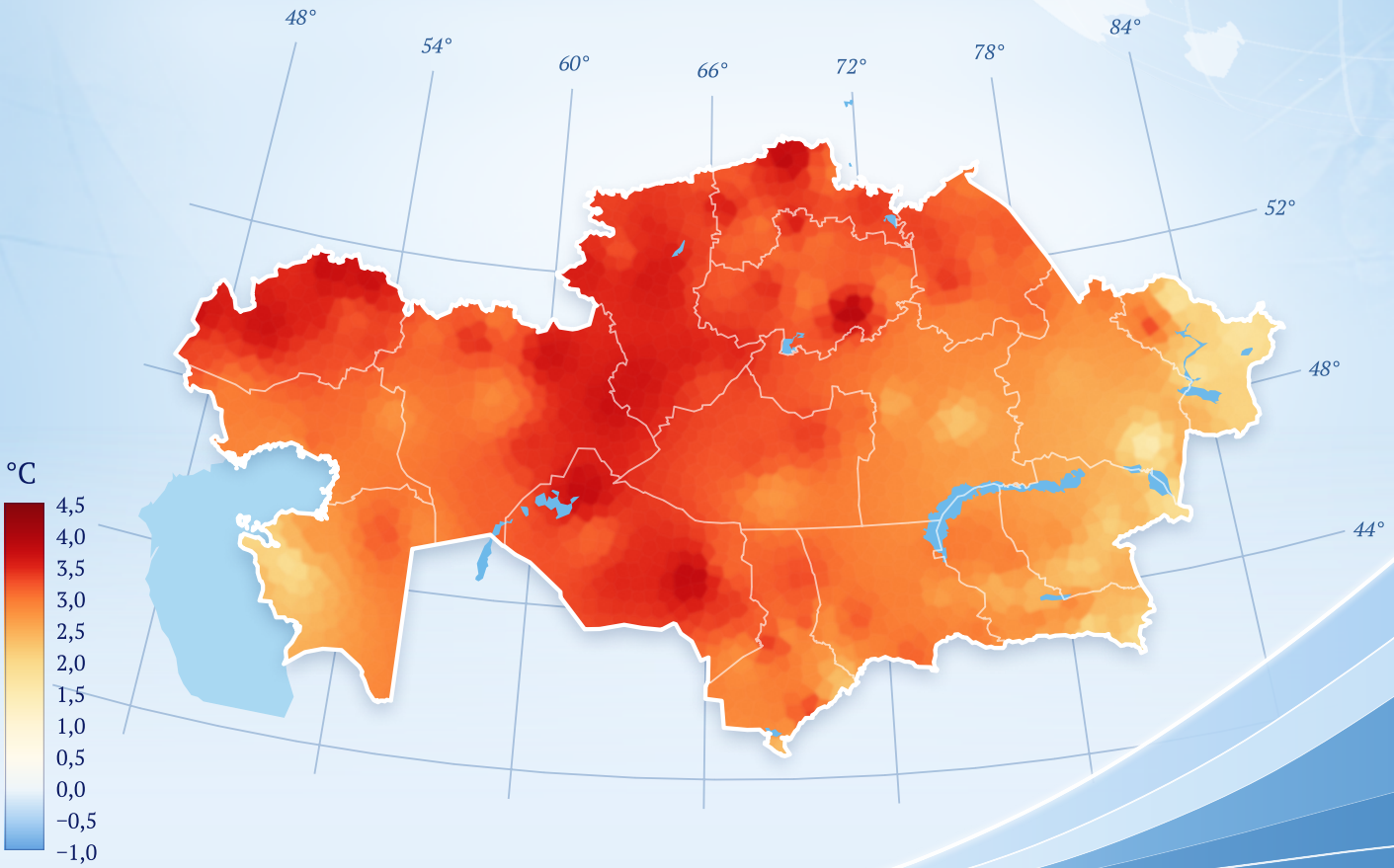
MINISTRY OF ECOLOGY AND
NATURAL RESOURCES OF
THE REPUBLIC OF KAZAKHSTAN

REPUBLICAN STATE ENTERPRISE
«KAZHYDROMET»

SCIENTIFIC RESEARCH CENTER

ANNUAL BULLETIN
ON CLIMATE CHANGE AND CONDITION MONITORING IN THE TERRITORY OF THE REPUBLIC OF KAZAKHSTAN
FOR 2025



ASTANA, 2026

MINISTRY OF ECOLOGY AND NATURAL RESOURCES OF THE REPUBLIC OF KAZAKHSTAN

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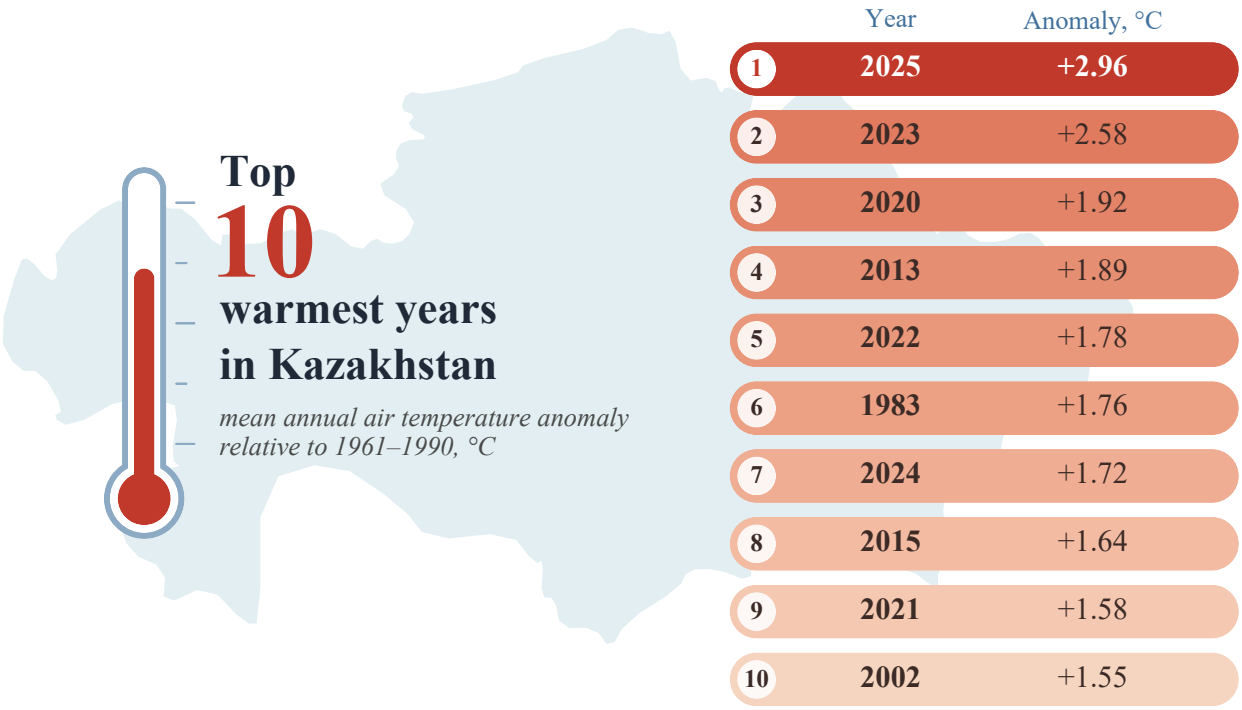
SHORT SUMMARY

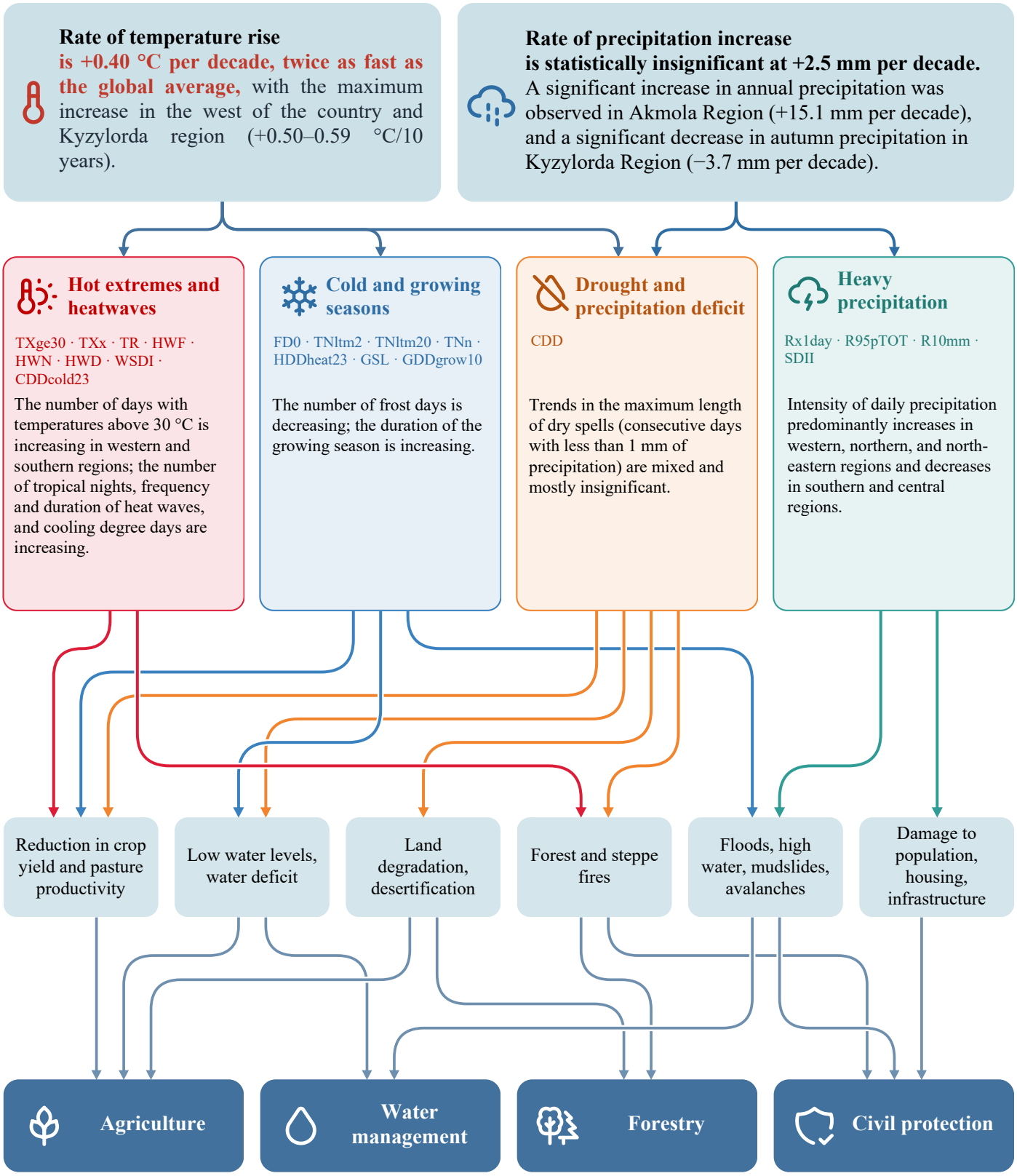
Climate Characteristics in 2025

- **The year 2025 became the warmest year in Kazakhstan on record since 1941.**
- The mean annual air temperature exceeded the 1961–1990 climatic norm by 2.96 °C and surpassed the previous record of 2023 by 0.38 °C.
- Extremely high mean annual air temperature values were recorded at 176 meteorological stations, and for 138 stations, 2025 became the warmest year since records began in 1941.



- The monthly mean air temperature in 2025 was above the climatic norm (1961–1990) in all months. January, April, May, June, and November ranked among the 5% of extremely warm months.
- The frequency of hot days during the warm period was particularly high in the south of the country, where the number of days with air temperatures exceeding 30 °C significantly increased, reaching 145–151 days.
- The annual amount of atmospheric precipitation averaged across Kazakhstan was within the normal range at 295.7 mm, or 93.1% of the norm. The most significant deficit was observed in the south of the Kostanay region and in certain areas of the southern regions.
- Changes in the maximum duration of dry periods with precipitation of less than 1 mm per day reached 1–3 days per decade, both in the direction of increase and decrease.

Climate change and potential risks in Kazakhstan



Indices are per the bulletin (index trends for 1961–2025); temperature and precipitation trends cover 1976–2025, significant ones at the 5% level based on the Fisher criterion. Sectors are priority areas for climate change adaptation (Environmental Code of the Republic of Kazakhstan, Art. 313, para. 2). Data from the meteorological stations of RSE "Kazhydromet".

INTRODUCTION

Climate is a natural resource that is vital for determining the directions of development of many sectors of the economy and the health of the population of any state. Meteorological information collected, managed and analyzed by national hydrometeorological services helps users of this information, including decision makers, to plan any activity taking into account current climatic conditions and observed climate changes. The use of up-to-date meteorological and climate information helps to reduce risks and damage and optimize socio-economic benefits. Monitoring of the climate system is carried out by national, regional and international organizations in coordination with the World Meteorological Organization and in cooperation with other environmental programs.

The study of the regional climate and the constant monitoring of its changes is one of the priorities of the national hydrometeorological Service of Kazakhstan RSE "Kazhydromet". Since 2010, Kazhydromet has been issuing annual bulletins to provide reliable scientific information about the regional climate, its variability and change. Taking into account the geographical location of Kazakhstan and its vast territory, the observed changes in climatic conditions in various regions of the Republic can have both negative and positive effects on biophysical systems, economic activity and the social sphere. Consideration of climatic conditions and assessment of their changes are necessary to identify potential consequences and take timely and adequate adaptation measures, ultimately, to ensure the sustainable development of Kazakhstan.

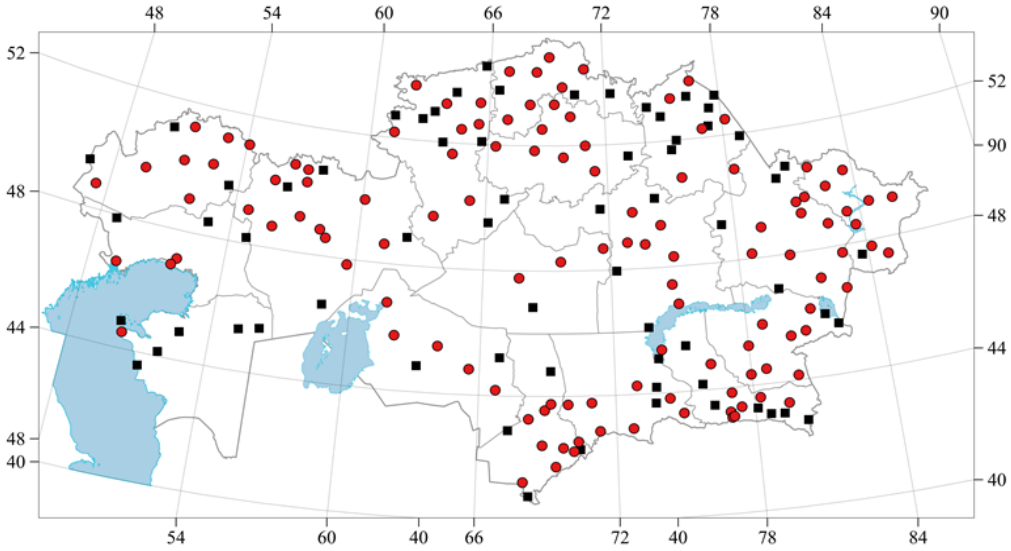
This issue of the bulletin describes the climatic conditions observed in 2025, including an assessment of the extremes of temperature and precipitation regimes, and provides historical information on changes in surface air temperature and precipitation that have occurred since 1941. This issue of the bulletin also contains estimates of climate change over a shorter period – since the mid-1970s of the last century, when, according to many experts, global climate change has become more intense, especially in the Northern Hemisphere. Appendices 3 and 4 show maps of the distribution of average long-term values of air temperature and precipitation for the period 1961–1990, averaged by season and per year.

The initial data. Data from the Republican Hydrometeorological Fund of RSE "Kazhydromet" are used to prepare the bulletin:

1) the series of average monthly air temperatures and monthly precipitation amounts, while about 121 meteorological stations have homogeneous series since 1941 and their data are involved in the generalization of information on the territory of the regions and in Kazakhstan as a whole, since 1961, there are about 190 such stations, and their data were used to assess climatic norms for the period 1961–1990, to assess anomalies and trends in a particular point;

2) the series of daily maximum and minimum air temperatures and daily precipitation since 1961 (about 190 meteorological stations).

The network of meteorological stations used for climate monitoring is shown on the schematic map below.

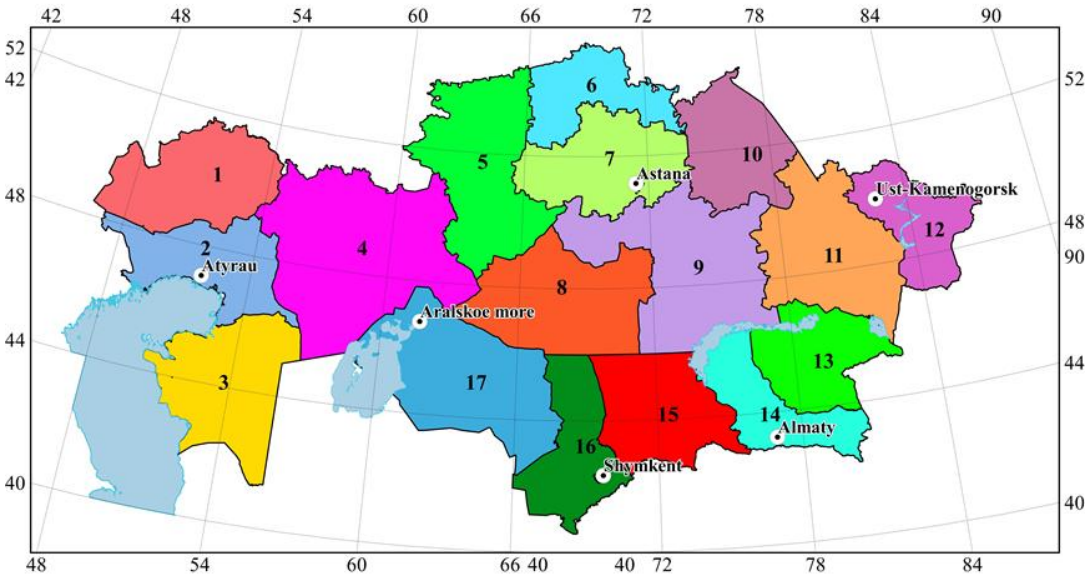


Network of meteorological stations in Kazakhstan used for climate monitoring (stations used for averaging over the area of regions are shown in red circles)

The main approaches and methods. The "norm" in the bulletin refers to the long-term mean value of the considered climatic variable over the period 1961–1990. Temperature anomalies are calculated as deviations of the observed value from the norm. Precipitation anomalies are usually considered both in deviations from the norm (similar to air temperature) and as a percentage of the norm. As additional characteristics of anomalies, indicators based on the distribution function (probability of non-exceedance, which characterizes the frequency (in %) of occurrence of the corresponding anomaly value in a series of observations) and ordinal statistics (ranks, i.e., ordinal numbers in an ordered series of values relative to other numbers in the dataset) are used, periods for evaluating these statistics are specifically specified in every case.

Linear trend coefficients determined by the least squares' method are used as an estimate of changes in climate characteristics over a certain time interval. The measure of trend materiality is the coefficient of determination (D), which characterizes the contribution of the trend component to the total variance of the climate variable over the period under consideration (as a percentage).

The assessment of trends in surface air temperature and precipitation, the average values of anomalies of meteorological variables are given both according to data from individual stations and on average for the territory of Kazakhstan as a whole and for 17 of its administrative-territorial regions. The average values of anomalies of meteorological variables for the territory are calculated by averaging station data on anomalies. The borders of the administrative-territorial regions of Kazakhstan are shown on the schematic map below.



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

The scheme of administrative-territorial division of the Republic of Kazakhstan

To assess the temperature and precipitation regime in a particular year and its changes since 1961, climate indices recommended by the World Meteorological Organization are used and contribute to the "detection" (mathematically) of significant climate change, including the characteristics of extremes. Some indices are based on fixed uniform thresholds for all stations, while others are based on thresholds that may vary from station to station. In the latter case, the thresholds are defined as the corresponding percentiles of the data series. The indices also allow us to assess the impact of the current climate and its changes on various aspects of socio-economic conditions in the studied region. There are indices reflecting the potential impact on human health, on energy generation needs in different seasons, on agrometeorological conditions, on transport infrastructure, on the extremity of hydrometeorological conditions, etc.

Responsible for the issue: Head of the Department of Climate Research Kuzhageldina N.U. Leading researchers Amanulla Ye.Ye., Dyussenova Zh.A., Zhakyp A.S., Sagiyev S.N. and leading engineer Abdolla N.S. also participated in the preparation of the bulletin.

1 OVERVIEW OF GLOBAL CLIMATE CHANGE AND ITS STATUS IN 2025

For more than 30 years, the World Meteorological Organization (WMO), through the Commission on Climatology and in cooperation with its members, has been issuing an annual report on the state of the climate, in response to concerns expressed in 1993 about projected climate change. The annual Global Climate report identifies indicators of the climate system, including greenhouse gas concentrations, rising land and ocean temperatures, rising sea levels, melting ice and retreating glaciers, as well as extreme weather events. It also highlights the impact on socio-economic development, migration and displacement, food security and terrestrial and marine ecosystems. Global climate indicators provide a broad view of climate change on a global scale, covering atmospheric composition, energy changes, and the response of land, ocean, and ice. These indicators are closely interrelated. For example, an increase in the content of CO_2 and other greenhouse gases in the atmosphere leads to an energy imbalance and, thus, to a warming of the atmosphere and the ocean. Ocean warming, in turn, leads to an increase in sea level, to which is added the melting of ice on land in response to an increase in atmospheric temperature.

Together, the indicators create a coherent picture of global warming, which affects all parts of the Earth's system. There are clear links between key climate indicators as a physical system and cascading risks for most of the 17 Sustainable Development Goals. Thus, monitoring global climate indicators, as well as the risks and consequences associated with them, is crucial for achieving the Sustainable Development Goals by 2030.

Key messages on the state of the global climate in 2025:

According to the World Meteorological Organization report “State of the Global Climate 2025”, the last 11 years, from 2015 to 2025, were the warmest in the entire history of instrumental observations. The year 2025 was the second or third warmest year in the 176-year observational record, depending on the dataset used. The global mean near-surface temperature was about 1.43 ± 0.13 °C above the average for the pre-industrial period 1850–1900. The year 2024 remains the warmest on record, with an exceedance of about 1.55 °C. The lower global temperature in 2025 compared with 2024 is partly due to the transition to La Niña conditions, which have a temporary cooling effect.

A single year in which the global mean temperature exceeds the 1850–1900 level by more than 1.5 °C does not mean that the long-term temperature threshold set by the Paris Agreement has been exceeded.

Greenhouse gas concentrations

Atmospheric concentrations of the main greenhouse gases continue to increase. The latest globally consolidated data are for 2024. The mean concentration of carbon dioxide (CO_2) reached 423.9 ± 0.2 parts per million, methane (CH_4) 1942 ± 2 parts per billion, and nitrous oxide (N_2O) 338.0 ± 0.1 parts per billion. Data from individual observing stations show that the levels of all three main greenhouse gases continued to rise in 2025.

WMO notes that the atmospheric CO_2 concentration in 2024 was the highest in at least the last 2 million years, and the concentrations of methane and nitrous oxide were the highest in at least 800 000 years. The annual increase in CO_2 concentration in 2024 was the largest since modern measurements began in 1957. Among the contributing factors, WMO cites continued anthropogenic CO_2 emissions and the reduced efficiency of land and ocean carbon sinks.

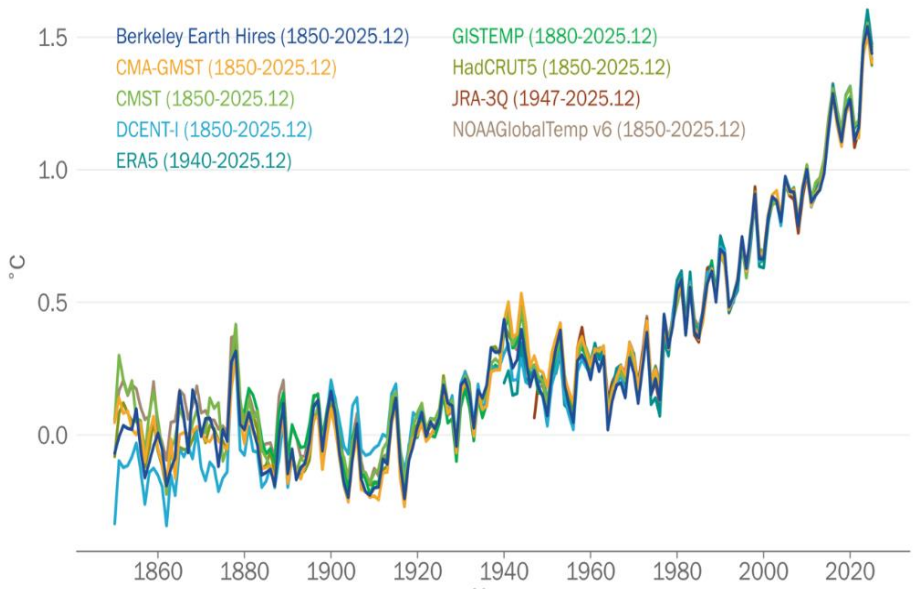


Figure 1.1 – *Annual global mean temperature anomalies relative to the pre-industrial (1850–1900) baseline, shown from 1850 to 2025.*

Source: data from the nine datasets listed in the legend.

Earth's energy imbalance

Earth's energy imbalance is the difference between the amount of energy entering the climate system from the Sun and the amount of energy leaving it back into space. Rising greenhouse gas concentrations disrupt this balance. According to WMO, Earth's energy imbalance has been increasing since observations began in 1960, particularly rapidly over the last two decades, and **in 2025 it reached the highest value on record.**

More than 91 % of the excess energy accumulates in the ocean, about 5 % in the land, about 3 % goes into warming and melting ice, and about 1 % into warming the atmosphere.

Ocean heat content

In 2025, the heat content of the global ocean in the 0–2000 m layer reached a new record level, exceeding the previous maximum of 2024. Thus, each of the last nine years has set a new ocean heat content record.

The rate of ocean warming over 2005–2025 was more than twice that over 1960–2005, at approximately 11.0–12.2 ZJ per year. According to WMO estimates, the amount of heat energy absorbed by the ocean each year over the last two decades was about 18 times humanity's annual energy consumption. Despite La Niña conditions, about 90 % of the ocean surface experienced at least one marine heatwave during 2025.

Global mean sea level

In 2025, global mean sea level remained close to the record high values of 2024 and was about 11 cm above the level at the start of satellite altimetry observations in 1993.

The rate of sea level rise has increased markedly: it was about 4.75 mm/year over 2012–2025, compared with about 2.65 mm/year over 1993–2011. The annual increase between 2024 and 2025 was smaller than between 2023 and 2024, which WMO attributes, among other things, to short-term natural variability under La Niña conditions.

Ocean acidification

The ocean absorbs a significant share of anthropogenic carbon dioxide emissions. About 29 % of the anthropogenic CO_2 emitted over 2015–2024 was absorbed by the ocean, contributing to a further decline in surface ocean pH. The global mean surface pH has continued to decline over the last four

decades. According to IPCC estimates, the current level of surface ocean acidity is unprecedented for at least the last 26 000 years.

Glacier mass balance

In the 2024/2025 hydrological year, the mass losses of reference glaciers were among the five largest on record. Accelerated glacier mass loss continues: eight of the ten years with the largest glacier ice loss have occurred since 2016. Particularly large glacier mass losses in 2025 were observed in Iceland and along the Pacific coast of North America.

Sea ice

The annual mean Arctic sea-ice extent in 2025 was the lowest or second lowest in the satellite record, which began in 1979. The maximum daily Arctic sea-ice extent after the winter season was about 14.19 million km², the lowest in the entire satellite record.

The annual mean Antarctic sea-ice extent in 2025 was the third lowest, after 2023 and 2024. The minimum daily Antarctic sea-ice extent after the summer melt was tied for the second lowest on record.

Extreme weather and climate events

In 2025, extreme weather and climate events – heat waves, wildfires, droughts, tropical cyclones, storms, and floods – caused thousands of deaths, affected millions of people, and resulted in billions of dollars in economic losses. WMO also highlights the cascading impacts of such events on food security, population displacement, and socio-economic resilience.

For this subsection, WMO issued a separate supplement, "Significant Weather and Climate Events 2025". For example, about 90 tropical cyclones were recorded worldwide in 2025, slightly above the long-term average. Severe floods affected a number of countries in Africa and Asia; the monsoon rains had particularly severe impacts in Pakistan, where more than a thousand flood-related deaths were recorded during the season.

Source: WMO Report No. 1391 — "State of the Global Climate in 2025", permanent link: *https://library.wmo.int/idurl/4/69807*

2 AIR TEMPERATURE

In 2025, the mean annual air temperature anomaly averaged over Kazakhstan was +2.96 °C relative to the long-term mean for the period 1961–1990 (5.4 °C). The year ranked 1st in the descending series of mean annual air temperatures since 1941 and exceeded the previous maximum, observed in 2023 (+2.58 °C), by 0.38 °C. Since the 1960s, each successive decade in Kazakhstan has been warmer than the previous one. The mean annual air temperature for the last decade, 2016–2025, was +7.11 °C, exceeding the climatic norm by 1.69 °C. This is a record value among positive decadal anomalies; the previous warmest decade, 2006–2015, had an anomaly of +0.95 °C. The last five-year period, 2021–2025, was also the warmest: the mean air temperature was +7.55 °C, which is 2.12 °C above the climatic norm.

Table 2.1 presents the lists and ranks of the ten warmest years for the Globe and for Kazakhstan (based on data from the ground-based network). Each year that is among the ten warmest years for both the Globe and Kazakhstan is assigned its own fill color, which makes it easy to see which years appear in both lists. The year 2025 was the warmest on record in Kazakhstan for the entire period of instrumental observations, whereas globally it was the second or third warmest year, depending on the dataset used. The year 2024, a record year for the Globe, ranks seventh in Kazakhstan.

Table 2.1 *– The warmest years in the history of observations for the Globe (since 1850) and for Kazakhstan for the period 1941–2025, and the corresponding anomalies of mean annual surface air temperature averaged over the territory of Kazakhstan. Anomalies are calculated relative to the period 1961–1990*

Rank	Globe	Kazakhstan	Mean annual temperature anomaly (Jan–Dec) averaged over the territory of Kazakhstan, °C
1	**2024**	**2025**	2.96
2	2023	2023	2.58
3	2025	2020	1.92
4	2020	2013	1.89
5	2016	2022	1.78
6	2019	1983	1.76
7	2017	2024	1.72
8	2022	2015	1.64
9	2015	2021	1.58
10	2021	2002	1.55

Figure 2.1 shows the ranked series of mean annual surface air temperature anomalies averaged over the meteorological stations of Kazakhstan for the period from 1941 to 2025. Globally, all 10 warmest years have occurred in the current century. This feature is also clearly evident in Kazakhstan, with the exception of 1983, which ranks sixth among the warmest years.

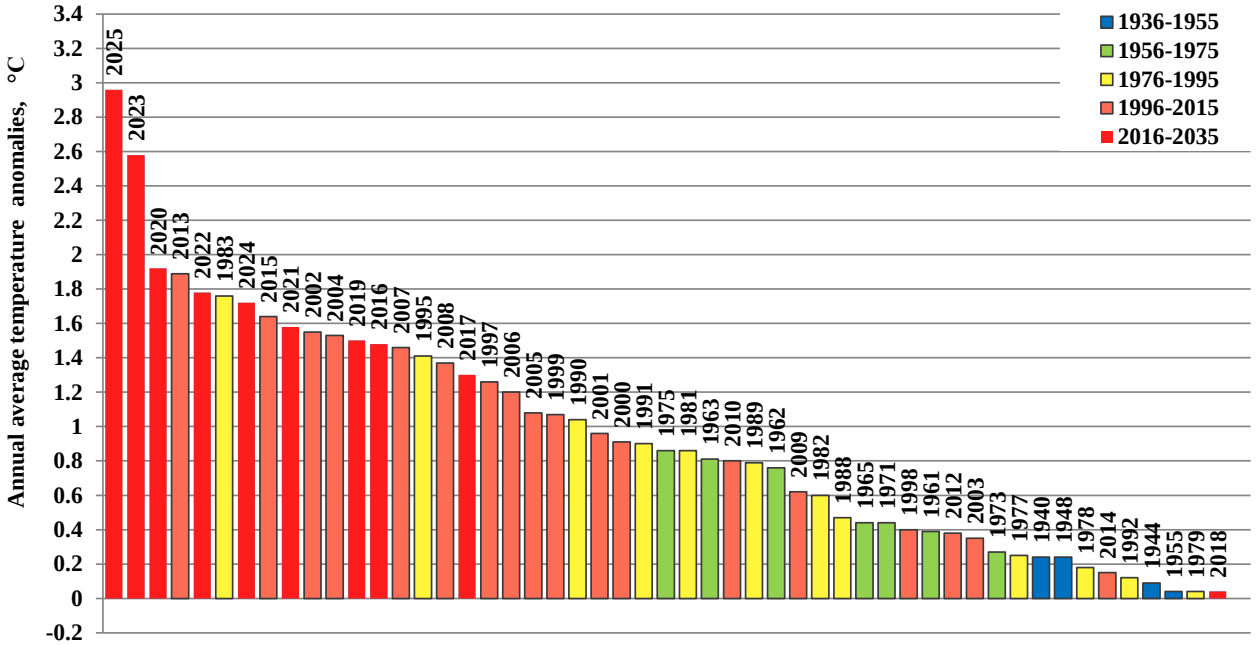


Figure 2.1 *– Ranked series of positive anomalies of mean annual (January–December) surface air temperature averaged over the territory of Kazakhstan (based on data from 121 meteorological stations) for the period 1941–2025.*
Anomalies are calculated relative to the base period 1961–1990

2.1 Air temperature anomalies in 2025

The mean annual air temperature averaged over Kazakhstan continues to rise. The year 2025, with an air temperature anomaly of 2.96 °C, ranked 1st in the descending series of mean annual temperatures since 1941. Nine of the ten warmest years have occurred in the 21st century.

Table 2.2 presents the mean annual and seasonal air temperature anomalies averaged by region and for Kazakhstan as a whole, and Table 2.3 presents the anomalies of mean monthly air temperature. For each anomaly value, the probability of non-exceedance calculated from data for the period 1941–2025 is given, as well as the standard deviation for 1961–1990 (Table 2.2). In Tables 2.2 and 2.3, temperature values above the 95th or below the 5th percentile (warm and cold extremes, respectively) are highlighted in bold and color.

In 2025, mean annual air temperature anomalies were positive throughout Kazakhstan and substantially exceeded the climatic norm for the base period 1961–1990 (Figure 2.2, top). Over most of the country, anomalies ranged from 2.5 to 3.5 °C. The largest values, from 3.5 to 4.0 °C, were observed in the northern and western regions – in the Kostanay, North Kazakhstan, Akmola, West Kazakhstan, and Aktobe regions, as well as in the Aral Sea area and the Kyzylorda region; the maximum anomaly of +4.0 °C was recorded in the Akmola region. Anomalies from 2.0 to 2.5 °C were observed in the east and southeast of the country and locally on the Caspian Sea coast. The smallest values, from 1.4 to 2.0 °C, were observed in the mountainous and foothill areas of the east, southeast, and south. Extremely warm conditions (probability of non-exceedance of 95 % and higher) covered almost the entire country, except for some areas in the east and southeast and the coastal areas of the Mangystau region (Figure 2.2, bottom).

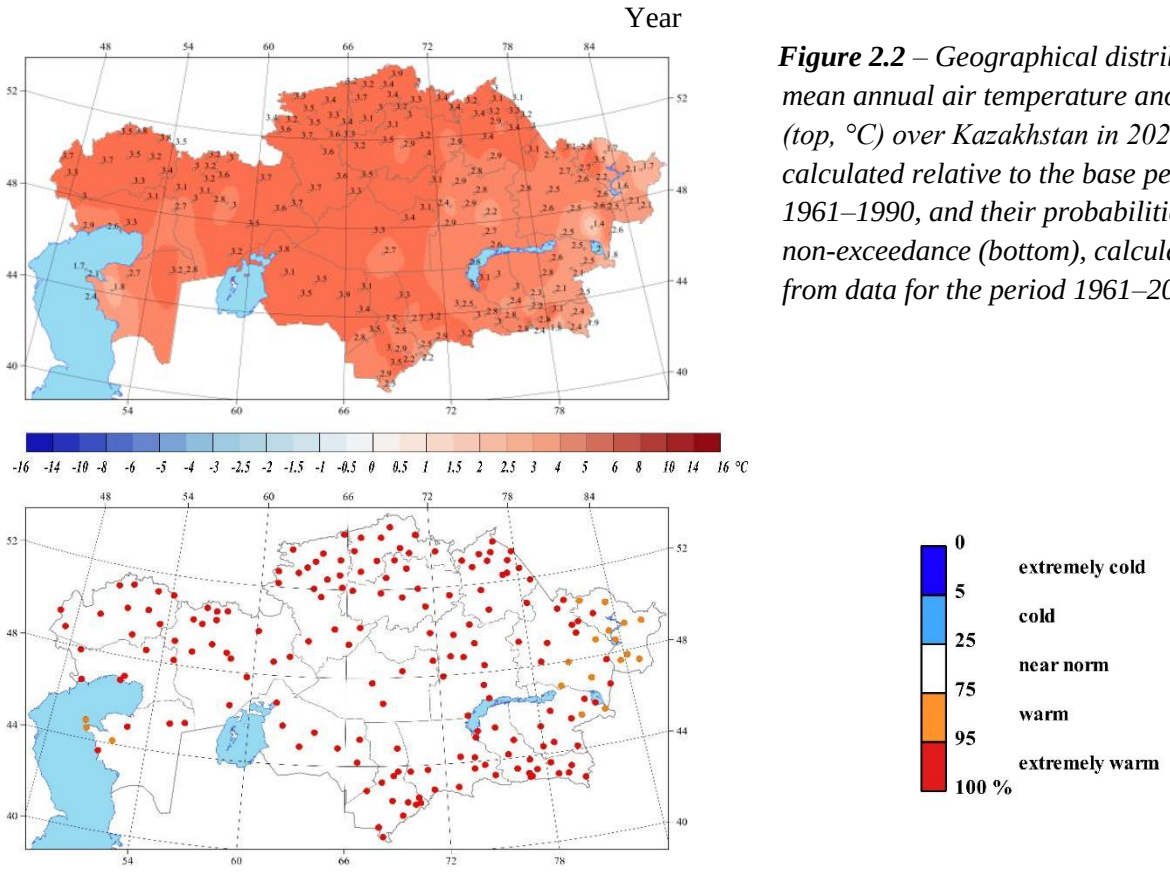


Figure 2.2 *– Geographical distribution of mean annual air temperature anomalies (top, °C) over Kazakhstan in 2025, calculated relative to the base period 1961–1990, and their probabilities of non-exceedance (bottom), calculated from data for the period 1961–2025*

The year was the warmest on record (rank 1, Table 2.2) in all regions of Kazakhstan except the Atyrau (rank 2), East Kazakhstan (rank 3), and Mangystau (rank 4) regions, where 2025 was among the 5 % of extremely warm years. Regionally averaged air temperature anomalies ranged from +2.1 to +3.5 °C.

Extremely high mean annual air temperatures (5 % extremes) were recorded at 176 meteorological stations in Kazakhstan, where positive anomalies reached +4.0 °C; at 138 of these stations, 2025 was the warmest year in the observation period since 1941. In the Kostanay, West Kazakhstan, Akmola, Turkestan, and Zhambyl regions, rank 1 was recorded at all meteorological stations.

In 2025, mean monthly air temperatures averaged over Kazakhstan were above the climatic norm (1961–1990) in every month of the year (Figure 2.3). The warmest months were January, with an anomaly of +5.32 °C, and April, with an anomaly of +4.89 °C. Five months were among the 5 % of extremely warm months: April (+4.89 °C) and May (+3.17 °C), with rank 2, and January (+5.32 °C), June (+2.43 °C), and November (+4.03 °C), with rank 4. The smallest positive anomaly was observed in August (+1.02 °C).

Table 2.2 – Regionally averaged mean annual (January–December) and seasonal air temperature anomalies in 2025: **vT** *— deviations from the long-term means for 1961–1990, °C;* ***P(t≤T$_{2025}$)*** *— probability of non-exceedance (in parentheses) calculated from data for the period 1941–2025, %;* ***s*** *— standard deviation in* °C *for the period 1961–1990*

Region	Year		Winter		Spring		Summer		Autumn	
	vT (P)	**s**	**vT (P)**	**s**	**vT (P)**	**s**	**vT (P)**	**s**	**vT (P)**	**s**
Kazakhstan	**2.96 (100)**	**0.87**	3.7 (93)	2.44	**4.12 (100)**	**1.27**	1.61 (94)	0.65	2.12 (94)	1.15
Abay	**2.54 (100)**	**1.08**	3.28 (88)	2.76	**3.85 (96)**	**1.53**	**1.99 (95)**	**0.79**	0.8 (60)	1.48
Almaty	**2.73 (100)**	**0.75**	1.76 (68)	2.24	**3.46 (99)**	**1.01**	**2.79 (100)**	**0.65**	1.67 (90)	1.03
Akmola	**3.31 (100)**	**1.08**	**5.41 (95)**	**2.84**	**5.03 (100)**	**1.82**	0.62 (74)	1.08	2.48 (93)	1.52
Aktobe	**3.23 (100)**	**0.92**	4.7 (92)	2.53	**4.44 (99)**	**1.83**	0.82 (71)	0.87	**3.49 (100)**	**1.43**
Atyrau	**2.91 (99)**	**0.83**	3.32 (82)	2.46	**3.52 (99)**	**1.54**	1.63 (83)	0.84	**2.97 (99)**	**1.22**
East Kazakhstan	**2.20 (98)**	**1.12**	3.14 (90)	2.75	**3.37 (95)**	**1.66**	1.54 (92)	0.86	0.69 (56)	1.51
Zhambyl	**2.98 (100)**	**0.88**	2.4 (74)	2.85	**4.01 (99)**	**1.03**	**2.52 (100)**	**0.8**	1.64 (88)	1.17
Zhetysu	**2.43 (100)**	**0.79**	1.54 (64)	2.46	**3.38 (98)**	**1.11**	**2.5 (100)**	**0.63**	1.01 (68)	1.12
West Kazakhstan	**3.51 (100)**	**1.05**	4.75 (90)	2.78	**4.09 (98)**	**1.96**	1.23 (67)	1.26	**3.8 (100)**	**1.3**
Karaganda	**2.65 (100)**	**0.86**	2.89 (93)	2.45	**3.79 (98)**	**1.33**	**1.68 (98)**	**0.82**	1.36 (82)	1.34
Kostanay	**3.51 (100)**	**1.04**	**6.04 (98)**	**2.74**	**5 (100)**	**1.84**	0.71 (71)	1.11	**3.14 (98)**	**1.53**
Kyzylorda	**3.54 (100)**	**0.92**	4.12 (89)	2.87	**5.26 (100)**	**1.26**	2.03 (94)	0.93	**2.43 (95)**	**1.2**
Mangystau	**2.10 (96)**	**0.74**	1.86 (75)	1.91	**2.33 (96)**	**1.28**	1.77 (80)	0.83	**2.43 (96)**	**1.18**
Pavlodar	**3.02 (100)**	**1.18**	**5.15 (95)**	**3.17**	**4.34 (99)**	**1.76**	0.9 (85)	0.99	1.43 (76)	1.61
North Kazakhstan	**3.28 (100)**	**1.16**	**5.98 (98)**	**2.94**	**4.64 (99)**	**1.84**	0.49 (67)	1.21	**2.75 (95)**	**1.55**
Turkestan	**2.93 (100)**	**0.8**	1.58 (60)	2.6	**4.03 (100)**	**0.84**	**2.56 (100)**	**0.84**	**2.2 (95)**	**1.08**
Ulytau	**3.27 (100)**	**0.97**	3.96 (93)	2.7	**4.24 (99)**	**1.41**	**1.82 (96)**	**0.92**	2.28 (93)	1.45

Notes: *1. For the Mangystau region, the assessment is based on data from MS Fort-Shevchenko only;*

2. values above the 95th or below the 5th percentile (warm and cold extremes, respectively) are highlighted in bold and bright color;

3. values above the 90th or below the 10th percentile are highlighted in pale color;

4. mean temperature anomalies over the territory of Kazakhstan were obtained by averaging data from 121 stations.

