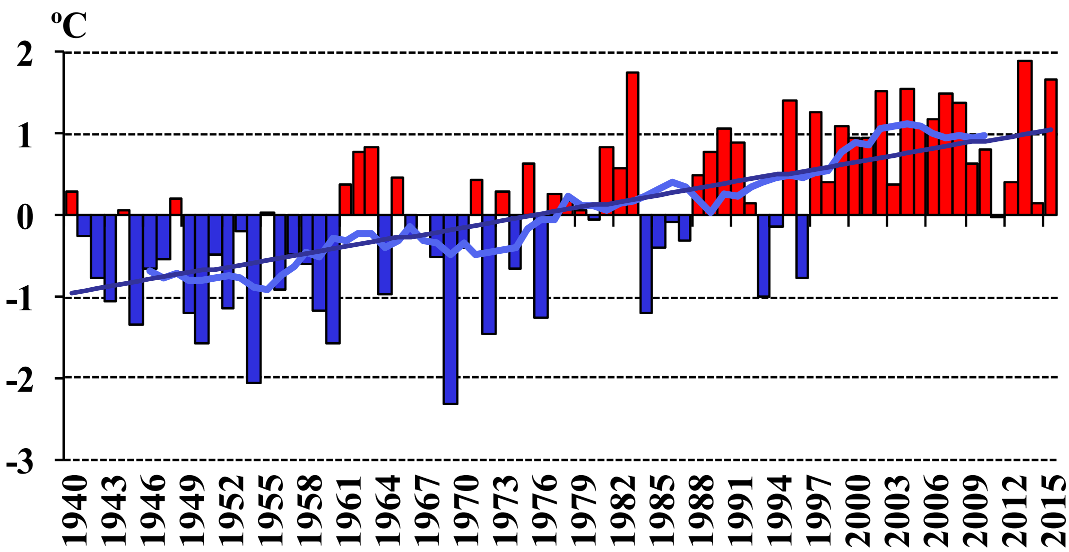
Ministry of Energy of the Republic of Kazakhstan

Republican State Enterprise "Kazhydromet"

ANNUAL BULLETIN OF CLIMATE CHANGE MONITORING IN KAZAKHSTAN:

2015



Astana, 2016

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INTRODUCTION

Climate is a natural resource and is very important for our well-being, health and prosperity. National Hydrometeorological services collect and analyze information that helps decision-makers and users to plan and adapt their activities and projects within the expected conditions. Thus, decisions can be made in the planning process, reduce risks and optimize socio-economic benefits. Climate system monitoring is carried out by national, regional and international organizations, coordinated by the World Meteorological Organization and in cooperation with other environment programs.

The study of regional climate and continuous monitoring of its change is one of the priority tasks of the National Hydrometeorological service "Kazhydromet." Since 2010 the National Hydrometeorological Service annually prepares and publishes the bulletin on the climate state in Kazakhstan to provide reliable scientific information on climate, its variability and change. Taking into account the geographic location of Kazakhstan and its vast territory, the observed changes in climatic conditions in different regions can have both negative and positive impacts on the biophysical system, economic activities and social services. A better understanding of climate formation and climate change are critical to assess the potential impact and to take timely and appropriate adaptation measures for sustainable development of Kazakhstan.

The given bulletin describes the climatic conditions of 2015 including the meteorological extremes assessment. It also includes historical information about climate variability and trends since the 1940's. Also in this bulletin added distribution maps of air temperature and precipitation averaged over the seasons for the period 1961...1990 (see. Annex 1 and 2).

Initial data. Bulletin is based on data of the National Hydrometeorological Fund of "Kazhydromet":

1) The series of average monthly air temperature and monthly precipitation from 1941 to 2015. Data of more than 190 weather stations were used to assess climate normal for 1961...1990. Also experts used more than 110 weather stations data to assess trends;

2) The series of daily maximum and minimum air temperatures and daily precipitation from 1941 to 2015 (more than 90 meteorological stations).

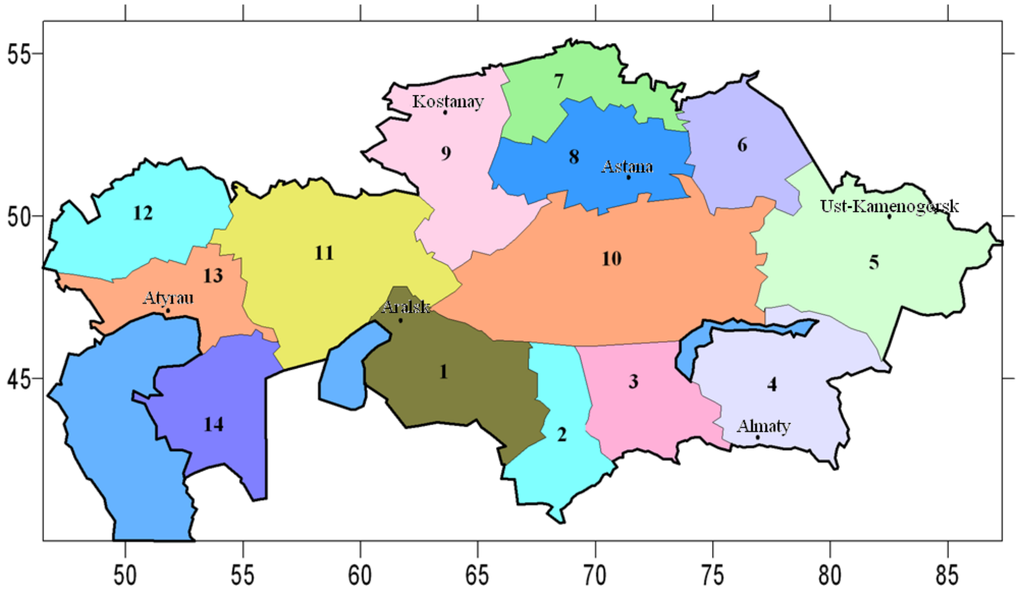
Basic approaches and methods.

Climate "normal" in the bulletin means average value of the considered climatic variable for the 1961…1990. Temperature anomalies are calculated as the deviation of the observed values from the norm. Precipitation anomalies are usually considered both as deviation from the norm (like temperature) and as percentage of the norm, i.e. ratio of observed precipitation and the norm. Probability of non-exceedance shows the percentage frequency of particular anomaly in the observation record.

Linear trend factors defined by the least-squares method were used as climate change indicators for a certain period. Trend significance was assessed with the determination factor (R^2), representing a percentage share of variance.

The surface air temperature and precipitation trends were assessed both for individual stations and on average for the 14 administrative areas in Kazakhstan. Experts fitted observation time series to the linear function using the least-squares method. The mean anomalies for the area were calculated by averaging the station data anomalies. The map below shows the administrative areas in Kazakhstan.

Experts used the WMO climate change indices to assess extreme temperatures and precipitation in 2015. Some indexes are based on a fixed threshold values for all stations, the other - on the threshold values, which can vary from station to station. In the latter case, the threshold values are defined as the corresponding percentile of the data series. Indices allow estimating many aspects of climate change, such, for example, the change in intensity, frequency and duration of extreme temperature in air and precipitation.



Administrative areas in Kazakhstan

1 – Kyzylorda oblast	8 – Akmola oblast
2 – Southern Kazakhstan oblast	9 – Kostanay oblast
3 – Zhambyl oblast	10 – Karaganda oblast
4 – Almaty oblast	11 – Aktobe oblast
5 – Eastern Kazakhstan oblast	12 – Western Kazakhstan oblast
6 – Pavlodar oblast	13 – Atyrau oblast
7 – Northern Kazakhstan oblast	14 – Mangistau oblast

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1 OVERVIEW OF GLOBAL CLIMATE CHANGE AND ITS STATUS IN 2015

World Meteorological Organization (WMO) conducts annual assessments of the state of the global climate. For over two decades, those assessments have been published in the six official languages of the United Nations in order to inform governments, international agencies and other WMO partners about global climate trends, and extreme and notable weather and climate events at the national and regional levels.

The Statement draws on in situ and space-based observations collected through various WMO and co-sponsored programmers. It also draws on numerical objective analyses. These observations are the Essential Climate Variables that have been defined by the Global Climate Observing System.

The year 2015 will stand out in the historical record of the global climate in many ways. Modern records for heat were broken: 2015 was a record warm year both globally and in many individual countries. Heat waves were extremely intense in various part of the world, leading to thousands of deaths in India and Pakistan. Record extreme precipitation led to flooding that affected tens of thousands of people across South America, West Africa and Europe. Dry conditions in southern Africa and Brazil exacerbated multi-year droughts. The influence of the strong El Nino that developed in the later part of 2015 can be discerned in many of the year's weather and climate events. While much work remains to be done, advances in international collaboration, the near-real-time sharing of data, and progress in attribution science are starting to make it possible to disentangle the respective roles played by El Nino, other natural climate variations and human-induced climate change.

In 2015 global warmth reached record levels as a result of the long-term rise in global temperatures (caused mostly by humanity's emissions of greenhouse gases) combined with the effects of a developing El Nino.

The global average near-surface temperature for 2015 was the warmest on record by a clear margin, according to data sources[1] analyzed by WMO (figure 1.1). The global average temperature for the year was about 0.76 ± 0.09 ºC above the 1961 – 1990 average, and approximately 1 ºC above the 1850 – 1900 average.

The global average of temperatures over land areas shows that 2015 was the joint warmest year on record over land: 2005, 2007 and 2010 are comparable. The global average temperature over the sea surface in 2015 was equal to the 2014 record. The combination of high land and sea temperatures made on the whole 2015 – the record year.

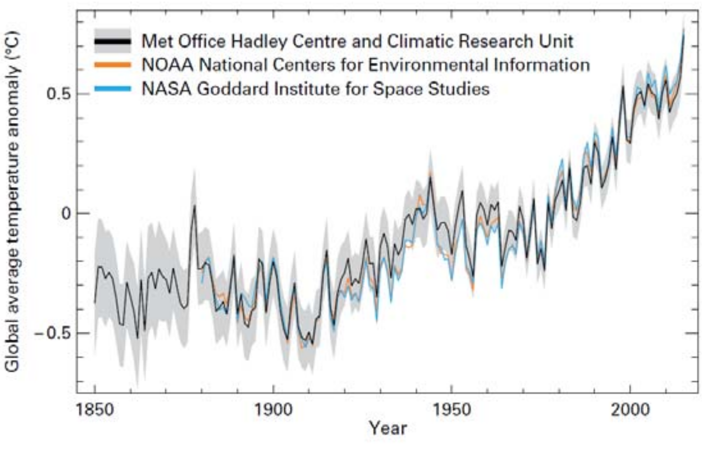


Figure 1.1 – Annual global average temperature anomalies (relative to the 1961 – 1990) from 1850 to 2015 from the Hadley Centre/CRU (HadCRUT4) (black line and grey area, representing average and 95 percent uncertainty range), the National Climatic Data Center (red), and the NASA Goddard Institute for Space Studies (blue). *(Source: WMO-№ 1167)*

In 2015, global ocean heat content reached record levels through both the upper 700 m and 2 000 m of the oceans (figure 1.2).

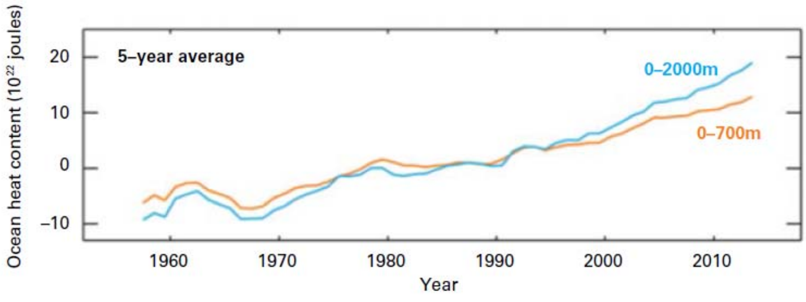


Figure 1.2 - Five-year-average ocean heat content. *(Source: WMO-№ 1167)*

The latest estimates of the global sea level from satellite altimeters indicate that the global average sea level for January to November 2015 was the highest ever recorded by satellites. In line with the long-term upward trend in sea level as estimated by tide gauges, the same period also saw the highest recorded sea level since global records began more than a century ago.

In 2015, sea surface temperature in the East Central Pacific was above average values during the spring period and in the northern hemisphere they have exceeded the threshold values that are typical of El Niño. During El Niño is a weakening of the prevailing trade winds or change their direction is reversed, thereby increasing the surface temperature (figure 1.3).

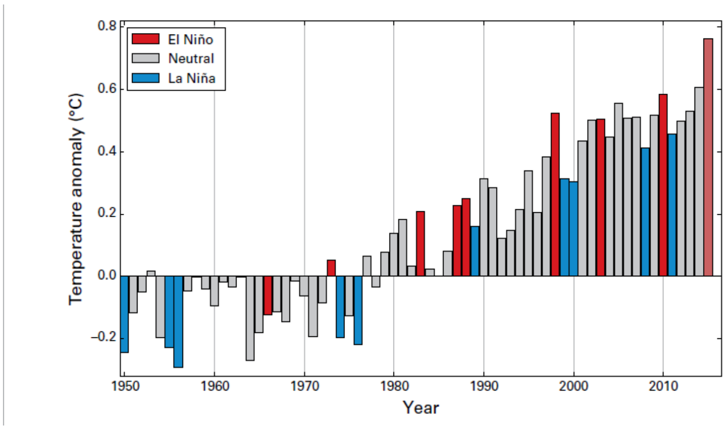


Figure 1.3 – Global annual average temperature anomalies (difference from the 1961–1990 average) based on an average of the three global temperature datasets. Coloured bars indicate years that were influenced by El Nino (red) and La Nina (blue), and the years without a strong influence (grey). The pale red bar indicates 2015. *(Source: Met Office Hadley Centre, United Kingdom, and Climatic Research Unit, University of East Anglia, United Kingdom).*

Figure 1.4 shows a schematic of typical precipitation anomaly patterns that are favored during El Nino. In 2015 Rainfall deficits consistent with El Nino were observed from Central America to northern Brazil, in southern parts of Africa, South-East Asia, large areas of Oceania and eastern Australia. Monsoon rains in India were also below average. Areas of above-average precipitation included southern Brazil and northern Argentina, and southern areas of the United States.

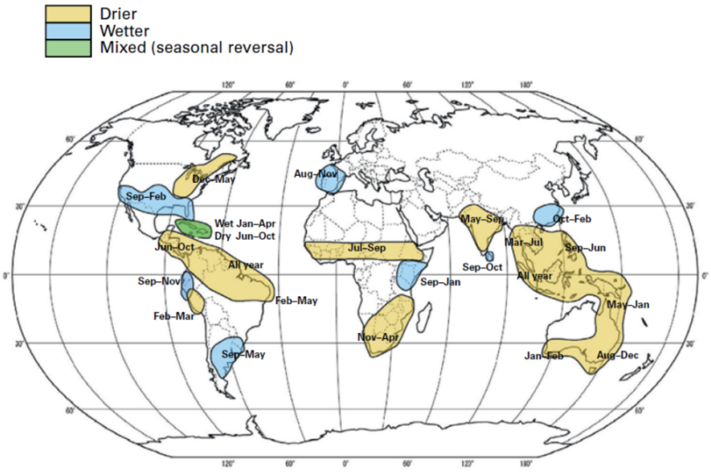


Figure1.4 - Precipitation anomalies favored during El Nino, based on historical rates of occurrence during previous El Nino events *(Source: adapted from Met Office Hadley Centre, United Kingdom)*

Moreover, El Nino affects the formation and development of tropical cyclones. It suppresses the formation of hurricanes in the North Atlantic and promotes the formation of hurricanes and typhoons in the Eastern North Pacific. That is consistent with observations from 2015

Globally, a total of 91 tropical storms formed during 2015. The figure of 91 storms is above the 1981 – 2010 annual average of about 85 storms. A named storm is defined as a tropical storm where the wind speed equals or exceeds 63 km/h.

In the northern hemisphere ever since consistent satellite records began in the late 1970s, there has been a general decline in sea-ice extent throughout the seasonal cycle. In 2015, the daily maximum extent, which occurred on 25 February, was the lowest on record, at 14.54 million km^2. That is 1.10 million km^2 below the 1981 – 2010 average and 0.13 million km^2 below the previous record set in 2011. The minimum sea ice extent was recorded on 11 September. It measured 4.41 million km^2. That was the fourth-lowest minimum extent in the satellite record (figure 1.5 left). On 30 December, unusually warm air moved northward into the polar region. Consequently, an above-freezing temperature of +0.7 ºC was, albeit briefly, recorded on that day by a weather buoy near the North Pole.

In the southern hemisphere in 2015 a daily maximum extent of 18.83 million km^2 was recorded on 6 October (figure 1.5 right). That is the sixteenth-highest maximum extent in the satellite record and 1.33 million km^2 below the 2014 record maximum. The minimum extent, recorded on 20 February, was 3.58 million km^2. That is the fourth-highest summer minimum extent on record and 0.17 million km^2 below the 2008 record.

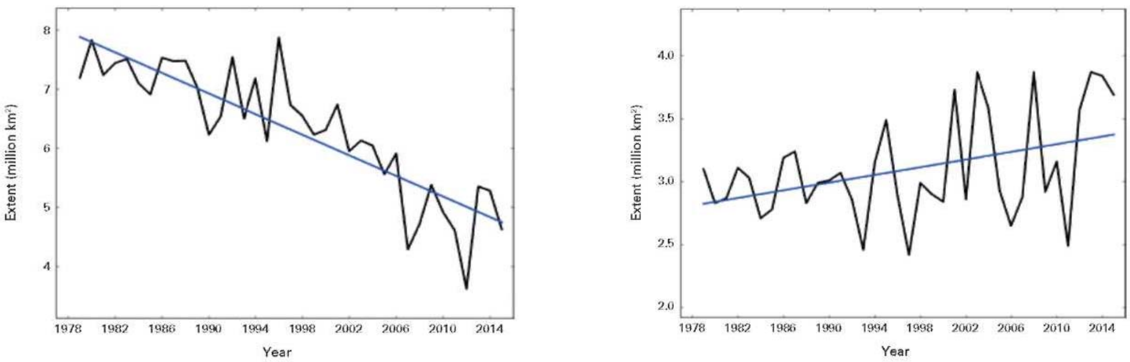


Figure 1.5 – Monthly sea-ice extent for February in the southern hemisphere (right) and September in the northern hemisphere (left) for 1979-2015 *(Source: National Snow and Ice Data Center, NOAA, United States)*

There were numerous extreme events recorded worldwide in 2015, with damages and casualties reported in several cases. Western Canada - warmest summer on record; Contiguous United States – month of May the wettest month of any month on record; Mexico – wettest March since national records began in 1941; Chile – driest January in at least five decades; South America – warmest year since continental records began in 1910; extreme rainfall registered in Paraguay, northern Argentina and southern Brazil in the last quarter of the year about 180 000 people affected and more than 80000 displaced; in Europe, as a whole, second-warmest year on record, behind 2014, heat waves on continent between May and September; Asia – warmest year on record for the Russian Federation; warmest June – August period on record for Hong Kong, China; China – Heavy rain from May to October causing floods affecting 75 million people; Major heat wave (20 – 30 May) in India, some locations reaching 47 ºC and about 2500 people dying due to the heat; in southern Pakistan, period of extreme heat (17 – 24 June) with more than 1600 people dying in the heat; driest calendar year in record in South Africa; Australia – October exceptionally warm, recording the largest anomaly for any month on record; in Marrakech, over 13 times the monthly precipitation average in one hour on 6 August; heavy rain in the western coastal region of Libya on 24 September, with more than 90 mm rainfall in 24 hours at Sorman, leading to flash floods. Activity of hurricanes in the North – East Pacific was 144 % (18 storms, 13 hurricanes). The hurricane Patricia is the most powerful in the basin north – eastern part of the Pacific and the North Atlantic, the maximum wind speed of 346 km/h.

2 AIR TEMPERATURE

2.1 Observed changes in air temperature in Kazakhstan

Climatic changes observed on the globe in the twenty and twenty-first century also have occurred in Kazakhstan. The territory of Kazakhstan is located in the center of the Eurasian continent, and it is removed from the ocean by a considerable distance (2000 – 3000 km). The territory is warming more dramatically than the northern hemisphere and the globe on average. There is a difference in the list of the warmest years in the whole of the globe and in Kazakhstan. The five warmest years in Kazakhstan correspond to the ten globally warmest years (table 2.1).

Table 2.1 – The ranked 10 warmest years for the globe (1850–2015) and for Kazakhstan (1941-2015) and corresponding annual average temperature anomalies for Kazakhstan. Anomalies estimated relative to 1961–1990 baseline

Rank	Globe	Kazakhstan	Annual average temperature anomaly for Kazakhstan, °C
1	2015	2013	1.89
2	2014	1983	1.76
3	2010	2015	1.66
4	2005	2002	1.53
5	1998	2004	1.54
6	2003	2007	1.48
7	2002	1995	1.41
8	2013	2008	1.38
9	2007	1997	1.26
10	2006	2006	1.19

In Kazakhstan 2015 year was the 3rd place in the ranked annual average temperature anomalies, while for the global temperature anomalies was the first place. The annual average temperature anomaly in 2015 was higher by 1.7 ºC than normal, which amounted 5.7 ºC.

Figure 2.1 presents the ranked annual average temperature anomalies estimated relative to the1961–1990 and averaged over 118 weather stations in Kazakhstan for the 1940–2015.

All of extremely warm years on average for the globe come from the last 20 years. In azakhstan, this feature is also clearly seen, with the exception of 1983. During the 75th last years in Kazakhstan, the coldest was 1969, when the annual average temperature anomalies was minus 2.52 ºC.

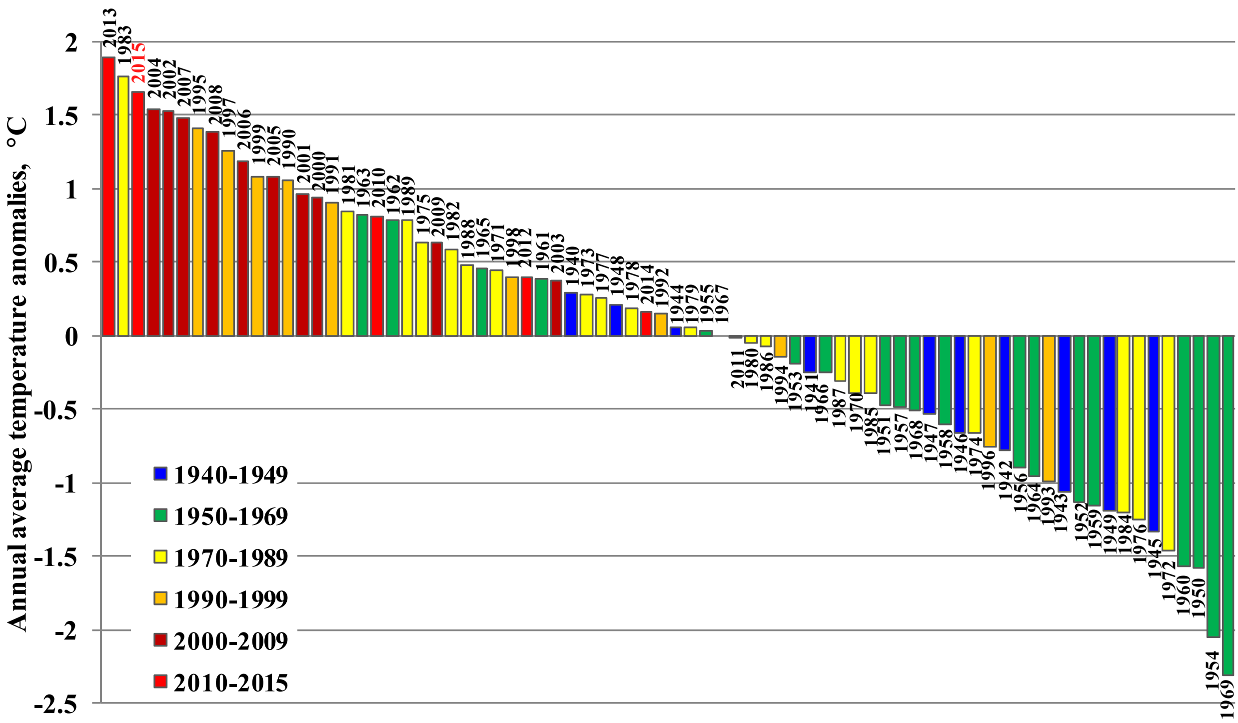


Figure 2.1 – Ranked annual average air temperature anomalies for Kazakhstan (date of 118 weather stations) for 1941–2015. Anomalies estimated relative to 1961-1990 baseline

Figures 2.2 – 2.3 and table 2.2 present the air temperature change for 1941–2015 for Kazakhstan and administrative areas. During the last 75 years the average annual and seasonal surface air temperatures have been increasing everywhere in Kazakhstan.

