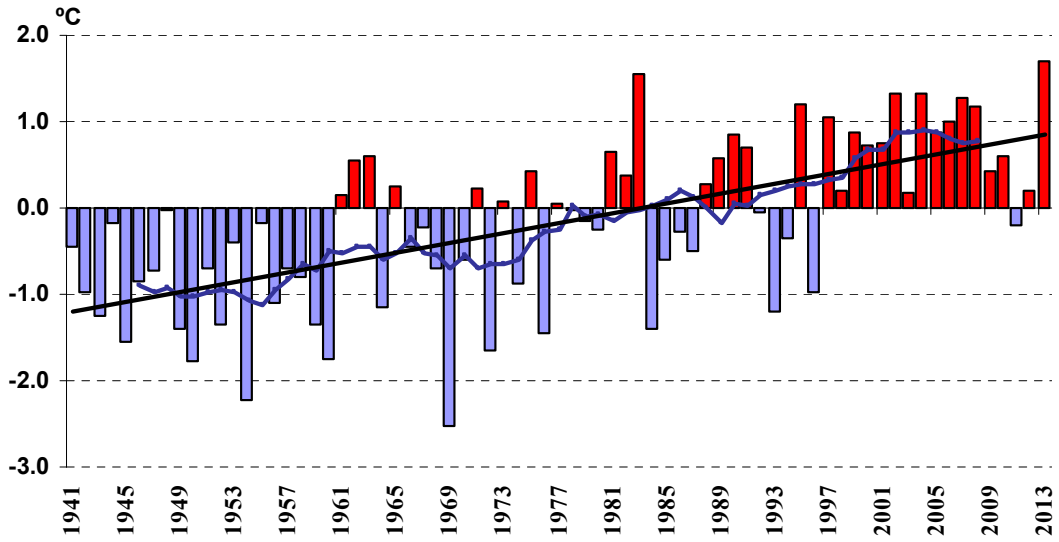
Ministry of Energy of the Republic of Kazakhstan

Republican State Enterprise
“Kazhydromet”

ANNUAL BULLETIN OF CLIMATE CHANGE MONITORING IN KAZAKHSTAN:

2014



Астана, 2015

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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 2014 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 1971 ... 2000 (the norm for the period 1971 ... 2000, 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 2014. Data of more than 190 weather stations were used to assess climate normal for 1971...2000. 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 2014 (more than 90 meteorological stations).

Basic approaches and methods.

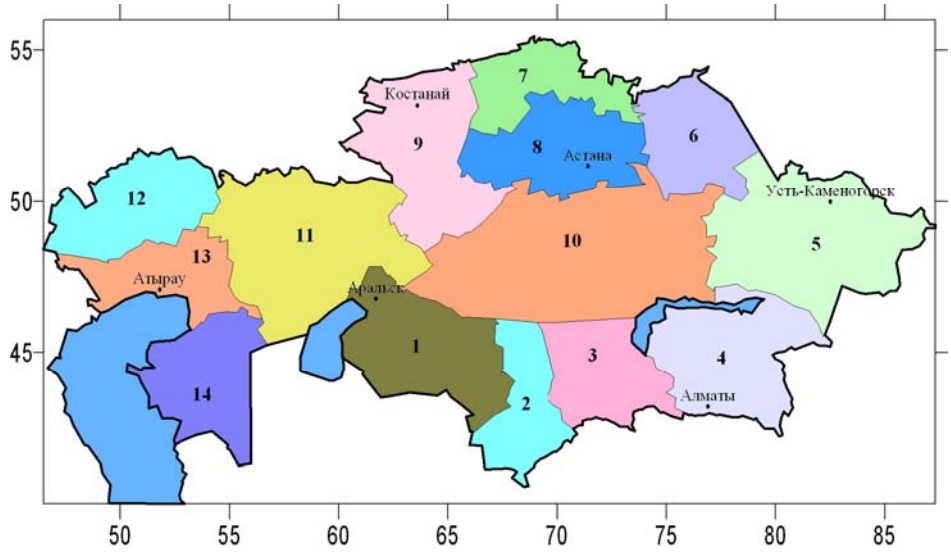
Climate "normal" in the bulletin means average value of the considered climatic variable for the 1971…2000. Temperature anomalies are calculated as the deviation of the observed values from the norm. Precipitation anomalies are usually considered both as deviation from the norm (like temperature) and 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 2014. 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
2 – Southern Kazakhstan oblast
3 – Zhambyl oblast
4 – Almaty oblast
5 – Eastern Kazakhstan oblast
6 – Pavlodar oblast
7 – Northern Kazakhstan oblast
8 – Akmola oblast
9 – Kostanay oblast
10 – Karaganda oblast
11 – Aktobe oblast
12 – Western Kazakhstan oblast
13 – Atyrau oblast
14 – Mangistau oblast

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1 OVERVIEW OF GLOBAL CLIMATE CHANGE AND ITS STATUS IN 2014

The observations of the climate system currently base on the Global Observing System of the atmosphere, land and ocean surfaces, which is a coordinated system of different subsystems observations. Observations of temperature and other variables on a global scale began in the middle of 19th century to the beginning of the instrumental era, but a more comprehensive and diverse set of observed parameters they became since the 1950s.

Estimates of change globally as averaging of land surface temperature and ocean, calculated on the basis of a linear trend, show a warming of 0,85 (0,65...1,06) °C for the period 1880...2012. The increase surface air temperature observed in most regions of the globe (Figure 1.1).

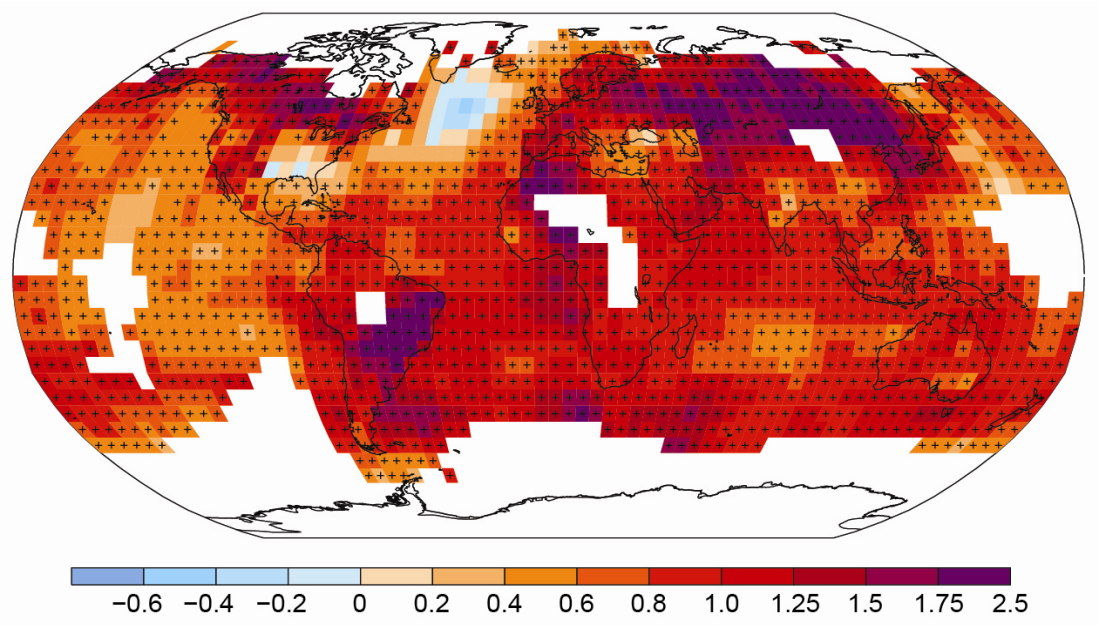


Figure 1.1 - Map of the observed changes in surface temperature from 1901 to 2012, compiled on the basis of temperature trends determined by linear regression based on a single data set (red line in Figure 1.2). Trends were identified for those places where the availability of data allows you to make a reliable estimate (i.e., only for grid cells in which there are more than 70% of the possible amount of data, more than 20% of the possible amount of data for the first and last 10% of the period observations). Other areas are painted white. Grid cells, for which statistically significant trend reaches 10%, marked with the symbol "+". Source: IPCC, 2013: Summary for Policymakers. Contained in the publication "Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change»

Figure 1.2 shows the variation of the global surface air temperature for the period of instrumental observations, calculated according to the three arrays. Data beginning from 1850 for the UK and from 1880 for the US. Warming was not constant in the 20st century. From the early 20th century and up to 40’s warming continued, then there was a slight cooling, and after that from the mid 70’s to present the intensive warming is observed. The warming trend

observed within the last several decades remained also in 2014 which on a rating of WMO became nominally warmest year since the beginning of carrying out modern tool measurements in the middle of the 1800th years. . Land-ocean global average air temperature in 2014 was 0,57 ºC ± 0,09 °C higher the 1961…1990 annual average of 14 °C. Fourteen of the fifteen warmest years on record, including 2014, have all occurred in the twenty-first century. Confirmation of global warming under the impact of anthropogenous factors, becomes more and more reasonable.

Figure 1.2 - Annual global average temperature anomalies (relative to the 1961…1990) from 1850 to 2014 from the Hadley Centre/CRU (HadCRUT4) (black line and grey area, representing average and 95 per cent uncertainty range), the National Climatic Data Center (red), and the NASA Goddard Institute for Space Studies (blue) *(Source: WMO-№ 1152)*

One of the largest driving forces of annual changes in global temperature is El Niño / the Southern fluctuation (ENSO, Figure 1.3). Sea surface temperatures in east tropical part of the Pacific Ocean at the end of 2013 were slightly low, than on average that specified that global temperature in 2014 will strongly not depend on influence of El Niño or La Nina. As a result of 2014 became year with a neutral phase of the phenomenon of El Niño / the Southern fluctuation (ENSO). El Niño is, as a rule, connected with increase of global temperatures. It means that 2014 was exclusively warm, despite the lack of El Niño.

The most part of the accumulative energy in climatic system finally comes to oceans (Figure 1.4). Global average sea surface temperature in 2014 was 0,44 ±0,03 °C above the 1961…1990 average that is warmer than in any previous year on record. Sea surface temperatures were especially high in the northern hemisphere from June to October.

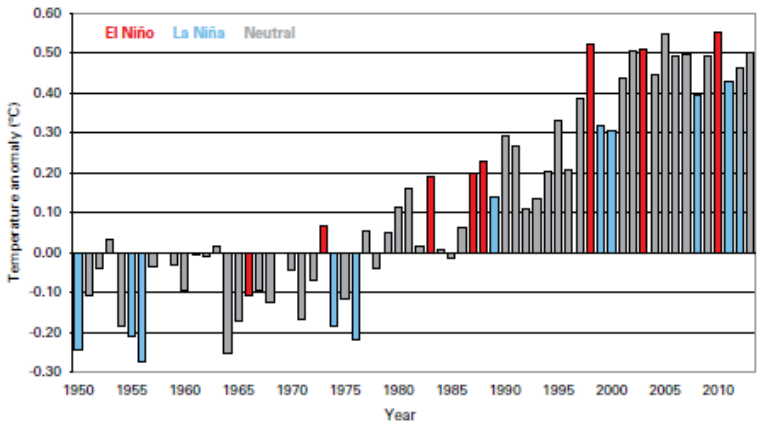


Figure 1.3 – Global average annual temperature anomalies (relative to 1961…1990) for the period 1950…2014 on the basis of average value of three sets of data (GISTEMP, MLOST и HadCRUT.4.3.0.0). Years under the influence of La Niña are shown in blue; years under the influence of El Niño are shown in red; other years are shown in grey. Source: ВМО-№ 1152

Sea level is one more the important measured indicator of climatic system. It is connected with heat of the ocean when the ocean increases in volume as a result of thermal expansion.

Water from melting ice sheets and glaciers also makes the contribution to sea level rise. Local variability of sea level depends on inflow, storms and the large-scale climatic regime, such as ENSO. In the majority of months 2014 the global average sea level reached record or nearly record levels.

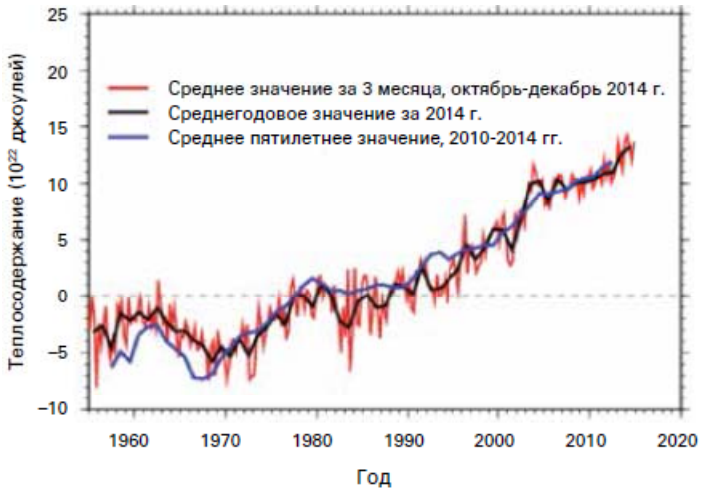


Figure 1.4 – Anomaly of heat content of the World Ocean (relative to 1955…2006) for the layer 0…700 m from 1955 to 2014 shows average value of tree months October – Desember 2014 (red liner), average annual value (black liner) and average five-year value (blue liner). Source: BMO-№ 1152

Arctic sea-ice extent reached its maximum in March and its minimum in September. Average monthly extent in September was the sixth of the lowest for observation period, on 1,24 million km^2 below average value for 1981…2010 and on 1,65 million km^2 above of record low extent fixed in September, 2012 (Figure 1.5). 2014 became the third year in a row when the record extent of sea ice in Antarctic was noted. Extent of the Antarctic sea ice fell below the record levels in the end of the year, and extent in December was the third largest for a history of observations since 1979.

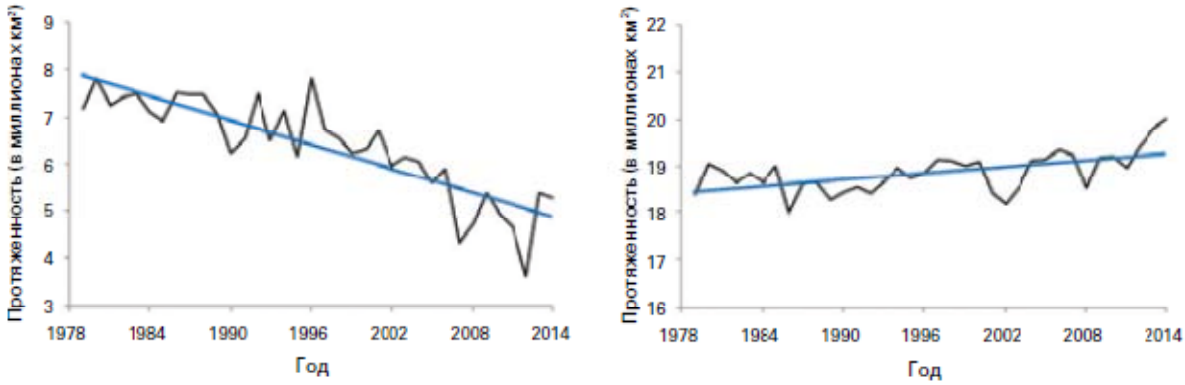


Figure 1.5 – Arctic (at the left) and Antarctic (on the right) sea-ice extent in September during 1979…2014, measured in millions of square kilometers. (Source: Data are provided by National data center for snow and ice, the USA)

The extreme phenomena which were observed at the national and regional levels are also especially noted in the Statement of WMO for a condition of global climate in 2014. In many countries, especially on the Balkans, in the Southern Asia and in separate parts of Africa, the South and Central America there were severe floods and high-growth rough floods. Such extreme phenomena arise every year by reason of natural climate variability. High frequency of emergence of floods world is a consequence of acceleration of a hydrological cycle which driving force is the complementary energy held by greenhouse gases in the atmosphere.

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. Only five of the warmest years in Kazakhstan entered the list of the ten warmest years of the globe (Table 2.1).

Table 2.1 – The ranked 10 warmest years for the globe (1850...2014) and for Kazakhstan (1941…2014) and corresponding annual average temperature anomalies for Kazakhstan

Rank	Globe	Kazakhstan	Annual average temperature anomaly for Kazakhstan, °C
1	2014	2013	1,69
2	2010	1983	1,56
3	2005	2002	1,33
4	1998	2004	1,33
5	2003	2007	1,27
6	2002	1995	1,21
7	2013	2008	1,17
8	2007	1997	1,05
9	2006	2006	0,99
10	2009	2005	0,88

2014 year was the thirty-sixth place in the ranked annual average temperature anomalies. The annual average temperature anomaly in 2014 was lower by 0,04 °C than normal (1971…2000) which was 5,7 °C. Therefore, 2014 approached nearer to mean annual value of air temperature during 1971…2000 (Table 2.1).

Figure 2.1 presents the ranked annual average temperature anomalies estimated relative to the1971…2000 and averaged over 118 weather stations in Kazakhstan for the 1940…2014. All of extremely warm years on average for the globe come from the last 20 years. In Kazakhstan, this feature is also clearly seen, with the exception of 1983.

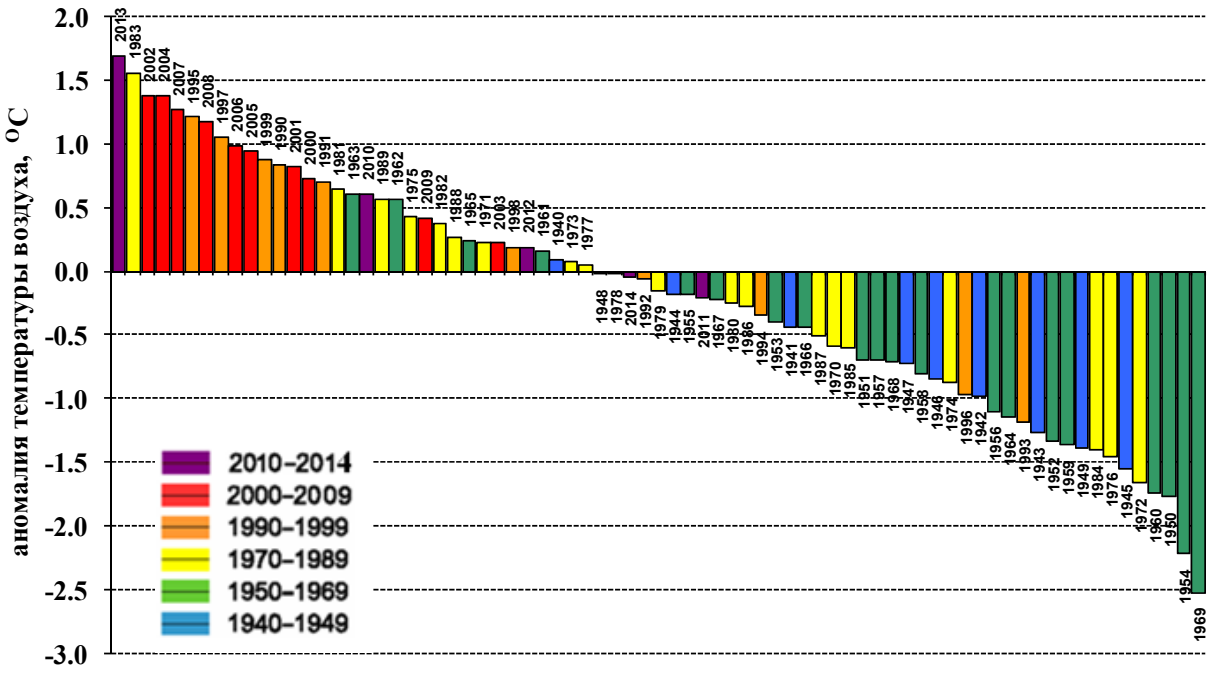


Figure 2.1 – Ranked average annual air temperature anomalies for Kazakhstan for 1941…2014. Anomalies estimated relative to 1971…2000 baseline

Figures 2.2…2.3 and Table 2.2 present the air temperature change for 1941…2014 for Kazakhstan and administrative areas. All trends in the ranks of the average annual and seasonal values are positive, and showed that the highest warming was observed everywhere in Kazakhstan from 1941 to 2014.

Country average annual temperature has been rising by 0,27 ºC /10 years (Table 2.2). The highest warming was in spring and in autumn by 0,31 ºC/10 years. Winter temperature has been increasing a little slower by 0,27 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 38 %, for seasons contribution varies from 6 to 24 % (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 are mostly negative (Figure 2.2). The fastest increase in the average annual temperature was in West Kazakhstan oblast equal to 0,38 ^{0}C/10 years. The lowest warming rates were in South-Kazakhstan Oblast, East Kazakhstan Oblast, Almaty, Mangistau and Pavlodar Oblasts amounting to 0,21...0,26 ºC/10 years. In other oblasts the temperature increase rates were within 0,27...0,31 ºC/ 10 years(Figure 2.3, Table 2.2).

Considering 2014 data the biggest temperature increase was observed in spring in northern, central and eastern oblasts (0,28…0,38 ºC/ 10 years), the warming following in size falls on an autumn season. In western oblasts the biggest temperature rise still occurred in winter by 0,26…0,46 ºC/10 years and in transition seasons by 0,25…0,43 ºC/10 years. In the majority of the southern areas the main peak of warming falls in an autumn season (0,29…0,40ºC/10years), the second – in winter or spring (0,21…0,33 ºC/10years). In summer almost everywhere in Kazakhstan the temperature increase linear trend factor was within 0,13…0,27 °C/10 years. However determination factor is rather high, especially in southern oblasts equal to 18…37 %. This means that air temperature increasing trend is stable.

