-Caspian basin, significant snow accumulations were recorded in the Toguzak, Kosistek, and Or-Bogetsay rivers, as well as on the Utva-Kentobek River, where they reached 127-221% of the norm. Meanwhile, snow accumulations 40-60% below the norm were recorded in the Sagyz, Zhem-Zhanbik, Shagan-Chuvashinskaya, and Ulenty rivers.

In the southern region's mountain rivers, significant snow accumulations (150% of normal) were recorded in the Karatau, Arys, and Zhetysu Alatau river basins, significantly exceeding last year's levels. In the remaining rivers, snow accumulations were slightly above normal, also exceeding the previous year's levels.

Table 4.1 . – Information on the maximum water reserves in the snow cover in the basins of large rivers and reservoirs of the Republic of Kazakhstan in the spring of 2024 (in comparison with the norm and snow reserves at the same time in 2023): W 2024 – water reserves in 2024, W 2023 – water reserves in 2023.

No.	Basins	*W2024*			*W2023*		
		Water supply	**Water reserve (norm)**	**Deviation from the norm in %**	**Water supply**	**Water reserve (norm)**	**Deviation from the norm in %**
Nura-Sarysu basin							
1	Tributary to the Samarkand Reservoir	23.0	52	44	75.3	52	144
2	Tributary to the Sherubaynura Reservoir	43.3	77	56	83.1	77	108
3	Tributary to the Kengir Reservoir	46.0	56.0	82	41.8	56.0	75
4	Sarysu River	95.3	82	116	82.6	82	100
5	Tokyrau River	102.7	102	101	82.0	102	80
Yesil basin							
1	Tributary to the Astana Reservoir	38.3	62	62	57.6	62	93
2	Tributary to the Sileti Reservoir	54.5	53	103	65.5	53	124
3	Tributary to the Shagaly Reservoir	65.0	43	151	47.0	43	109
4	R. Calcutan	123.0	107	115	100.5	107	94
5	Zhabai River	167.0	126	133	145.5	126	116
6	Tributary to the Sergeevskoye Reservoir	114.3	71	160	120.0	71	168
Yertis basin							
1	Bukhtarma Reservoir	125.6	75.6	166	143.9	75.6	190
2	Shulbi Reservoir	261	124	211	123.0	124	101
3	Left-bank tributaries of the Ertis	123.6	81.0	153	105.4	81.0	130
4	Southwestern ridge of Tarbagatai	71.7	104.7	68	116.3	104.7	111
Tobyl-Torgay basin							
1	Tributary to the Verkhne-Tobolsk Reservoir	99.5	73	136	99.0	73	136
2	Tributary to the Karatamar Reservoir	114.8	69	166	83.0	69	120
3	r. Torgai - Tusum Sands	65.3	81	80	70.0	81	80
4	Karatorgai river - Akotkel	53.0	42	126	58.0	42	138
Zhaiyk-Caspian basin							
1	Tributary to the Aktobe Reservoir	61.0	63	97	82.0	63	130
2	Tributary to the Karagalinskoye Reservoir	152.5	144	106	154.0	144	107
3	Toguzak River	146.0	66	221	132.0	66	224
4	Kosistek River	177.0	132	134	195.0	132	148
5	Or-Bugetsay River	194.0	113	172	142.6	113	126
6	Temir-Leninsky River	65.5	92	71	64.5	92	70
7	river Oyil	70.0	68	103	62.0	68	91
8	Irgiz river - Shenbertal	56.0	89	63	80.5	89	91

No.	Basins	*W2024*			*W2023*		
		Water supply	**Water reserve (norm)**	**Deviation from the norm in %**	**Water supply**	**Water reserve (norm)**	**Deviation from the norm in %**
9	Sagiz River	23.5	52	46	31.0	52	60
10	r.Zhem - Zhanbike	40.2	61	66	40.8	61	67
11	Derkul River - Beles Village	68.0	102	67	93.3	102	91
12	Utva-Kentobek River	71	56	127	74	56	132
13	r. Shagan-Chuvshinskaya	38.0	72	53	34.2	72	48
14	Ulenty River	57.0	84.0	68	53.0	84.0	63
Shu-Talas basin							
1	Karatau river basin	45.0	30.0	150	15.4	30	51
2	Arys river basin southwestern Karatau ridge	45.0	30.0	150	15.4	30	51
3	The Northwestern Spur of the Talas Alatau River Basin	218.5	197.5	111	300.5	198	153
Balkhash-Alakol basin							
1	The northern slope of the Ile Alatau	116	113	103	67	113	60
2	The northern slope of the Ile Alatau and the Ketmen ridge	53.3	47	114	65	47	139
3	Zhetysu Alatau	104	68	151	115.2	68	168

5. LONG-TERM CHANGES IN SNOW COVER CHARACTERISTICS

5.1 Long-term trends in snow cover characteristics by region

The spatial distribution of local trend estimates characterizing the sign and average rate of change of maximum winter snow depth values for the period 1970–2024, calculated based on station observations in Kazakhstan, is shown in Figure 5.1; the trend is expressed in cm/10 years.

Between 1970 and 2024, an increase in the linear trend coefficient for maximum winter snow depth was observed in the northern, eastern, central, and southeastern regions of the country. The greatest increase in snow depth was observed in the mountainous areas of East Kazakhstan and the south of Akmola region. When averaging across regions, statistically significant positive trends at the 5% level were observed in Kostanay, North Kazakhstan, Akmola, East Kazakhstan, Abay, Karaganda, and Almaty regions, as well as for Kazakhstan as a whole. A decreasing trend was recorded in Ulytau and Atyrau regions (Table 5.1).

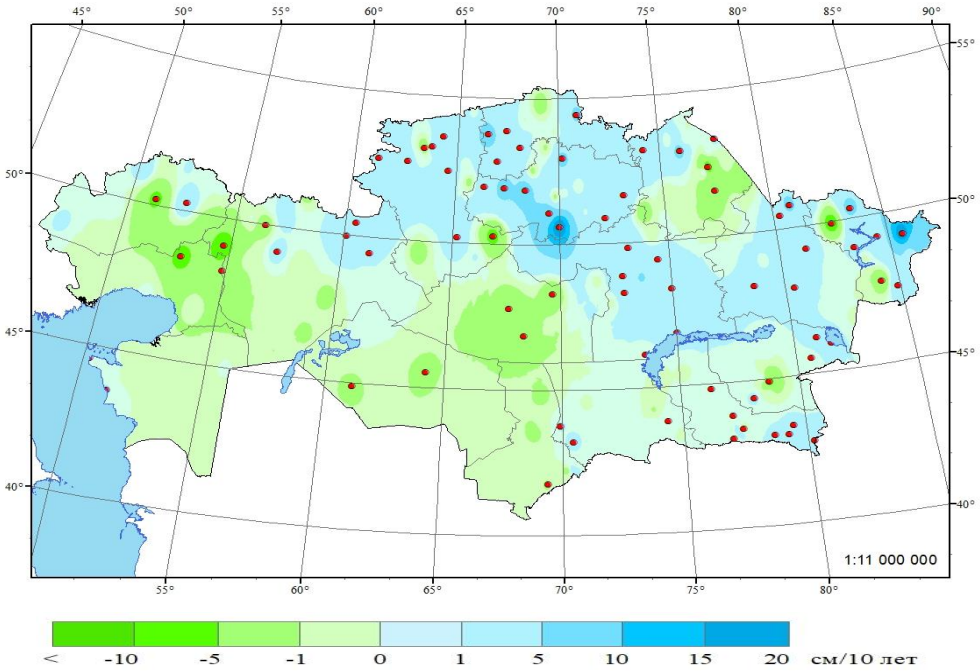

Figure 5.1 – Linear trend coefficient (cm/10 years) in the series of maximum snow depth during winter (statistically significant at the 5% level are marked in red)

The spatial distribution of the linear trend coefficients for the number of days with snow cover greater than 50% of the area around the meteorological station is shown in Figure 5.2 (statistically significant at the 5% level are shown in red). Positive anomalies are observed in the west, east, southeast, and center of the country.