Country average annual temperature has been rising by 0.28 ºC/10 years (table 2.2). The highest warming was in autumn and in spring by 0.30 – 0.31 ºC/10 years. Winter temperature has been increasing a little slower by 0.28 ºC/10 years. The slowest warming was in summer – 0.19ºC/10 years (table 2.2). In most cases the trends are statistically significant for the 95 % confidence interval. The contribution of trend to the total average annual temperature dispersion is 40 %, for seasons contribution varies from 7 to 27 % (table 2.2). It should be noted that in this century temperature anomalies of spring, summer and autumn were mostly positive, while in winter temperature anomalies were mostly negative and positive(figure 2.2).

The fastest increase in the average annual temperature was in West Kazakhstan oblast equal to 0.38 ºC every 10 years and the lowest warming rates were in South–Kazakhstan Oblast (0.22 ºC every 10 years). In all areas, in the last 30 years, period dominated by the years with considerable positive anomalies average annual temperature (figure 2.3).

The increase in winter temperatures was within 0.18 – 0.31 ºC/10 years, except for Atyrau and West Kazakhstan Oblasts, where it was 0.38 and 0.46 ºC, respectively. In spring the temperature increase was observed in southern and eastern areas by 0.21 – 0.28 ºC every 10 years, in western and south–western areas by 0.32 – 0.42 ºC every 10 years and in the central and northern areas by 0.35 – 0.38 ºC every 10 years.

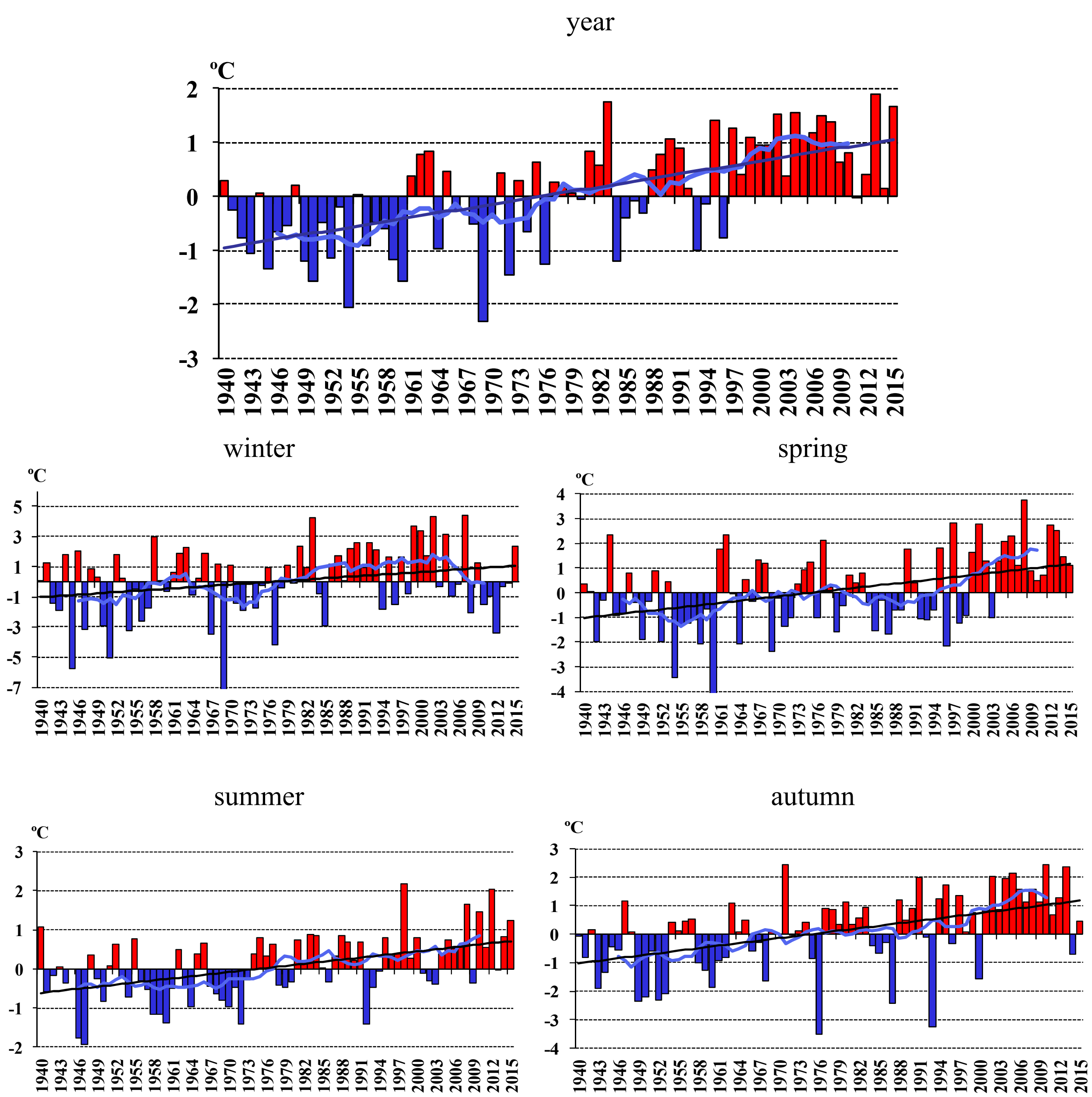


Figure 2.2 – Time series and linear trends of the annual and seasonal air temperatures anomalies relative to 1961–1990 for 1941–2015 for Kazakhstan. *The smooth curve represents the 11-year moving average*

In most areas, the smallest warming occurs by 0.14 – 0.28 °C/10 years, with the exception of Mangistau oblast, where the rate of warming is much higher than 0.45 °C/10 years (table 2.2). In autumn rise in air temperature is in the range of 0.26 – 0.37 °C/10 years. In the southern and eastern regions autumn temperatures were greater than in other seasons.

Table 2.2 – Parameters of the air temperature anomaly linear trend for Kazakhstan and its administrative oblasts for 1941–2015

Oblast	Year		Winter		Spring		Summer		Autumn	
	*a	**R^2	a	R^2	a	R^2	a	R^2	a	R^2
Kazakhstan	0.28	40	0.28	7	0.31	18	0.19	27	0.30	24
Kyzylorda	0.30	34	0.23	3	0.33	17	0.28	36	0.29	22
South Kazakhstan	0.22	29	0.18	2	0.21	12	0.18	20	0.31	26
Zhambyl	0.30	41	0.28	5	0.25	14	0.27	39	0.37	34
Almaty	0.24	34	0.28	8	0.23	13	0.14	15	0.28	25
East Kazakhstan	0.26	27	0.28	6	0.28	12	0.15	12	0.30	18
Pavlodar	0.27	26	0.29	4	0.38	18	0.14	9	0.26	12
North Kazakhstan	0.30	31	0.31	6	0.37	17	0.19	11	0.30	14
Akmola	0.29	32	0.27	5	0.38	16	0.17	11	0.31	15
Kostanay	0.31	34	0.31	6	0.36	14	0.23	15	0.31	16
Karaganda	0.28	32	0.25	5	0.35	17	0.20	19	0.31	19
Aktobe	0.29	32	0.30	6	0.32	11	0.22	15	0.29	16
West Kazakhstan	0.38	41	0.46	11	0.42	20	0.27	18	0.34	22
Atyrau	0.29	35	0.38	9	0.31	16	0.21	21	0.27	17
Mangistau	0.31	30	0.20	2	0.34	14	0.45	38	0.26	10

* a – linear trend factor,°°C per 10 years
** R^2 – determination factor, %
Mangistau oblast ─ parameters calculations were performed for 1960 ─ 2015

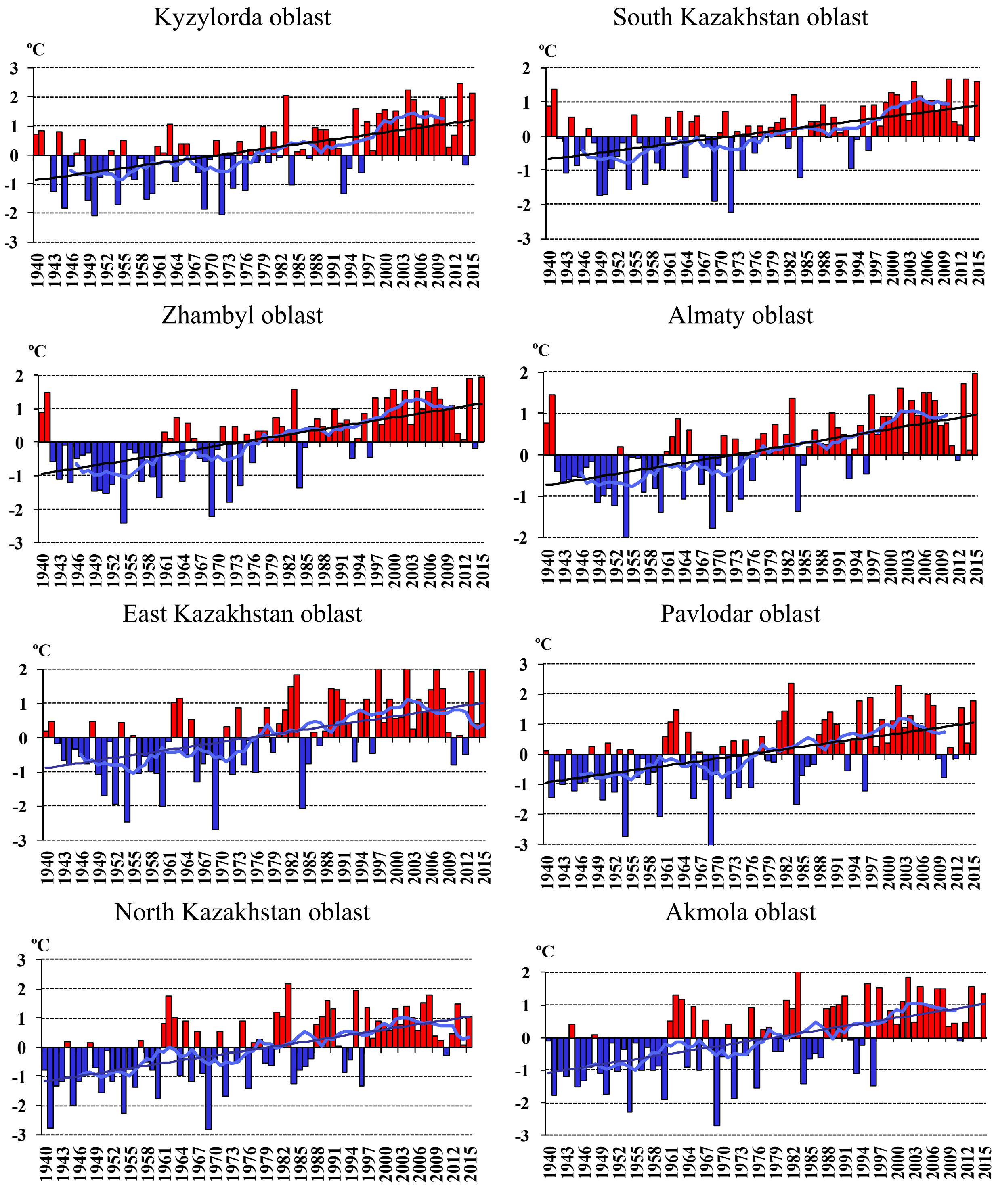


Figure 2.3 – Time series and linear trends of the annual average air temperatures anomalies relative to 1961 – 1990 for 1941 – 2015 for Kazakhstan (°C). *The smooth curve represents the 11-year moving average.* List 1

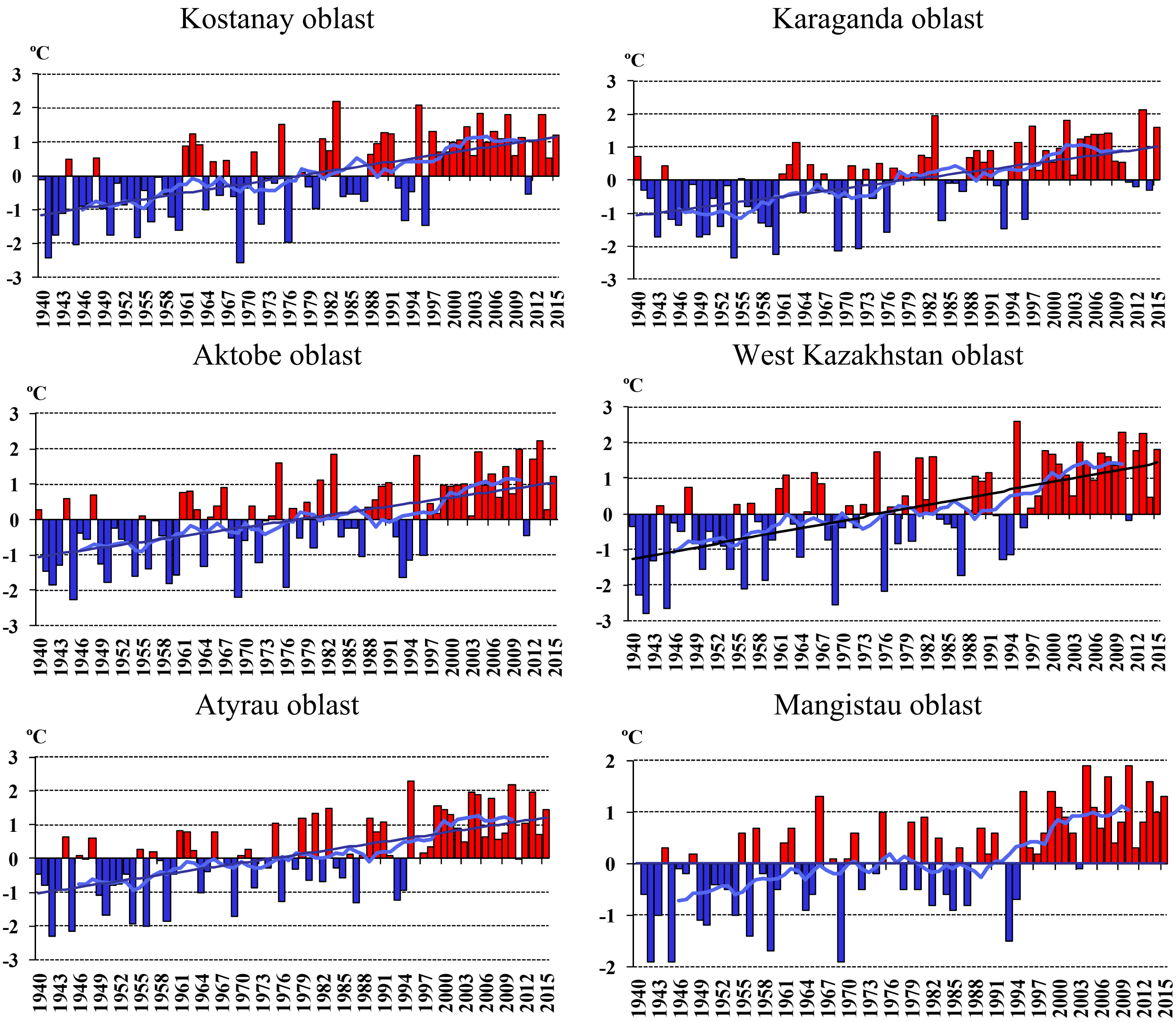


Figure 2.3 – Time series and linear trends of the annual average air temperatures anomalies relative to 1961 – 1990 for 1941 – 2015 for Kazakhstan (°C). *The smooth curve represents the 11-year moving average.* List 2

Figure 2.4 provides more detailed information about changes in average annual, seasonal and monthly air temperatures (°C/10 years) for 1941 – 2015 in Kazakhstan. Positive and statistically significant trend of average monthly air temperatures is observed almost everywhere in Kazakhstan (year, spring, summer, autumn). Average annual air temperature of Kazakhstan increased generally by 0.21 – 0.40º C/10 years. In the western and some northern places of republic the increase in temperature reached 0.41 – 0.60 ºC/10 years (winter and spring), in summer in the south-eastern, eastern and northern regions the temperature rose no more than 0.21°°C/10 years.

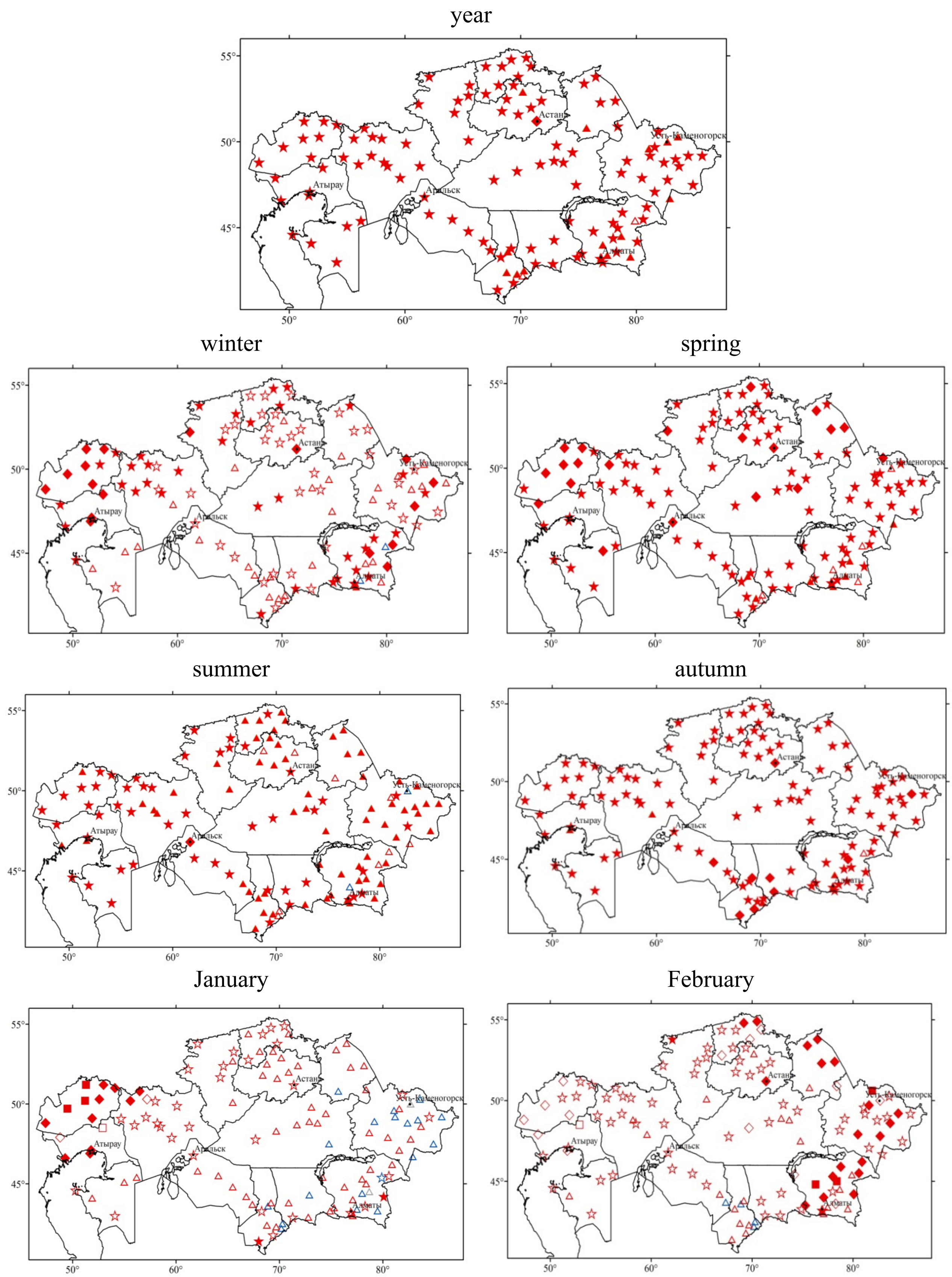


Figure 2.4 – The spatial distribution of the linear trend factors of monthly surface air temperature (ºC/10 years) in Kazakhstan for 1941–2015. Legend keys shaded for statistically significant trend. List 1

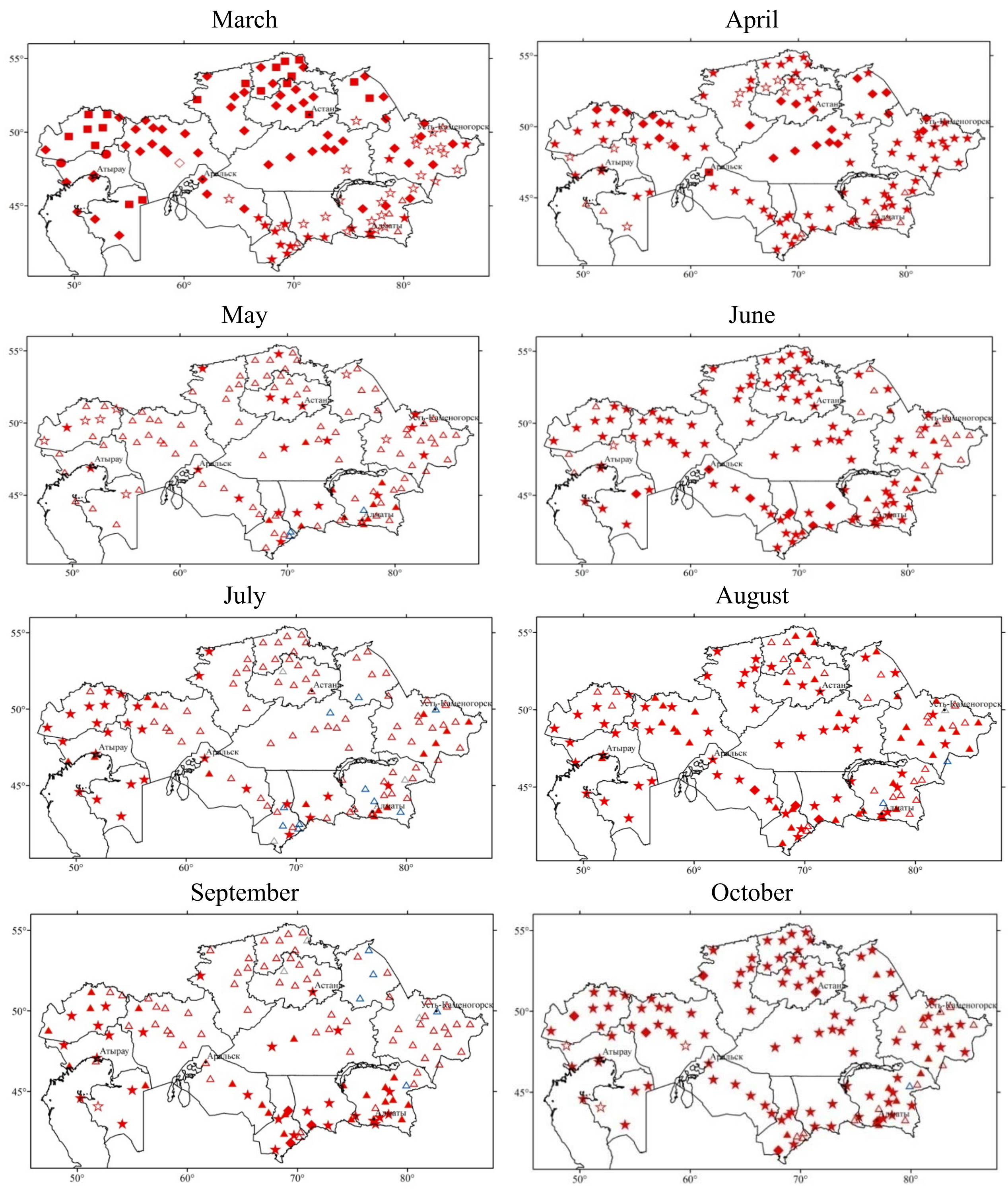


Figure 2.4 – The spatial distribution of the linear trend factors of monthly surface air temperature (ºC/10 years) in Kazakhstan for 1941 – 2015. Legend keys shaded for statistically significant trend. List 2