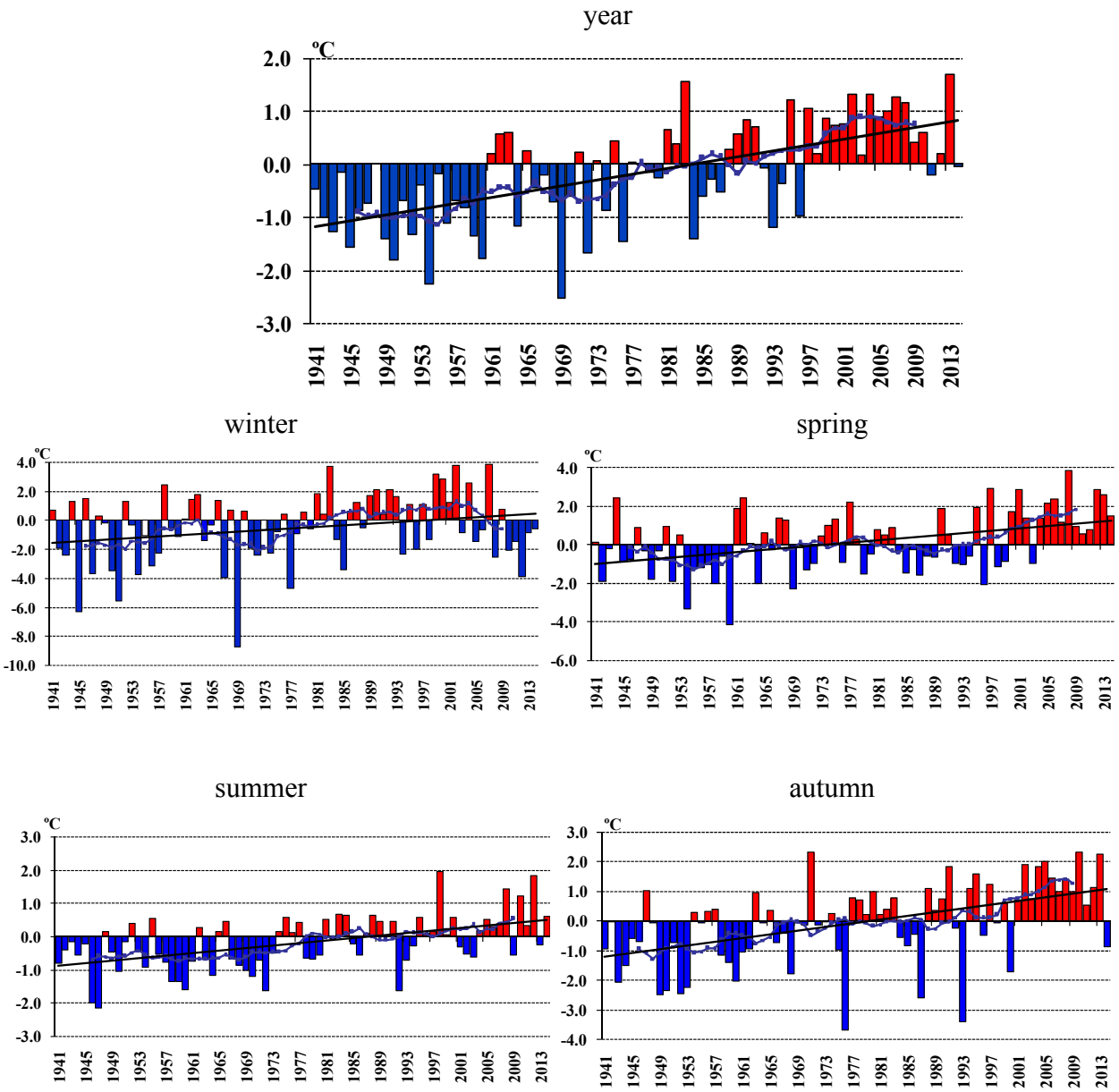


Figure 2.2 – Time series and linear trends of the annual and seasonal air temperatures anomalies (relative to 1971…2000) for 1941...2014 for Kazakhstan. The smooth curve represents the 11-year moving average

Table 2.2 – Parameters of the air temperature anomaly linear trend for Kazakhstan and its administrative oblasts for 1941...2014

Oblast	Year		Winter		Spring		Summer		Autumn	
	*a	**R^2	a	R^2	a	R^2	a	R^2	a	R^2
Kazakhstan	0,27	38	0,27	6	0,31	17	0,19	25	0,31	24
Kyzylorda	0,29	32	0,21	2	0,33	16	0,27	34	0,30	22
South Kazakhstan	0,21	27	0,16	2	0,21	11	0,17	18	0,32	27
Zhambyl	0,29	39	0,27	5	0,23	12	0,27	37	0,40	34
Almaty	0,23	31	0,27	7	0,22	12	0,13	13	0,29	25
East Kazakhstan	0,25	25	0,27	5	0,28	12	0,14	11	0,31	18
Pavlodar	0,26	25	0,26	4	0,37	17	0,14	8	0,28	13
North Kazakhstan	0,30	31	0,30	5	0,37	16	0,20	12	0,32	15
Akmola	0,28	31	0,25	4	0,38	16	0,18	11	0,32	16
Kostanay	0,31	33	0,30	5	0,37	14	0,24	15	0,32	17
Karaganda	0,28	31	0,24	4	0,35	16	0,20	17	0,32	19
Aktobe	0,29	31	0,30	5	0,33	12	0,21	14	0,30	16
West Kazakhstan	0,38	39	0,46	10	0,43	20	0,27	16	0,34	21
Atyrau	0,29	34	0,38	9	0,32	17	0,20	19	0,27	17
Mangistau	0,25	35	0,26	8	0,24	13	0,23	21	0,25	16

* a – linear trend factor. ºC per 10 years
** R^2 – determination factor. %
Mangistau oblast - parameters calculations were performed only on stations Fort Shevchenko

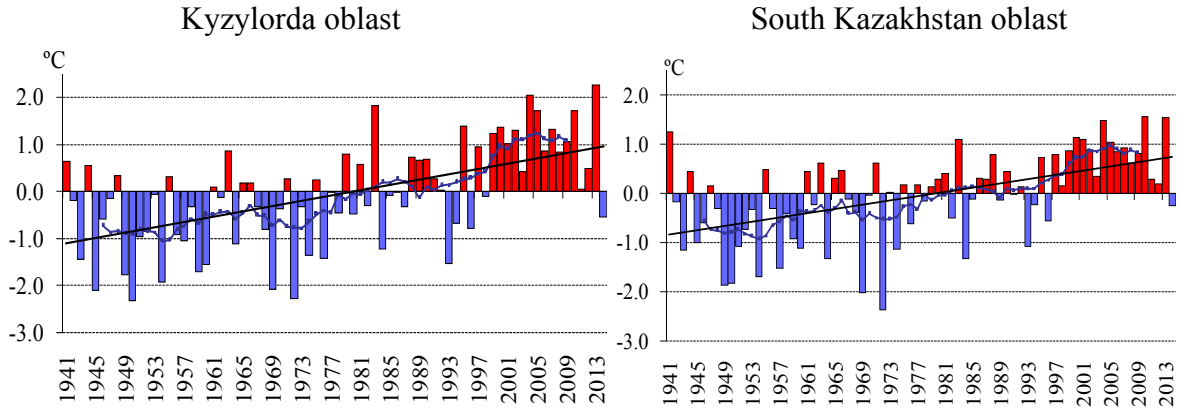


Figure 2.3 – Time series and linear trends of the annual average air temperatures anomalies (relative to 1971…2000) for 1941...2014 for Kazakhstan (°C). The smooth curve represents the 11-year moving average

List 1

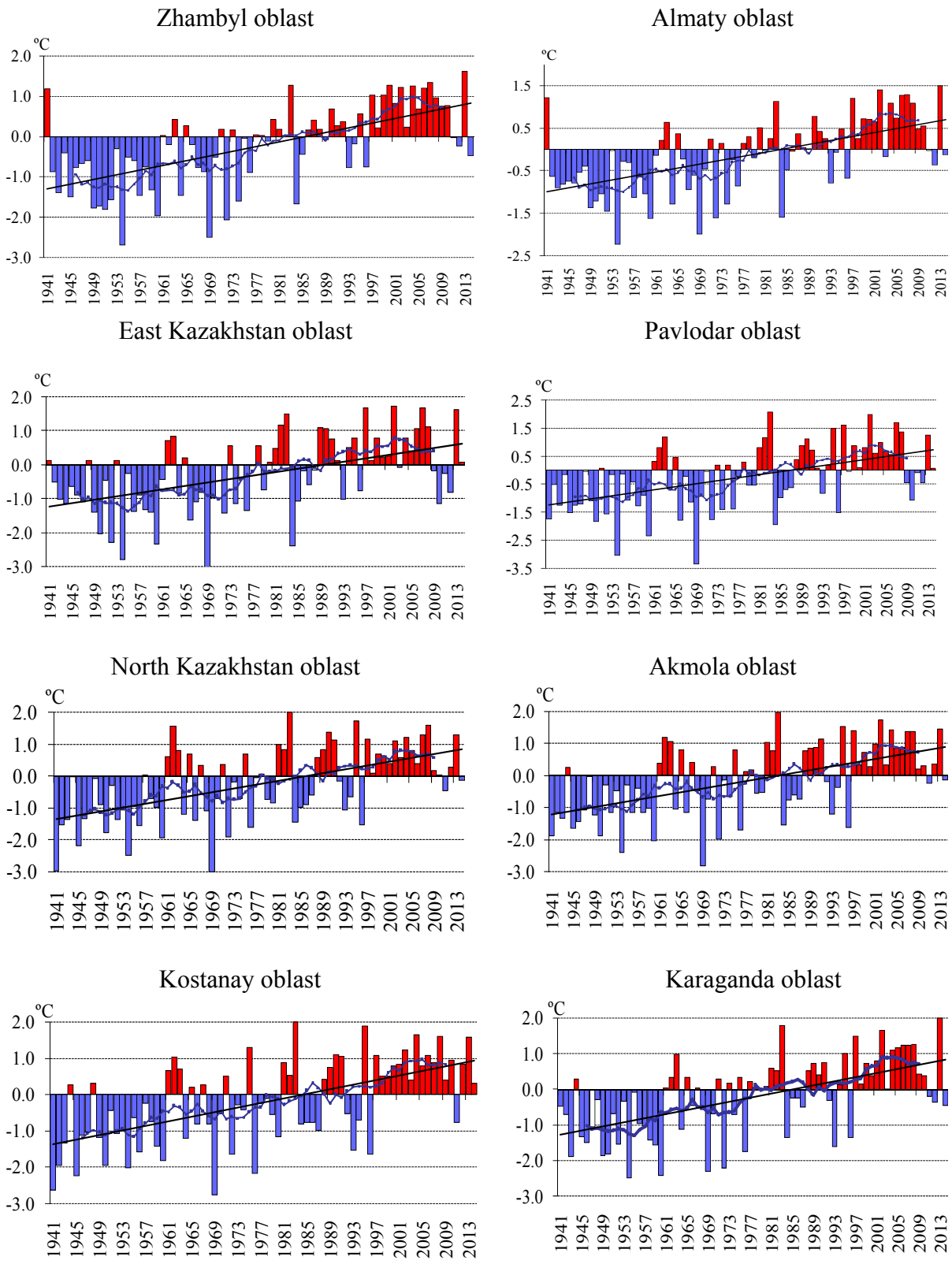


Figure 2.3 – Time series and linear trends of the annual average air temperatures anomalies (relative to 1971…2000) for 1941...2014 for Kazakhstan (°C). The smooth curve represents the 11-year moving average

List 2

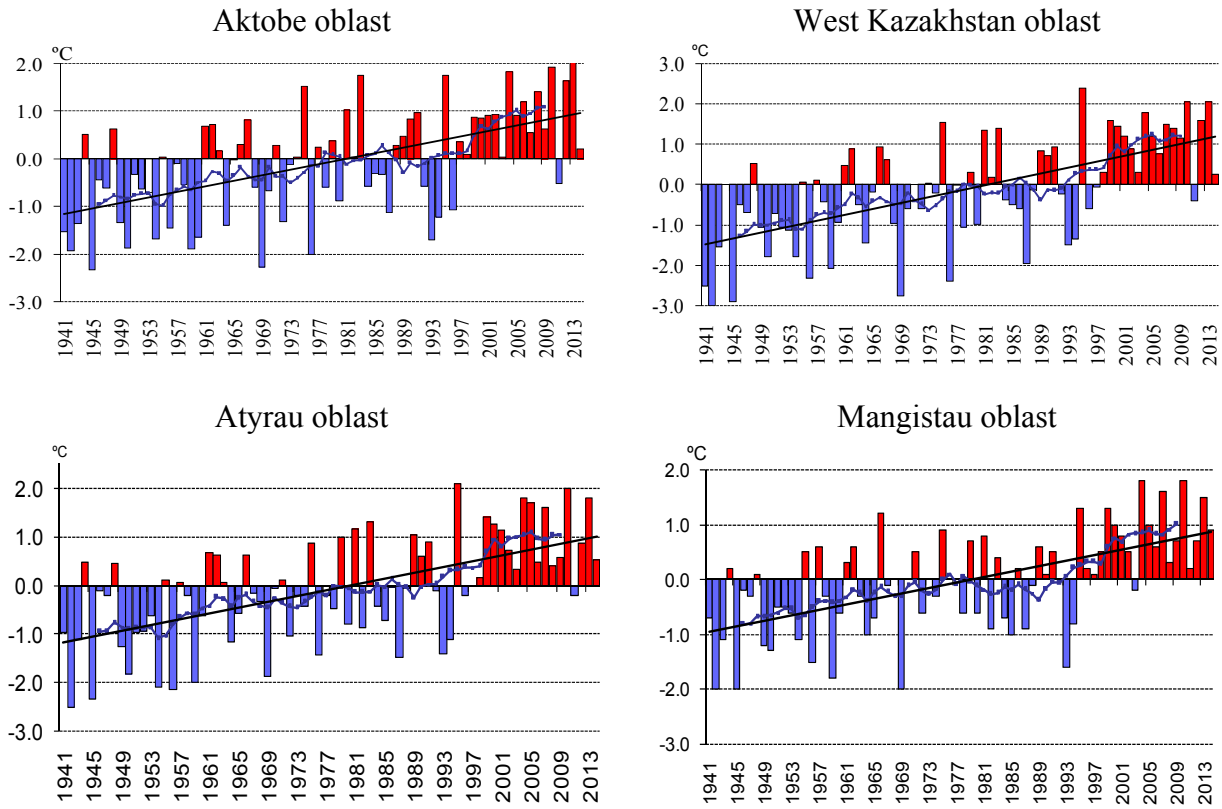


Figure 2.3 – Time series and linear trends of the annual average air temperatures anomalies (relative to 1971…2000) for 1941...2014 for Kazakhstan (^{0}C). The smooth curve represents the 11-year moving average. List 3

Figure 2.4 provides more detailed information about changes in seasonal and monthly air temperatures (ºC/10 years) for 1941...2014 in Kazakhstan. Positive and statistically significant trends of average monthly air temperatures are observed almost everywhere in Kazakhstan. Average annual and seasonal air temperature of Kazakhstan increased generally on 0,21...0,40º C/10 years. In the western part of the republic the increase in temperature reached 0,41...0,60º C/10 years (winter and spring).

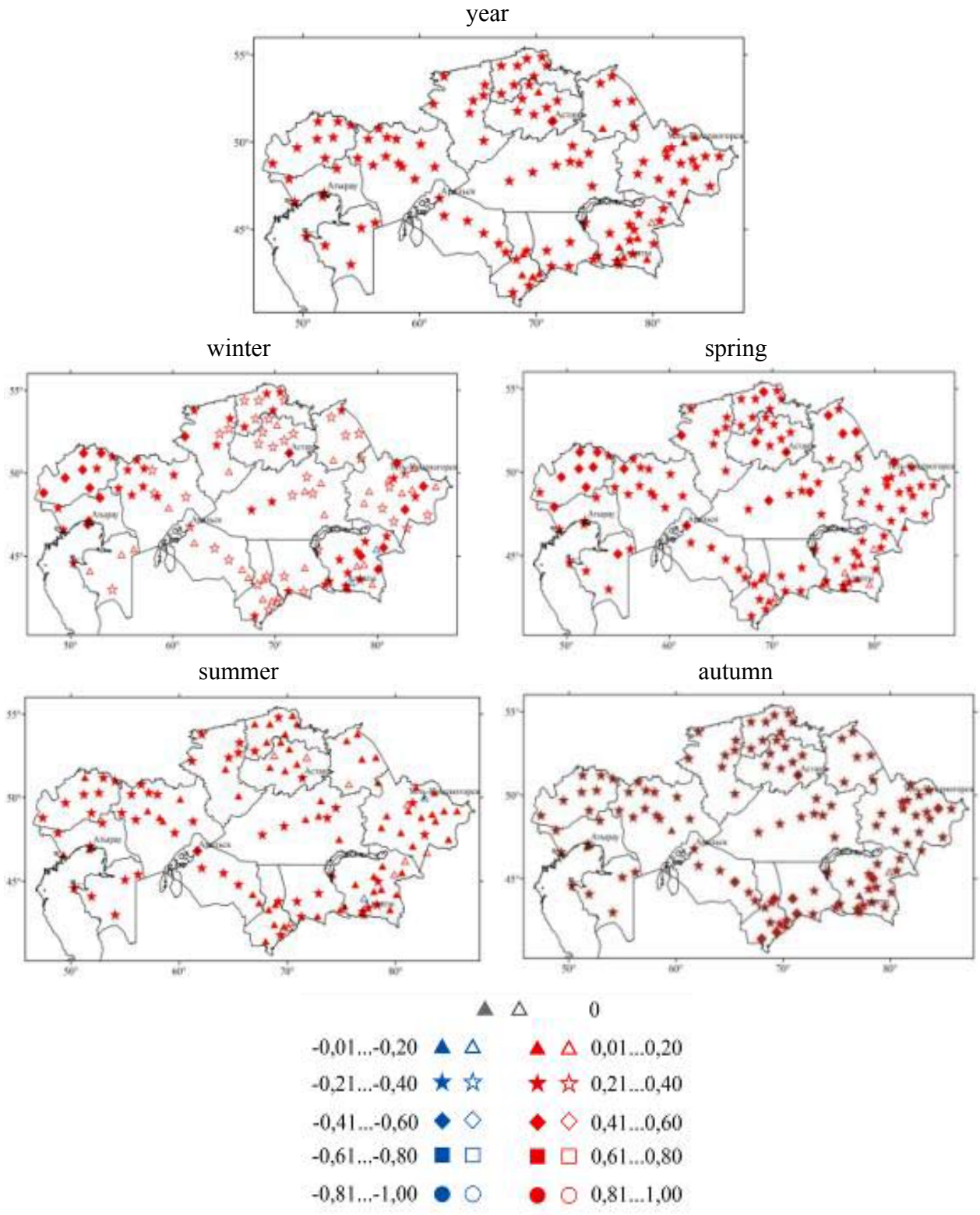


Figure 2.4 – The spatial distribution of the surface air temperature linear trend factors (ºC/10 years) in Kazakhstan for 1941...2014. Legend keys shaded for statistically significant trend. List 1

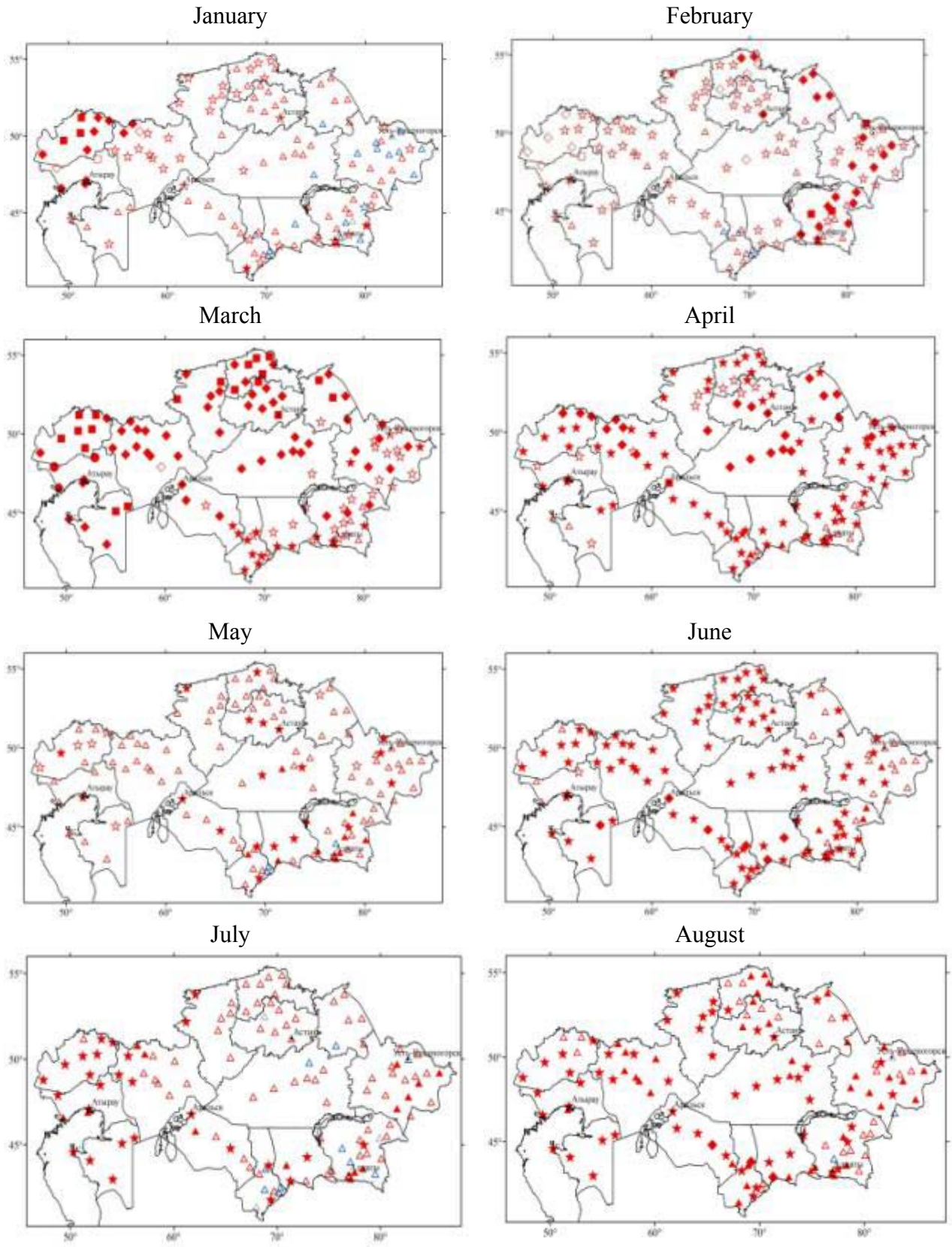


Figure 2.4 – The spatial distribution of the linear trend factors of monthly surface air temperature (ºC/10 years) in Kazakhstan for 1941...2014. Legend keys shaded for statistically significant trend. List 2

