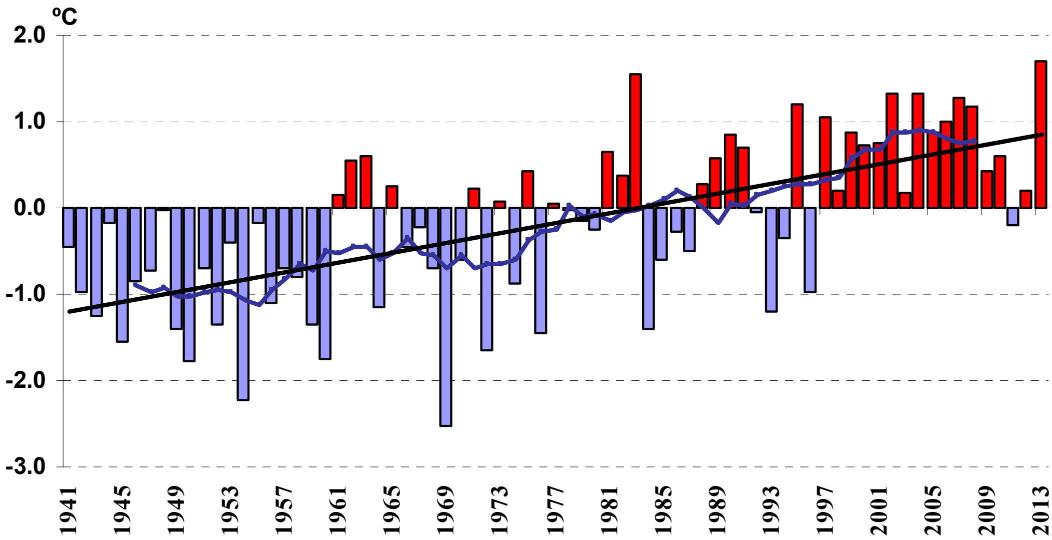
Ministry of Energy of the Republic of Kazakhstan

Republican State Enterprise "Kazhydromet"

ANNUAL BULLETIN OF CLIMATE CHANGE MONITORING IN KAZAKHSTAN:

2013



Астана, 2014

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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 2013 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 2013. 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 2013 (more than 90 meteorological stations).

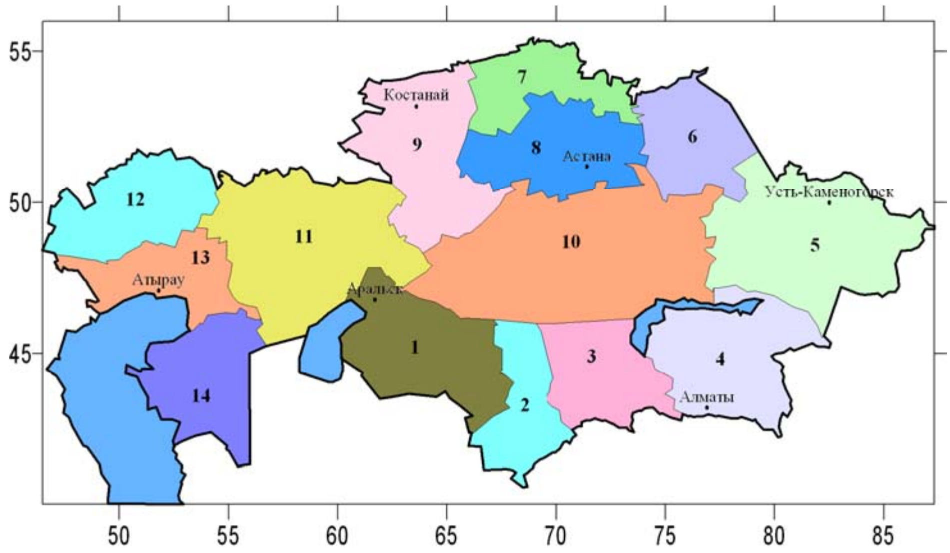
Basic approaches and methods.