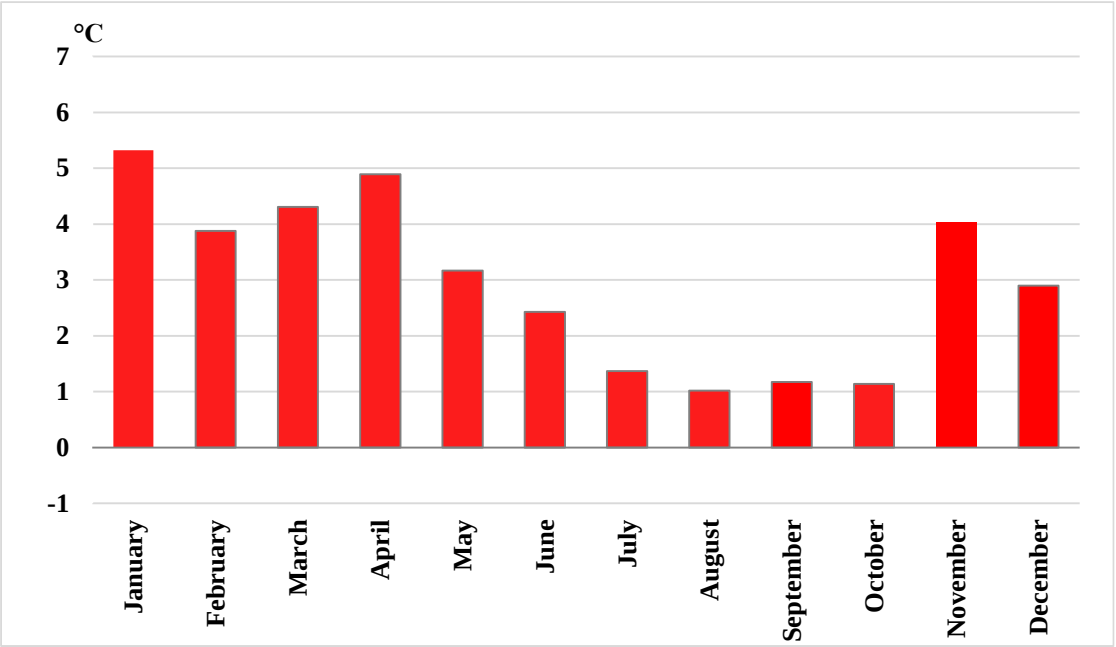


Figure 2.3 *– Mean monthly air temperature anomalies averaged over the territory of Kazakhstan in 2025, calculated relative to the means for the period 1961–1990*

Winter 2024/2025 (December 2024–February 2025) was marked by anomalously warm weather conditions in Kazakhstan. The mean air temperature anomaly for the country was +3.7 °C, which corresponds to the 7th place in the ranked series of winter seasons since 1941 (Table 2.2).

Positive air temperature anomalies were observed over almost the entire country (Figure 2.4). Regionally averaged air temperature anomalies ranged from +1.54 °C in the Zhetysu region to +6.04 °C in the Kostanay region (Table 2.2). No record values were registered in any region: the Kostanay and North Kazakhstan (rank 3) and Akmola and Pavlodar (rank 5) regions were among the 5 % of extremely warm winter seasons, while 10 % extremes were recorded in the Karaganda and Ulytau (rank 7), Aktobe (rank 8), and West Kazakhstan and East Kazakhstan (rank 9) regions. The largest values, from 5.0 to 6.7 °C, were observed in the Kostanay, North Kazakhstan, Akmola, and Pavlodar regions, in the north of the Aktobe and West Kazakhstan regions, and locally in the Kyzylorda region and in the east of the country. The maximum value of +6.7 °C was recorded at MS Petropavlovsk, Rudny, and Kushmurun. Anomalies from 4.0 to 5.0 °C covered most of the West Kazakhstan, Aktobe, and Atyrau regions and were also observed in the Kyzylorda region, in places in the east, and in the south of the northern regions. Values from 3.0 to 4.0 °C were observed in the eastern and central regions, in the south of the Atyrau and Aktobe regions, and in places in the southern and southeastern areas. Anomalies from 2.0 to 3.0 °C were observed in the central, eastern, and southern regions, as well as in the coastal areas of the Mangystau region. Values from 1.0 to 2.0 °C were observed in the southeast of the country, in the southern regions, and in the coastal areas of the Mangystau region.

Temperature conditions close to the climatic norm (deviations within ±1 °C) were observed in the mountainous and foothill areas of the south and southeast. Negative anomalies reaching −1.0 °C were also observed locally in these areas.

Extremely high air temperatures were observed at 26 meteorological stations in the Kostanay, North Kazakhstan, and Akmola regions, with probabilities of non-exceedance of 95 % and higher, and 10 % extremes were recorded at another 50 meteorological stations. Record high mean seasonal air temperatures for the entire observation period since 1941 were registered at two meteorological stations

in the Kostanay region (Annex 1) (Figure 2.4).

In **December 2024**, the air temperature anomaly averaged over the territory of Kazakhstan relative to the 1961–1990 climatic norm was +1.89 °C (rank 19, probability of non-exceedance 79 %, Table 2.3).

Positive air temperature anomalies prevailed over most of the country (Figure 2.5). Regionally averaged air temperature anomalies ranged from −1.38 °C in the Turkestan region to +5.18 °C in the North Kazakhstan region (Table 2.3). In the Kostanay region, December was among the 5 % of extremely warm Decembers (rank 4), and 10 % extremes were recorded in the Akmola and North Kazakhstan regions (rank 6), whereas in the Turkestan region the probability of non-exceedance was 32 %. The largest values, exceeding 3.0 °C, were observed in the Kostanay, North Kazakhstan, and Akmola regions, as well as in the northern areas of the West Kazakhstan, Aktobe, Pavlodar, and East Kazakhstan regions; maximum values reached +6.1 °C in the Kostanay and North Kazakhstan regions. At 62 meteorological stations in these regions and in the Abay region, 10 % extremes of positive anomalies ranging from 2.9 to 6.1 °C were registered.

Anomalies from 1.0 to 3.0 °C were observed in the western and eastern regions, as well as in the Ulytau region. In the central and southern regions, as well as in the mountainous and foothill areas of the south, southeast, and east of the country, temperature conditions were close to the climatic norm.

Negative air temperature anomalies were observed in the extreme southern and southeastern areas, where they ranged from −2.0 to −2.8 °C, reaching −3.8 °C in places (MS Shuyldak, Turkestan region).

Table 2.3 – Regionally averaged mean monthly air temperature anomalies in 2025: **vT** — *deviations from the means for 1961–1990, °C;* ***P(t≤T$_{2025}$)*** *— probability of non-exceedance (in parentheses) calculated from data for the period 1941–2025 and expressed in %*

Region	12 (2024)	1	2	3	4	5	6	7	8	9	10	11
Kazakhstan	1.89 (79)	**5.32 (96)**	3.88 (81)	4.31 (88)	**4.89 (99)**	**3.17 (99)**	**2.43 (96)**	1.37 (89)	1.02 (69)	1.17 (82)	1.14 (61)	**4.03 (96)**
Abay	2.15 (74)	**4.95 (96)**	2.68 (68)	3.19 (76)	**4.92 (98)**	**3.41 (98)**	**3.85 (100)**	**1.95 (95)**	0.19 (44)	0.65 (65)	-1.67 (11)	3.40 (80)
Almaty	-0.25 (46)	3.1 (86)	2.41 (61)	2.64 (75)	**3.89 (96)**	**3.91 (100)**	**3.69 (100)**	**2.94 (99)**	1.77 (90)	1.47 (80)	1.08 (65)	2.49 (83)
Akmola	4.08 (94)	5.86 (94)	6.23 (92)	5.08 (88)	**6.11 (99)**	**3.89 (96)**	1.63 (82)	-0.30 (54)	0.55 (55)	0.96 (65)	0.46 (39)	**6.03 (98)**
Aktobe	2.71 (80)	**6.83 (95)**	4.59 (87)	6.40 (92)	**4.97 (95)**	1.94 (82)	0.67 (64)	0.43 (65)	1.33 (68)	1.39 (87)	3.72 (92)	**5.38 (99)**
Atyrau	1.50 (71)	**6.33 (98)**	2.07 (58)	**5.57 (95)**	3.37 (92)	1.63 (79)	0.50 (55)	2.17 (90)	2.2 (85)	1.23 (75)	3.63 (94)	**4.00 (98)**
East Kazakhstan	2.77 (75)	**5.38 (96)**	1.27 (54)	3.11 (75)	**4.60 (98)**	2.42 (89)	**3.36 (100)**	1.39 (86)	-0.11 (31)	0.79 (71)	-1.47 (10)	2.72 (76)
Zhambyl	-0.40 (46)	3.74 (85)	3.81 (70)	3.03 (77)	**4.47 (98)**	**4.51 (100)**	**3.47 (100)**	**2.54 (98)**	1.59 (86)	1.53 (85)	1.19 (65)	2.17 (75)
Zhetysu	-0.6 (43)	3.61 (88)	1.6 (56)	2.58 (71)	**4.28 (99)**	**3.26 (99)**	**3.91 (100)**	**2.71 (100)**	0.94 (71)	0.78 (63)	-0.13 (33)	2.34 (79)
West Kazakhstan	2.53 (76)	**8.45 (98)**	3.24 (69)	**7.34 (96)**	3.78 (90)	1.14 (74)	0.85 (63)	1.26 (74)	1.64 (70)	1.81 (87)	**3.84 (95)**	**5.74 (100)**
Karaganda	0.86 (65)	3.94 (93)	3.87 (81)	2.69 (75)	**4.94 (98)**	**3.71 (99)**	**2.96 (98)**	1.67 (93)	0.40 (52)	0.40 (60)	-0.40 (23)	**4.09 (98)**

Region	12 (2024)	1	2	3	4	5	6	7	8	9	10	11
Kostanay	**4.98 (96)**	**7.13 (96)**	6.01 (93)	6.18 (93)	**6.18 (98)**	2.69 (87)	1.36 (76)	-0.33 (49)	1.09 (65)	1.21 (75)	2.28 (75)	**5.94 (98)**
Kyzylorda	0.89 (69)	5.44 (94)	6.06 (82)	5.38 (86)	**5.92 (99)**	**4.48 (99)**	2.40 (87)	1.94 (92)	1.80 (81)	1.12 (81)	2.74 (87)	3.36 (94)
Mangystau	0.77 (62)	**4.5 (95)**	0.30 (40)	3.60 (92)	2.30 (87)	1.10 (75)	0.20 (46)	2.40 (94)	2.80 (82)	0.40 (49)	3.40 (93)	**3.50 (98)**
Pavlodar	2.96 (77)	**6.8 (98)**	5.68 (88)	4.50 (85)	**5.48 (96)**	3.02 (90)	2.48 (92)	0.04 (61)	0.12 (43)	1.04 (69)	-1.68 (8)	4.90 (94)
North Kazakhstan	5.18 (94)	**6.57 (95)**	6.17 (93)	5.23 (94)	**5.86 (99)**	2.77 (87)	1.57 (81)	-0.7 (48)	0.60 (56)	1.30 (74)	0.77 (46)	**6.21 (98)**
Turkestan	-1.38 (32)	2.69 (69)	3.43 (67)	2.80 (80)	**4.57 (98)**	**4.73 (100)**	**3.03 (100)**	**2.92 (99)**	1.70 (86)	1.89 (90)	3.02 (92)	1.73 (74)
Ulytau	1.77 (73)	**4.93 (95)**	5.20 (83)	3.47 (83)	**5.27 (99)**	**4.03 (99)**	**2.73 (95)**	1.43 (88)	1.27 (69)	1.03 (71)	1.3 (61)	**4.47 (98)**

Notes: *1. For the Mangystau region, the assessment is based on data from MS Fort-Shevchenko only;*
2. values above the 95th or below the 5th percentile (warm 95 % and cold 5 % extremes, respectively) are highlighted in bold and bright color.

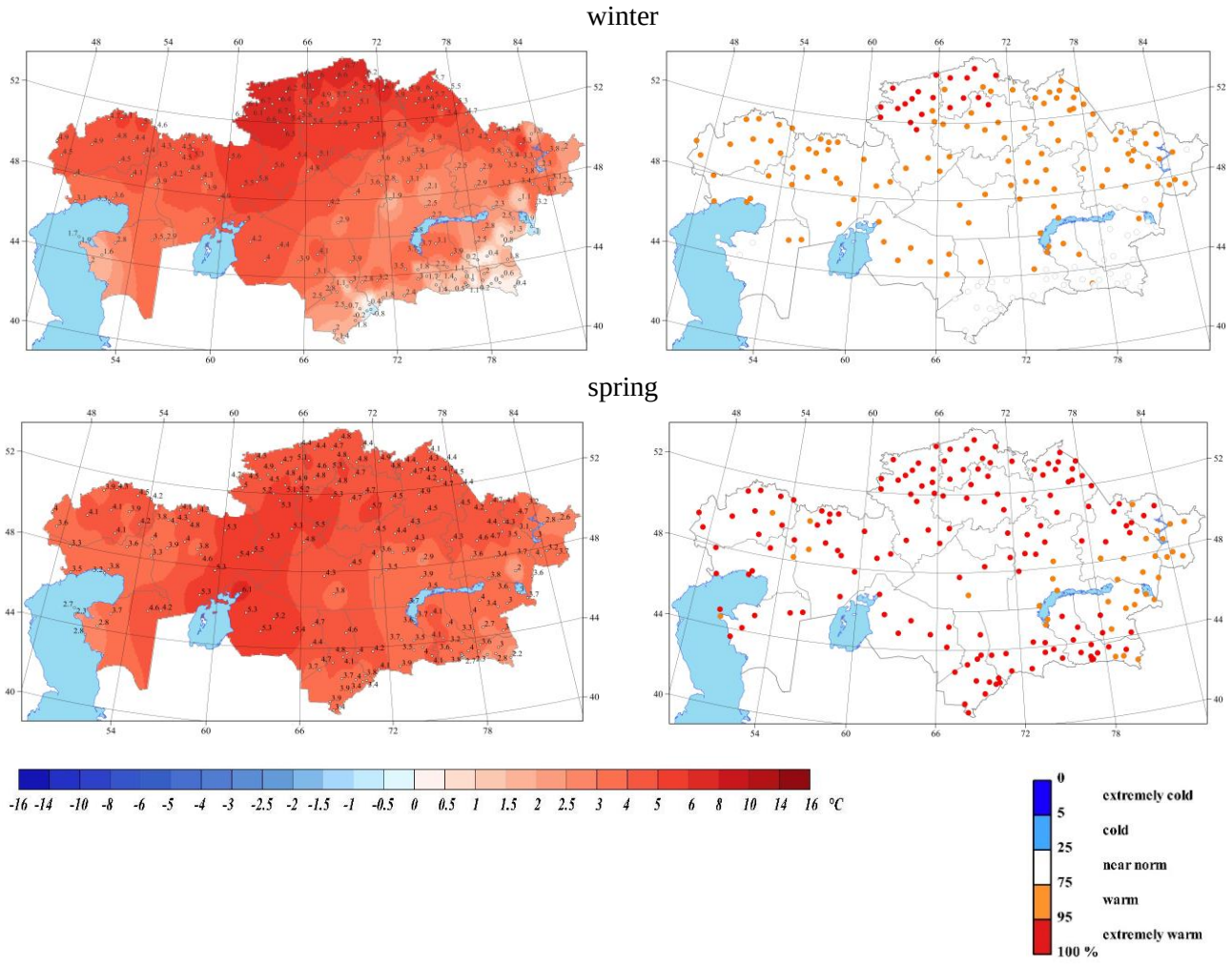


Figure 2.4 – *Spatial distribution of air temperature anomalies (°C) in 2025, calculated relative to the base period 1961–1990, and probabilities of non-exceedance of air temperature values in 2025, calculated from data for the period 1961–2025. Sheet 1*

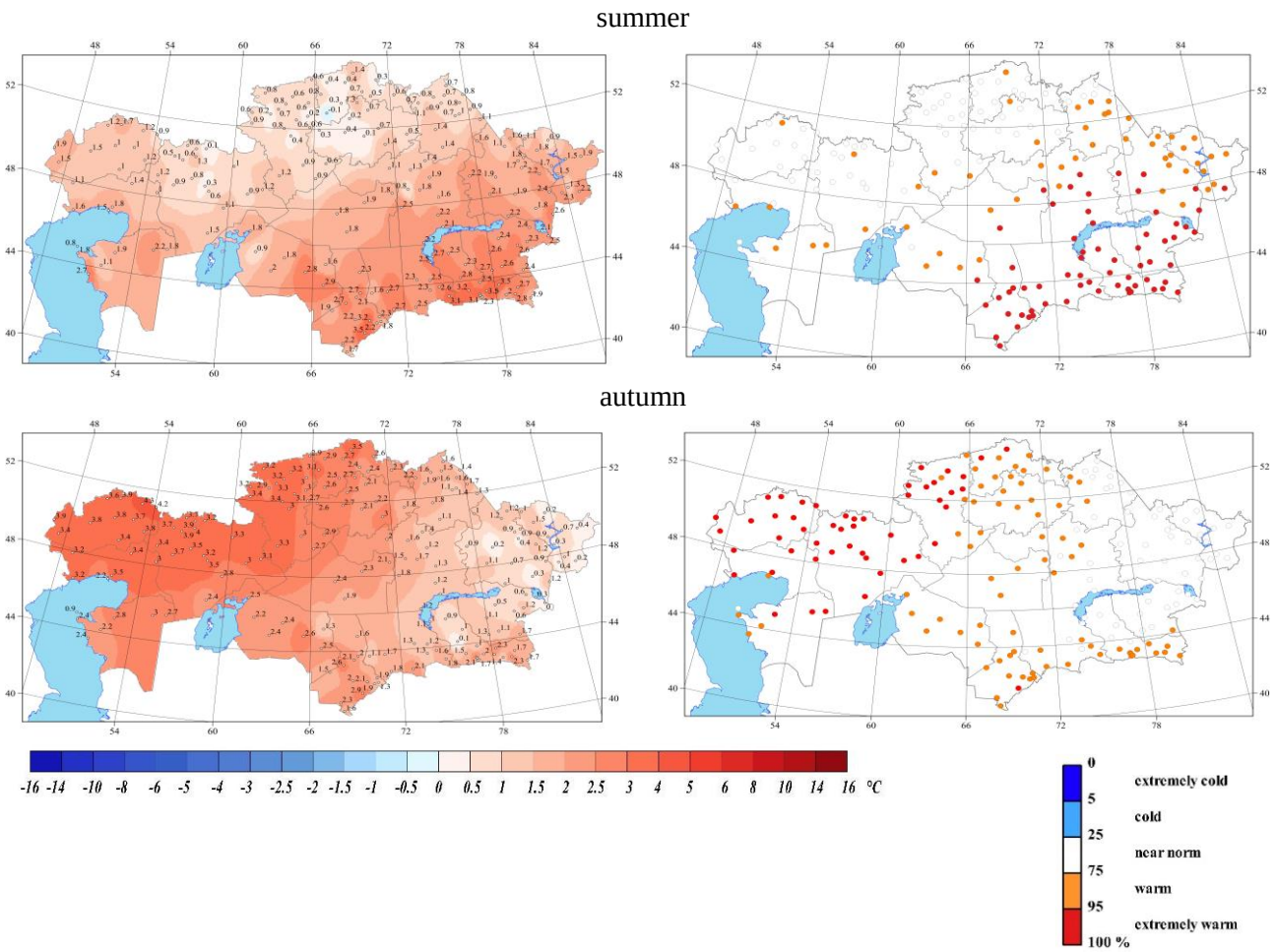


Figure 2.4 – *Spatial distribution of air temperature anomalies (°C) in 2025, calculated relative to the base period 1961–1990, and probabilities of non-exceedance of air temperature values in 2025, calculated from data for the period 1961–2025. Sheet 2*

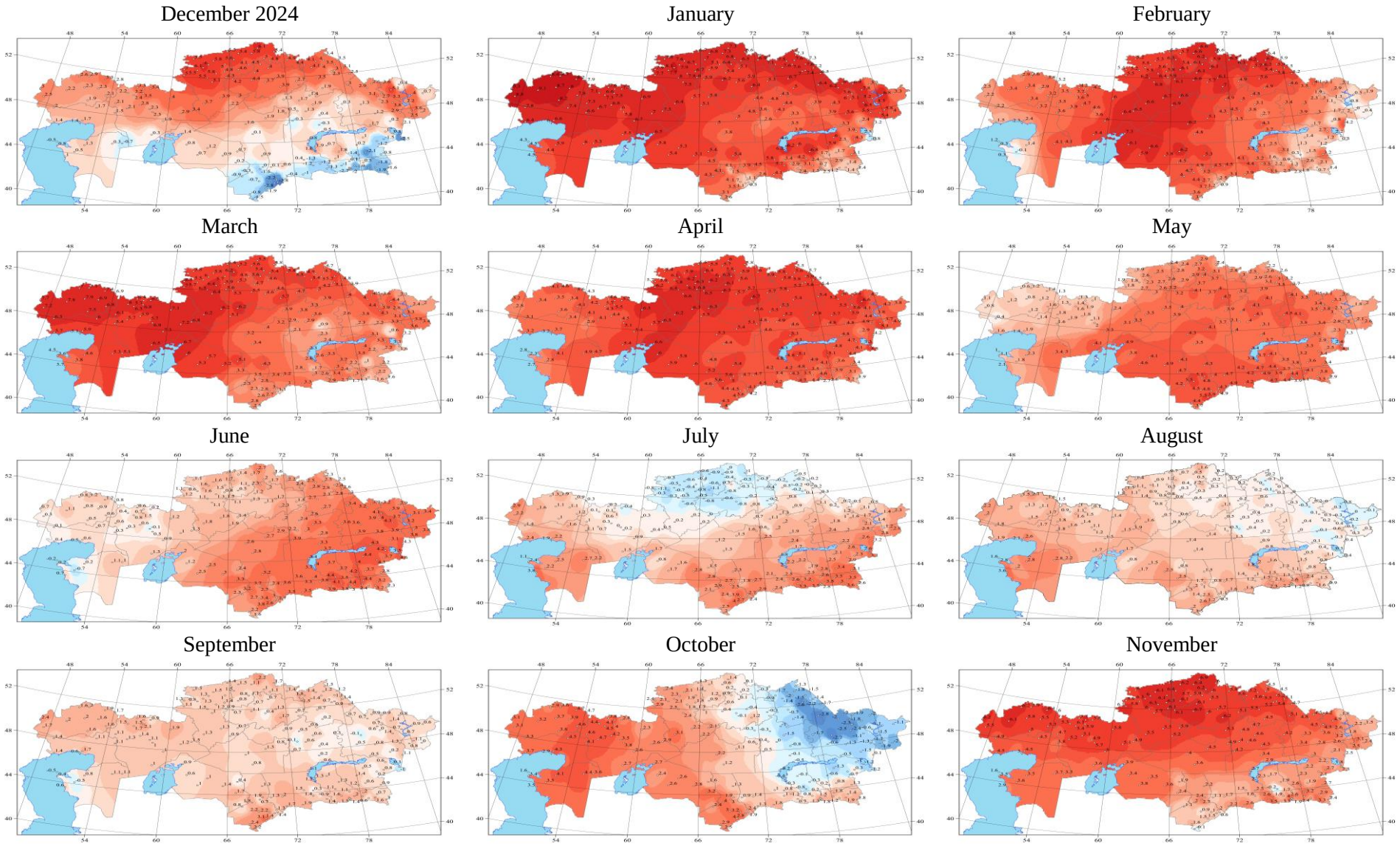


Figure 2.5 – *Spatial distribution of mean monthly air temperature anomalies (°C) in 2025, calculated relative to the base period 1961–1990*

In **January 2025**, the air temperature anomaly averaged over Kazakhstan was above the climatic norm and amounted to +5.32 °C, which corresponds to rank 4 for the observation period since 1941 (probability of non-exceedance 96 %, Table 2.3).

Positive air temperature anomalies were observed over almost the entire country (Figure 2.5). The largest values, from 8.0 to 9.3 °C, were observed in the West Kazakhstan region and in the northwest of the Kostanay region; the maximum anomaly of +9.3 °C was recorded at MS Zhanibek. Anomalies from 7.0 to 8.0 °C covered the Pavlodar, Kostanay, and Aktobe regions, the east of the West Kazakhstan region and the north of the Atyrau region, and in places the North Kazakhstan region. Values from 6.0 to 7.0 °C were observed in the North Kazakhstan, Akmola, Aktobe, and Atyrau regions, as well as in the east of the country. Anomalies from 5.0 to 6.0 °C were observed in the east of the country, in the Kyzylorda, Akmola, and Kostanay regions, in the coastal areas of the Mangystau region, and locally in the southeast. Values from 4.0 to 5.0 °C prevailed in the central regions and were also observed in the coastal areas of the Mangystau region and in the southern regions. The smallest values, from 2.0 to 4.0 °C, were observed in the southeast, east, and south of the country. In the mountainous and foothill areas of the south and southeast, anomalies did not exceed 2.0 °C, and in places air temperature was close to the climatic norm; the lowest value of the month, −0.8 °C, was recorded at MS Zhalanashkol.

Extremely warm conditions (5 % extremes) were registered at 71 meteorological stations, and 10 % extremes at 126 meteorological stations.

In **February**, the air temperature anomaly averaged over the territory of Kazakhstan was +3.88 °C, which corresponds to rank 17 for the observation period since 1941 (probability of non-exceedance 81 %, Table 2.3).

Positive air temperature anomalies were observed over almost the entire country (Figure 2.5). The largest values, from 6.0 to 7.3 °C, were observed in the Akmola, Kostanay, North Kazakhstan, and Pavlodar regions, as well as in the Kyzylorda region and in the north of the Aktobe region; the maximum anomaly of +7.3 °C was recorded at MS Aral Teniz. Anomalies from 5.0 to 6.0 °C covered most of the Kostanay and Pavlodar regions and were also observed in the North Kazakhstan, Aktobe, and Kyzylorda regions. Values from 4.0 to 5.0 °C prevailed in the central regions and were observed in the Aktobe, Zhambyl, and Turkestan regions, in places in the east, and in the coastal areas of the Mangystau region. Anomalies from 3.0 to 4.0 °C were observed in the West Kazakhstan, Aktobe, and Zhambyl regions, as well as in the central, southern, and eastern areas of the country. Values from 2.0 to 3.0 °C were observed in the southeast and east of the country and in the West Kazakhstan and Atyrau regions.

The smallest values, not exceeding 2.0 °C, were observed in the southeast and east of the country and in the coastal areas of the Mangystau region. In the mountainous and foothill areas of the south and southeast, as well as in the east, temperature conditions were close to the climatic norm; the lowest value of the month, −0.8 °C, was recorded at MS Kurshim.

Extremely warm conditions (5 % extremes) were registered at three meteorological stations in the North Kazakhstan region, and 10 % extremes at 38 meteorological stations.

In spring, record warm conditions were observed in Kazakhstan. The mean air temperature anomaly for the country was +4.12 °C and ranked 1st in the ranked series of spring seasons since 1941 (probability of non-exceedance 100 %, Table 2.2).

Positive air temperature anomalies were observed throughout the country, and no negative values were recorded at any meteorological station (Figure 2.4). Regionally averaged air temperature anomalies ranged from +2.33 °C in the Mangystau region to +5.26 °C in the Kyzylorda region (Table 2.2). Spring 2025 was the warmest on record in the Akmola, Kostanay, Kyzylorda, and Turkestan regions (rank 1); in all other regions, the season was among the 5 % of extremely warm seasons, including rank 2 in the

Almaty, Aktobe, Atyrau, Zhambyl, Pavlodar, North Kazakhstan, and Ulytau regions. Significant anomalies, from 5.0 to 6.1 °C, were observed in the Kostanay, Akmola, and North Kazakhstan regions, in the east of the Aktobe region, as well as in the Kyzylorda region and the Aral Sea area, where the maximum anomaly of +6.1 °C was recorded (MS Aral Teniz). Air temperature anomalies from 4.0 to 5.0 °C covered the Pavlodar and West Kazakhstan regions, most of the Kostanay, Akmola, North Kazakhstan, and Aktobe regions, the eastern and central areas of the country, as well as the Turkestan and Zhambyl regions. Anomalies from 3.0 to 4.0 °C were observed in the southeast and east of the country, in the central regions, in the Atyrau and West Kazakhstan regions, and in places in the south of the country. Anomalies from 2.0 to 3.0 °C were observed in the mountainous and foothill areas of the southeast and east, as well as in the coastal areas of the Mangystau region; the smallest anomaly was +2.0 °C (MS Urzhar).

Extremely high air temperatures were observed at 161 meteorological stations in Kazakhstan, with probabilities of non-exceedance of 95 % and higher. At 60 of them (Annex 1), located mainly in the Kostanay, Turkestan, Aktobe, Kyzylorda, and Akmola regions, record high mean seasonal air temperatures for the entire observation period since 1941 were registered (Figure 2.4). Conditions of the "warm" category (75–95 %) were observed at 26 meteorological stations in the east, southeast, and central regions.

In **March**, the air temperature anomaly averaged over Kazakhstan was +4.31 °C, which corresponds to rank 11 for the observation period since 1941 (probability of non-exceedance 88 %, Table 2.3).

Positive air temperature anomalies were observed throughout the country (Figure 2.5). Significant anomalies, from 6.0 to 7.9 °C, were observed in the West Kazakhstan, Aktobe, and Kostanay regions and locally in the Atyrau, Kyzylorda, and North Kazakhstan regions; the maximum anomalies were observed in the West Kazakhstan region, where they reached +7.9 °C (MS Chapaevo). Air temperature anomalies from 5.0 to 6.0 °C covered most of the Kostanay and North Kazakhstan regions and were also observed in the Atyrau, Kyzylorda, Akmola, and Pavlodar regions and in the coastal areas of the Mangystau region. Anomalies from 3.0 to 5.0 °C were observed in the Pavlodar and Akmola regions, in the east, and in the central regions of the country. Anomalies from 2.0 to 3.0 °C were observed in the southeast, south, and east of the country, as well as in the central regions. The smallest anomalies, not exceeding 2.0 °C, were observed in the mountainous and foothill areas of the southeast, in places in the east, and in the southern regions. Anomalies close to the climatic norm, within ±1 °C, were recorded at individual meteorological stations in the east and in the central regions; the smallest anomaly was +0.6 °C (MS Urzhar).

5 % and 10 % extremes were registered at 50 meteorological stations in the Kostanay, West Kazakhstan, Aktobe, North Kazakhstan, Atyrau, Akmola, and Mangystau regions.

In **April**, the air temperature anomaly averaged over the territory of Kazakhstan was +4.89 °C, which corresponds to rank 2 for the observation period since 1941 (probability of non-exceedance 99 %, Table 2.3).

Positive air temperature anomalies were observed throughout the country (Figure 2.5). Regionally averaged air temperature anomalies ranged from +2.30 °C in the Mangystau region to +6.18 °C in the Kostanay region (Table 2.3). No record values were registered; however, fourteen regions were among the 5 % of extremely warm Aprils, including the Akmola, Kyzylorda, North Kazakhstan, Zhetysu, and Ulytau regions with rank 2. Significant anomalies, from 5.0 to 6.8 °C, covered the Kostanay, Pavlodar, North Kazakhstan, and Akmola regions, the eastern and central areas of the country, as well as the Aktobe and Kyzylorda regions; the maximum anomaly of +6.8 °C was recorded

in the Kostanay region (MS Zheleznodorozhny state farm). Air temperature anomalies from 4.0 to 5.0 °C were observed in the southeast and east of the country, in the Zhambyl, Turkestan, and Aktobe regions, in the central regions, as well as in the West Kazakhstan region and in the coastal areas of the Mangystau region. Anomalies from 3.0 to 4.0 °C were observed in the southeast of the country, in the Atyrau and West Kazakhstan regions, and in places in the east and south of the country. The smallest anomalies, from 1.9 to 3.0 °C, were observed in the mountainous and foothill areas of the southeast and in the coastal areas of the Mangystau region; the smallest anomaly was +1.9 °C (MS Narynkol).

Extremely warm conditions (probability of non-exceedance 95–100 %) were registered at 141 meteorological stations in the southeast, east, north, center, and south of the country. At 12 of them, record high mean monthly air temperatures for the entire observation period since 1941 were registered. Conditions of the "warm" category (75–95 %) were observed at 46 meteorological stations, mainly in the western regions.

In **May** the air temperature anomaly averaged over the territory of Kazakhstan was +3.17 °C, which corresponds to rank 2 for the observation period since 1941 (probability of non-exceedance 99 %, Table 2.3).

Positive air temperature anomalies were observed throughout the country (Figure 2.5). Regionally averaged air temperature anomalies ranged from +1.10 °C in the Mangystau region to +4.73 °C in the Turkestan region (Table 2.3). May 2025 was the warmest on record in the Turkestan, Zhambyl, and Almaty regions (rank 1); the Zhetysu, Karaganda, Kyzylorda, and Ulytau regions (rank 2), the Abay region (rank 3), and the Akmola region (rank 4) were also among the 5 % of extremely warm Mays. Significant anomalies, from 4.0 to 5.5 °C, were observed in the Turkestan, Zhambyl, and Kyzylorda regions, in the southeast of the country and in the central regions, and in places in the east and north of the country; the maximum anomaly of +5.5 °C was recorded in the Turkestan region (MS Turkestan). Air temperature anomalies from 3.0 to 4.0 °C covered the southeast, the east, and the central regions, as well as the Akmola, Kostanay, and Pavlodar regions. Anomalies from 2.0 to 3.0 °C were observed in the northern regions, in the east of the country, and in the coastal areas of the Mangystau region. Anomalies from 1.0 to 2.0 °C were observed in the West Kazakhstan, Aktobe, and Atyrau regions, and in places in the Kostanay region and in the east of the country. Anomalies close to the climatic norm, within ±1 °C, were observed in the western border areas of the Atyrau and West Kazakhstan regions; the smallest anomaly was +0.4 °C (MS Novy Ushtagan).

Extremely warm conditions (probability of non-exceedance 95–100 %) were registered at 95 meteorological stations in the southeast, south, center, and east of the country. At 33 of them, located in the Almaty, Turkestan, Zhambyl, and Zhetysu regions, record high mean monthly air temperatures were registered. Conditions of the "warm" category (75–95 %) were observed at 68 meteorological stations in the north, east, and west of the country.

In summer, predominantly positive air temperature anomalies were observed in Kazakhstan. The mean anomaly for the country was +1.61 °C, which corresponds to the 6th place in the ranked series of summer seasons since 1941 (probability of non-exceedance 94 %, Table 2.2).

Regionally averaged air temperature anomalies ranged from +0.49 °C in the North Kazakhstan region to +2.79 °C in the Almaty region (Table 2.2). Summer 2025 was the warmest on record in the Almaty, Zhambyl, Turkestan, and Zhetysu regions (rank 1); the Karaganda region (rank 3), the Ulytau region (rank 4), and the Abay region (rank 5) were also among the 5 % of extremely warm summer seasons, and 10 % extremes were recorded in the Kyzylorda (rank 6) and East Kazakhstan (rank 8) regions. Significant anomalies, from 2.0 to 3.7 °C, were observed in the southeast of the country, in the Turkestan and Zhambyl regions, in the east of the country and in the central regions, and locally in the

Kyzylorda region and in the coastal areas of the Mangystau region; the maximum anomaly of +3.7 °C was recorded in the Almaty region (MS Almaty OGMS) (Figure 2.4). Air temperature anomalies from 1.0 to 2.0 °C covered the eastern and central regions and the West Kazakhstan, Atyrau, Kyzylorda, and Pavlodar regions, as well as the coastal areas of the Mangystau region. Anomalies close to the climatic norm, within ±1 °C, were observed in the northern regions – Kostanay, North Kazakhstan, Akmola, and Pavlodar – as well as in the Aktobe region. The only negative anomaly, −0.1 °C, was recorded at MS Ruzaevka.

Extremely warm conditions (probability of non-exceedance 95–100 %) were registered at 70 meteorological stations in the southeast, south, east, and central regions. At 44 of them, located in the Almaty, Turkestan, Zhambyl, and Zhetysu regions, record high mean seasonal air temperatures for the entire observation period since 1941 were registered (Figure 2.4). Conditions of the "warm" category (75–95 %) were observed at 47 meteorological stations in the east, center, and north of the country.

In **June** the air temperature anomaly averaged over the territory of Kazakhstan was +2.43 °C, which corresponds to rank 4 for the observation period since 1941 (probability of non-exceedance 96 %, Table 2.3).

Positive air temperature anomalies were observed over most of the country (Figure 2.5). Regionally averaged air temperature anomalies ranged from +0.20 °C in the Mangystau region to +3.91 °C in the Zhetysu region (Table 2.3). June 2025 was the warmest on record in six regions – East Kazakhstan, Almaty, Zhambyl, Turkestan, Abay, and Zhetysu (rank 1); the Karaganda region (rank 3) and the Ulytau region (rank 5) were among the 5 % of extremely warm Junes. Significant anomalies, from 3.0 to 4.6 °C, were observed in the east and southeast of the country, in the Zhambyl and Turkestan regions, and in places in the central regions; the maximum anomaly of +4.6 °C was recorded in the Zhetysu region (MS Zhalanashkol). Air temperature anomalies from 2.0 to 3.0 °C covered the Pavlodar region, the central regions, the Turkestan and Kyzylorda regions, and in places the southeast and north of the country. Anomalies from 1.0 to 2.0 °C were observed in the Kostanay, Akmola, and North Kazakhstan regions, and in places in the Aktobe and West Kazakhstan regions. Anomalies close to the climatic norm, within ±1 °C, were observed in the Aktobe, West Kazakhstan, and Atyrau regions and in the coastal areas of the Mangystau region. Negative anomalies were recorded at three meteorological stations in the Mangystau and Aktobe regions, where they reached −0.7 °C (MS Tushchibek).

Extremely warm conditions (probability of non-exceedance 95–100 %) were registered at 84 meteorological stations in the east, southeast, south, and central regions. At 48 of them, located in the southeastern and eastern parts of the country – in the Almaty, East Kazakhstan, Zhambyl, Zhetysu, and Abay regions – record high mean monthly air temperatures for the entire observation period since 1941 were registered. Conditions of the "warm" category (75–95 %) were observed at 41 meteorological stations in the north and south of the country.

In **July**, the air temperature anomaly averaged over the territory of Kazakhstan was +1.37 °C, which corresponds to rank 10 for the observation period since 1941 (probability of non-exceedance 89 %, Table 2.3).

Regionally averaged air temperature anomalies ranged from −0.70 °C in the North Kazakhstan region to +2.94 °C in the Almaty region (Table 2.3). July 2025 was the warmest on record in the Zhetysu region (rank 1); the Almaty and Turkestan (rank 2), Zhambyl (rank 3), and Abay (rank 5) regions were among the 5 % of extremely warm Julys, whereas in the Kostanay and North Kazakhstan regions the probability of non-exceedance did not reach 50 %. Significant air temperature anomalies, from 2.0 to 4.0 °C, were observed in the southeast of the country, in the Turkestan and Zhambyl regions, in the east of the country, as well as in the coastal areas of the Mangystau region and in the Atyrau region; the

maximum anomaly of +4.0 °C was recorded in the Turkestan region (MS Kazygurt), and in the Caspian areas it reached +3.8 °C (MS Aktau) (Figure 2.5). Air temperature anomalies from 1.0 to 2.0 °C covered the central and eastern regions and the West Kazakhstan, Atyrau, and Kyzylorda regions. Anomalies close to the climatic norm, within ±1 °C, were observed in the Aktobe and Pavlodar regions, and in places in the east and in the central regions.

Negative air temperature anomalies were observed in the northern regions – Kostanay, North Kazakhstan, Akmola, and Pavlodar – and in places in the Aktobe region, where they ranged from −0.1 to −1.1 °C. The lowest values were observed at MS Tobol and Ruzaevka.

Extremely warm conditions (probability of non-exceedance 95–100 %) were registered at 53 meteorological stations in the southeast and south of the country. At seven of them, located in the Almaty, Turkestan, and Zhetysu regions, record high mean monthly temperatures were registered. Conditions of the "warm" category (75–95 %) were observed at 51 meteorological stations in the east, center, and west of the country. Despite the negative anomalies in the north, the probability of non-exceedance did not fall below 25 % at any meteorological station.

In **August** the air temperature anomaly averaged over the territory of Kazakhstan was +1.02 °C, which corresponds to rank 27 for the observation period since 1941 (probability of non-exceedance 69 %, Table 2.3).

Significant air temperature anomalies, from 2.0 to 3.6 °C, were observed in the coastal areas of the Mangystau region, in the southeast of the country, and in the Atyrau, West Kazakhstan, Kyzylorda, Turkestan, and Zhambyl regions; the maximum anomaly of +3.6 °C was recorded in the Mangystau region (MS Aktau) (Figure 2.5). Air temperature anomalies from 1.0 to 2.0 °C covered the Aktobe, West Kazakhstan, and Kostanay regions, the southeast of the country, the Turkestan and Zhambyl regions, and in places the central regions. Anomalies close to the climatic norm, within ±1 °C, were observed in the east of the country, in the central regions, and in the Kostanay, North Kazakhstan, Akmola, and Pavlodar regions. Negative anomalies were recorded at 12 meteorological stations, mainly in the East Kazakhstan and Pavlodar regions, where they reached −0.8 °C (MS Leninogorsk).

Conditions of the "warm" category (probability of non-exceedance 75–95 %) were observed at 38 meteorological stations in the southeast and south of the country, and extremely warm conditions (95–100 %) at three meteorological stations in the Almaty and Zhambyl regions. At six meteorological stations in the East Kazakhstan, Abay, and Zhetysu regions, conditions corresponded to the "cold" category (5–25 %).

In autumn predominantly positive air temperature anomalies were observed in Kazakhstan. The mean anomaly for the country was +2.12 °C, which corresponds to the 6th place in the ranked series of autumn seasons since 1941 (probability of non-exceedance 94 %, Table 2.2).

Positive air temperature anomalies were observed throughout the country, and no negative values were recorded at any meteorological station (Figure 2.4). Regionally averaged air temperature anomalies ranged from +0.69 °C in the East Kazakhstan region to +3.80 °C in the West Kazakhstan region (Table 2.2). Autumn 2025 was the warmest on record in the West Kazakhstan and Aktobe regions (rank 1); the Atyrau (rank 2), Kostanay (rank 3), Mangystau (rank 4), and Kyzylorda, North Kazakhstan, and Turkestan (rank 5) regions were among the 5 % of extremely warm autumn seasons, and 10 % extremes were recorded in the Akmola and Ulytau regions (rank 7) and in the Almaty region (rank 9). Significant anomalies, from 3.0 to 4.3 °C, were observed in the Aktobe, Kostanay, West Kazakhstan, and Atyrau regions, and in places in the North Kazakhstan region and in the coastal areas of the Mangystau region; the maximum anomaly of +4.3 °C was recorded in the West Kazakhstan region (MS Aksai).

Air temperature anomalies from 2.0 to 3.0 °C covered the North Kazakhstan and Akmola regions, most of the Kostanay region, the Kyzylorda and Turkestan regions, as well as the coastal areas of the Mangystau region. Anomalies from 1.0 to 2.0 °C were observed in the Pavlodar region, in the central regions, in the southeast and east of the country, and in the Zhambyl and Turkestan regions. Anomalies close to the climatic norm, within ±1.0 °C, were observed in the east of the country and in the mountainous and foothill areas of the southeast; the smallest anomaly was 0.0 °C (MS Zhalanashkol).

Extremely high air temperatures were observed at 61 meteorological stations in Kazakhstan, with probabilities of non-exceedance of 95 % and higher. At 25 of them, located in the western part of the country – in the West Kazakhstan, Aktobe, Atyrau, and Kostanay regions – record high mean seasonal air temperatures for the entire observation period since 1941 were registered. Conditions of the "warm" category (75–95 %) were observed at 65 meteorological stations in the southeast, south, center, and north of the country.

In **September** the air temperature anomaly averaged over the territory of Kazakhstan was +1.17 °C, which corresponds to rank 16 for the observation period since 1941 (probability of non-exceedance 82 %, Table 2.3).

Positive air temperature anomalies were observed over most of the country (Figure 2.5). The largest anomalies, from 1.5 to 3.1 °C, were observed in the West Kazakhstan and Turkestan regions, in places in the Aktobe, Atyrau, Zhambyl, Kyzylorda, North Kazakhstan, and Akmola regions, and in the southeast of the country; the maximum anomaly of +3.1 °C was recorded in the Turkestan region (MS Kazygurt). Air temperature anomalies from 1.0 to 1.5 °C covered the Kostanay, Aktobe, Pavlodar, and Atyrau regions, the southeast of the country, as well as the Zhambyl and Turkestan regions; in the North Kazakhstan region they reached +2.2 °C (MS Petropavlovsk). Anomalies close to the climatic norm, within ± 1.0 °C, were observed in the east of the country, in the central regions, in places in the north, south, and southeast of the country, and in the coastal areas of the Mangystau region. Negative anomalies were recorded at five meteorological stations in the southeast, the east, the central regions, and the coastal areas of the Mangystau region, where they reached −1.0 °C (MS Zhalanashkol).

Conditions of the "warm" category (probability of non-exceedance 75–95 %) were observed at 73 meteorological stations in the west, south, and north of the country. No extremely warm conditions were recorded at any meteorological station in September; at two meteorological stations in the southeast and in the coastal areas of the Mangystau region, conditions corresponded to the "cold" category (5–25 %).

In **October**, the air temperature anomaly averaged over the territory of Kazakhstan was +1.14 °C, which corresponds to rank 34 for the observation period since 1941 (probability of non-exceedance 61 %, Table 2.3). The temperature regime was spatially contrasting: positive anomalies prevailed in the west and south of the country, and negative anomalies in the east, southeast, and central regions (Figure 2.5).

Regionally averaged air temperature anomalies ranged from −1.68 °C in the Pavlodar region to +3.84 °C in the West Kazakhstan region (Table 2.3). October was among the 5 % of extremely warm Octobers only in the West Kazakhstan region (rank 5), whereas the probability of non-exceedance was 8 % in the Pavlodar region, 10 % in the East Kazakhstan region, and 11 % in the Abay region, which corresponds to the "cold" category. Significant anomalies, from 3.0 to 4.7 °C, were observed in the Aktobe, West Kazakhstan, and Atyrau regions, in the coastal areas of the Mangystau region, and in places in the Turkestan, Kyzylorda, and Kostanay regions. The maximum anomaly of +4.7 °C was recorded at MS Karaukeldy, Aksai, and Chingirlau. Air temperature anomalies from 2.0 to 3.0 °C covered the Kostanay, Turkestan, Kyzylorda, and Aktobe regions. Anomalies from 1.0 to 2.0 °C were

observed in the southeast of the country and in the Kostanay, Zhambyl, Turkestan, and North Kazakhstan regions. Anomalies close to the climatic norm, within ±1 °C, were observed in the North Kazakhstan and Akmola regions, and in places in the central regions and in the southeast of the country.