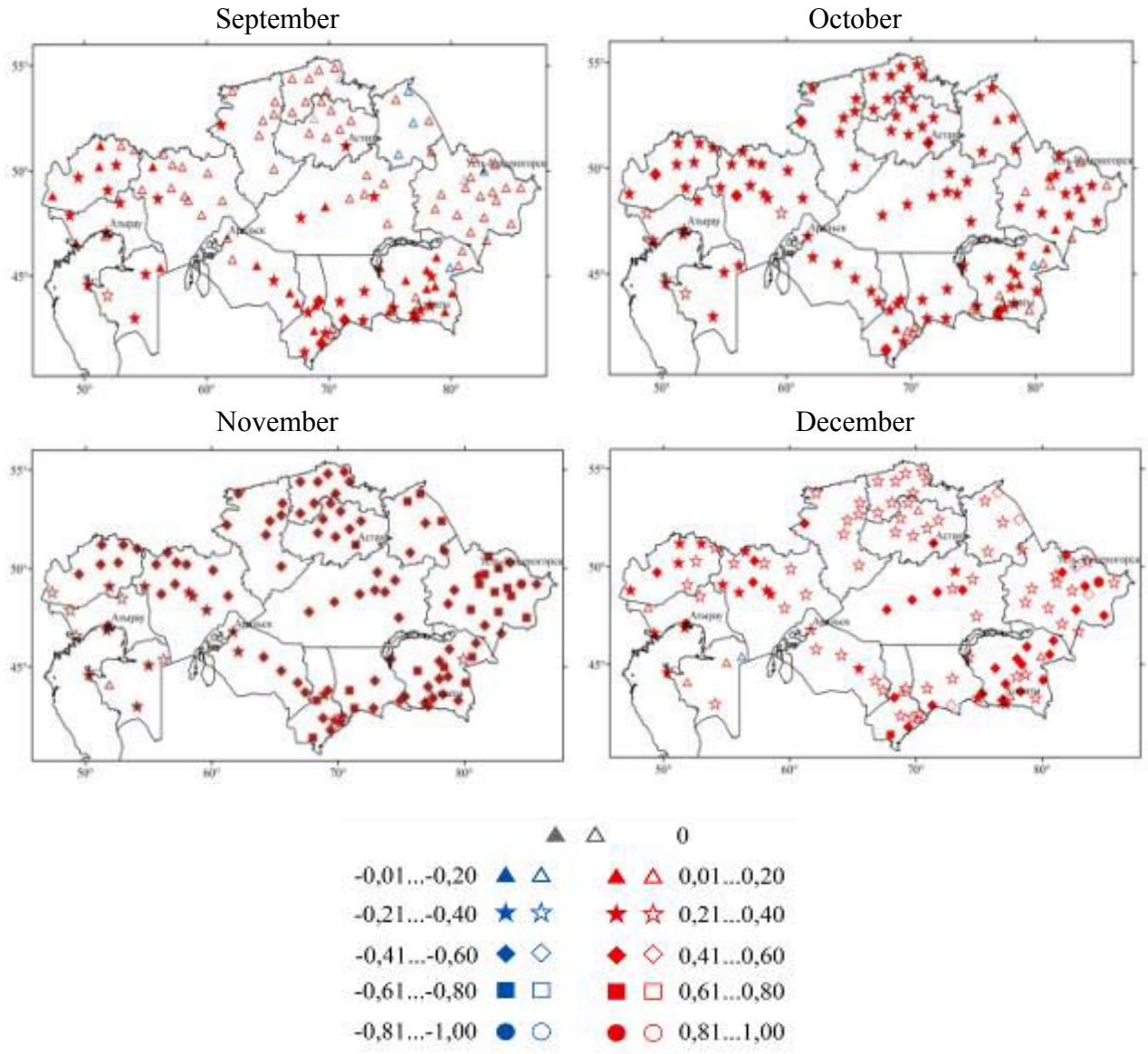


Figure 2.4 – The spatial distribution of the surface air temperature linear trend factors (ºC/10 years) in Kazakhstan for 1941...2014. Legend keys shaded for statistically significant trend. List 3

In March-April and November the air temperature increase was most significant from 0,41 to 0,80º C/10 years. In June, August and October the warming rate was slower 0,21...0,40 ºC/10 years. Basing on the spatial distribution of the linear trend factor it is evident that characteristics of circulation processes have changed.

2.2 Temperature anomalies in Kazakhstan in 2014

Figure 2.5 shows geographical distribution of heat and cold areas in Kazakhstan by seasons.

Annual average temperature anomalies (December 2013-November 2014) were within the norm practically in all territory of Kazakhstan except for south areas with negative anomalies and some areas of north, east and southwest were slightly higher the norm (Figure 2.5).

Winter

The winter of 2014 (December 2013 - February 2014) was within the norm.

The winter is characterized as cold in the southern areas of the republic with anomaly of seasonal temperature minus 2…4 ºC. Extremely low temperatures are noted at the following meteorological stations: in January at Zlikha and Zhetykonur stations were 4.2 and 4.8 lower than norm (respectively), in February at Uyuk, Zlikha, Tole bi stations were 8,6 ºC; 8,2 ºC; 8,1 ºC lower than norm (respectively). In some eastern regions the winter was warm, for example, temperature in January at Ust-Kamenogorsk was 4,0 ºC above the norm (Figure 2.5).

Spring

Spring 2014 was warm everywhere in Kazakhstan. The highest anomalies (higher than 2,5 ºC) were recorded in the western and partly northern and northeast regions of Kazakhstan. In these regions the 2014 spring added to the 10 % of the extremely warm seasons.

The hottest month was March and its anomaly was 1,0…6,2 ºC above the norm. The centre of heat was in region of Pavlodar and East Kazakhstan oblasts. In May anomaly was 1,0…5,8 ºCabove the norm, the centre of heat was in West Kazakhstan, Mangictau and Atyrau oblasts (Figure 2).

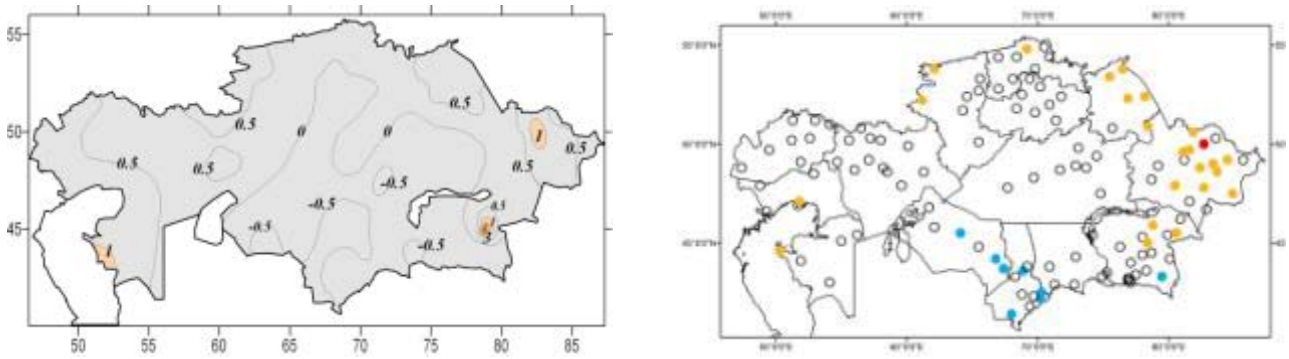
Summer

Summer was warm in the most part of territory of Kazakhstan (Figure 2.5). In the territory of Mangistau, Atyrau and Aktobe oblasts, and also in certain regions of Kyzylorda, South Kazakhstan, Zhambyl and Almaty oblasts the summer was extremely warm. In July occurred negative anomalies 1,0…4,7 ºC with the cold center in North Kazakhstan, Kostanay and Akmola oblasts. In August air temperature anomalies were positive and increased from 1,0 to 5,2 ºC with heat centers in the West Kazakhstan, Atyrau, Aktobe, Mangistau and Kostanay areas.

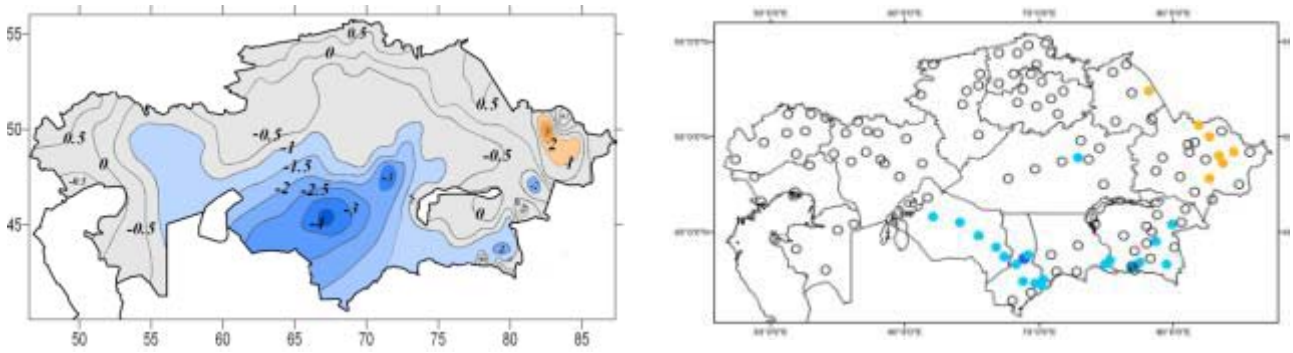
Autumn

Autumn was cold everywhere in Kazakhstan and extremely cold in the western of Kazakhstan (probabilities of non-exceedance from 0...9 % to 10...29 %). In East Kazakhstan, Almaty and South Kazakhstan oblasts air temperature anomalies were within the norm (Figure 2.5).

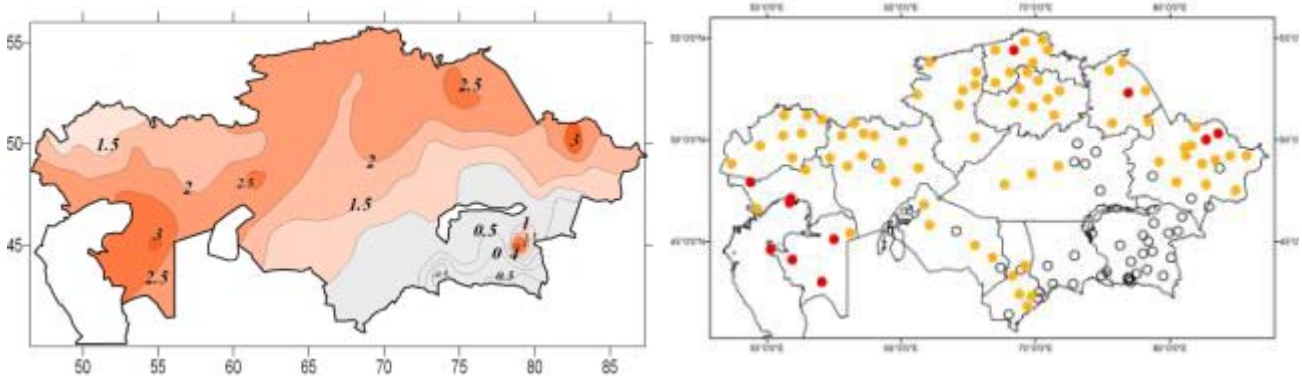
year



winter



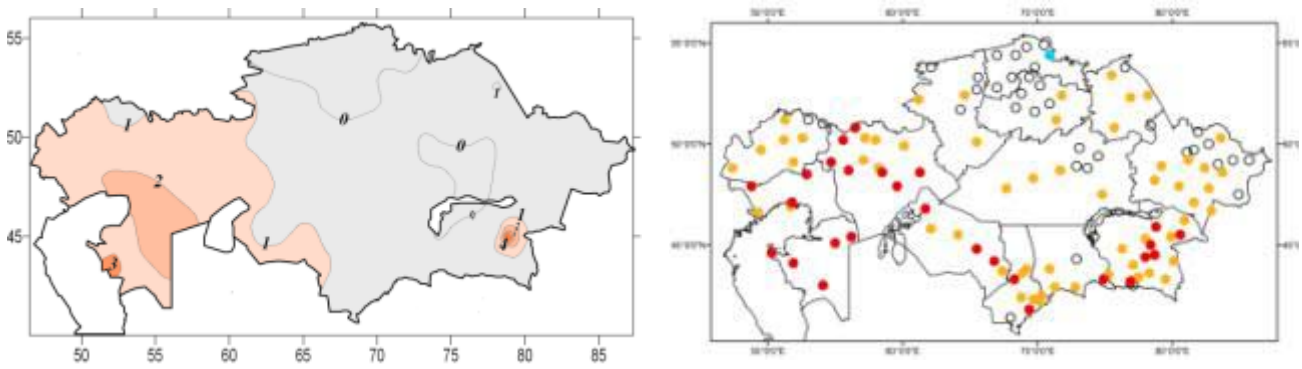
spring



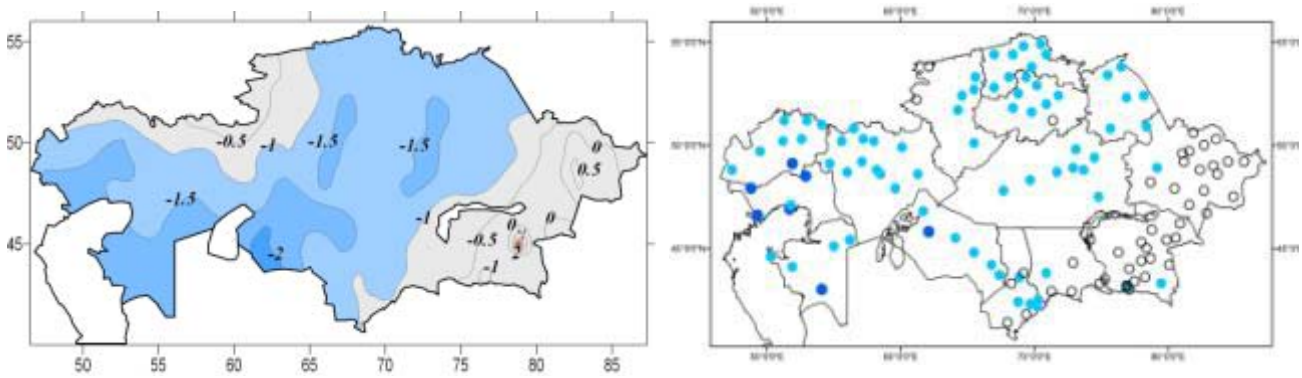
(0…9 %) – extremely cold;
(10…29 %) – cold;
(30…69 %) – about normal;
(70…89 %) – warm;
(90…100 %) – extremely warm

Figure 2.5 – Spatial distribution of air temperature anomalies in 2014 relative to the 1971…2000 baseline (°C) and nonexceedance probabilities for 2014 air temperatures calculated over 1941…2014. List 1

summer



autumn



(0…9 %) – extremely cold;
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(70…89 %) – warm;
(90…100 %) – extremely warm

Figure 2.5 – Spatial distribution of air temperature anomalies in 2014 relative to the 1971…2000 baseline (°C) and nonexceedance probabilities for 2014 air temperatures calculated over 1941…2014. List 2

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 2014 is considered below.

Daily maximum of air temperatures in 2014. Figure 2.6 presents in red the absolute maximum of air temperature recorded since the opening of weather station until 2013. The maximum of daily air temperature observed in 2014 is in blue. Absolute maximum temperature since the beginning of records has not been exceeded in 2014 at any considered weather stations. The absolute maximum in the north republic reached 33…39 °C, in the south republic was 34…43°C.

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

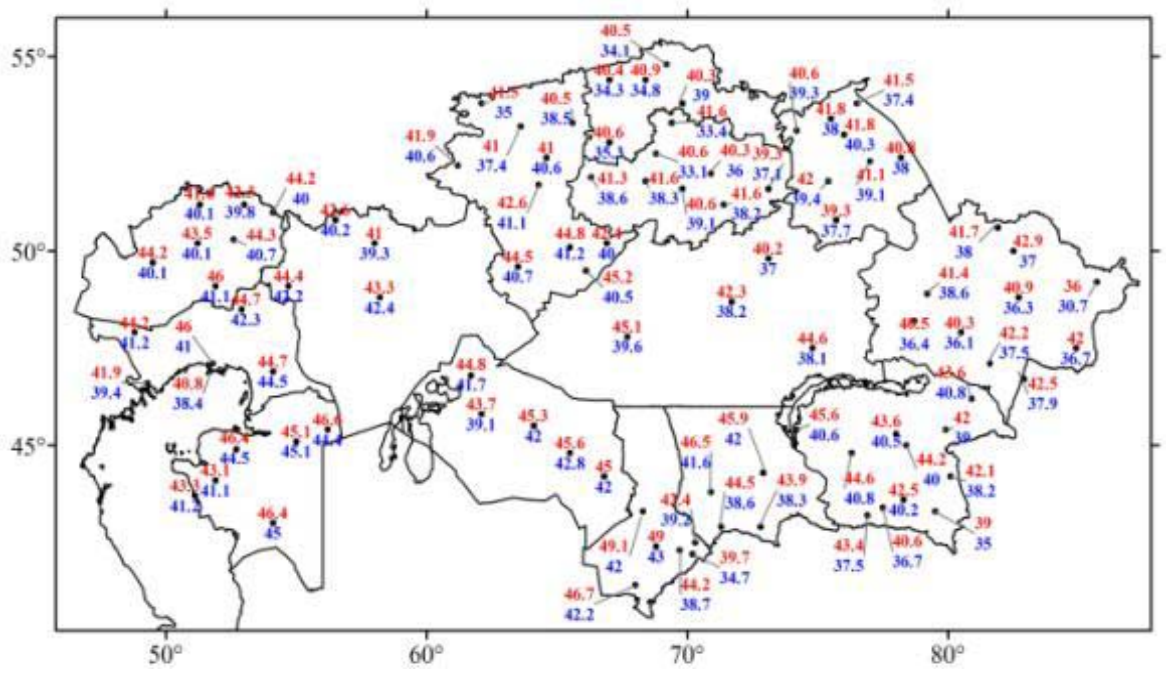


Figure 2.6 – Absolute maximum temperature (°C) since the beginning of records until 2013(red) and the 2014 daily maximum temperature (°C) (blue)

Daily minimum of air temperature in 2014. Absolute minimum temperature since the beginning of records has not been exceeded in 2014 at any considered weather stations (Figure 2.7). The lowest air temperatures (minus 39…35 °C) were observed generally in the northern, the eastern and the central Kazakhstan, and also on some stations of the western part of the republic. In all territory the absolute minimum were higher, than the absolute minimum of temperature ever reached. The lowest values of air temperature (absolute minimum) in Kazakhstan were recorded in January 1893 (minus 52 °C, Astana) and in January 1931 (minus 54 °C, Orlovsky Poselok).

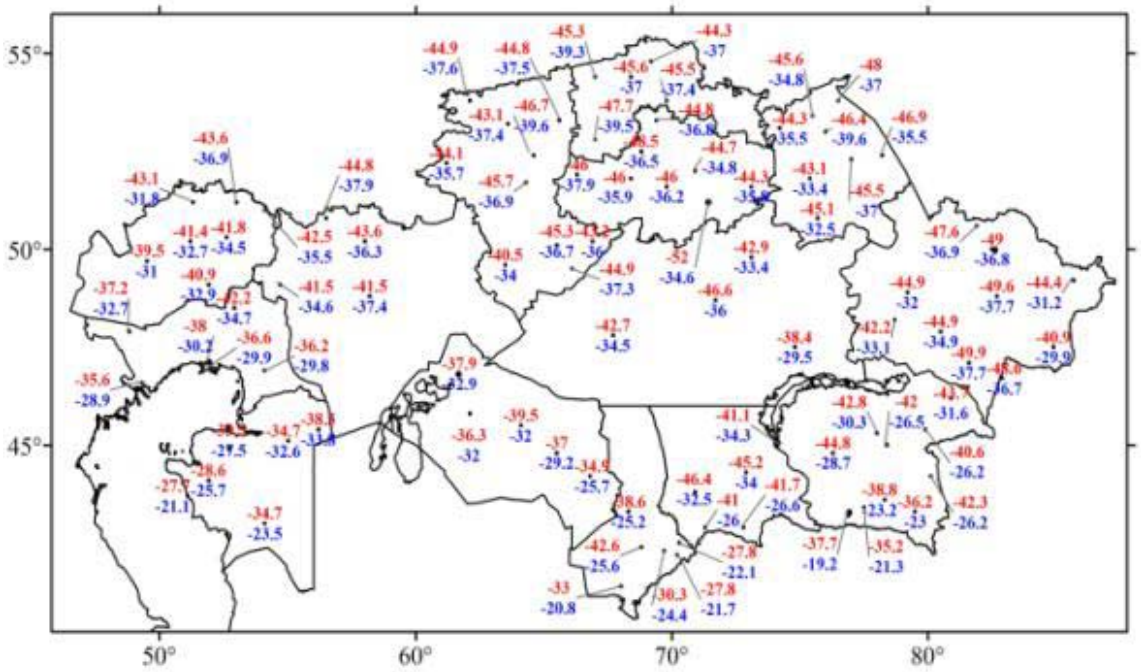


Figure 2.7 – Absolute minimum temperature (°C) since the beginning of records until 2013 (red) and the 2014 daily maximum temperature (°C) (blue)

Number of days with temperatures above 35 ℃ in 2014. Figure 2.8a presents spatial distribution of the number of days with temperatures above 35 °C in 2014.

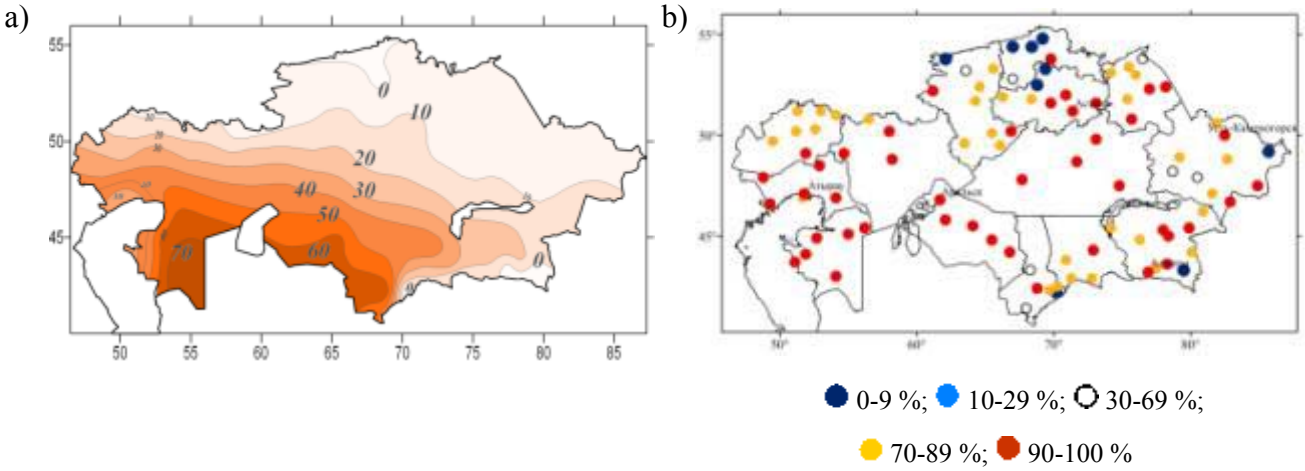


Figure 2.8 – Number of days (a) and the probability of nonexceedance of the number of days with temperatures above 35 ºC in 2014 (b) for 1941...2014

The number of days with high temperatures increased equal to 20 to 70 days from the north to the south of Kazakhstan. In some areas the number days with high temperatures was high or extremely high, their probability of non-exceedance made 30…69% and 0…9% respectively. Temperature above 35 °C was observed more than 40…70 days in Mangistau, Atyrau, Aktyubinsk, West Kazakhstan, Kyzylorda, South Kazakhstan and Zhambyl oblasts.