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 2013. 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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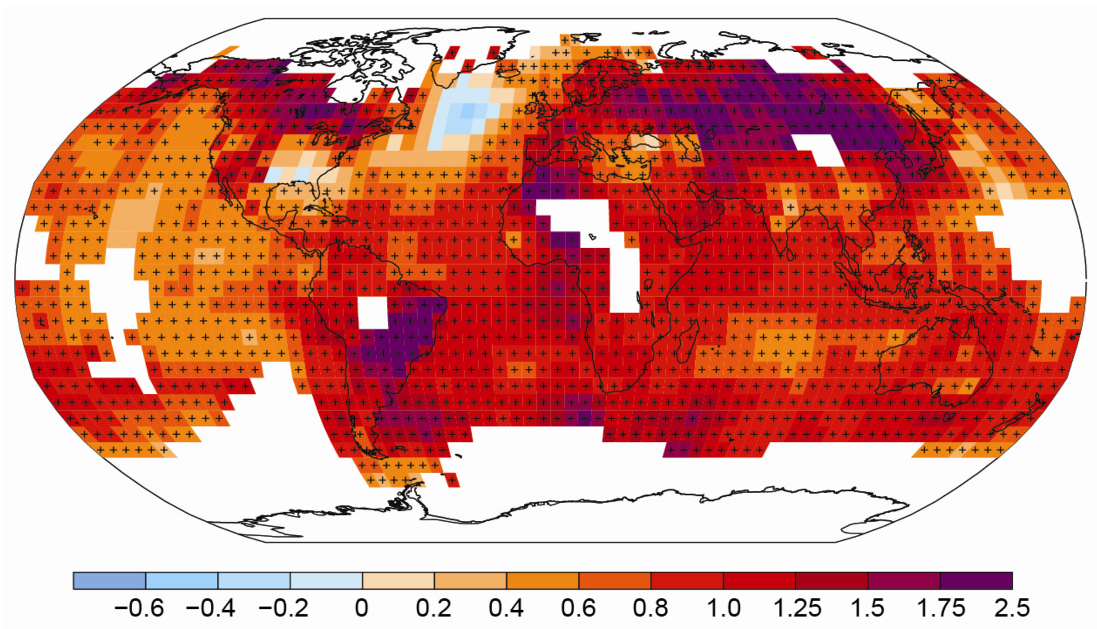
1 OVERVIEW OF GLOBAL CLIMATE CHANGE AND ITS STATUS IN 2013

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 of global temperature over the period 2003 ... 2012 is on average 0,78 (0,72 ... 0,85) ° C, compared with the period of 1850 ... 1900. The increase surface air temperature observed in most regions of the globe (Figure 1.1).



Trend (°C for the period 1901…2012)

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 21st 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. Some pause occurred from 2000 in the process of global warming: a global temperature fluctuates at the level reached high values. The warmest period in the observational records was from 2001 to 2010 but in this period the monotonic warming was not observed.