Negative air temperature anomalies were recorded at 61 meteorological stations – in the East Kazakhstan and Pavlodar regions, in the southeast of the country, in the central regions, and in places in the Akmola, North Kazakhstan, and Zhambyl regions. The lowest values, from −2.5 to −2.8 °C, were observed in the east of the country and in the Pavlodar region; the lowest anomaly was −2.8 °C (MS Semiyarka).

Conditions of the "cold" category (probability of non-exceedance 5–25 %) were observed at 53 meteorological stations in the east, the Pavlodar region, the southeast, and the central regions, and extremely cold conditions (0–5 %) at four meteorological stations in the Pavlodar and Abay regions. Extremely warm conditions (95–100 %) were registered at 14 meteorological stations in the western and southern regions.

In **November** the air temperature anomaly averaged over the territory of Kazakhstan was +4.03 °C, which corresponds to rank 4 for the observation period since 1941 (probability of non-exceedance 96 %, Table 2.3).

Positive air temperature anomalies were observed over almost the entire country (Figure 2.5). Regionally averaged air temperature anomalies ranged from +1.73 °C in the Turkestan region to +6.21 °C in the North Kazakhstan region (Table 2.3). November 2025 was the warmest on record in the West Kazakhstan region (rank 1); the Aktobe region (rank 2), as well as the Akmola, Atyrau, Karaganda, Kostanay, Mangystau, North Kazakhstan, and Ulytau regions (rank 3), were among the 5 % of extremely warm Novembers. Significant anomalies, from 5.0 to 6.9 °C, covered the Kostanay, North Kazakhstan, Akmola, Aktobe, West Kazakhstan, and Pavlodar regions; the maximum anomaly of +6.9 °C was recorded in the North Kazakhstan region (MS Petropavlovsk). Air temperature anomalies from 4.0 to 5.0 °C were observed in the central regions, in the east of the country, in the Atyrau region, and in places in the Aktobe and Pavlodar regions. Anomalies from 3.0 to 4.0 °C were observed in the Kyzylorda region, in the coastal areas of the Mangystau region, in the east and southeast of the country, and in the central regions. Anomalies from 1.5 to 3.0 °C were observed in the southeast of the country, in the east, and in the Zhambyl and Turkestan regions. Anomalies close to the climatic norm, within ±1 °C, were observed in the Turkestan region and in the mountainous and foothill areas of the southeast; the smallest anomaly was −0.2 °C (MS Aidarli).

Extremely warm conditions (probability of non-exceedance 95–100 %) were registered at 86 meteorological stations in the western, northern, and central regions. At 12 of them, located in the West Kazakhstan and Aktobe regions, record high mean monthly air temperatures were registered. Conditions of the "warm" category (75–95 %) were observed at 47 meteorological stations in the Pavlodar region and in the southeast and east of the country.

For the purpose of monitoring extreme values of the climate variables that are most significant for specific sectors of the economy and the social sphere, the WMO Commission for Climatology developed the ClimPACT software (www.climpact-sci.org), which allows a set of specialized climate indices to be calculated from daily maximum and minimum air temperature and precipitation data. The indices that best characterize the degree of extremity of the temperature regime in 2025 are presented below.

In 2025, the number of days with a maximum air temperature above 30 °C (Txge30 index) in Kazakhstan increased from the north to the south of the country (Figure 2.6). The largest values, from 120 to 151 days, were observed at 14 meteorological stations in the Turkestan, Kyzylorda, and Zhambyl

regions; the absolute maximum was observed in the Turkestan region, where the duration of the period with air temperature above 30 °C reached 145–151 days (MS Arys, Kyzylkum, Zhetysay, and Shardara). From 90 to 120 days with temperatures above 30 °C were recorded in the southeast of the country, in the Zhambyl and Kyzylorda regions, in the Ulytau region, and in the Mangystau region (up to 106 days, MS Sam). From 20 to 90 hot days were observed in the Abay, Aktobe, Pavlodar, Karaganda, and West Kazakhstan regions, in the southeast and east of the country, and in the Atyrau and Kostanay regions. The smallest values, from 0 to 16 days, were observed in the North Kazakhstan, Akmola, and Kostanay regions, as well as in the mountainous and foothill areas of the southeast and east, where no days with temperatures above 30 °C were recorded at some meteorological stations.

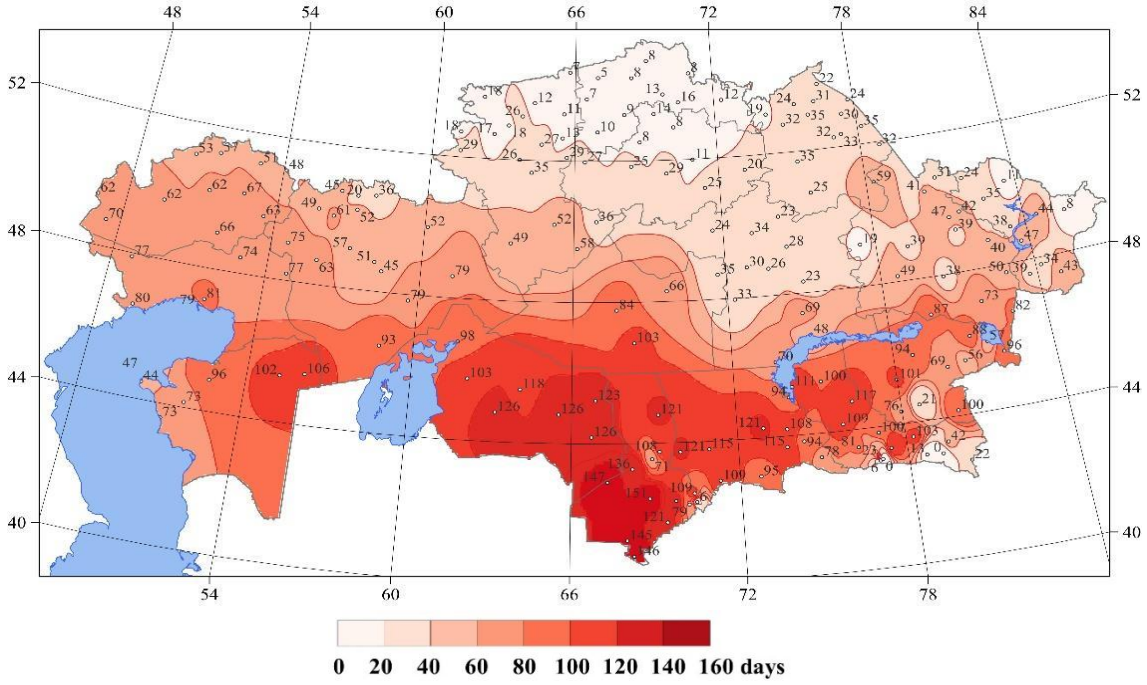


Figure 2.6 *– Number of days in 2025 when the maximum air temperature exceeded 30 °C (Txge30 index)*

One of the indicators of the extremity of the temperature regime during the warm period is the total duration of heat waves (HWF/EHF index), which characterizes the total number of days within periods of abnormally high air temperature (Figure 2.7). The index is calculated relative to the local temperature distribution; therefore, its high values may also occur in areas with relatively low absolute air temperatures. In 2025, the distribution of the index in Kazakhstan was characterized by an increase in heat wave duration from the north to the south and southeast of the country. The longest heat wave durations were observed in the southeast and south of the country: at 12 meteorological stations in the Almaty, Turkestan, Zhambyl, and Zhetysu regions, they exceeded 50 days, and the absolute maximum of 104 days was recorded in the mountainous areas of the Almaty region (MS Mynzhilki). Heat waves lasted from 30 to 50 days in the southeast of the country, in the Abay, Turkestan, Zhambyl, and Kyzylorda regions, in the Karaganda and East Kazakhstan regions, as well as in the Atyrau and Mangystau regions, where values reached 43 and 39 days, respectively. Heat waves lasted from 17 to 30 days in the West Kazakhstan, Aktobe, East Kazakhstan, Pavlodar, and Karaganda regions, in the Abay and Ulytau regions, as well as in the coastal areas of the Mangystau region. The smallest values, from 0 to 16 days, were observed in the Kostanay, North Kazakhstan, Akmola, Aktobe, and Pavlodar regions; no heat waves were recorded at some meteorological stations.

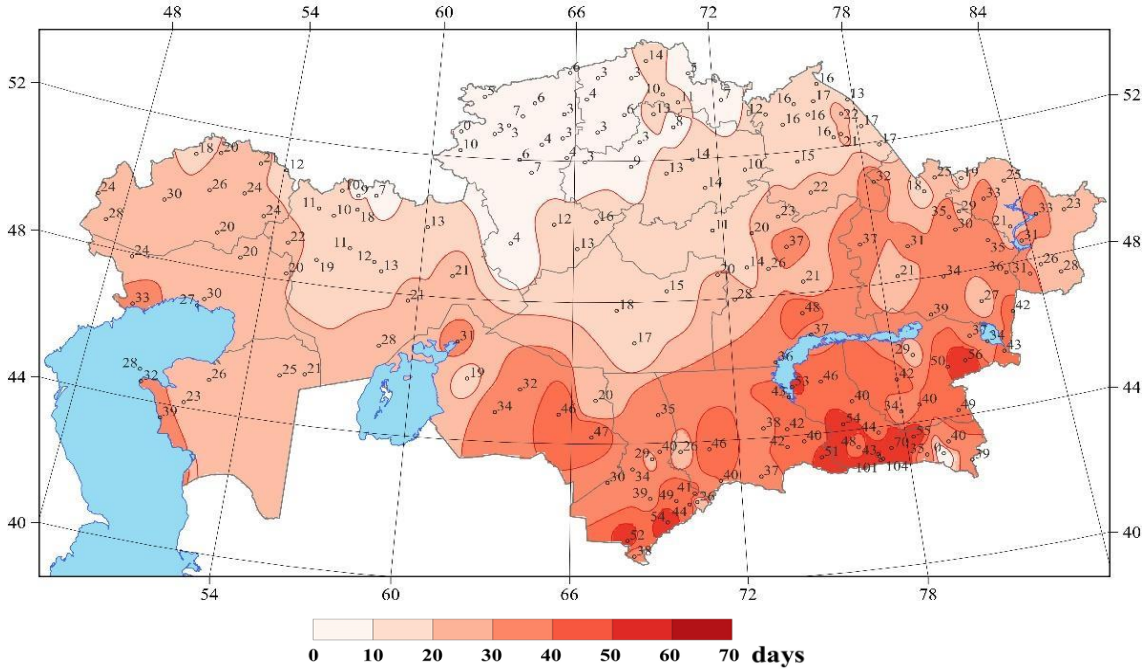


Figure 2.7 *– Total duration of warm-period heat waves in 2025 (HWF/EHF index, days)*

In 2025, over most of Kazakhstan, ***the values of the daily maximum air temperature (TXx index)*** were within 35–44 °C (Figure 2.8). The highest values, from 44.0 to 47.5 °C, were observed in the southern regions – Turkestan and Kyzylorda – and locally in the southeast of the country; the absolute maximum of +47.5 °C was recorded in the Turkestan region (MS Kyzylkum). Daily maximum air temperatures reached 40 to 44 °C in the southeast of the country, in the Zhambyl, Turkestan, and Kyzylorda regions, in the Abay region, in the Atyrau region, in the Ulytau region, as well as in the coastal areas of the Mangystau region. The TXx index varied from 35 to 40 °C in the Kostanay, Pavlodar, Aktobe, Karaganda, and West Kazakhstan regions, in the southeast and east of the country, and in the Abay and Akmola regions. The lowest index values were observed in the North Kazakhstan and Akmola regions, as well as in the mountainous and foothill areas of the southeast, where TXx ranged from 19.5 to 33.0 °C.

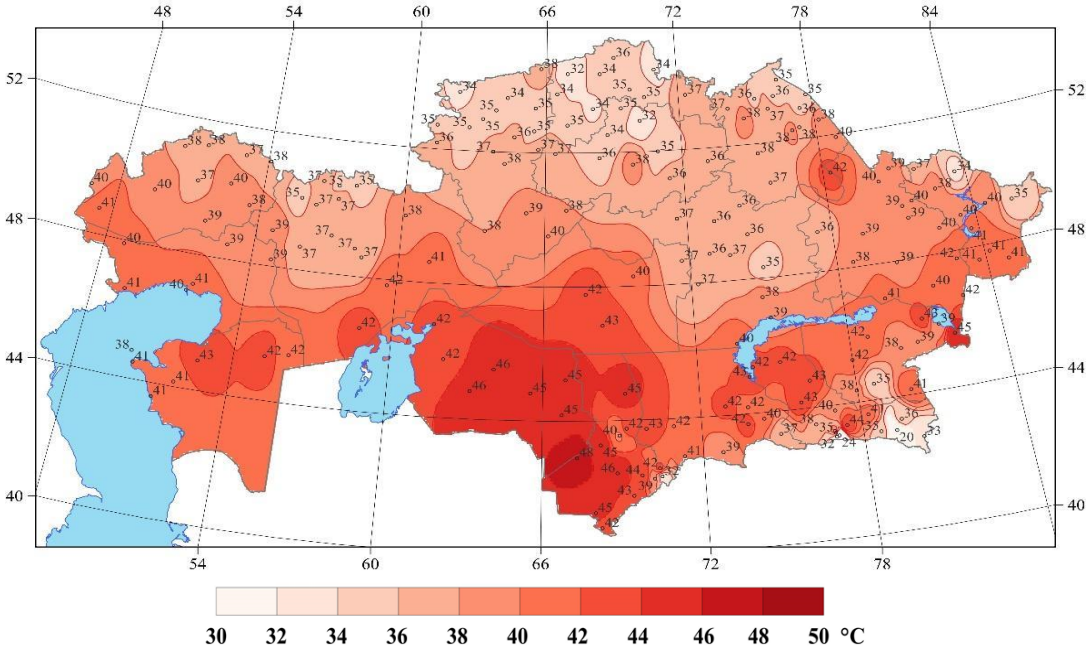


Figure 2.8 – *Values of the daily maximum air temperature (°C, TXx index) recorded in 2025*

As a result of the elevated temperature background in the summer months of 2025, the previous absolute daily maximum air temperatures were updated at some meteorological stations (shown in red, Figure 2.9). The values of absolute maximums recorded from the opening of the station to 2025 are shown in blue. In 2025, previously recorded absolute maximum air temperatures were equaled or exceeded at four meteorological stations in the Almaty and Zhetysu regions. The largest exceedance was recorded at MS Ulken Almaty Lake/BAO, by +4.3 °C (previous maximum 27.7 °C), and at MS Esik, by +3.3 °C (40.6 °C); the smallest exceedance was recorded at MS Zhalanashkol, by +0.6 °C (44.6 °C), while at MS Mynzhilki the previous maximum of 23.5 °C was equaled. In Kazakhstan, most of the highest air temperatures (absolute maximums) were recorded in July 1983, when air temperatures at meteorological stations in the Turkestan region reached 49–50 °C (MS Tasty – 50.0 °C, MS Turkestan – 49.1 °C, MS Arys – 49.0 °C), as well as in July 1995, when the air temperature at MS Kyzylkum rose to +51.0 °C, the highest value in the country for the entire observation period (Figure 2.9).

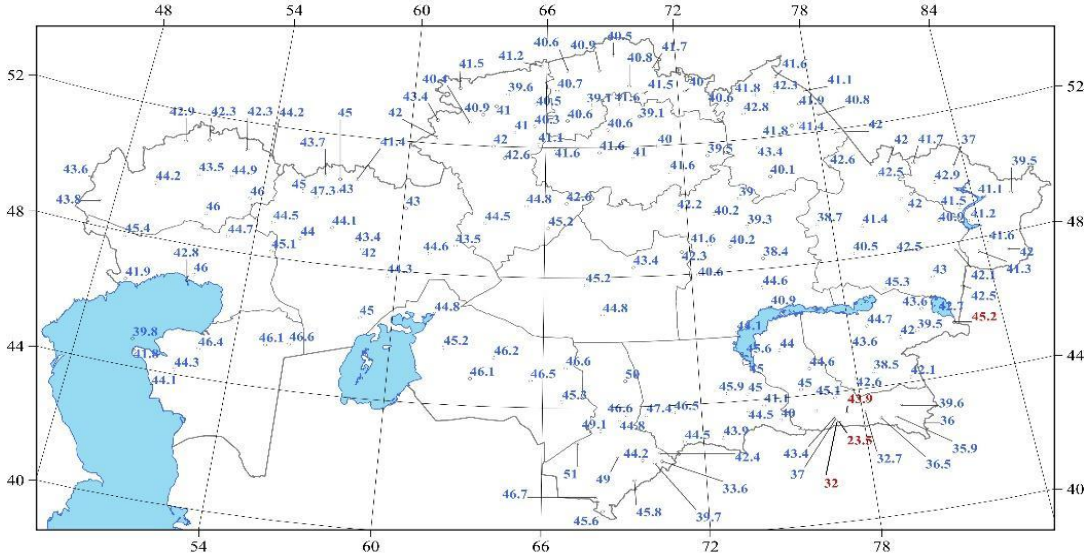


Figure 2.9 – *Absolute maximum air temperature values (°C) recorded from the opening of the meteorological station to 2025. If the record value of the daily maximum air temperature was recorded in 2025, this value is plotted in red*

Following the WHO recommendations, an index has been introduced that characterizes ***the number of days when the daily minimum temperature does not fall below 20 °C (TR index, "tropical nights"***), since high nighttime temperatures reduce the body's ability to recover from daytime heat. In 2025, the largest number of tropical nights was observed in the southern and western parts of Kazakhstan (Figure 2.10). The maximum values, from 65 to 99 days, were recorded in the coastal areas of the Mangystau region and in the Turkestan and Zhambyl regions; the absolute maximum of 99 days was recorded at MS Shardara. From 33 to 65 tropical nights were recorded in the Mangystau, Atyrau, Kyzylorda, Turkestan, and Zhambyl regions, as well as in the southeast of the country, where values reached 55 days. From 13 to 33 days with nighttime temperatures above 20 °C were observed in the Aktobe, West Kazakhstan, and Karaganda regions, in the Abay region, and in places in the east and southeast of the country. The smallest values were observed in the North Kazakhstan, Akmola, Pavlodar, and Kostanay regions, in the Ulytau region, as well as in the mountainous and foothill areas of the southeast and east, where the number of tropical nights did not exceed 17 days. No tropical nights were recorded at 29 meteorological stations in the country.

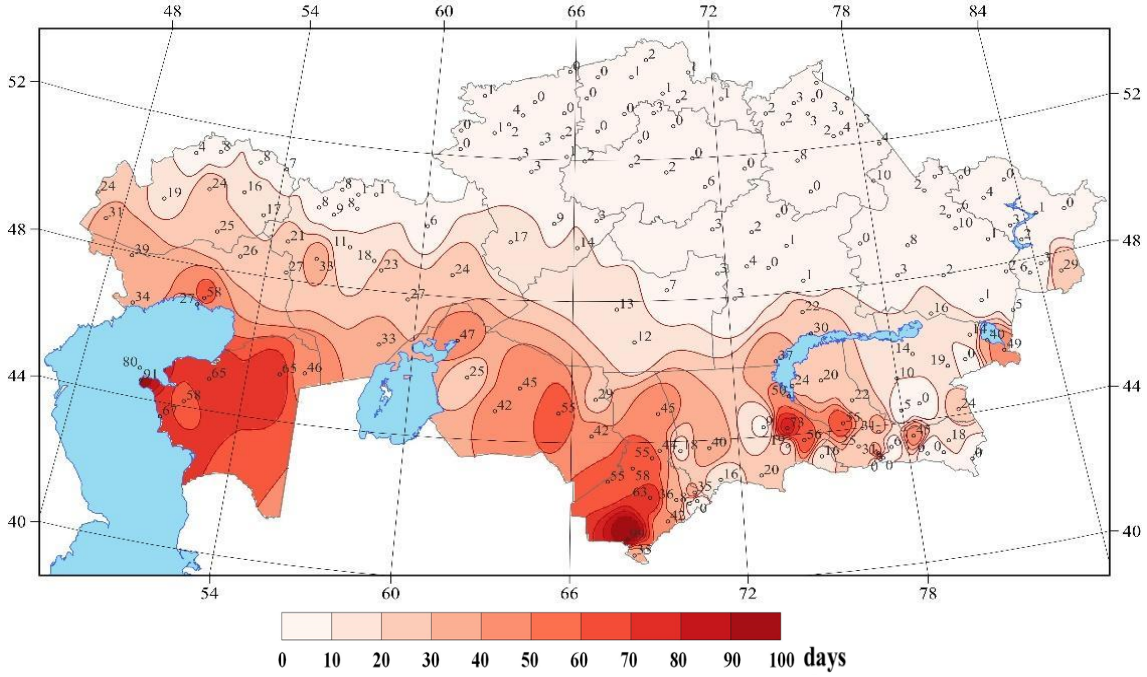


Figure 2.10 *– Number of days when the daily minimum temperature was above 20 °C in 2025 (TR index)*

Due to the high air temperatures observed during a significant part of the warm period of the year, especially in the western and southern parts of Kazakhstan, the need for indoor cooling increased. To assess the cooling demand, the cold deficit index ***CDDcold23*** was used, which reflects the sum of the excesses of the mean daily air temperature over the threshold value of 23 °C (Figure 2.11). The highest index values were observed in the Turkestan region, where the cold deficit ranged from 653 to 867 degree-days (MS Turkestan, Kyzylkum, Arys, and Shardara). The cold deficit ranged from 400 to 580 degree-days in the Kyzylorda and Zhambyl regions, in the rest of the Turkestan region, in the coastal areas of the Mangystau region, as well as in the southeast of the country. The index varied from 250 to 400 degree-days in the Atyrau and Mangystau regions, in places in the Aktobe, West Kazakhstan, and Karaganda regions, in the Abay and Ulytau regions, and in the southeast of the country. The cold deficit

ranged from 90 to 250 degree-days in the West Kazakhstan, Aktobe, and Kostanay regions, in the Abay region, in the central regions, and in the east of the country. The smallest values, not exceeding 90 degree-days, were observed in the North Kazakhstan, Akmola, and Pavlodar regions, in places in the Kostanay and East Kazakhstan regions, as well as in the mountainous and foothill areas of the southeast, where the cold deficit was close to zero at some meteorological stations.

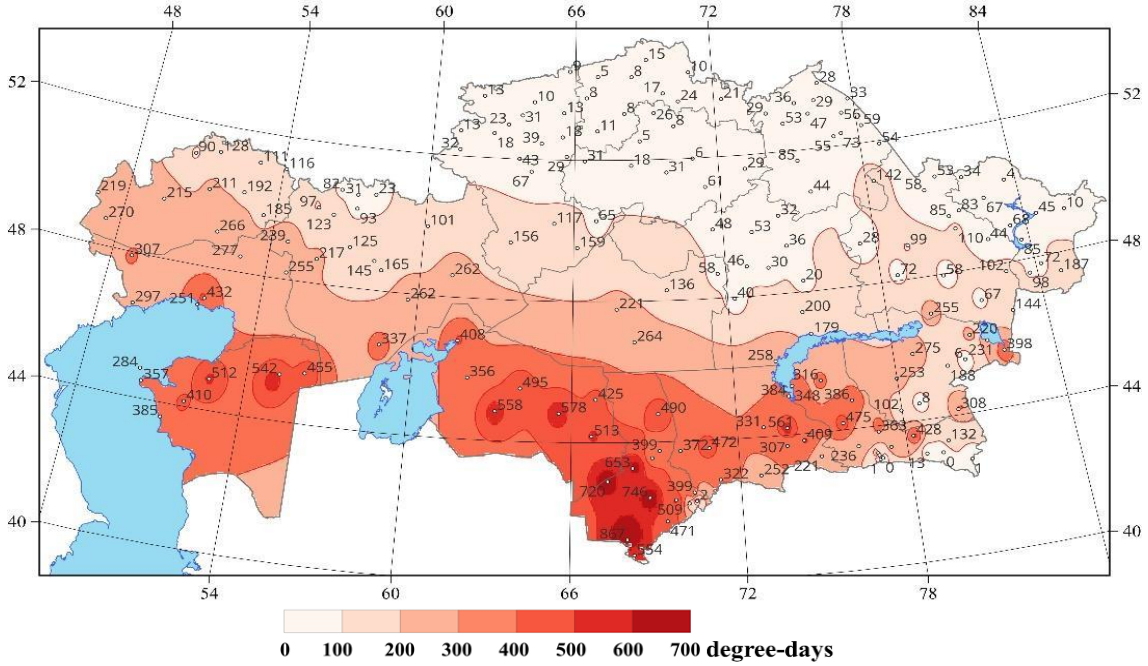


Figure 2.11 *– Cold deficit (degree-days) observed in 2025 (CDDcold23 index)*

The lowest values of the daily minimum air temperature (*TNn index*, Figure 2.12) in 2025 were observed in the central, eastern, and northern parts of the country. Air temperature fell below minus 35 °C at eight meteorological stations in the Karaganda, North Kazakhstan, Abay, and Ulytau regions; the absolute minimum of the year, minus 38.8 °C, was recorded at MS Aktogay (Karaganda region). Air temperatures below minus 30 °C were observed at 83 meteorological stations – in the Kostanay, North Kazakhstan, Akmola, Pavlodar, Karaganda, and East Kazakhstan regions, in the Abay and Ulytau regions, in the north of the Aktobe region, and in places in the southeast of the country. The highest values of the TNn index were observed in the south and west of the country – in the Turkestan, Kyzylorda, and Zhambyl regions and in the coastal areas of the Mangystau region, where the daily minimum air temperature did not fall below minus 20 °C; the highest value, minus 10.4 °C, was recorded at MS Zhetysay.

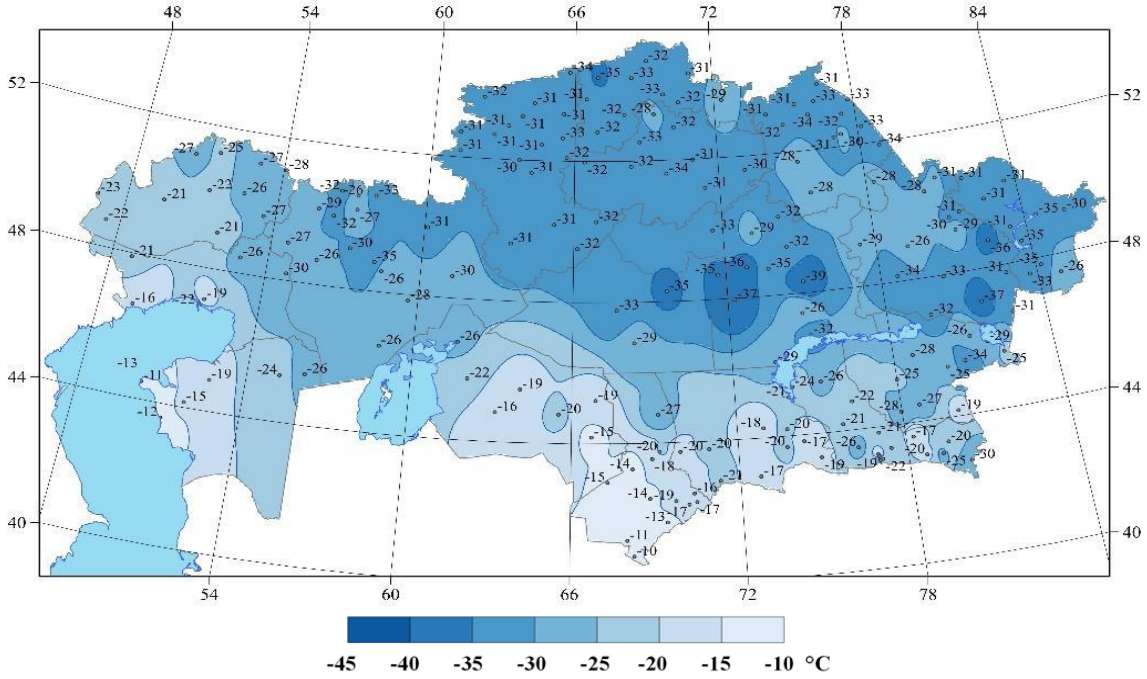


Figure 2.12 *– Values of the daily minimum air temperature (°C) recorded in 2025 (TNn index)*

Figure 2.13 shows the absolute minimum air temperatures recorded since the opening of each meteorological station. In Kazakhstan, absolute minimum air temperatures below minus 50 °C were recorded at two stations: in January 1931 at MS Shaganatty/Orlovsky settlement (minus 54.2 °C) and in January 1893 at MS Astana (minus 52 °C). Air temperatures below minus 45 °C were observed mainly in the northern and eastern parts of Kazakhstan. No new records of the daily minimum temperature were registered in 2025.

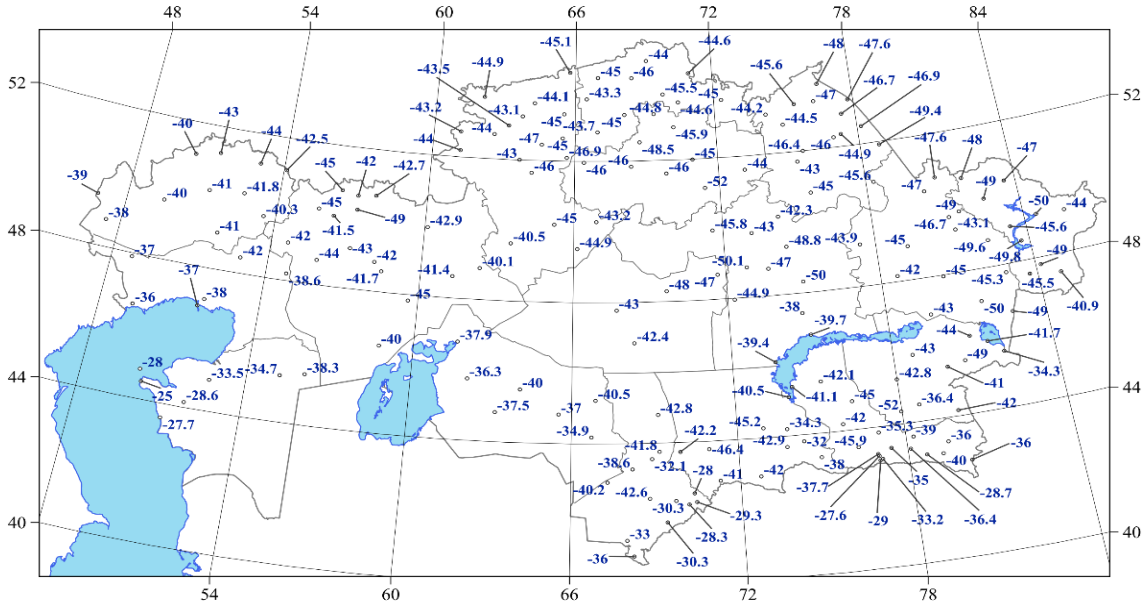


Figure 2.13 *– Absolute minimum air temperature values (°C) recorded from the opening of the meteorological station to 2025. If the record value of the daily minimum air temperature was recorded in 2025, this value is plotted in red*

2.2 Observed changes in air temperature

Figures 2.14–2.15 show the time series of mean annual and seasonal surface air temperature anomalies averaged over the territory of Kazakhstan and its administrative regions and their 11-year moving averages for the period 1941–2025, as well as the linear trends in air temperature for the period 1976–2025. Anomalies are calculated relative to the base period 1961–1990. The linear trends clearly illustrate the gradual increase in mean annual and seasonal surface air temperatures over recent decades. Table 2.4 presents estimates of air temperature change for the period 1976–2025: the linear trend coefficient, which characterizes the average rate of change of the air temperature anomaly over the time interval under consideration, and the coefficient of determination, which shows the contribution of the trend to the total variance of the time series.

On average over the territory of Kazakhstan, the mean annual air temperature increased by 0.40 °C every 10 years over the period 1976–2025, and the trend accounts for 39 % of the total temperature variability (Figure 2.14, Table 2.4). On average over the territory of all regions of Kazakhstan, a steady increase in mean annual air temperature has also been observed during 1976–2025: the coefficients of determination range from 18 to 61 %, and the trends are significant at the 5 % level (Figure 2.15, Table 2.4). Warming is faster in the western regions and the Kyzylorda region (from 0.50 °C/10 years to 0.59 °C/10 years) and slower in the central, northeastern, eastern, and southeastern regions (from 0.29 °C/10 years to 0.40 °C/10 years).

On average over the territory of Kazakhstan, the **winter** season shows a tendency toward increasing air temperature at a rate of 0.31 °C/10 years (Table 2.4). However, this trend explains only about 4 % of the total variance of the time series and is not statistically significant at the 5 % level. Mean winter temperatures show positive trends in all regions of Kazakhstan; however, in most cases they are statistically insignificant and explain no more than 5 % of the variance of the observed series. The most intensive warming (0.36–0.55 °C/10 years) is observed in the western and southern parts of the country, including the West Kazakhstan, Atyrau, Mangystau, Aktobe, Kyzylorda, and Turkestan regions. In these regions, the coefficient of determination is 6–15 %, which indicates a more pronounced influence of the long-term trend on temperature change. The most stable and statistically significant warming trends were identified in the West Kazakhstan, Atyrau, and Mangystau regions, where the trend explains 9, 11, and 15 % of the total variance, respectively, and is significant at the 5 % level. According to data from individual meteorological stations located in the far west and south of the country, this trend is also stable (Figure 2.16).

At the same time, there are still areas in Kazakhstan with a tendency toward decreasing winter air temperature. These areas cover the eastern, southeastern, and central parts of the country, as well as some parts of the south, where the rate of temperature change ranges from −0.01 to −0.31 °C/10 years.

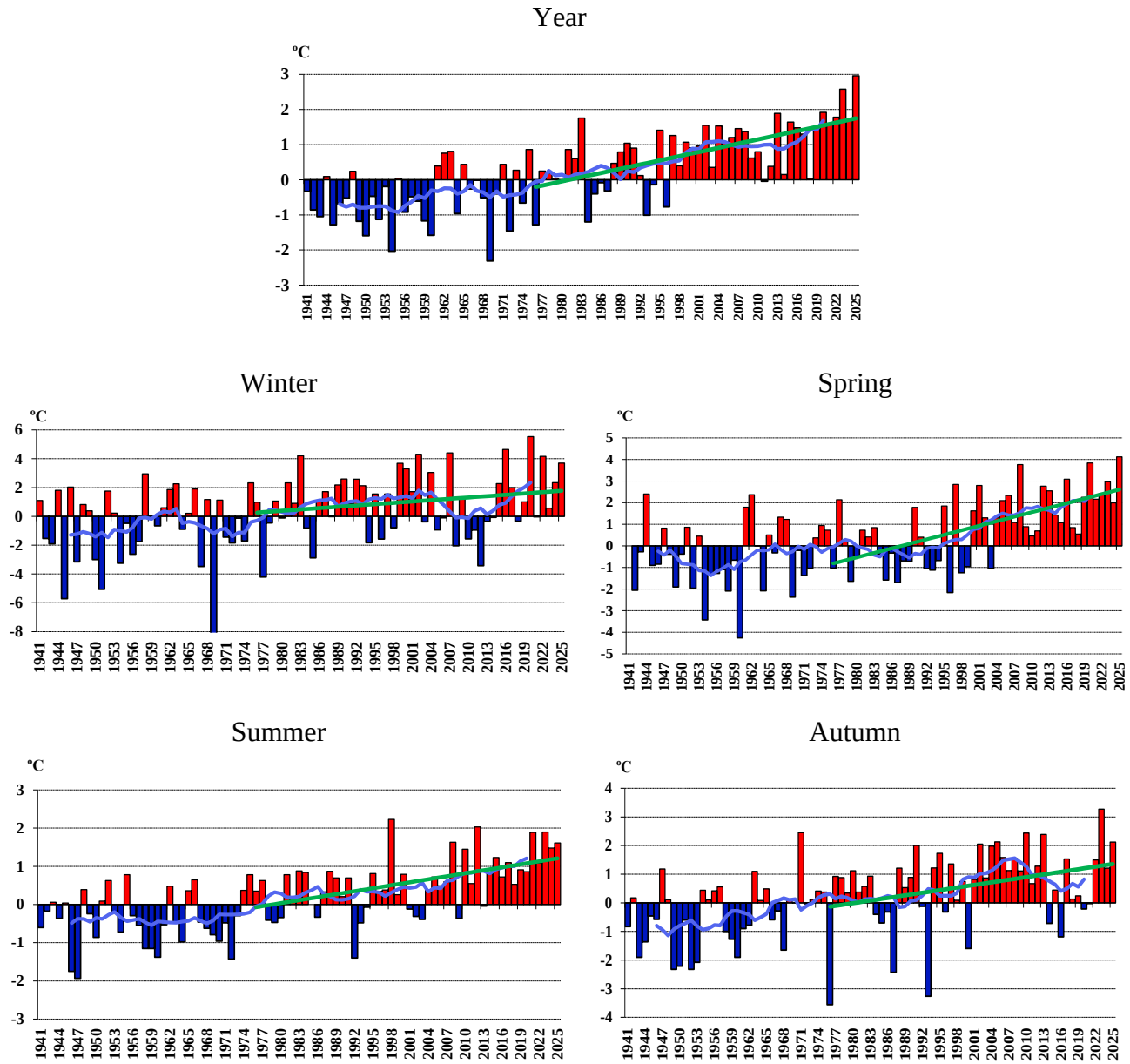


Figure 2.14 – *Time series of annual and seasonal air temperature anomalies (°C) averaged over the territory of Kazakhstan for the period 1941–2025. Anomalies are calculated relative to the base period 1961–1990. The linear trend for the period 1976–2025 is shown in green. The smoothed curve is obtained by an 11-year moving average*

In **December**, there are no stable trends in mean monthly air temperatures: the trend is not significant at the 5 % level at any meteorological station, and the contribution of the trend component to the total variance for the country does not exceed 1 % (Figure 2.17). Over most of Kazakhstan, the trends are positive, with the maximum values observed at MS Ust-Kamenogorsk (0.58 °C/10 years, East Kazakhstan region) and MS Zhanibek (0.52 °C/10 years, West Kazakhstan region). Decreasing air temperature trends are observed in the southern half of the country, as well as locally in the east and in the central regions; the largest decrease reaches −0.41 °C/10 years (MS Shuyldak, Turkestan region).

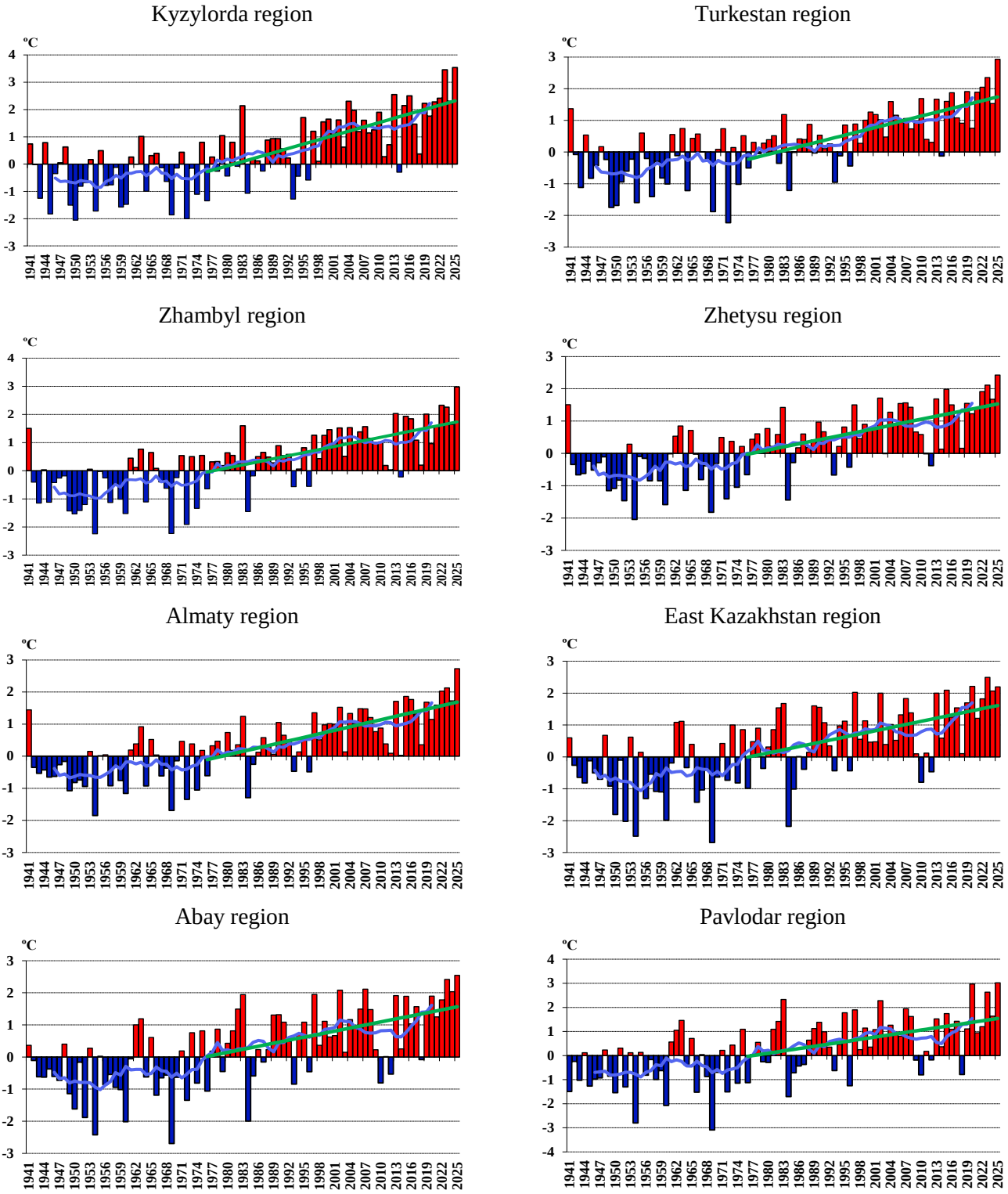
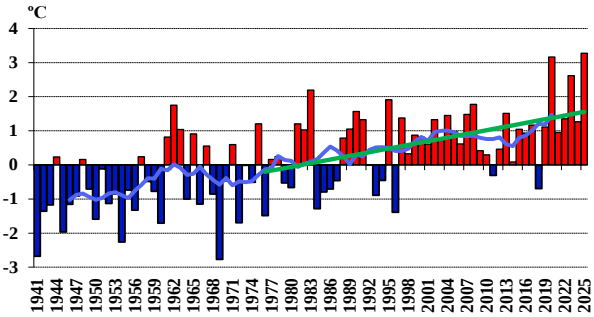
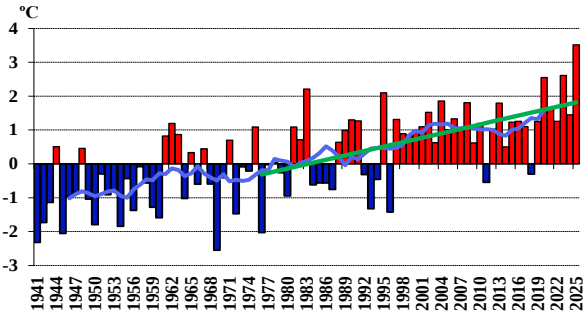


Figure 2.15 – *Time series of annual air temperature anomalies (°C) averaged over the regions of Kazakhstan for the period 1941–2025. Anomalies are calculated relative to the base period 1961–1990. The linear trend for the period 1976–2025 is shown in green. The smoothed curve is obtained by an 11-year moving average. Sheet 1*

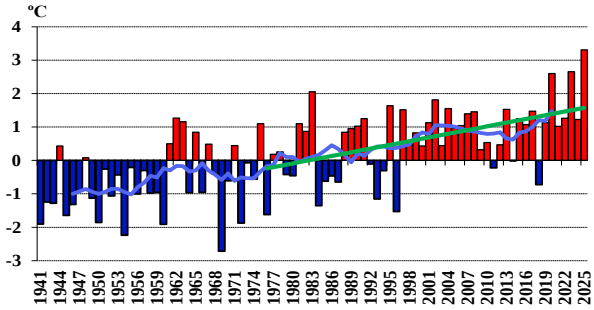
North Kazakhstan region



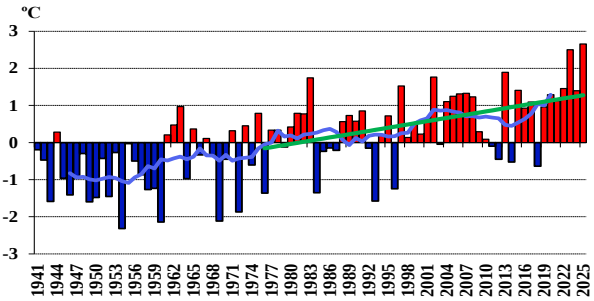
Kostanay region



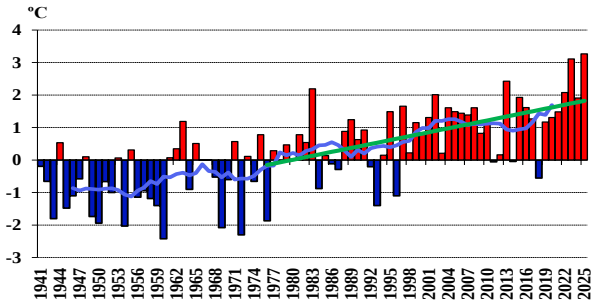
Akmola region



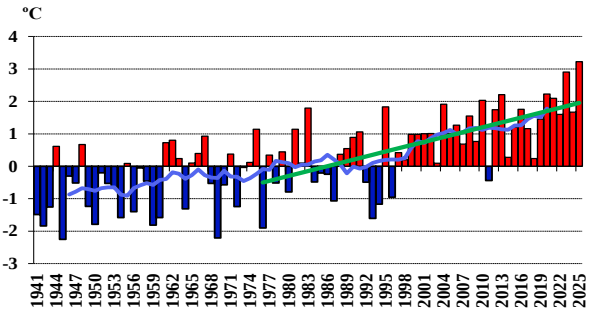
Karaganda region



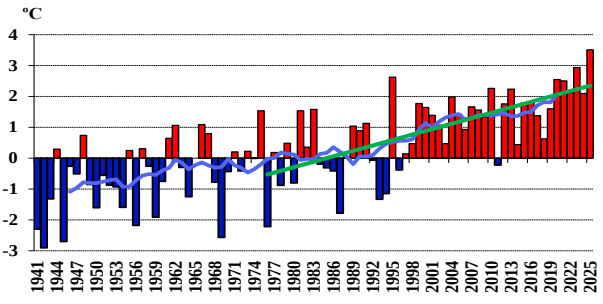
Ulytau region



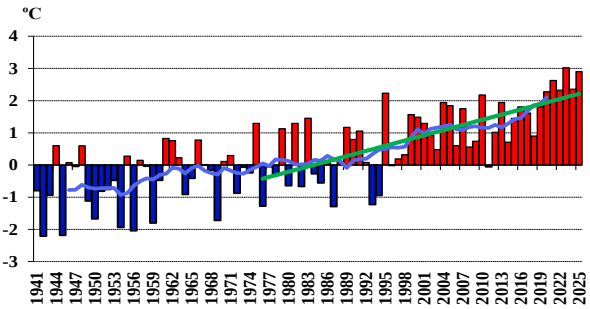
Aktobe region



West Kazakhstan region



Atyrau region



Mangystau region

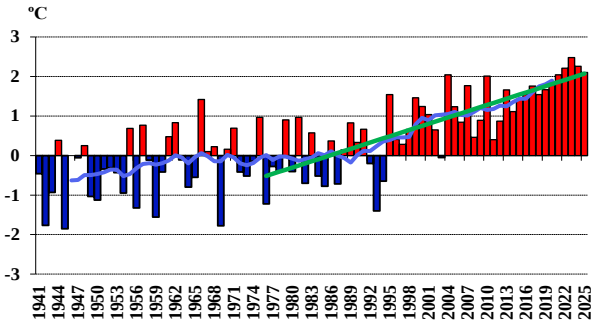


Figure 2.15 *– Time series of annual air temperature anomalies (°C) averaged over the regions of Kazakhstan for the period 1941–2025. Anomalies are calculated relative to the base period 1961–1990. The linear trend for the period 1976–2025 is shown in green. The smoothed curve is obtained by an 11-year moving average. Sheet 2*

In **January**, the area with a decreasing air temperature trend covered a vast territory in the central, northeastern, eastern, and southeastern parts of the country; the largest decrease was observed in the east, reaching −0.40 °C/10 years (MS Urzhar) (Figure 2.17). The largest positive trends, up to 0.68 °C/10 years (MS Kazygurt), were observed in the west and south. Although the slope coefficients for December and January temperatures are rather high, owing to the large interannual variability of temperature in these months the contribution of the trend component to the total variance is small: a trend significant at the 5 % level was identified at only one meteorological station.