On some mountain meteorological stations of the south and south-eastern, and also in Akmola and Kostanay oblasts the number of such days made about 10 with their probability of non-exceedance from 70…89 % to 90…100 %.

Percentage of days with the daily maximum temperatures above the 90th percentile amounted to 8…20 % in Kazakhstan (Figure 2.9a). Distribution of repeatability of high daily air temperatures on the territory of the country was contrast, for example, in north-western, northern and south-eastern areas from 8 % to 12 % (Figure 2.9a). Most frequently maximum temperatures exceeded 90th percentile (16…20 %) were in the western, south-western and Kyzylorda oblast and made about 1/5 year.

Percentage of days with the daily minimum temperatures below the 10th percentile characterizes the frequency of extremely low temperatures. In 2014 the maximum number of such days (more than 18 %) was observed in Kyzylorda oblast, and also with the centers in the eastern of the country (more than 22 %) and in Almaty oblast (more than 19%, Figure 2.9b).

a) b)

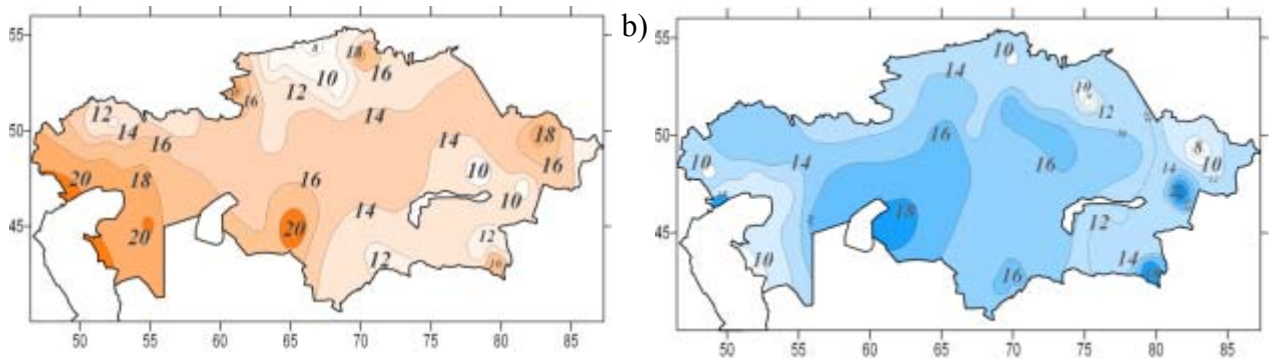


Figure 2.9 – Percentage of days with the daily maximum temperatures above the 90th percentile (a) and with the daily minimum temperatures below the 10th percentile (b) in 2014

Figure 2.10a shows the total duration of heat waves in Kazakhstan in 2014 (***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 of Kazakhstan with maximum in Aktobe, Atyrau, Mangistau oblasts (18…30 days) and also in eastern and northern of Kazakhstan (18…24 days).

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 2014 cold waves from 6 till 18 days were observed in the western part of Kazakhstan, and in certain regions of central, southern and eastern of republic (Figure 2.10b). In all other territory of the country the cold waves with duration more than 6 days wasn't observed.

а) б)

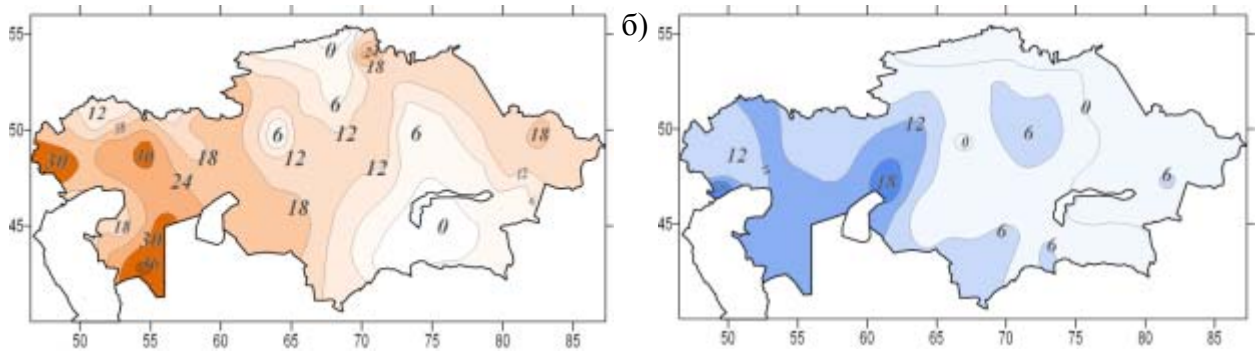


Figure 2.10 – Total sum of days with at least of 6 consecutive days the daily maximum temperature above the 90th percentile (a); and at least of 6 consecutive days the daily minimum temperature below the 10th percentile (b) in 2014

Figure 2.11 presents duration of vegetation period in 2014 (the period between the first 5-day average daily temperature ≥5 °C, and the last 5- day average daily temperature ≤5 °C). The vegetation period was about 160…180 days in the north and more than 260 days in the south of Kazakhstan.

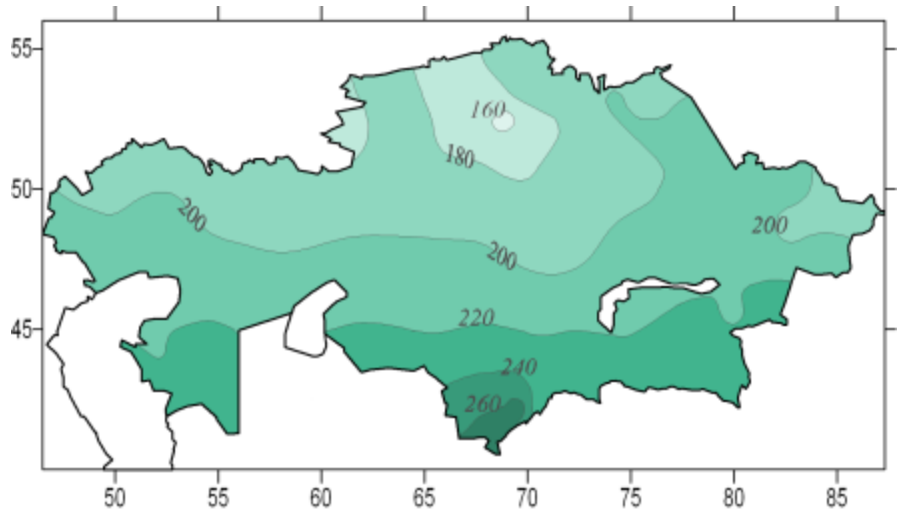


Figure 2.11 - The duration of vegetation period (days) in 2014

2.3 Trends in surface air temperature extremes

Trend analysis of the surface air temperature extremes was performed for 1941...2014. The ***daily maximum surface air temperatures*** tend 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 every 10 years, were observed.

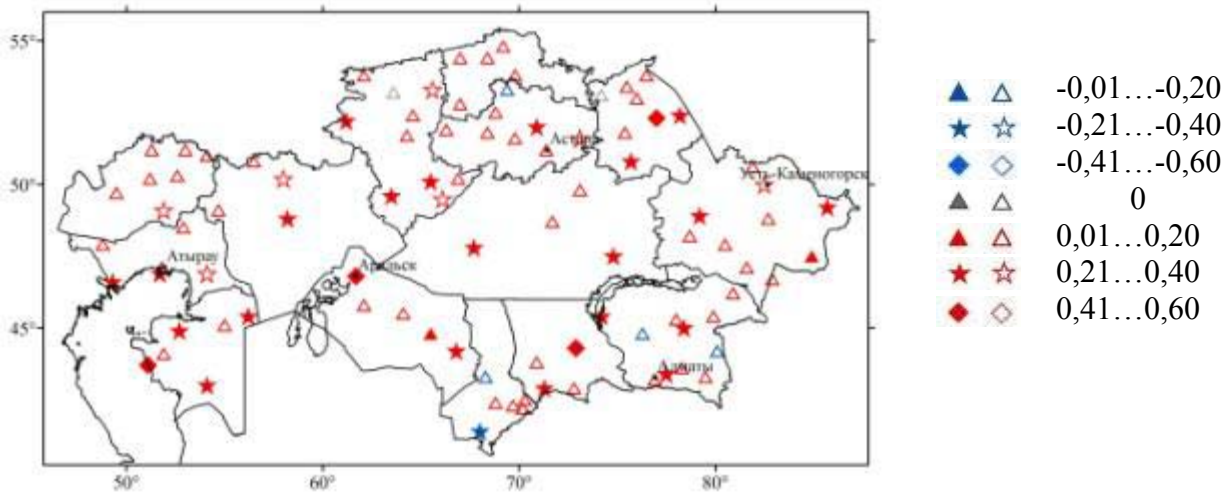


Figure 2.12 – Spatial distribution of the linear trend factors of daily maximum air temperatures (ºC/10 years) for 1941...2014. Shaded keys are for statistically significant trend

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 2.13). In the northern, eastern and south-eastern regions the frequency of hot days has not changed during 1941...2014.

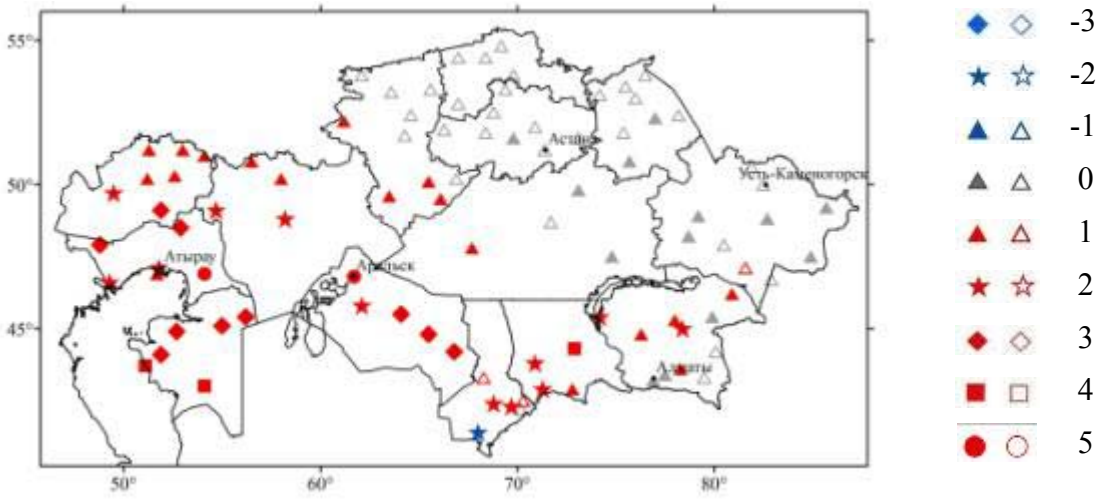


Figure 2.13 – Spatial distribution of the linear trend factors for the number of days with temperatures above 35 ºC (days/10 years) for 1941...2014. Shaded keys are for statistically significant trend

The total duration of heat waves increased throughout the country by 1 to 3 days/10 years (Figure 2.14). 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.

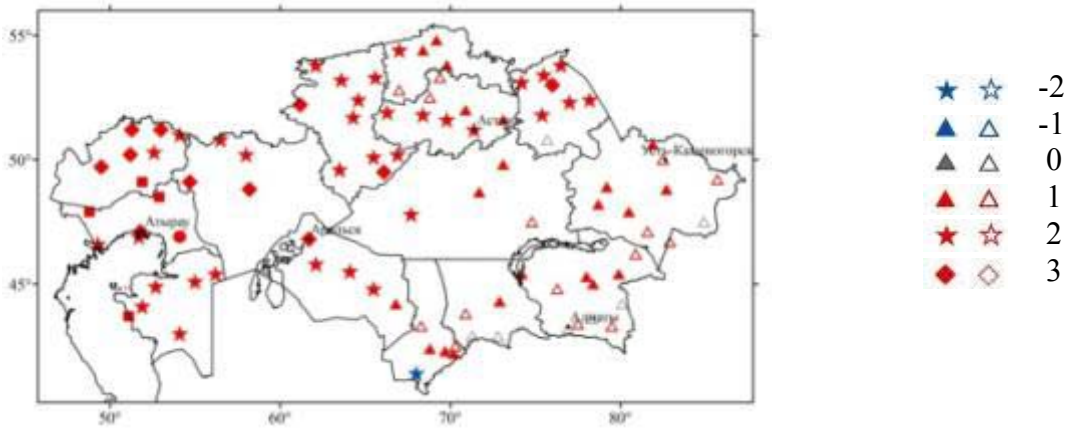


Figure 2.14 – Spatial distribution of the linear trend factors of the total duration of heat waves (day/10 years) during 1941...2014. Shaded keys stand for statistically significant trend

It should be noted that all temperature extremes listed above (Figures 2.12-2.14) 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.

Almost everywhere in Kazakhstan the frequency of frost days when **the daily minimum temperature is below 0 °C** tends to decrease (Figure 2.15). 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.

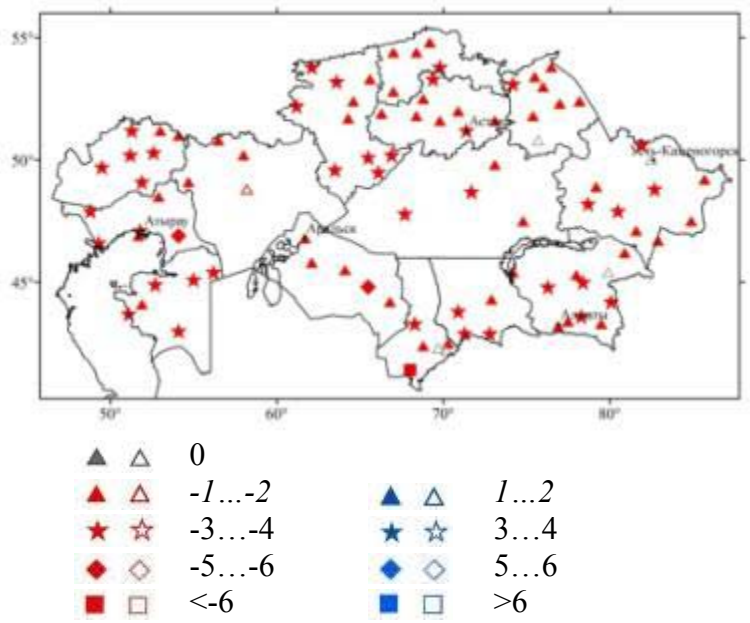


Figure 2.15 – Spatial distribution of the linear trend factors of the number of days with daily minimum temperature below 0 °C (day/10 years) for 1941...2014. Shaded keys stand for statistically significant trend

A significant decreasing trend in **the daily temperature amplitude** was observed in Kazakhstan amounting to 0,1...0,2 ºC (Figure 2.16). This trend means mitigation of the climate continentality. The significant increase trend the daily temperature amplitude was observed in Pavlodar, West Kazakhstan, Almaty, Sauth Kazakhstan, Kyzylorda and Mangistau regions amounting to 0,1...0,2 ºC (Figure 2.16).

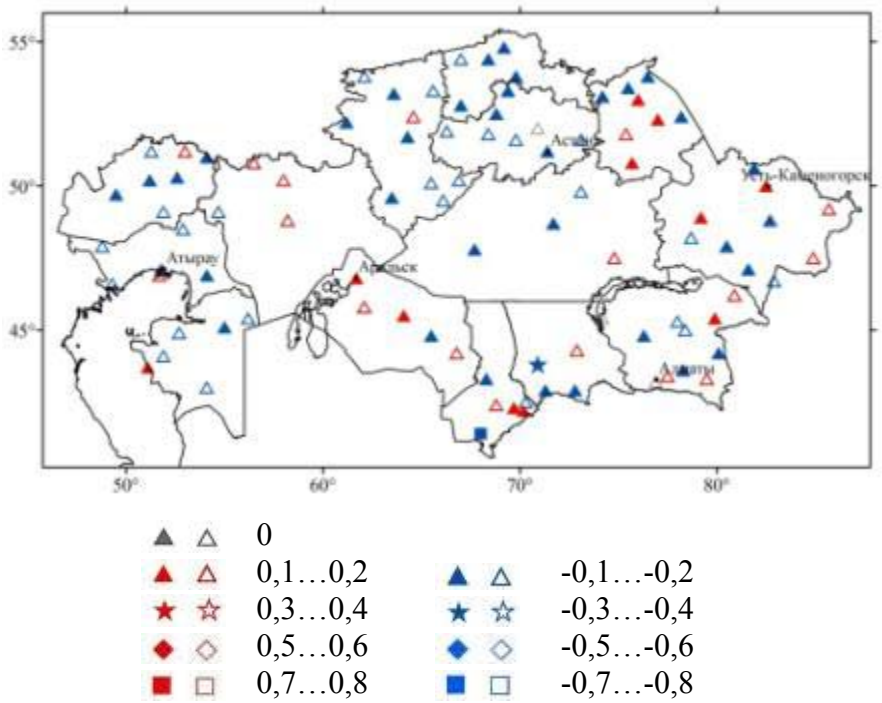


Figure 2.16 – Spatial distribution of the linear trend factors of the daily air temperature amplitude (°C/10 years) for 1941...2014. Shaded keys stand for statistically significant trend

3 PRECIPITATION

3.1 Observed changes in precipitation in Kazakhstan for 1941-2014

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.

Figure 3.1 shows the time series of annual precipitation anomalies for 1941...2014, calculated relative to the 1971...2000 baseline and spatially averaged for Kazakhstan and oblasts. On average annual precipitation has been decreasing slightly by 0,8 mm every 10 years, or about by 0,4 % of normal per 10 years (Table 3.1).

A slight decrease in annual precipitation (by 1,1...4,1 mm/10 years) was observed in West-Kazakhstan, Atyray, Kostanay, Kyzylorda, South-Kazakhstan, Zhambyl, East-Kazakhstan oblasts. In other oblasts precipitation has been increasing by 0,1…3,7 mm per 10 years. All annual trends are statistically insignificant.

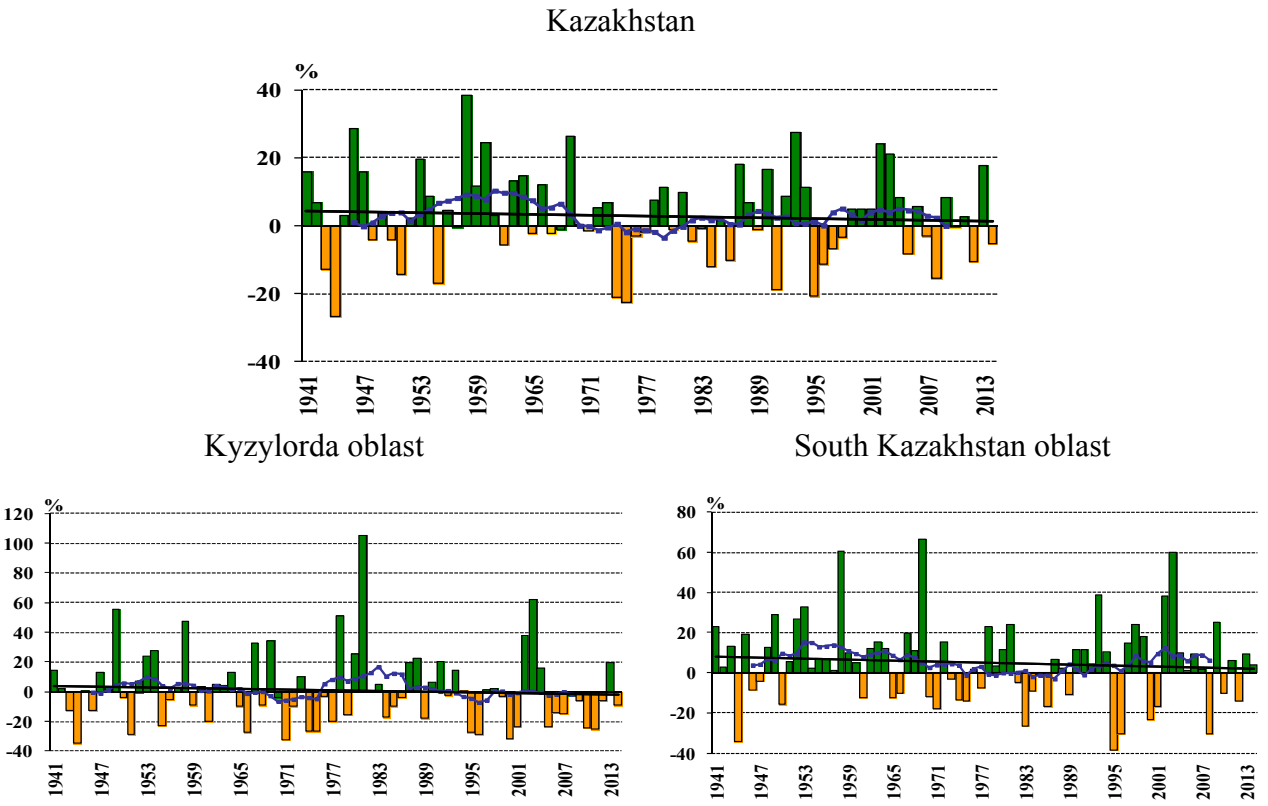


Figure 3.1 – Time series and linear trends of annual and seasonal precipitation anomalies (%) for 1941...2014 calculated relative to the 1971...2000 baseline. *The smooth curve shows the 11-year moving average.* List 1