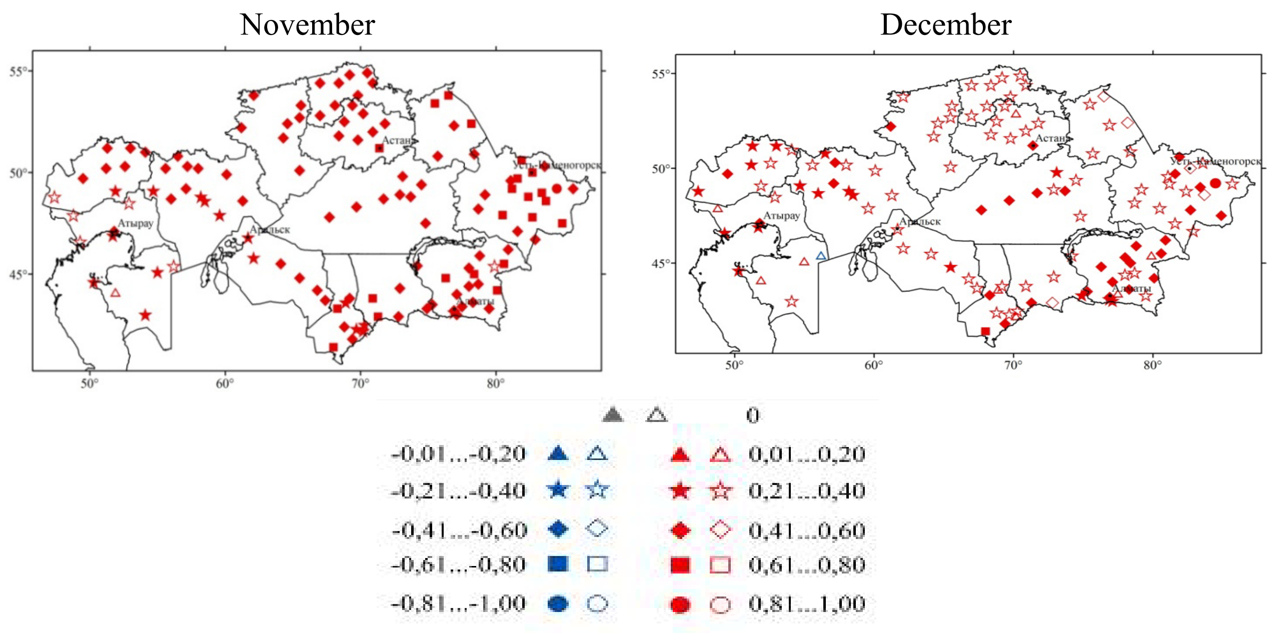


Figure 2.4 – The spatial distribution of the linear trend factors of monthly surface air temperature (ºC/10 years) in Kazakhstan for 1941–2015. Legend keys shaded for statistically significant trend. List 3

Positive trend of average monthly air temperatures is observed almost everywhere in Kazakhstan for all winter months (from 0.41 to 0.80 ºC/10 years). In the west and southeast of the republic positive significant trends are observed. In March the air temperature increase was most significant from 0.41 to 0.81 ºC/10 years. The warming rate was slower 0.20-0.60 ºC/10 years in April and in May the trend was not significant practically all regions of Kazakhstan. In June, August and September and October the warming rate was significant (0.21 – 0.40 ºC/10 years). In July several weather stations recorded positive trends which are statistically insignificant but in the western the south – eastern and eastern of the country were significant trends. Positive significant trends (0.40 – 0.60 ºC/10 years) are observed throughout the country in November.

2.2 Temperature anomalies in Kazakhstan in 2015

Figure 2.5 provides average monthly air temperature in 2015 and climate normal averaged for the period 1961 – 1990 over the territory of Kazakhstan and its regions.

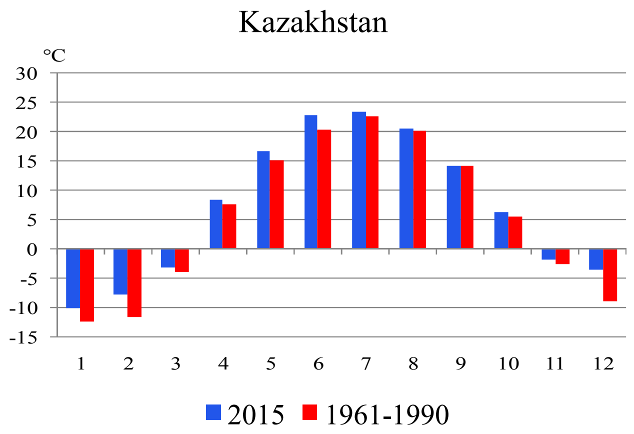


Figure 2.5 – Average monthly air temperature in 2015 and climate normal 1961–1990 over the territory of Kazakhstan and its regions. List 1

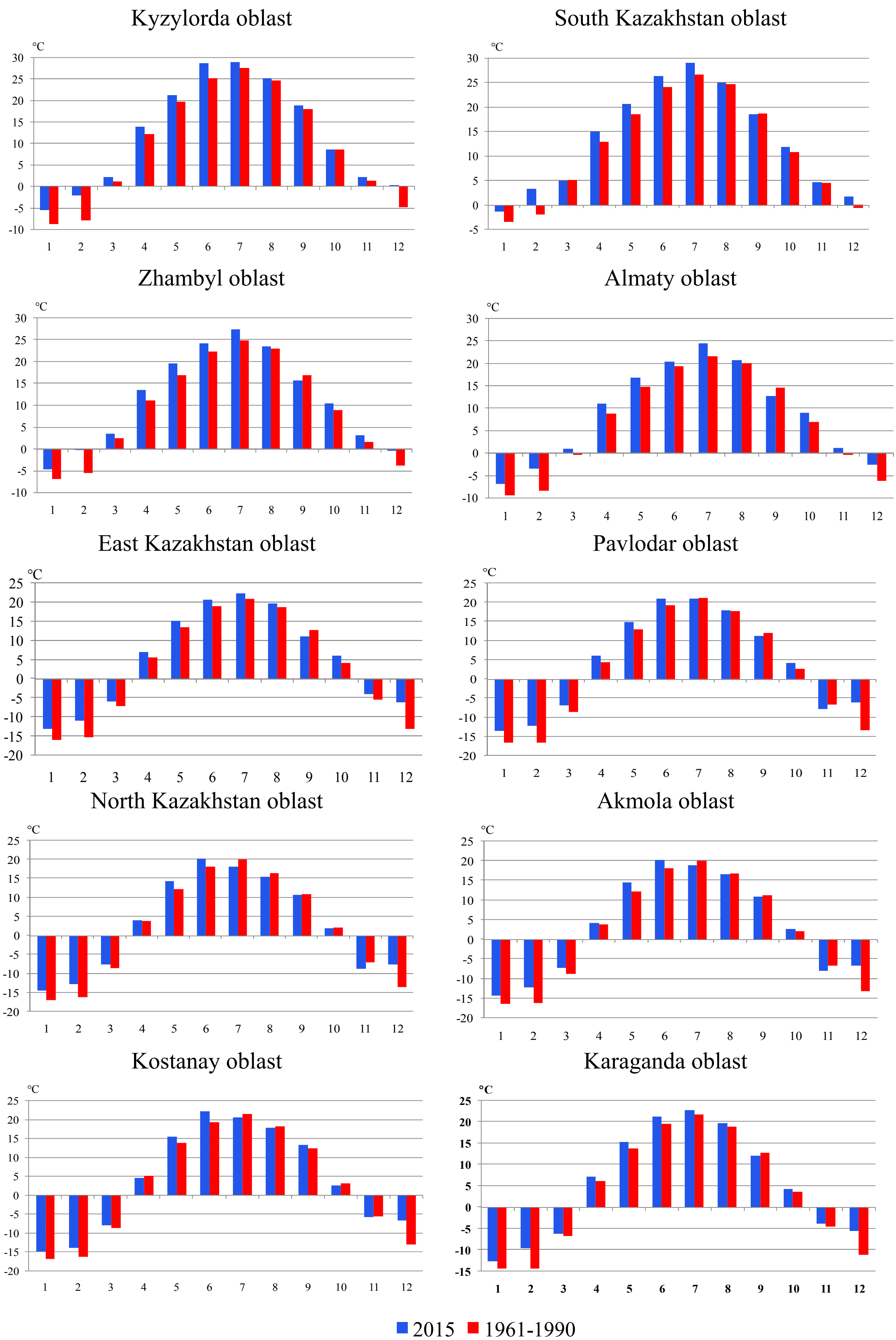


Figure 2.5 – Average monthly air temperature in 2015 and climate normal 1961–1990 over the territory of Kazakhstan and its regions. List 2

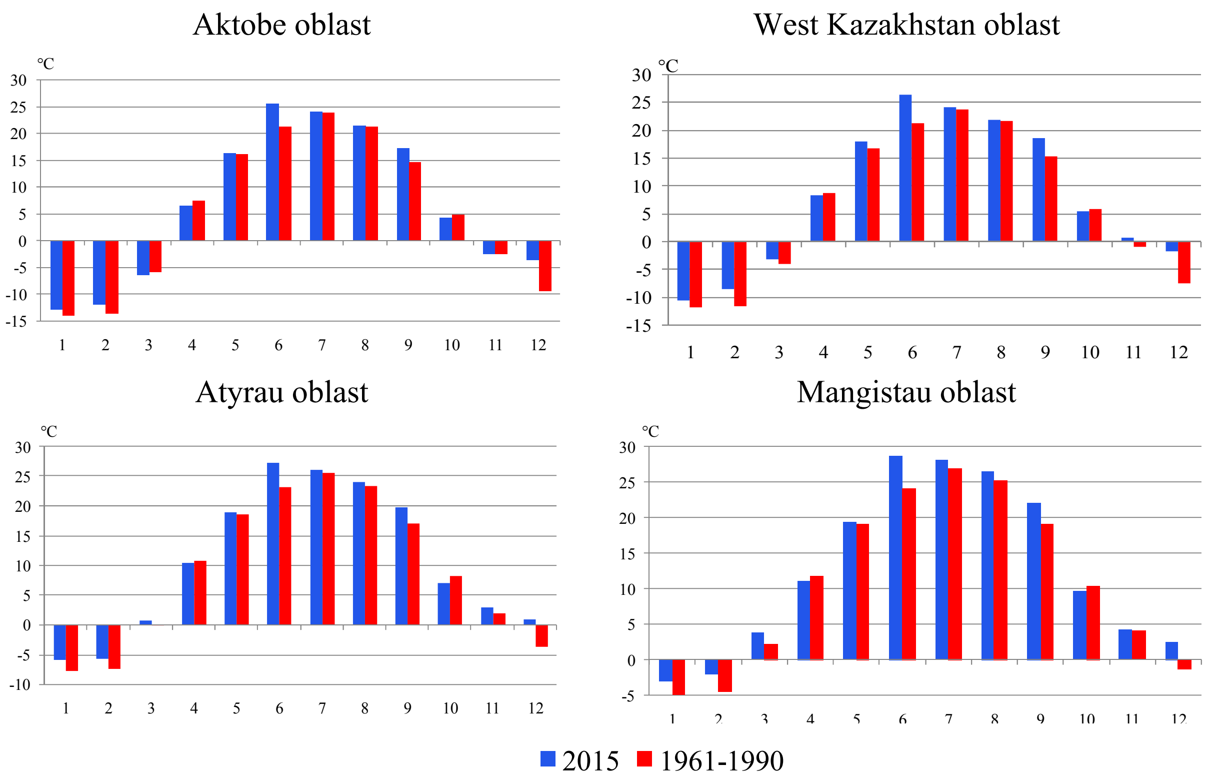


Figure 2.5 – Average monthly air temperature in 2015 and climate normal 1961–1990 over the territory of Kazakhstan and its regions. List 3

The air temperature in 2015 exceeded the norm almost the entire territory of Kazakhstan and was below the norm in the West Kazakhstan, Atyrau, Aktobe and Mangistau regions (March – May and October), North Kazakhstan, Akmola, Kostanay and Pavlodar (July, August, September, November). Maximum positive anomalies typical for winter months and early summer (figure 2.5).

Figure 2.6 shows geographical distribution of heat and cold areas in Kazakhstan for the whole year and seasons.

year

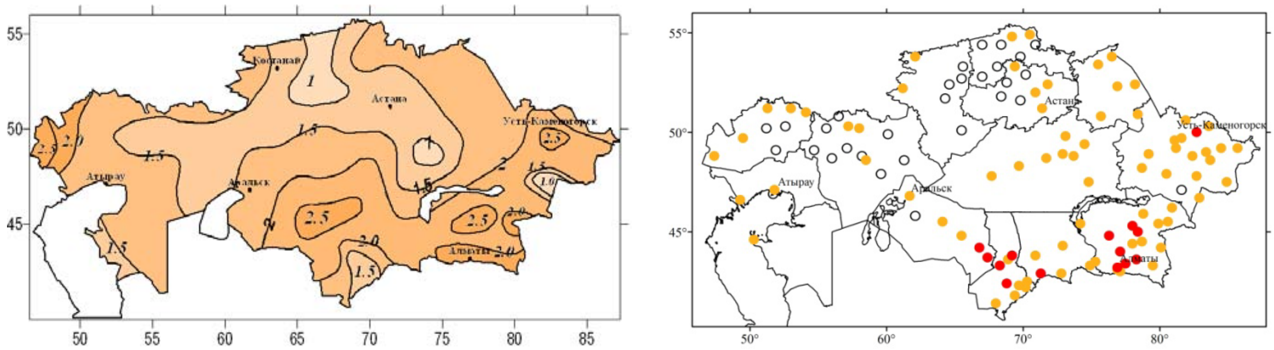


Figure 2.6 – Spatial distribution of air temperature anomalies(^{0}C) in 2015 relative to the 1961–1990 baseline and nonexceedance probabilities for 2015 air temperatures calculated over 1941–2015. List 1

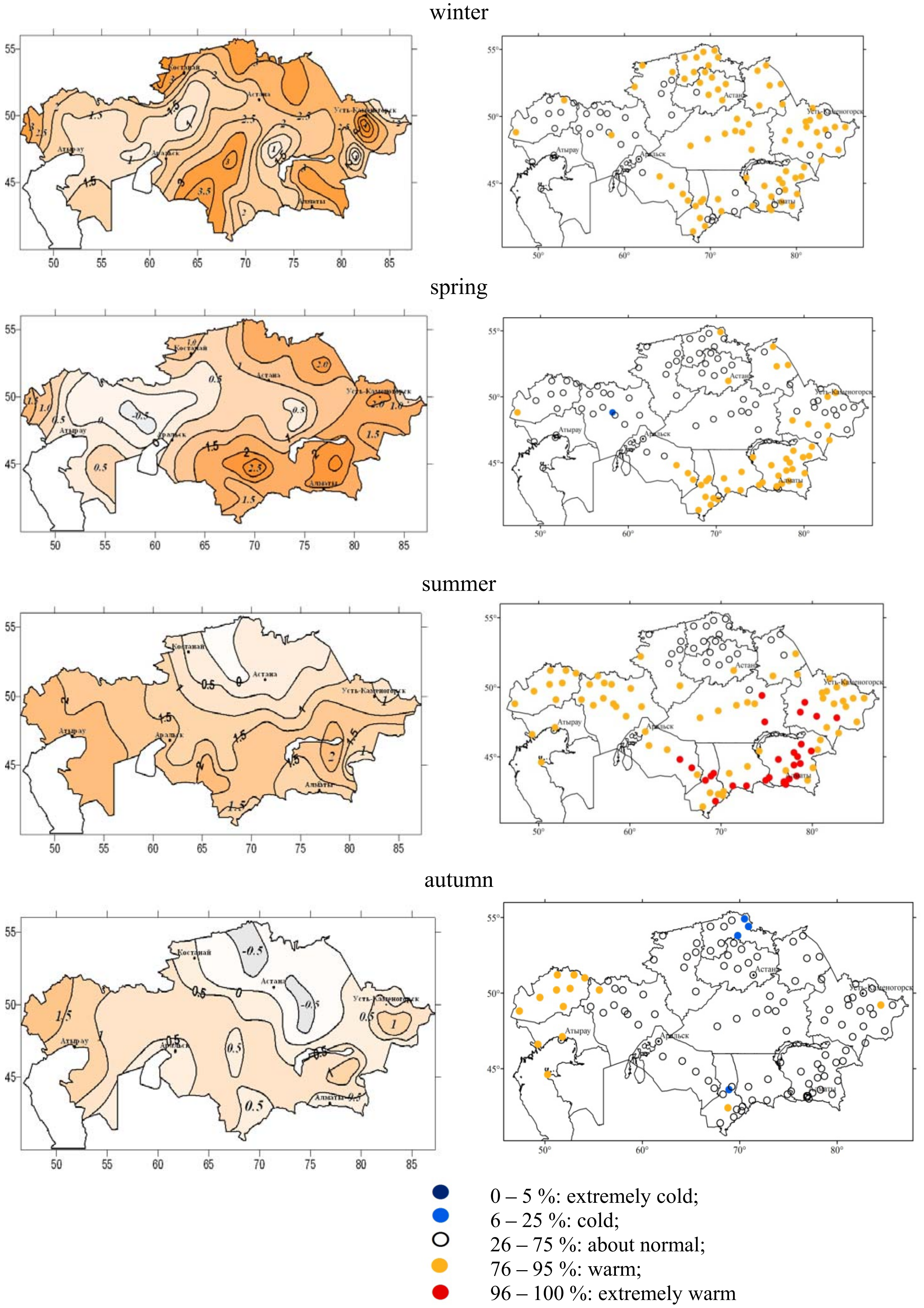


Figure 2.6 – Spatial distribution of air temperature anomalies (°C) in 2015 relative to the 1961-1990 baseline and nonexceedance probabilities for 2015 air temperatures calculated over 1941–2015. List 2

Year

Annual average temperature anomalies (December 2014 – November 2015) were above the norm practically in all territory of Kazakhstan by 1 – 2.5 ºC. 2015 was extremely warm partly southern and south – eastern regions of Kazakhstan (figure 2.6a).

Winter

Winter (December 2014 – February 2015) was warm everywhere in Kazakhstan. Anomalies of temperature higher than 2.5 ºC were recorded in the northern, north – eastern, southeastern, southern and western of the country. In Ust-Kamenogorsk station temperature anomaly was 4.5 ºC. In the rest of the territory temperature anomalies were within the norm (figure 2.6b).

Spring

In spring on the territory of Kazakhstan the air temperature anomalies were near the norm. Above the norm by 2 – 2.5 ºC air temperatures were in the southern and south – eastern of the country (figure 2.6c).

Summer

In summer the air temperature was within the norm in the northern of the republic (figure 2.6d). Extremely warm was in the southern and south-eastern of Kazakhstan (probability of non exceedance of 96 – 100 %). In June air temperature anomalies ranged from 3.4 to 5.6 ºC (West Kazakhstan, Mangistau, Atyrau and Aktobe regions).

Autumn

Autumn temperatures in 2015 were within the norm in the most part of territory of Kazakhstan but in the same northern and southern stations occurred negative anomalies (probabilities of non-exceedance 6 – 25 %). Only in the western of the country air temperature anomalies exceeded the norm by 1.0 – 1.5 ºC (figure 2.6e).

In order to assess the extreme temperature conditions in particular year experts used the climate change indices recommended by the World Meteorological Organization. The analysis of the most representative indices and their distribution in Kazakhstan in 2015 is considered below.

Daily maximum of air temperatures in 2015. Figure 2.7 presents in red the absolute maximum of air temperature recorded since the opening of weather station until 2014. The maximum of daily air temperature observed in 2015 is in blue. Absolute maximum air temperature has been exceeded in 2015 by the following stations:

1. Ereimentau (Akmola region): by 0.2 ºC C;
2. Akkuduk (Mangistau region): by 0.4 ºC C;
3. Kyrgyzsay (Almaty region): by 0.6ººC;
4. Bayanaul (Pavlodar region), by 0.8ººC;
5. Aktau (Mangistau region): by 0.8ººC;
6. Zhusaly(Kyzylorda region): by 0.9ººC;
7. Beyneu (Mangistau region): by 1 ºC;
8. Martuk (Aktobe region): by 1.1 ºC;
9. Peshnoy (Atyrau region) by 1.4 ºC.

The highest values of air temperature (absolute maximum) in Kazakhstan were recorded in July 1983 – 49ººC and 50ººC (Turkestan, Chayan, Aris, Tasty) and in July 1995, when air temperature rose to 51 ºC (Kizilkum).

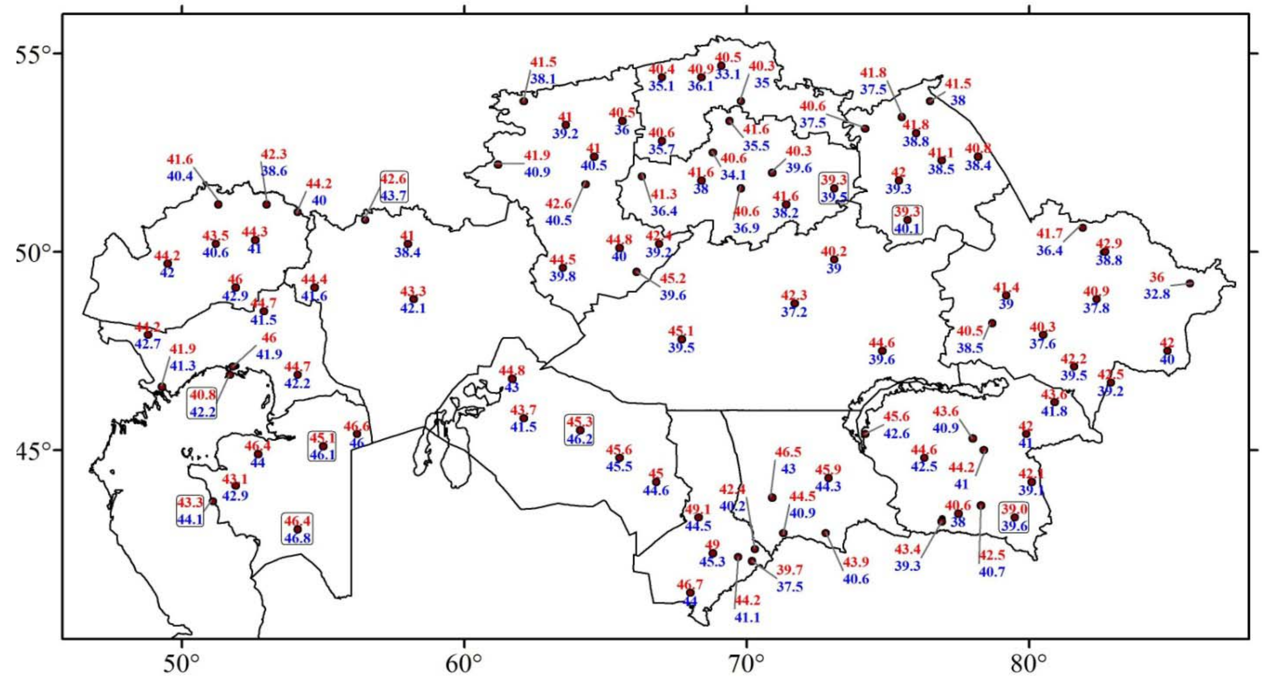


Figure 2.7 – Absolute maximum temperature (°C, red) since the beginning of records until 2014 and the 2015 daily maximum temperature (°C, blue)

Daily minimum of air temperature in 2015. Absolute minimum temperature since the beginning of records has not been exceeded in 2015 at any considered weather stations (figure 2.8). In 2015, the lowest temperature (from minus 39 to minus 35°ºC) were observed at some weather stations in the Akmola, North Kazakhstan, Kostanay, Pavlodar and East Kazakhstan regions.