In **February**, a tendency toward increasing air temperature is observed throughout Kazakhstan, with maximum values in the western regions, the Kyzylorda and Turkestan regions, and the western part of the South Balkhash area (0.80–1.22 °C/10 years). Only in the south of the Abay region does an area of weak cooling persist; in the center of this region, the cooling rate reaches −0.18 °C/10 years (MS Urzhar), the only meteorological station in the country with a negative February trend. Statistically significant rates of air temperature increase in February were observed at 66 meteorological stations located in the western, southern, and southeastern parts of the country, as well as in the Kostanay and Karaganda regions and in the city of Astana (Figure 2.17).

The **spring** season shows the most intensive warming trend in all regions of Kazakhstan except the Mangystau region, where the summer trend is more pronounced (Table 2.4). The average rate of air temperature increase by region ranges from 0.48 °C/10 years (Mangystau region) to 0.94 °C/10 years (Kyzylorda region), with 24–45 % of the variance explained. Hotspots of the most intensive warming are observed in the Kyzylorda, Pavlodar, Kostanay, and Akmola regions, in the western part of the East Kazakhstan region, in the southeastern part of the Aktobe region, in the Abay and Ulytau regions, as well as in the southeastern areas of the country (0.71–1.03 °C/10 years) (Figure 2.16). The lowest rate of spring warming is observed in the mountainous and foothill areas of the south and southeast, in the Zhaisan (Zaisan) Basin, in the coastal areas of the Mangystau and Atyrau regions, as well as in the extreme northern and northwestern areas (0.45–0.63 °C/10 years). The trends are statistically significant at all meteorological stations in the country. On average over the territory of Kazakhstan, the rate of air temperature increase was 0.70 °C/10 years (contribution of the trend component 39 %). The trend estimates are significant at the 1 % level.

Table 2.4 – Characteristics of the linear trend of surface air temperature anomalies averaged over the territory of Kazakhstan and its regions for the period 1976–2025

Region	Year		Winter		Spring		Summer		Autumn	
	a	D	a	D	a	D	a	D	a	D
Kazakhstan	**0.40**	39	0.31	4	**0.70**	39	**0.26**	26	**0.30**	11
Abay	**0.32**	21	0.13	1	**0.73**	35	**0.23**	19	0.17	3
Almaty	**0.36**	44	0.25	4	**0.66**	41	**0.33**	36	0.21	8
Akmola	**0.37**	26	0.30	3	**0.72**	28	0.08	1	**0.35**	8
Aktobe	**0.50**	42	0.46	7	**0.72**	26	**0.33**	14	**0.47**	17
Atyrau	**0.54**	49	**0.54**	11	**0.61**	31	**0.51**	42	**0.46**	21
East Kazakhstan	**0.33**	22	0.19	1	**0.69**	31	**0.24**	19	0.20	4
Zhambyl	**0.36**	38	0.29	3	**0.67**	39	**0.29**	31	0.19	4
Zhetysu	**0.32**	33	0.19	2	**0.65**	36	**0.29**	32	0.15	3
West Kazakhstan	**0.59**	46	**0.55**	9	**0.66**	26	**0.53**	28	**0.54**	25
Karaganda	**0.29**	21	0.19	2	**0.72**	33	0.09	3	0.14	2
Kostanay	**0.43**	32	0.38	4	**0.70**	24	0.18	5	**0.46**	15
Kyzylorda	**0.53**	45	0.49	6	**0.94**	45	**0.35**	32	**0.32**	10
Mangystau	**0.53**	61	**0.46**	15	**0.48**	30	**0.63**	55	**0.52**	29
Pavlodar	**0.32**	18	0.16	1	**0.72**	32	0.11	3	0.27	6

Region	Year		Winter		Spring		Summer		Autumn	
	a	D	a	D	a	D	a	D	a	D
North Kazakhstan	**0.36**	23	0.27	2	**0.62**	24	0.08	1	**0.43**	12
Turkestan	**0.40**	49	0.36	6	**0.64**	40	**0.33**	32	**0.25**	9
Ulytau	**0.40**	30	0.30	3	**0.85**	38	**0.18**	10	0.25	5

Notes: *1. a – linear trend coefficient, °C/10 years;*

2. D – coefficient of determination, %;

3. trends statistically significant at the 5 % level are shown in bold.

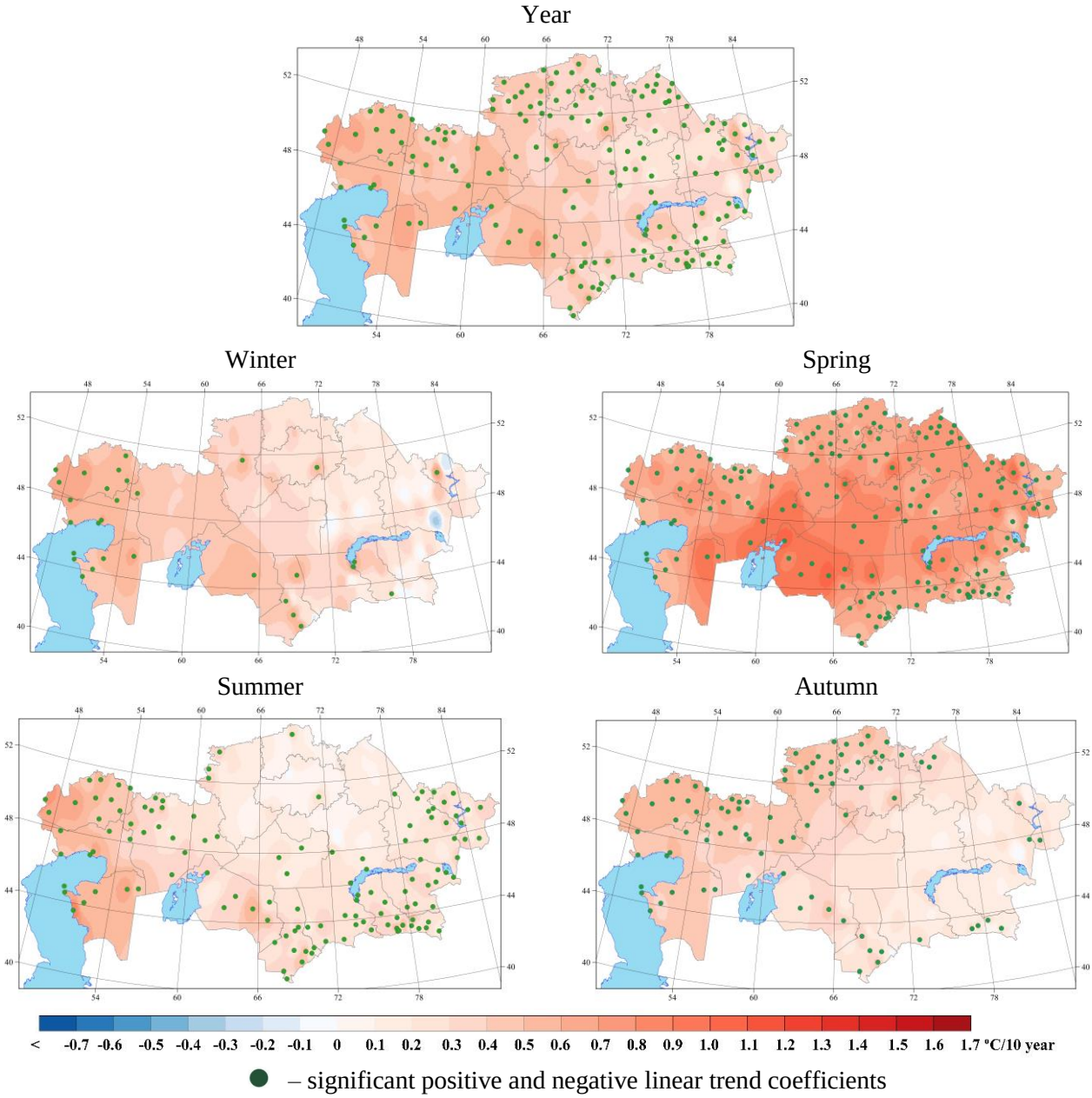


Figure 2.16 – *Spatial distribution of the linear trend coefficient of mean annual and seasonal surface air temperature (°C/10 years) calculated from observations for the period 1976–2025*

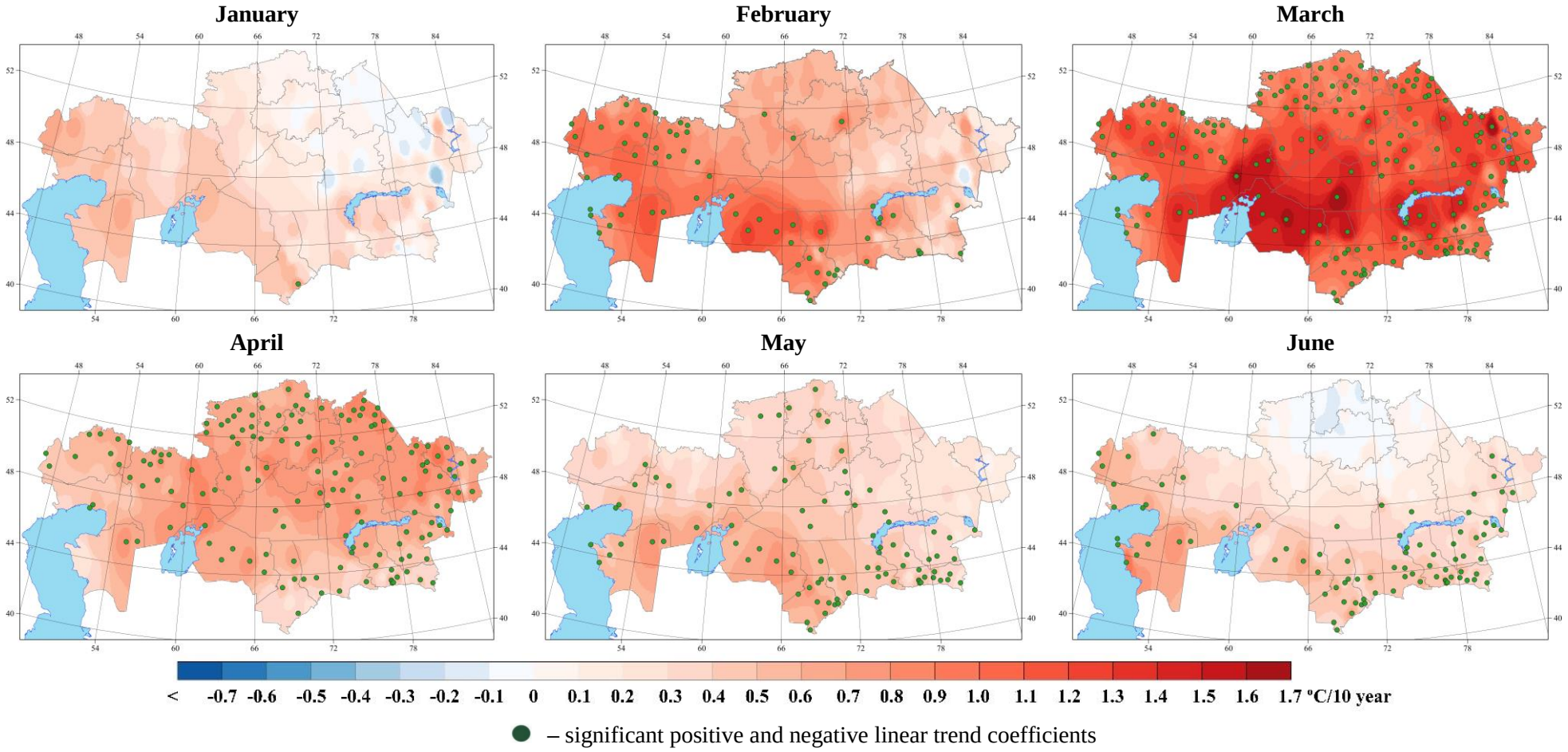


Figure 2.17 – *Spatial distribution of the linear trend coefficient of mean monthly surface air temperature (°C/10 years) calculated from observations for the period 1976–2025. Sheet 1*

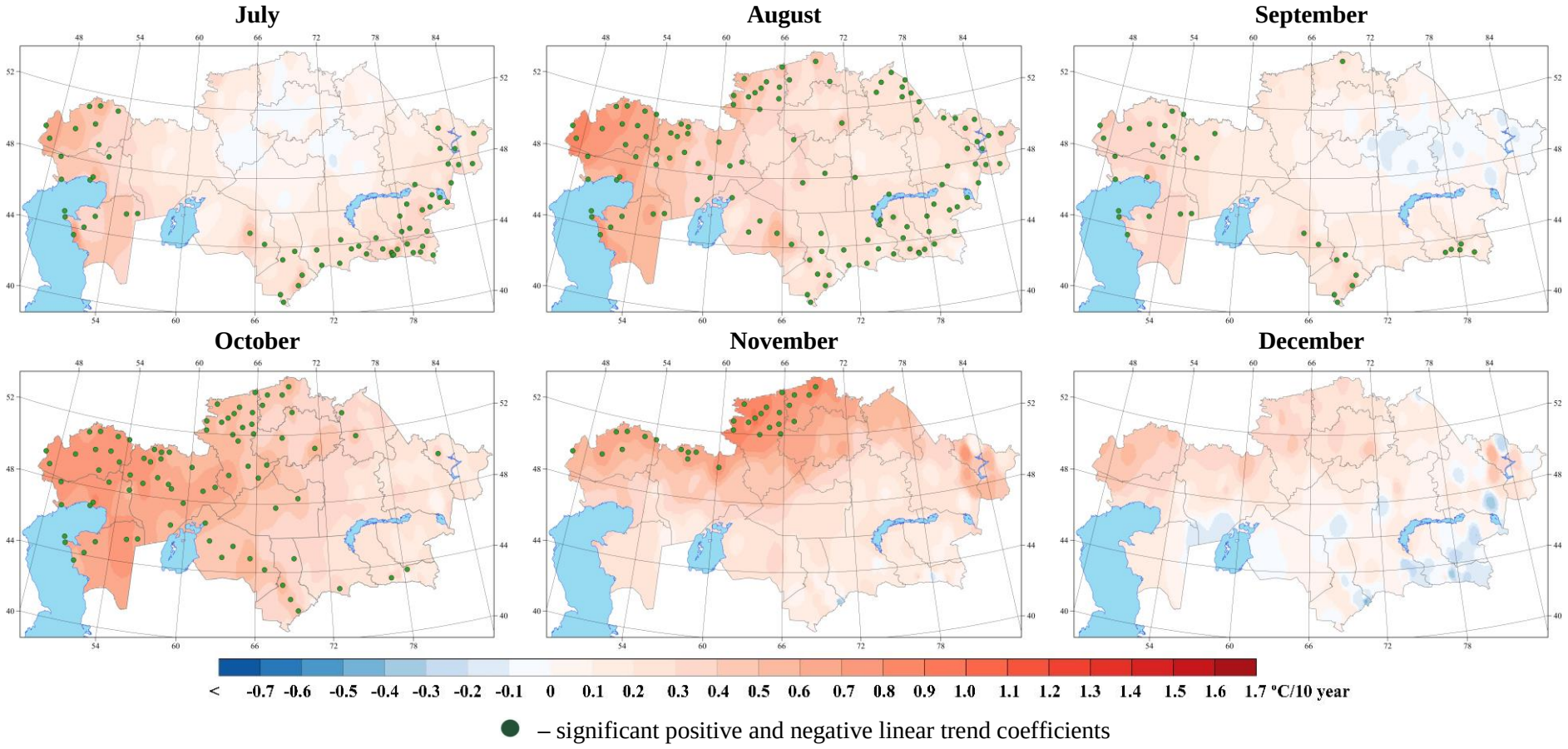


Figure 2.17 – *Spatial distribution of the linear trend coefficient of mean monthly surface air temperature (°C/10 years) calculated from observations for the period 1976–2025. Sheet 2*

The highest rate of air temperature increases in spring, statistically significant according to data from all stations, was observed in *March* (from 0.65 to 1.73 °C/10 years, Figure 2.17). In April and *May*, a tendency toward a significant increase in air temperature was also observed throughout the country. In *April*, statistically significant rates of increase are observed almost everywhere – at 84 % of meteorological stations, ranging from 0.32 to 1.00 °C/10 years; insignificant trends persist mainly in the Turkestan, Atyrau, Almaty, and Zhambyl regions. In May, a steady increase in mean air temperature at a rate of 0.24 to 0.79 °C per 10 years is observed in the southeastern, southern, and central parts of the country, as well as in the Kyzylorda, Aktobe, and Kostanay regions.

In summer, the seasonal air temperature averaged over Kazakhstan increases by 0.26 °C/10 years (coefficient of determination 26 %, Table 2.4). The most significant rates of air temperature increase, 0.41–0.84 °C/10 years, are observed in the western regions and in places in the south and southeast of the country. Less intensive warming is observed in most of the southern, southeastern, and eastern regions of Kazakhstan, as well as in the Aktobe region, where summer air temperatures tend to increase by 0.23–0.35 °C/10 years (Figure 2.16). Here the trends describe 14 to 36 % of the variance of the time series. In the northern, northeastern, and central parts of the country, trends are practically absent in places (0.0–0.1 °C/10 years): the share of the trend component in the total variance of the series in these areas is practically zero, although the trend remains positive. At some meteorological stations in the central and northern parts of the country, air temperature even decreased over the period 1976–2025, with the cooling rate reaching −0.03 °C/10 years.

In *June* and *July*, a tendency toward slight cooling is observed in the northern, northeastern, and central areas (maximum of −0.16 °C/10 years, Figure 2.17). In the western, southwestern, southern, and southeastern parts of the country, statistically significant rates of surface air temperature increase of 0.21–0.99 °C/10 years were observed. In *August*, most parts of Kazakhstan show statistically significant positive air temperature trends ranging from 0.17 to 0.87 °C/10 years. The highest rate of air temperature increase in August is observed in the west of the country.

In autumn, a warming tendency is observed in all regions of Kazakhstan. On average over the territory of Kazakhstan, the seasonal temperature increases by 0.30 °C/10 years (coefficient of determination 11 %, Table 2.4). The most significant rates of temperature increase, 0.35–0.54 °C/10 years, are observed in the western and northern regions, with the share of variance explained by the trend being 8–29 %. In the central, some southern, and eastern parts of the country, warming trends are practically absent: although the trend sign is positive, the share of the trend component in the total variance of the series does not exceed 9 %. It should be noted that over the period 1976–2025, the average rate of autumn warming increased slightly in all regions and on average over the country, and the trends became statistically significant at the 5 % level for the country as a whole and in three more regions: Akmola, Kyzylorda, and Turkestan. It should also be noted that in summer the largest significant trends were observed in the western, southern, and southeastern parts of the country, and in autumn in the western and northern parts (Figure 2.16). In other words, significant climate warming was observed in the western part of the country in all seasons of the year.

In **September**, warming occurs over most of the country, and statistically significant rates of surface air temperature increase of 0.22–0.49 °C/10 years were observed in some southern and western parts of the country (Figure 2.17). In the central and some eastern parts of the country, trends are practically absent: although the trend sign is positive, the share of the trend component in the total variance of the series does not exceed 4 %. In some areas of the eastern and central parts of the country, there were pockets of slight cooling of up to −0.16 °C/10 years.

In **October**, warming occurred throughout Kazakhstan; statistically significant positive air temperature trends in the range from 0.33 to 0.85 °C/10 years are observed in the west and north of the country, and in places in the south – in the Kyzylorda and Turkestan regions.

In **November** positive air temperature trends (0.06–0.95 °C/10 years) were observed mainly in the northern half of Kazakhstan, including its eastern, northern, and northwestern parts. However, in most cases these trends were statistically insignificant: they reached significance at the 5 % level at 30 meteorological stations in the Kostanay, West Kazakhstan, Aktobe, and North Kazakhstan regions, where the rate of air temperature increase ranged from 0.58 to 0.95 °C/10 years. In the southern, southeastern, and central parts of the country, warming was weak – from 0.14 to 0.27 °C/10 years on average by region – and negative air temperature trends (from −0.01 to −0.37 °C/10 years) were observed at some meteorological stations. The most pronounced cooling trend was recorded at the Shuyldak meteorological station (Turkestan region), where the rate of temperature decrease was −0.37 °C/10 years; however, this trend is not statistically significant either.

2.3 Trends in surface air temperature extremes

Not only the mean levels of air temperature and precipitation are changing, but also other characteristics of the regimes of these basic climate elements, including the frequency and intensity of extremes. Thus, climate change can affect virtually all spheres of human activity, as well as physical and chemical processes in the biosphere.

A correct assessment of climate change impacts must be distinctly regional and even local in nature, since both climate change and the vulnerability of systems, as well as the opportunities for adaptation, depend significantly on the physical-geographical, economic, and demographic features of regions, each of which has its own specifics in this respect.

Rising air temperature leads to shifts in the timing of phenological events in plants and animals and in the boundaries of vegetation zones, mainly northward and upward in mountainous areas, as well as to changes in the structure of ecosystems.

Throughout Kazakhstan, there is a tendency toward an increase in the length of the growing season (GSL index, Figure 2.18), ranging from 0.3 to 6.2 days per decade. The most pronounced and statistically significant changes (3–6 days/10 years) are observed at most meteorological stations in the West Kazakhstan, Aktobe, Kyzylorda, Zhambyl, and Almaty regions, as well as at individual stations in the Mangystau, Turkestan, East Kazakhstan, Zhetysu, Ulytau, and Abay regions. In the figures, trends statistically significant at the 5 % level are marked with red or green circles; in total, significant trends were identified at 114 of 186 meteorological stations. The lowest rates of increase in the length of the growing season are typical of the northern and northeastern parts of the country: in the Pavlodar, Akmola, and North Kazakhstan regions they average 1.3–1.6 days per decade. The largest increase in the length of the growing season was recorded at the Shardara meteorological station (Turkestan region), where this indicator increases by 6.2 days per decade.

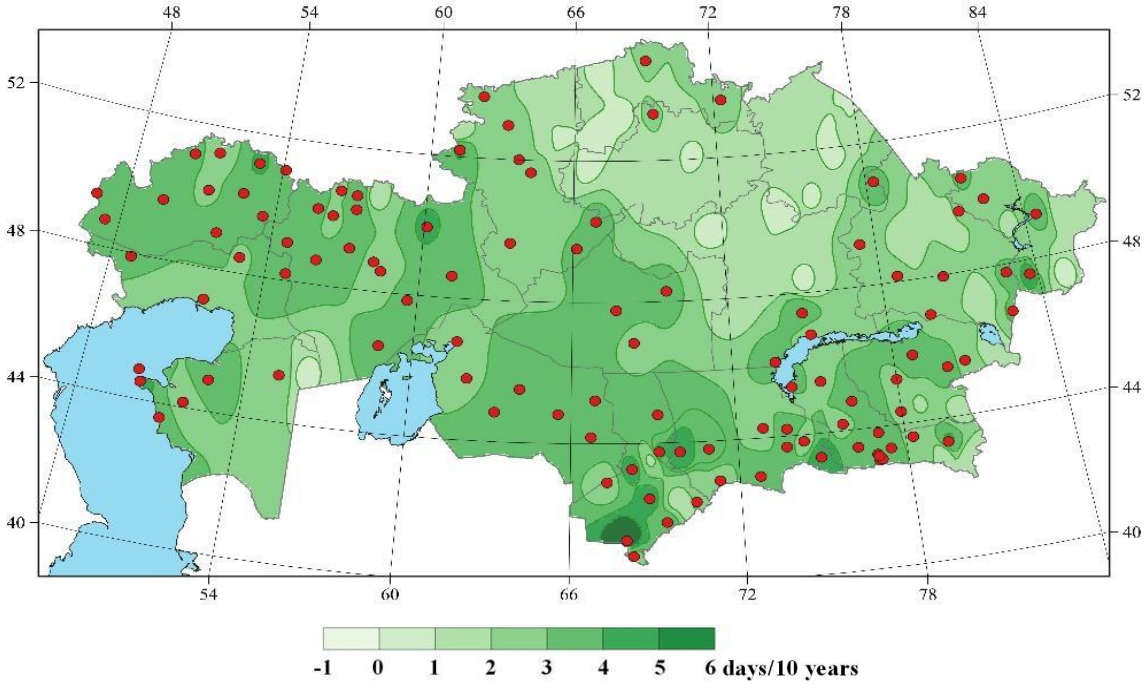


Figure 2.18 *– Rates of change in the length of the growing season (days/10 years) for the period 1961–2025 (GSL index)*

In addition to the increase in the length of the growing season, a statistically significant increase in the sum of temperatures during the growing season (*GDDgrow10* index, Figure 2.19) is observed at almost all meteorological stations in Kazakhstan: significant trends were identified at 184 of 186 stations. In the southern and western parts of the country, the increase in the sum of temperatures is considerably greater than in the northern and eastern parts. The largest increase, of more than 100 degree-days/10 years, is observed at 12 meteorological stations in the Kyzylorda, Turkestan, Mangystau, Zhambyl, and Atyrau regions; the maximum value was recorded at MS Aktau (139.3 degree-days/10 years).

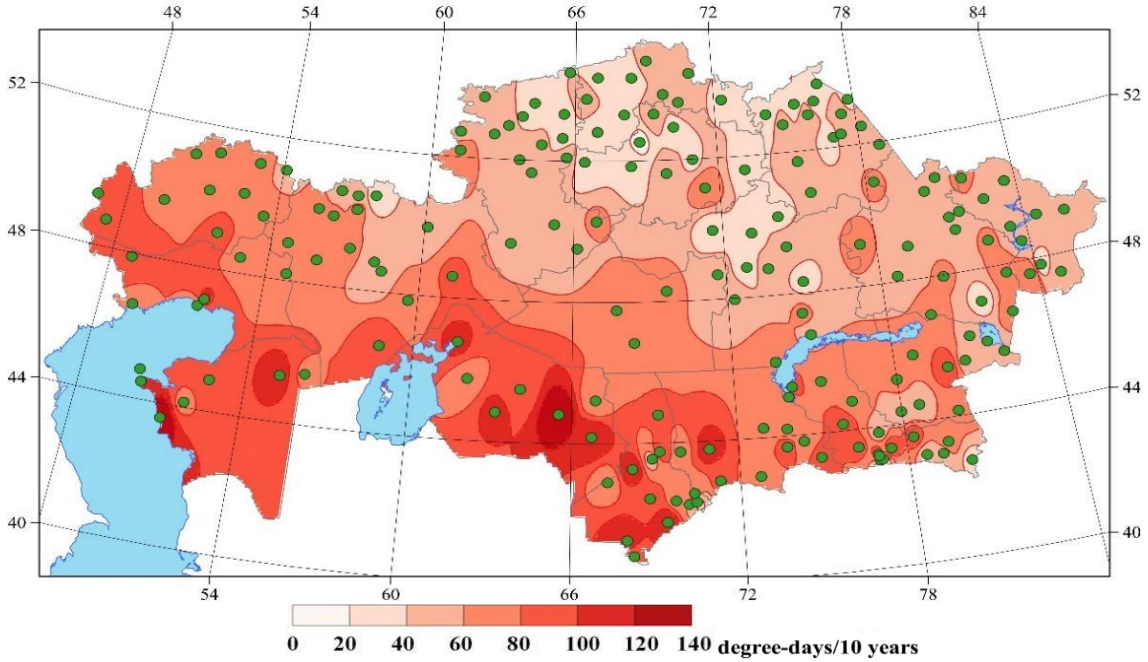


Figure 2.19 *– Rates of change in the sum of temperatures during the growing season (degree-days/10 years) for the period 1961–2025 (GDDgrow10 index)*

Not only is the mean air temperature rising, but the frequency of high summer temperatures is also increasing. Under the hot and dry summer conditions of the southern parts of Kazakhstan, this has an adverse effect not only on vegetation but also on humans and animals. The number of days with temperatures above 30 °C is increasing almost everywhere, most noticeably in the western and southern parts of the country, by 4–7 days per 10 years (*TXge30 index*, Figure 2.20). The highest rate of increase in the frequency of high summer temperatures was observed at the Aktau (7.2 days/10 years, Mangystau region) and Aral Teniz (6.8 days/10 years, Kyzylorda region) meteorological stations.

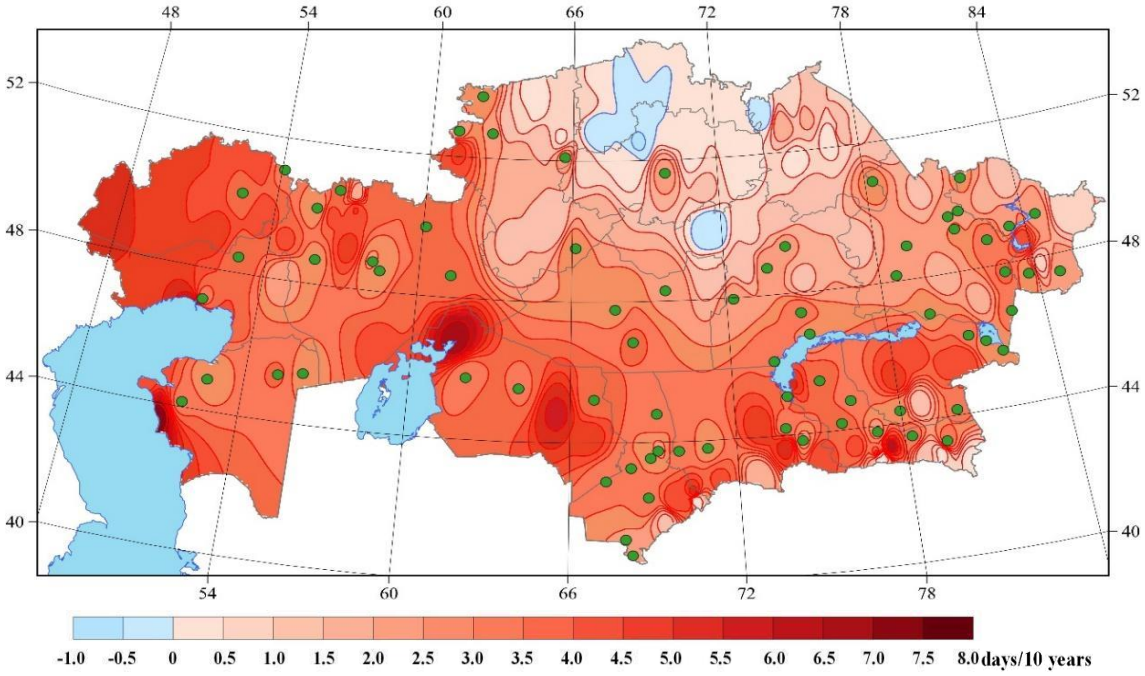


Figure 2.20 *– Rates of change in the number of days when the daily maximum temperature is equal to or above 30 °C (days/10 years) for the period 1961–2025 (TXge30 index)*

Over most of the country, there is a statistically significant positive trend in the total duration of all heat waves during the warm period (a heat wave is three or more consecutive days when the excess heat factor is positive, *HWF/EHF index*, Figure 2.21); significant trends were identified at 135 of 186 meteorological stations. The largest statistically significant positive trend, from 6.2 to 7.3 days/10 years, was observed at 3 meteorological stations: Aktau (7.3 days/10 years) in the Mangystau region, Kazygurt (6.4 days/10 years) in the Turkestan region, and Kyzylorda (6.2 days/10 years) in the Kyzylorda region.

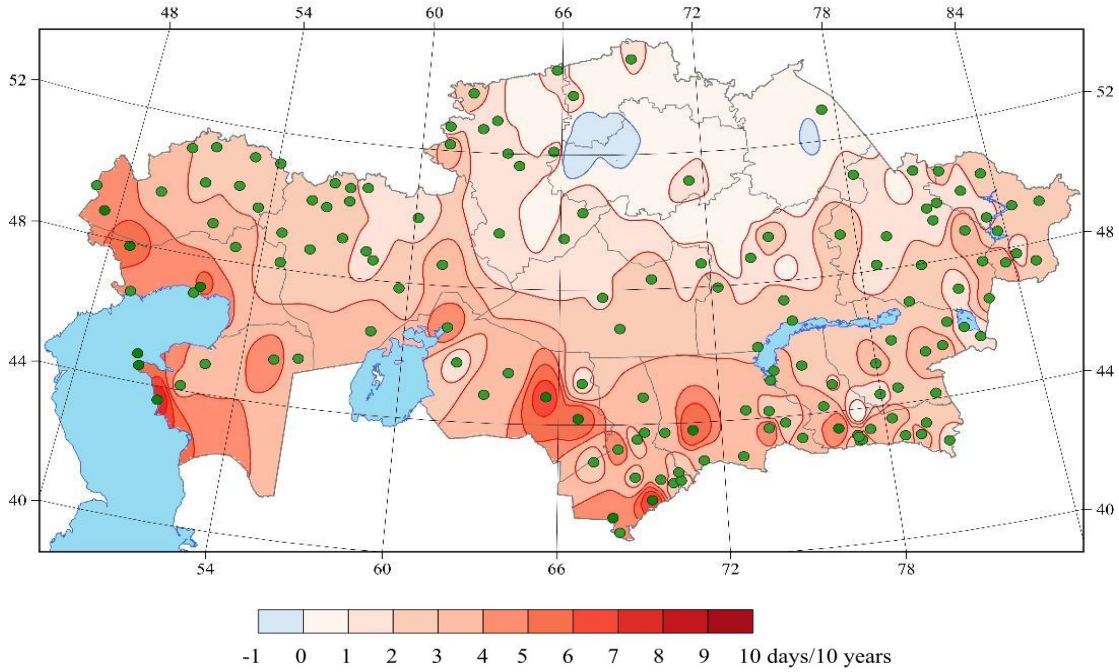


Figure 2.21 *– Rates of change in the total duration of warm-period heat waves (days/10 years) for 1961–2025 (HWF/EHF index)*

Almost throughout the country, there is a tendency toward an increase in the number of individual heat waves during the warm period (*HWN index*, Figure 2.22); no negative trends were identified at any meteorological station, and statistically significant trends were recorded at 128 of 186 stations. At stations in the southern and southwestern regions, the number of heat waves increases on average by 0.3–0.5 every 10 years, with the largest value recorded at MS Kyzylorda (0.67 events/10 years).

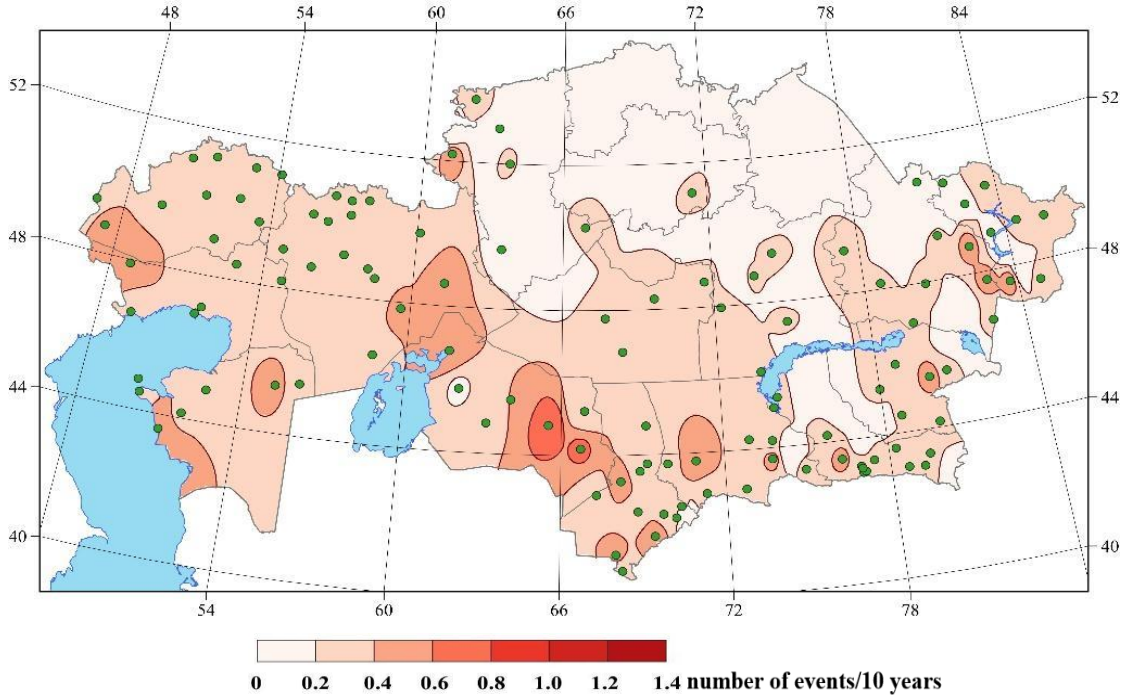


Figure 2.22 *– Rates of change in the number of warm-period heat waves (number of events/10 years) for 1961–2025 (HWN index)*

Over most of the country, *the duration of the longest warm-period heat wave is increasing* (*HWD index*, Figure 2.23). In the Mangystau, Atyrau, Zhambyl, Turkestan, and Kyzylorda regions, the longest wave is becoming longer by more than one day on average every 10 years, with the largest increase recorded at MS Aktau (2.6 days/10 years). At some meteorological stations in the northern regions, by contrast, it is becoming shorter, by up to 0.4 days per 10 years (MS Ruzaevka, North Kazakhstan region), where this trend is statistically significant.

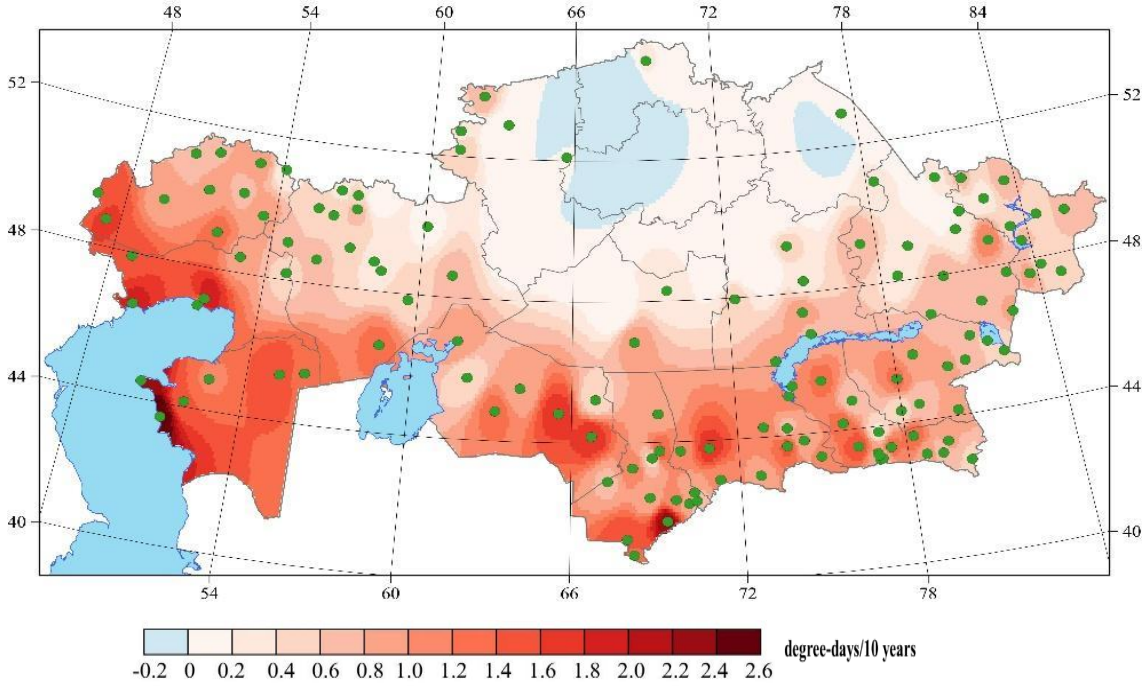


Figure 2.23 *– Rates of change in the maximum duration of warm-period heat waves (days/10 years) for 1961–2025 (HWD index)*

Rising air temperatures in all seasons of the year lead to an increase in the *total annual duration of warm spells* (when the daily maximum air temperature exceeds the 90th percentile for at least six consecutive days, WSDI index) almost throughout the country (Figure 2.24); no negative trends were identified at any meteorological station, and statistically significant trends were recorded at 175 of 186 stations. In the northern areas and in some central, southern, and eastern parts of the country, the increase is 1 to 3 days/10 years. The most substantial increase, from 3 to 6.4 days/10 years, is observed in the western half of the country and in the areas adjacent to the Aral Sea; the maximum value was recorded at MS Ganyushkino (Atyrau region).

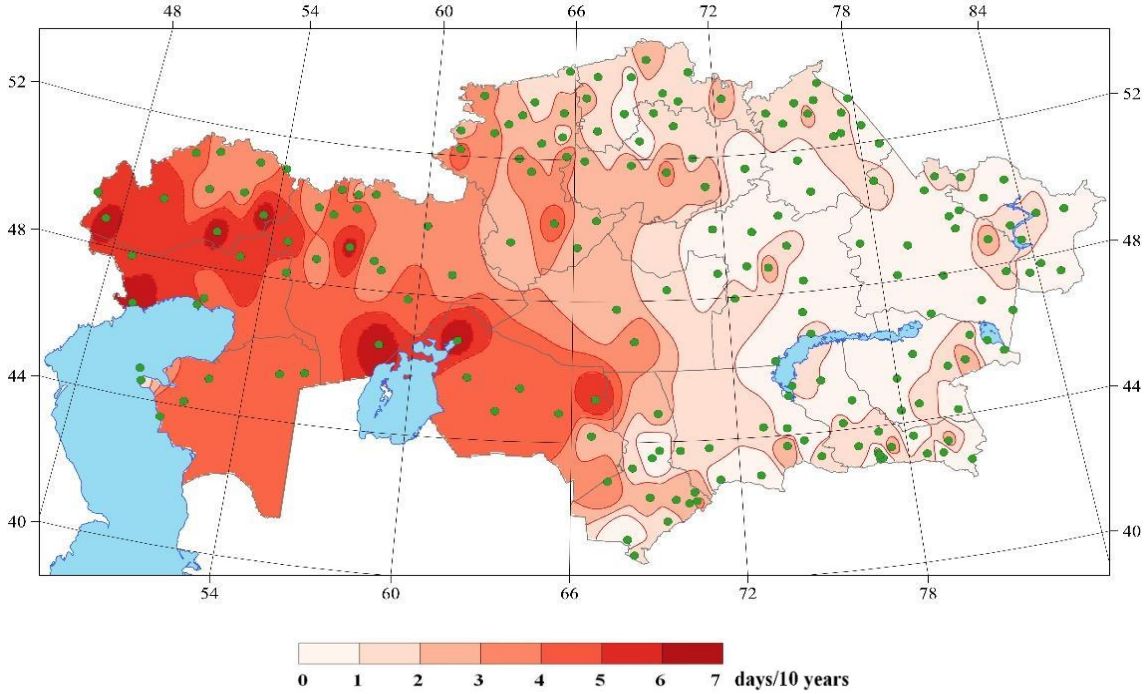


Figure 2.24 *– Rates of change in the total annual duration of warm spells (days/10 years) for the period 1961–2025 (WSDI index)*

As a consequence of rising air temperatures in most months of the warm period of the year, the need for indoor cooling increases, as characterized by the cold deficit index CDDcold23; in this case, the temperature threshold is 23 °C (CDDcold23 index, Figure 2.25). Only in the north and northeast of the country are there small pockets with some decrease in the cold deficit – at seven meteorological stations in the Akmola, North Kazakhstan, and Pavlodar regions. Over the rest of the country, the cold deficit is increasing; in the western parts, the southwest, and the south, the rate of increase mostly exceeds 15 degree-days every 10 years. The largest increase is observed in the western and southern parts of the country – from 30 to 54 degree-days/10 years, with the largest value recorded at MS Kyzylorda.