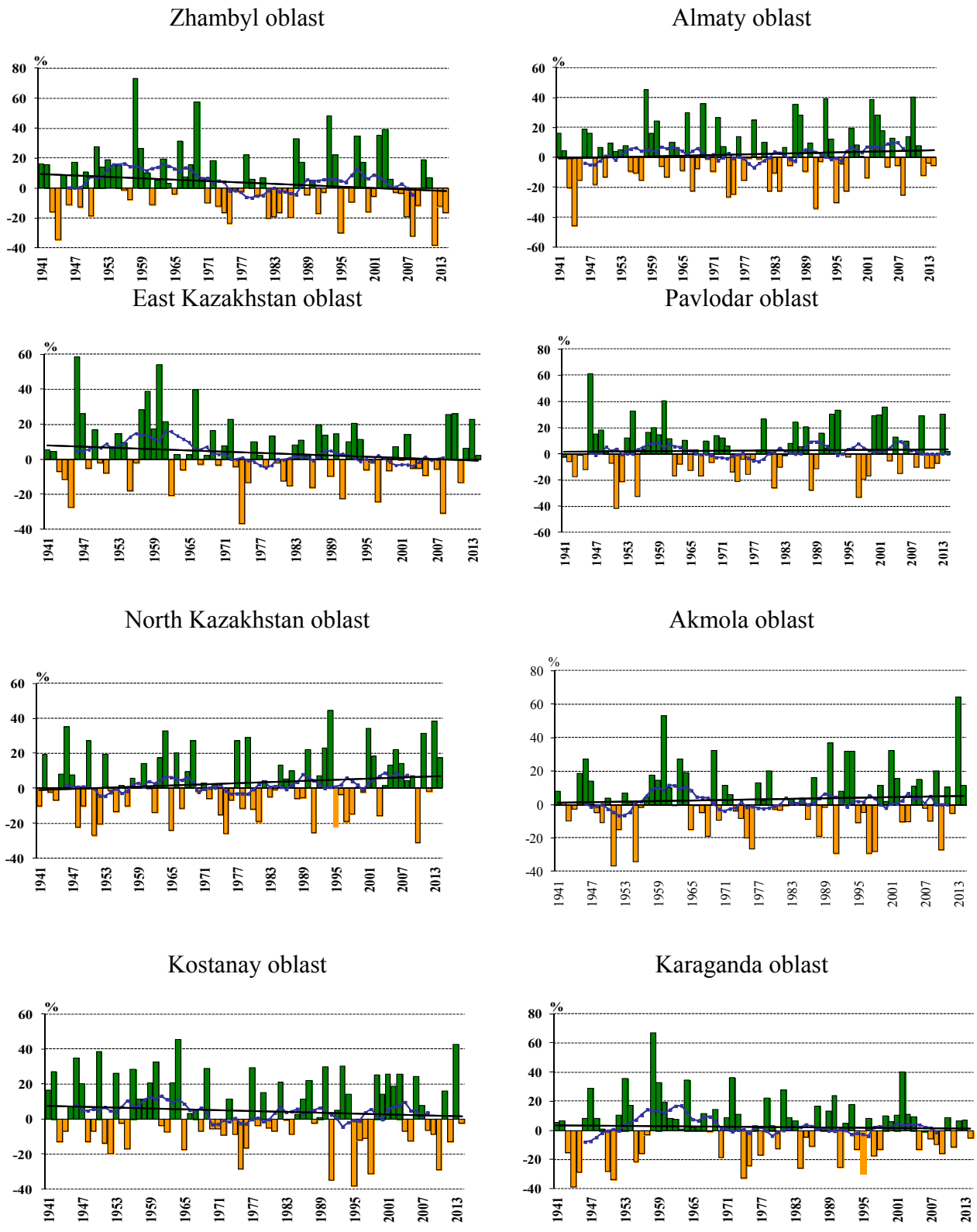


Figure 3.1 – Time series and linear trends of annual and seasonal precipitation anomalies (%) for 1941...2014 calculated relative to the 1971...2000 baseline. *The smooth curve shows the 11-year moving average.* List 2

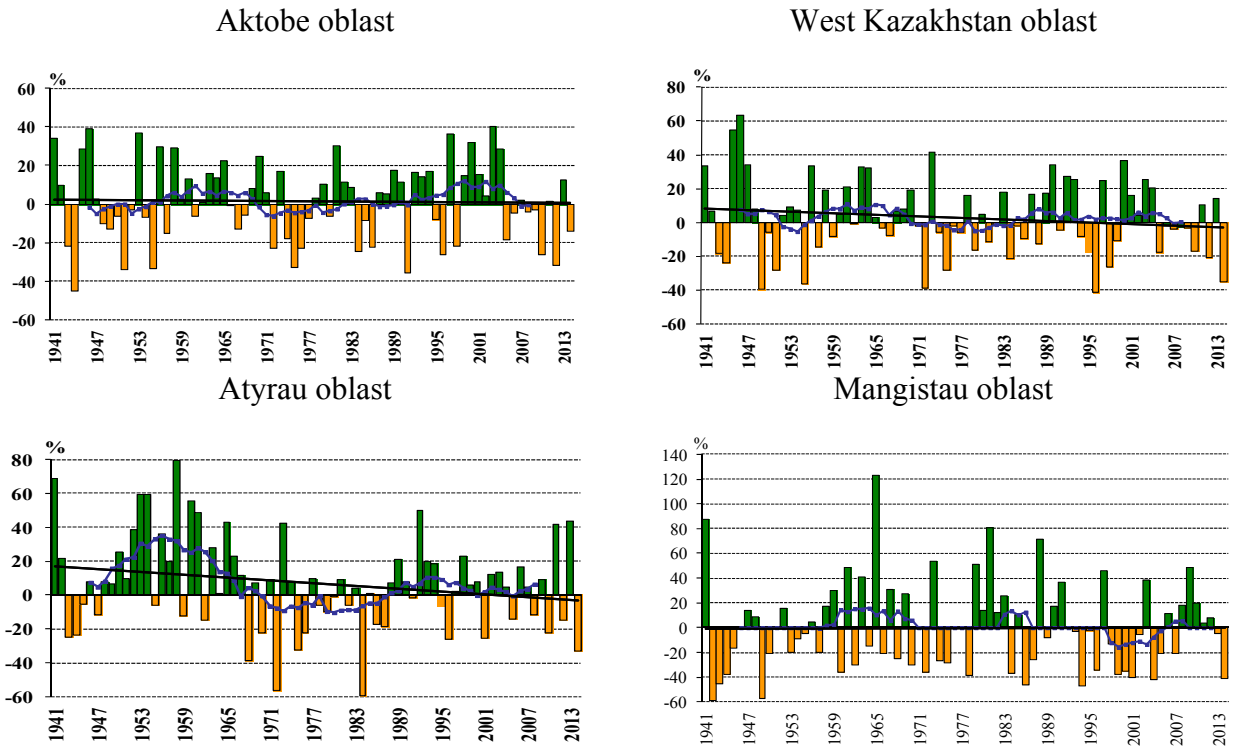


Figure 3.1 – Time series and linear trends of annual and seasonal precipitation anomalies (%) for 1941...2014 calculated relative to the 1971...2000 baseline. *The smooth curve shows the 11-year moving average.* List 3

Table 3.1 – Linear trend parameters of the seasonal and annual precipitation anomalies (mm/10 years, %/ 10 years) for Kazakhstan and oblasts for 1941...2014 relative to the 1971...2000 baseline.

Region/oblast	Unit	Year		Winter		Spring		Summer		Autumn	
		*a	**R^2	a	R^2	a		*a	**R^2	a	R^2
Kazakhstan	mm	-0,8	0	1,5	7	-0,7	1	-0,8	1	-0,7	1
	%	-0,4		2,1		-0,4		-1,1		-1,0	
Kyzylorda	mm	-1,1	1	-0,6	1	-0,3	0	0,1	0	-0,1	0
	%	-1,0		-1,4		-0,7		0,6		-0,2	
South Kazakhstan	mm	-2,8	1	1,1	0	-4,3	2	0,3	0	0,3	0
	%	-0,8		0,3		-2,8		-0,6		1,2	
Zhambyl	mm	-2,8	3	1	1	-3,6	5	-0,2	0	0	0
	%	-1,4		0,6		-3,7		-1		-0,5	
Almaty	mm	3,1	1	3,5	10	-2,6	2	1,3	1	0,8	0
	%	0,8		4,5		-1,9		1,1		1,1	
East Kazakhstan	mm	-4,1	2	0,7	1	-1,4	2	-2,6	2	-0,9	1
	%	-1,2		1,2		-2,1		-2,2		-1,0	
Pavlodar	mm	0,6	0	1,4	7	1,1	2	0,1	0	-2,1	4

Region/oblast	Unit	Year		Winter		Spring		Summer		Autumn	
		*a	**R^2	a	R^2	a		*a	**R^2	a	R^2
	%	0,3		2,7		2,0		0,1		-3,0	
North Kazakhstan	mm	3,7	2	3,4	17	1,9	4	-2,2	1	0,7	0
	%	1,1		6,2		3,0		-1,4		0,8	
Akmola	mm	1,9	0	2,3	8	1,0	1	0,2	0	-1,7	2
	%	0,5		4,2		1,2		0,2		-2,4	
Kostanay	mm	-2,0	1	0,6	1	1,0	1	-1,3	1	-2,5	5
	%	-1,0		1,2		1,4		-1,7		-3,4	
Karaganda	mm	0,2	0	1,9	7	-0,1	0	-1,0	1	-0,3	1
	%	-0,4		1,9		-0,5		-1,8		-1,3	
Aktobe	mm	0,1	0	2,0	5	1,9	3	-1,6	2	-2,1	4
	%	-0,1		2,4		2,7		-2,4		-3,4	
West Kazakhstan	mm	-4,0	2	1,2	2	-0,6	0	-2,5	3	-2,1	3
	%	-1,6		1,9		-1,0		-3,4		-3,2	
Atyrau	mm	-3,9	4	-2,2	10	-0,3	0	-1,4	1	-0,4	0
	%	-2,4		-7,5		-1,1		-3,0		-1,1	
Mangistau	mm	0,1	0	0,5	1	1,6	1	-1,7	2	-0,1	0
	%	0,1		2,0		3,3		-6,1		-0,3	

* a – linear trend factor, %/10years, mm/10 years;
** R^2 – determination factor,%

Figure 3.2 shows the inter-annual course of seasonal precipitation anomalies (%) averaged for Kazakhstan. 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 (statistically significant trend) (Table 3.1).

Figures 3.3 and 3.4 provide more detailed information about changes in seasonal and monthly air temperatures (ºC/10 years) for 1941...2014 in Kazakhstan. Changes in the seasonal precipitation are diverse.

In summer and in autumn in most parts of Kazakhstan except mountain south-eastern regions 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 north-western and the north-eastern, other regions precipitation decreased. It should be noted that almost all seasonal trends are statistically insignificant, except winter precipitation.

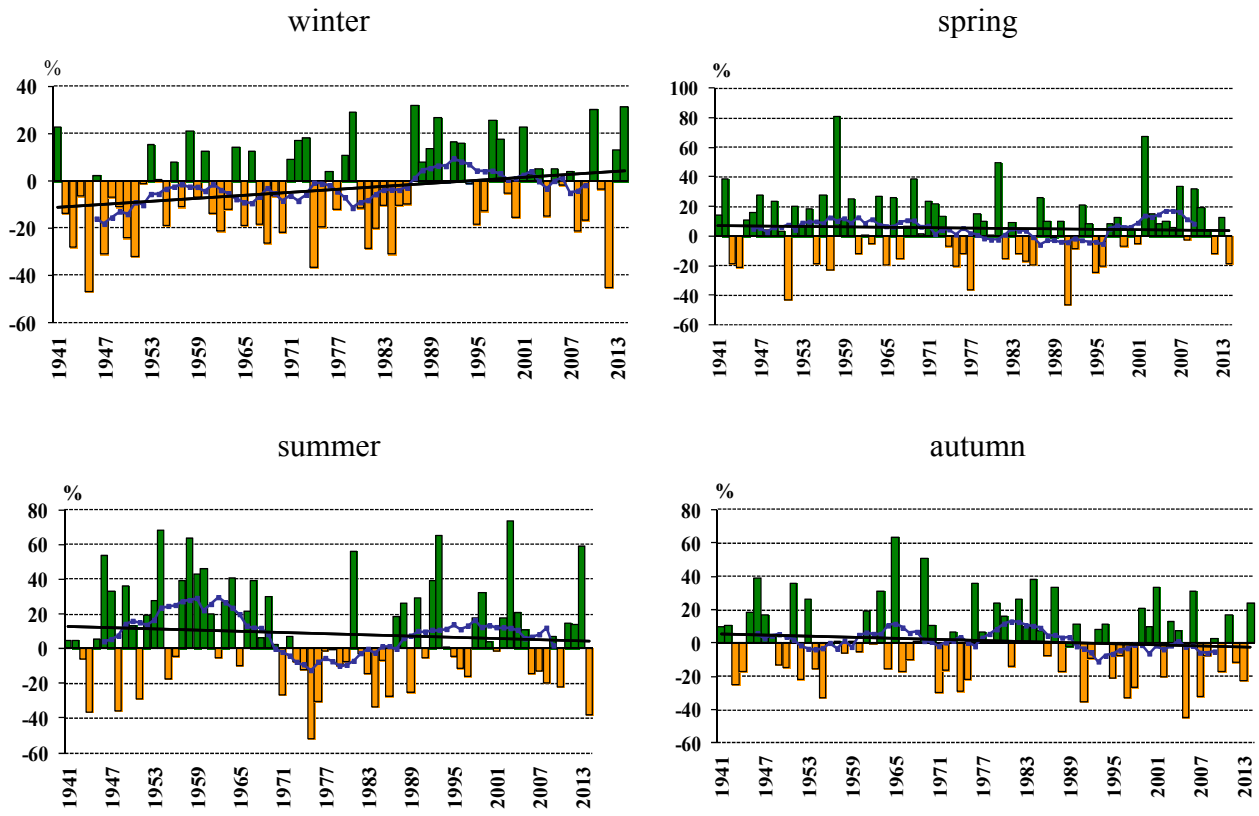


Figure 3.2 – Time series and linear trends of seasonal precipitation anomalies (%) for 1941...2014 relative to the 1971...2000 baseline. *The smooth curve represents the 11-year moving average*

In January-February statistically significant increase of precipitation by 0,1…13,0 %/10years were observed in certain regions of Almaty, Pavlodar, North Kazakhstan, Akmola oblasts and in the northwestern regions of Kazakhstan. In spring precipitation decreased in most part of Kazakhstan by 0,1…14,0% of/10 years and in some areas of Aktobe, North Kazakhstan and Kostanay oblasts precipitation reduction was statistically significant. In summer change in precipitation both negative and positive was negligible all over Kazakhstan, except July where in Almaty, Zhambyl, South Kazakhstan oblasts 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. In September precipitation reduction was statistically significant practically of all areas of Kazakhstan, except for south-eastern part where precipitation slightly increased. In November and December, change in precipitation was mostly positive. In North-Kazakhstan and Karaganda oblasts precipitation increase was statistically significant and amounted to 6...11 %/10 years.

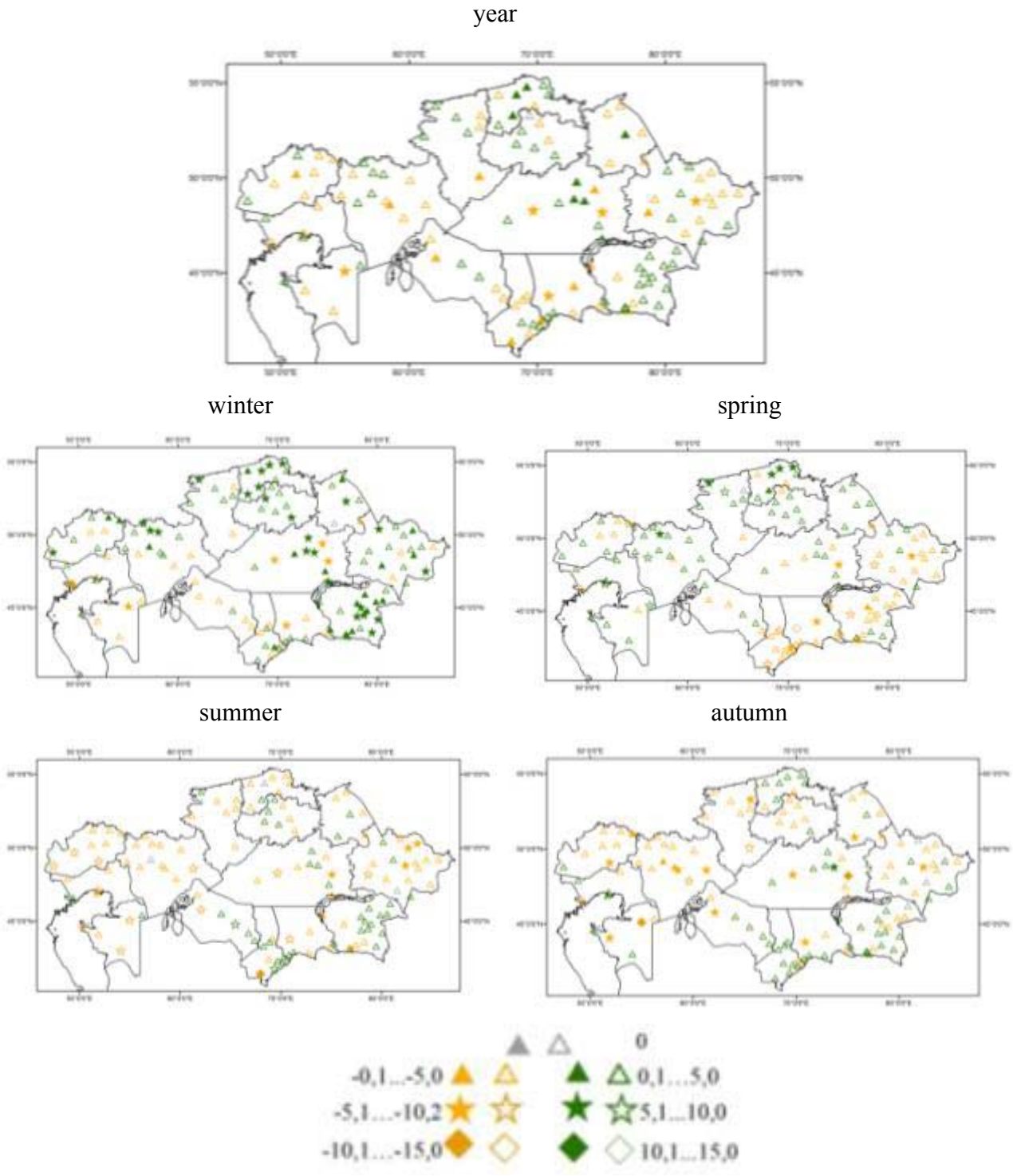


Figure 3.3 – Spatial distribution of the linear trend factor of seasonal and annual precipitation anomalies (%/10 years), over 1941...2014, relative to the 1971…2000 baseline. Shaded keys stand for statistically significant trend

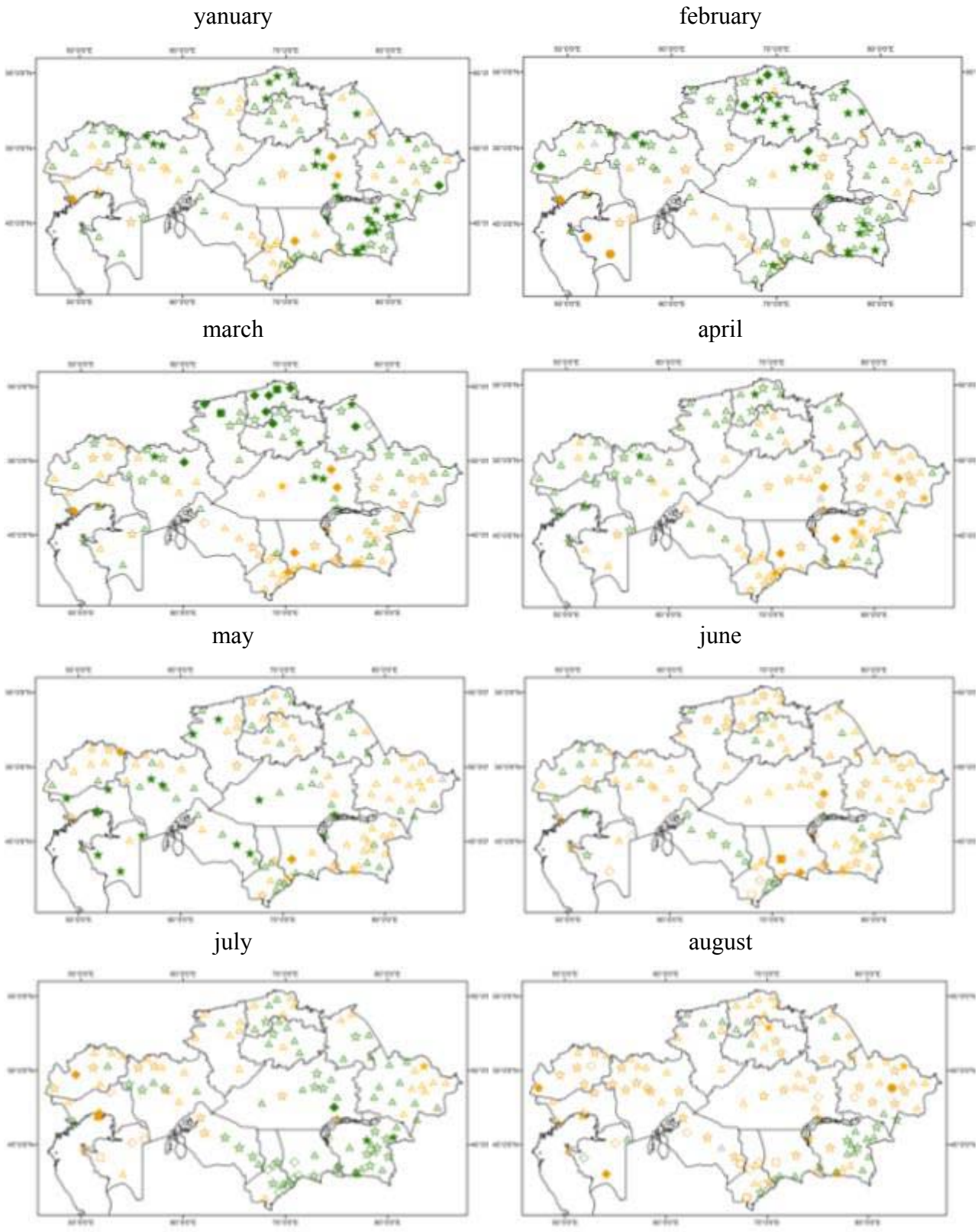


Figure 3.4 – Spatial distribution of the linear trend factor of monthly precipitation (% of normal/10 years), over 1941...2014, relative to the 1971…2000 baseline. Shaded keys stand for statistically significant trend. List 1