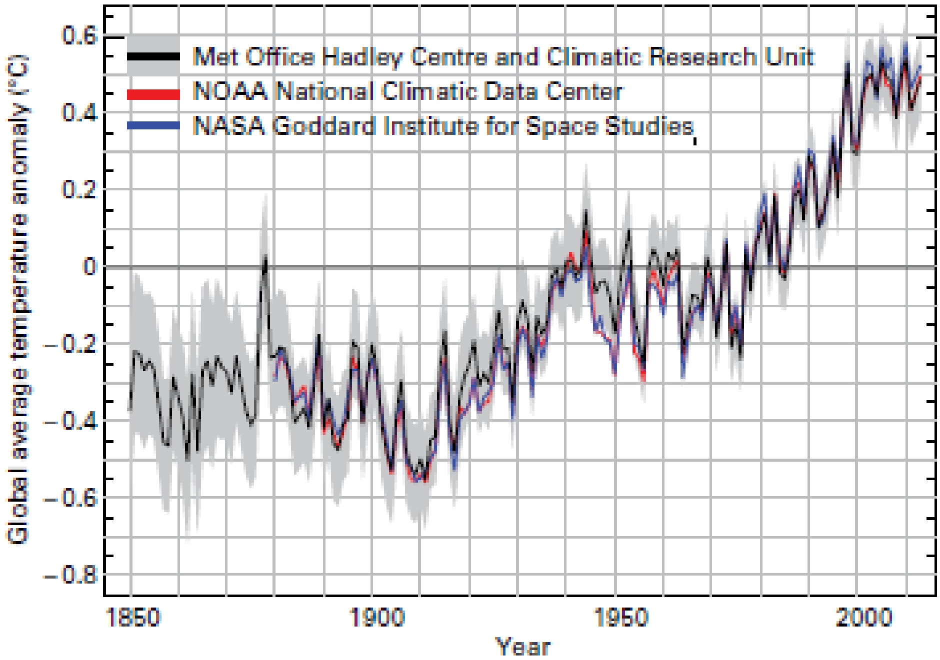


Figure 1.2 - Annual global average temperature anomalies (relative to the 1961…1990) from 1850 to 2013 from the Hadley Centre/CRU (HadCRUT4) (black line and grey area, representing average and 95 per cent uncertainty range), the NOAA National Climatic Data Center (red), and the NASA Goddard Institute for Space Studies (blue) *(Source: Met Office Hadley Centre, United Kingdom, and Climatic Research Unit, University of East Anglia, United Kingdom)*

Each of the last three decades was characterized by higher surface temperature than any other decade since 1850. In the northern hemisphere from 1983 to 2012 was probably the warmest in the last 1400 years (mean confidence level). In relation to changes in average precipitation over land there is a low degree of reliability from 1901 to 1951 and the average - from 1901 to 2013

Precipitation in the middle latitudes of the Northern Hemisphere has increased since 1901 (medium confidence until 1951 and high - after). For other latitudes there is low confidence of positive or negative trends. Around 1950 there are changes in extreme weather and climate events. It is very likely that the global number of cold days and nights has decreased, while the number of warm days and nights has increased. It is likely that the frequency of heat waves has increased in large areas of Europe, Asia and Australia. The frequency and intensity of heavy rainfall is probably increased in North America and Europe. (Source: IPCC, 2013.: Summary for Policymakers. Contained in the publication of Climate Change, 2013. The Physical Science

Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change).

According to the «Statement of the World Meteorological Organization (WMO) on the status of the global climate» (WMO-№ 1130) 2013 became one of the warmest ten years since 1850. Land-ocean global average air temperature in 2013 was 0,50 ºC ± 0,10 °C higher the 1961, 1990 annual average of 14 °C. This makes 2013 nominally the sixth warmest year on record since 1850 (Figure 1.3).