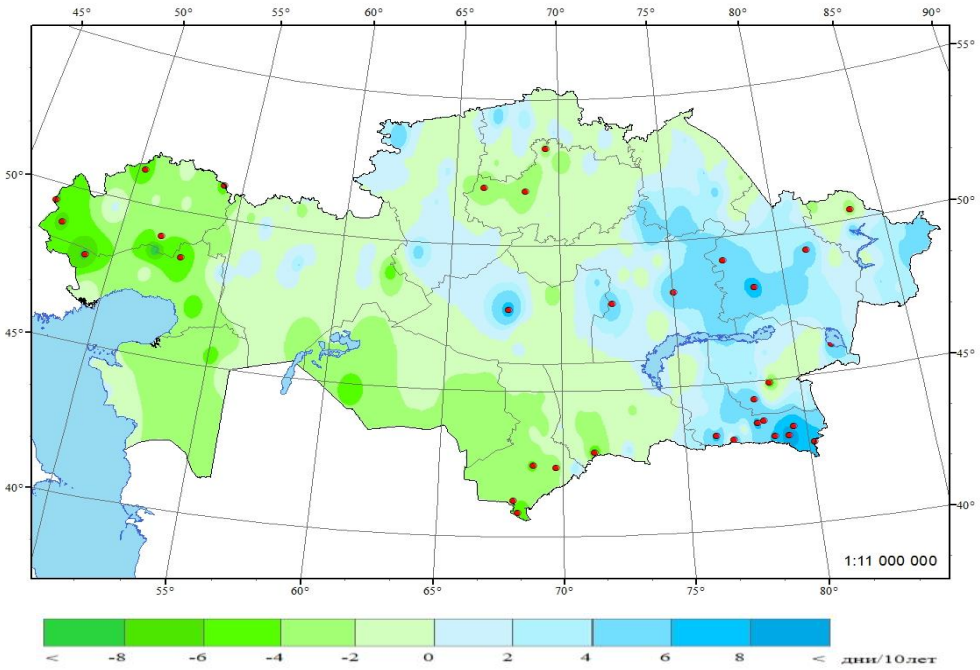

Figure 5.2 – Linear trend coefficient (days/10 years) in the series of the number of days with snow coverage of more than 50% of the territory around the weather station for 1970-2024. (statistically significant at the 5% level are marked in red)

In the period from 1970 to 2024, when averaging the number of days with snow cover across regions, no statistically significant linear trend coefficients were found.

Table 5.1 – Estimate of the linear trend (significant at level 5) of average snow cover characteristics for regions of Kazakhstan for 1970–2024;
H max, cm/10 years – maximum depth of snow cover; **Nd , days/10 years** – number of days with snow cover; **SWEn, mm/10 years –** water content in snow (field)

No.	**Region**	**H max**	**Nd**	**SWEn**
1	North Kazakhstan	**2.00**	0.74	**3.8**
2	Akmola	**3.87**	-1.77	**3.7**
3	Kostanay	0.8	-0.38	**5.8**
4	Pavlodar	0.01	-0.02	**3.5**
5	East Kazakhstan	**3.44**	1.14	**14.4**
6	Abai	**1.79**	1.73	**6.7**
7	Karaganda	**2.04**	0.74	**3.7**
8	Ulytau	**-1.94**	0.43	-1.16
9	West Kazakhstan	0.37	-2.84	0.97
10	Atyrau	**-1.79**	-3.52	-0.14
11	Mangystau	-0.01	-1.69	1.35
12	Aktobe	0.1	-0.72	2.24
13	Kyzylorda	-0.63	-2.75	**-2.65**
14	Turkestan	-0.54	-2.94	3.35
15	Zhambyl	0.3	-0.94	1.52

No.	Region	H max	Nd	SWEn
16	Almaty	**1.41**	2.14	1.31
17	Zhetisu	0.23	0.28	1.12

Trends in the maximum winter snow water content (field) from 1970 to 2024, based on route observations, are shown in Figure 5.3 (statistically significant at the 5% level are shown in red). A statistically significant increase in snow water content at level 5 was recorded in the North Kazakhstan region, Akmola, Pavlodar, Kostanay, Karaganda, East Kazakhstan, and Abay regions. A significant increase in the positive linear trend coefficients was noted in the East Kazakhstan and Abay regions, amounting to 6.7 and 14.4 mm/10 years, respectively. A statistically significant decrease in snow water content was recorded in the Kyzylorda region.

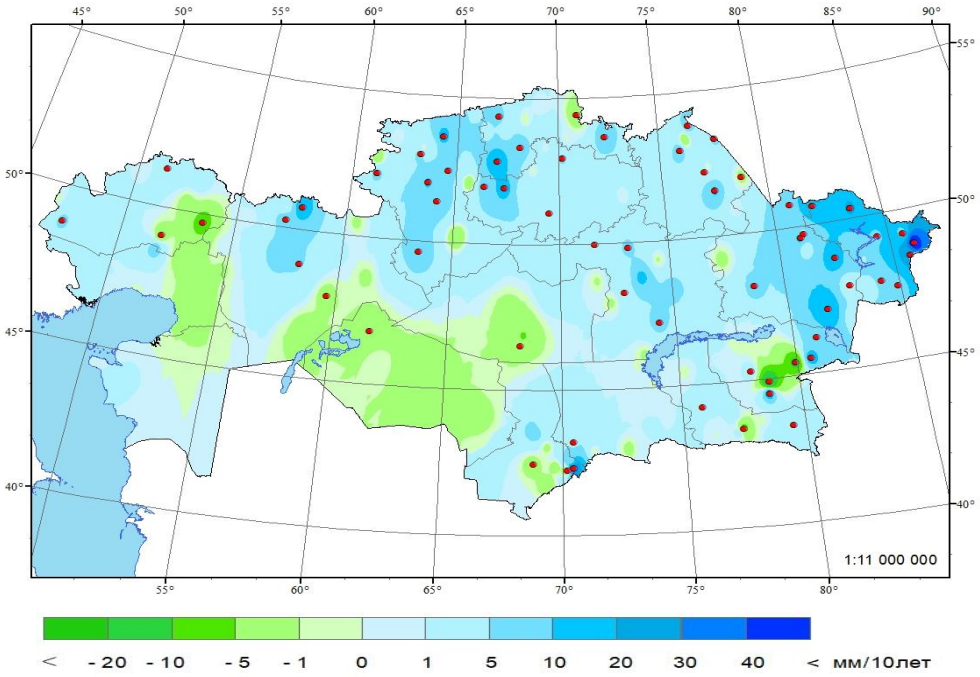

Figure 5.3. Linear trend coefficient (mm/10 years) of water storage in snow during the winter period in the field. 1970-2024 (statistically significant at the 5% level are marked in red)

5.2 Long-term trends in water management basins

According to averaged data for watersheds, statistically significant increases in snow water storage were found in the Balkhash-Alakol, Yertis, Yesil, and Tobyl-Torgay basins. A significant increase in positive linear trend coefficients was recorded in the Yertis basin, reaching 7.73 mm/10 years. Statistically significant negative trends in snow water storage were found in the Aral-Syrdarya basin (Table 5.2).

Table 5.2 – Estimation of the linear trend of averaged characteristics of water reserves for water management basins of Kazakhstan for 1970–2023.