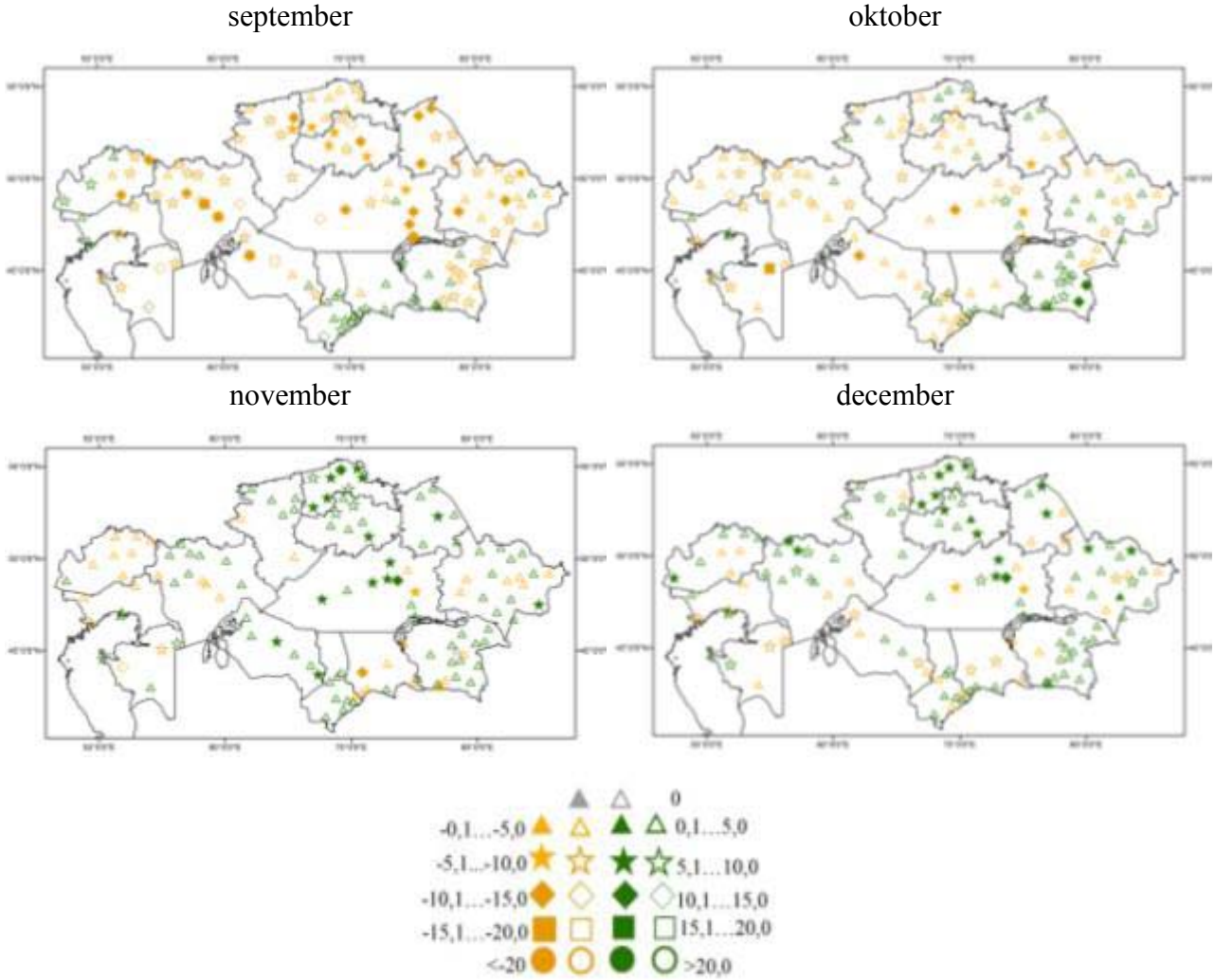


Figure 3.4 – Spatial distribution of the linear trend factor of monthly precipitation (% of normal/10 years), over 1941...2014, relative to the 1971…2000 baseline. Shaded keys stand for statistically significant trend. List 2

3.2 Precipitation anomalies in Kazakhstan in 2014

Figure 3.5 shows the spatial distribution of annual and seasonal precipitation in 2014, expressed as percentage of normal over 1971...2000 and nonexceedance probability of annual and seasonal precipitation in 2014. The nonexceedance probability means the frequency of the corresponding anomaly in the observational records.

In North Kazakhstan and South Kazakhsatn oblasts annual precipitation was 20…60 % higher than normal. In 2014 these regions was within 10 % of extremely wet since 1941. In some areas of western and southe-western Kazakhstan 2014 annual precipitation was 20…60 % below normal (non-exceedance probability 0…9 %).

Winter (December 2013 through November 2014).

In most of Kazakhstan winter precipitation in 2014 was nearly normal, or 20...100 % higher.

Extremely dry winter was in some regions of East Kazakhstan, Karaganda, Kyzylorda oblasts and in the western regions (Figure 3.5), where precipitation was less than 60% of norm.

Spring

In spring precipitation deficit (20…80 %) occurred throughout the country (Figure 3.5). In Mangistau, Atyrau and Aktobe oblasts was extremely dry. Nonexceedance probabilities in this regions amount 0…9%. The centers with considerable positive presipitation anomalies by 40…80% higher than norm, were observed in West Kazakhstan, Kostanay and East Kazakhstan oblasts.

Summer

Summer 2014 was dry and extremely dry in the most part of the territory of Kazakhstan. The centers with considerable negative presipitation anomalies – more than 60 % below the norm were recorded in some stations of the West Kazakhstan, Aktobe, Atyrau, Mangistau, Kyzylorda oblasts and the south-eastern of the republic. In these regions, summer appeared to be within 10 % of extremely dry since 1941. In northern and north-eastern of Kazakhstan summer presipitation exceeded the norm by 20…80 % (Figure 3.5).

Autumn

In autumn on the vast area of Kazakhstan the amount of precipitation was within the norm. In the territory of mountainous and foothill regions of the south-eastern of the republic, and also in Kyzylorda and Karaganda oblasts precipitation was two times as many. In autumn precipitation deficit of 20 to 60 % appeared in the western of the republic. According to results of majority meteorological stations in the western Kazakhstan autumn 2014 was within 10 % of the extremely dry seasons (Figure 3.5).

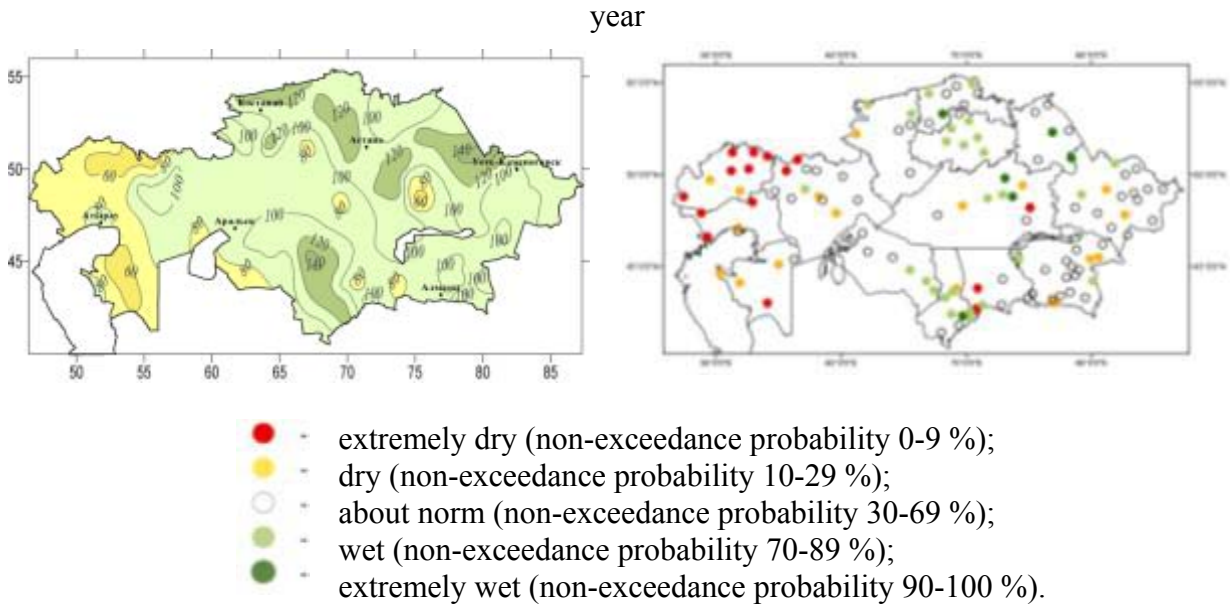


Figure 3.5 – Precipitation in 2014 as % of the norm (over 1971…2000) and non - exceedance probabilities in 2014 calculated according to the period 1941...2014. List 1

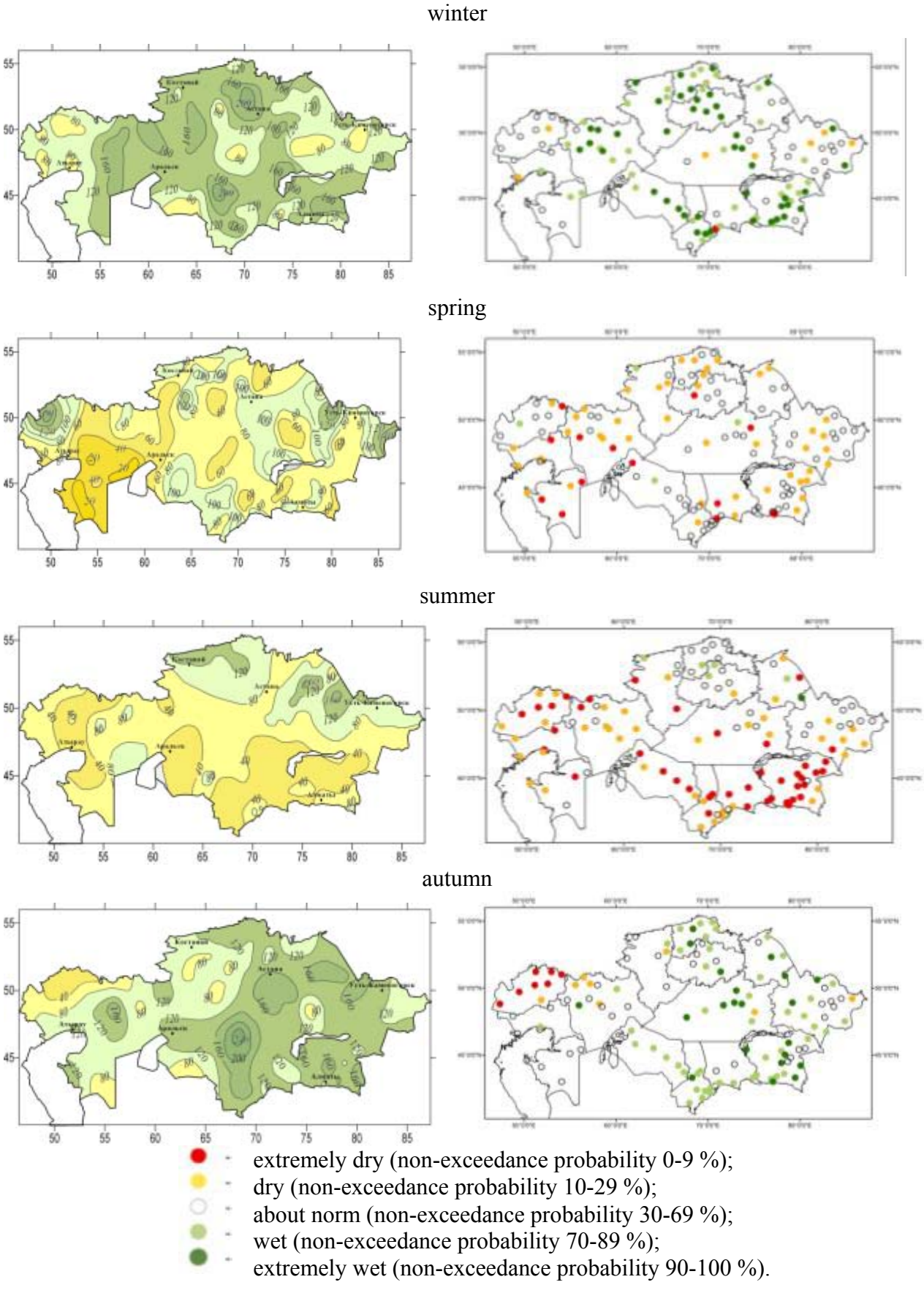


Figure 3.5 – Precipitation in 2014 as % of the norm (over 1971…2000) and non - exceedance probabilities in 2014 calculated according to the period 1941...2014. List 2

To assess precipitation extremes in 2014 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 2014 are presented below.

Maximum of daily precipitation in 2014. Figure 3.6 shows absolute maximum daily precipitation, since the beginning of records to 2013 in red. Daily maximum observed in 2014 are in blue. In 2014 the absolute maximum of daily precipitation has not been exceeded at any considered weather stations.

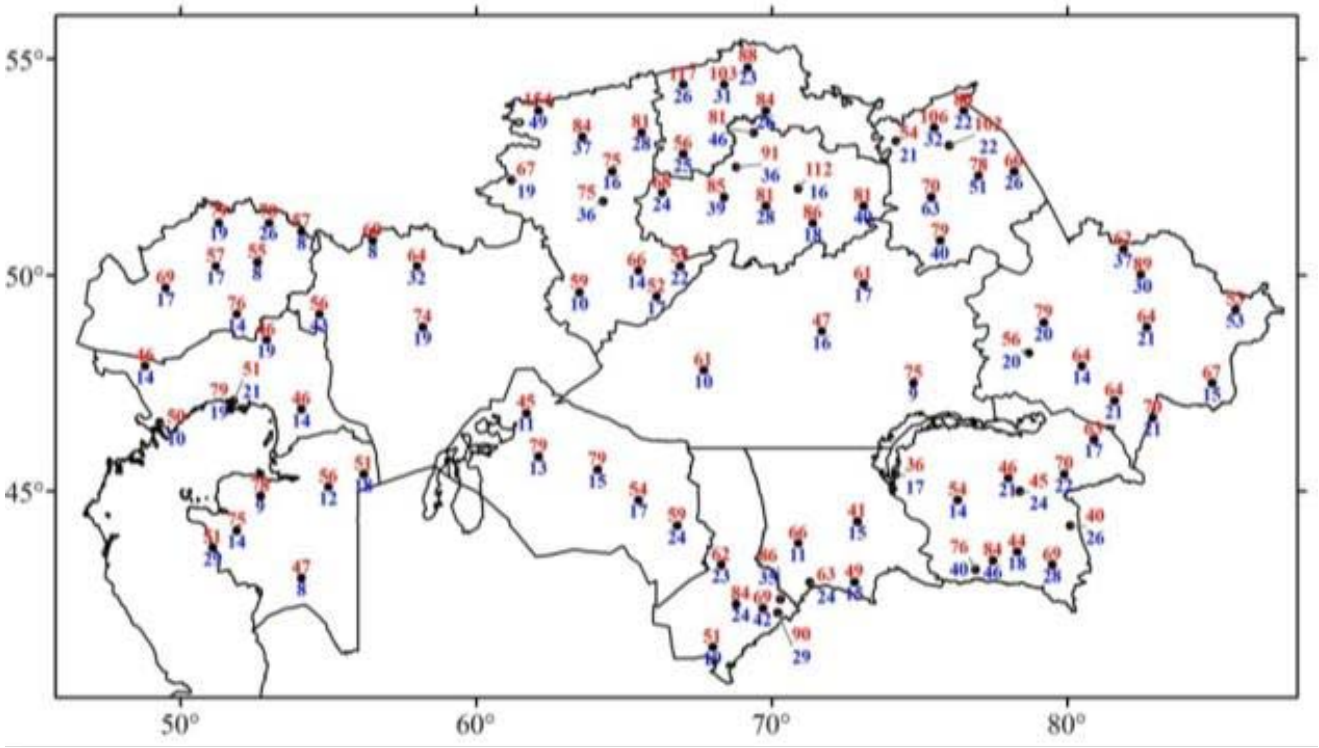


Figure 3.6 – Absolute maximum of daily precipitation, since the beginning of records until 2013 (in red) and the daily maximum in 2014 (in blue), mm

Figure 3.7 shows the share of extreme precipitation (above 95th percentile) in the total precipitation of 2014. 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 Uil (46 %) and at Ekibastuz (42 %) stations. 34 of stations also recorded rather high share of extreme precipitation – 20...39 % which means irregularity of precipitation in time.

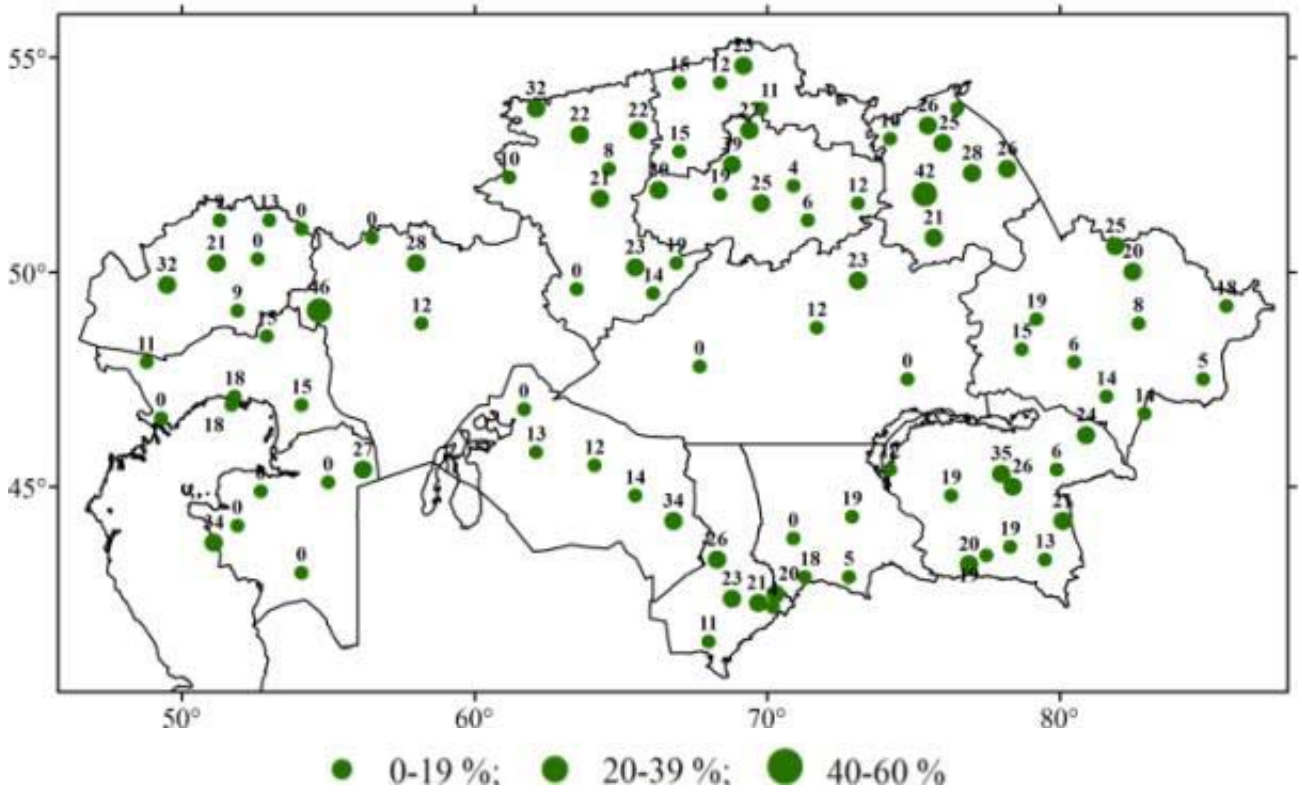


Figure 3.7 – Percentage share of extreme precipitation in the annual total in 2014. Extreme precipitation is the sum of daily precipitation exceeding 95th percentile

The CDD index which represents the ***maximum length of time when precipitation was less than 1 mm*** (duration of dry period, Figure 3.8), is very important in the arid climate of Kazakhstan. In 2014the dry period lasted for about a month at almost all weather stations. The dry period of 61to 89 days was recorded in West Kazakhstan, Atyrau, Mangistau, Aktobe and Almaty oblasts. The longest dry periods from 90 to 142 days were in Kyzylorda, South Kazakhstan and Zhambyl oblasts.