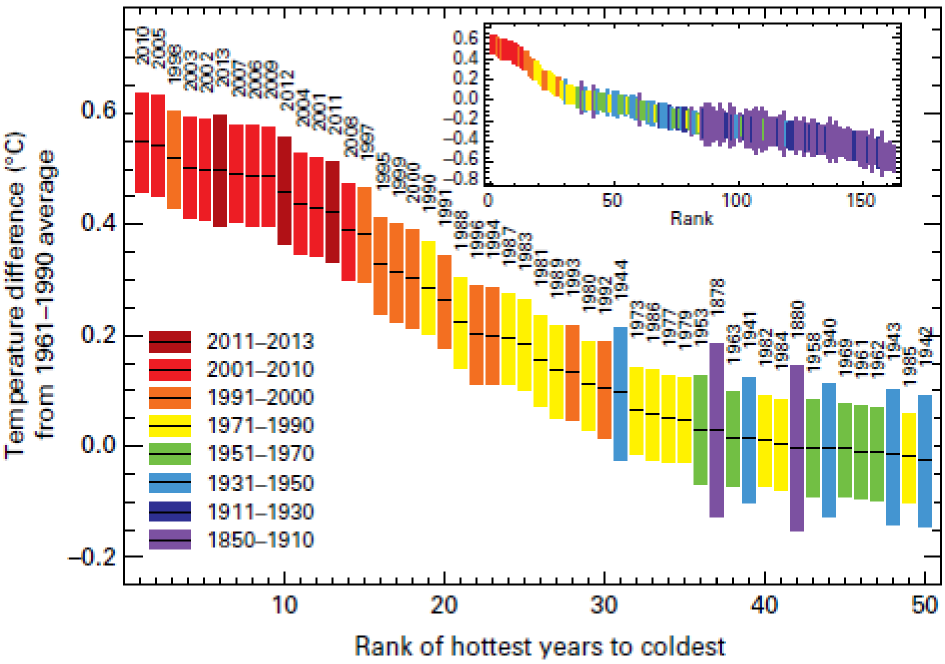


Figure 1.3 – Global ranked surface temperatures for the warmest 50 years. Inset shows global ranked surface temperatures from 1850. The size of the bars indicates the 95 per cent confidence limits associated with each year. Values are simple area-weighted averages for the whole year. (Source: WMO statement on the status of the global climate in 2013)

The past year was also warmer than both 2011 and 2012, which, though marked by cooling La Niña conditions, were 0,43°C and 0,46°C above average, respectively (Figure 1.3, 1.4). Warming El Niño and cooling La Niña events are major drivers of natural variability in the climate system. Neither condition was present during 2013, which was among the four warmest ENSO-neutral years on record (Figure 1.4). Thirteen of the fourteen warmest years on record, including 2013, have all occurred in the twenty-first century. The warmest on record are 2010 and 2005, followed by 1998. El Niño conditions dominated the early months of 2010 and 1998, and weak El Niño-type conditions extended from 2004 to the first half of 2005.

Because the capacity for heat absorption differs over land and over sea, the air over the land tends to warm up faster. Across the world's land surfaces, the 2013 global air temperature was 0,85°C ±0,17°C above the 1961…1990 average and 0,06 °C above the 2001…2010 average, the fourth highest on record. A very warm November–December period that ranked second behind 2006 contributed to this high temperature anomaly. Over the global ocean, the surface temperature for 2013 tied with 2004 and 2006 as the sixth warmest on record, at 0,35 °C±0,07 °C above the 1961…1990 average.

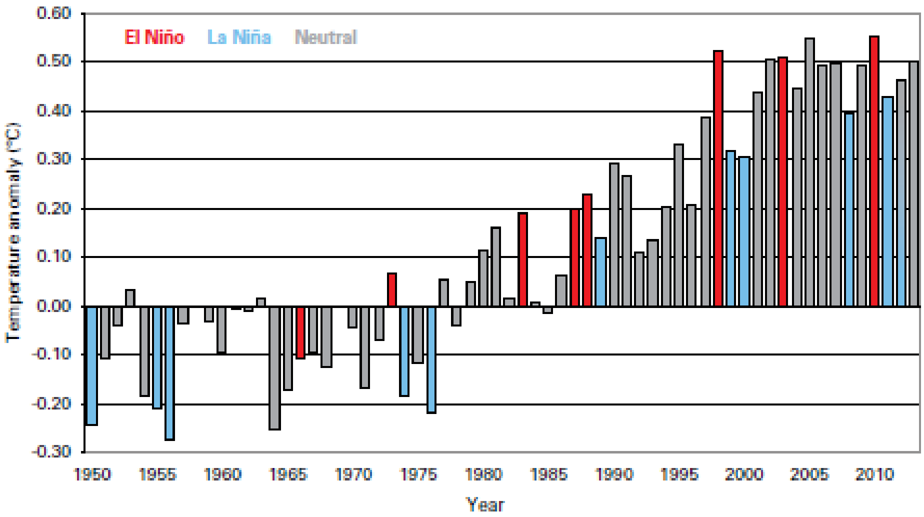


Figure 1.4. - January– December global land and ocean surface temperature anomalies (relative to 1961…1990) for the period 1950…2013; years that started with a moderate or strong La Niña already in place are shown in blue; years that started with a moderate or strong El Niño already in place are shown in red; other years are shown in grey.