SWEn /10 years is the linear trend coefficient, D is the trend contribution to the variance. Trend values significant at level 5 are highlighted.

No.	**Basins**	**SWEn**	D
1	Aral-Syrdarya basin	**-3.53**	**6.25**
2	Balkash-Alakol basin	**2.96**	**5.00**
3	Yertis basin	**7.73**	**17:47**
4	Yesil basin	**3.56**	**6:00**
5	Zhaiyk (Ural)-Caspian basin	-0.3	0.01
6	Nura-Sarysu basin	0.33	0.19
7	Tobyl-Torgay basin	**3.02**	**6.14**
8	Shu-Talas basin	1.03	0.93

6. ASSESSMENT OF SNOW COVER DURATION AND DISTRIBUTION BASED ON SATELLITE DATA

Snow cover in Kazakhstan during the 2024-2025 season (January 1 to March 31, 2025) was consistent with current trends in the characteristics of the Western Transport atmospheric currents. Recent climate warming has been accompanied by a transformation of the Siberian Anticyclone (SA), which plays a key role in snow cover formation in central Eurasia, including Kazakhstan. The previously stable position of the SA center in Mongolia has begun to shift in recent years. Its center frequently shifts northeast. This increases winter air temperatures in southern Siberia and Kazakhstan. The blocking effects of the Siberian Anticyclone are weakening, facilitating the access of moist air masses from the Atlantic to central Eurasia. Another feature of current weather trends is an active spring and early snow melt.

The third ten-day period of March (March 21-31) was characterized by high temperatures across much of the Republic. As a result, snow depth continued to decline rapidly. Snow depth dropped significantly, reaching levels close to the multi-year minimum (Figs. 6.1-6.3, Table 6.1).

Thus, the peculiarity of the snow covers in Kazakhstan as of March 31, 2025 is its insignificant prevalence. The total area of coverage is the smallest for the entire period of satellite monitoring (2001-2025), Fig. 6.2, Table 6.1. Within the administrative boundaries, relatively large snow reserves still remain in the East Kazakhstan and Akmola regions. The territory of the country is divided into 8 water basins: 1. Aral-Syrdarya; 2. Balkhash - Alakol; 3. Yertis; 4. Yesil; 5. Nura-Sarysu; 6. Tobyl-Torgay; 7. Ural-Caspian; 8. Shu-Talas (Fig. 6.4, Application 1).

Snow depth in the Ertis, Nura-Sarysu and Balkhash-Alakol water basins are close to the average long-term norms. In all other WB there is little snow, levels are close to multi-year minimums, Fig. 6.5, 6.6. Application 1

The main question regarding snow cover in Kazakhstan is the spring flood forecast and the likelihood of a repeat of last year's catastrophic flooding. The causes of the exceptionally high floods in the 2023-2024 season were abnormal autumn soil moisture before the snow cover set in, a system of thaws during the cold period, and a very powerful Arctic intrusion with extremely low air temperatures at the end of winter, which contributed to the deep freezing of water-saturated soils.

Most of the snow cover in Kazakhstan (with the exception of the Akmola and East Kazakhstan regions) has already melted. No severe frosts were observed in the second half of the winter period or in March. Soil absorption remained high, ensuring effective meltwater absorption and preventing significant spring flooding.

Soil moisture in Kazakhstan before snow cover can be monitored using satellite data, Fig. 6.8. It should be noted that soil moisture in northern Kazakhstan, which was covered by snow in the 2024-2025 season, was quite high, Figs. 6.8 and 6.9. Application 1. The threat of high spring flooding in the 2025 season remains in the Akmola and East Kazakhstan regions.

A comparison of snowfall conditions in the WB in 2024 and 2025 is shown in Figure 6.7. As of March 31, 2025, the most unfavorable conditions for spring flood height remain in the

Akmola region (Figure 6.9) Application 1. Three unfavorable factors are recorded in the region: abnormally high soil moisture during snow cover, increased snow water equivalent in the first ten days of March, and rapid snowmelt in the second half of March. Flood activity in these regions in the 2025 season will be determined by the absorption properties of soils during the period of active snowmelt. The winter temperature regime was not characterized by prolonged periods of very low temperatures. Therefore, it appears that soil absorption capacity will not be abnormally low, which will allow for the spring flood to occur without abnormal conditions.

Table 6.1. Share (%) of snow cover in Kazakhstan's regions and its changes for the period from January 1 to March 31, 2025, according to FEWS satellite information NET (decadal data).

Region	**1.01**	**10.01**	**20.01**	**31.01**	**10.02**	**20.02**	**28.02**	**10.03**	**20.03**	**31.03**
Kazakhstan	91	88	88	89	86	81	9 2	65	35	10
West Kazakhstan	91	47	88	78	59	93	100	51	0	0
Atyrau	49	30	81	60	36	77	100	42	0	0
Mangystau	10	47	35	21	15	45	100	0	0	0
Kostanay	100	100	100	100	100	100	100	100	22	0
Aktobe	100	100	100	100	100	92	100	100	4	0
Akmola	100	100	100	100	100	100	100	100	81	35
North Kazakhstan	100	100	100	100	100	100	100	100	39	11
Pavlodar	100	100	100	100	100	100	100	100	44	0
Karaganda	100	100	100	100	100	100	100	100	67	11
Ulytau	100	100	100	100	100	100	100	100	35	4
East Kazakhstan	100	100	100	100	100	100	100	100	78	48
Turkestan	51	45	44	59	45	27	34	27	12	0
Kyzylorda	72	67	48	67	84	23	82	35	0	0
Almaty	96	92	77	100	100	47	76	56	22	13
Zhetysu	99	100	97	100	100	83	83	81	28	11
Zhambyl	90	77	60	100	73	32	54	15	6	0