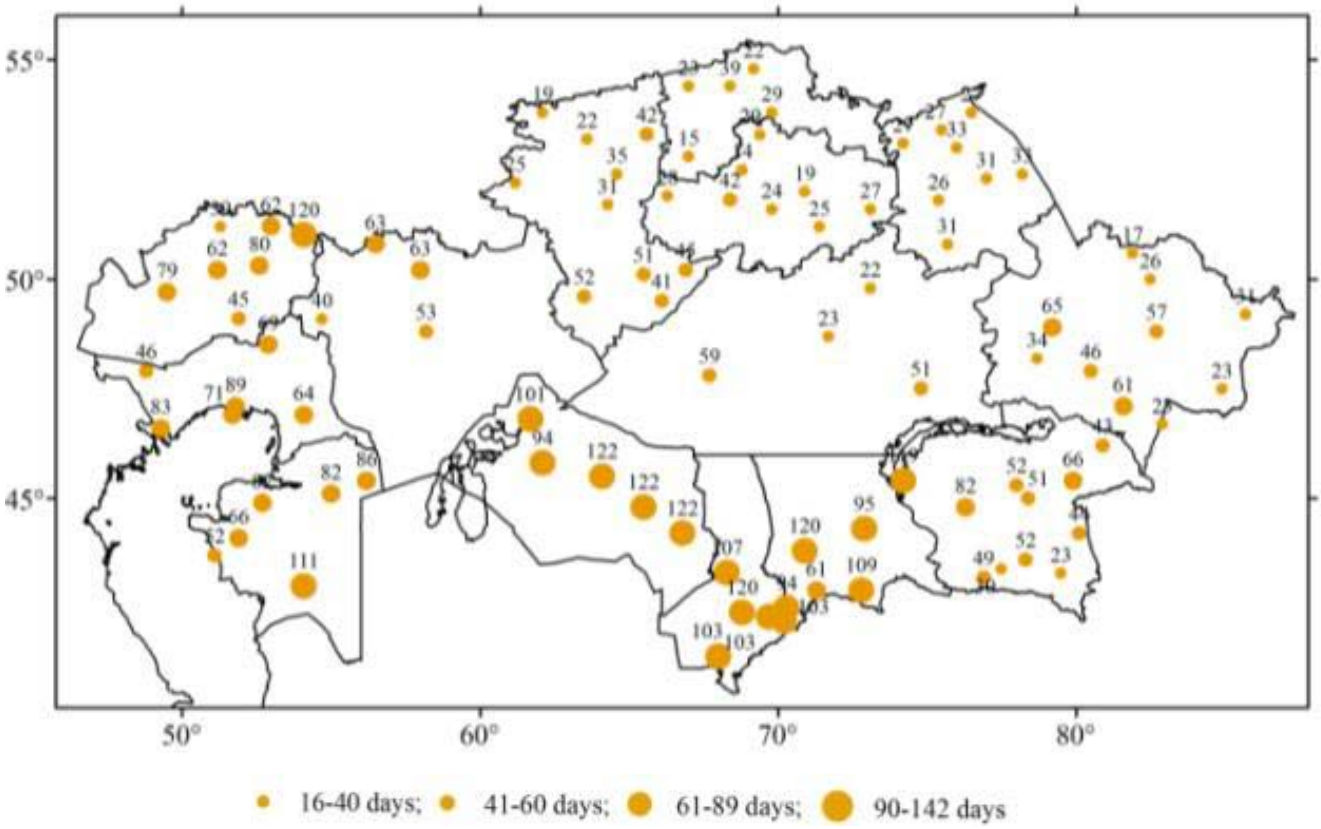


Figure 3.8 – Maximum duration (in days) of dry period in 2014

Figure 3.9 shows ***the maximum duration of the period*** in 2014 ***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 9 days. At some stations of North Kazakhstan, Akmola, Kostanay, as well as in the south-eastern and north-western of Kazakhstan precipitation was within 5 ... 7 consecutive days. The longest wet periods of 8…9 days were observed in South Kazakhstan (aul Turara Ryskulova, Tasaryk).

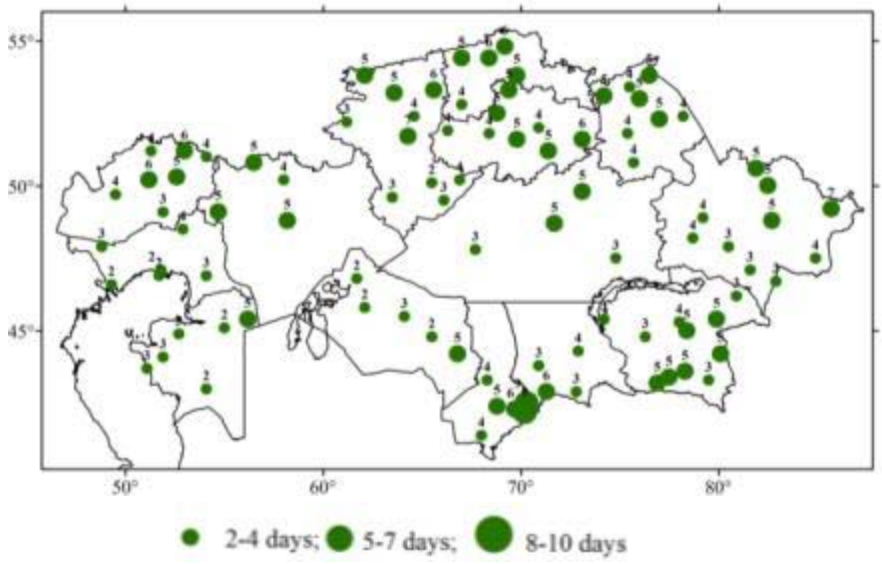


Figure 3.9 – Maximum duration (in days) of wet period in 2014

3.3 Trends in precipitation extremes

Trend analysis of precipitation extremes was prepared over 1941…2014.

The maximum daily precipitation (Rx1day) in Kazakhstan remained almost unchanged (Figure 3.10). 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.

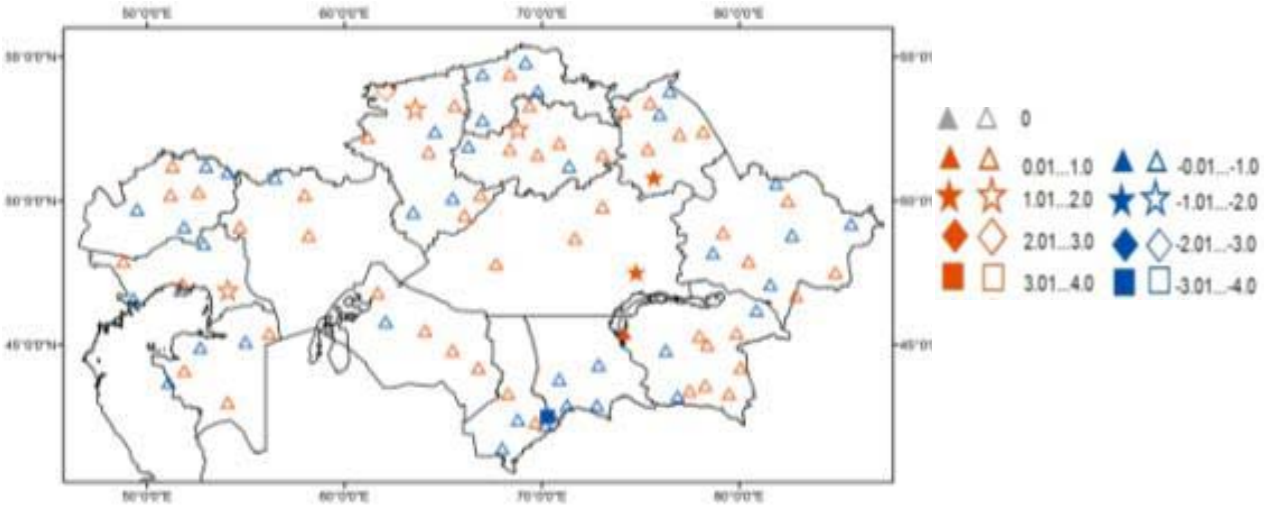


Figure 3.10 – Spatial distribution of the linear trend factor of maximum daily precipitation (mm/10 years), for 1941...2014. Shaded keys stand for statistically significant trend

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 3.11). The increase in extreme precipitation during summer cause the higher risk of erosion, and rain-fed mudflow in mountain regions.

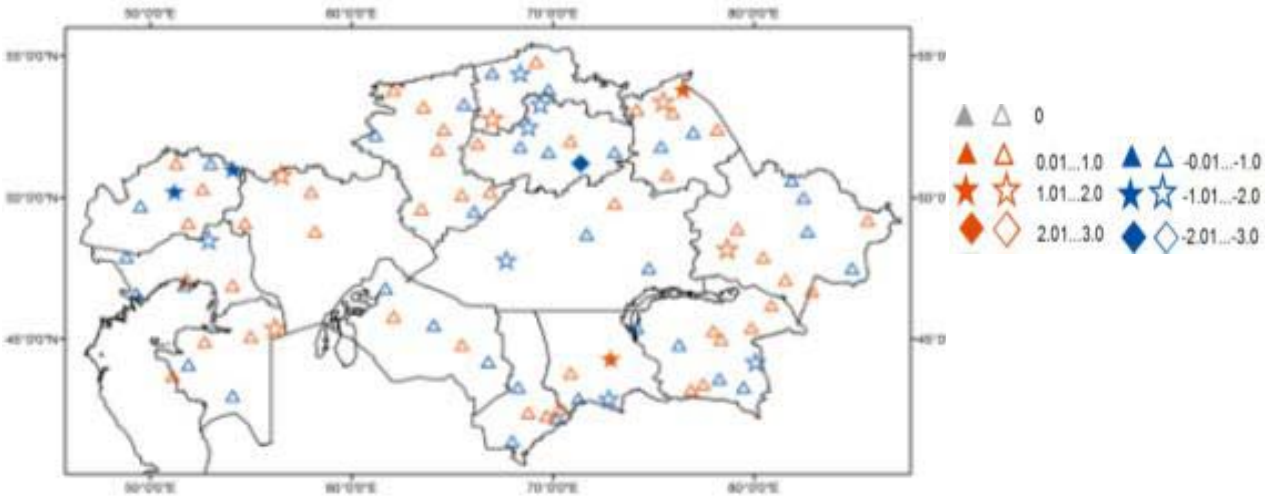


Figure 3.11 – Spatial distribution of the linear trend factor of extreme precipitation share in annual total (%/10 years) over 1941...2014. Extreme precipitation is the sum of daily precipitation above the 95th percentile. Shaded keys stand for statistically significant trend.

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 3.12). In other regions of Kazakhstan tendencies of the maximum duration of dry period were statistically insignificant (Figure 3.12).

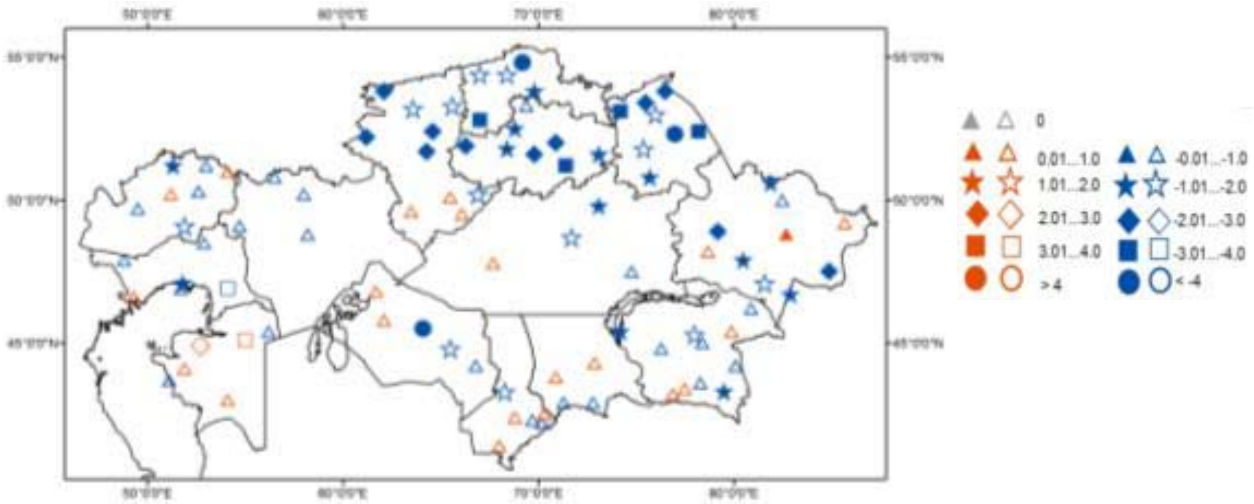


Figure 3.12 – Spatial distribution of the linear trend factor of the maximum dry period duration (day/10 years) over 1941...2014. Shaded keys stand for statistically significant trend.

CONCLUSION

Features of 2014 year. Globally, in 2014 became the nominally warmest year for all history of observations. In 2014, the average air temperature over land and ocean areas, on average around the globe was 0,57 ± 0,9 °C above the baseline period (1961…1990, 14 °C).

In Kazakhstan 2014 year by the value of the average annual air temperature (January-December) was the warmest year since 1941. Country average annual temperature anomaly in 2014 amounted to 1,69 °C which is 0,1 °C above the previous high observed in 1983. The Six months of 2013 - January, March, April, October, November and December were very warm, and that affected the value of the mean annual air temperature and brought this year for 1st place among themselves warm years.

Country average annual temperature anomaly in 2014 amounted to 5,65 °C which was 0,13 °C lower than mean annual value of the period from 1971 to 2000. The four months of 2014 – February, July, September, October were cold, March, June were warm and August was extremely warm. All that affected that 2014 became the thirty sixth warmest year on record since 1941. Air average temperature, in a year, practically in all territory of Kazakhstan was within norm, except for certain southern regions with negative anomalies and in eastern regions with positive anomalies. Temperature also in certain northern and southwestern regions was slightly higher than norm.

The winter of 2014 (December 2013 - February 2014) was within the norm. Extremely low temperatures are noted at the following meteorological stations: in January at Zlikha and Zhetykonur stations were 4.2 ºC and 4.8 ºC lower than norm (respectively) , in February at Uyuk, Zlikha, Tole bi stations were 8,6 ºC; 8,2 ºC; 8,1 ºC (respectively). In some eastern regions the winter was warm, for example, temperature in January at Ust-Kamenogorsk was 4,0 ºC above the norm.

In most of Kazakhstan winter precipitation in 2014 was nearly normal, or 20...100 % higher. Extremely dry winter was in some regions of East Kazakhstan, Karaganda, Kyzylorda oblasts and in the western regions, where precipitation was less than 60% of norm.

Spring 2014 was warm everywhere in Kazakhstan. The highest anomalies (higher than 2,5 ºC) were recorded in the western and partly northern and northeast regions of Kazakhstan. In these regions the 2014 spring added to the 10 % of the extremely warm seasons. In Mangistau, Atyrau and Aktobe oblasts was extremely dry. The centers with considerable positive presipitation anomalies by 40…80% higher than norm, were observed in West Kazakhstan, Kostanay and East Kazakhstan oblasts.

Summer was warm in the most part of territory of Kazakhstan. In July occurred negative anomalies 1,0…4,7 ºC with the cold center in North Kazakhstan, Kostanay and Akmola oblasts. In August air temperature anomalies were positive and increased from 1,0 ºC to 5,2 ºC with heat centers in the West Kazakhstan, Atyrau, Aktobe, Mangistau and Kostanay areas. The greatest deficiency of summer precipitation was observed in western and southern of Kazakhstan. The summer season of this year in these areas entered 10% of extremely dry seasons. Precipitation exceeded norm by 20 … 80% in northern and northeastern of Kazakhstan.

Autumn was cold everywhere in Kazakhstan and extremely cold in the western of Kazakhstan. In East Kazakhstan, Almaty and South Kazakhstan oblasts air temperature anomalies were within the norm. In this season precipitation throughout the country was within the norm. In the territory of mountainous and foothill regions of the south-eastern, and also in Kyzylorda and Karaganda oblasts precipitation was two times as many. Extremely dry observed in the western part of the republic.

In 2014 absolute maximum and minimum of air temperature in Kazakhstan has not been exceeded at any considered weather stations. The number of days with high temperatures above 35 ^{0}C exceeded 20...70 days from the north to the south of Kazakhstan.

In 2014, there was irregularity of precipitation in time. The largest share of extreme precipitation was observed at Uil station (46%) and Ekibastuz (42 %). At 34 stations share of extreme precipitation amounted 20…39 %. The absolute maximum of daily precipitation has not been exceeded at any considered weather stations. The maximum duration of the wet period composted 2…9 days. The longest wet periods of 8…9 days were observed in South Kazakhstan (aul Turara Ryskulova, Tasaryk). The longest dry periods from 90 to 142 days were observed in Kyzylorda, South Kazakhstan and Zhambyl oblasts.

Climate Change in Kazakhstan. Average monthly, seasonal, and annual air temperature were increased practically everywhere in Kazakhstan, for the period 1941...2014 (74 year).

Country average annual temperature has been rising by 0,27ºC every 10 years.

The highest warming was in spring and in autumn by 0,31 ºC every 10 years. Winter temperatures have been increasing a little slower by 0,27 ºC every 10 years respectively . The slowest warming was in summer – 0,19 ºC every 10 years. 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 38 %, for seasons contribution varies from 6 to 24 %.

The fastest increase in the average annual temperature was in West Kazakhstan oblast equal to 0,38 ^{0}C every 10 years. The lowest warming rates were in South Kazakhstan, Almaty, East Kazakhstan, Mangistau and Pavlodar Oblasts amounting to 0,21...0,26 ºC every 10 years. In other oblasts the temperature increase rates were within 0,27...0,31 ºC over 10 years (1941…2013).

The biggest temperature increase was observed in spring in northern, central and eastern oblasts (0,28…0,38 ºC every 10 years). In western regions the biggest temperature rise still occurred in winter (0,26…0,46 ºC every 10 years) and in southern oblasts the biggest temperature increase was observed in autumn (0,29…0,40 ºC every 10 years). In summer almost everywhere in Kazakhstan the temperature increase linear trend factor was within 0,13…0,27 ^{0}C every 10 years. However determination factor is rather high, especially in southern oblasts equal to 18-37%. This means that air temperature increasing trend is stable.

In January, February, March, and November the air temperature increase was most significant from 0,41 to 0,81º C/10 years. In April, June and October the warming rate was slower 0,21...0,60 ºC/10 years. In all other months slight growth of temperature was observed.

The maximum temperature in the north republic reached 33…39 °C, in the south republic was 34…43°C.

The lowest air temperatures (minus 39…35 °C) were observed generally in the northern, the eastern and the central Kazakhstan, and also on some stations of the western part of the republic. In all territory the absolute minimum were higher, than the absolute minimum of temperature ever reached.

The total duration of heat waves was high in western and south-western of Kazakhstan with maximum in Aktobe, Atyrau, Mangistau oblasts (18…30 days) and also in eastern and northern of Kazakhstan (18…24 days).

In 2014 cold waves from 6 till 18 days were observed in the western part of Kazakhstan, and in certain regions of central, southern and eastern of republic. In all other territory of the country the cold waves with duration more than 6 days wasn't observed.

In 2014 the maximum number days with the daily minimum temperatures below the 10th percentile (more than 18%) was observed in Kyzylorda oblast, and also with the centers in the eastern of the country (more than 22%) and in Almaty oblast (more than 19%).

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. In the northern, eastern and south-eastern regions the frequency of hot days has not changed during 1941...2014.

The significant increase trend the daily temperature amplitude was observed in Pavlodar, West Kazakhstan, Almaty, Sauth Kazakhstan, Kyzylorda and Mangistau regions amounting to 0,1...0,2 ºC.

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.

The annual precipitation has been decreasing slightly by 0,8 mm every 10 years, or about by 0,4 % of normal per 10 years during 1941…2014. On average in Kazakhstan precipitation tends to slightly decrease in all seasons except winter when precipitation tends several increased. All tends were statistically insignificant.

In summer and in autumn in most parts of Kazakhstan except mountain south-eastern regions 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 north-western and the north-eastern, other regions precipitation decreased. It should be noted that almost all seasonal trends are statistically insignificant, except winter precipitation.

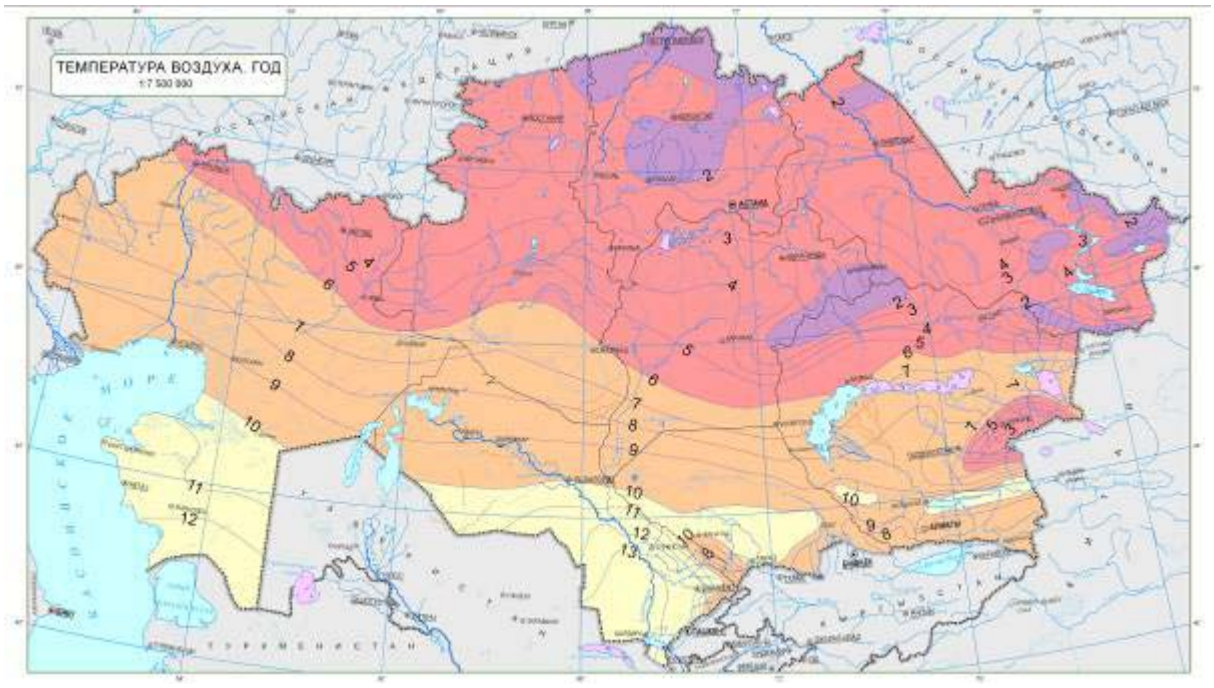
Both increasing and decreasing trends were weak – around 0,01…1,0 mm/10 years in all oblasts Kazakhstan. Almost all trends are statistically insignificant except few stations.