The northern hemisphere's weather patterns during early 2013 were largely influenced by the Arctic Oscillation. This brought cooler-than-average spring temperatures to much of Europe, the south-eastern United States, north-western Russian Federation and parts of Japan (Figure 1.5). The Arctic region, meanwhile, was considerably warmer than average, along with much of central and northern Africa, the eastern Mediterranean, southern Russian Federation and much of China. This so-called warm Arctic, cold continents pattern is characteristic of the Arctic Oscillation's negative phase. The year 2013 saw the most negative Arctic Oscillation on record for the month of March. A similar pattern with high pressure over Greenland and low pressure to the south re-emerged in late spring, once again causing cold Arctic air to surge into western and central Europe.

In the southern hemisphere, summer was extremely warm, with monthly January temperature anomalies reaching plus 5 °C in parts of Australia. Exceptional warm conditions were also present during the winter, with New Zealand experiencing its warmest winter on record. The beginning of austral summer 2013/2014 was very hot in parts of South America, with the December temperature reaching new record highs. As a result of the continued warmth throughout the year across parts of the southern hemisphere, 2013 was the warmest year on record in Australia, second warmest in Argentina and third warmest in New Zealand. Modeling experiments have indicated that the odds of the record Australian hot summer occurring were increased fivefold by human-induced climate change.

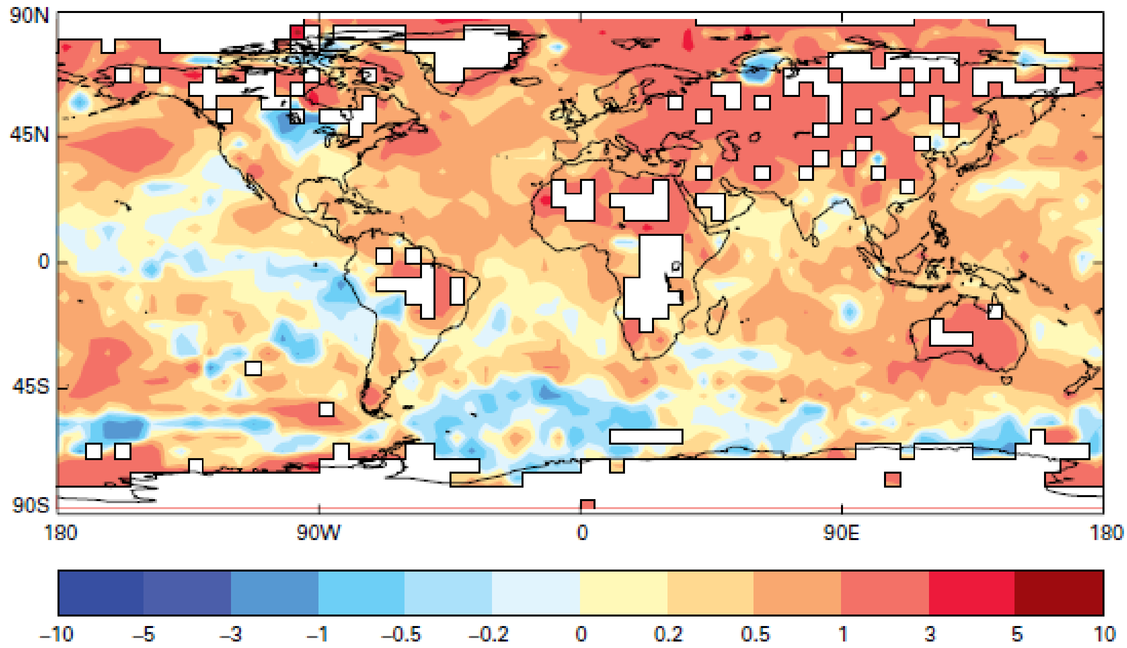


Figure 1.5 - Global land air surface and sea surface temperature anomalies (°C) for 2013, relative to 1961…1990 *(Source: Met Office Hadley Centre, United Kingdom, and Climatic Research Unit, University of East Anglia, United Kingdom)*