APPLICATION 1

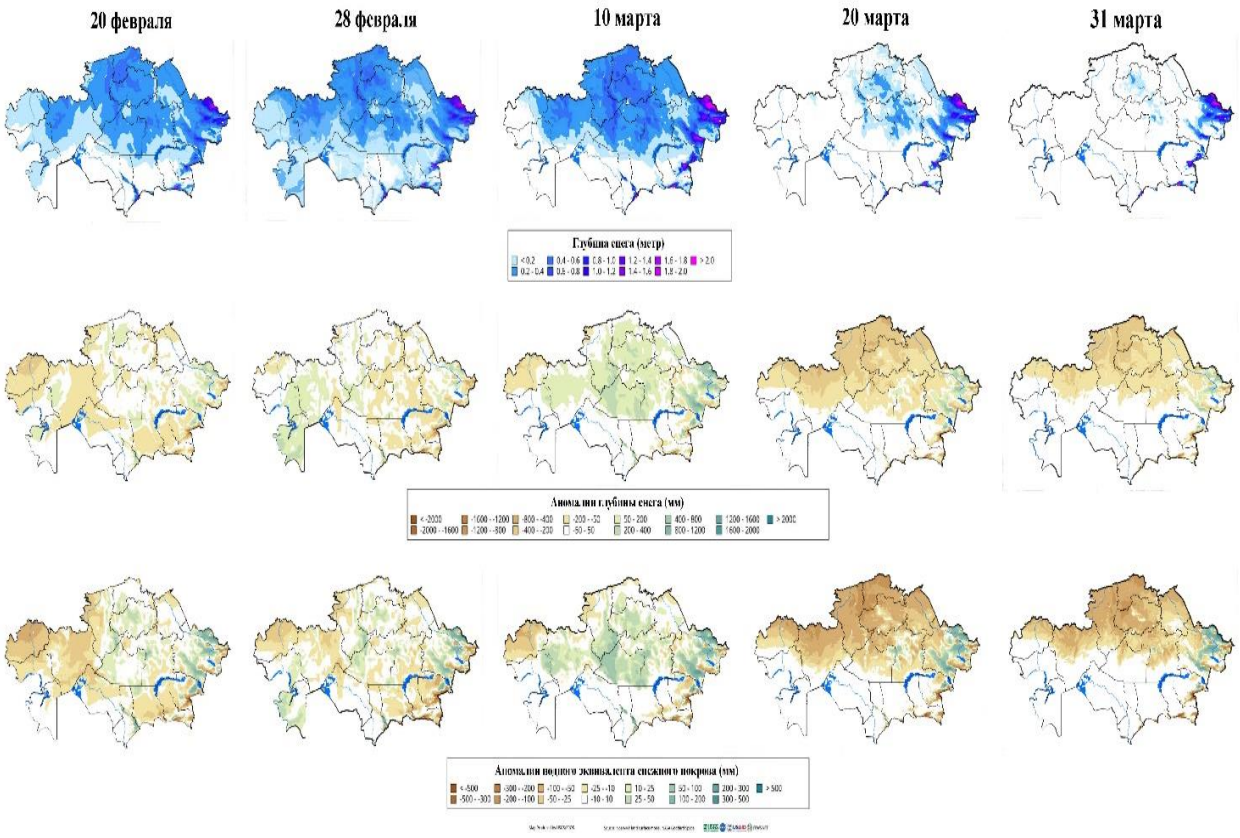

Figure 6.1 - Main characteristics of snow cover (height, height anomaly, water equivalent anomaly) in the territory of Kazakhstan
on February 20, 28, March 10, 20, and 31, 2025 (FEWS maps NET).

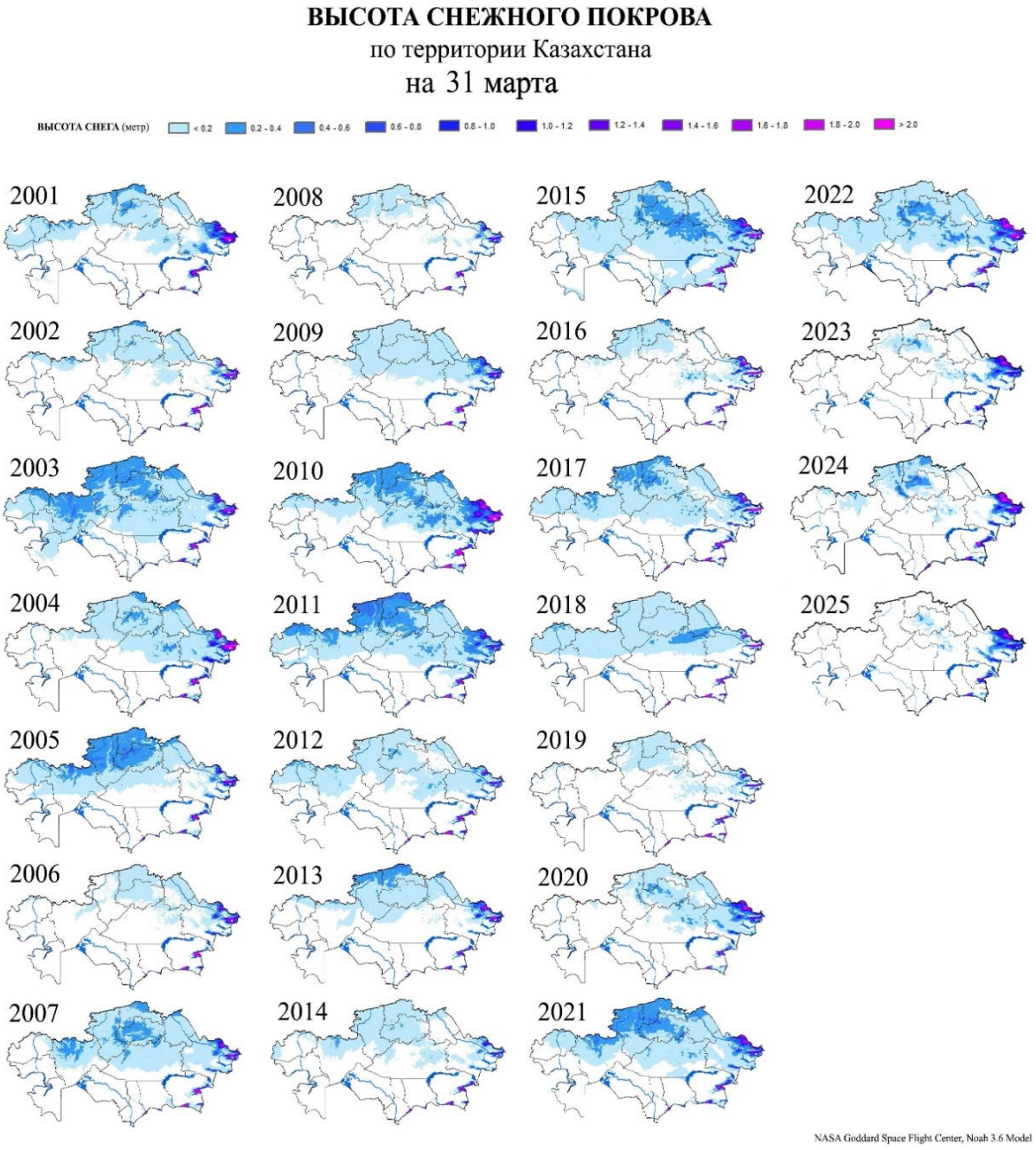

Figure 6.2 – Snow depth on March 31 in the period 2001–2025.

Snow Depth FEWS data NET USGS .