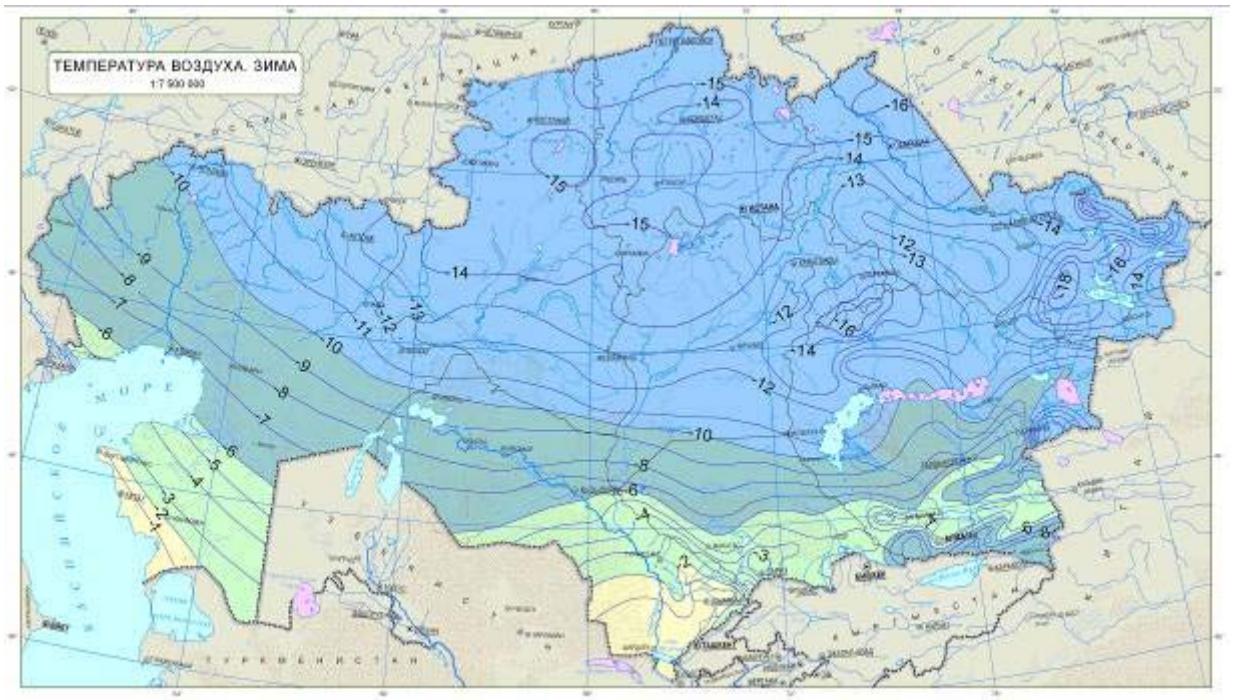
Analysis of the percentage share of extreme precipitation in annual total (R95pTOT) showed that weak trends both decreasing and increasing by 0,01...1,0 %/10 years was observed everywhere in Kazakhstan except few stations.

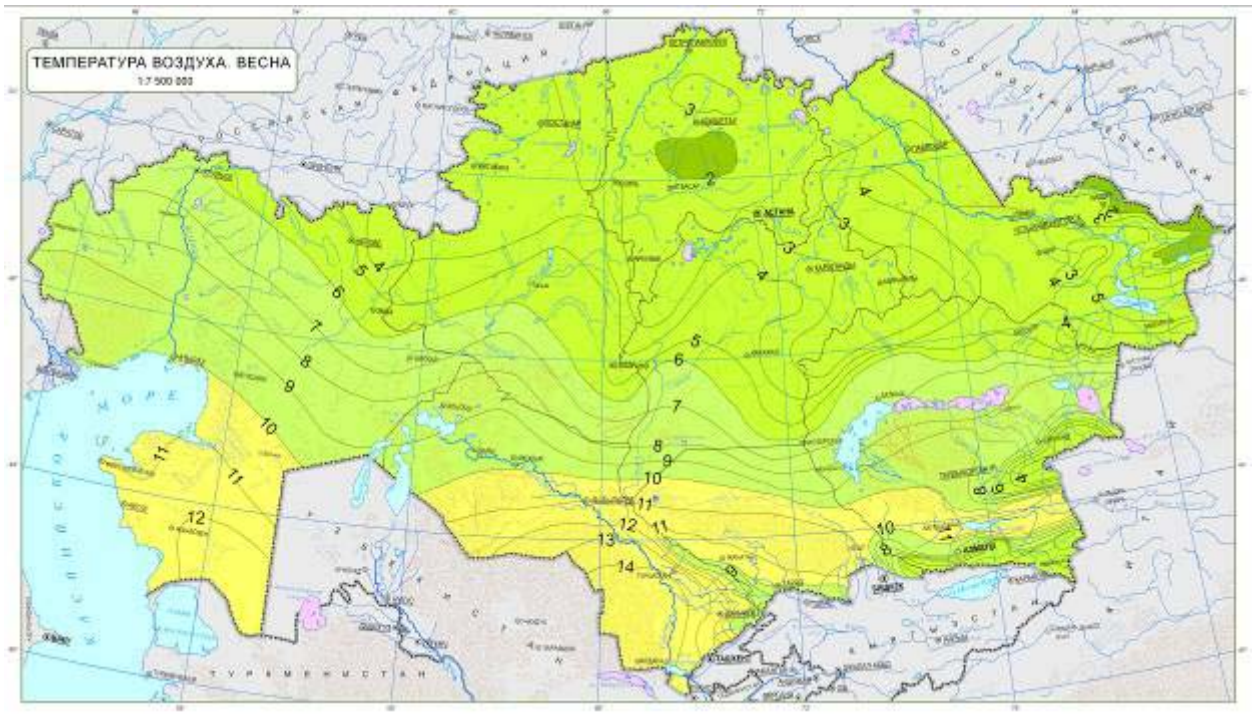
Statistically significant decrease occurred in the northern and northeastern regions of Kazakhstan by 1...4 days every 10 years, at Zhusaly, Pavlodar, Petropavlovsk stations by 5 days per 10 years. Statistically significant increase of dry period occurred at Kokpekty station by 2 days every 10 years (Figure 3.12). In other regions of Kazakhstan tendencies of the maximum duration of dry period were statistically insignificant (Figure 3.12).

ANNEX 1

SPATIAL DISTRIBUTION OF ANNUAL AND SEASONAL MEAN AIR TEMPERATURE IN KAZAKHSTAN, CALCULATED OVER THE PERIOD 1971…2000



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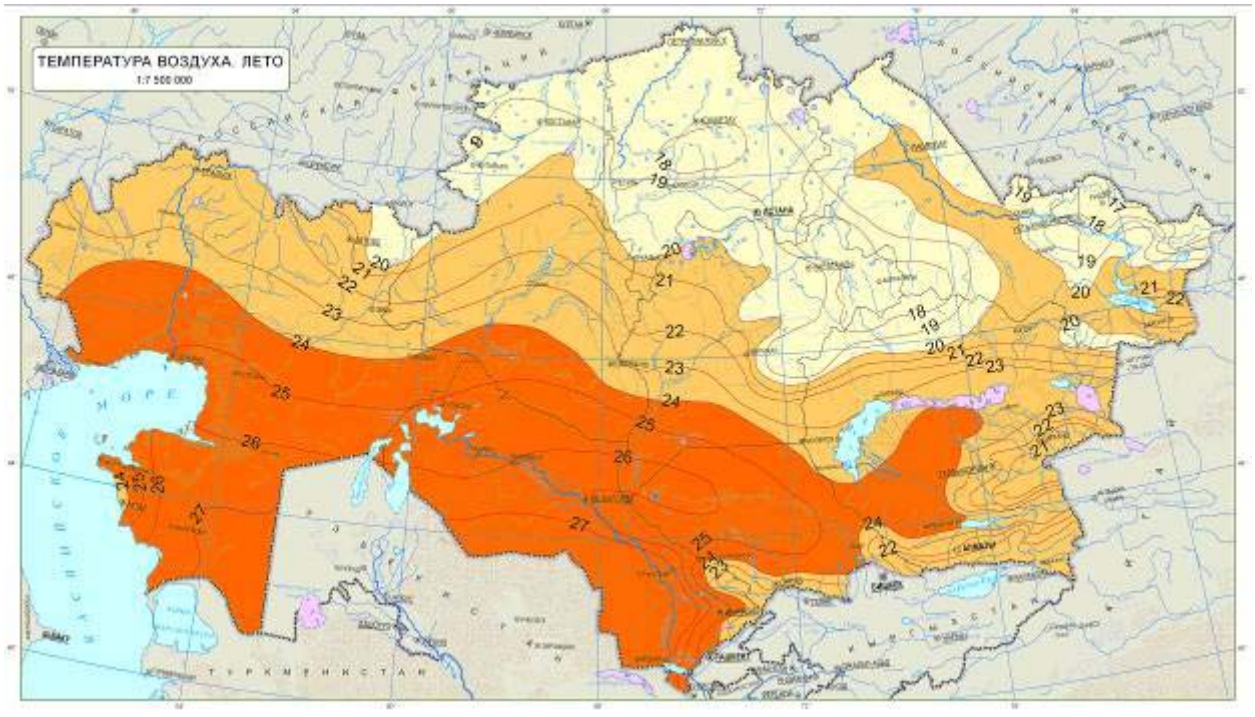
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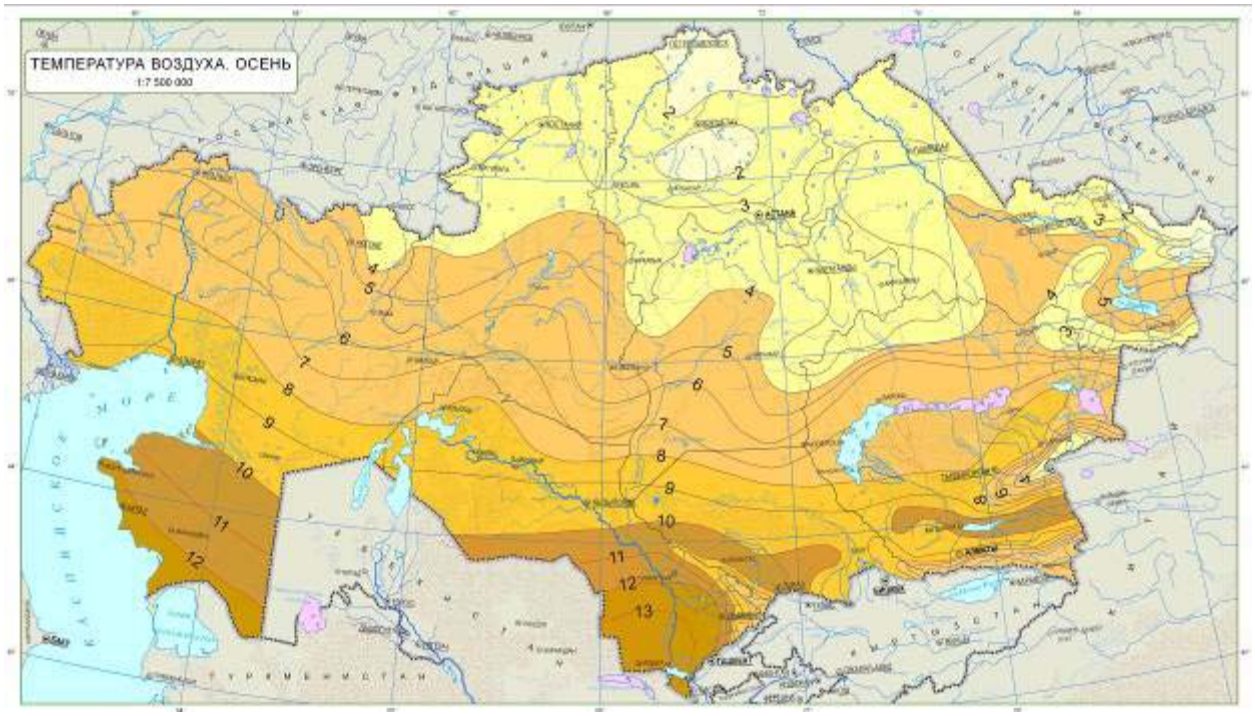
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ANNEX 2

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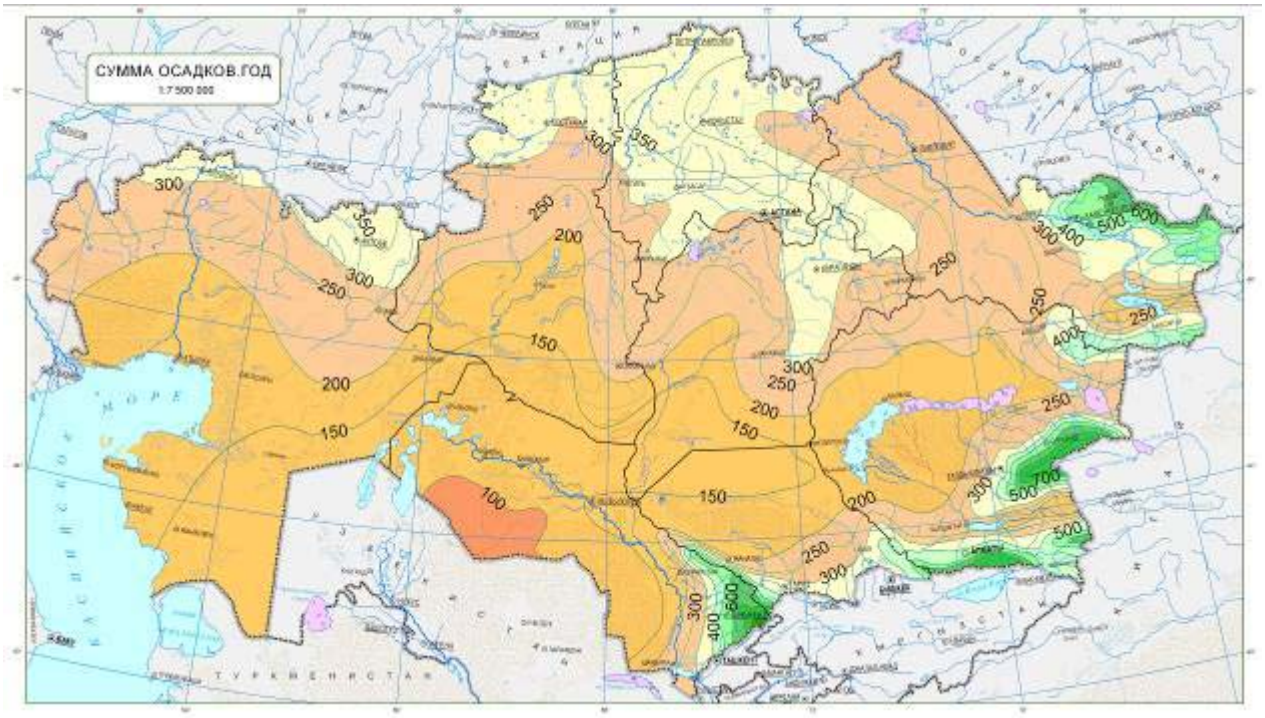

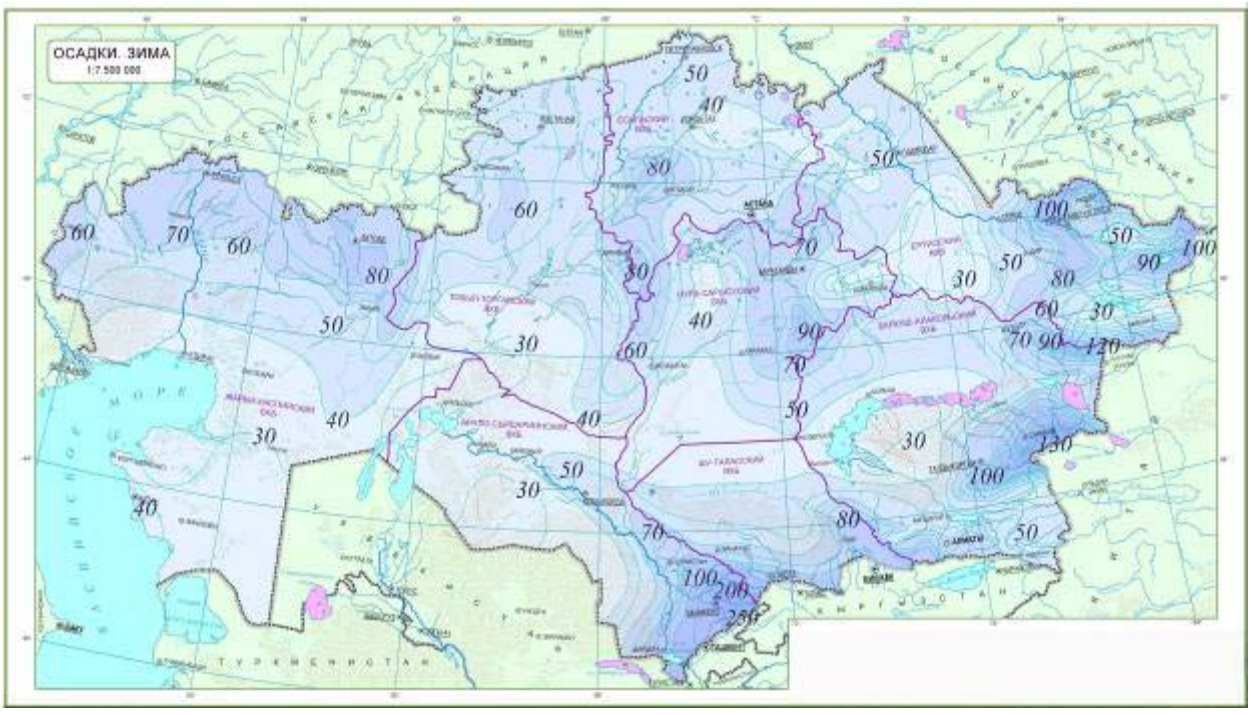


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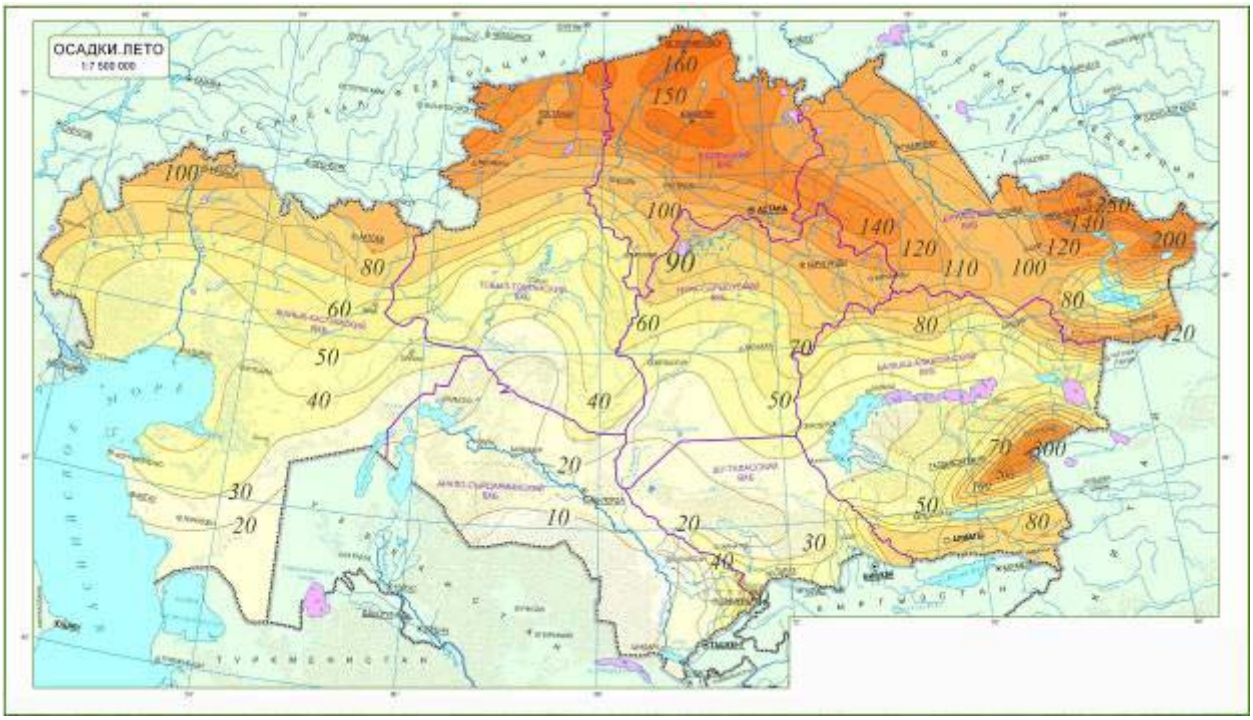
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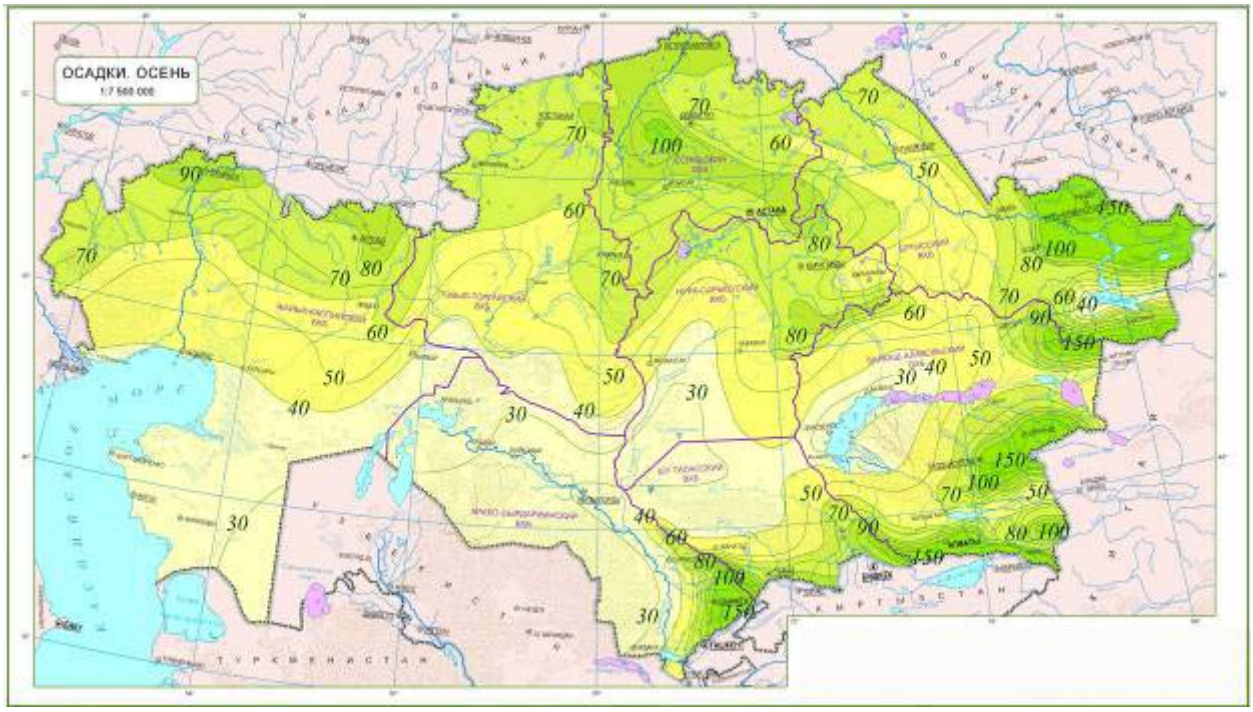
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