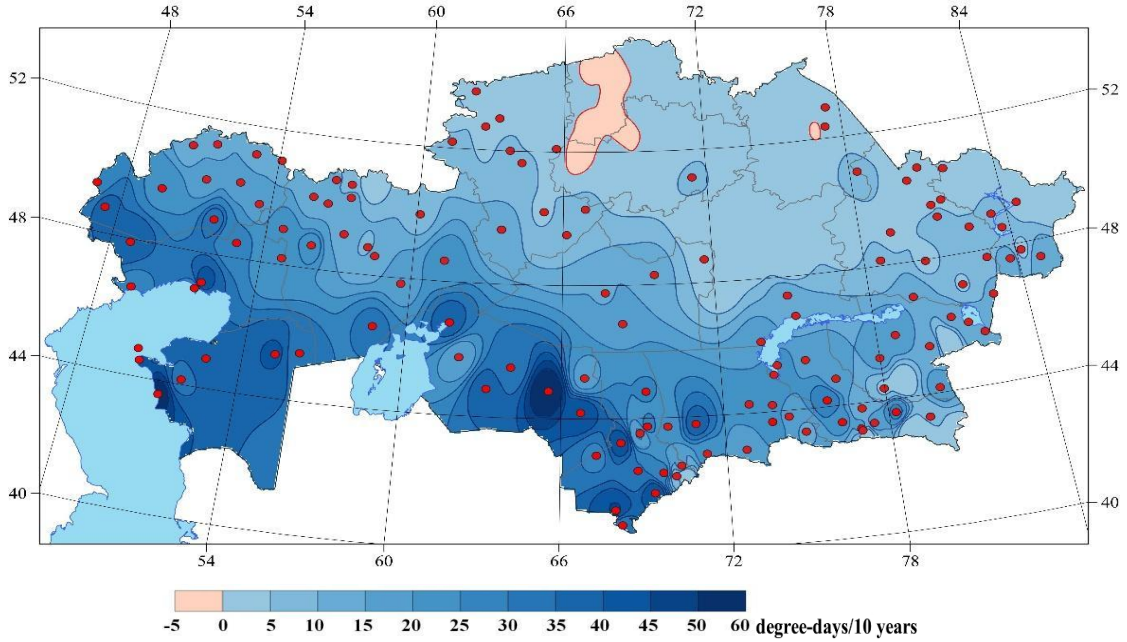


Figure 2.25 *– Rates of change in the cold deficit (degree-days/10 years) for the period 1961–2025 (CDDcold23 index)*

Figure 2.26 shows the *change in the number of days when the minimum temperature is ≥ 20 °C* (*TR index*, number of tropical nights). Over the past more than 60 years, the number of such days in Kazakhstan has mostly increased, and no negative trends were identified at any meteorological station. The highest rates, of 4 days/10 years and more, are observed in the western and southwestern parts of the country. In the Mangystau, Atyrau, Kyzylorda, and Turkestan regions, the increase reaches 6.5–7.9 days/10 years, with the largest value recorded at MS Aktau. At the same time, at 66 meteorological stations, including all stations in the North Kazakhstan region, the trend is zero, as no tropical nights occur there.

Thus, conditions for the human body to rest at night from the daytime heat, which, as shown above, is also intensifying, are deteriorating significantly in these areas.

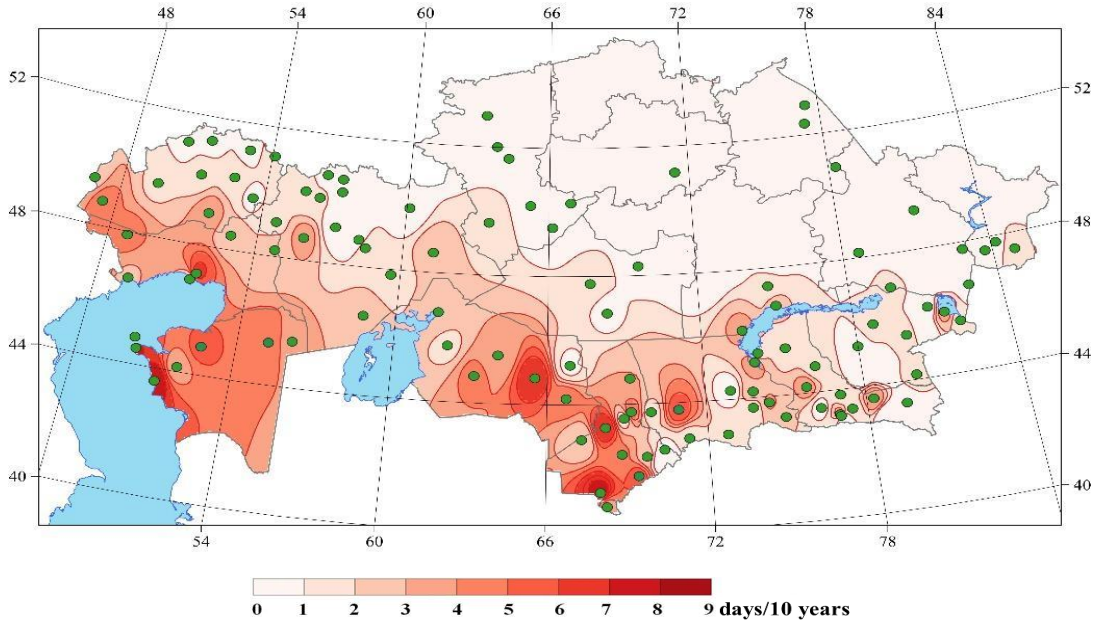


Figure 2.26 – *Rates of change in the number of tropical nights (days/10 years) for the period 1961–2025 (TR index)*

As a consequence of rising air temperatures, throughout Kazakhstan there is a decrease in the *number of days per year when the daily minimum temperature is equal to or below 0 °C* (frost days, *FD0 index*, Figure 2.27) and, almost everywhere, in the *number of days with temperatures below minus 2 °C* (hard frosts, *TNltm2 index*, Figure 2.28). The rate of decrease varies across the territory, mainly from 1 to 4 days/10 years, reaching 5–6.5 days per 10 years in places – at meteorological stations in the Turkestan, Zhambyl, and Mangystau regions.

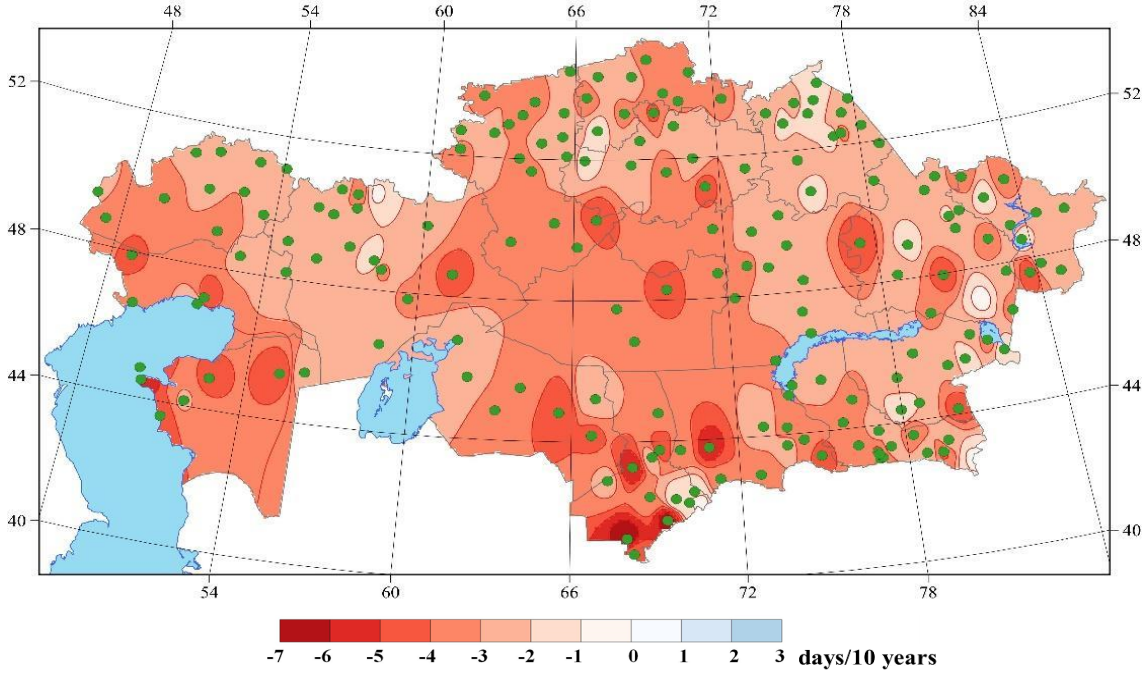


Figure 2.27 *– Rates of change in the number of frost days (days/10 years) for the period 1961–2025 (FD0 index)*

The *number of days with very severe frosts* (when the daily minimum air temperature is below minus 20 °C, *TNltm20 index*, Figure 2.29) is decreasing almost everywhere in the country. A substantial decrease in the number of such days, by 2–3 days/10 years, is observed in the northwestern and central parts of the country, as well as in the Balkhash area. In the Abay region and in some areas of the East Kazakhstan region, the frequency of days with very severe frosts is decreasing at a faster rate, by 4–5.6 days/10 years, with the largest decrease recorded at MS Akzhar.

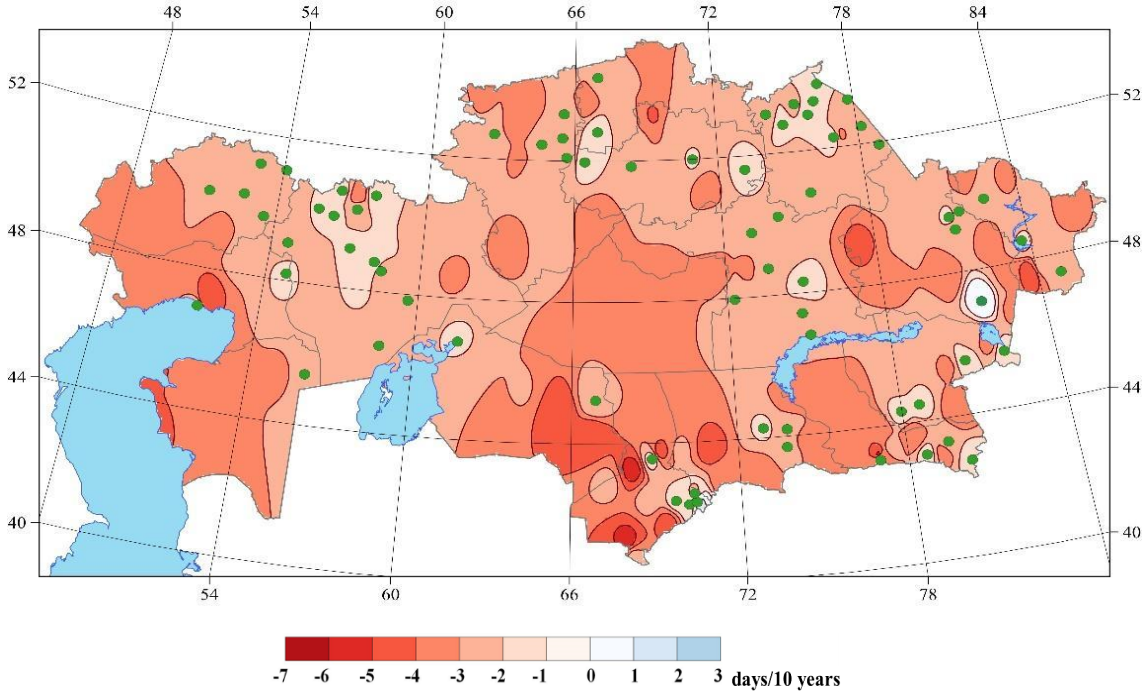


Figure 2.28 *– Rates of change in the number of days with hard frosts (days/10 years) for the period 1961–2025 (TNltm2 index)*

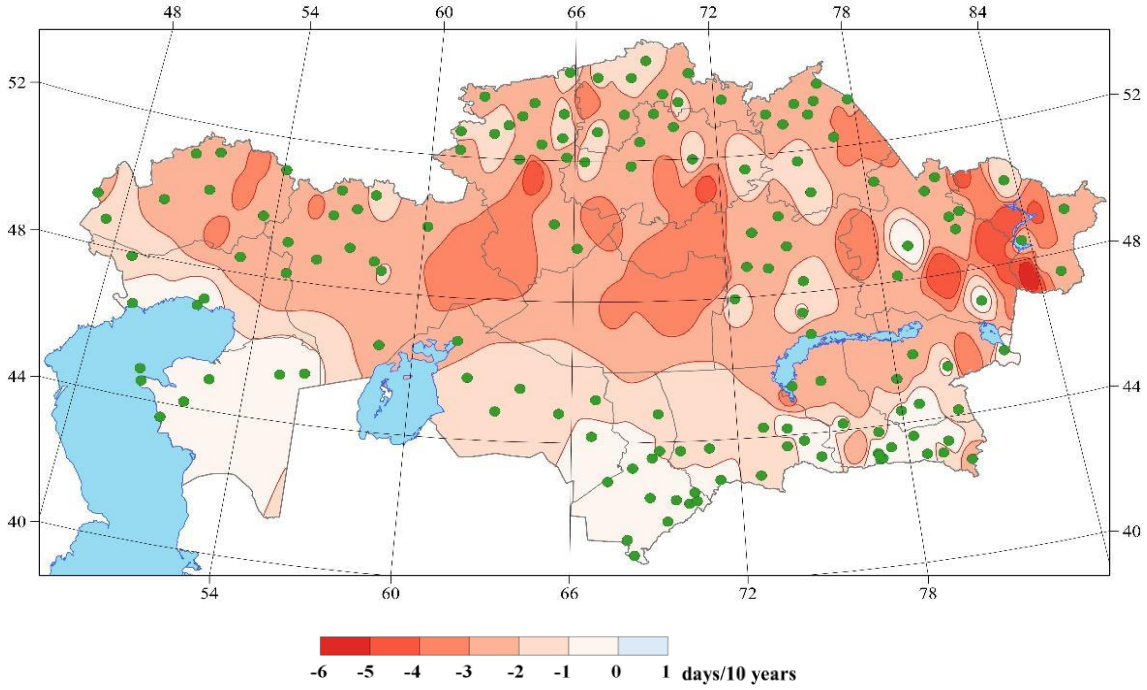


Figure 2.29 *– Rates of change in the number of days with very severe frosts (days/10 years) for the period 1961–2025 (TNltm20 index)*

The decrease in the number of days with sub-zero temperatures leads to a widespread decrease in the *heat deficit during the cold period of the year* (Figure 2.30), which was recorded at all 186 meteorological stations. Here, the threshold air temperature that is desirable to maintain indoors is taken to be 23 °C. Over most of Kazakhstan, the heat deficit is decreasing by 100–130 degree-days every 10 years. In the Karaganda and Turkestan regions, as well as in places in the southeast, the decrease is

smaller, amounting to 60–100 degree-days every 10 years; the smallest decrease was recorded at MS Shuyldak (33 degree-days/10 years). The largest changes were recorded in the West Kazakhstan, Kostanay, Kyzylorda, Aktobe, Almaty, and Abay regions, where the decrease in the heat deficit reaches 130–173 degree-days/10 years.

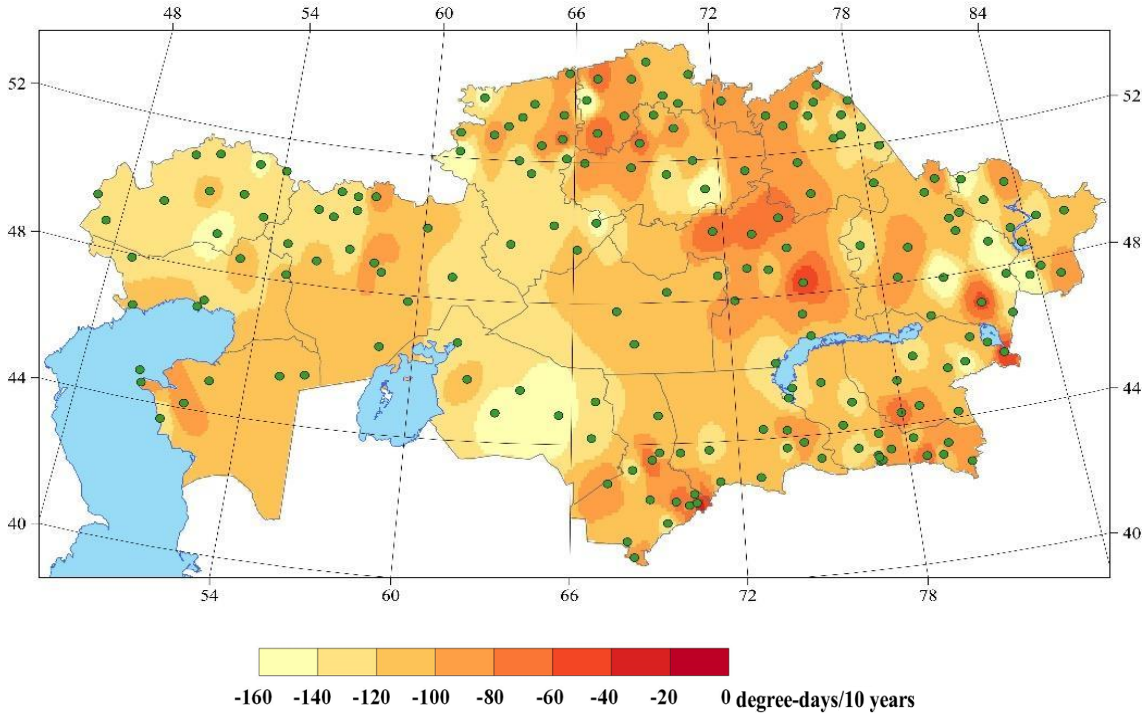


Figure 2.30 *– Rates of change in the heat deficit (degree-days/10 years) for the period 1961–2025 (HDDheat23 index)*

3 ATMOSPHERIC PRECIPITATION

To describe the climatic conditions observed in 2025, including an assessment of the extremity of the precipitation regime and of climate change, data on monthly and daily precipitation totals from about 190 meteorological stations of the Republican Hydrometeorological Fund of RSE "Kazhydromet" were used. Annual, seasonal, and monthly precipitation totals are expressed in mm or as a percentage of the norm for the period 1961–1990. Table 3.1 presents the anomalies of annual and seasonal precipitation totals, and Table 3.2 presents the anomalies of monthly precipitation totals observed in 2025 and averaged over the territory of Kazakhstan as a whole and its regions. For each anomaly value, the probability of non-exceedance calculated for the period 1941–2025 is given. Precipitation anomalies that ranked first or fifth in the observation series are highlighted in bold.

3.1 Precipitation anomalies in 2025

In 2025, the mean annual precipitation total over the territory of Kazakhstan was within the norm and amounted to 93.1 % of the norm, or 295.7 mm (rank 66, probability of non-exceedance 22 %). In 9 regions of the country, precipitation was close to the norm, and in 3 regions it was in excess (more than 120 %). The maximum annual precipitation was observed over the Akmola, North Kazakhstan, and Pavlodar regions, amounting to 121–131 % of the norm, with the mean precipitation depth reaching 384.3–439.9 mm; however, only for the Pavlodar region was 2025 among the 10 % of extremely wet years (Table 3.1).

Over most of Kazakhstan in 2025, precipitation was within or below the norm (Figure 3.1). Hotspots of the highest precipitation relative to the norm were located in the northern (126–160 % of the norm), eastern (127–142 % of the norm), and southwestern (135–150 % of the norm) parts of the country. The largest annual precipitation deficit was observed in the south of the Kostanay region, where 29–30 % of the norm fell; small pockets of precipitation deficit were also observed in the southern regions of the country (22–44 % of the norm).

A record annual precipitation total of 72.1 mm was registered at the Amangeldy meteorological station in the Kostanay region, and at MS Torgay the year was among the 5 % of extremely dry years (Figure 3.1). In addition, according to data from 9 meteorological stations in the Zhambyl (MS Korday, MS Uyuk, MS Saudakent), Turkestan (MS Aul T. Ryskulov, MS Shymkent, MS Tasaryk, MS Sholakkorgan), and Almaty (MS Aksengir, MS Aidarli) regions, located in the south of the country, the record values of minimum annual precipitation were updated (Annex 2). Excess precipitation (10 % extremes) was recorded at 20 MS located in the southwestern, northern, and eastern parts of the country, and extremely wet conditions (5 % extremes) were observed at 8 meteorological stations.

On average over the territory of Kazakhstan, 58.2 mm and 85.3 mm of precipitation fell in the winter and summer periods, respectively, which amounted to 92.0 % and 97.0 % of the seasonal norm. The moisture regime of spring 2025 as a whole was also within the norm: 75.7 mm of precipitation fell, or 86.7 % of the norm (rank 62, Table 3.1).

Table 3.1 – Regionally averaged mean annual (January–December) and seasonal precipitation anomalies in 2025: **vR** – *deviations from the long-term means for 1961–1990, mm/season;* ***P(r≤R$_{2025}$)*** *– probability of non-exceedance (in parentheses) calculated from data for the period 1941–2025, %;* ***RR*** *– ratio of* R_{2025} to the norm, %

Region	Year		Winter		Spring		Summer		Autumn	
	vR (P)	RR	vR (P)	RR	vR (P)	RR	vR (P)	RR	vR (P)	RR
Kazakhstan	-22.0 (22)	93.1	-5.1 (36)	92.0	-11.6 (27)	86.7	-2.7 (41)	97.0	-11.6 (34)	85.3
Abay	24.1 (66)	108.4	9.2 (65)	116.0	-4.4 (46)	93.6	-1.4 (46)	98.4	22.9 (85)	130.4
Almaty	**-132.8 (5)**	72.4	-11.2 (21)	82.6	-21.9 (32)	87.7	**-73.3 (1)**	47.0	-31.0 (20)	69.3
Akmola	69.5 (84)	121.4	19.9 (83)	142.0	15.5 (79)	122.4	24.4 (70)	118.8	4.2 (58)	105.4
Aktobe	-4.8 (46)	98.2	-0.1 (47)	99.8	5.2 (58)	108.1	11.8 (65)	117.3	-32.3 (9)	55.2
Atyrau	-3.5 (34)	97.6	-0.6 (38)	98.0	-9.6 (26)	74.5	21.0 (80)	151.7	-17.8 (13)	55.9
East Kazakhstan	69.9 (83)	117.7	10.5 (70)	116.9	9.3 (51)	110	14.5 (65)	111.3	29.6 (86)	126.7
Zhambyl	**-166.3 (0)**	45.4	**-31.9 (4)**	56.6	**-79.8 (0)**	33.1	-15.4 (16)	59.7	-44.9 (2)	39.3
Zhetysu	-52.1 (21)	86.4	-5.4 (33)	92.5	-6.6 (44)	94.4	-38.9 (7)	57.6	-14.5 (44)	85.6
West Kazakhstan	-15.8 (45)	94.4	-21.8 (16)	66.7	3.5 (48)	106.1	-3.0 (53)	96.3	-2.8 (46)	96.4
Karaganda	-30.2 (28)	88.1	3.9 (67)	107.7	-20.2 (13)	68.8	-4.0 (40)	94.9	-12.1 (40)	80.5
Kostanay	12.5 (55)	104.3	-11.6 (22)	76.2	8.9 (57)	114.9	9.3 (64)	108.7	-5.8 (48)	92.1
Kyzylorda	-29.6 (23)	79.1	6.5 (65)	116.2	-21.6 (16)	55.9	2.2 (60)	111.5	**-23.5 (4)**	29.2
Mangystau	-24.1 (44)	83.1	10.8 (79)	145.0	5.4 (70)	111.6	-24.4 (22)	29.5	-20.9 (13)	44.0
Pavlodar	91.5 (91)	131.3	-7.9 (26)	82.5	3.7 (57)	106.7	46.7 (80)	138.7	32.7 (92)	145.2
North Kazakhstan	87.3 (84)	124.7	11.1 (79)	123.4	**51.2 (98)**	178.1	22.5 (66)	114.8	1.6 (57)	101.9
Turkestan	**-196.0 (0)**	55.1	-42.9 (10)	71.5	**-106.8 (0)**	36.2	-15.8 (14)	34.8	**-67.5 (1)**	28.1
Ulytau	-61.9 (10)	71.3	-16.0 (22)	69.5	-23.5 (15)	60.4	-9.9 (36)	81.7	-23.9 (13)	51.9

Notes: *1. For the Mangystau region, the assessment is based on data from MS Fort-Shevchenko only;*
2. values above the 95th or below the 5th percentile are highlighted in bold and bright color;
3. values above the 90th or below the 10th percentile are highlighted in pale color;
4. mean precipitation anomalies were obtained by averaging data from 121 stations in Kazakhstan.

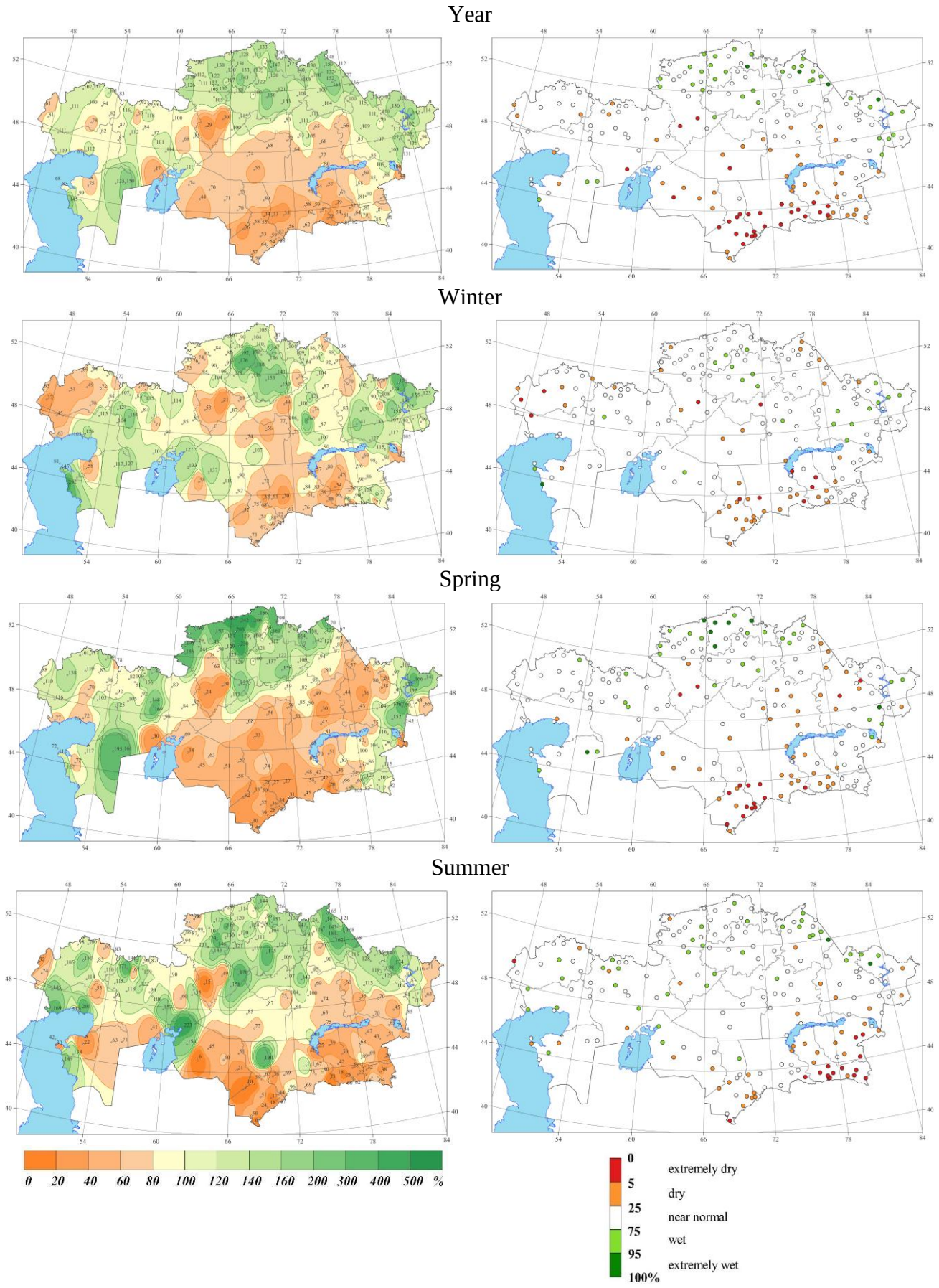


Figure 3.1 *– Geographical distribution of annual and seasonal precipitation in 2025, expressed as % of the norm (left), and its probability of non-exceedance (right), calculated for the period 1961–2025. Sheet 1*

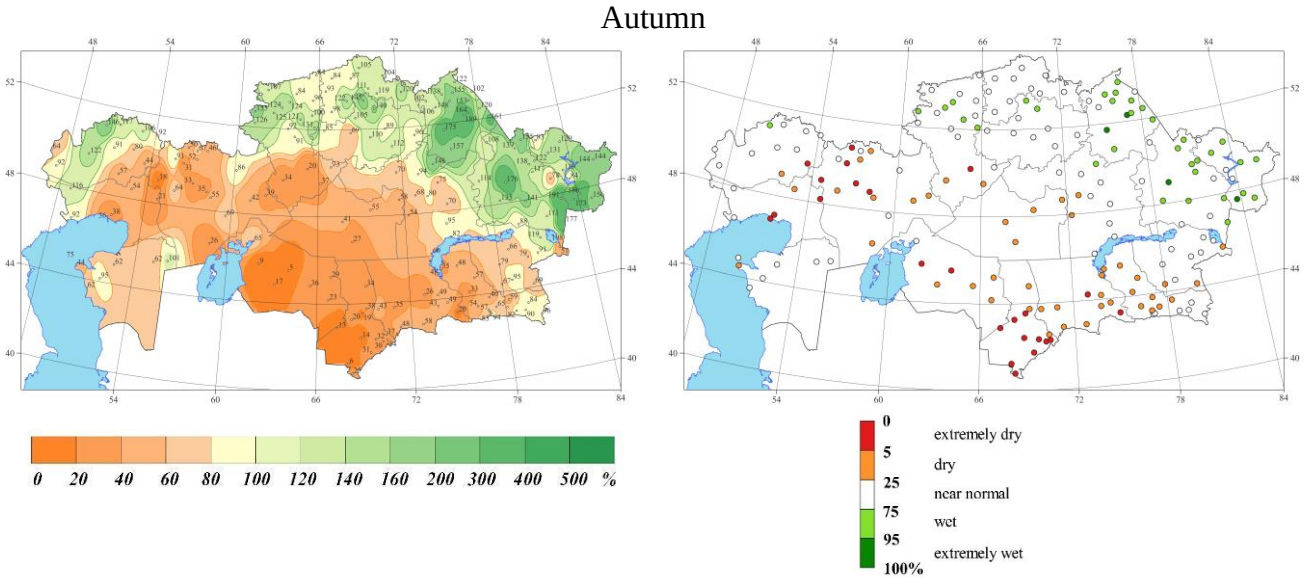


Figure 3.1 *– Geographical distribution of annual and seasonal precipitation in 2025, expressed as % of the norm (left), and its probability of non-exceedance (right), calculated for the period 1961–2025. Sheet 2*

Figure 3.1 shows the spatial distribution of annual and seasonal precipitation in 2025, expressed as a percentage of the norm for the period 1961–1990, as well as the probabilities of non-exceedance of annual and seasonal precipitation totals.

Figure 3.2 presents the intra-annual distribution of precipitation in 2025 averaged over the territory of Kazakhstan, as well as the long-term mean monthly precipitation for the period 1961–1990.

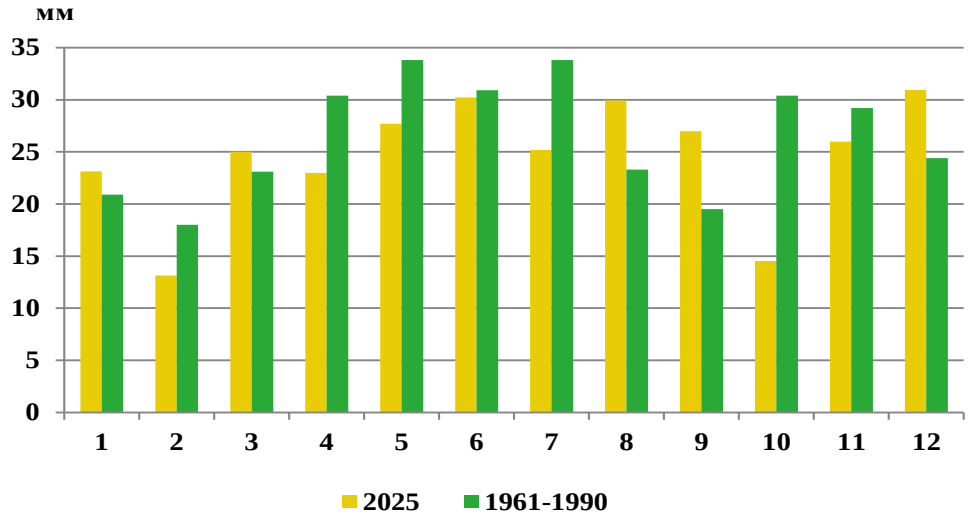


Figure 3.2 *– Monthly precipitation totals averaged over the territory of Kazakhstan in 2025 and their norms calculated for the period 1961–1990*

In 2025, excess precipitation was observed in Kazakhstan in January, March, August, September, and December, whereas in the other months of the year (February, April–July, and October–November) moisture levels were below the norm (Figure 3.2). September 2025 was extremely wet: the mean precipitation depth over the country was 27.0 mm, or 138.4 % of the norm, which corresponds to the 90th percentile (this is the 8th wettest month; the record of 37.9 mm was registered in 1946). In addition, in August an average of 29.9 mm fell over the country, or 128.4 % of the norm, and in December precipitation amounted to 30.9 mm, or 126.8 % of the norm, placing it among the 19 wettest months. In

January (23.1 mm, 110.7 % of the norm) and March (25 mm, 108.2 % of the norm), the mean monthly precipitation total was within the norm. A precipitation deficit was observed in February, April, July, and October. In February, the mean precipitation over the country was 13.1 mm (72.9 % of the norm), in April 23 mm (75.6 % of the norm), in July 25.2 mm (74.5 % of the norm), and in October 14.5 mm (47.7 % of the norm), corresponding to probabilities of non-exceedance of 16 %, 26 %, 21 %, and 7 %, respectively.

Winter 2024/2025 (December 2024 – February 2025) in Kazakhstan was characterized by mean precipitation within the norm (Table 3.1), amounting to 92.0 % of the norm (rank 54). Excess precipitation (more than 120 % of the norm) was observed in some areas in all parts of the country (Figure 3.1): in the west of the country (124–202 % of the norm), in the northern parts (136–192 % of the norm), in the east (123–176 % of the norm), in the center (121–160 % of the norm), and over most of the Kyzylorda region (127–137 % of the norm). Excess precipitation was observed at the Aktau meteorological station in the Mangystau region, where the winter was among the 5 % of extremely wet winter periods. Alongside the wet zones, the largest pockets of precipitation deficit (21–78 % of the norm) were observed over most of the western and southern parts of the country, as well as in some areas of the northwestern and central parts. According to data from 16 meteorological stations located in some areas of the western, northern, central, and southern parts of Kazakhstan, winter precipitation was characterized by 10 % dry extremes. In winter, new precipitation minimums were registered at MS Amangeldy in the Kostanay region (11 mm, 20.5 % of the norm), as well as at MS Uyuk (18.3 mm, 30.3 % of the norm) and MS Korday (37.7 mm, 40 % of the norm) in the Zhambyl region.

In December 2024, precipitation was unevenly distributed over the country (Figure 3.2); the averaged relative precipitation anomaly was 90.2 % of the 1961–1990 norm, or 2.4 mm below the norm (probability of non-exceedance 39 %, Table 3.2). A precipitation deficit was observed in the western, northwestern, and southern parts of the country. Excess precipitation (more than 120 % of the norm) was observed in the Akmola, Karaganda, East Kazakhstan, Abay, and Zhetysu regions. Regional pockets of extreme wetness formed in the Mangystau (190 % of the norm), Akmola, and Karaganda regions (162–175 % of the norm), in the eastern part of the country (151–188 % of the norm), in the north of the Aral Sea area (149 % of the norm), south of Lake Balkhash (149 % of the norm), and in the mountainous areas of East Kazakhstan (130–188 % of the norm). A significant moisture deficit (30–70 % of the norm) was observed over most of the West Kazakhstan, Atyrau, Aktobe, Kostanay, Kyzylorda, Turkestan, and Ulytau regions. Individual pockets of precipitation deficit were recorded in the east of the Kostanay region (19 % of the norm) and in the central part of the Kyzylorda region (15 % of the norm).

Table 3.2 – Regionally averaged monthly precipitation anomalies in 2025, calculated as deviations from the long-term means for 1961–1990 (in mm), and *the probability of non-exceedance (in parentheses) calculated from data for the period 1941–2025 and expressed in %*

Region	12 (2024)	1	2	3	4	5	6	7	8	9	10	11
Kazakhstan	-2.4 (39)	2.2 (61)	-4.9 (16)	1.9 (55)	-7.4 (26)	-6.1 (29)	-0.7 (46)	-8.6 (21)	6.6 (70)	7.5 (90)	-15.9 (7)	-3.2 (46)
Abay	6.0 (71)	14.1 (94)	**-10.9 (5)**	8.5 (79)	-6.4 (20)	-6.5 (45)	-5.0 (34)	-21.8 (7)	25.4 (92)	**33.5 (100)**	-17.3 (14)	6.7 (69)
Almaty	0.4 (51)	1.7 (59)	**-13.4 (0)**	9.5 (70)	-17.9 (29)	-13.5 (34)	**-32.7 (5)**	**-30.7 (5)**	-9.9 (22)	16.6 (89)	-29.5 (7)	-18.1 (10)
Akmola	6.3 (70)	16.8 (94)	-3.1 (38)	12.4 (84)	3.2 (64)	0.0 (52)	15.1 (72)	0.7 (57)	8.7 (71)	6.5 (66)	**-27.0 (1)**	**24.6 (95)**
Aktobe	-10.4 (21)	-4.5 (38)	14.8 (92)	-1.4 (36)	12.9 (86)	-6.3 (32)	6.9 (71)	3.1 (63)	1.7 (61)	-9.7 (28)	-18.0 (10)	-4.7 (39)

Region	12 (2024)	1	2	3	4	5	6	7	8	9	10	11
Atyrau	-1.1 (45)	-1.6 (32)	2.1 (58)	2.1 (64)	-1.2 (54)	**-10.6 (4)**	**25.1 (98)**	-3.2 (55)	-0.9 (55)	-9.8 (13)	6.5 (70)	**-14.5 (5)**
East Kazakhstan	4.6 (71)	17.0 (92)	-11.0 (7)	5.0 (67)	7.1 (58)	-2.8 (52)	1.9 (59)	-12.1 (25)	24.6 (88)	**35.4 (96)**	-15.0 (27)	9.3 (72)
Zhambyl	-9.7 (26)	-7.7 (17)	**-14.5 (2)**	-16.2 (15)	-35.9 (7)	**-27.7 (4)**	-14.9 (8)	1.3 (59)	-1.8 (50)	-6.2 (26)	-15.2 (29)	**-23.5 (3)**
Zhetysu	0.7 (54)	7.3 (73)	**-13.4 (2)**	20.6 (82)	-8.3 (40)	-19.0 (21)	-23.8 (9)	-22.5 (13)	7.4 (72)	10.6 (83)	-14.1 (40)	-11.0 (34)
West Kazakhstan	-10.7 (29)	-10.9 (16)	-0.3 (50)	-0.1 (46)	-5.9 (29)	9.5 (69)	7.5 (73)	-3.6 (44)	-6.9 (42)	-12.5 (23)	28.2 (92)	-18.4 (20)
Karaganda	2.8 (64)	7.9 (82)	-6.8 (25)	-2.8 (36)	-2.9 (40)	-14.4 (23)	2.1 (54)	-13.7 (22)	7.7 (70)	15.1 (91)	**-22.6 (1)**	-4.5 (42)
Kostanay	-11.3 (11)	-3.2 (45)	2.9 (69)	-0.5 (47)	-0.5 (46)	9.9 (69)	5.7 (64)	3.3 (66)	0.3 (51)	6.6 (73)	**-20.1 (5)**	7.7 (79)
Kyzylorda	-2.1 (48)	0.8 (47)	7.7 (79)	-0.5 (54)	-13.7 (10)	-7.5 (23)	0.3 (64)	-3.4 (36)	5.2 (83)	0.6 (72)	**-12.7 (0)**	-11.4 (7)
Mangystau	10.4 (88)	-0.5 (42)	0.9 (66)	28.8 (97)	-13.4 (21)	-10.0 (50)	-8.3 (52)	-8.5 (27)	-7.6 (35)	-0.8 (59)	-8.4 (21)	**-11.7 (4)**
Pavlodar	-2.8 (26)	1.8 (66)	-6.9 (16)	0.7 (52)	12.6 (80)	-9.6 (25)	31.4 (91)	-16.9 (17)	32.2 (92)	9.7 (69)	-5.6 (47)	**28.6 (98)**
North Kazakhstan	2.0 (55)	4.3 (77)	4.7 (80)	11.4 (86)	-3.3 (41)	43.1 (100)	6.5 (63)	3.2 (58)	12.8 (70)	9.0 (71)	**-27.2 (1)**	19.8 (90)
Turkestan	-9.5 (36)	-11.5 (27)	-22.0 (9)	-21.6 (19)	**-53.1 (2)**	**-32.1 (5)**	-6.2 (23)	-8.4 (7)	-1.3 (64)	-6.9 (11)	-26.6 (16)	**-34.1 (5)**
Ulytau	-4.2 (38)	-3.8 (47)	-8.1 (16)	-8.3 (20)	0.7 (57)	-15.9 (15)	0.6 (58)	-8.9 (35)	-1.6 (52)	3.1 (73)	**-20.1 (2)**	-7.0 (23)

Notes: *1. For the Mangystau region, the assessment is based on data from MS Fort-Shevchenko only;*

2. values above the 95th or below the 5th percentile are highlighted in bold and bright color;

3. values above the 90th or below the 10th percentile are highlighted in pale color;

4. mean precipitation anomalies were obtained by averaging data from 121 stations in Kazakhstan.

In January, moisture levels over most of the country were also unevenly distributed and within the norm; the mean precipitation was 110.7 % of the norm, or 2.2 mm above the long-term mean (rank 33, Table 3.2). Extremely excessive precipitation over the territory as a whole (more than 165 % of the norm) was recorded in the North Kazakhstan, Akmola, Pavlodar, Karaganda, East Kazakhstan, and Zhetysu regions, as well as in a separate small pocket in the Mangystau region. At meteorological stations located in the mountainous areas of East Kazakhstan, precipitation exceeded the norm by 2.4–3.5 times (244–348 % of the norm) (Figure 3.3). In almost all of the above-mentioned parts of the country, extremely wet conditions were observed at 20 MS, where 5 % and 10 % extremes were registered, including a station record of 32.2 mm at MS Chkalovo (North Kazakhstan region), which amounted to 259.7 % of the norm and broke the 1997 record (31.9 mm, 257.3 % of the norm). In January, a severe precipitation deficit (14–40 % of the norm) covered a significant part of the regions in the western and southern parts of the country and some areas of the Kostanay and Abay regions; in addition, separate small pockets (60–79 % of the norm) were located in the North Kazakhstan, Karaganda, East Kazakhstan, and Ulytau regions. According to data from 9 meteorological stations located in areas with a precipitation deficit, moisture conditions were characterized as “dry” and a 10 % extreme was recorded; at MS Urda (West Kazakhstan region), January was among the 5 % of extremely dry months.