Global precipitation during 2013 equaled the 1961…1990 average of 1033 mm, according to the National Oceanic and Atmospheric Administration (United States). Precipitation at the regional level, however, varied significantly. For example, wetter-than-average conditions were seen across most of Greenland, the southern Arabian Peninsula, central India and western China. Drier-than-average conditions were present over the western United States, much of northern Canada, northern Siberia and the eastern inland of Australia (Figure 1.6).

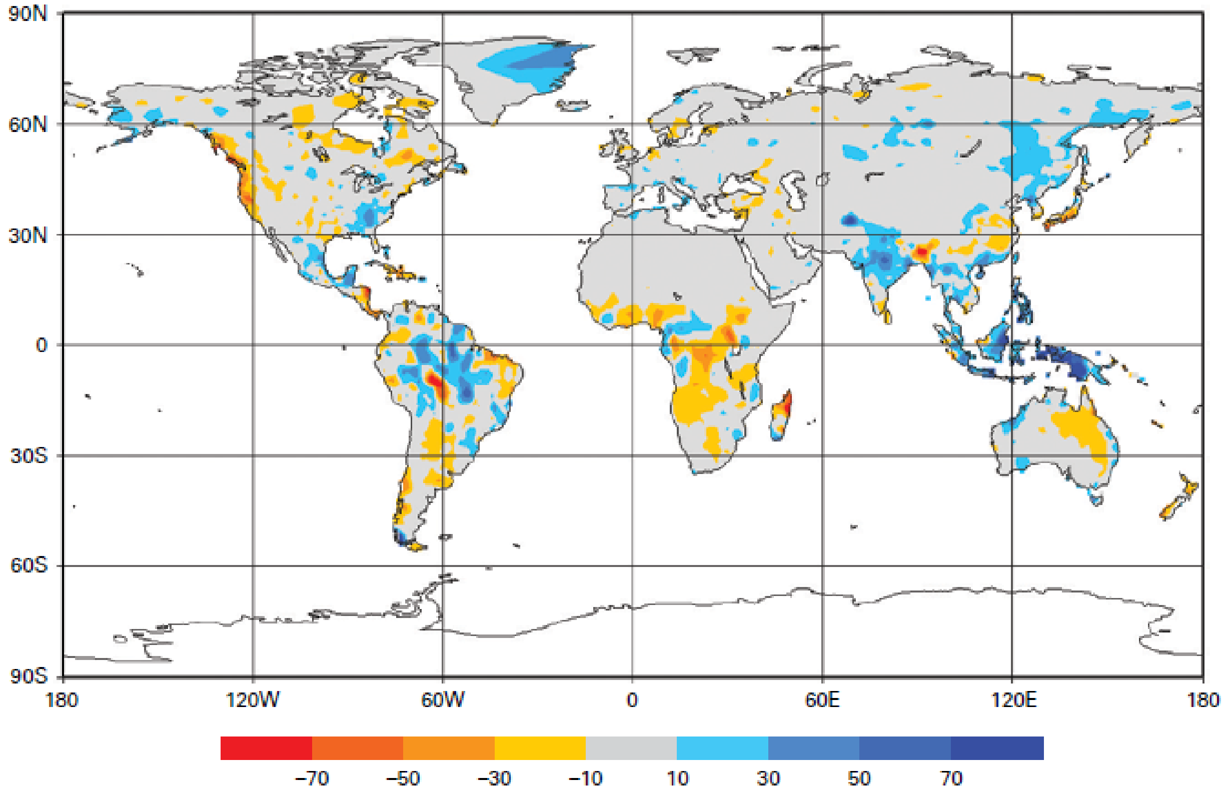


Figure 1.6- Annual precipitation anomalies for global land areas for 2013; gridded 1,0-degree raingauge-based in mm/month (relative to 1951…2000) *(Source: Global Precipitation Climatology Centre, Deutscher Wetterdienst, Germany)*