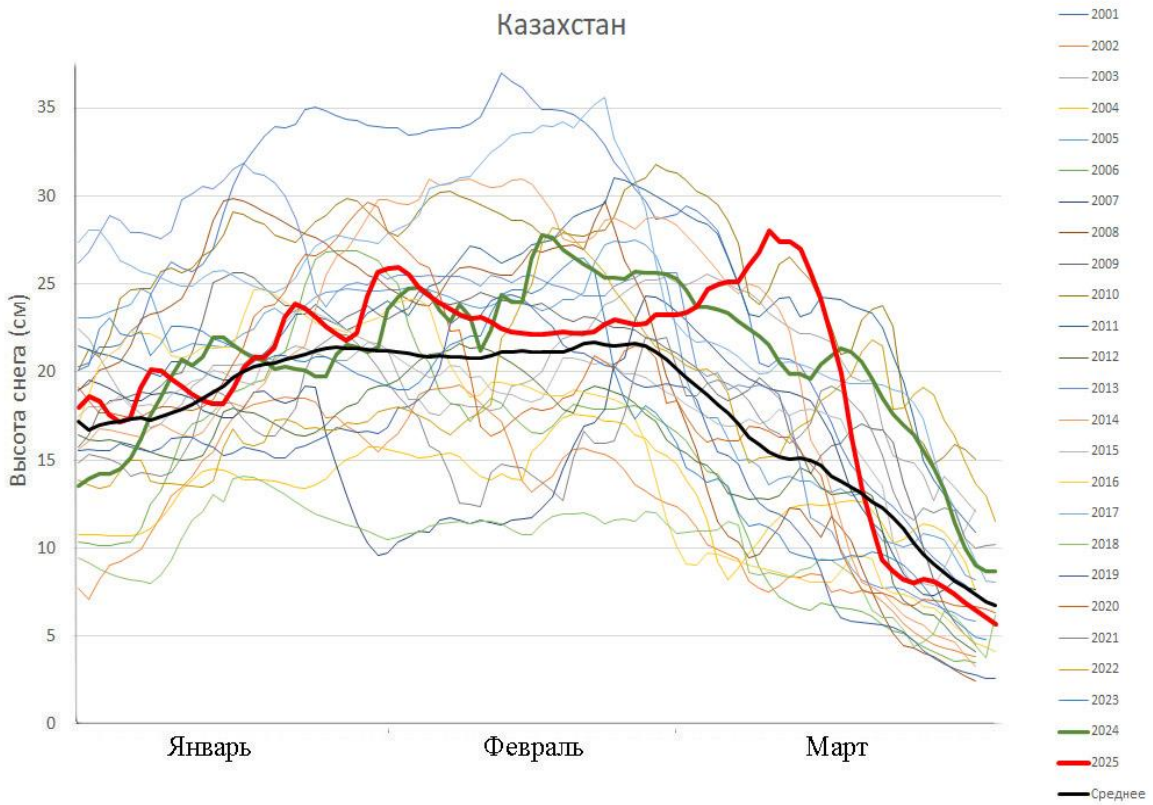

Figure 6.3 – Daily monitoring of the average snow depth in Kazakhstan from 2001 to 2025. Data from January 1 to March 31 are presented. The result of SD data processing FEWS NET .

Figure 6.4 – Boundaries of water management basins of Kazakhstan on January 1, 10, and 20, 2025 (FEWS maps NET).

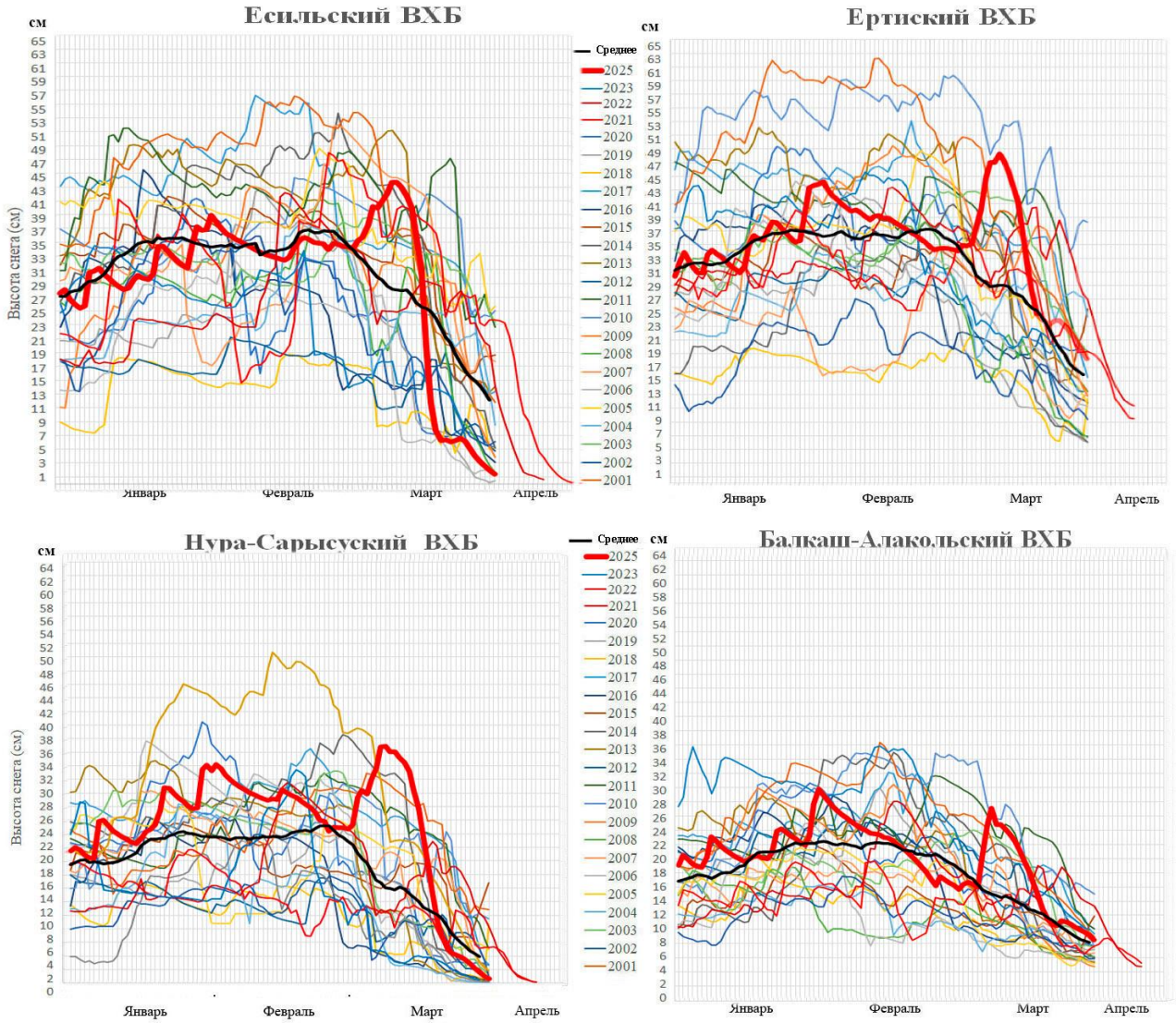

Figure 6.5 – Daily monitoring of the average snow depth in the territories of four water management basins for the period from 2001 to 2025. Data from January 1 to March 31 are presented. The result of SD data processing FEWS NET .