The lowest values of air temperature (absolute minimum) in Kazakhstan were recorded in January 1893 (minus 52°ºC, Astana) and in January 1931 (minus 54°ºC, Orlovsky Poselok).

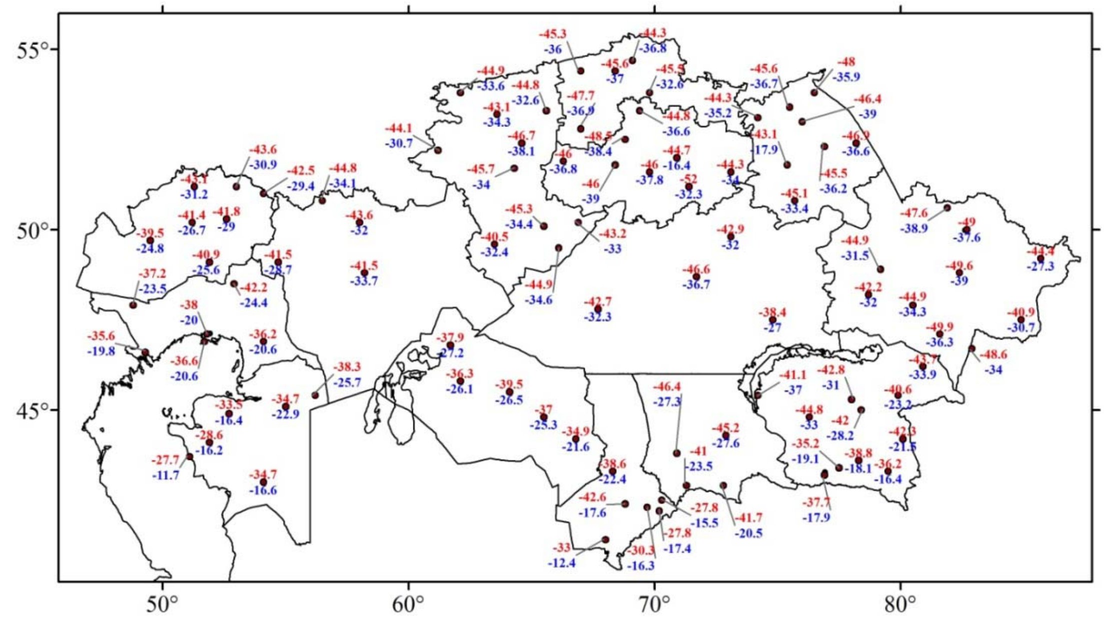


Figure 2.8 – Absolute minimum temperature (ºC, red) since the beginning of records until 2014 and the 2015 daily maximum temperature (ºC, blue)

Number of days with temperatures above 35 ºC in 2015. Figure 2.9a presents spatial distribution of the number of days with temperatures above 35 ºC in 2015.

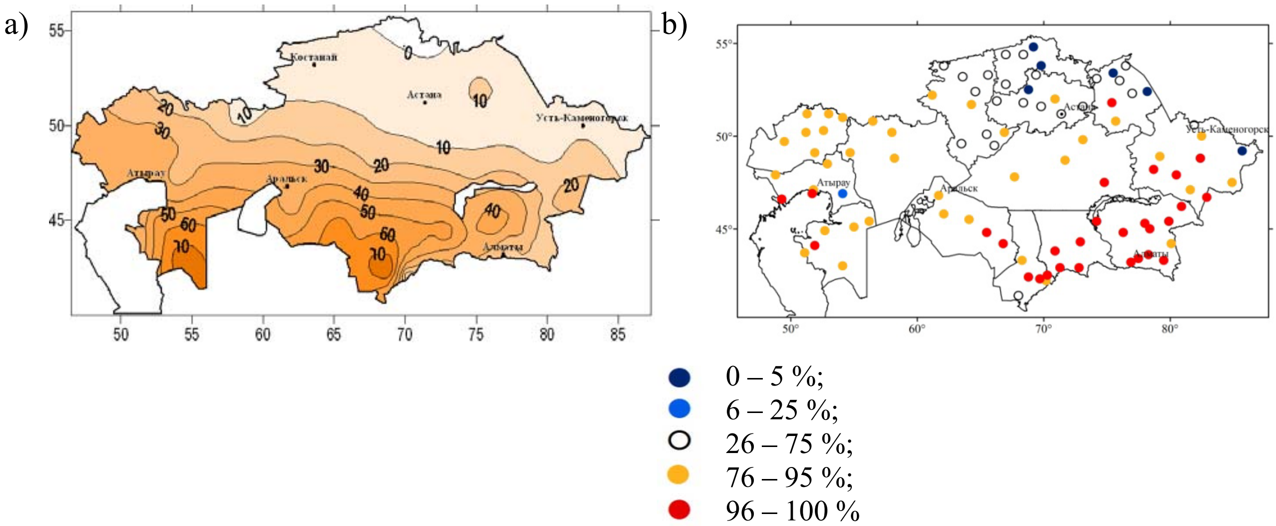


Figure 2.9 – Number of days (a) and the probability of nonexceedance of the number of days with temperatures above 35 ºC in 2015 (b) for 1941–2015

The number of days with high temperatures increased equal to 10 to 70 days from the north to the south of Kazakhstan. . Temperature above 35 ºC was observed more than 60-70 days in Mangistau and South Kazakhstan, more than 30 – 60 days in Atyrau, West Kazakhstan, Kyzylorda, Zhambyl, Almaty oblasts. Some areas of Zhambyl, South Kazakhstan, East Kazakhstan, Atyrau oblasts had the number of days with extremely high air temperature, where probability of nonexceedance was 96–100 %.

Percentage of days with the daily maximum temperatures above the 90th percentile amounted to 12–24 % in Kazakhstan (figure 2.10a). In the western of Kazakhstan and Kyzylorda, Almaty, East Kazakhstan, Zhambyl regions, where percentage of days with the daily maximum temperatures above the 90th percentile amounted about 16–24 % or 1/5 of the year.

Percentage of days with the daily minimum temperatures below the 10th percentile characterizes the frequency of extremely low temperatures (figure 2.10 b). In 2015 yr. the maximum number of such days 8–10 % was observed in northern, western and central areas, as well as in foothill and mountain areas of the southeastern of Kazakhstan.

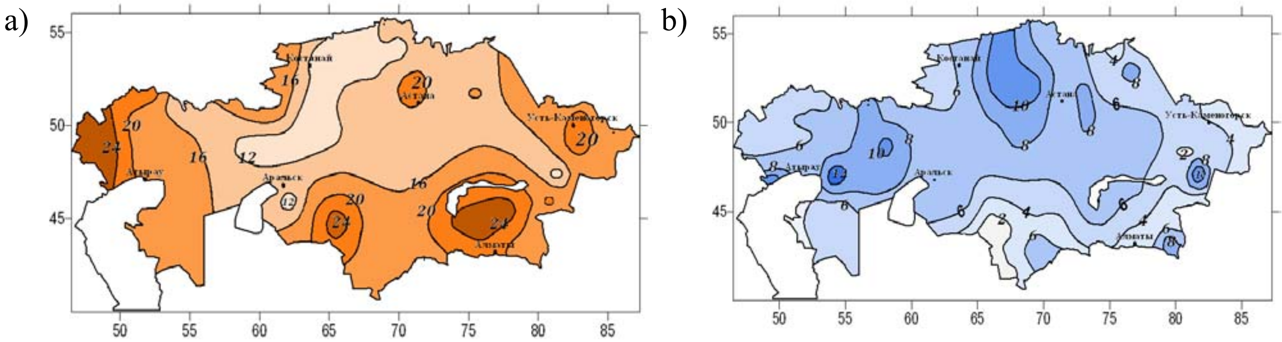


Figure 2.10 – Percentage of days with the daily maximum temperatures above the 90th percentile (a) and with the daily minimum temperatures below the 10th percentile (b) in 2015

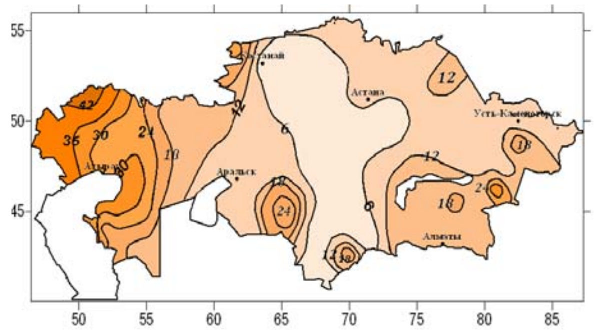
Figure 2.11a shows the total duration of heat waves in Kazakhstan in 2015 (***sum of days when at least six consecutive days the daily maximum temperature was above 90th percentile***).

The total duration of heat waves was high in western and south-western parts of Kazakhstan with maximum in West Kazakhstan, Aktobe, Atyrau and Mangistau, Kyzylorda, South Kazakhstan oblasts (18 - 42 days). The less than the maximum duration of heat waves (12–18 days) occurred in Almaty, Pavlodar, Kostanay oblasts.

Sum of days during the year when ***at least 6 consecutive days the daily minimum temperature was below the 10th percentile*** characterizes the total duration of cold waves.

In 2015 cold waves from 6 till 12 days were observed in the certain regions of northern and central parts of Kazakhstan (figure 2.11b). In all other territory of the country the maximum duration of cold waves was less than 6 days wasn't observed.

a)



b)

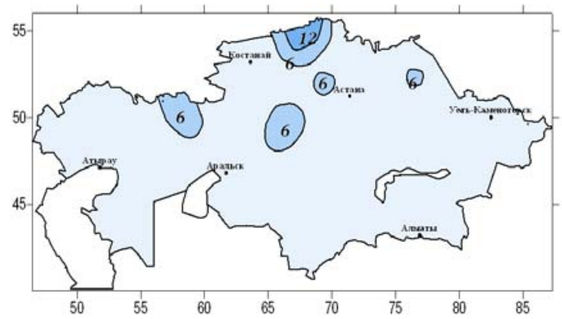


Figure 2.11 – Total sum of days with at least of 6 consecutive days the daily maximum temperature above the 90th percentile (a); and at least of 6 consecutive days the daily minimum temperature below the 10th percentile (b) in 2015

Figure 2.12 presents ***duration of vegetation period*** in 2015 (the period between the first 5 days when the average daily temperature was ≥5 °C, and the last 5days when the average daily temperature was ≤5 ºC). The vegetation period about 180 days was in the northern, 180-210 days in central part and more than 240 days in the south of Kazakhstan.

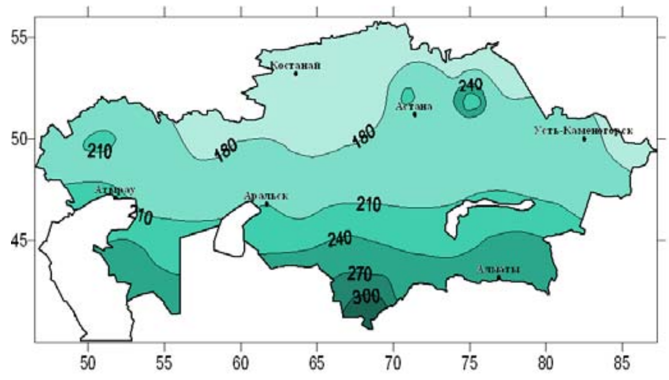


Figure 2.12 - The duration of vegetation period (days) in 2015

2.3 Trends in surface air temperature extremes

Trend analysis of the surface air temperature extremes was performed for 1941–2015. The ***daily maximum surface air temperatures*** trend to increase at most meteorological stations of Kazakhstan. However in the most part of territory of Kazakhstan were statistically insignificant trends except some meteorological stations in various regions (figure 2.12) where daily maximum temperatures increase by 0.20 – 0.60 ºC every 10 years. Only in the southern of the country negative values of linear trend factors, generally to minus 0.20 ºC every10 years, were observed.

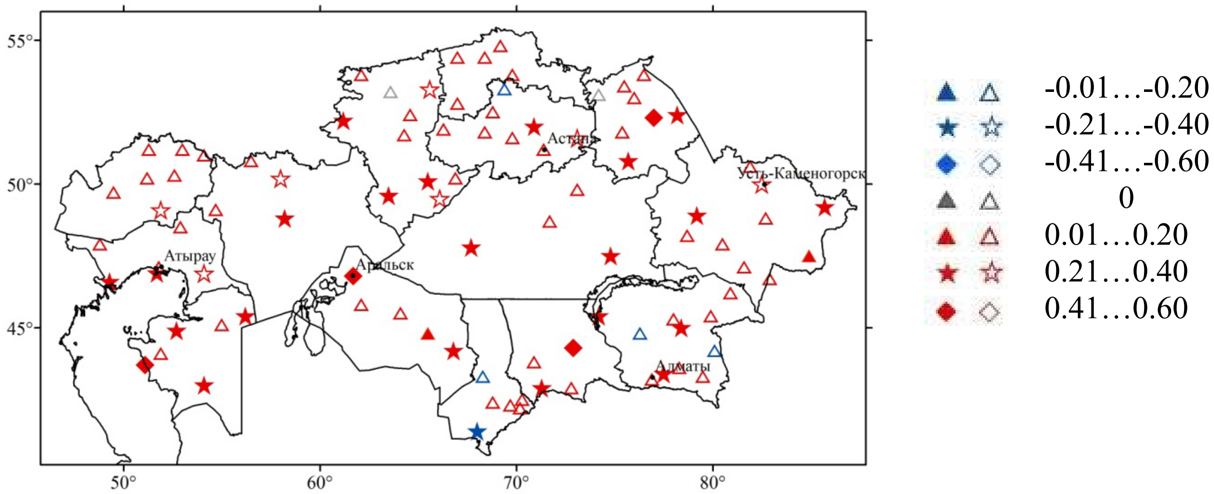


Figure 2.13 – Spatial distribution of the linear trend factors of daily maximum air temperatures (ºC/10 years) for 1941 – 2015. Shaded keys are for statistically significant trend

Statistically significant increase (1 to 5 days every 10 years) in the ***number of days with temperatures above 35 ºC*** appeared in western, southern regions and Kostanay oblast of Kazakhstan (figure 2.14). In the northern, eastern and south-eastern regions the frequency of hot days has not changed during 1941–2015.

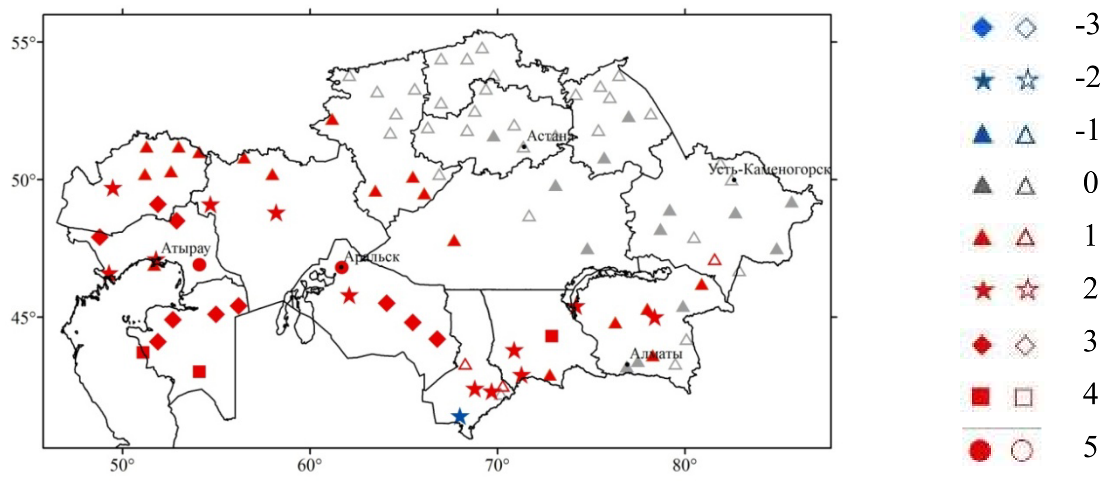


Figure 2.14 - Spatial distribution of the linear trend factors of the total duration of heat waves (day/10 years) during 1941–2015. Shaded keys stand for statistically significant trend

The total duration of heat waves increased throughout the country by 1 to 3 days/10 years (figure 2.15). Heat wave is recorded when ***the daily maximum temperature was above 90th percentile at least six consecutive days***. Statistically significant trends were observed at over 70 % of meteorological stations. It should be noted that all temperature extremes listed above (figures 2.13 – 2.15) have adverse (negative) trend at one weather station Chardara in far south of Kazakhstan. Chardara station is surrounded by Chardara reservoir by three sides causing a cooling effect and forming local climatic conditions.

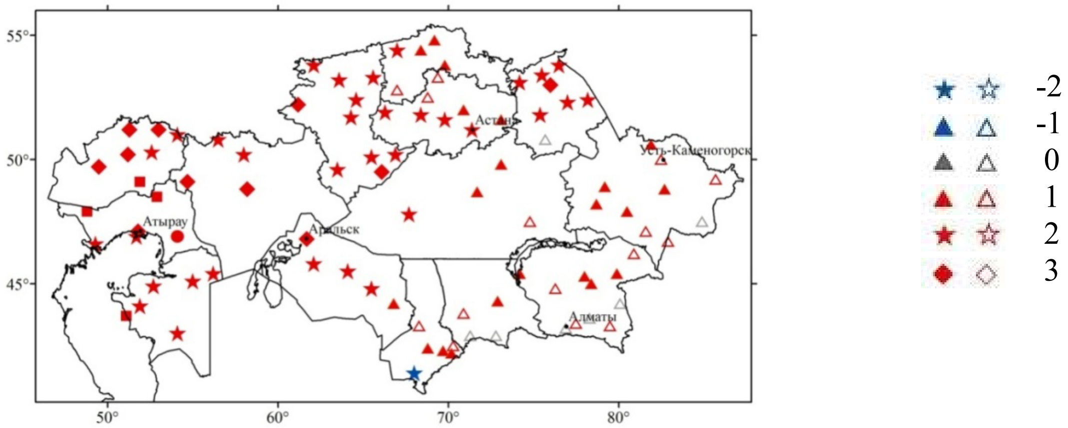


Figure 2.15 – Spatial distribution of the linear trend factors of the total duration of heat waves (day/10 years) during 1941–2015. Shaded keys stand for statistically significant trend

Almost everywhere in Kazakhstan the frequency of frost days when **the daily minimum temperature is below 0 ºC** tends to decrease (figure 2.16). The fastest rates of the frost day frequency decrease are in certain regions of the South Kazakhstan, Kyzylorda and Atyrau regions (5 – 6 days every 10 years). In other regions the number of frost days reduces by 1-4 days every 10 years.

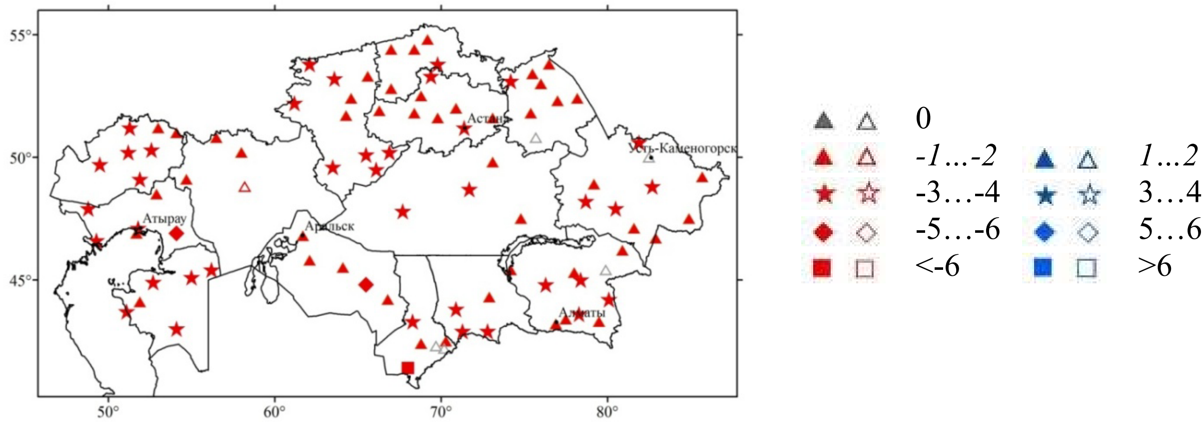


Figure 2.16 – Spatial distribution of the linear trend factors of the number of days with daily minimum temperature below 0 ºC (day/10 years) for 1941–2015. Shaded keys stand for statistically significant trend

A significant decreasing trend in **the daily temperature amplitude** was observed in Kazakhstan amounting to 0.1 – 0.2 ºC (figure 2.17). This trend means mitigation of the climate continentality. The significant increase trend the daily temperature amplitude was observed in Pavlodar, West Kazakhstan, Almaty, South Kazakhstan, Kyzylorda and Mangistau regions amounting to 0.1 – 0.2 ºC.

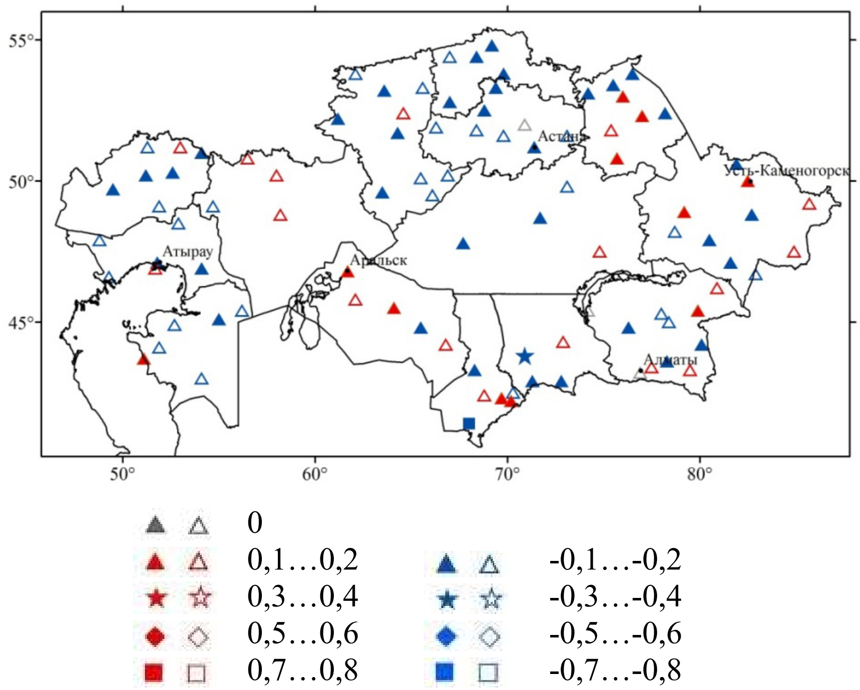


Figure 2.17 – Spatial distribution of the linear trend factors of the daily air temperature amplitude (ºC/10 years) for 1941–2015. Shaded keys stand for statistically significant trend

3 PRECIPITATION

3.1 Observed changes in precipitation in Kazakhstan

In contrast to the air temperature, changes in precipitation in Kazakhstan are more diverse. Experts estimated linear trends of the monthly, seasonal and annual precipitation time series for 121 weather stations.

Figures 3.1 and 3.2 shows the time series of annual precipitation anomalies for 1941-2015, calculated relative to the 1961–1990 baseline and spatially averaged for Kazakhstan and its oblasts. On average annual precipitation has been decreasing slightly by 0.2 mm every 10 years, (table 3.1). A slight increase in annual precipitation (by 0.1 – 5.0 mm/10 years) was observed in Aktobe, Karaganda, Pavlodar, Akmola, Almaty and North Kazakhstan oblasts. In other oblasts precipitation has been decreasing by 0.1 – 4.2 mm per 10 years. All annual trends are statistically insignificant.