In February, a precipitation deficit was observed over most of the country; the averaged monthly precipitation was 72.9 % of the norm, or 4.9 mm below the long-term mean (rank 71, probability of non-exceedance 16 %, Table 3.2). Considerably more precipitation than normal fell in the Caspian Lowland

(1.3–2.7 times the norm), over most of the western part of the country (1.2–2.2 times the norm), and over most of the Kostanay, North Kazakhstan, and Kyzylorda regions (1.2–1.8 times the norm) (Figure 3.3). According to data from 8 MS, including 6 MS in the Aktobe region, extreme wetness was observed, with 90 % and 95 % extremes registered. A considerable excess over the norm was recorded at MS Aktau (Mangystau region) – 45.7 mm, or 328.8 % of the norm, breaking the 1983 precipitation record (44.8 mm) (Annex 2). A significant moisture deficit (0–79 % of the norm) was observed in the northeastern, central, eastern, southern, and southeastern parts of the country, as well as in the western part of the West Kazakhstan and Atyrau regions, in the south of the Kostanay region, and in the eastern part of the Akmola region. A precipitation deficit was observed at 33 % of meteorological stations across the country (according to data from 63 MS, 10 % extremes were registered), including 31 MS where extreme moisture conditions (5 % extremes) were observed during February. The smallest monthly precipitation (1.1 mm) fell at MS Aul No. 4 (Almaty region), which amounted to 15.8 % of the norm, and February was among the 5 % of extremely dry months. At the same time, record low February precipitation totals were set at MS Kegen (Almaty region) – 1.2 mm, 15.8 % of the norm, MS Kertindy (Karaganda region) – 2.7 mm, 14.8 % of the norm, MS Korday (Zhambyl region) – 4.0 mm, 13.7 % of the norm, and MS Mynzhilki (Almaty region) – 6 mm, 27.1 % of the norm; the previous records dated back to 1992 (3.6 mm), 1957 (8.1 mm), and 1942 (7.9 mm), respectively (Annex 2).

In spring, the mean precipitation over the territory of Kazakhstan was 86.7 % of the norm, with a probability of non-exceedance of 27 % (Table 3.1). Precipitation was unevenly distributed across the country (Figure 3.1). Excess precipitation (more than 120 % of the norm) was observed over most of the western and northern parts of the country, as well as in some areas of the eastern and southeastern parts. According to data from 15 MS located in these parts of the country, 5 % and 10 % extremes were recorded. Significant precipitation hotspots were located in the North Kazakhstan region, in the north of the Kostanay and Pavlodar regions, in the east of the Mangystau region, in the central part of the Aktobe region, and in some areas of East Kazakhstan and the Abay region: the precipitation averaged over the territory was 161–242 % of the norm (probability of non-exceedance 95 % and 100 %), and new maximums of seasonal precipitation were set at 3 meteorological stations located in these areas: MS Presnogorkovka – 134.4 mm, MS Ruzaevka – 152.5 mm, and MS Blagoveshchenka – 154.6 mm; their previous records were set in 2015, 2011, and 1970, respectively (Annex 2). A significant precipitation deficit (20–57 % of the norm) covered most of the southern and central parts of the country and the Abay region, as well as the southern areas of the Aktobe and Kostanay regions and the Alakol Depression. In spring, minimum seasonal precipitation was recorded at 6 meteorological stations across the country: a 5 % extreme was registered, the season was characterized as extremely dry, and the record low values set during 1989–2011 were updated (Annex 2).

In March, the mean precipitation over the territory of Kazakhstan was 108.2 % of the 1961–1990 norm, or 1.9 mm above the long-term mean (rank 38, probability of non-exceedance 55 %, Table 3.2). Excess precipitation was observed over most of the western, northern, eastern, and southeastern parts of the country, as well as in the Balkhash area, where precipitation was 1.3 to 2.8 times the norm (Figure 3.3).

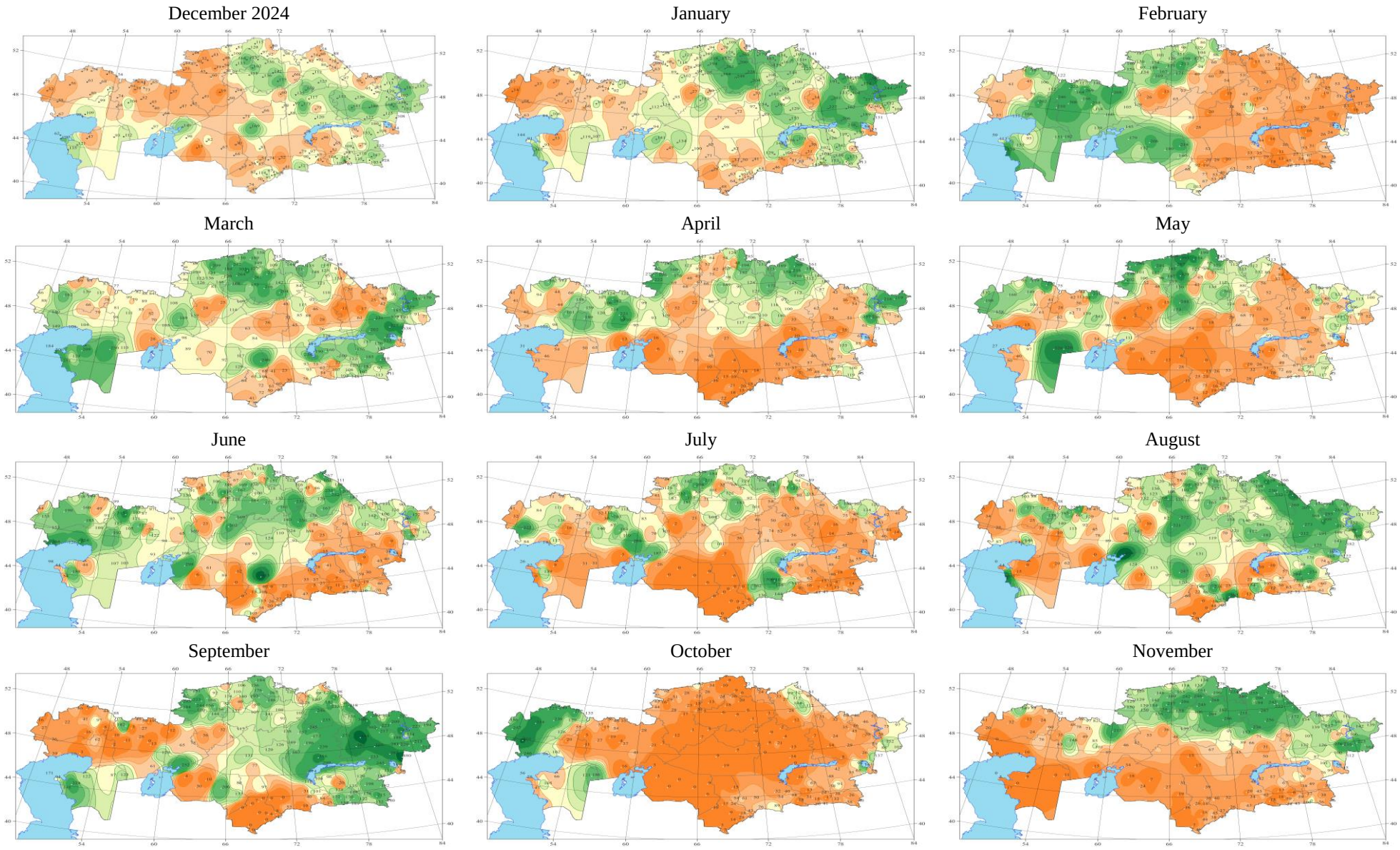


Figure 3.3 – *Spatial distribution of monthly precipitation in 2025 (in % of the norm calculated relative to the base period 1961–1990)*

The largest pockets of significant excess moisture were observed over almost the entire Mangystau region (184–251 % of the norm), in the northeast of the Kostanay region (204 % of the norm), over most of the Akmola and North Kazakhstan regions (168–302 % of the norm), in the mountainous terrain of the East Kazakhstan region (138–253 % of the norm), in the southeast of the Abay region (202–338 % of the norm), in the Alakol Depression (222–234 % of the norm), south of Lake Balkhash (160–234 % of the norm), as well as in the southeast of the Zhetysu region (170–210 % of the norm) and in the north of the Turkestan region (240 % of the norm). At 12 meteorological stations located in these parts of the country, extremely wet conditions were observed, with 5 % and 10 % extremes registered. A significant precipitation deficit covered the south of the Aktobe region (28 % of the norm), the Kostanay region (24–25 % of the norm), most of the Abay region (11–36 % of the norm), and some areas of the Ulytau, Karaganda, Almaty, and Zhambyl regions (28–30 % of the norm). Small pockets of precipitation deficit (below 41–79 % of the norm) were observed in the West Kazakhstan, Atyrau, Pavlodar, East Kazakhstan, Turkestan, and Kyzylorda regions, as well as in the Zhetysu region. According to data from 3 meteorological stations located in the Almaty and Abay regions, March was among the 5 % of extremely dry months.

In April, the mean precipitation over the country was 75.6 % of the norm, which was 7.4 mm below the long-term mean (rank 62, probability of non-exceedance 26 %, Table 3.2). A precipitation deficit (below 70 % of the norm) was observed over most of the country. Large pockets of precipitation deficit (1–54 % of the norm) were observed over most of the western, central, and southern parts of the country, in the North Kazakhstan and Abay regions, and in the south of the Kostanay region (Figure 3.3). Small local pockets were observed in some areas of the Kostanay (63–75 % of the norm), Karaganda (72 % of the norm), East Kazakhstan (71–74 % of the norm), and Zhetysu (64–76 % of the norm) regions. According to data from 10 MS, conditions were characterized as extremely dry (5 % extremes were registered), including a new precipitation minimum of 3.8 mm at the Korday meteorological station in the Zhambyl region, which broke the 2000 record (11.1 mm) (Annex 2). Pockets of significant precipitation (190–310 % of the norm) were observed mainly in the north of the West Kazakhstan region, in the north and center of the Aktobe region, in the northwest of the Kostanay region, in the south of the North Kazakhstan region, in the northern part of the Pavlodar region, in the East Kazakhstan region, and in the border areas of the Abay region; in addition, they were observed in some areas of the West Kazakhstan, Akmola, Karaganda, and Zhetysu regions, where the precipitation averaged over the territory ranged from 120 to 189 % of the norm. At 12 meteorological stations located in these parts of the country, moisture conditions fell into the “wet” category (10 % extremes), including monthly 5 % extremes recorded at 7 meteorological stations.

In May, the precipitation deficit persisted over most of the country, although for the month as a whole precipitation was close to the norm, amounting to 81.9 % (6.1 mm below the long-term mean, Table 3.2). Significant pockets of excess precipitation (179–395 % of the norm) persisted in some areas of the western and northern parts of the country, and small pockets (121–141 % of the norm) were observed in places in the eastern part of the country (Figure 3.3). Four large pockets of wetness were observed in the West Kazakhstan (232 % of the norm), Mangystau (320–326 % of the norm), Kostanay (244–264 % of the norm), and North Kazakhstan (285–395 % of the norm) regions, where the precipitation averaged over the territory ranged from 137.3 to 236.5 %. At 10 MS located in these parts of the country, conditions fell into the “extremely wet” category (5 % extremes were registered). A considerable amount of precipitation, 118.1 mm, fell at MS Blagoveshchenka (North Kazakhstan region), which was 88.2 mm above the long-term mean and set a new maximum. In addition, record

precipitation maximums were registered in May at 3 MS located in the North Kazakhstan and Kostanay regions: MS Presnogorkovka (88.6 mm; the previous record of 84.0 mm was set in 1963), MS Ruzaevka (104 mm; the previous record of 100.2 mm was set in 2007), and MS Yavlenka (96.3 mm; the previous record of 88.6 mm was set in 1940) (Annex 2). Significant pockets of precipitation deficit (below 75 % of the norm) were observed over most of the western, southern, central, and eastern parts of the country, and small pockets were observed in some areas of the northern part of the country (Figure 3.3). A severe precipitation deficit (0–20 % of the norm) was observed in the Caspian area, in the east of the Aktobe region, in the south of the Kostanay region, in the west of the Pavlodar region, in the center of the Ulytau region, over most of the Kyzylorda and Turkestan regions, in some areas of the Zhambyl and Almaty regions, and in the Alakol Depression. According to data from 29 MS, 5 % and 10 % precipitation extremes were registered in May, including monthly precipitation minimums at MS Korday (6.8 mm) in the Zhambyl region and MS Shcherbakty (1.1 mm) in the Pavlodar region (the previous record minimums were observed in 1953 and 1974), while at MS Tasty (Turkestan region) no precipitation fell during the month (Annex 2).

In summer, precipitation was unevenly distributed over the country; the mean precipitation was 97.0 % of the norm (probability of non-exceedance 41 %, Table 3.1). In summer, large pockets of excess moisture (more than 170 % of the norm) were observed in some areas of the Atyrau, Aktobe, Kostanay, Akmola, Pavlodar, East Kazakhstan, and Turkestan regions and in the Aral Sea area. At 4 MS located in these areas, a 5 % extreme was recorded (Figure 3.1). At MS Aral Sea in the Kyzylorda region, the norm was exceeded by more than 2 times: 57.9 mm fell, which amounted to 223 % of the norm. Small pockets of precipitation deficit (50–75 % of the norm) were located in some areas of the western, northern, central, eastern, and southern parts of the country. Zones of severe precipitation deficit (0–47 % of the norm) were observed in some areas of the Mangystau and West Kazakhstan regions, in the south of the Kostanay and Abay regions, and over most of all the southern regions. According to data from 27 MS located in these areas, a low level of moisture (10 % extreme) was recorded, and 17 of these meteorological stations fell into the “extremely dry” category (5 % extreme). At 3 meteorological stations in the Almaty region (Narynkol, Kamenskoe Plato, and Aksengir), new minimums of summer precipitation were registered, breaking the seasonal records of 1984 and 2002. A significant monthly precipitation deficit persisted in many areas throughout all three summer months and, including April and May, for 5 consecutive months; at MS Zhetysay, no precipitation was recorded during the entire summer period (Annex 2).

In June, the mean precipitation over the territory of Kazakhstan was 97.8 % of the norm, which was 0.7 mm below the long-term mean (Table 3.2). Precipitation was unevenly distributed across the country (Figure 3.3). A significant precipitation deficit (0–30 % of the norm) covered most of the southern parts of the country, as well as the south of the Kostanay region, the center of the Karaganda region, and some areas of the Balkhash area. Small pockets of precipitation deficit (below 38–75 % of the norm) were observed in some areas of the Mangystau, West Kazakhstan, Aktobe, Kostanay, North Kazakhstan, Pavlodar, East Kazakhstan, and Karaganda regions, as well as the Ulytau region. In the Almaty (probability of non-exceedance 5 %), Zhambyl (probability of non-exceedance 8 %), and Zhetysu (probability of non-exceedance 9 %) regions, the precipitation averaged over the territory ranged from 24 % to 47.4 % of the norm, which was 14.9 mm to 32.7 mm below the long-term mean, respectively. According to data from 22 meteorological stations located in these areas, June was among the 5 % and 10 % driest Junes (Table 3.2); at the Kyzylkum and Zhetysay (Turkestan region) and Shieli (Kyzylorda region) meteorological stations, no precipitation was recorded during the month (Annex 2).

At the Aidarli and Kamenskoe Plato meteorological stations, located in the Almaty region, new June precipitation records were set (Annex 2). Excess precipitation in June was observed over most of the West Kazakhstan (183–190 % of the norm), Atyrau (192–324 % of the norm), Akmola (172–233 % of the norm), and Pavlodar (205–267 % of the norm) regions, in the north and center of the Aktobe region (177–315 % of the norm), in the center and south of the Kostanay region (190–202 % of the norm), in the east of the North Kazakhstan region (181 % of the norm), in the northern areas of the Karaganda (250 % of the norm), Turkestan (433 % of the norm), and Kyzylorda (298 % of the norm) regions, as well as in some areas of the East Kazakhstan region (Figure 3.3). Extremely high precipitation (90 % and 95 % extremes) was recorded at 11 MS in these parts of the country.

In July, a precipitation deficit was observed over most of Kazakhstan; the mean precipitation was 74.5 % of the norm, or 8.6 mm below the long-term mean (rank 67 in the observation series since 1941, probability of non-exceedance 21 %, Table 3.2). A precipitation deficit (below 70 % of the norm) was observed over most of the country (Figure 3.3). The precipitation deficit (less than 60 % of the norm), in places extreme (less than 40 % and even less than 20 % of the norm) and record-breaking (less than 6 % of the norm), covered most of the western, southern, central, and eastern parts of the country, as well as the adjacent southern parts of the Kostanay and Pavlodar regions; the precipitation averaged over the territory of the regions was 3.4 mm to 30.7 mm below the norm (5 % extremes were registered). According to data from 16 MS located in the Turkestan (Zhetysay, Kyzylkum, Kazygurt, Arys, Sholakkorgan, Shymkent, Shardara, Turkestan, and Ashysai), Kyzylorda (Karak, Kyzylorda, Zhosaly, and Zlikha), Zhambyl (Korday and Saudakent), and Mangystau (Aktau) regions, no precipitation was recorded during the month (Annex 2). At the Almaty meteorological station in the Almaty region, a monthly precipitation minimum of 2.30 mm (7.3 % of the norm) was set, breaking the 1943 record (3 mm) (Annex 2). In July, pockets with precipitation considerably exceeding the norm (by 1.5–2.5 times) were located in the north of the Atyrau and Pavlodar regions, over most of the Aktobe region, in the center of the Kostanay region and the adjacent border area of the North Kazakhstan region, in the center and south of the Zhambyl region, and in the Aral Sea area; the moisture level averaged over the territory ranged from 184 % to 306 % of the norm. According to data from MS Zhaltyr (Akmola region) and MS Sarykol and Kushmurun (Kostanay region), moisture conditions in July were characterized as “extremely wet”, with 5 % extremes recorded.

In August, the mean precipitation over the territory of Kazakhstan was 128.4 % of the norm, with a probability of non-exceedance of 70 % (Table 3.2). Pockets of excess precipitation exceeding the norm by almost 4 times were observed in all parts of the country (Figure 3.3). The largest precipitation pockets were observed in the Pavlodar (312–329 % of the norm), Zhambyl (362 % of the norm), Mangystau (403 % of the norm), Kyzylorda (454 % of the norm), and Abay (309 % of the norm) regions. The moisture level averaged over the territory of the Abay region fell within the 10 % of extremely wet cases and amounted to 222.5 % of the norm. According to data from 26 meteorological stations located in these areas, August 2025 was wet (10 % extreme), and “extremely wet” conditions (5 % extremes) were recorded at 16 of these MS. At the Shaldai meteorological station in the Pavlodar region, the 2013 precipitation record (85.9 mm) was broken: 96.9 mm fell, which amounted to 311.6 % of the norm (Annex 2). A significant precipitation deficit (3–77 % of the norm) covered many areas of the western and southern regions, and relatively small pockets of deficit were observed in the north and center of the country. The values averaged over the territory of the regions were as follows: Mangystau – 13.6 % of the norm, Almaty – 67.6 % of the norm, West Kazakhstan – 70.3 % of the norm, Turkestan – 70.7 % of the norm, and Zhambyl – 74.8 % of the norm, which was 1.8 mm to 9.9 mm below the long-term mean.

According to data from 9 meteorological stations in these areas, August was among the 5 % and 10 % driest months (Figure 3.3), and at 8 meteorological stations no precipitation fell during the whole of August (Annex 2).

In autumn, the mean precipitation depth over the territory of Kazakhstan was 85.3 % of the norm, or 67.5 mm. Although the averaged precipitation was within the norm, a precipitation deficit prevailed over most of the country (Figure 3.1). The main pockets of precipitation deficit (5–60 % of the norm) were located over most of the Mangystau, Atyrau, Aktobe, Kostanay, Kyzylorda, Turkestan, Zhambyl, Almaty, and Ulytau regions, with the values averaged over the territory of these regions ranging from 29.2 to 69.3 % of the norm. Small pockets of precipitation deficit (64–79 % of the norm) were observed in some areas of the West Kazakhstan, Akmola, and Karaganda regions, as well as the Abay and Zhetysu regions. According to data from 69 meteorological stations located in these areas, 5 % and 10 % extremes were observed, including new minimums of autumn precipitation registered at 5 meteorological stations: 12.2 mm and 23.8 mm were recorded at MS Uil and MS Ilyinsky (Aktobe region) (the previous minimums of 12.3 mm and 24.6 mm were observed in 1937 and 1991, respectively); MS Kazaly (Kyzylorda region), with 3.4 mm, broke the 1992 minimum (3.9 mm); 6.8 mm was recorded at MS Arys (Turkestan region) (the previous minimum was observed in 2002); and MS Korday (Zhambyl region), with 22.9 mm, broke the 2005 minimum (29.4 mm). Excess precipitation averaged over the territory of the regions was observed in the Pavlodar, East Kazakhstan, and Abay regions, where the averaged moisture level ranged from 126.7 to 145.2 % of the norm, making this autumn the 7th, 12th, and 13th wettest in the observation series, respectively. In addition, small pockets of excess precipitation were located in some northern areas of the West Kazakhstan, Kostanay, and Akmola regions (Figure 3.1). According to data from 21 MS, conditions over most of the northern and northeastern parts of the country and in some areas of the western and central parts were wet (10 % extremes); 5 % extremes were recorded at 6 MS, including a record seasonal precipitation total at MS Pavlodar (Pavlodar region).

In September, precipitation was unevenly distributed over the country; its mean value was 138.4 % of the norm (probability of non-exceedance 90 %, the 8th wettest September in the observation series), which was 7.5 mm above the long-term mean (Table 3.2). Areas with excess precipitation covered most of the northwestern, northern, northeastern, and central parts of the country (144–440 % of the norm), some areas of the Mangystau, Aktobe, Almaty, and Kyzylorda regions (155–252 % of the norm), the area north of Lake Balkhash (274–299 % of the norm), the Alakol Depression (189 % of the norm), and the mountainous areas of the southeastern part of the country (131–215 % of the norm) (Figure 3.3). At 43 MS located in these areas, conditions were characterized as very wet (5 % and 10 % extremes were recorded), including record maximums of monthly precipitation set at 4 meteorological stations in the Pavlodar region (MS Ekibastuz) and the Abay region (MS Shar, Karauyl, and Ayagoz) (Annex 2). Large pockets of precipitation deficit (less than 40 % of the norm), in addition to the Mangystau region, covered all of the western parts of the country, the south of the Kostanay region, the central part of the Kyzylorda region, and almost the entire Turkestan and Zhambyl regions (Figure 3.3). Small areas with a precipitation deficit (40–77 % of the norm) were observed in some parts of the northern, central, and southeastern regions. According to data from 12 MS located in these areas, conditions fell into the “extremely dry” category (5 % extremes were registered), and according to data from 11 MS, no precipitation fell during September. A severe precipitation deficit averaged over the territory of the regions was observed in the Turkestan, Atyrau, Zhambyl, West Kazakhstan, and Aktobe regions, ranging from 3.4 to 50.5 % of the norm, which was 6.9 mm to 12.5 mm below the long-

term mean.

In October, moisture conditions over almost the entire country were characterized by a precipitation deficit; the mean value was 47.7 % of the norm, or 15.9 mm below the long-term mean (probability of non-exceedance 7 %, Table 3.2). The precipitation deficit (less than 70 % of the norm), in places extreme (less than 40 % and even less than 20 % of the norm) and record-breaking (less than 6 % of the norm), covered all of the central regions, most of the northern, southern, and eastern parts of the country, as well as the eastern part of the Caspian Sea area, the Aktobe region, and the border areas of the Atyrau and West Kazakhstan regions; the precipitation averaged over their territory was 5.6 mm to 29.5 mm below the norm (Figure 3.3). According to data from 80 MS located in these regions, very dry conditions in terms of precipitation were observed and 10 % extremes were registered, and 49 of these meteorological stations fell into the "extremely dry" category. According to data from 6 MS located in the Karaganda (Balkhash, Saryshagan, and Kyzyltau) and Kyzylorda (Karak, Kyzylorda, and Zhosaly) regions, no precipitation was recorded during the month; in addition, monthly precipitation minimums were set at 7 meteorological stations in the North Kazakhstan, Akmola, and Karaganda regions (Annex 2). Pockets of excess moisture were located over the entire West Kazakhstan region (126–314 % of the norm), in the western half of the Atyrau region (246–401 % of the norm), and in the east of the Mangystau region (121–186 % of the norm), and also covered the central part of the Pavlodar region (122–144 % of the norm), small separate areas in the south of the East Kazakhstan and Abay regions (132–137 % of the norm), and the Alakol Depression (165 % of the norm) (Figure 3.3). At 8 meteorological stations located in these areas, moisture conditions were characterized by 90 % and 95 % extremes. The largest monthly precipitation in October was recorded at MS Zhalpaktal (West Kazakhstan region) – 76.9 mm, which amounted to 313.9 % of the norm.

In November, the precipitation deficit persisted over most of the country; however, the mean value was 89.0 % of the norm (rank 44, probability of non-exceedance 46 %, Table 3.2). Significant pockets of moisture deficit (0–60 % of the norm) covered most of the western, central, and southern regions, as well as the south of the Kostanay region. Several small pockets of precipitation deficit (60–78 % of the norm) were observed in the east of the Abay region and in the adjacent areas of the East Kazakhstan region (Figure 3.3). According to data from 34 MS located in these areas, a low level of moisture (10 % extreme) was recorded, and 18 of these meteorological stations fell into the "extremely dry" category (5 % extreme). According to data from 5 MS in the Mangystau (MS Kulaly Island, MS Tushchibek, and MS Beineu) and Atyrau (MS Ganyushkino and MS Zhana Ushtogan) regions, no precipitation at all fell during the month; in addition, the smallest November 2025 precipitation total, 0.4 mm (2.5 % of the norm), was registered at MS Peshnoy (Atyrau region). The values averaged over the territory of the regions were as follows: Mangystau – 3.3 % of the norm, Atyrau – 6.5 %, Kyzylorda – 21.2 %, Zhambyl – 30.3 %, and Turkestan – 32.9 %, which was 11.4 mm to 34.1 mm below the long-term mean (probability of non-exceedance from 3 to 7 %). Excess precipitation (more than 120 % of the norm) was observed over most of the northern and eastern parts of the country, in the northern areas of the West Kazakhstan and Karaganda regions, and in small pockets in the west and north of the Aktobe region. The largest zones of increased moisture (more than 200 % of the norm) covered the Pavlodar, North Kazakhstan, and Akmola regions and the adjacent border areas of the Kostanay region (probability of non-exceedance 90–98 %), the southern areas of the Abay and East Kazakhstan regions, and a separate area in the north of the Aktobe region (Figure 3.3). On average over the territory of the regions, November was among the ten wettest in the observation series for the northern regions: Pavlodar (rank 2, 233.6 % of the norm), Akmola (rank 5, 208.0 % of the norm), and North Kazakhstan (rank 9, 178.1 %

of the norm), where precipitation exceeded the long-term mean by 19.8 mm to 28.6 mm. According to data from 35 meteorological stations, moisture conditions were characterized as “extremely wet” (90 % and 95 % extremes). At the Ruzaevka, Zheleznodorozhny, and Astana meteorological stations, the record maximums of monthly precipitation set in 1984 and 2022 were broken (Annex 2).

To assess the extremity of precipitation in 2025, the climate change indices recommended by the World Meteorological Organization were evaluated. An analysis of some of the most indicative precipitation indices and of the spatial distribution of their values over Kazakhstan in 2025 is presented below.

Absolute maximums of daily precipitation from the beginning of observations to 2025 are shown in blue, and the 2025 values that exceeded the previous maximum are shown in red (Figure 3.4).

In 2025, new absolute maximums of daily precipitation were registered at two meteorological stations in Kazakhstan: at MS Ruzaevka (North Kazakhstan region), 58.9 mm fell in one day (the previous maximum of 56.4 mm was observed in 1969); at MS Kushmurun (Kostanay region), daily precipitation reached 82.2 mm (the previous maximum of 75.2 mm was observed in 1961).

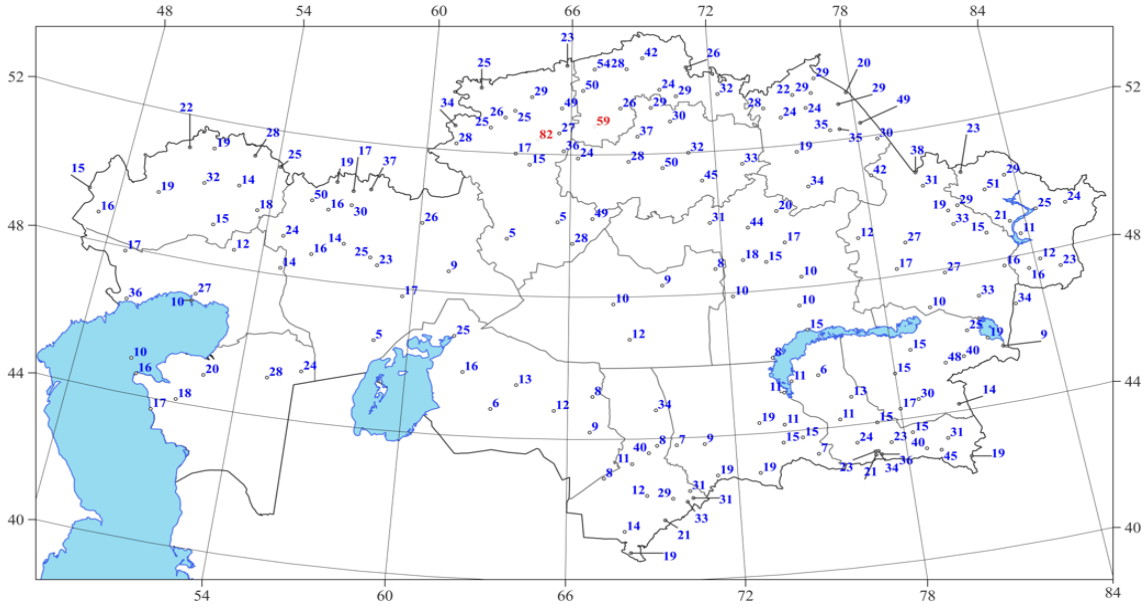


Figure 3.4 *– Absolute maximum of daily precipitation (mm) selected for the period from the opening of the meteorological station to 2025. If the record daily precipitation was recorded in 2025, the value is plotted in red*

The daily precipitation maximum selected from the 2025 data (Rx1day index) was 20–40 mm over most of Kazakhstan (Figure 3.5). The largest daily precipitation maximums were observed in the Kostanay region and in the northern part of the Aktobe region, where they reached 50–80 mm, and in the northern part of the East Kazakhstan region (51 mm); in the north, northeast, east, and central parts of the country, in the foothill and mountainous areas of the south and southeast, and in the northern part of the western and northwestern regions, they exceeded 30–50 mm in places. The smallest daily precipitation maximums (less than 10 mm) were observed in the southern and eastern parts of the Aktobe region, in the south of the Kostanay region, in the northeast of the Ulytau region, in the eastern and western parts of the Balkhash area, in the area of Lake Alakol (Zhetysu region), in the southern and western parts of the Zhambyl region, at the extreme eastern and western points of the Turkestan region, and in the central and eastern parts of the Kyzylorda region.

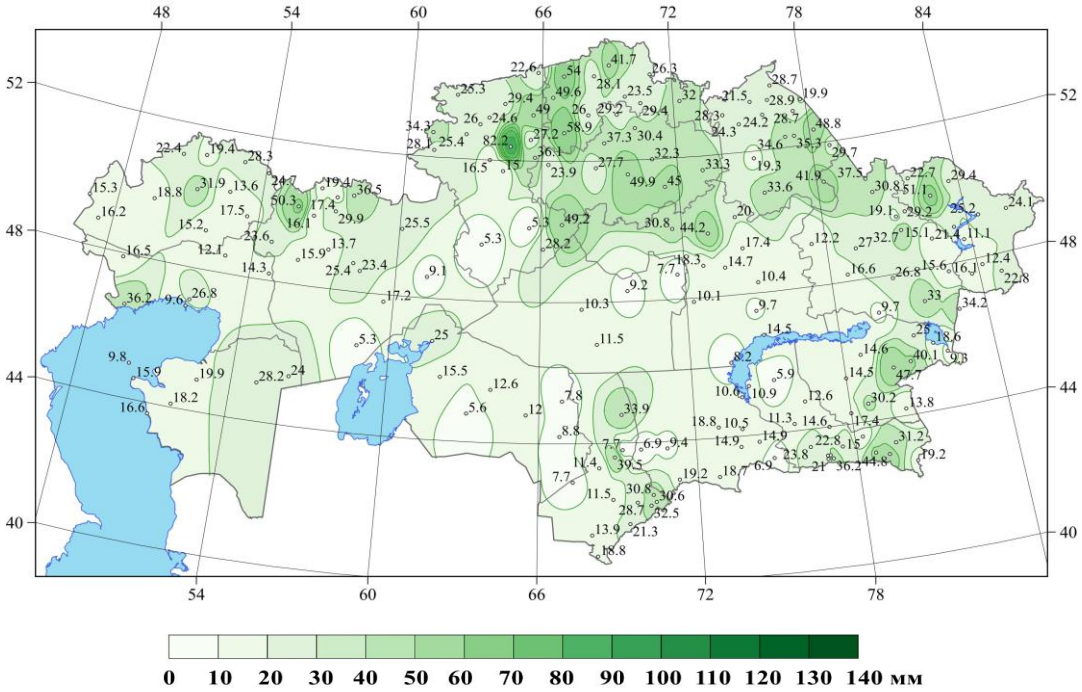


***Figure 3.5** – Daily precipitation maximum in 2025 (Rx1day index)*

In 2025, the share of very heavy precipitation (when daily precipitation is equal to or greater than the 95th percentile, r95ptot index) in the annual precipitation total was less than 30 % over most of Kazakhstan (Figure 3.6). The largest contribution of very heavy precipitation (more than 40–50 %) was observed in places in the northern regions, in the Turkestan region, and in the Aktobe and Almaty regions. At the same time, in a number of areas daily precipitation totals did not reach the 95th percentile, which indicates the absence of extreme precipitation at these meteorological stations.

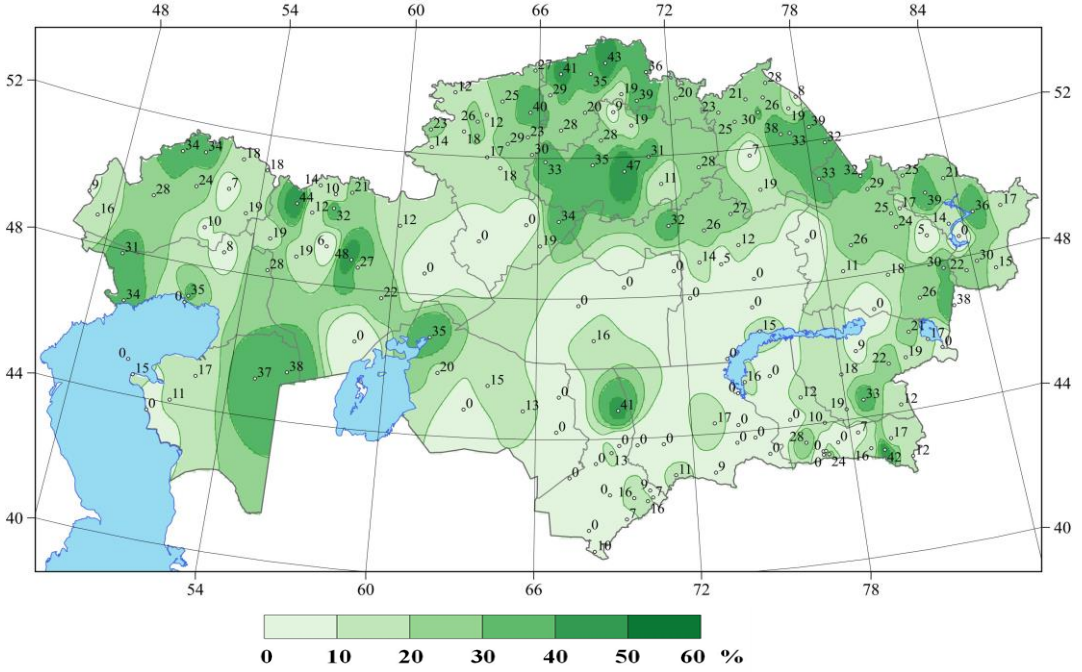


***Figure 3.6** – Share (%) of extreme daily precipitation in the annual precipitation total for 2025 (r95ptot index)*

The R10mm index characterizes the number of days per year when daily precipitation was 10 mm or more. In 2025, over most of Kazakhstan there were from 1 to 9 such days (Figure 3.7). The largest

number of days with precipitation of 10 mm or more, from 15 to 24, was observed in the mountainous and foothill areas of the southeast and east of the country – in the Almaty, East Kazakhstan, Zhetysu, and Abay regions; the maximum value, 24 days, was recorded at MS Kegen (Almaty region). The smallest values, from 0 to 4 days, were observed in the western, central, and southern parts of the country – in the Atyrau, Mangystau, Kyzylorda, and Zhambyl regions, in the Ulytau region, and over most of the Karaganda and Aktobe regions, where daily precipitation never reached 10 mm at 21 meteorological stations.

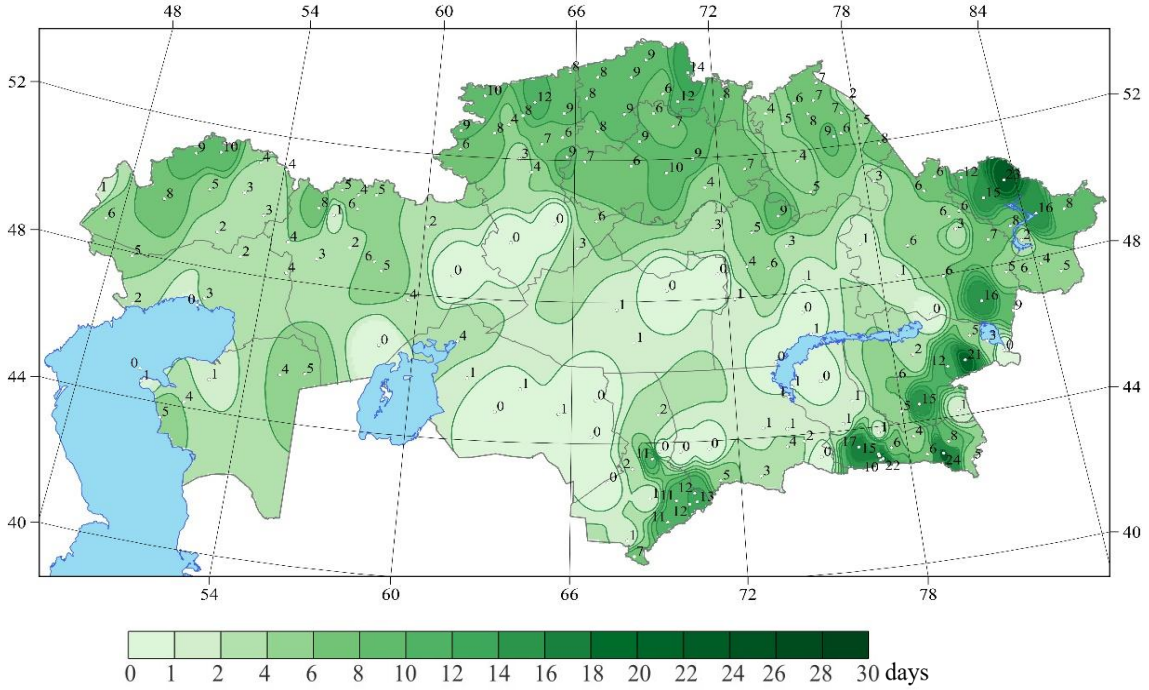


Figure 3.7 *– Number of days with daily precipitation of 10 mm or more in 2025 (R10mm index, days)*

The simple daily intensity index (SDII) characterizes the average amount of precipitation per wet day and is calculated as the ratio of the annual precipitation total on days with precipitation of 1 mm or more to the number of such days. In 2025, precipitation intensity over most of Kazakhstan ranged from 3 to 5 mm/day (Figure 3.8). The highest intensity, from 6.0 to 8.2 mm/day, was observed in the mountainous and foothill areas of the southeast, south, and east of the country – in the Almaty, Turkestan, East Kazakhstan, Zhetysu, and Abay regions; the maximum value, 8.2 mm/day, was recorded at MS Kamenskoe Plato (Almaty region). The lowest intensity, less than 3.0 mm/day, was observed in the Ulytau region, in the south of the Kostanay and Aktobe regions, and in places in the Kyzylorda, Turkestan, Zhambyl, Almaty, and Zhetysu regions; the minimum value, 2.1 mm/day, was recorded at MS Ayakkum.

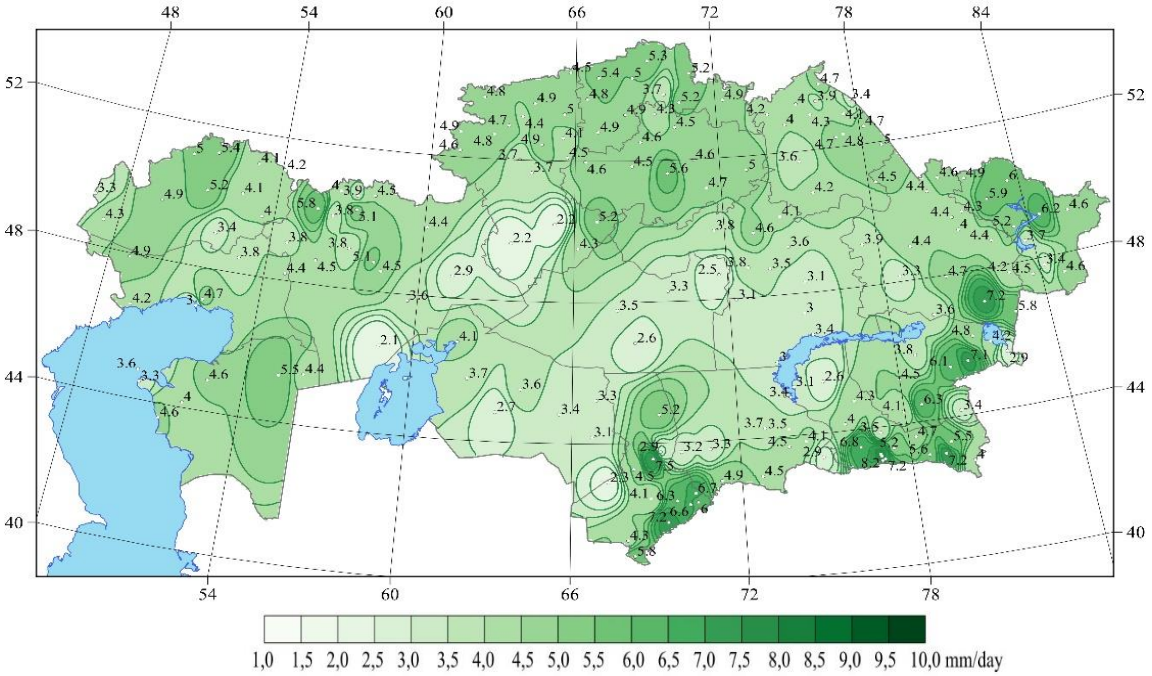


Figure 3.8 *– Mean intensity of daily precipitation on wet days in 2025 (SDII index, mm/day)*

3.2 Observed changes in precipitation

Linear trends in the series of monthly, seasonal, and annual precipitation totals were estimated using data from 121 stations.

Time series of anomalies of annual and seasonal precipitation totals for the period 1941–2025, calculated relative to the base period 1961–1990 and spatially averaged over the territory of Kazakhstan and its regions, give a general idea of the nature of current changes in the precipitation regime (Table 3.3, Figures 3.9 and 3.10). Annual precipitation averaged over the territory of Kazakhstan decreased in the 1960s and 1970s; in recent decades there have been no pronounced long-term trends, and short periods with positive and negative precipitation anomalies have alternated.

Table 3.3 – Characteristics of the linear trend of anomalies of seasonal and annual precipitation totals (% of the norm/10 years) averaged over the territory of Kazakhstan and its regions for the period 1976–2025

Region	Year		Winter		Spring		Summer		Autumn	
	a	**D**	**a**	**D**	**a**	**D**	**a**	**D**	**a**	**D**
Kazakhstan	0.8	1	1.4	1	2.0	2	0.4	0	-0.7	0
Abay	2.1	3	2.2	1	0.4	0	3.5	2	1.8	1
Almaty	0.1	0	1.6	1	0.5	0	-1.8	1	1.1	0
Akmola	**4.7**	**11**	**10.8**	**15**	3.4	2	3.5	2	3.6	3
Aktobe	-0.6	0	-0.1	0	4.3	2	-1.8	0	-4.4	5
Atyrau	3.1	3	8.3	7	**14.9**	**11**	-6.4	3	-2.2	1
East Kazakhstan	1.7	3	3.5	3	1.8	1	0.5	0	1.9	1
Zhambyl	-2.4	3	-1.3	0	-2.3	1	-0.6	0	-4.1	3
Zhetysu	0.9	0	3.9	2	2.6	2	-2.0	1	-0.8	0
West Kazakhstan	0.0	0	-2.2	2	**9.0**	**11**	-4.0	2	-1.0	0
Karaganda	0.9	1	1.6	1	-1.5	1	4.1	3	-2.0	1
Kostanay	0.0	0	0.0	0	4.9	4	-0.7	0	-2.8	2
Kyzylorda	-4.1	5	-0.4	0	-2.4	1	-4.2	1	**-11.2**	**15**

Region	Year		Winter		Spring		Summer		Autumn	
	a	**D**	**a**	**D**	**a**	**D**	**a**	**D**	**a**	**D**
Mangystau	-4.1	3	5.7	2	-7.7	4	-6.6	2	-4.1	1
Pavlodar	2.9	5	2.3	2	4.5	3	2.2	1	3.3	2
North Kazakhstan	3.1	6	4.8	3	**9.2**	**13**	1.9	1	0.0	0
Turkestan	-0.5	0	-0.8	0	0.2	0	0.0	0	-2.3	1
Ulytau	0.3	0	-2.9	3	1.7	0	3.4	1	-1.1	0

Notes: *1. a – linear trend coefficient, % of the norm/10 years;*

2. D – coefficient of determination, %;

3. statistically significant trends are shown in bold.