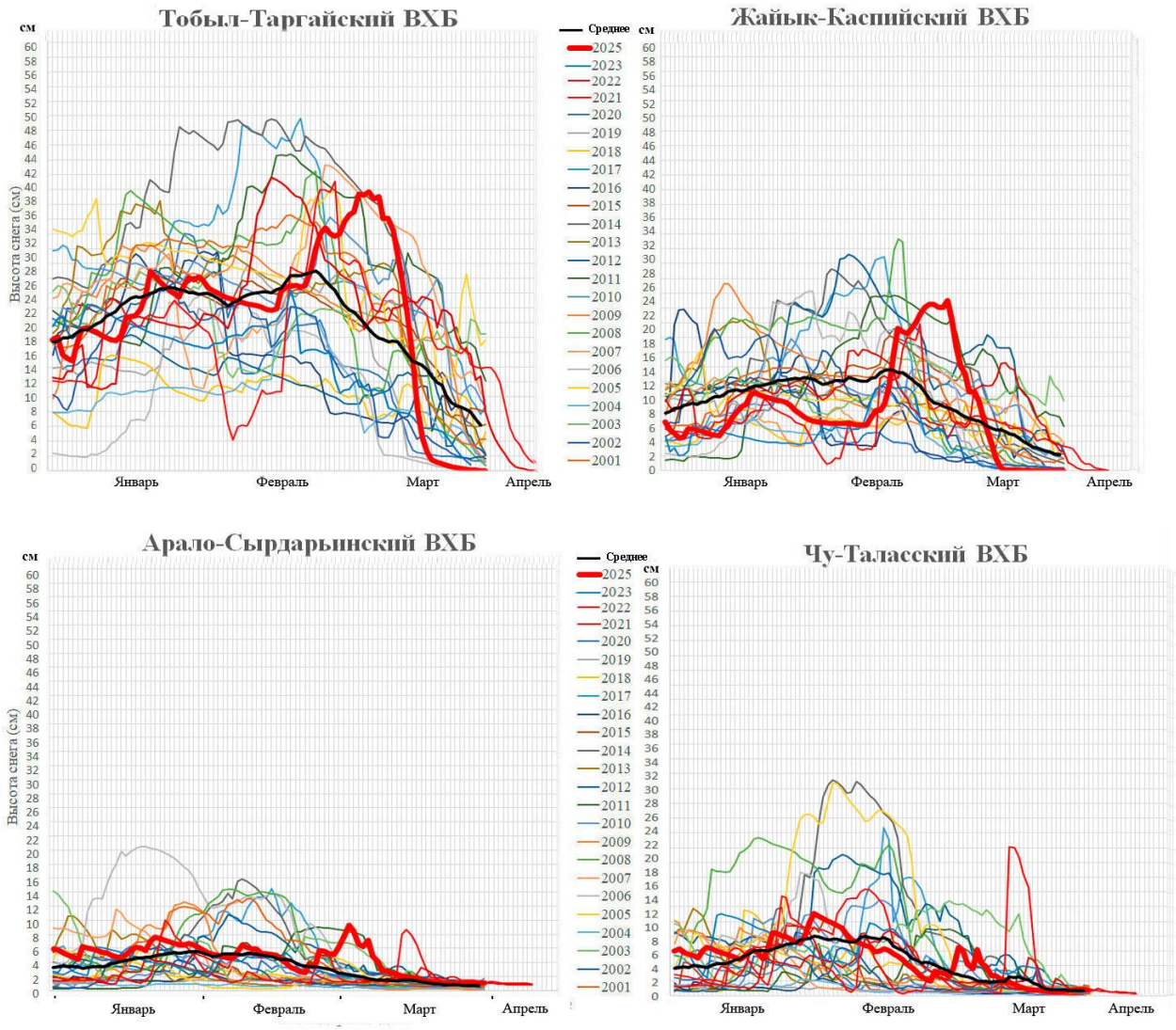

Figure 6.6 – Daily monitoring of the average snow depth in the territories of four water management basins for the period from 2001 to 2025. Data from January 1 to March 31 are presented. The result of SD data processing FEWS NET

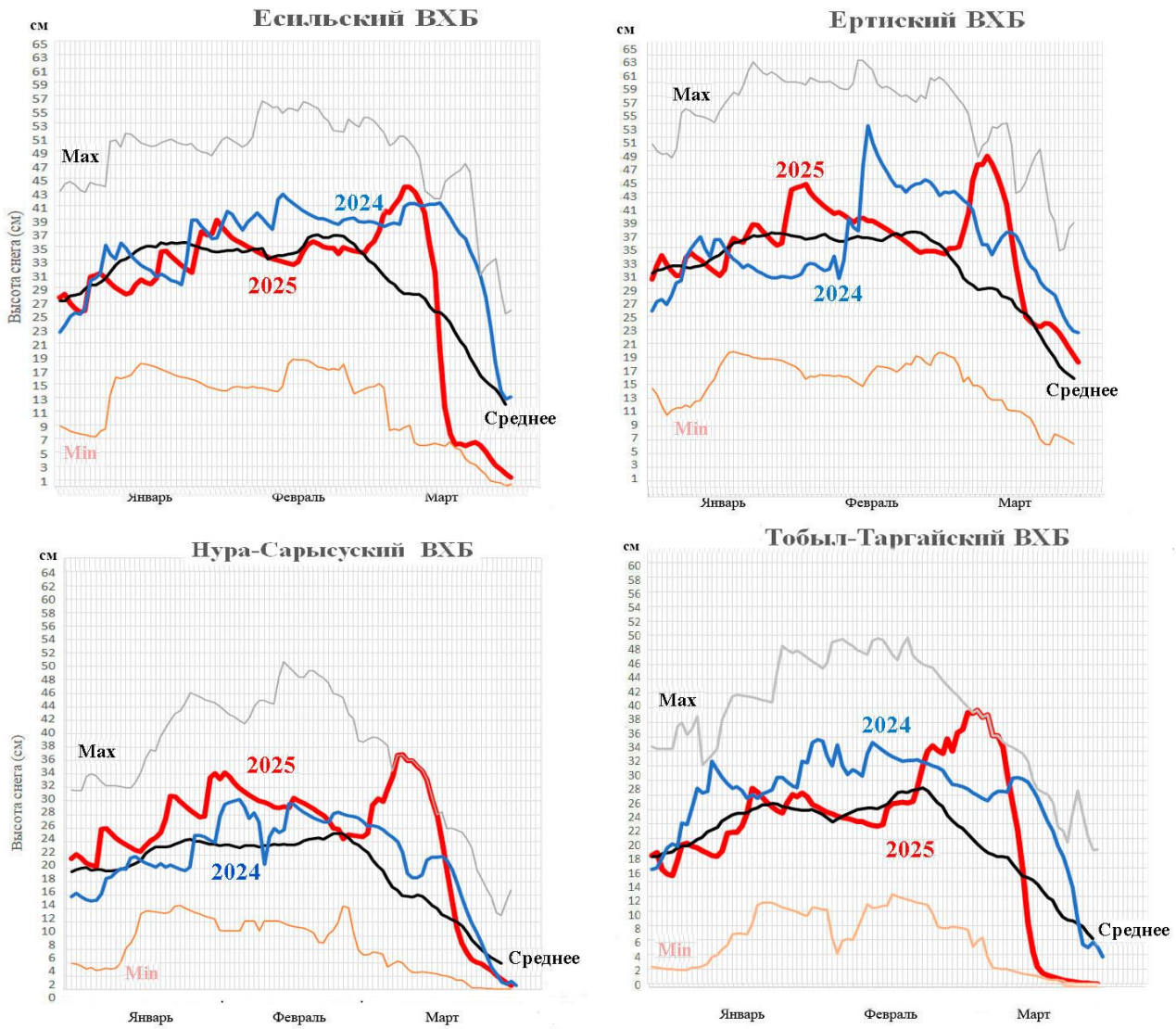

Figure 6.7 – Daily monitoring of the average snow depth in the territories of four water management basins for the 2024 and 2025 seasons (from January 1 to March 31). Statistical data (min , max , average) for the period 2001-2022 are shown. The result of SD data processing FEWS NET .