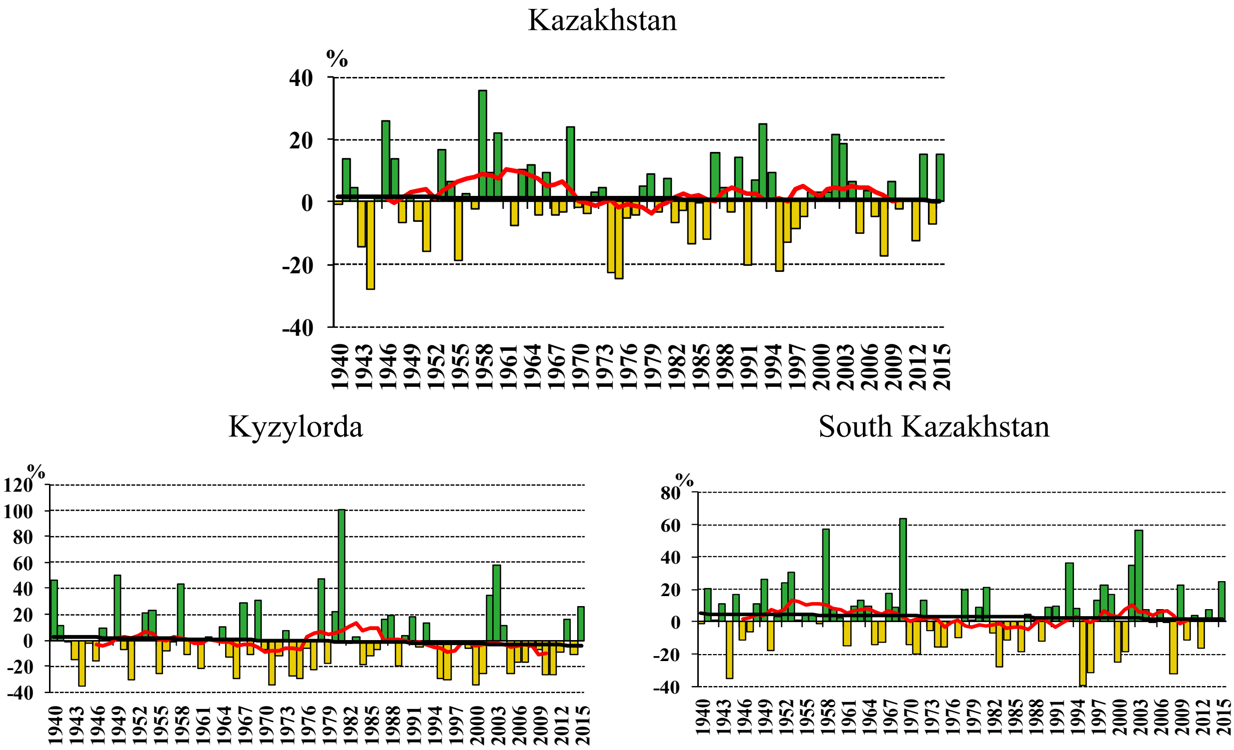


Figure 3.1 – Time series and linear trends of annual and seasonal precipitation anomalies (%) for 1941–2015 calculated relative to the 1961–1990 baseline. *The smooth curve shows the 11-year moving average.* List 1

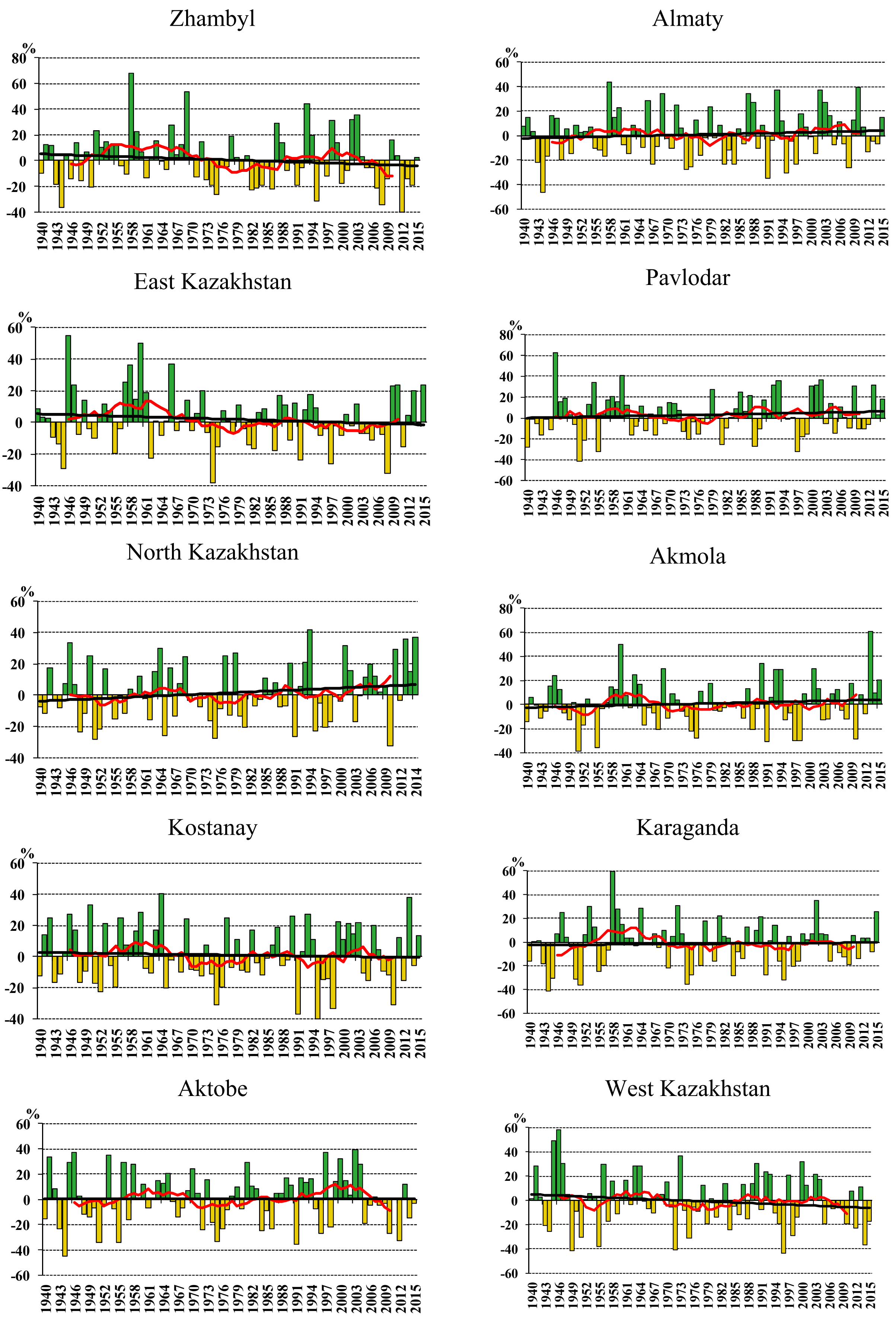


Figure 3.1 – Time series and linear trends of annual and seasonal precipitation anomalies (%) for 1941–2015 calculated relative to the 1961–1990 baseline. *The smooth curve shows the 11-year moving average.* List 2

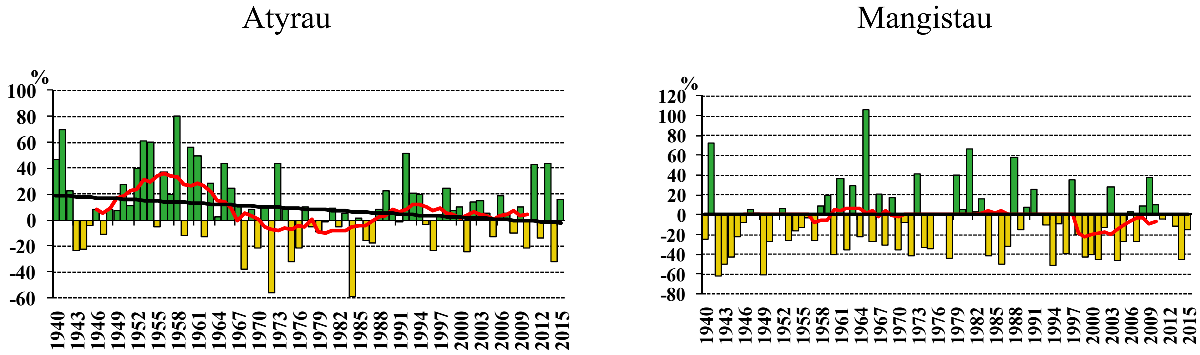


Figure 3.1 – Time series and linear trends of annual and seasonal precipitation anomalies (%) for 1941–2015 calculated relative to the 1961–1990 baseline. *The smooth curve shows the 11-year moving average.* List 3

Figure 3.2 shows the inter–annual course of seasonal precipitation anomalies (%) averaged for Kazakhstan in 1941–2015. On average in Kazakhstan precipitation tends to slightly decrease by 0.7 mm every 10 years in all seasons except winter when precipitation tends to increase by 1.5 mm every 10 years and were significant (table 3.1). Therefore changing the precipitation regime during the analyzed period is maintained statistically significant trend towards for increased amount of precipitation in winter and towards for decreased them in other seasons.

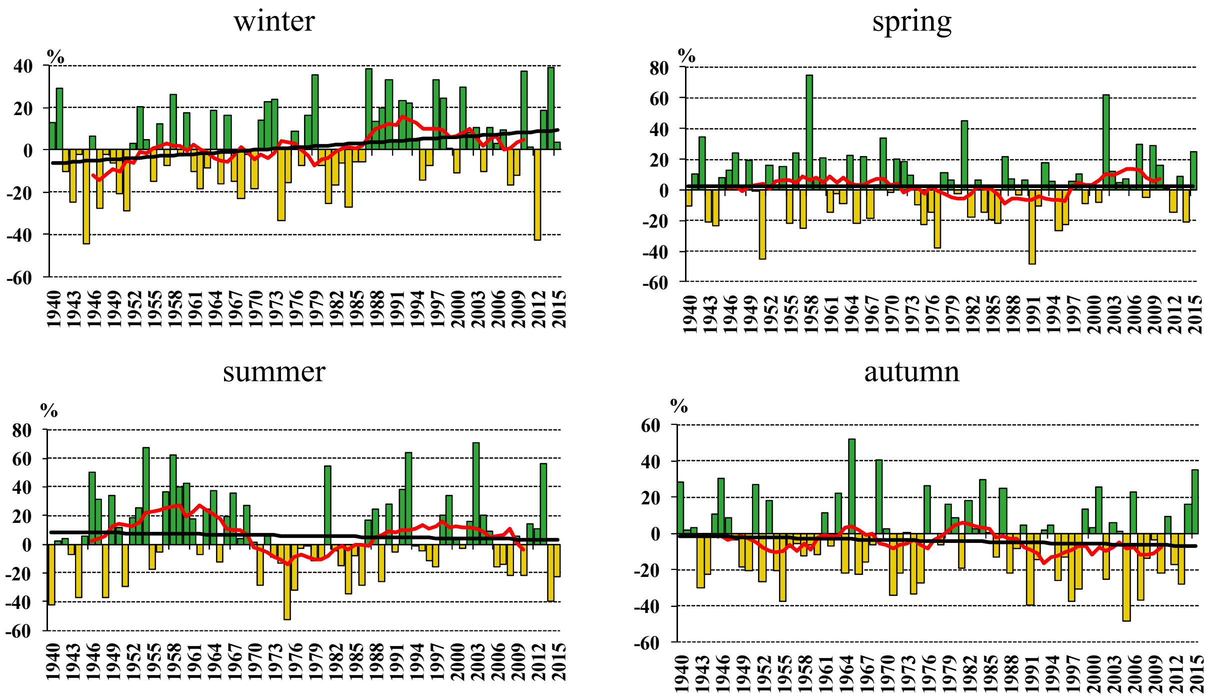


Figure 3.2 – Time series and linear trends of seasonal precipitation anomalies (%) for 1941–2015 relative to the 1961–1990 baseline. *The smooth curve represents the 11-year moving average*

Table 3.1 – Linear trend parameters of the seasonal and annual precipitation anomalies (mm/10 years, %/10 years) for Kazakhstan and oblasts for 1941 – 2015 relative to the 1961 – 1990 baseline

Region/oblast	Unit	Year		Winter		Spring		Summer		Autumn	
		*a	**R^2	a	R^2	a	R^2	a	R^2	a	R^2
Kazakhstan	мм	-0.2	0	1.5	**7**	-0.6	0	-1.1	1	-0.3	0
	%	-0.2		2.3		-0.1		-1.3		0.3	
Kyzylorda	мм	-0.6	0	-0.7	1	-0.1	0	-0.1	0	0.1	0
	%	-0.4		-1.4		-0.1		0		0.6	
South Kazakhstan	мм	-2.2	0	0.8	0	-4.6	3	0.2	0	1.1	1
	%	-0.5		0.3		-2.7		-0.6		2.2	
Zhambyl	мм	-2.9	2	0.8	0	-3.9	**5**	-0.1	0	0.3	0
	%	-1.4		0.5		-3.5		-0.5		0	
Almaty	мм	3.3	1	3.3	**10**	-2.4	1	0.9	0	1.3	1
	%	0.9		4.6		-1.8		0.9		1.7	
East Kazakhstan	мм	-2.9	1	0.8	1	-1.1	1	-2.8	3	-0.3	0
	%	-0.9		1.3		-1.7		-2.3		-0.3	
Pavlodar	мм	1.3	0	1.3	**6**	1.2	2	0.1	0	-1.7	3
	%	0.5		2.9		2.1		0.2		-2.3	
North Kazakhstan	мм	5.0	3	3.4	**19**	2.2	5	-1.9	1	1.2	1
	%	1.4		7.0		3.3		-1.3		1.3	
Akmola	мм	2.5	1	2.2	**9**	1.5	2	0	0	-1.6	2
	%	0.7		4.5		2.0		0		-2.0	
Kostanay	мм	-1.5	0	0.6	1	1.5	2	-1.8	1	-2.3	4
	%	-0.6		1.3		2.2		-1.7		-2.9	
Karaganda	мм	1.2	0	2.0	7	0.3	0	-1.4	1	0	0
	%	0.1		2.4		0.3		-2.1		-0.3	
Aktobe	мм	0.1	1	2.0	5	2.0	3	-2.1	3	-2.1	4
	%	-0.2		2.9		3.0		-3.0		-3.1	
West Kazakhstan	мм	-4.2	2	1.1	1	-0.6	0	-2.7	4	-2.1	3
	%	--1.5		1.9		-1.0		-3.7		-2.8	
Atyrau	мм	-4.0	4	-2.2	**10**	0.1	0	-1.6	2	-0.4	0
	%	-2.5		-7.0		0.2		-3.6		-1.0	
Mangistau	мм	-0.9	0	0.6	1	-0.1	0	-0.9	1	-0.5	0
	%	-0.2		1.9		0.1		-2.5		-1.1	

* a – linear trend factor, %/10years, mm/10 years;
** R^2 – determination factor,%
***«bold» type indicates statistically significant trend
Mangistau oblast - parameters calculations were performed for 1960-2015

Figures 3.3 and 3.4 provide more detailed information about changes in seasonal and monthly air temperatures (ºC/10 years) for 1941–2015 in Kazakhstan. Changes in the seasonal precipitation are diverse.

In summer and autumn in most parts of Kazakhstan, except mountain regions of south-eastern and northern, precipitation decreased by 1 – 14% of norm every 10 years. In winter and spring, a positive trend was observed on the vast area of whereas in the south–western and the south-eastern precipitation decreased by 1 – 11 %/10 лет. It should be noted that almost all seasonal trends are statistically insignificant, except winter precipitation (figure 3.3).

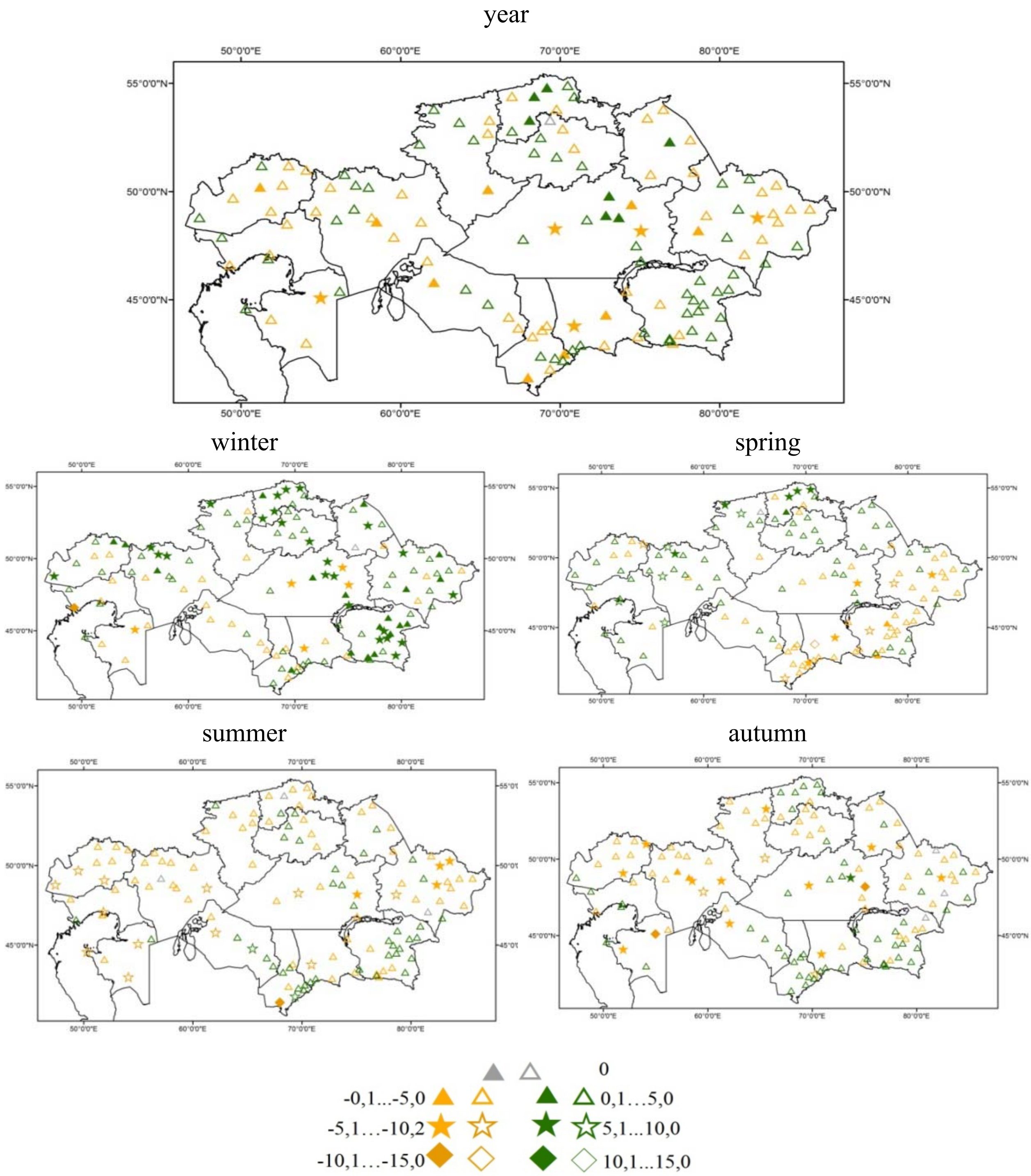


Figure 3.3 – Spatial distribution of the linear trend factor of annual and seasonal precipitation anomalies (%/10 years), over 1941–2015. *Shaded keys stand for statistically significant trend.*

Further, consider the changes in the monthly precipitation of Kazakhstan (figure 3.4).In January–February statistically significant increase of precipitation by 0.1 – 13.0 %/10 years were observed in certain regions of Almaty, Pavlodar, North Kazakhstan, Akmola oblasts and in the northwestern regions of Kazakhstan. In spring months precipitation decreased in most part of Kazakhstan by 0.1 – 14.0 % /10 years and in some areas of Karaganda, Zhambyl, Almaty oblasts precipitation reduction was statistically significant. In June–August change in precipitation both negative and positive was negligible all over Kazakhstan, except July where at Lepsy, Ushtobe, Bektau-ata weather stations precipitation increase was statistically significant and amounted to 6 – 13 %/10 years. In September–October in the most part of Kazakhstan precipitation reduction were noted, and precipitation of September reduction was statistically significant practically of all areas of Kazakhstan, except south–eastern part, where precipitation slightly was increased. At Zharkent and Kyrgyzsay weather stations precipitation increase was statistically significant and amounted to 11 %/10 years. In November–December, precipitation trend was mostly positive. In North-Kazakhstan, Akmola and Karaganda oblasts precipitation increase was statistically significant and amounted to 6 – 11 %/10 years.