During 1976–2025, there are practically no trends in the relative anomalies of annual and seasonal precipitation totals averaged over the territory of Kazakhstan: the share of the trend component in the total variance of the series generally does not exceed 6 %; the trend sign is positive for annual, winter, spring, and summer precipitation totals and negative for autumn totals (Table 3.3, Figure 3.9).

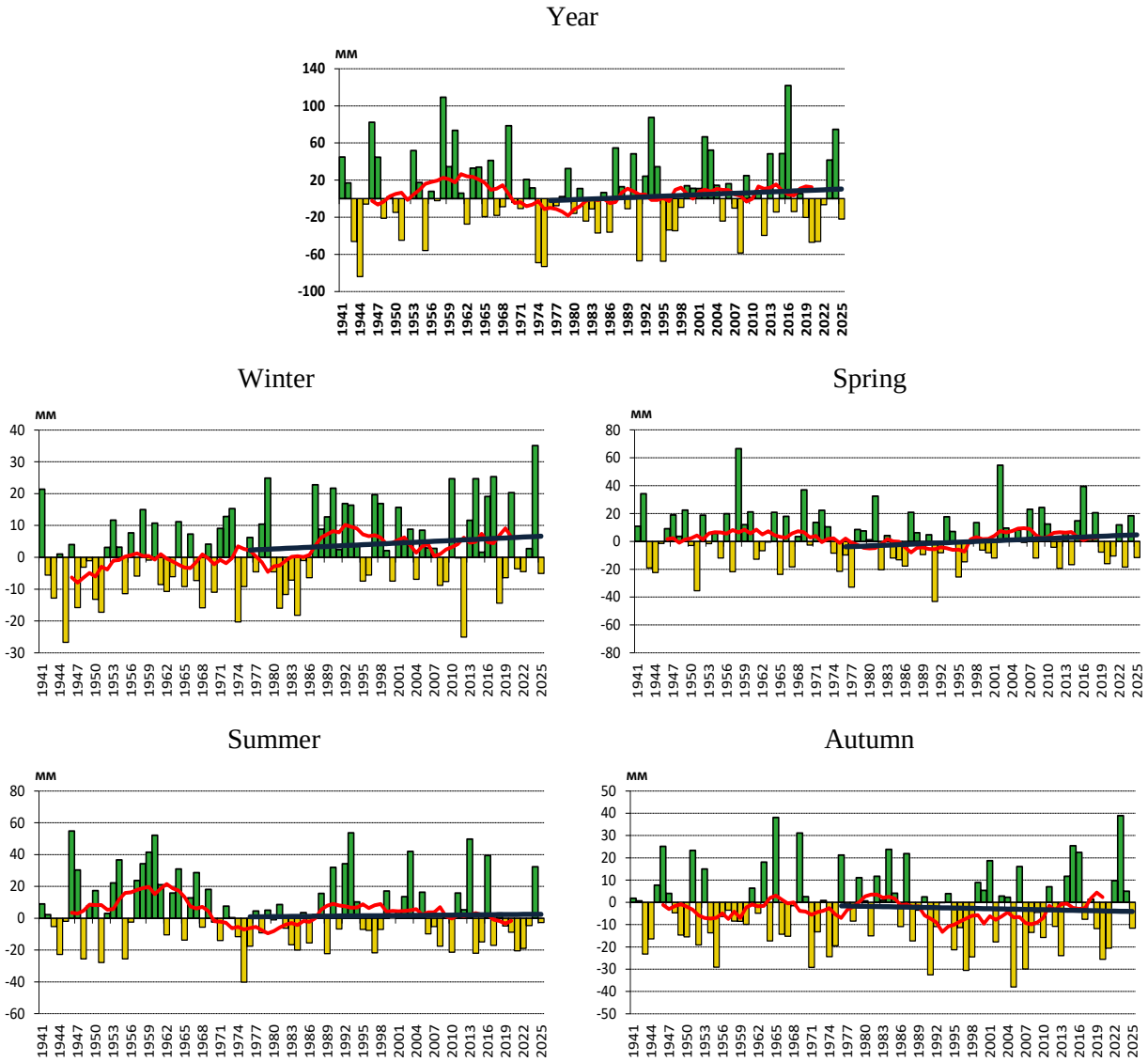


Figure 3.9 *– Time series of anomalies of annual and seasonal precipitation totals (%) spatially averaged over the territory of Kazakhstan for the period 1941–2025.*

Anomalies are calculated relative to the base period 1961–1990. The linear trend for the period 1976–2025 is shown in black. The smoothed curve is obtained by an 11-year moving average

In most regions, both increasing and decreasing trends in annual precipitation are small, with a coefficient of determination of 6 % or less. In the Akmola region, the rate of increase in annual precipitation was about 4.7 % of the norm/10 years, with a coefficient of determination of 11 %. In the Kyzylorda and Mangystau regions, precipitation decreased at rates of 4.1 and 4.1 % of the norm/10 years, with coefficients of determination of 5 % and 3 %, respectively (Table 3.3, Figure 3.9). On average over the territory of Kazakhstan, a slight tendency toward an increase in ***annual*** precipitation of 0.8 % of the norm/10 years is observed for the period 1976–2025 (Table 3.3).

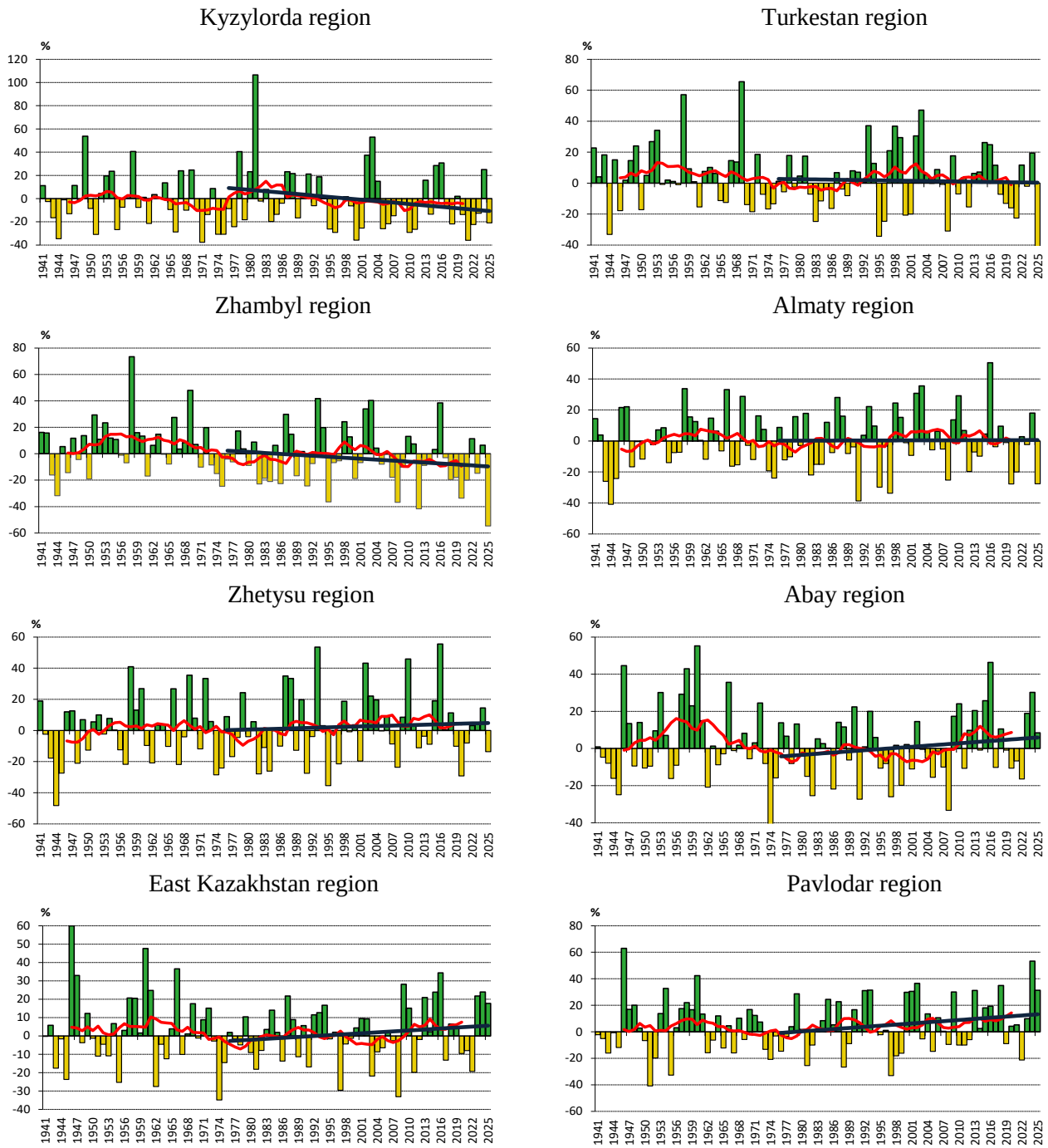


Figure 3.10 *– Time series of anomalies of annual precipitation totals (%) for the period 1941–2025, spatially averaged over the regions of Kazakhstan.*
Anomalies are calculated relative to the base period 1961–1990. The linear trend for the period 1976–2025 is shown in black. The smoothed curve is obtained by an 11-year moving average. Sheet 1

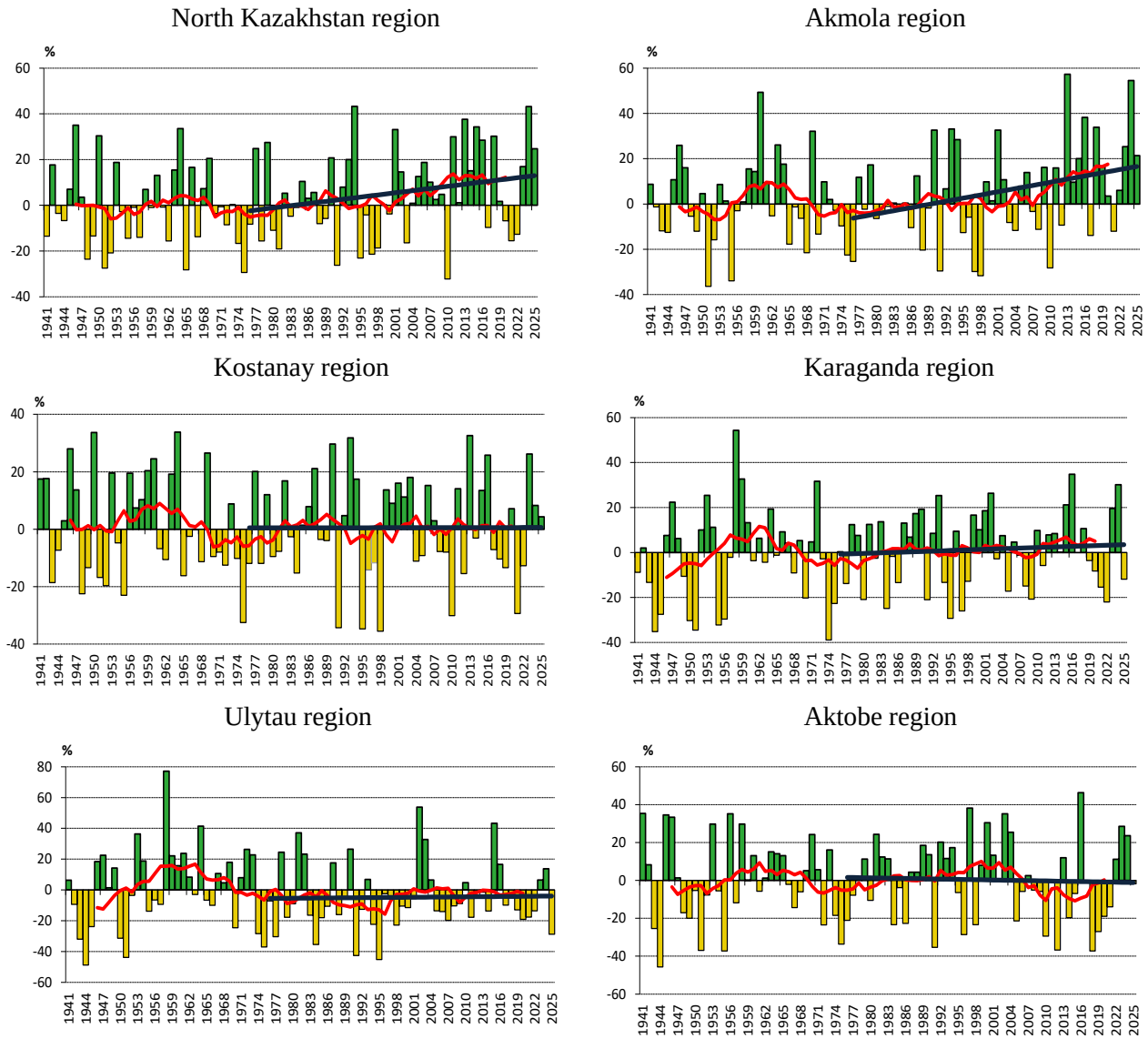


Figure 3.10 *– Time series of anomalies of annual precipitation totals (%) for the period 1941–2025, spatially averaged over the regions of Kazakhstan. Anomalies are calculated relative to the base period 1961–1990. The linear trend for the period 1976–2025 is shown in black. The smoothed curve is obtained by an 11-year moving average. Sheet 2*

In the ***winter period***, the relative anomalies of seasonal precipitation totals averaged over Kazakhstan increased slightly, by 1.4 % of the norm every 10 years. The most substantial increasing trends in precipitation are observed in the Akmola region – 10.8 % of the norm/10 years (coefficient of determination 15 %), the Atyrau region – 8.3 % of the norm/10 years (coefficient of determination 7 %), the Mangystau region – 5.7 % of the norm/10 years (coefficient of determination 2 %), the North Kazakhstan region – 4.8 % of the norm/10 years (coefficient of determination 3 %), and the Zhetysu region – 3.9 % of the norm/10 years (coefficient of determination 2 %) (Table 3.3, Figure 3.10). The increasing precipitation trends in the Akmola region are statistically significant. A noticeable decrease in precipitation averaged over the territory is observed in the West Kazakhstan region and in the Ulytau region, by 2.2 and 2.9 % of the norm/10 years, respectively (coefficients of determination 2 % and 3 %).

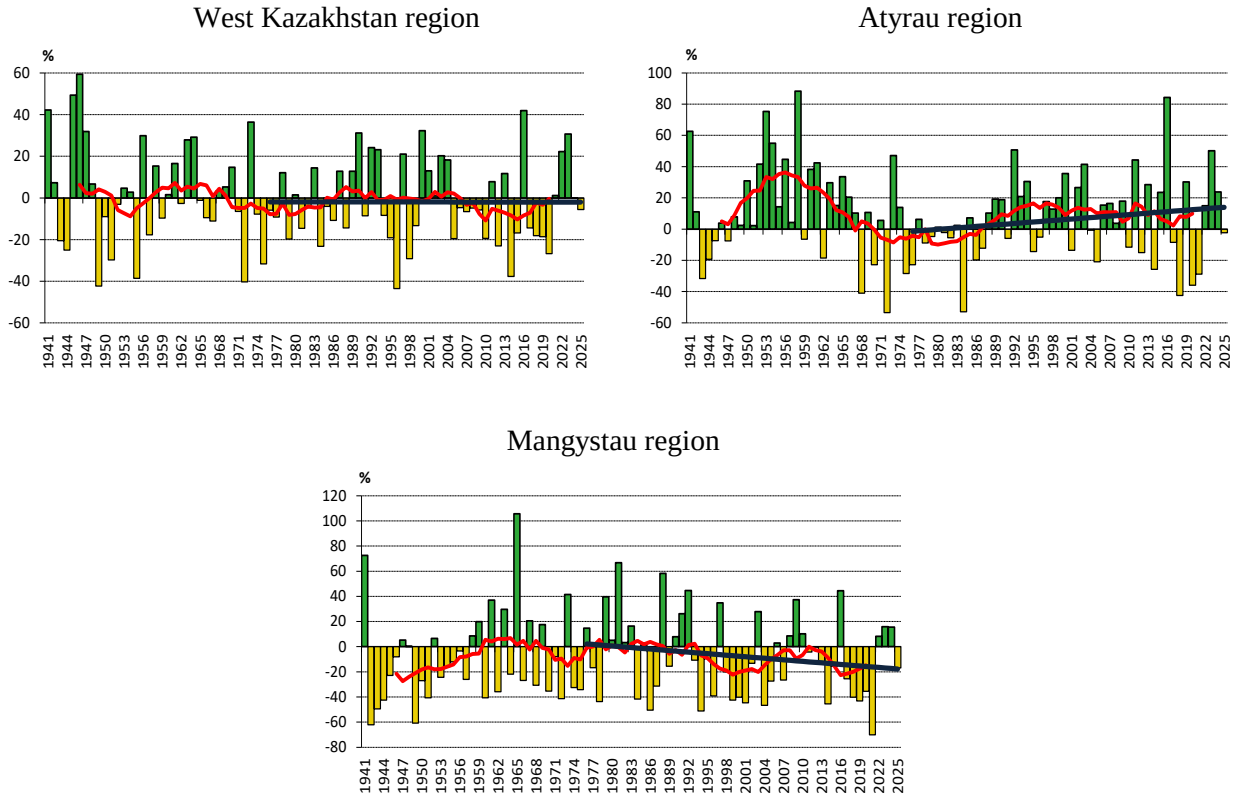


Figure 3.10 *– Time series of anomalies of annual precipitation totals (%) for the period 1941–2025, spatially averaged over the regions of Kazakhstan. Anomalies are calculated relative to the base period 1961–1990. The linear trend for the period 1976–2025 is shown in black. The smoothed curve is obtained by an 11-year moving average. Sheet 3*

In spring, precipitation averaged over Kazakhstan increased slightly, by 2.0 % of the norm every 10 years. Positive but also insignificant trends are observed over most regions. The highest rate of increase in precipitation was recorded in the western and northern parts of the country. In the western regions – Atyrau (14.9 % of the norm/10 years), West Kazakhstan (9.0 % of the norm/10 years), and Aktobe (4.3 % of the norm/10 years) – the coefficients of determination are 11 %, 11 %, and 2 %, respectively. In the north, a statistically significant trend was identified in the North Kazakhstan region (9.2 % of the norm/10 years), with a coefficient of determination of 13 % (Table 3.3, Figure 3.10). A steady decreasing trend in precipitation is observed in the Mangystau region, by 7.7 % of the norm every 10 years, with a coefficient of determination of 4 %. The largest contribution to the increase in spring precipitation comes from March, when stable, statistically significant trends are observed almost throughout Kazakhstan, reaching 13.3 % of the norm/10 years.

In summer, trends in seasonal precipitation over the regions of Kazakhstan are weak. On average over the country, there is a slight positive trend of +0.4 % of the norm/10 years. The most significant positive trends in precipitation were observed in the Karaganda region, at 4.1 % of the norm/10 years, and in the Ulytau region, at 3.4 % of the norm/10 years, with coefficients of determination of 3 % and 1 %, respectively. Summer is also marked by notable decreasing trends in precipitation. They were observed in the Mangystau region – by 6.6 % of the norm/10 years (coefficient of determination 2 %), the Atyrau region – by 6.4 % of the norm/10 years, and the Kyzylorda region – by 4.2 % of the norm/10 years, where the coefficients of determination were 3 % and 1 %, respectively (Table 3.3, Figure 3.10).

In autumn, trends in autumn precipitation are negative over most regions, with the average for

Kazakhstan being -0.7 % of the norm/10 years. Positive trends are observed in some eastern, southeastern, and northern regions; the most noticeable increase is observed in the Akmola region, at +3.6 % of the norm/10 years. The highest rates of decrease in precipitation are observed in the Kyzylorda (11.2 % of the norm/10 years) and Aktobe (4.4 % of the norm/10 years) regions. The decreasing trend in the Kyzylorda region is statistically significant, with a coefficient of determination of 15 % (Table 3.3, Figure 3.10).

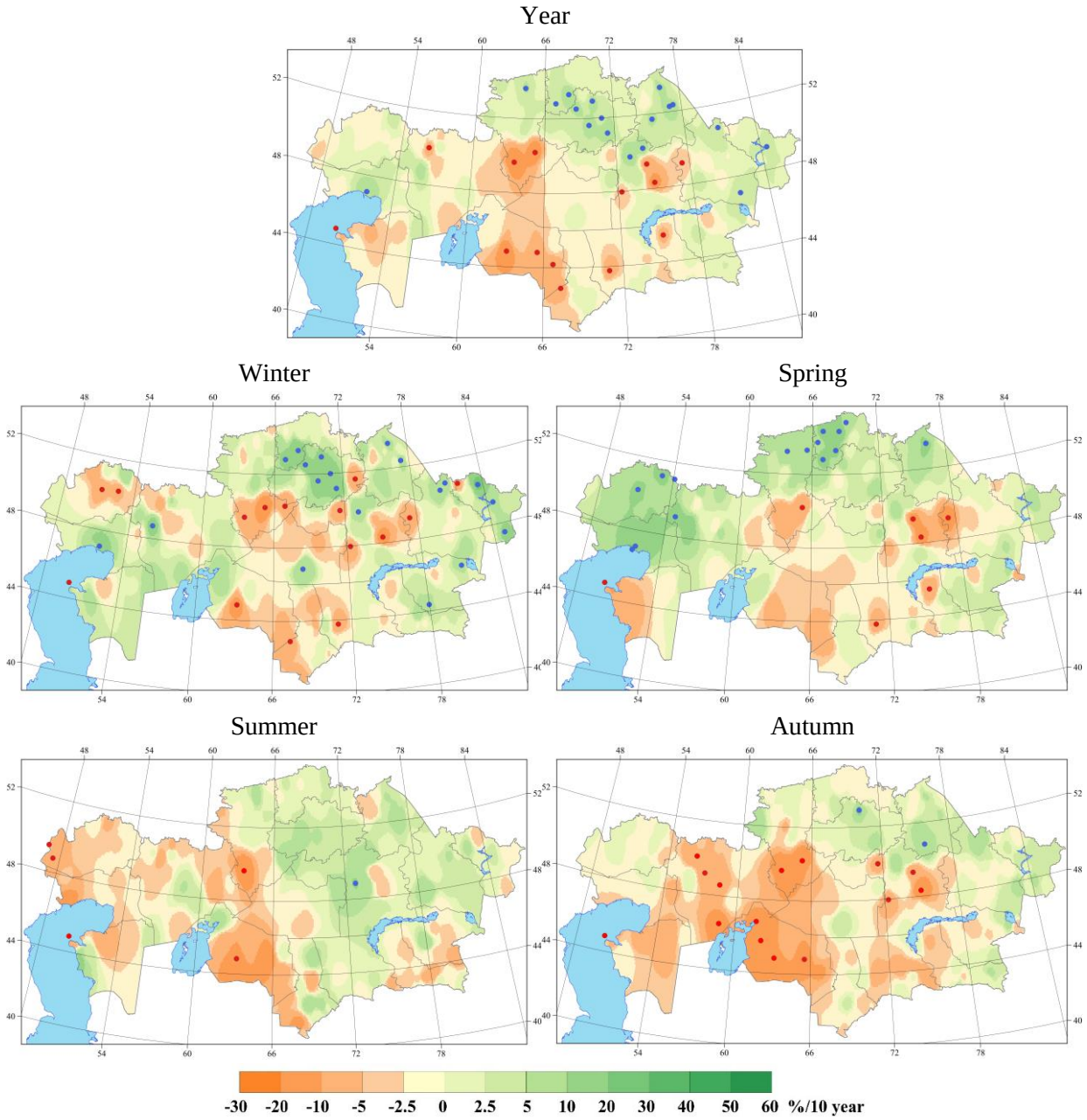
More detailed information on the nature of changes in the precipitation regime in Kazakhstan is provided by the spatial distribution of the linear trend coefficient of annual precipitation totals and of relative anomalies of seasonal and monthly precipitation totals (% of the norm/10 years), presented in Figures 3.11 and 3.12. The estimates were obtained from station time series of annual, seasonal, and monthly precipitation anomalies for the period 1976–2025. The direction of change in seasonal and monthly precipitation is spatially patchy across the country.

In winter, a significant increase in precipitation was recorded in almost all parts of the country – in the west, the north (mainly in the Akmola region), the southeast, the east, and the central parts (by 8–23 % of the norm/10 years). The main contribution to this increase came from February (Figure 3.12). Pockets of statistically significant decreasing trends in seasonal precipitation, within 2–7 % of the norm/10 years, are observed in the center of the West Kazakhstan region, in the west of the Mangystau region, in the south of the Kostanay region, in the east of the Akmola region, in some areas of the Karaganda region, in the south of the Kyzylorda and Turkestan regions, and in the west of the Abay region.

In **December**, decreasing precipitation trends were observed in the western and northwestern parts, in the eastern part of Central Kazakhstan, and in the southern and southeastern half of Kazakhstan (Figure 3.12). Significant decreasing precipitation trends were observed mainly in the south, in the Turkestan and Zhambyl regions (by 12–15 % of the norm/10 years), at some meteorological stations in the north of the West Kazakhstan region and the south of the Kostanay region (by 12–14 % of the norm/10 years), and in Central Kazakhstan (by 12 % of the norm/10 years). Increasing precipitation trends were observed in the northern, northeastern (by 14–19 % of the norm/10 years), and central (by 13 % of the norm/10 years) parts of the country.

In **January**, decreasing precipitation trends are observed in the western and central parts of the country, as well as in separate small pockets in the southwest and north of the country (Figure 3.12). Statistically significant decreasing precipitation trends, from 9.6 % to 13.4 % of the norm/10 years, are observed at some stations in the central and northern parts of the country. Increasing precipitation trends are observed in some areas of the north (by 13.2–20.8 % of the norm/10 years), the east (by 13.6–25.7 % of the norm/10 years), and the south of the country (11–18 % of the norm/10 years).

In **February**, precipitation is increasing over most of Kazakhstan, except for pockets of decreasing precipitation in the west, in the south of the Kostanay region, in the southern parts of the country, and in the east of Central Kazakhstan. Statistically significant decreasing precipitation trends are observed at five meteorological stations in the west, south, center, and east, ranging from 10 % to 17 % of the norm per decade. In the northern, eastern, and southeastern parts of the country, as well as at four meteorological stations in the west and one in Central Kazakhstan, statistically significant increasing precipitation trends are observed, ranging from 14 % to 29 % of the norm per decade.



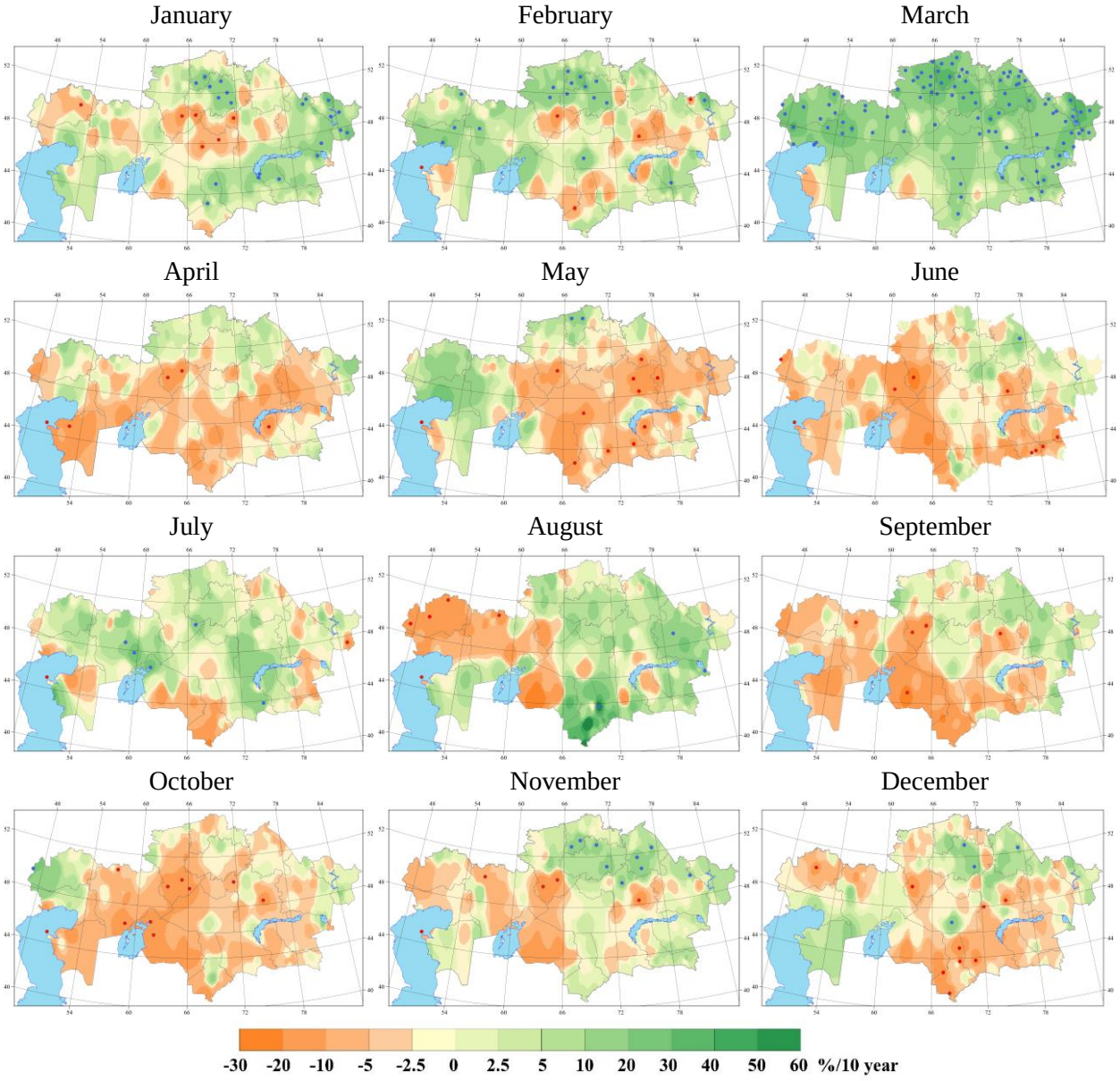
Significant positive and negative linear trend coefficients are highlighted in blue (increase in precipitation) and red (decrease in precipitation).

Figure 3.11 *– Spatial distribution of the linear trend coefficient of annual and seasonal precipitation totals (%/10 years) calculated for the period 1976–2025*

In spring, increasing or decreasing precipitation trends are not as large; nevertheless, statistically significant values are present. An increase in seasonal precipitation is observed in the west, northwest, and north of the country. Statistically significant increasing precipitation trends range from 8.1 % to 21 % of the norm/10 years. A decrease in precipitation is observed in the Mangystau region, the Turan Lowland, the Kyzylorda region, the east of Central Kazakhstan, and in separate small pockets in the west and east of the country. Statistically significant decreasing trends, from 9.4 to 26 % of the norm per decade, were identified at 7 meteorological stations.

Among the spring months, **March** stands out, when a statistically significant increase in monthly precipitation totals is recorded almost throughout Kazakhstan. Decreasing precipitation trends are

observed in small pockets in the west of the Mangystau region, in the south of the Kyzylorda region, and in the west of the Zhambyl region. On average over Kazakhstan, the increasing precipitation trend exceeded 13 % of the norm/10 years, with a coefficient of determination of 23 %. Statistically significant increasing precipitation trends were recorded almost everywhere (by 11.1–40.2 % of the norm/10 years) (Figure 3.12).



Significant positive and negative linear trend coefficients are highlighted in blue and red.

Figure 3.12 *– Spatial distribution of the linear trend coefficient of monthly precipitation (%/10 years) calculated for the period 1976–2025*

In **April**, a decreasing trend in monthly precipitation totals prevails across Kazakhstan from west to east, also covering the southern parts of the country. In the area of the Caspian Lowland and the Mugodzhar Hills, the decreasing trend ranges from 10.5 to 32.4 % of the norm/10 years (MS Kulaly Island in the Mangystau region). In the Aral Sea area, Sary-Arka, and the south of the Kostanay region, precipitation is decreasing by up to 16 % of the norm per decade. April was characterized by insufficient moisture, and statistically significant trends ranging from 12.7 % to 32.4 % of the norm/10 years were

identified at 5 meteorological stations.

In **May**, an increasing precipitation trend is observed in the west, northwest, and north, as well as in small pockets in the southeast, while a significant decrease in precipitation is observed in the central and eastern parts of the country. Two meteorological stations in the North Kazakhstan region show a statistically significant increasing trend of 15–17 % of the norm/10 years. According to data from 10 meteorological stations located in the central and southern parts of the country, decreasing precipitation trends are observed. At MS Kulaly Island in the Mangystau region, the decreasing precipitation trend was 32 % of the norm/10 years, the largest decrease in the entire country.

In summer, decreasing precipitation trends are observed in the western half of Kazakhstan, with pockets of increasing moisture in the southern part of the Mangystau region and in the southwest of the country, while a steady increasing precipitation trend is recorded in the eastern half. In the west, the decrease reaches 18 % of the norm/10 years. An increasing trend in summer precipitation is observed in the coastal part of the Caspian Sea and in the south of the country; however, statistically significant increasing precipitation trends are observed in the Kazakh Uplands, ranging from 9 % to 10.9 % of the norm/10 years (Figure 3.11).

In **June**, the western half of Kazakhstan, the central part of the Kazakh Uplands, and the southeastern part of the country are in the zone of decreasing precipitation (Figure 3.12). The most substantial and statistically significant decreasing trends in monthly precipitation are observed in the coastal areas of the Caspian Sea and in the west of the country (16–18 % of the norm/10 years), in the central part of the country (12–24 % of the norm/10 years), and in the southeast of the country (11–15 % of the norm/10 years). An increasing precipitation trend is observed mainly in the south and north of the country; a statistically significant increase in precipitation was recorded only in the Pavlodar region – 19 % of the norm/10 years.

In **July**, increasing precipitation trends are observed over most of the country (Figure 3.12). A decreasing precipitation trend is observed in the coastal areas of the Caspian Sea, in the southern parts of the Kyzylorda and Turkestan regions, and in small pockets in the east of the country. Of these, the trends are statistically significant at MS Kulaly Island in the Mangystau region (24 % of the norm/10 years) and MS Zaisan in the East Kazakhstan region (11 % of the norm/10 years). At seven meteorological stations located in the Aktobe, Kostanay, Kyzylorda, and Zhambyl regions, an increasing precipitation trend is observed (15–26 % of the norm/10 years).

In **August**, precipitation is decreasing in the western half of the country, except for the Mangystau region and the southern part of the Aktobe region, while a rapid increase in precipitation is observed in the other half of the country. Statistically significant decreasing precipitation trends were recorded only at 5 meteorological stations located in the western and northern parts of the West Kazakhstan and Aktobe regions and in the coastal part of the Caspian Sea, amounting to 16–18 % of the norm/10 years (Figure 3.12). Statistically significant increasing precipitation trends are observed at three meteorological stations located in the eastern and southeastern parts of the country, amounting to 14–19 % of the norm/10 years. In the Zhambyl region, the increasing precipitation trend at MS Saudakent was 54 % of the norm/10 years, with a coefficient of determination of 12 %.

In autumn, most of the territory was in the zone of negative precipitation trends (Figure 3.11). According to data from many meteorological stations, autumn precipitation totals decreased considerably in the Aktobe region, the southern part of the Kostanay region, and the Kyzylorda region, and in places in the central and southern parts of the country. In these areas, a statistically significant (at the 5 % level) decrease in precipitation within 6.2–19 % of the norm/10 years is observed at some

stations, while only in the Kyzylorda region does the coefficient of determination reach 15 %. Statistically significant positive trends are observed, in particular, at MS Bayanaul in the Pavlodar region (+8.4 % of the norm/10 years) and MS Shchuchinsk in the Akmola region (+10.0 % of the norm/10 years) (Figure 3.11).

In **September**, decreasing precipitation trends are recorded over most of the country. The highest rates of decrease in precipitation are observed at five meteorological stations located in the Aktobe, Kyzylorda, Kostanay, and Karaganda regions (12–23 % of the norm/10 years). In some northern, eastern, and southeastern parts of the country, a weak increasing precipitation trend is observed, and it is statistically insignificant (Figure 3.12).

In **October**, precipitation is decreasing over most of the country (Figure 3.12). Statistically significant rates of decrease in precipitation of 9.3–19 % of the norm/10 years are observed in the western, northwestern, southwestern, and central parts of the country. The highest rates of decrease in precipitation were recorded at MS Kulaly Island (Mangystau region). Weak positive trends are observed in some areas of the extreme west, north, and east, where the share of the trend component in the total variance of the series does not exceed 2 %. The highest rates of increase in precipitation are observed in the extreme west and northwest of the country (6.9–17 % of the norm/10 years), and a statistically significant increase in precipitation, of 25 % of the norm/10 years, is observed only at MS Zhanibek (West Kazakhstan region).

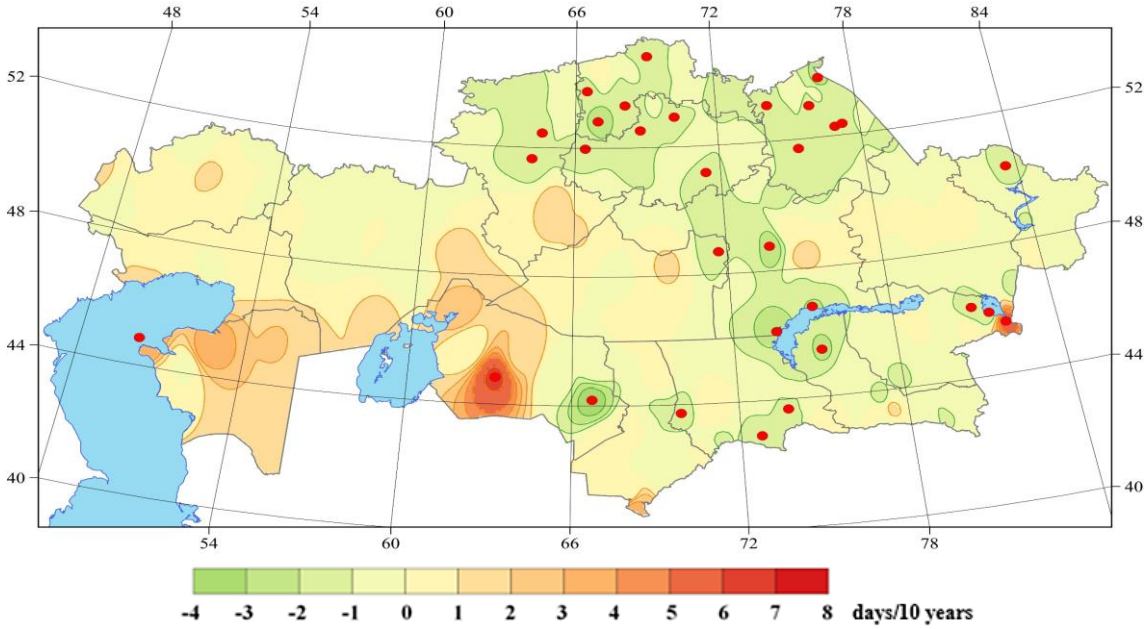
In **November**, decreasing precipitation trends were observed mainly in the western half of Kazakhstan, in the Kazakh Uplands, and in some areas of the south. At most stations, the trends are statistically insignificant. Statistically significant trends were recorded at only four meteorological stations located in these areas, where the rate of decrease in precipitation ranged from 9.6 to 18 % of the norm/10 years. The most substantial steady decreasing trend in precipitation is observed at MS Kulaly Island (Mangystau region), by 22 % of the norm/10 years, with the share of variance explained by the trend being 17 %. Increasing precipitation trends are observed over most of the northern and northeastern parts, the western part of the central part, and the mountainous and foothill areas of the eastern and southern parts of Kazakhstan. At most stations in these areas, the trends are mostly statistically insignificant, except at nine meteorological stations located in the northern and northeastern parts of the country, where a significant increasing precipitation trend of 9.5–20 % of the norm/10 years is observed (Figure 3.12).

Annual precipitation totals are decreasing substantially in some western, northwestern, central, and southern parts of the country (by 4.2–13 % of the norm/10 years); in addition, statistically significant decreasing precipitation trends are observed in all months at MS Kulaly Island in the Mangystau region, where the decreasing trend is 19 % of the norm/10 years and the coefficient of determination is 63 %. A statistically significant increase in annual precipitation, of 4.1–7.8 % of the norm/10 years, is observed at 18 meteorological stations in the northern, northeastern, central, and eastern parts of the country (Figure 3.11).

3.3 Trends in precipitation extremes

Figure 3.13 shows the change in the *maximum length of the dry period, when daily precipitation was less than 1 mm*. Across Kazakhstan, weak trends of both decrease and increase in the length of the dry period, by 1–3 days/10 years, are observed. The trends are mostly insignificant, except at some stations in the northern, northeastern, and northern part of the central parts of the country, as well as locally in the eastern, southeastern, and southern areas, where a statistically significant decrease in the length of this period was recorded; in the southwest, the Aral Sea area, and some mountainous areas of

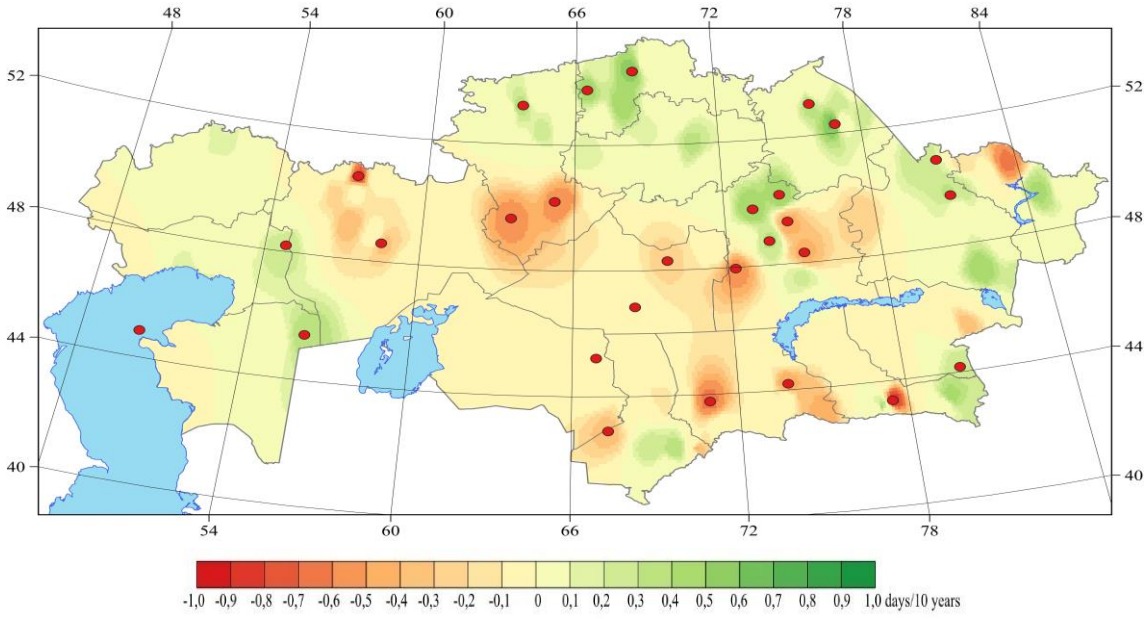
the southeast, an increase in the maximum length of the dry period of 1–6 days/10 years was recorded.



Trends statistically significant at the 5 % level are marked with red circles.

Figure 3.13 *– Rates of change in the maximum length of the dry period (days/10 years) for the period 1961–2025 (CDD index)*

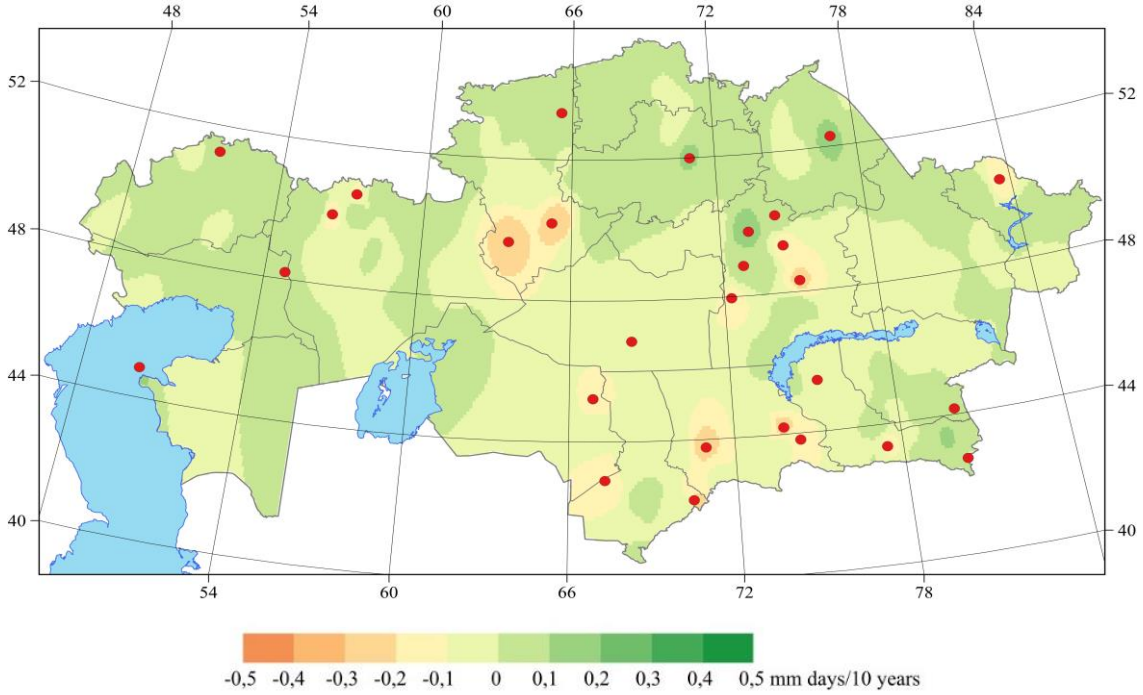
Over the period 1961–2025, *changes in the number of days with daily precipitation of 10 mm or more are weak* (R10mm index, Figure 3.14). At 128 of 186 meteorological stations, the trend coefficient is zero; at the other stations, the trends are of different signs and do not exceed 1 day per 10 years. The largest increase in the number of such days is observed in the northern and central regions, with the maximum at MS Pavlodar (0.62 days/10 years, Pavlodar region). The largest decrease is observed in the southern, central, and western parts of the country, with the maximum at MS Esik (−0.83 days/10 years, Almaty region). A significant increase was identified at 13 meteorological stations, and a significant decrease also at 13.