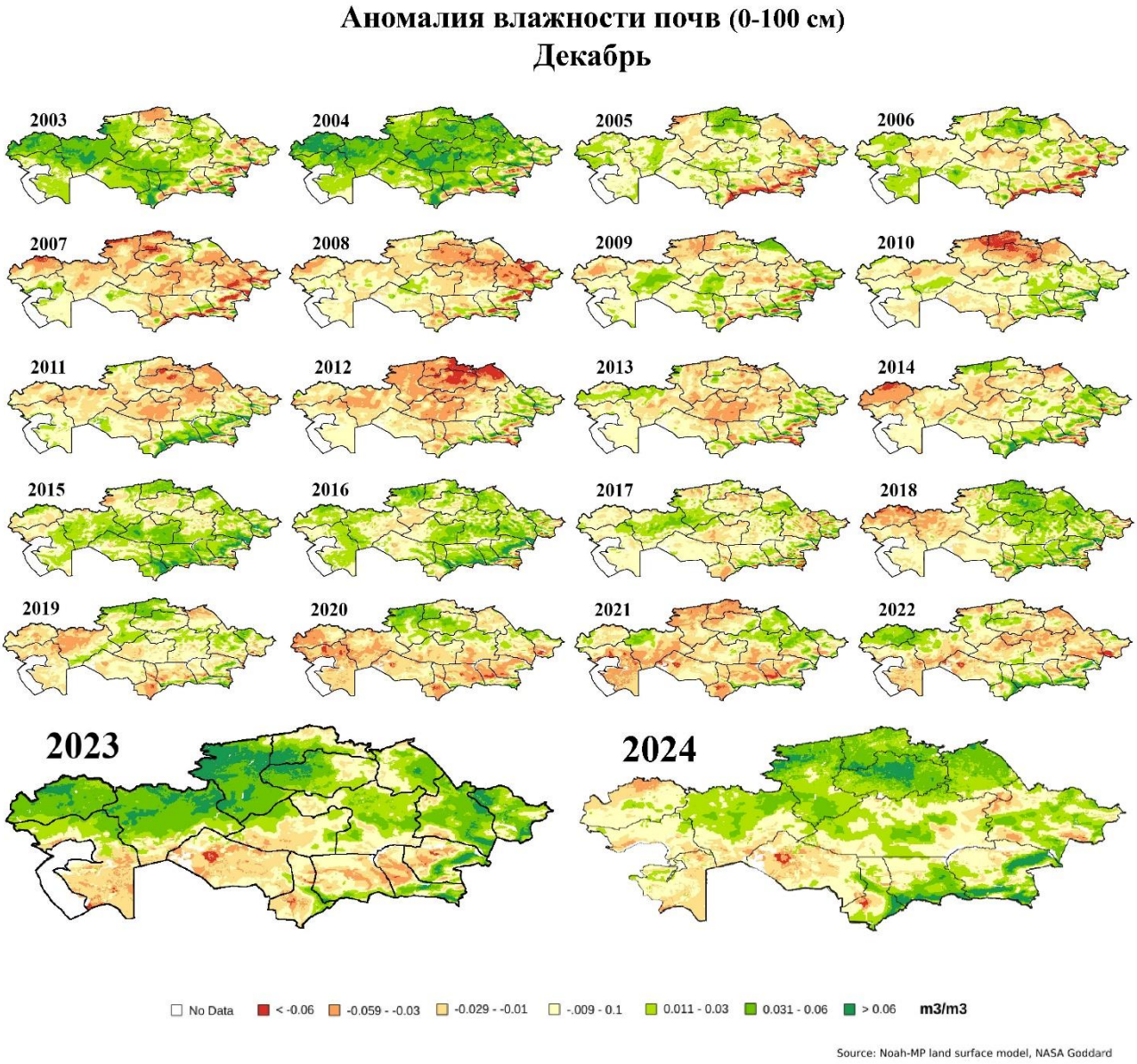

Figure 6.8 – Monitoring of soil moisture anomalies in the 0-100 cm layer for the first ten days of December (the period before the establishment of stable snow cover) for the territory of Kazakhstan in the period 2003-2024. Result of SD data processing FEWS NET .

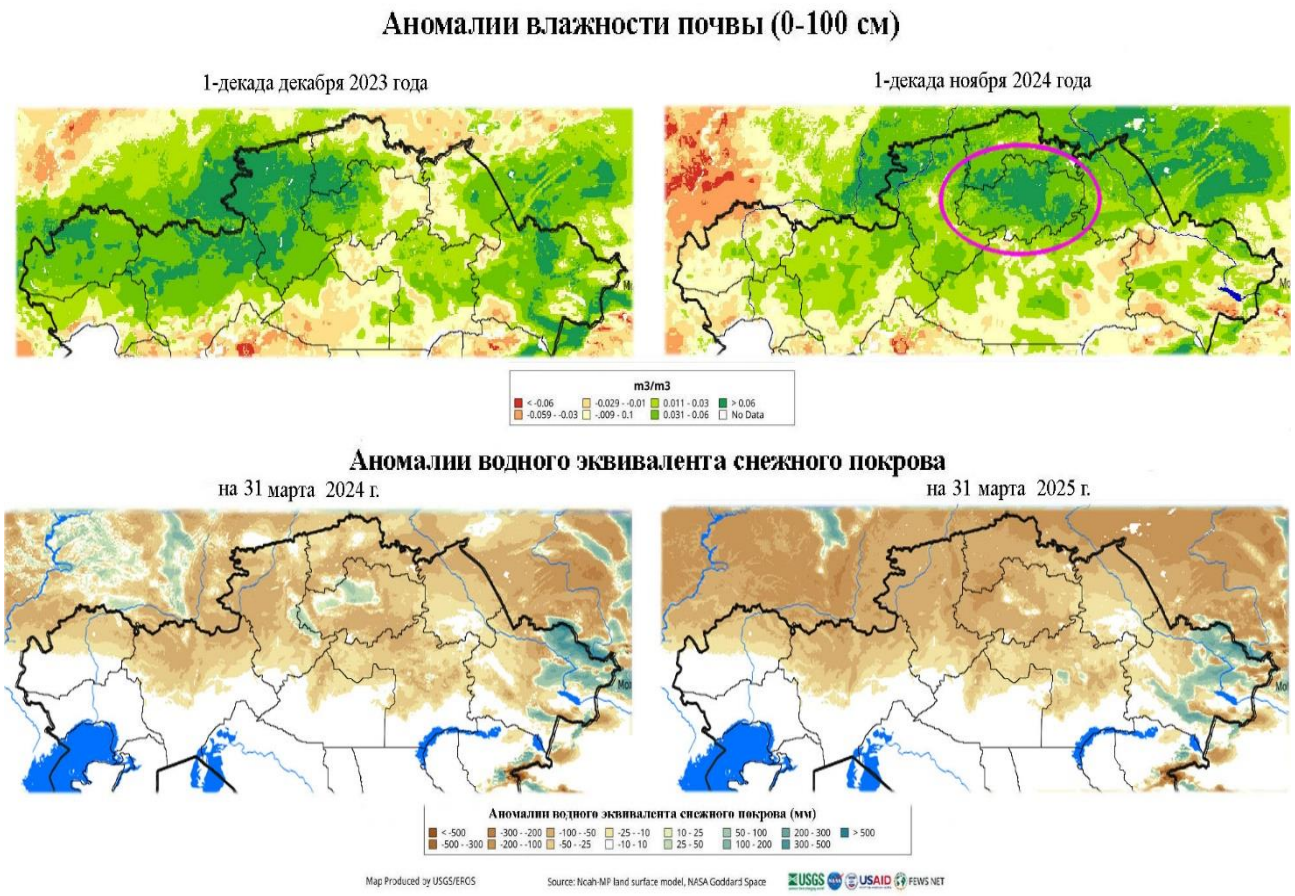

Figure 6.9 – Map of soil moisture anomalies in the 0-100 cm layer for the first ten days of November 2024 (the period before the establishment of stable snow cover in the 2023-2024 and 2024-2025 seasons) and snow cover water equivalent anomalies as of March 31, 2024 and 2025 for the territory of Northern Kazakhstan. Result of FEWS data processing NET USGS .

APPLICATION 2

MAXIMUM HEIGHT, MAXIMUM WATER CONTENT IN SNOW AND NUMBER OF DAYS OF SNOW COVER AT WEATHER STATIONS OF THE REPUBLIC OF KAZAKHSTAN FOR THE WINTER PERIOD (2023-2024)

No.	Station	Water storage in snow	Snow depth	Number of days with snow cover
1 North Kazakhstan region				
1	Blagoveshchenka	122	34	151
2	Vozvyshenka	98	69	151
3	Kishkenekol	279	113	157
4	Petropavlovsk	122	53	149
5	Ruzaevka	133	31	129
6	Saumalkol	151	46	156
7	Sergeevka	137	67	153
8	Taiynsha	87	24	139
9	Timiryazevo	119	102	158
10	Chkalov	83	41	141
11	Yavlenka	125	56	150
2 Akmola region				
1	Akkol	122	39	140
2	Arshaly	32	35	127
3	Astana		42	129
4	Atbasar	129	107	151
5	Balkashino	205	81	161
6	Egindykol	78	56	133
7	Ereimentau	68	51	138
8	Yesil	75	64	141
9	Zhaksy	144	60	149
10	Zhaltyr	92	33	127
11	Kokshetau	31	21	139
12	Korgalzhyn	132	130	124
13	Shchuchinsk	109	76	150
3 Kostanay region				
1	Amangeldy	39	30	121
2	Arkalyk	88	39	111
3	Arshalinsky agricultural holding	99	72	145
4	Jetygara	100	37	140
5	Dievskaya	84	26	135
6	Dokuchaevka (Karamendy)	68	44	142
7	Zhekeznodorozhnyi temporary storage warehouse	115	37	145
8	Karasu	109	40	147