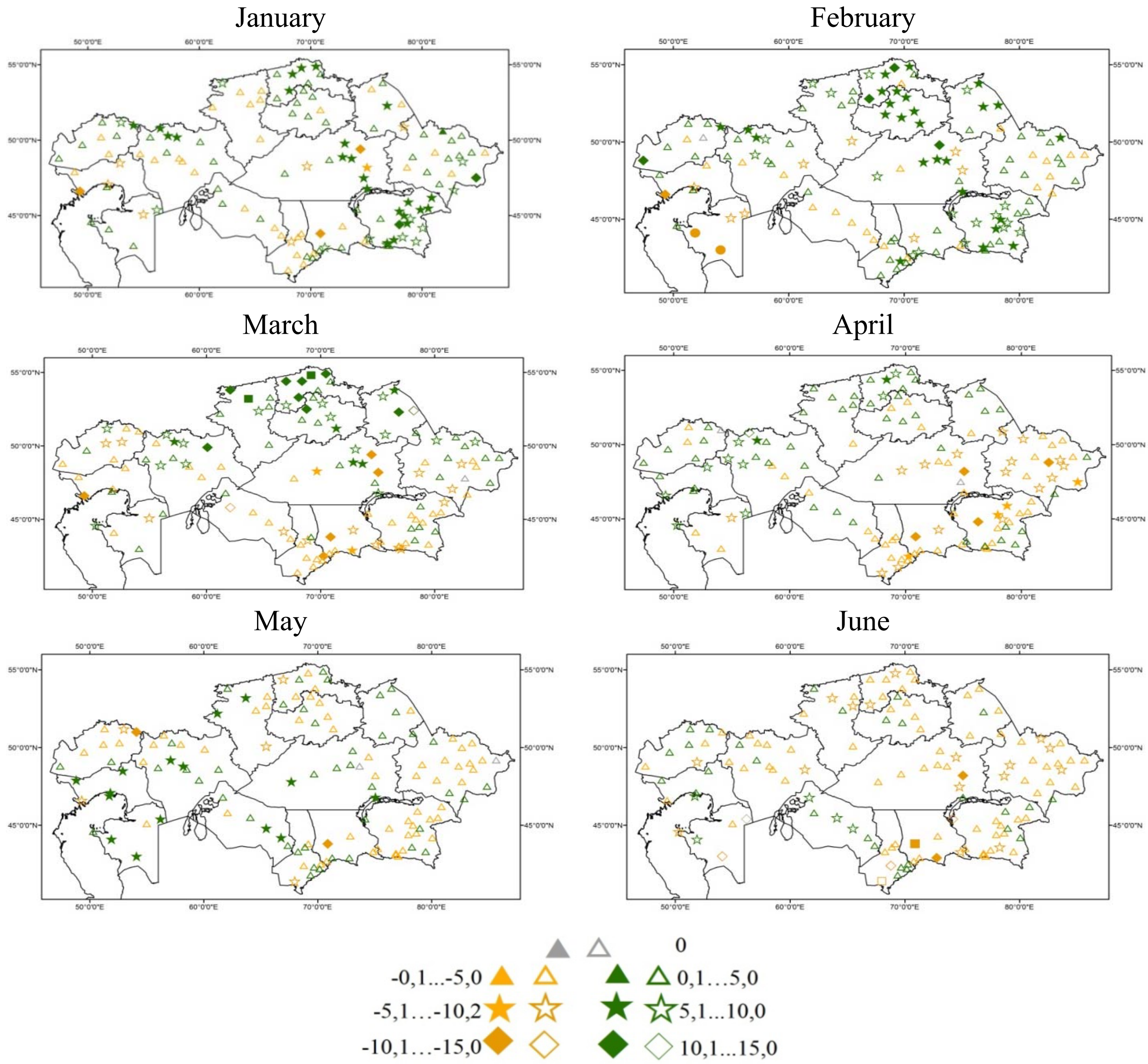


Figure 3.4 – Spatial distribution of the linear trend factor of monthly precipitation (% of normal/10 years), over 1941–2015. *Shaded keys stand for statistically significant trend. List 1*

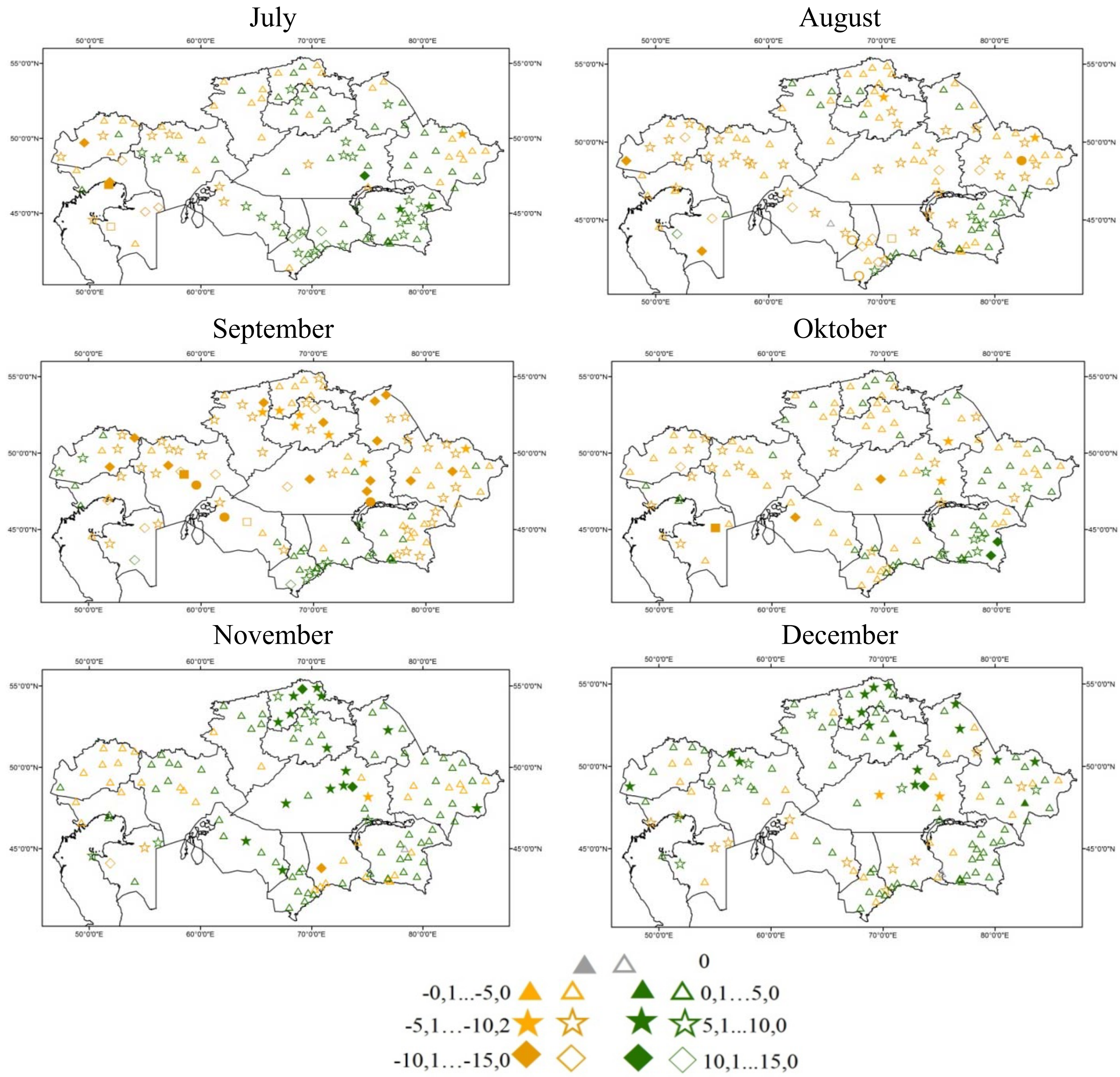


Figure 3.4 – Spatial distribution of the linear trend factor of monthly precipitation (% of normal/10 years), over 1941–2015. *Shaded keys stand for statistically significant trend. List 2*

3.2 Precipitation anomalies in Kazakhstan in 2015

Monthly precipitation averaged for Kazakhstan was mainly above normal, except April and summer months, when precipitation was 1.7 – 8.8 mm below (figure 3.5). Precipitation significantly exceeded the norm in May (by 13.1 mm), November (by 17.8 mm) and December (by 17 mm). The monthly maximum precipitation has be exceeded in 2015 in May, September, November and December at the 9, 3, 12, 16 weather stations of Kazakhstan respectively.

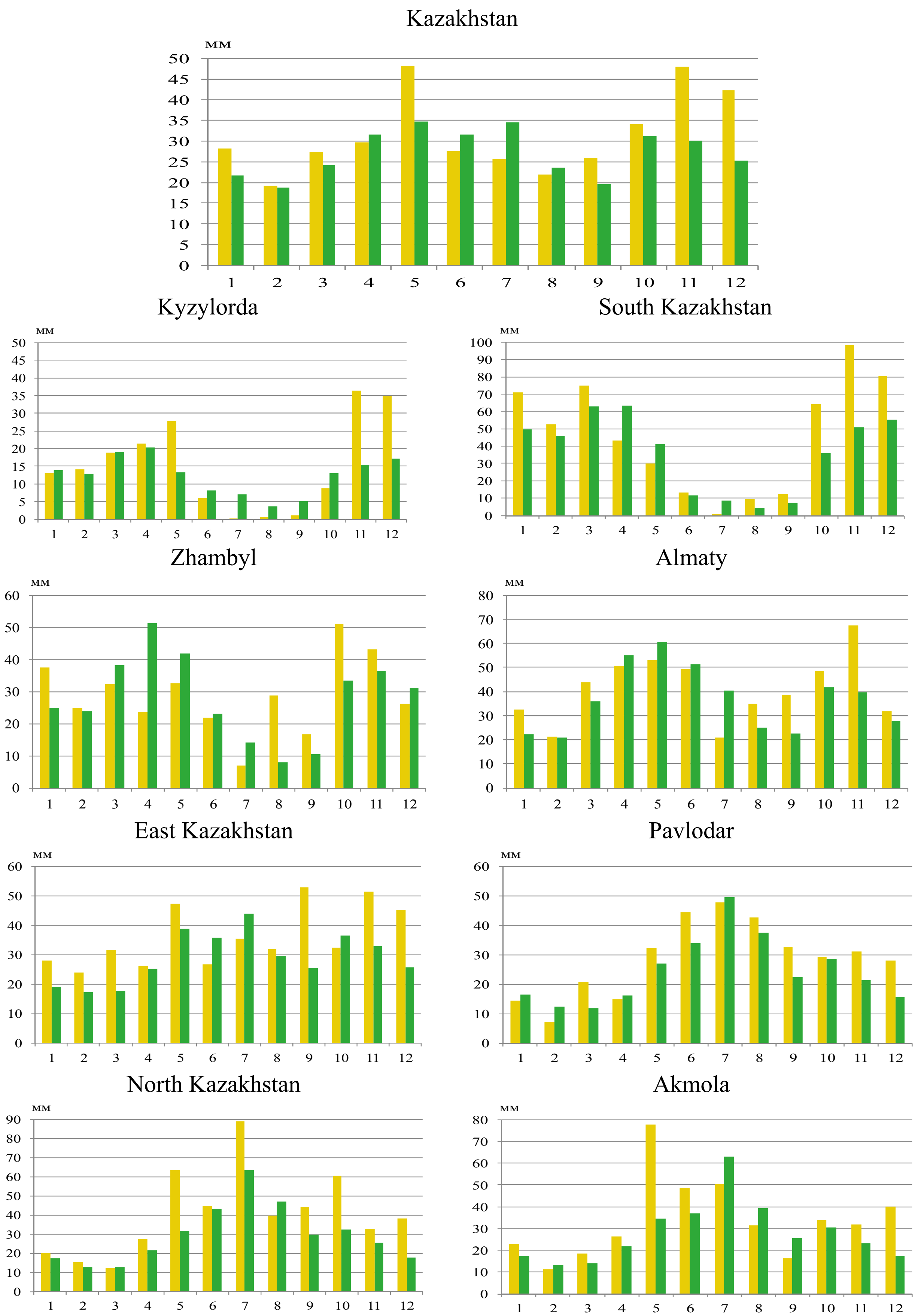


Figure 3.5 – Monthly precipitation in 2015 and climate normal 1961–1990 over the territory of Kazakhstan and its regions. List 1

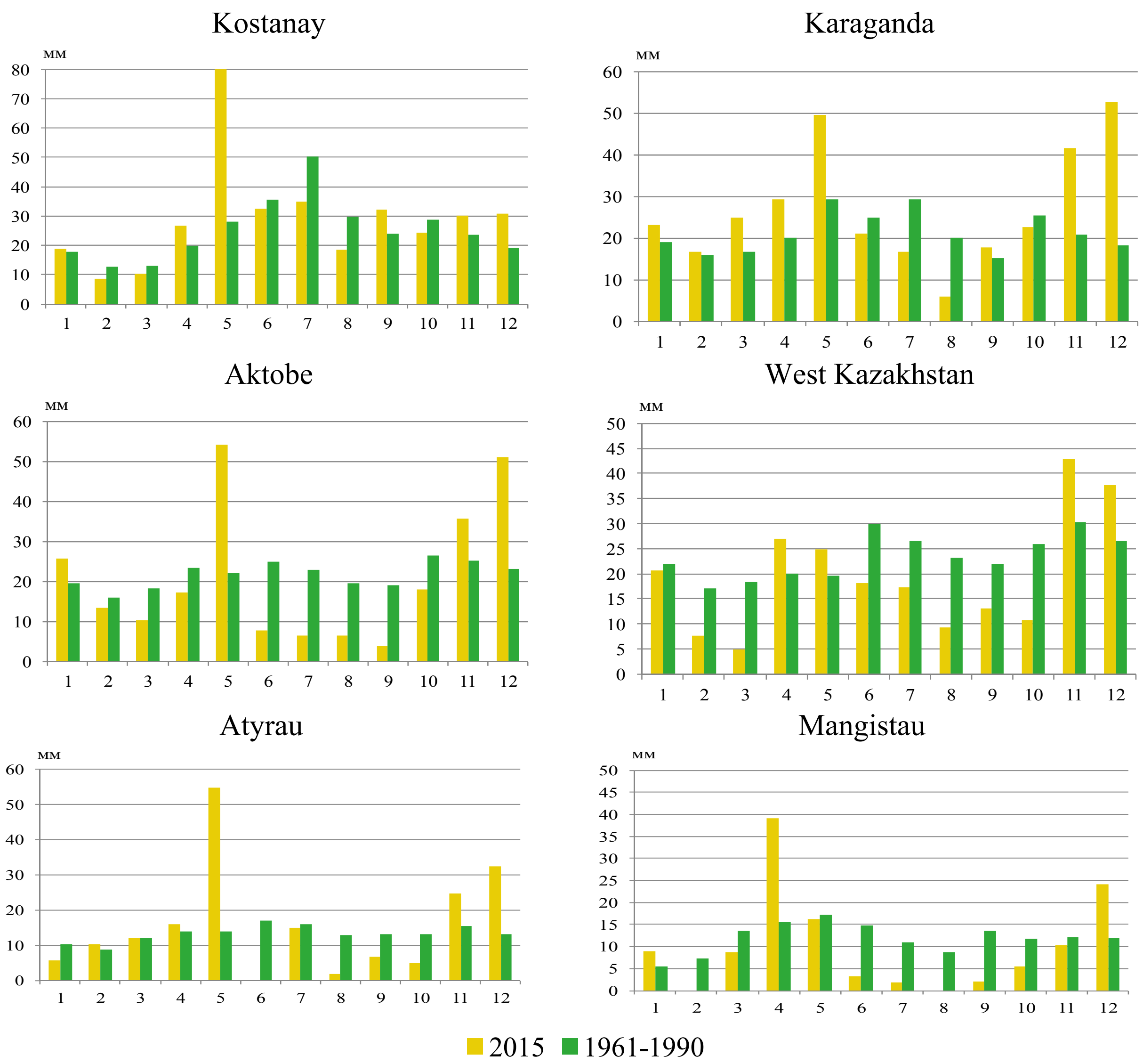


Figure 3.5 – Monthly precipitation in 2015 and climate normal 1961–1990 over the territory of Kazakhstan and its regions. List 2

Figure 3.6 shows the spatial distribution of annual and seasonal precipitation in 2014, expressed as percentage of normal over 1961 – 1990 and nonexceedance probability of annual and seasonal precipitation in 2015. The nonexceedance probability means the frequency of the corresponding anomaly in the observational records.

In 2015 (December 2014 through November 2015) the annual precipitation was observed within norm (80 – 120 %) almost everywhere in Kazakhstan (figure 3.6a). In north–eastern and some areas of the central and south of Kazakhstan precipitation was higher than normal by 20-60 %. Extremely wet winter was in some regions of weather stations Vozvyshenka, Bulaevo, Petropavlovsk, Ulken Naryn, Karaganda (nonexceedance probabilities 96–100 %). In these regions 2015 was within 10 % of extremely wet since 1941. In West Kazakhstan, Aktobe, Karaganda oblasts and in southern of republic observed precipitation deficit (20–60 %). At stations Chingirlau, Zhambeity was extremely dry (non-exceedence probabilities 1–2 %).

Winter (December 2014 – February 2015 гг.)

In most of Kazakhstan winter precipitation in 2015 was nearly normal. Precipitation exceeded the norm by 20 – 100 % in some stations of the northern, the south-western and eastern regions. Anomalously dry was in southern and in some regions of central and western areas of Kazakhstan, where negative precipitation anomalies were 40 – 60 % (figure 3.6b)

Spring

Spring 2015 was wet in the most part of the territory of Kazakhstan (figure 3.6c). Precipitation exceeded the norm by 50 – 100 % in North Kazakhstan, Akmola, Karaganda, Atyrau oblasts. Seasonal precipitation in Kostanay, Akmola, Karaganda oblasts took 1st, 2nd and 5th place respectively. In these regions spring of 2015 was within 10 % of the extremely wet season. Precipitation deficit of 20 – 60 % was observed in the southern areas and in some places in the western of the republic. Extremely dry (non-exceedance probability 5 %) was in Uyuk station

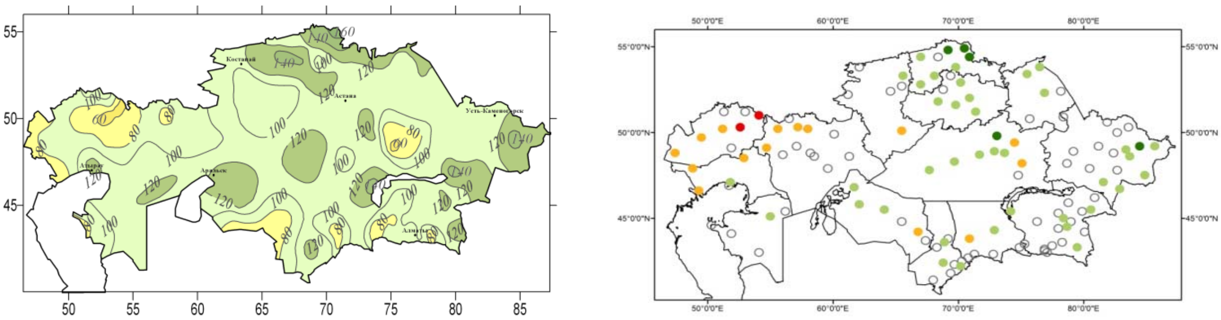
Summer

Summer 2015 was dry in the most part of the territory of Kazakhstan. Precipitation deficit was 23 % on average for Kazakhstan. Considerable deficit of precipitation observed in the western of republic, in Aktobe, Mangistau, Kyzylorda, Atyrau oblasts. In these regions summer of 2015 was within 10 % of the extremely dry season (figure3.6d).

Autumn

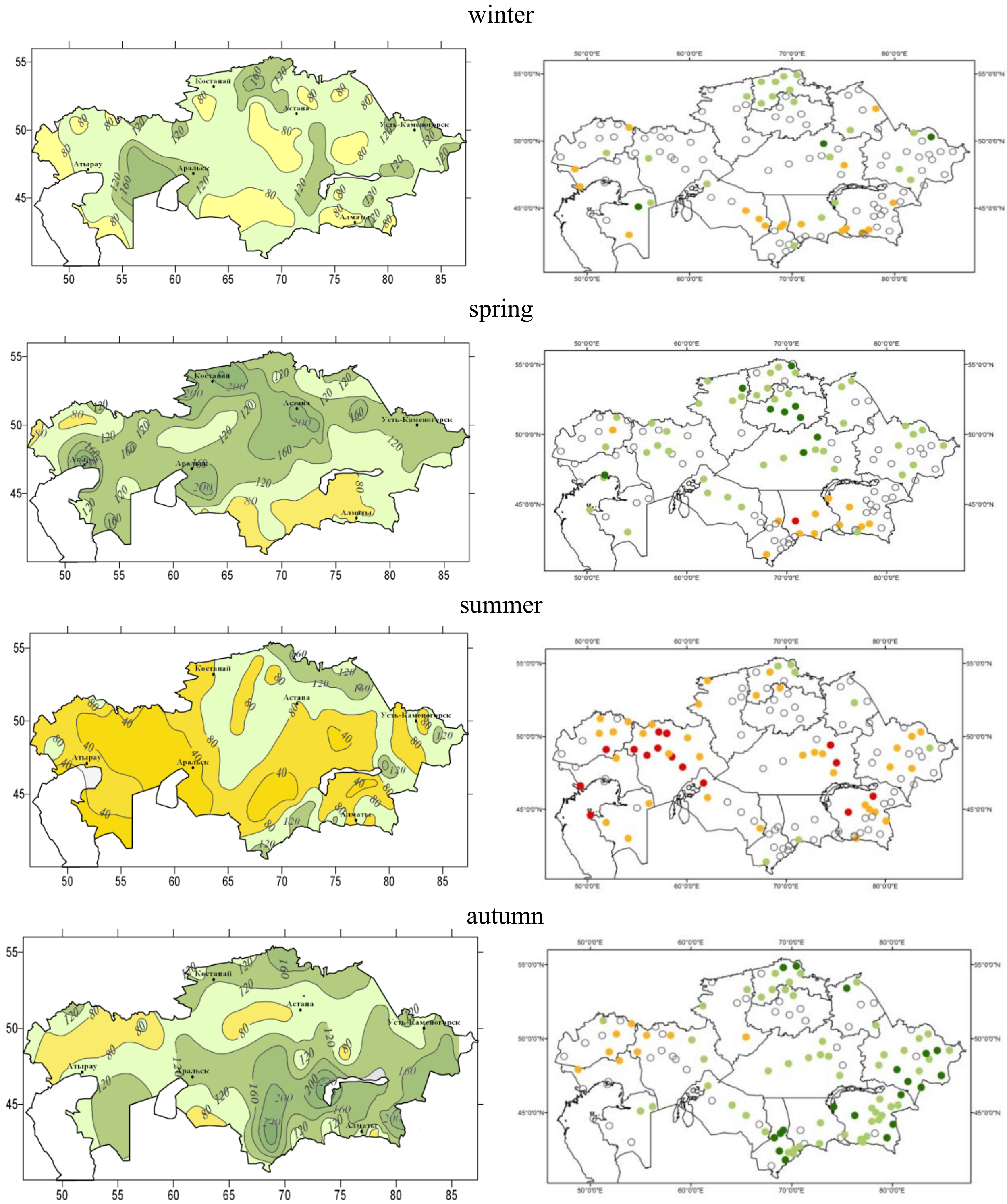
Autumn 2015 was wet in the most part of the territory of Kazakhstan (figure 3.6e). Only in western and some regions precipitation deficit amounted 20 – 60 %. Average amount of precipitation in republic maked 135 % of the norm (3-rd place of the wet rank). In far north, southern, south-eastern of Kazakhstan precipitation amounted 40 – 100 % above the norm. According to results of majority stations of these regions autumn was within 10 % of the extremely wet seasons (figure 3.5e).

year



- extremely dry (non-exceedance probability 0-5 %);
- dry (non-exceedance probability 6-25 %);
- about norm (non-exceedance probability 26-75 %);
- wet (non-exceedance probability 75-95 %);
- extremely wet (non-exceedance probability 96-100 %).

Figure 3.6 – Precipitation in 2015 as % of the norm 1961–1990 (left) and non–exceedance probabilities in 2015 calculated according to the period 1941–2015 (right). List 1



- extremely dry (non-exceedance probability 0-5 %);
- dry (non-exceedance probability 6-25 %);
- about norm (non-exceedance probability 26-75 %);
- wet (non-exceedance probability 75-95 %);
- extremely wet (non-exceedance probability 96-100 %).

Figure 3.6 – Precipitation in 2015 as % of the norm 1961–1990 (left) and non – exceedance probabilities in 2015 calculated according to the period 1941–2015 (right). List 2

To assess precipitation extremes in 2015 experts used Indexes of climate change proposed by the World Meteorological Organization. The analysis of the most representative indexes and their distribution throughout Kazakhstan in 2015 are presented below.

Maximum of daily precipitation in 2015. Figure 3.7 shows absolute maximum daily precipitation, since the beginning of records to 2014 in red. Daily maximum observed in 2015 are in blue. In 2015 the absolute maximum of daily precipitation has been exceeded at station Aturay, where precipitation amounted to 57 mm.

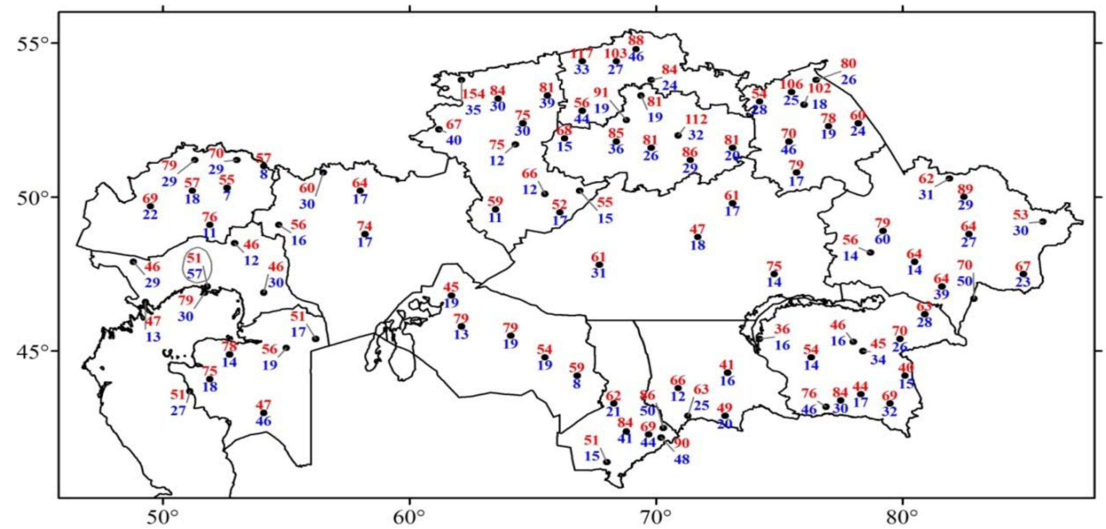


Figure 3.7 – Absolute maximum of daily precipitation, since the beginning of records until 2014 (in red) and the daily maximum in 2015 (in blue), mm

Figure 3.8 shows the share of extreme precipitation (above 95th percentile) in the total precipitation of 2015. Two indexes R95 and PRPTOT were used for calculation. R95 index represents precipitation exceeding the 95th percentile, whereas PRPTOT index shows annual precipitation. The largest share of extreme precipitation was observed at Kulsary (46 %), Peshnoy (42 %), Aral Sea (41 %) and Atyrau (50 %) stations. 35 stations also recorded rather high share of extreme precipitation – 20...39 % which means irregularity of precipitation in time.