Trends statistically significant at the 5 % level are marked with red circles.

Figure 3.14 *– Rates of change in the number of days with daily precipitation of 10 mm or more (days/10 years) for the period 1961–2025 (R10mm index)*

In the western, northern, and northeastern regions, the *intensity of daily precipitation* is mostly increasing (SDII index, Figure 3.15), generally by no more than 0.10 mm/day per 10 years; the largest increase, 0.13 mm/day per 10 years, was recorded at MS Karaganda (Karaganda region) and Pavlodar (Pavlodar region). In the southern and central parts of the country, precipitation intensity is mostly decreasing, in places by 0.20–0.29 mm/day per 10 years (MS Shuyldak, Kyzylkum, Uyuk, Khantau, Aktogay, Amangeldy, and Torgay). Statistically significant trends were identified at 28 of 186 meteorological stations: positive at 10 and negative at 18.



Trends statistically significant at the 5 % level are marked with red circles.

Figure 3.15 *– Rates of change in the intensity of daily precipitation (mm/day per 10 years) for the period 1961–2025 (SDII index)*

ANNEX 1

RECORD VALUES OF MEAN MONTHLY AIR TEMPERATURE SET IN 2025

№	Meteorological station	Region	Mean monthly air temperature, °C	Previous record, °C (year)	№	Meteorological station	Region	Mean monthly air temperature, °C	Previous record, °C (year)
April 2025					7	Ulken Almaty Lake	Almaty	9.1	9.0 (2008)
1	Saryshagan	Karaganda	13.1	12.7 (2020)	8	Esik	Almaty	19.4	19.1 (2001)
2	Ust-Kamenogorsk	East Kazakhstan	11.5	11.3 (2020)	9	Kapshagay	Almaty	21.6	21.2 (1961)
3	Karauyl	Abay	11.0	10.9 (2020)	10	Kegen	Almaty	13.2	12.9 (2008)
4	Kishkenekol	North Kazakhstan	9.8	9.6 (2020, 2012)	11	Kuigan	Almaty	21.3	21.1 (2008, 2001)
5	Ruzaevka	North Kazakhstan	10.4	10.3 (2012)	12	Kyrgyzsay	Almaty	18.5	18.4 (2008)
6	Esil	Akmola	11.5	11.4 (2012)	13	Mynzhilki	Almaty	6.0	5.6 (2008)
7	Kokshetau	Akmola	10.3	9.6 (2012)	14	Narynkol	Almaty	13.9	13.8 (1961)
8	Zheleznodorozhny	Kostanay	10.9	10.6 (2012, 1995)	15	Shelek	Almaty	22.0	21.6 (2001)
9	Aul No. 4	Almaty	15.6	15.4 (2022)	16	Zhalanashkol	Zhetysu	22.3	21.6 (2022)
10	Kuigan	Almaty	14.6	14.4 (2022)	17	Aul Turar Ryskulov	Turkestan	21.8	21.5 (2001, 1961)
11	Shuyldak	Turkestan	9.9	9.0 (2012)	18	Ashysai	Turkestan	21.9	21.8 (2001)
12	Chiganak	Zhambyl	15.1	14.8 (2022)	19	Kazygurt	Turkestan	23.3	22.6 (2001)
May 2025					20	Tasty	Turkestan	23.9	23.6 (2001)
1	Besoba	Karaganda	15.8	15.5 (2001)	21	Turkestan	Turkestan	26.1	25.6 (2001)
2	Kainar	Abay	15.9	15.6 (2020)	22	Shardara	Turkestan	25.8	25.6 (2001)
3	Karauyl	Abay	17.5	17.3 (2022)	23	Sholakkorgan	Turkestan	22.9	22.4 (2001)
4	Aidarli	Almaty	22.3	22.1 (2001)	24	Shuyldak	Turkestan	14.9	14.1 (2001)
5	Almaty OGMS	Almaty	20.8	20.6 (2008)	25	Shymkent	Turkestan	23.3	22.9 (2001)
6	Bakanas	Almaty	21.6	21.5 (2022, 2008)	26	Taraz	Zhambyl	22.0	21.4 (2001)

№	Meteorological station	Region	Mean monthly air temperature, °C	Previous record, °C (year)	№	Meteorological station	Region	Mean monthly air temperature, °C	Previous record, °C (year)
27	Korday	Zhambyl	18.7	18.3 (2008)	14	Karauyl	Abay	22.8	21.9 (2022)
28	Kulan	Zhambyl	21.1	20.4 (2008)	15	Kokpekty	Abay	22.4	22.2 (1955)
29	Moyinkum	Zhambyl	22.8	22.7 (2001)	16	Semiyarka	Abay	23.9	23.6 (2006)
30	Tole Bi	Zhambyl	22.3	21.8 (2001)	17	Shalabay	Abay	23.1	21.9 (2017, 2012)
31	Uyuk	Zhambyl	23.3	23.0 (2001)	18	Shar	Abay	23.2	22.3 (2017)
32	Shokpar	Zhambyl	22.1	21.3 (2001)	19	Aidarli	Almaty	27.9	27.0 (2024, 2022)
33	Khantau	Zhambyl	23.4	23.2 (2008)	20	Aksengir	Almaty	25.2	24.5 (2023, 2022)
June 2025					21	Almaty OGMS	Almaty	25.4	24.8 (2008)
1	Balkhash	Karaganda	25.5	25.0 (1955)	22	Almaty, Kamenskoe Plato	Almaty	22.4	21.9 (2024)
2	Saryshagan	Karaganda	25.9	25.8 (2022)	23	Aul No. 4	Almaty	26.9	26.4 (2024, 2022)
3	Katon-Karagay	East Kazakhstan	18.1	17.8 (2017, 1955)	24	Bakanas	Almaty	27.3	26.8 (2022)
4	Ust-Kamenogorsk	East Kazakhstan	22.4	21.9 (2012, 1955)	25	Esik	Almaty	24.0	23.2 (2008)
5	Aksuat	Abay	23.6	22.8 (1977)	26	Kapshagay	Almaty	26.4	26.0 (1977)
6	Akzhar	Abay	23.1	22.6 (1977)	27	Kegen	Almaty	16.5	16.4 (2008)
7	Aktogay	Abay	26.3	25.2 (1977)	28	Kuigan	Almaty	26.9	26.1 (2024)
8	Ayagoz	Abay	22.3	21.9 (1977)	29	Shelek	Almaty	26.7	25.7 (2008)
9	Bakty	Abay	24.9	23.8 (1977)	30	Alakol	Zhetysu	25.4	25.1 (1977)
10	Barshatas	Abay	23.2	22.3 (1977)	31	Kogaly	Zhetysu	19.1	18.4 (2008)
11	Dmitrievka	Abay	22.4	21.7 (2012)	32	Lepsi	Zhetysu	19.2	18.4 (1977)
12	Zhalgyztobe	Abay	23.5	22.8 (2017)	33	Matai	Zhetysu	27.1	26.2 (2008)
13	Kainar	Abay	20.6	19.9 (2022, 1990, 1977)	34	Sarkand	Zhetysu	24.4	23.9 (1977)

№	Meteorological station	Region	Mean monthly air temperature, °C	Previous record, °C (year)	№	Meteorological station	Region	Mean monthly air temperature, °C	Previous record, °C (year)
35	Saryozek	Zhetysu	24.0	22.9 (2008)	4	Alakol	Zhetysu	27.1	26.8 (2017, 1974, 1965)
36	Usharal	Zhetysu	26.2	26.1 (1977)	5	Zhalanashkol	Zhetysu	28.7	28.4 (1974)
37	Ushtobe	Zhetysu	26.2	25.3 (2008)	6	Kazygurt	Turkestan	30.1	29.9 (2019)
38	Zhalanashkol	Zhetysu	27.9	26.7 (1977)	7	Shymkent	Turkestan	30.3	30.0 (2023)
39	Aul Turar Ryskulov	Turkestan	25.9	25.8 (1990)	November 2025				
40	Tasaryk	Turkestan	22.5	22.4 (2023, 1990)	1	Aksai	West Kazakhstan	3.9	3.1 (2023)
41	Taraz	Zhambyl	26.0	25.5 (2008)	2	Dzhambeyty	West Kazakhstan	4.1	3.8 (2010)
42	Korday	Zhambyl	23.1	22.8 (2023)	3	Zhanibek	West Kazakhstan	6.2	5.6 (2010)
43	Kulan	Zhambyl	25.6	25.0 (2024, 2008)	4	Zhalpaktal	West Kazakhstan	5.5	4.9 (2010)
44	Moyinkum	Zhambyl	27.2	26.9 (2024)	5	Uralsk	West Kazakhstan	4.0	3.4 (2010)
45	Tole Bi	Zhambyl	26.3	26.1 (2024)	6	Urda	West Kazakhstan	6.5	6.2 (2010)
46	Chiganak	Zhambyl	27.4	27.0 (2022)	7	Chapaevo	West Kazakhstan	4.8	4.4 (2010)
47	Shokpar	Zhambyl	26.6	26.1 (1941)	8	Chingirlau	West Kazakhstan	3.6	2.9 (2023)
48	Khantau	Zhambyl	28.4	28.1 (2001)	9	Kamenka	West Kazakhstan	4.1	3.1 (2010)
July 2025					10	Karaukeldy	Aktobe	3.8	3.6 (2023, 2010)
1	Almaty OGMS	Almaty	27.5	27.3 (2015)	11	Mugodzhar	Aktobe	3.1	2.6 (2023)
2	Almaty, Kamenskoe Plato	Almaty	24.6	24.2 (2023, 2019)	12	Rodnikovka	Aktobe	1.7	1.4 (2023)
3	Kegen	Almaty	18.9	18.6 (2015)					

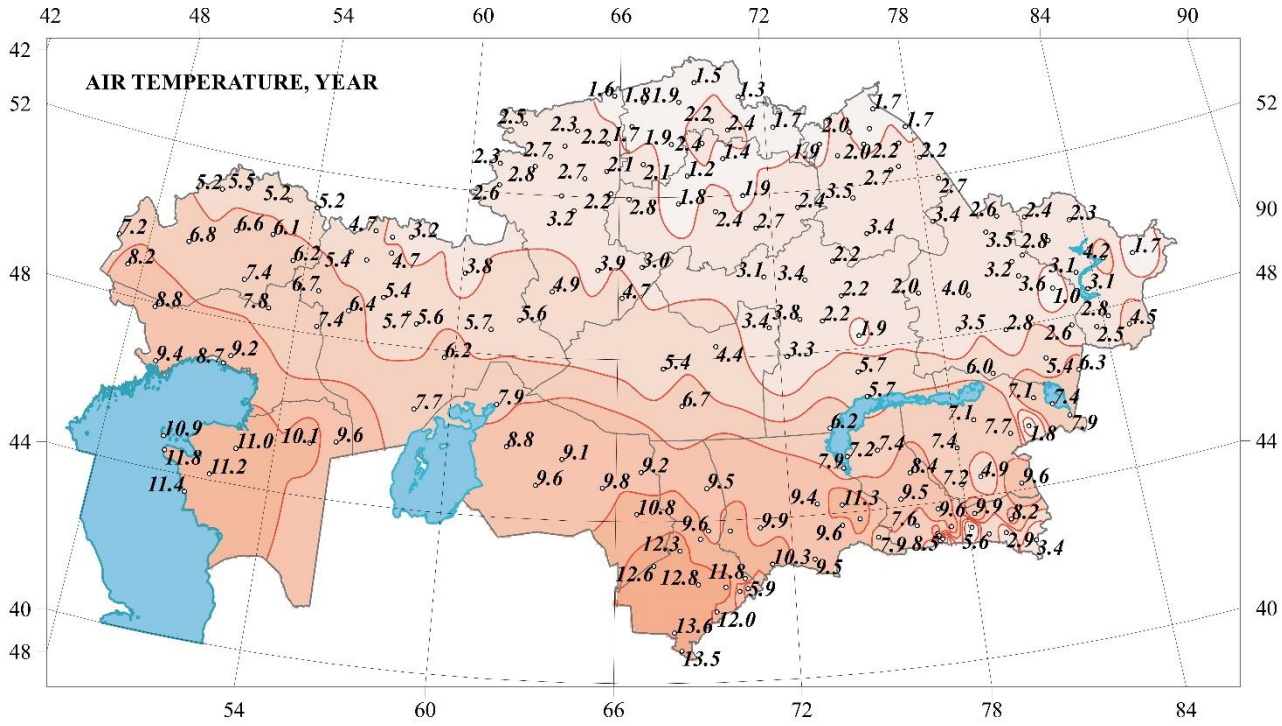
ANNEX 2

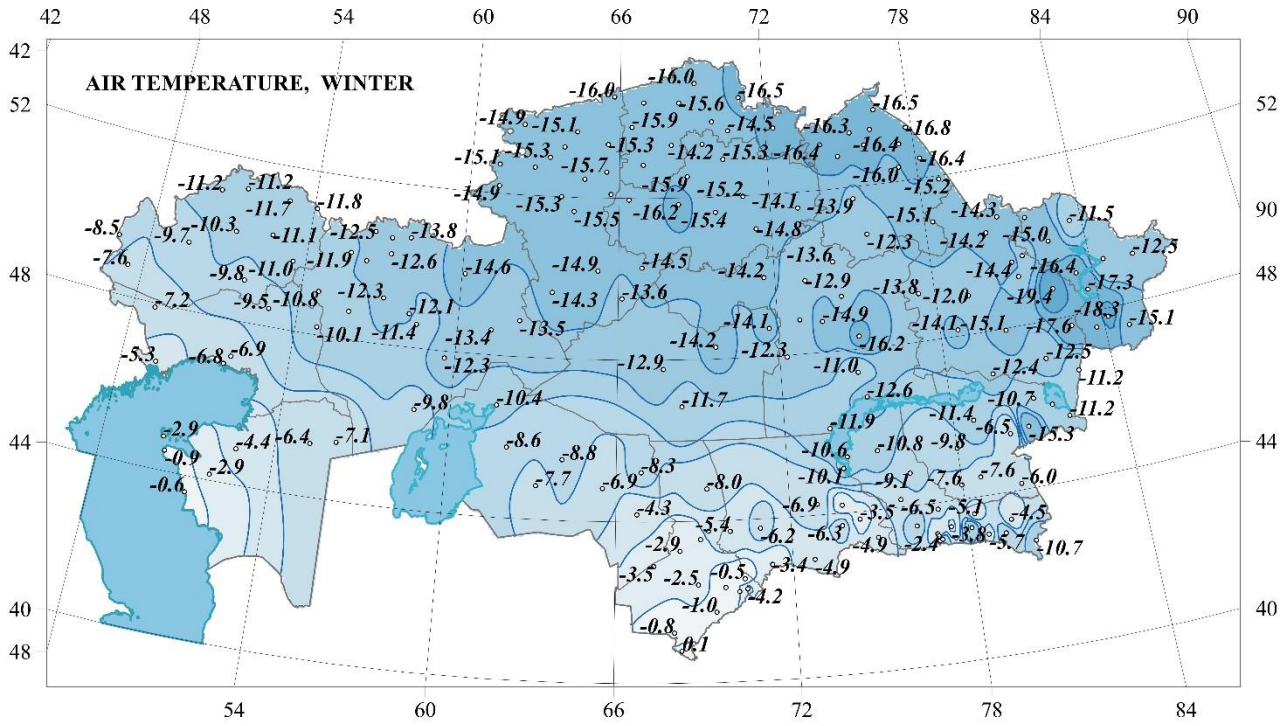
RECORD VALUES OF MONTHLY PRECIPITATION SET IN 2025

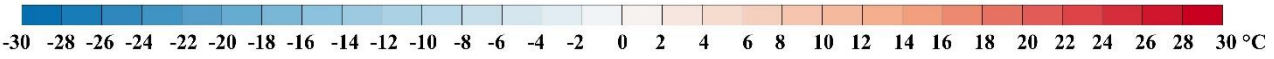
№	Meteorological station	Region	Maximum precipitation, mm	Previous maximum precipitation, mm (year)	Minimum precipitation, mm	Previous minimum precipitation, mm (year)
December 2024						
1	Aul No. 4	Almaty	75.2	37.0 (2002)		
2	Aul Turar Ryskulov	Turkestan	47.6		6.1	8.1 (1965)
January 2025						
1	Chkalovo	North Kazakhstan	32.2	31.9 (1997)		
February 2025						
1	Aktau	Mangystau	45.7	44.8 (1983)		
2	Kertindy	Karaganda			2.70	3.6 (1992)
3	Korday	Zhambyl			4.0	8.1 (1957)
4	Kegen	Almaty			1.2	1.5 (1962)
5	Mynzhilki	Almaty			6.0	7.9 (1942)
April 2025						
1	Korday	Zhambyl			3.8	11.1 (2000)
May 2025						
1	Blagoveshchenka	North Kazakhstan	118.1	99.8 (1953)		
2	Yavlenka	North Kazakhstan	96.3	88.6 (1940)		
3	Ruzaevka	North Kazakhstan	104.0	100.2 (2007)		
4	Presnogorkovka	Kostanay	88.6	84.0 (1963)		
5	Sharbakty	Pavlodar			1.1	2.5 (1974)
6	Korday	Zhambyl			6.8	7.3 (1953)
June 2025						
1	Kamenskoe Plato	Almaty			11.8	16.2 (2023)
2	Aidarli	Almaty			1.4	2.2 (2020)
July 2025						
1	Almaty	Almaty			2.3	3.0 (1943)
August 2025						
1	Shaldai	Pavlodar	96.9	85.9 (2013)		
September 2025						
1	Ekibastuz	Pavlodar	57.1	52.0 (2023)		
2	Shar	Abay	57.6	56.7 (2023)		
3	Karauyl	Abay	74.5	51.1 (1992)		
4	Ayagoz	Abay	68.7	58.3 (1986)		
October 2025						
1	Taiynsha	North Kazakhstan			2.6	3.4 (1994)
2	Besoba	Karaganda			0.9	1.9 (1955)
3	Kertindy	Karaganda			3.2	4.9 (2005)
4	Korneevka	Karaganda			0.7	6.5 (1993)
5	Kyzyltau	Karaganda			0	0 (1955)
6	Zhaltyr	Akmola			1.6	2.6 (1974)
7	Astana	Akmola			0.4	2.8 (1994)
November 2025						
1	Ruzaevka	North Kazakhstan	69.1	66.9 (2022)		
2	Zheleznodorozhny	Kostanay	51.9	49.8 (1984)		
3	Astana	Akmola	62.4	57.3 (1984)		

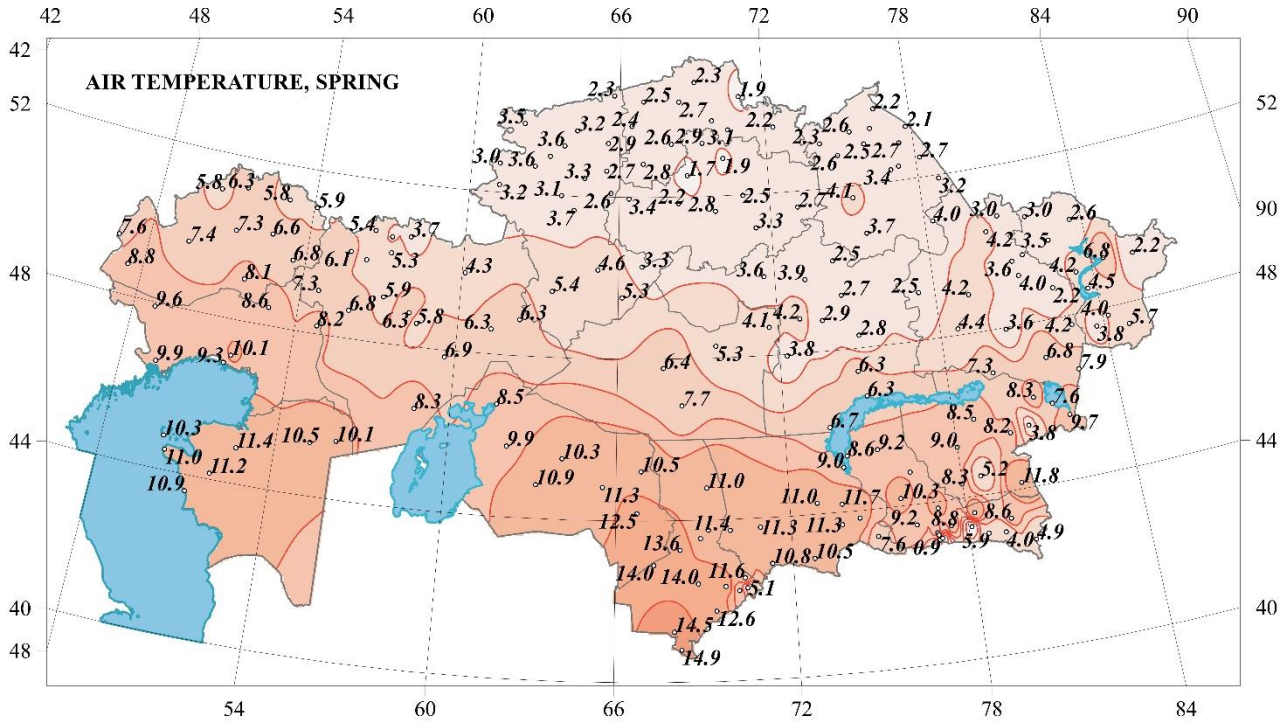
ANNEX 3

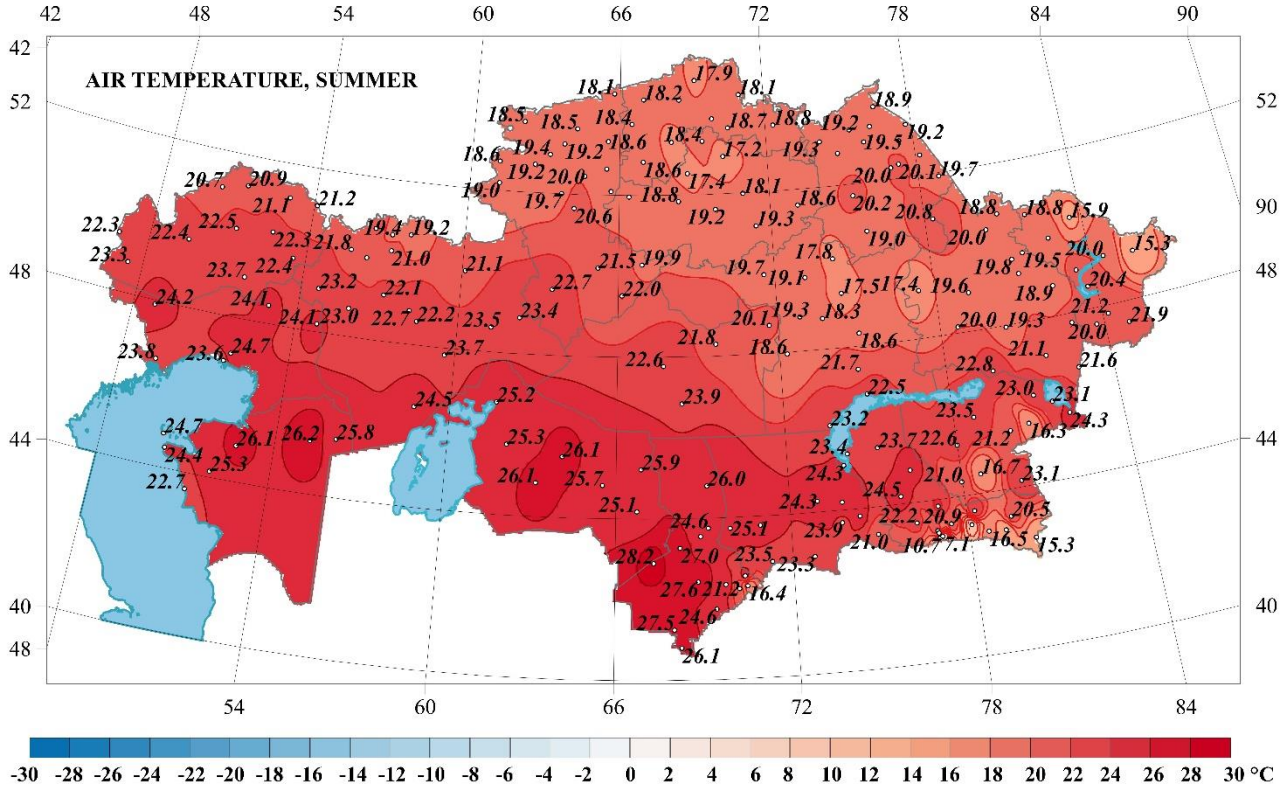
SPATIAL DISTRIBUTION OF AVERAGE ANNUAL AND SEASONAL AIR TEMPERATURES OVER THE TERRITORY OF KAZAKHSTAN, CALCULATED FOR THE PERIOD 1961–1990



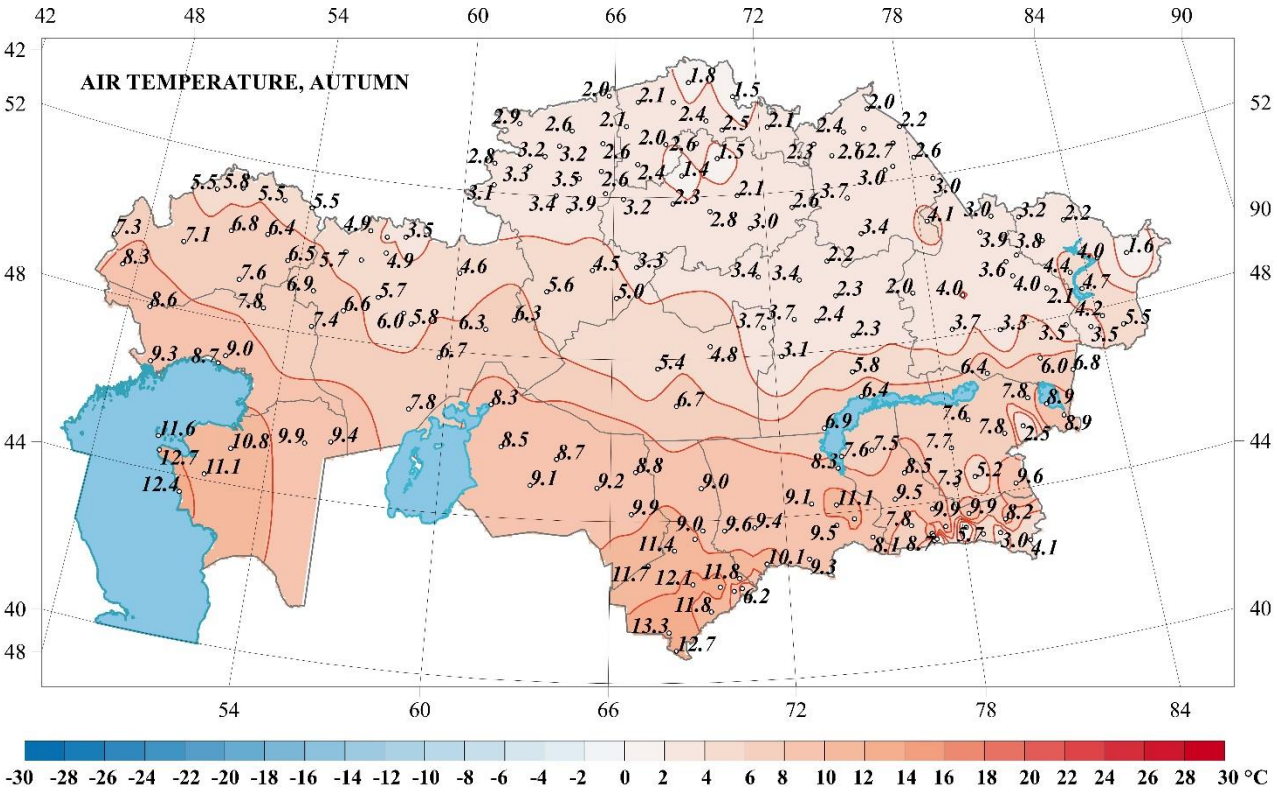





AIR TEMPERATURE, SPRING
42
48
54
60
66
72
78
84
90
52
44
40

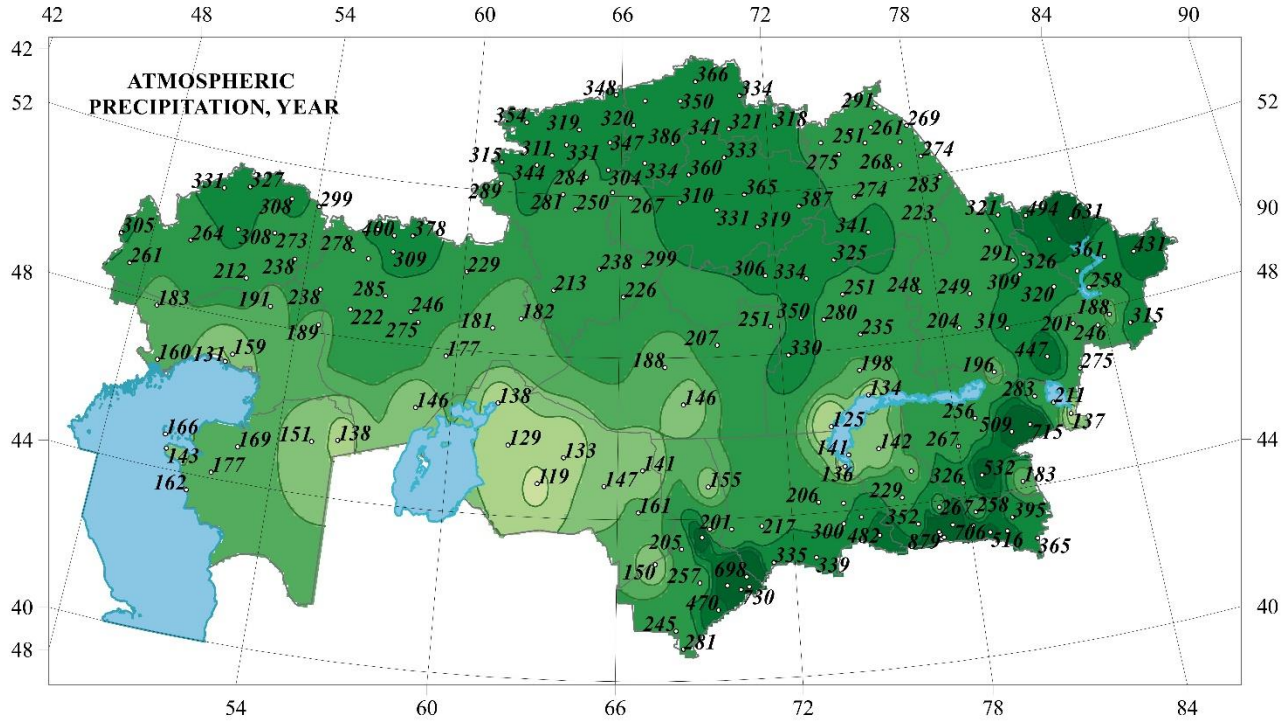

AIR TEMPERATURE, SUMMER
42
48
54
60
66
72
78
84
90
52
44
40

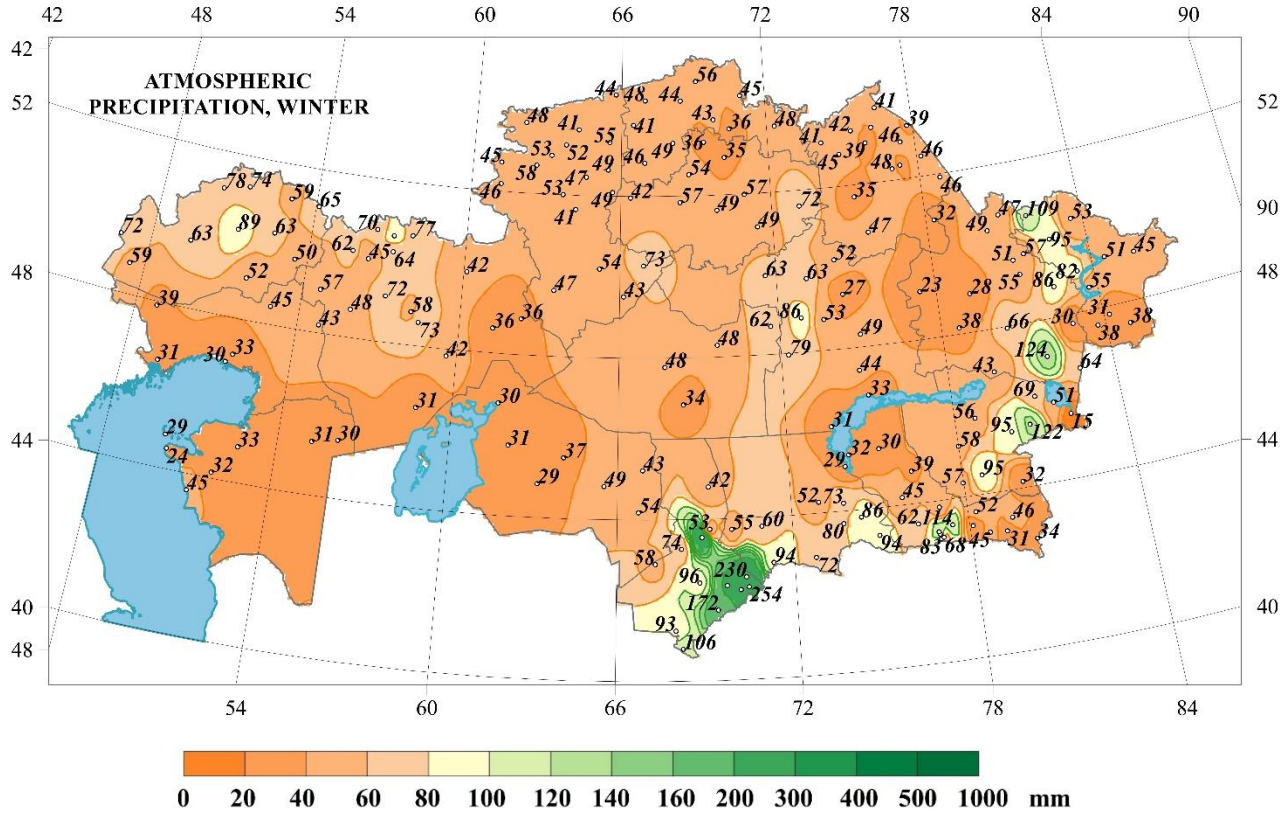
-30 -28 -26 -24 -22 -20 -18 -16 -14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 °C

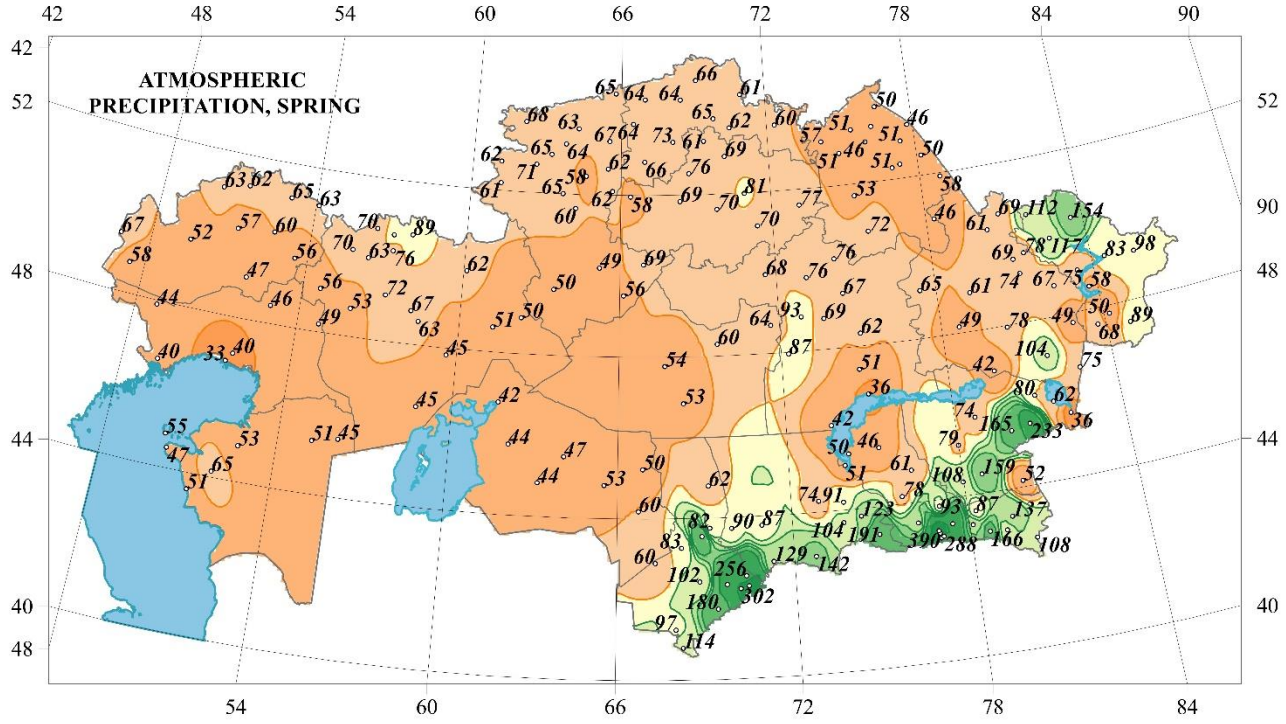

AIR TEMPERATURE, AUTUMN
42
48
54
60
66
72
78
84
90
52
44
40
-30 -28 -26 -24 -22 -20 -18 -16 -14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 °C

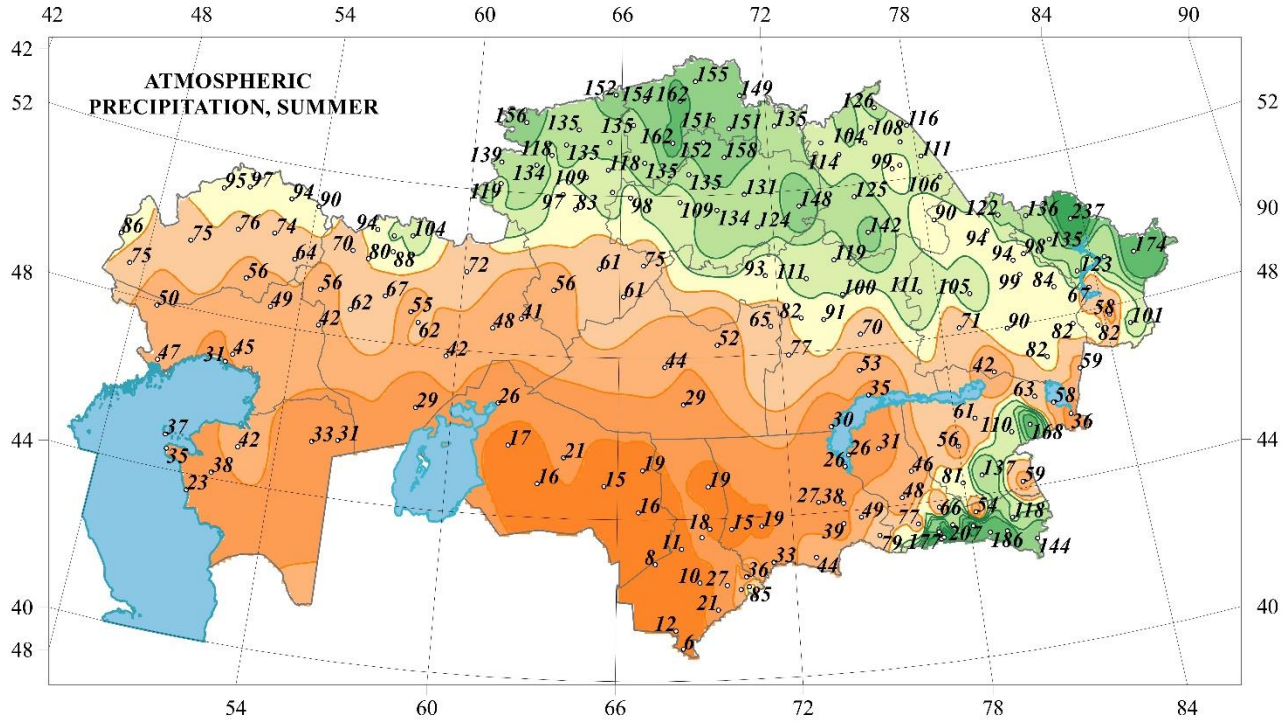
ANNEX 4

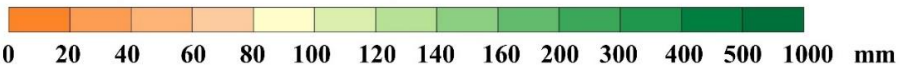
SPATIAL DISTRIBUTION OF ANNUAL AND SEASONAL PRECIPITATION AMOUNTS OVER THE TERRITORY OF KAZAKHSTAN, CALCULATED FOR THE PERIOD 1961– 1990

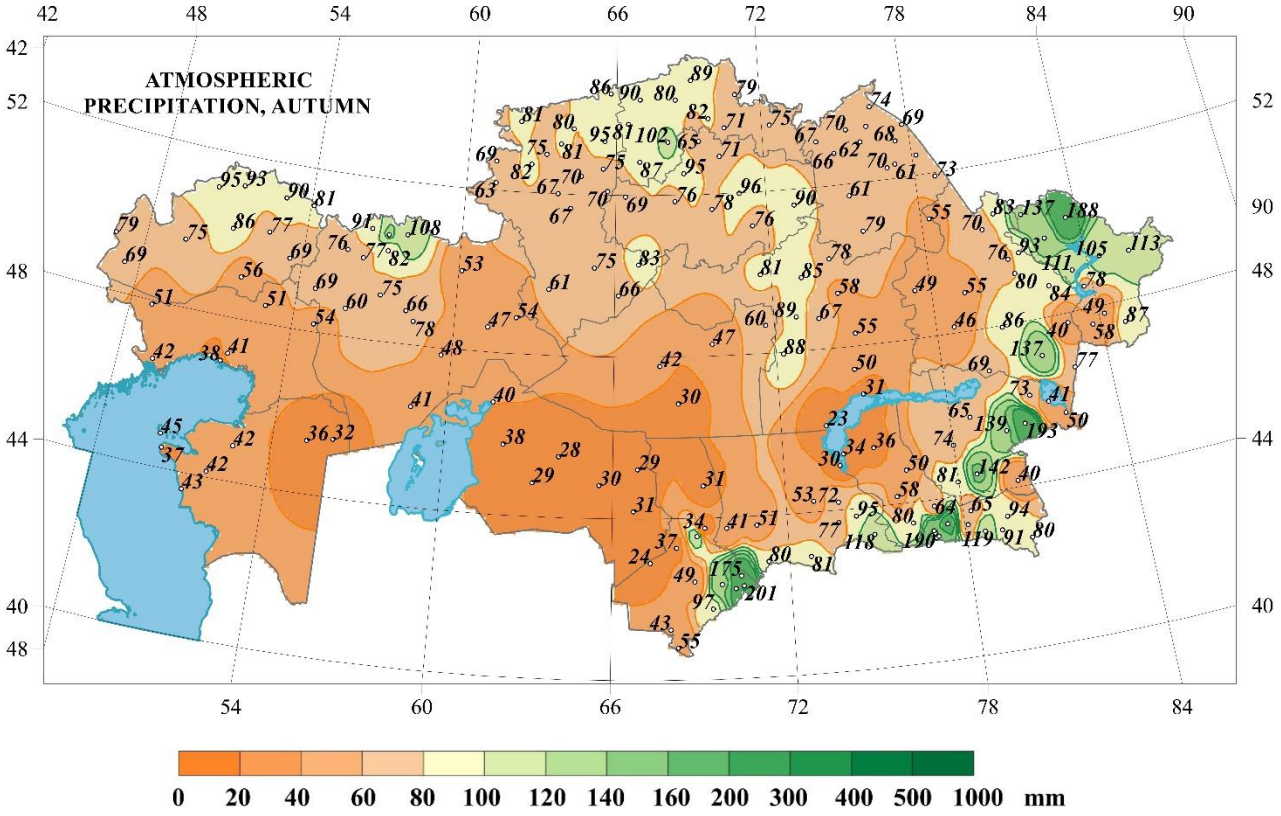





ATMOSPHERIC
PRECIPITATION, SPRING
42
48
54
60
66
72
78
84
90
52
44
40


ATMOSPHERIC
PRECIPITATION, SUMMER
42
48
54
60
66
72
78
84
90
52
44
40


0 20 40 60 80 100 120 140 160 200 300 400 500 1000 mm


ATMOSPHERIC
PRECIPITATION, AUTUMN
42
48
54
60
66
72
78
84
90
52
44
40
0 20 40 60 80 100 120 140 160 200 300 400 500 1000 mm

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