No.	Station	Water storage in snow	Snow depth	Number of days with snow cover
9	Komsomol (Karabalyk)	147	46	144
10	Kostanay	109	48	143
11	Kushmurun	96	26	142
12	Mikhailovka	140	36	139
13	Presnogorkovka	91	48	147
14	Rudnyi	150	39	135
15	Tobol	101	37	137
16	Torgai	69	23	117
17	Uritsky (Sarykol)	132	54	143
18	Ekydin	53	41	103
4 Pavlodar region				
1	Aktogay	94	47	140
2	Bayanaul		27	127
3	Golubovka	125	42	144
4	Ekibastuz		9	106
5	Ertis	90	28	139
6	Zholboldy	83	74	138
7	Koktobe	81	26	117
8	Krasnoarmeyka	80	31	123
9	Lozovaya	83	29	126
10	Mikhailovka	107	32	143
11	Pavlodar	85	37	130
12	Uspenka	48	21	130
13	Fedorovka	180	27	135
14	Shaldai	86	34	110
15	Sharbakty	82	22	127
5 East Kazakhstan region				
1	Akzhar	29	13	124
2	Zaisan	65	22	117
3	Katon-Karagay	56	72	165
4	Kurshim	58	29	114
5	Leninogorsk	366	99	165
6	Markakol Nature Reserve	468	164	206
7	Samara	200	83	134
8	Seleznevka		56	141
9	Terekty	324	116	137
10	Tugyl	30	12	110
11	Ulken Naryn	109	50	119
12	Ust-Kamenogorsk		26	113
13	Shemonaikha	189	32	124
6 Abay region				
2	Aksuat	48	9	114
3	Aktogay		8	80

No.	Station	Water storage in snow	Snow depth	Number of days with snow cover
4	Ayagoz		35	117
5	Barshatas	51	42	101
6	Bakty	16	12	97
7	Dmitrievka	105	62	129
8	Zhalgyztobe	48	33	122
9	Kainar	28	10	112
10	Karaauyl		20	80
11	Kokpekty	188	73	136
12	Semipalatinsk		28	111
1	Semiyarka	42	23	100
13	Urzhar	173	69	110
14	Shalabai	133	42	120
15	Shar	108	32	124
7 Karaganda region				
1	Akadyr	49	19	115
2	Aksu-Ayuly	51	38	117
3	Aktogay	128	50	115
4	Balkhash	24	21	89
5	Bektauata	103	40	91
6	Bes-Oba	31	21	112
7	Zharyk	96	34	121
8	Karaganda	16	29	133
9	Kertindy	21	33	120
10	Kyzyltau	64	58	126
11	Korneevka	38	11	121
12	Rodnikovskoye	39	19	109
13	Saryshagan	17	8	70
8 Region Ulytau				
1	Zhana-Arka	38	22	102
2	Kzylzhar	32	28	103
3	Jetykonur	24	11	73
4	Zhezkazgan	32	17	95
9 West Kazakhstan Region				
1	Aksai	85	43	108
2	Jambeits	57	46	110
3	Dzhanybek	28	12	80
4	Zhalpaktal	32	17	83
5	Kamenka	82	17	108
6	Karatobe	54	48	112
7	Taipak	17	17	94
8	Uralsk	65	21	118
9	Urda	61	20	73
10	Chapaevo	41	13	107

No.	Station	Water storage in snow	Snow depth	Number of days with snow cover
11	Chyngyrlau	80	38	106
12	Yanvartsevo	81	26	105
10 Atyrau region				
1	Atyrau	13	11	48
2	Ganyushkino	7	5	29
3	Inderborsky	14	12	55
4	Karabau	20	10	54
5	Kulsary	16	8	47
6	Makhambet	16	9	48
7	Zhana Ushtogan		12	50
8	Peshnoi	7	8	54
9	Sagiz	26	10	69
11 Mangystau region				
1	Aktau	8	6	24
2	Beineu		4	30
3	Kyzan		4	25
4	Sam		3	26
5	Tushibek	13	5	39
6	Fort-Shevchenko		2	19
12 Aktyubinsk region				
1	Aktobe	75	28	122
2	Ayakkum	14	13	74
3	Ilyinsky	70	36	116
4	Irgiz	18	14	81
6	Karabutak	47	56	128
7	Karaulkeldy	21	6	101
8	Komsomolskoye	65	29	128
9	Kos-Istek	177	60	132
10	Martuk	66	45	127
11	Mugodzharskaya	41	21	127
12	Novoalekseevka	48	17	121
13	Nura	22	20	101
14	Rodnikovka	166	98	141
15	Temir	103	23	125
16	Oyil	70	14	111
17	Shalkar	11	16	89
18	Emba	41	18	121
13 Kyzylorda region				
1	Aral Sea	15	9	65
2	Zhhusaly	11	9	36
3	Zlikha		7	25
4	Kazalinsk	19	13	38
5	Karak		7	17

No.	Station	Water storage in snow	Snow depth	Number of days with snow cover
6	Kyzylorda		12	19
7	Shieli	4	11	37
14 Turkestan region				
1	Arys	7	7	35
2	village of Turar Ryskulov	57	42	76
3	Ashysai	76	25	69
4	Zhetysay	29	16	19
5	Kazygurt	14	14	38
6	Kyzylkum		5	35
7	Tasaryk	38	36	83
8	Tasty	27	13	38
9	Turkestan		7	29
10	Shardara		23	22
11	Shayan	13	14	45
12	Shulakkurgan	9	7	47
13	Shuuldak	437	113	143
14	Shymkent	23	37	57
15 Zhambyl region				
1	Karatau	22	32	57
2	Kordai	55	32	103
3	Kulan	17	30	74
4	Merke	53	28	82
5	Moyynkum	7	15	73
6	Saudakent	22	14	53
7	Taraz	22	25	17
8	Tole bi	24	22	69
9	Uyuk	24	21	58
10	Khantau	59	25	67
11	Shyganak	12	10	57
12	Shokpar	9	30	55
16 Almaty region				
1	Aydarly	32	25	71
2	Aksengir	64	25	101
3	AlmatyOGMS		31	
4	Almaty, Kam pl		59	118
5	Aul № 4	20	13	61
6	Bakanas	13	13	69
7	about Ulken Almaty		100	188
8	Yesik	45	25	93
9	Zhalanash	70	38	125
10	Kapchagay	9	13	69
11	Kegen	31	17	111
12	Kuigan	14	8	60

No.	Station	Water storage in snow	Snow depth	Number of days with snow cover
13	Mynzhylky	327	273	224
14	Narynkol	90	48	136
15	Kyrgyzsai	22	29	97
16	Uzunagach	68	29	101
17	Shelek	14	13	68
18	Shymbulak		99	174
19	Karashoky		21	46
17 Region Zhet i su				
1	Alakol		13	84
2	Zharkent	13	11	66
3	Kogaly	196	73	127
4	Lepsi	199	52	127
5	Matai	41	21	86
7	Sarkand	34	22	106
8	Saryozek		24	92
9	Taldykorgan		22	84
10	Tekeli	28	22	88
11	Usharal	42	8	85
12	Ushtobe	18	17	83

The bulletin was compiled by the Meteorological Research and Calculations Department
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