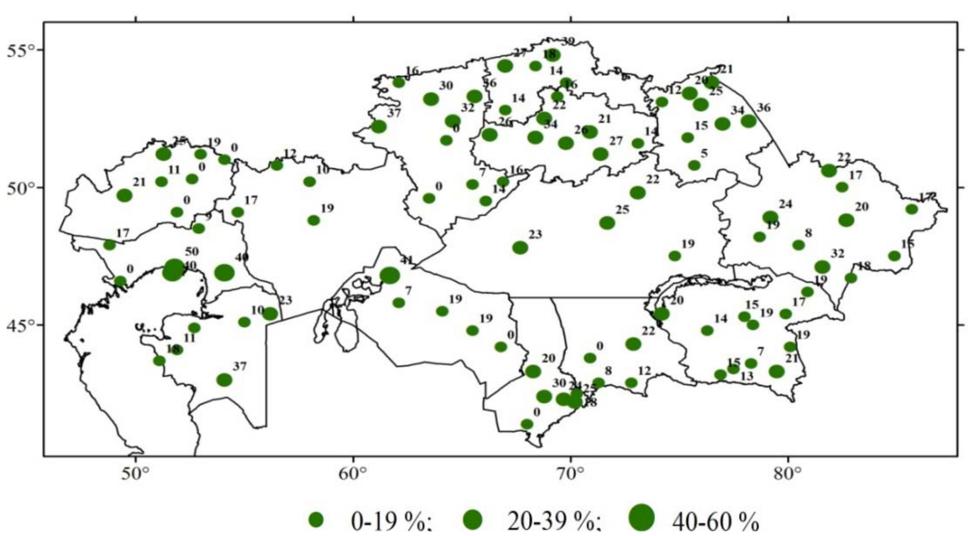


Figure 3.8 - Percentage share of extreme precipitation in the annual total in 2015. Extreme precipitation is the sum of daily precipitation exceeding 95th percentile

The CDD index which represents the ***maximum length of time when precipitation was less than 1 mm*** (duration of dry period, figure 3.9), is very important in the arid climate of Kazakhstan. In 2015the dry period lasted for more than a month at almost all weather stations. The largest dry period of 107 days was recorded at station Uil, Kyzylorda (116 days), Kazalinsk (145%) and Apal Sea (152 days).

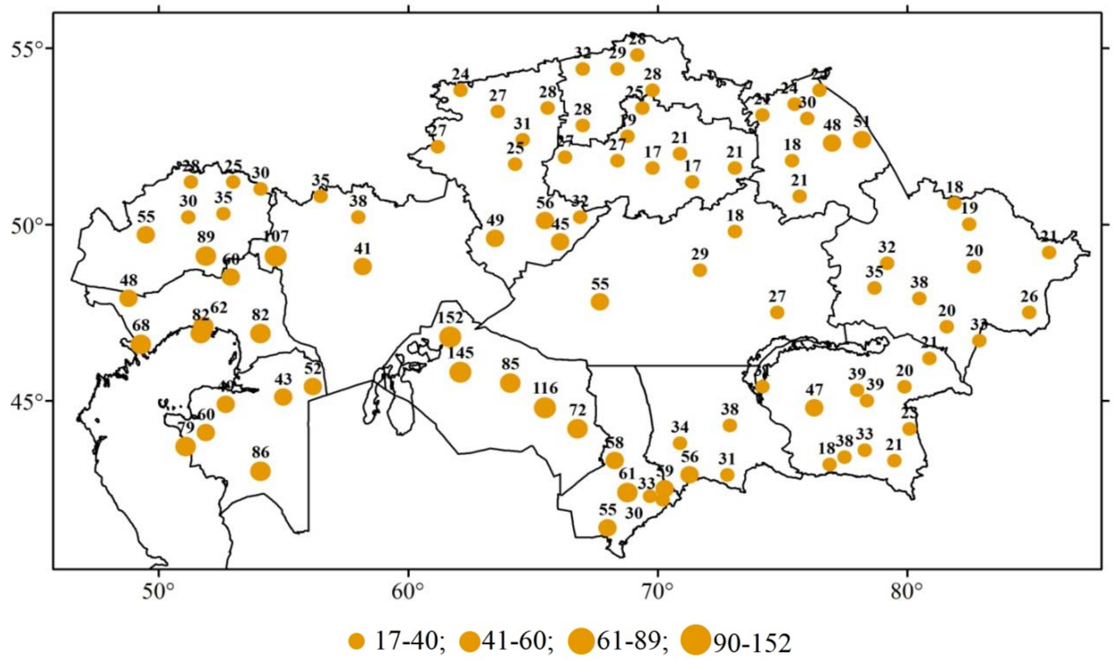


Figure 3.9 – Maximum duration (in days) of dry period in 2015

Figure 3.10 shows ***the maximum duration of the period*** in 2015 ***when precipitation was equal or greater than 1 mm (CWD)***. The CWD index shows that the maximum duration of wet period varied from 2 to 11 days. The longest wet periods of 10 – 11 days were observed at station Novorossiyskoe, Emba and Martuk.

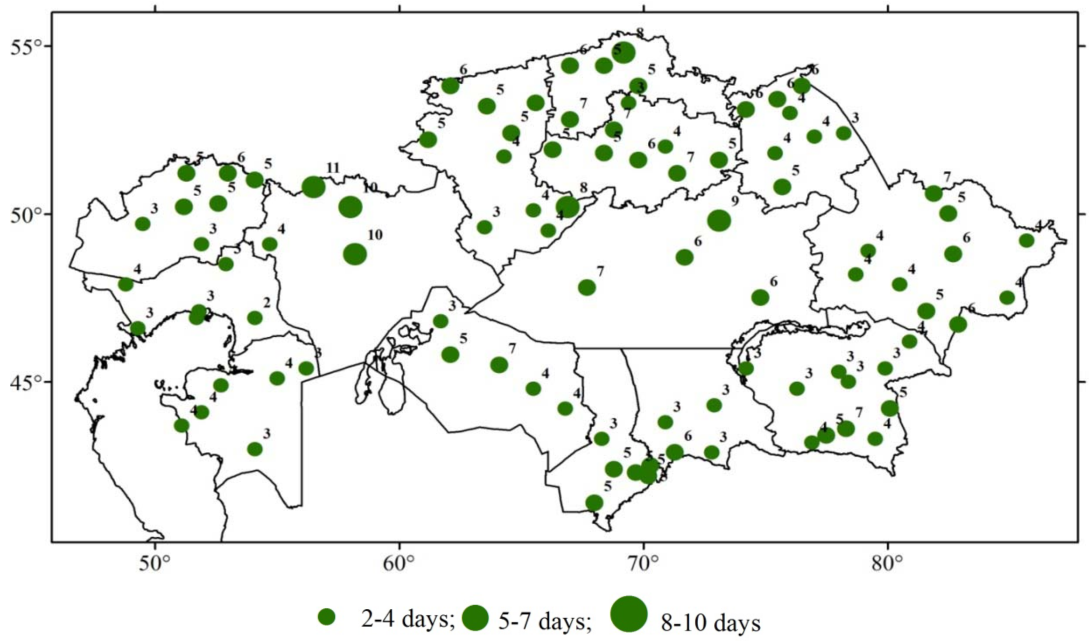


Figure 3.10 – Maximum duration (in days) of wet period in 2015

3.3 Trends in precipitation extremes

Trend analysis of precipitation extremes was prepared over 1941 – 2015.

The maximum daily precipitation (Rx1day) in Kazakhstan remained almost unchanged (Figure 3.11). Both increasing and decreasing trends were weak - around 0.01 – 1.0 mm per 10 years in all oblasts Kazakhstan. Almost all trends are statistically insignificant except few stations. For instance, maximum daily precipitation decreased by 3.6 mm per 10 years at aul Turar Ryskulov station, whereas at Kuigan, Bektau-ata, Bayanaul stations maximum daily precipitation increased by 0.75 – 1.6 mm per 10 years, respectively.

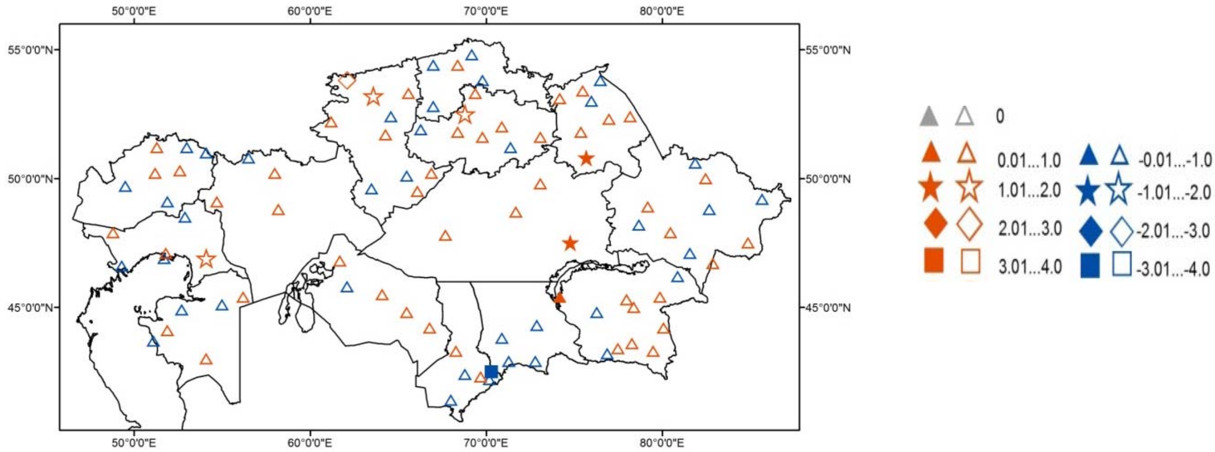


Figure 3.11 – Spatial distribution of the linear trend factor of maximum daily precipitation (mm/10 years), for 1941 – 2015. Shaded keys stand for statistically significant trend

Analysis of ***the percentage share of extreme precipitation in annual total*** (***R95pTOT***) showed that weak trends both decreasing and increasing by 0.01 – 1.0 %/10 years was observed everywhere in Kazakhstan except few stations.

For example, at Mikhailovka and Moinkum stations the share of extreme precipitation increased by 1.2 and 1.5 % every 10 years, respectively. At Chapaevo, Chingirlau and Astana stations extreme precipitation share decreased by 1.2 – 2.5 % every 10 years (figure 3.12). The increase of extreme precipitation during warm period leads the higher risk of erosion, and rain–fed mudflow in mountain regions.

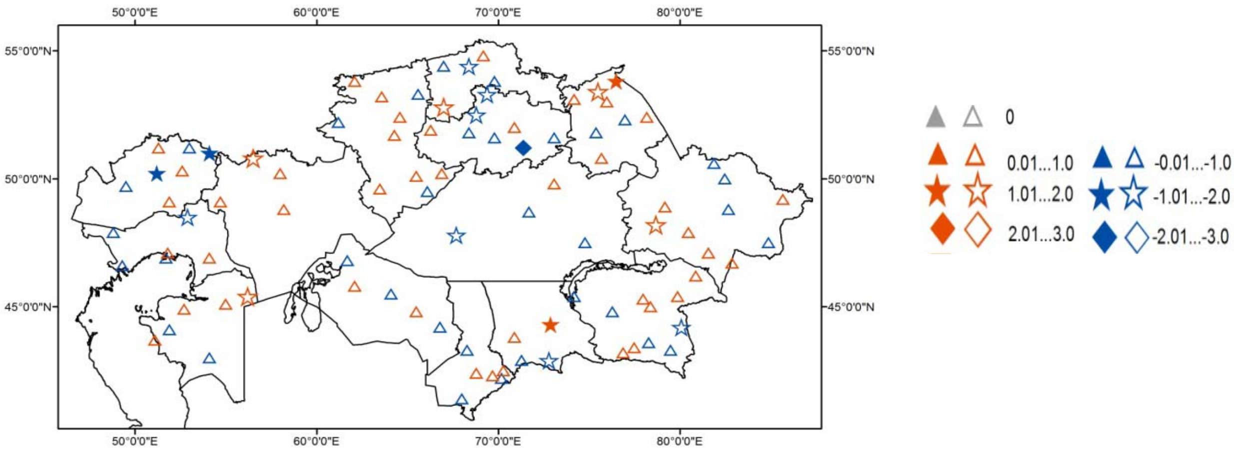


Figure 3.12 – Spatial distribution of the linear trend factor of extreme precipitation share in annual total (%/10 years) over 1941–2015. Extreme precipitation is the sum of daily precipitation above the 95th percentile. Shaded keys stand for statistically significant trend

The maximum duration of dry period (CDD)tend to decrease almost everywhere in Kazakhstan. Statistically significant decrease occurred in the northern and northeastern regions of Kazakhstan by 1 – 4 days every 10 years, at Zhusaly, Pavlodar, Petropavlovsk stations by 5 days per 10 years. Statistically significant increase of dry period occurred at Kokpekty station by 2 days every 10 years (figure 3.13). In other regions of Kazakhstan tendencies of the maximum duration of dry period were statistically insignificant (figure 3.13).

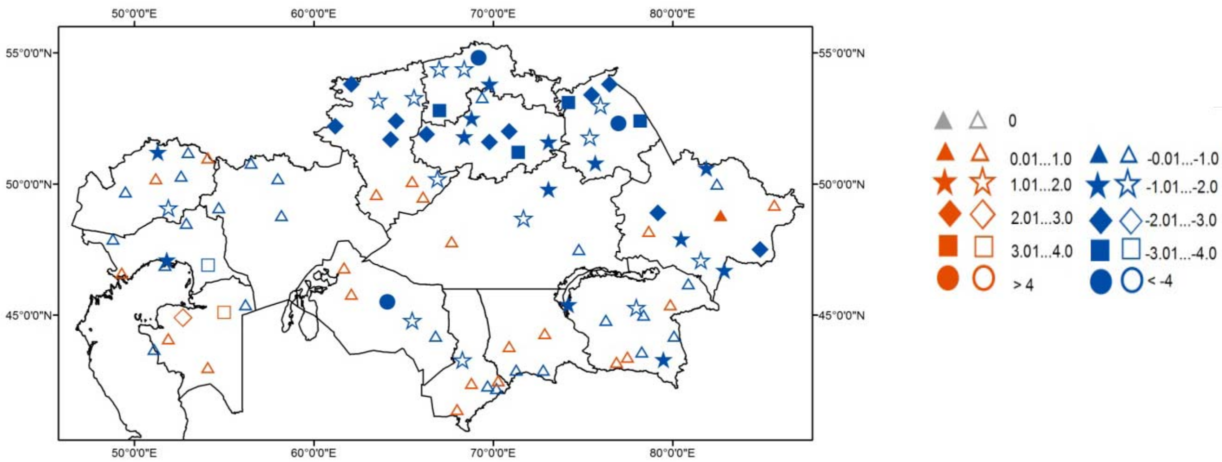


Figure 3.13 – Spatial distribution of the linear trend factor of the maximum dry period duration (day/10 years) over 1941–2015. Shaded keys stand for statistically significant trend

CONCLUSION

Features of 2015 year

2015 was a record warm at both the global level and in many individual countries over the entire observation period. The warming reached record levels as a result of long-term temperature increase caused mainly by emissions of greenhouse gases due to human activities, combined with the effects of the El Niño phenomenon.

In 2015, the average air temperature over land and ocean areas, on average around the globe was 0.76 °C ± 0.09 °C above the baseline period 1961 – 1990 and about 1 °C higher than the values of the period 1850 – 1900. Global average temperatures over land show that the highest temperature on record was in 2015 and is comparable to 2005, 2007 and 2010.

Global average sea surface temperature in 2015 was equal to the record value of 2014. In result of the combination of high temperatures on the surface of the land and sea in 2015 was the total record year. The heat content of the upper 700 m layer and at depths 2000 m in the global ocean reached record levels in 2015.

There were also documented numerous extreme events all over the world, in a few cases reported high material damage, the loss of human lives and even death.

Country average annual air temperature in 2015 was above the baseline period 1961-1990 by 1.6 °C. Practically all the monthly air temperatures in Kazakhstan has been higher than normal, which allowed 2015 to take the 3rd place in the ranked annual average temperature anomalies, while for the global temperature anomalies it is the first place. A characteristic feature of 2015 was that average monthly temperatures were mainly above the norm in most regions of Kazakhstan. The average annual air temperature (Meteorological year is from December 2014 to November 2015) on the territory of Kazakhstan was above the norm by 1.0-2.5 °C. In some areas of the southern and south-eastern of the republic 2015 was extremely warm.

In 2015 (December 2014 through November 2015) the annual precipitation was observed within norm (80 – 120 %) almost everywhere in Kazakhstan. Extremely wet winter was in some regions of weather stations Vozvyshenka, Bulaevo, Petropavlovsk, Ulken Naryn, Karaganda. In these regions 2015 was within 10 % of extremely wet. At stations Chingirlau, Zhambeity was extremely dry. In these regions 2015 was within 10 % of extremely wet. The absolute maximum of daily precipitation has been exceeded at station Aturay, where precipitation amounted to 57 mm. The largest dry period of 107 days was recorded at station Uil, Kyzylorda (107,116 days), Kazalinsk (145 days) and Apal Sea (152 days). The longest wet periods of 10 - 11 days were observed at station Novorossiyskoe, Emba and Martuk.

The winter of 2015 (December 2014 – February 2015) in most part of Kazakhstan was warm, the temperatures of the winter season were above the norm by 1ºC – 4.5 ºC. The highest temperature anomalies were recorded at meteorological stations of East Kazakhstan, Kyzylorda, Kostanay, and North Kazakhstan oblasts.

Winter precipitation throughout the country was about normal. At separate stations in the northern, south–western and eastern regions, the precipitation exceeded the norm by 20 – 100%.

It was anomalously dry in the southern, and also in some parts of central and western Kazakhstan, where the deficit of precipitation was 20 – 60%.

Temperature conditions in spring 2015 were within the norm. Above the norm at 2 - 2.5 ºC the temperatures were in the southern and south–eastern regions.

A considerable excess of precipitation in the spring by 50 – 100% above the norm was observed in Karaganda, North Kazakhstan, Akmola and Atyrau oblasts. In these regions spring of 2015 was within 10 % of the extremely wet season. Precipitation deficit of 20 – 60 % was observed in the southern areas and in some places in the west of the republic. Extremely dry was in Uyuk station.

Summer 2015 in most regions of Kazakhstan was characterized as warm. Extremely warm was in Almaty, East Kazakhstan oblasts and And also in some regions of Kyzylorda, South Kazakhstan, Zhambyl the summer was extremely warm. In June air temperature anomalies ranged from 3.4 to 5.6 ºC (West Kazakhstan, Mangistau, Atyrau and Aktobe regions). Absolute maximum air temperature has been exceeded by 0.2 – 1.1 ºC on the eight stations in 2015. The total duration of heat waves was high and amounted to 18 – 42 days in western and south-western parts of Kazakhstan and as well as in some regions of Kyzylorda and South Kazakhstan regions. Temperature above 35 ºC was observed in Almaty, Zhambyl, South Kazakhstan, East Kazakhstan and Atyrau oblasts. In the southern of Kazakhstan, the vegetation period was longer compared to 2014 (270 – 300 days). Precipitation deficit was 23 % on average for Kazakhstan.

The amount of precipitation in Aktobe region was only 30 % of the norm (2nd rank for precipitation deficit), in Mangistau – 36 %, Kyzylorda – 38 %, West Kazakhstan – 53 % and Atyrau oblasts – 37 %. In these regions summer of 2015 was within 10 % of the extremely dry season.

The temperature regime of autumn 2015, as apposite to autumn 2014, was within the norm in the most part of territory of Kazakhstan. It was cold in some areas of North Kazakhstan and South Kazakhstan oblasts. Only in West Kazakhstan and Atyrau oblasts the temperature anomalies were above the norm by 1.0 – 1.5 ºC. Autumn 2015 was wet in the most part of the territory of Kazakhstan. Average amount of precipitation in republic maked 135 % of the norm (3-rd place of the wet rank). In far north, southern, south-eastern of Kazakhstan precipitation was by 60 – 100 % above the norm. According to results of majority stations of these regions autumn was within 10 % of the extremely wet seasons.

Climate Change in Kazakhstan

On average, the rate of rise in the average annual air temperature in Kazakhstan is 0.28 ºC every 10 years. The highest warming was in spring and autumn by 0.30 and 0.31 ºC every 10 years. Winter and summer temperatures have been increasing a little slower by 0.28 ºC and 0.19 ºC every 10 years respectively. The highest rate of increase in the average annual air temperature was observed in the West Kazakhstan region (0.38 ºC every 10 years), the lowest in the South Kazakhstan region (0.22 ºC every 10 years). Over the past 30 years, dominate years with considerable positive average annual air temperature anomalies in all oblasts.

There is a tendency to increase ***the daily maximum values of surface air tempera***ture at most weather stations in all regions of Kazakhstan. However, in most part of Kazakhstan, trends in extremes were insignificant, with the exception of some meteorological stations in different regions, where the daily maximum temperature increased by 0.20 – 0.60 ºC every 10 years. Only in the southern of the country there were negative values of linear trend coefficient (0.20 ºC every 10 years).

There is a tendency to increase ***the number of days with air temperature above 35 ºC*** in West Kazakhstan, South Kazakhstan, Atyrau, Aktobe, Mangistau, Kyzylorda ,Almaty, Zhambyl and in southern Kostanay oblasts by 1 – 5 days every 10 years.

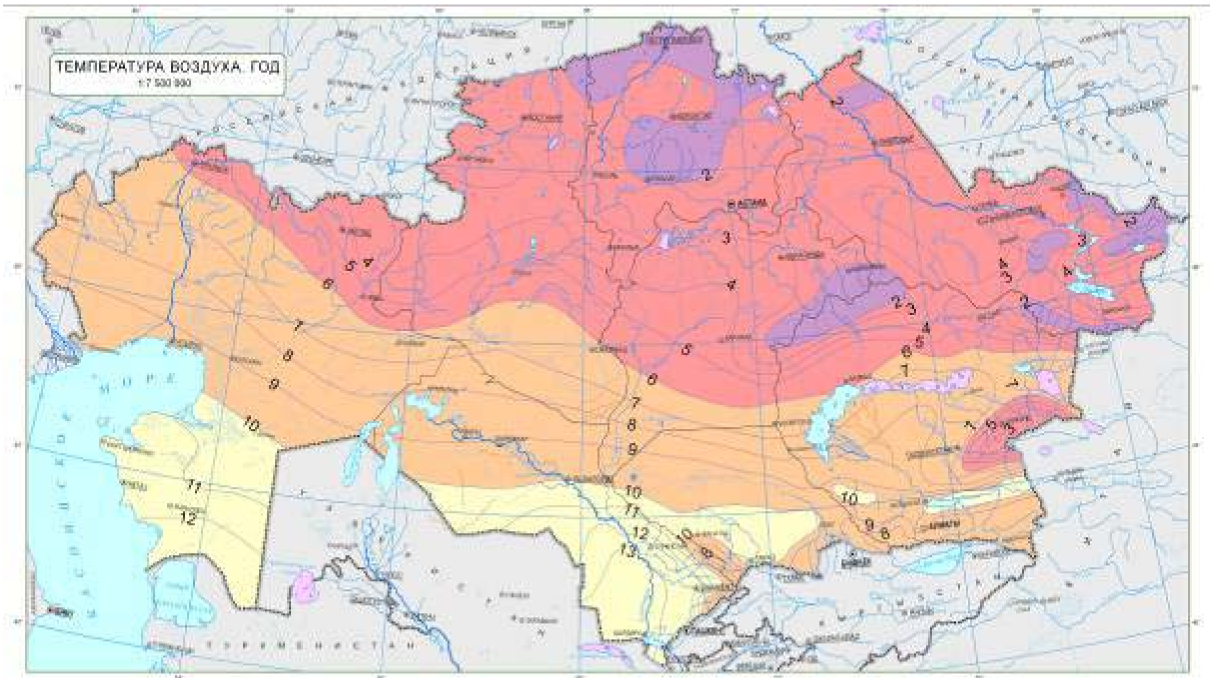
The total duration of heat waves increases by 1 – 3 days/10 years in throughout the republic.

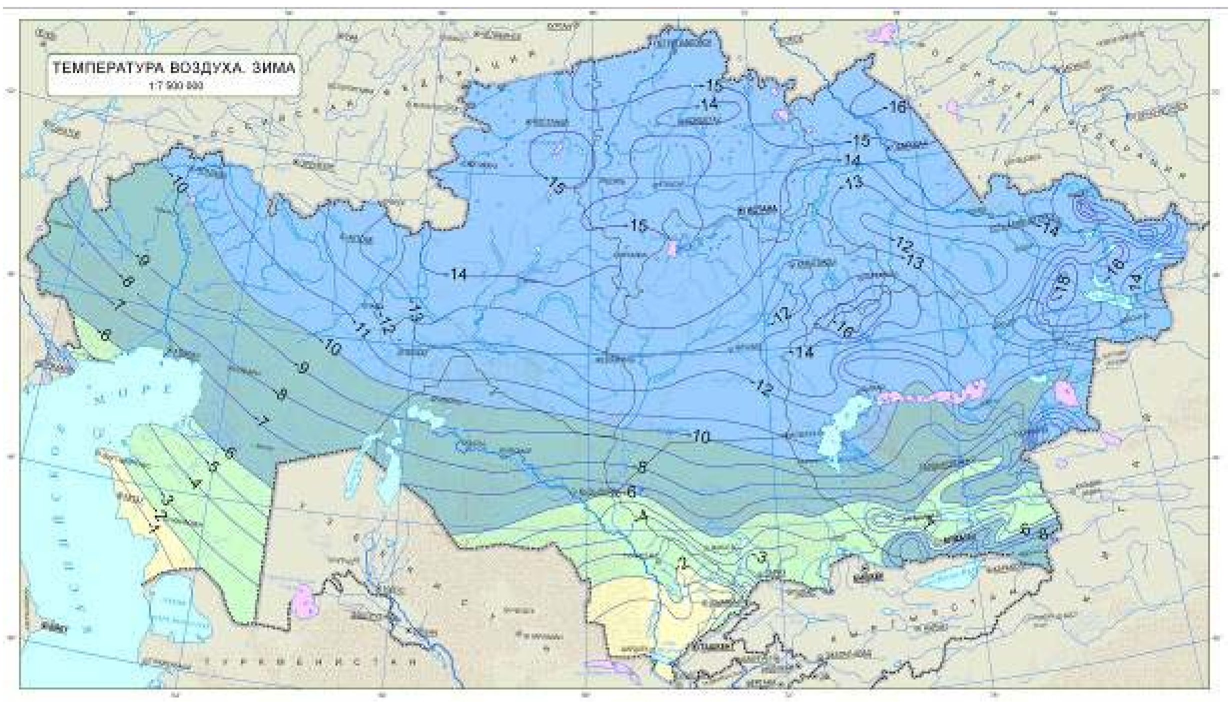
Practically everywhere there is a tendency to decrease ***the frequency of frosty days.*** In some areas of South Kazakhstan, Kyzylorda and Atyrau oblasts, the reduction is 5 – 6 days every 10 years.

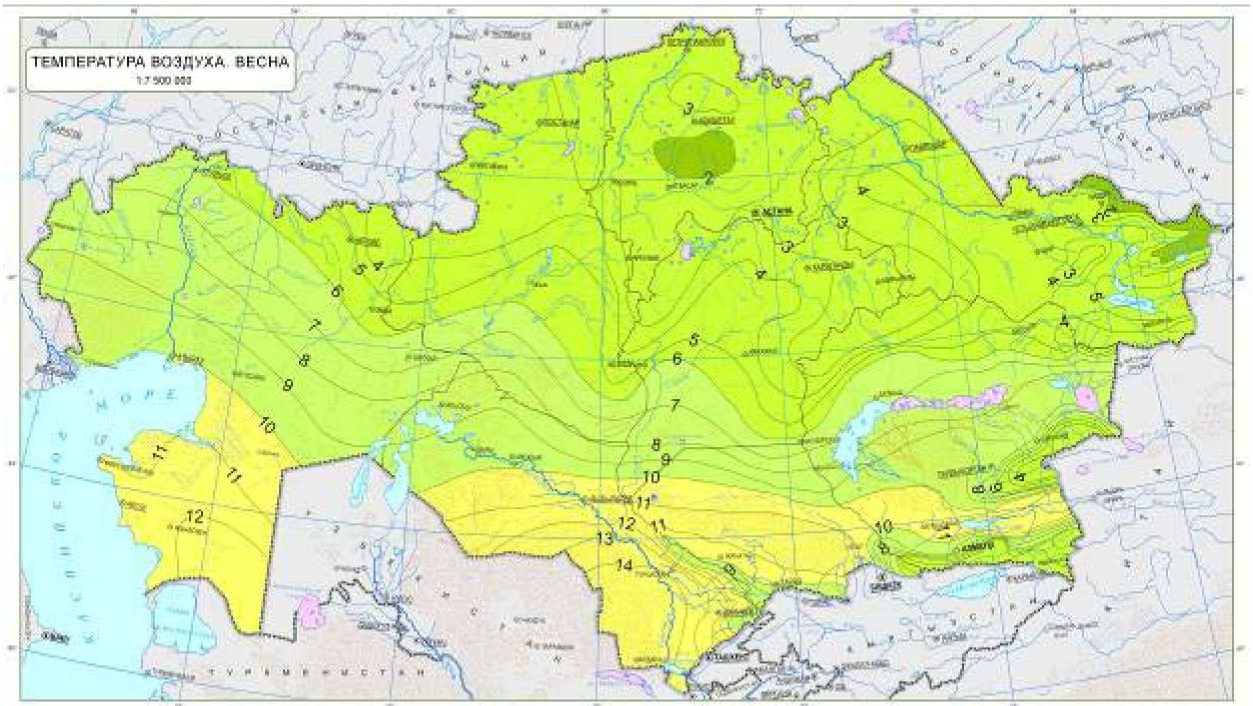
During the period 1941–2015, on average for Kazakhstan, the annual precipitation amount decrease slightly by 0.2 mm every 10 years. In winter period, stable positive trends were observed almost throughout the territory, except for the south-western and southern of the republic. In the remaining seasons, in most of the territory of Kazakhstan, with the exception of some mountainous and foothill areas of the southeastern and northern regions, the precipitation decreased by 1 – 14% of the norm every10 years. Most of the territory of Kazakhstan has a tendency to reduce the maximum duration of the period without precipitation.

ANNEX 1

SPATIAL DISTRIBUTION OF ANNUAL AND SEASONAL MEAN AIR TEMPERATURE IN KAZAKHSTAN, CALCULATED OVER THE PERIOD 1961 – 1990



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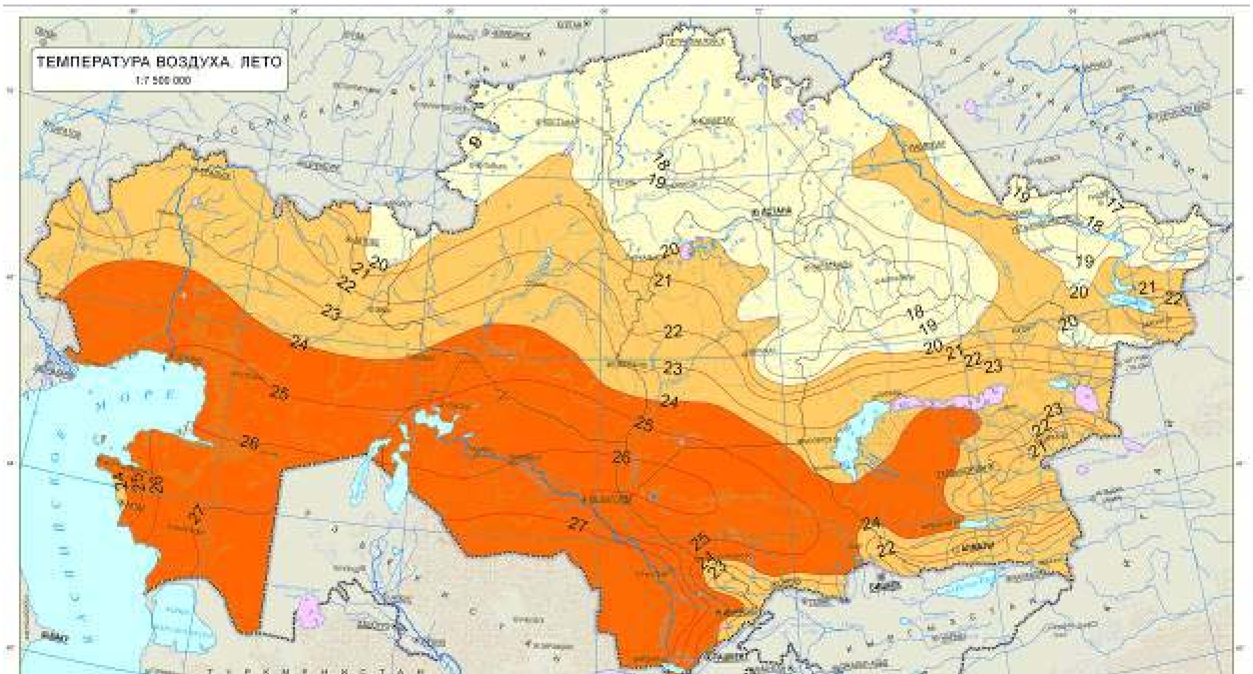
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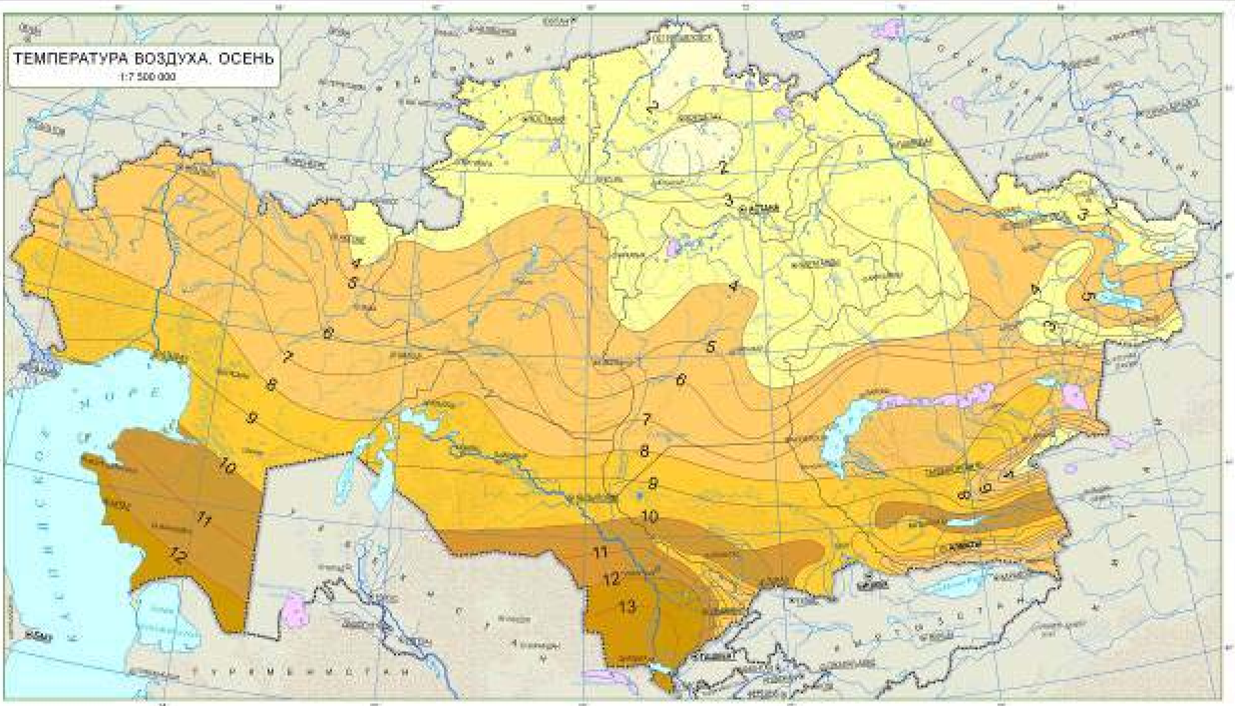
ТЕМПЕРАТУРА ВОЗДУХА. ОСЕНЬ
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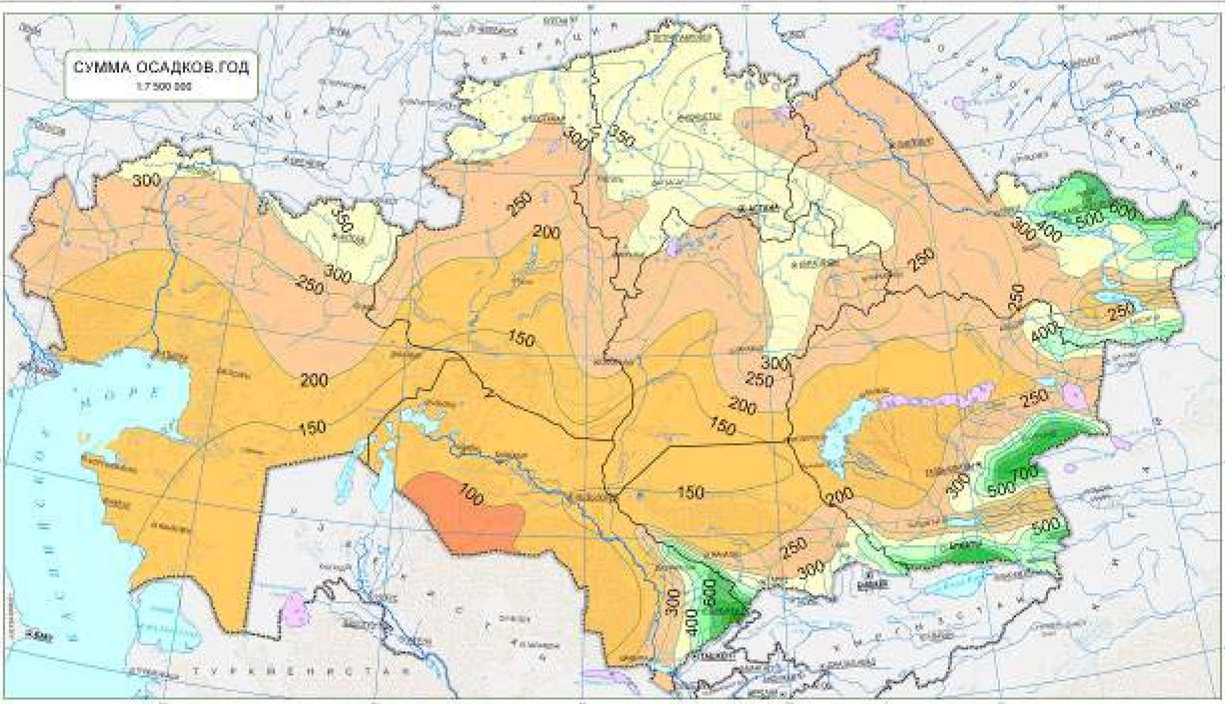
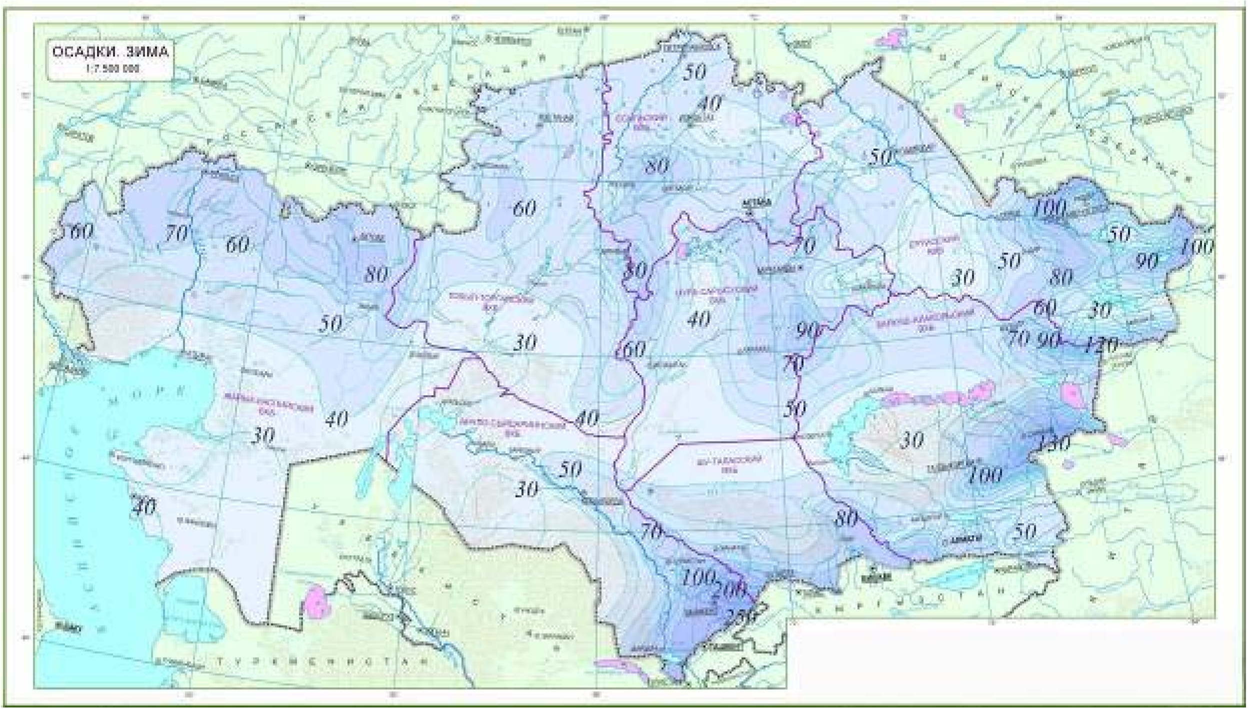
ANNEX 2

SPATIAL DISTRIBUTION OF ANNUAL AND SEASONAL PRECIPITATION IN KAZAKHSTAN, CALCULATED OVER THE PERIOD 1961 - 1990



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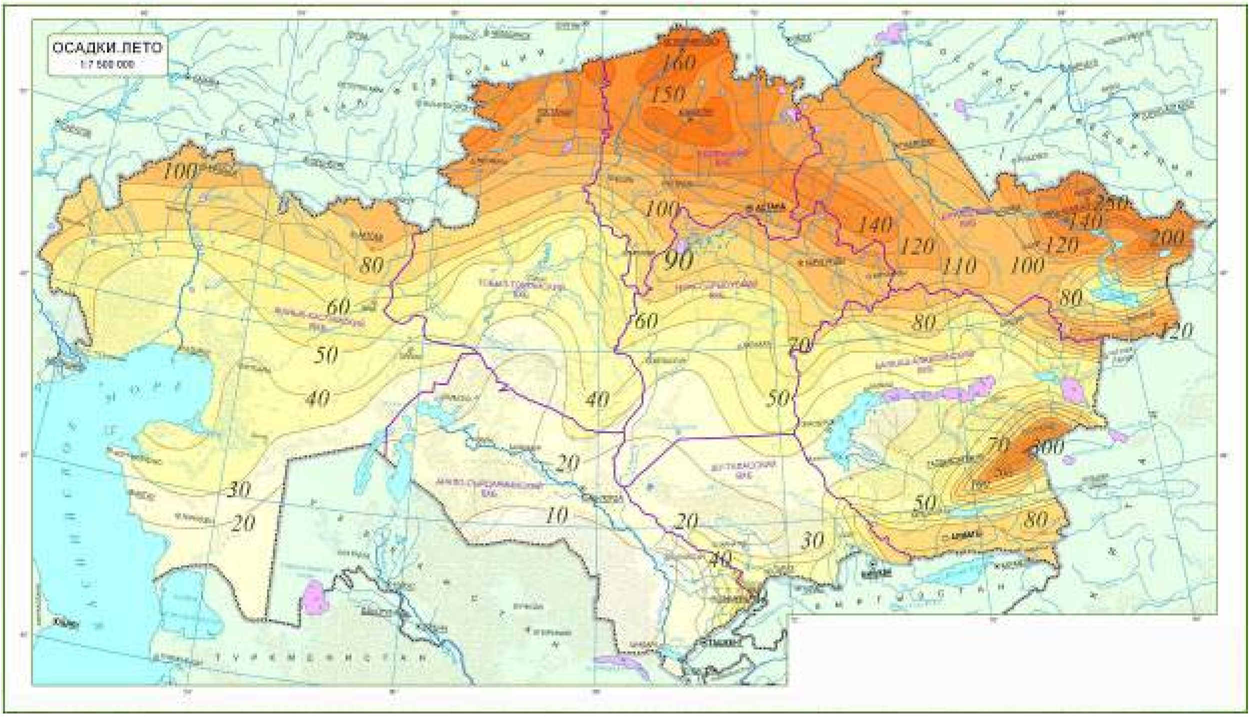
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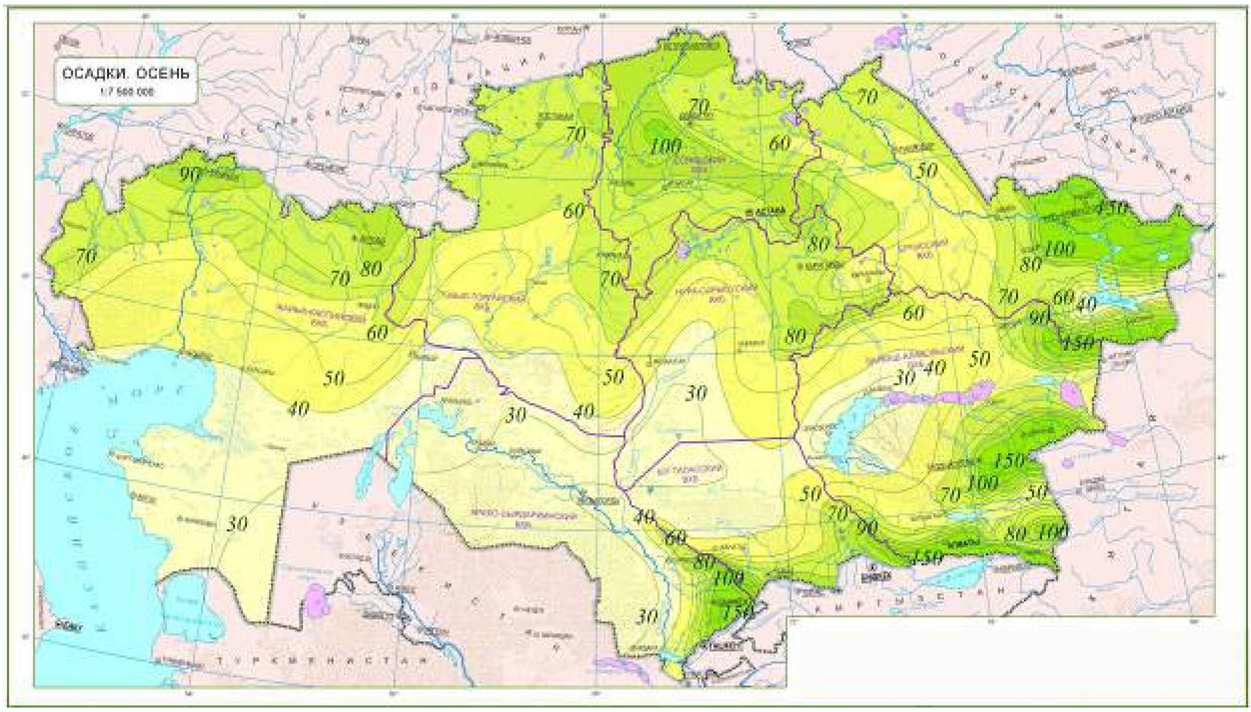
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