Winter snow cover in North America has varied widely over the past few years. During the 2012…2013 winter, snow cover extent was 500 000 km^2 above the 1981…2010 average, resulting in the fourteenth largest winter extent for the continent since records began in 1966. During the spring, North American snow cover was 830 000 km^2 above average, making it the tenth largest spring extent for the continent and the largest since 1997.

During the same period, snow cover extent across the Eurasian continent was 1.71 million km^2 above the 1981…2010 average, the third largest winter extent on record for this region and the largest since 2003. In the spring, the continent's snow cover contracted significantly to 430 000 km^2 below average, resulting in the fourteenth smallest extent on record for the season. In May, Eurasian snow cover dipped to 7,3 million km^2, setting a new record low for that month.

As further evidence of the rapid response of the Arctic cry sphere to increasing air temperatures, the northern hemisphere June snow cover is currently decreasing at a faster rate than Arctic summer minimum sea-ice extent, and at rates that exceed the projection of climate models. June 2013 snow cover across the hemisphere was the second lowest, greater only than the record low of 2012.

Soil moisture is a key variable for monitoring the climate system because it strongly influences the exchange of water and energy between the land surface and the atmosphere. Very wet soil conditions resulting from hydro meteorological events were noticeable and had an impact on floods in a number of regions including eastern parts of the Russian Federation, north-eastern China, India, the Philippines and central Europe. On the other hand, annual soil moisture anomalies indicated dryness in the southern hemisphere, where Australia, South America and southern Africa experienced severe drought conditions during the first part of the year.

Arctic sea-ice extent reached its annual maximum on 15 March at 15,13 million km^2. This was approximately 0,5 million km^2 below the average 1981…2010 annual maximum, making it the sixth smallest maximum sea-ice extent since satellite records began in 1979. During the 2012/2013 growth season, Arctic sea-ice extent grew by 11.72 million km^2, the largest seasonal increase on record; this growth can be explained by the record small sea-ice extent of September 2012. Arctic maximum sea-ice extent in March has decreased at an average rate of 2,6 per cent per decade.

Another way to assess the state of the Arctic sea ice is to estimate the age of the ice, given that first-year ice is the thinnest and most susceptible to melting. Ice that was four years of age and older decreased from 18 per cent of the ice cover in March 1984 to 2 per cent in March 2012. It increased slightly to 3 per cent in 2013. In March 1984, 56 per cent of the ice pack was composed of first-year ice, while in March 2013 first-year ice comprised 78 per cent of total ice cover at its peak.

The Arctic reached its annual minimum sea-ice cover on 13 September, at 5,10 million km^2 or 18 per cent below the 1981…2010 average minimum, making it the sixth smallest annual minimum on record. All seven of the lowest Arctic sea-ice extents in the satellite record have occurred in the last seven years, beginning with 2007. September Arctic sea-ice extent has decreased at an average rate of 13,7 per cent per decade. The total minimum sea-ice volume, which combines measures of ice extent and model simulations of ice thickness, was higher in 2013 than in 2010, 2011 and 2012, but lower than in 2007 and well below the 1979…2012 average.

February marked the end of the Antarctic sea-ice melt season in 2013.The annual minimum extent of sea ice was reached on 20 February at 3,68 million km^2. This was the second largest annual minimum sea-ice extent for Antarctica. In addition, Antarctic sea-ice extent reached a record maximum for the second year in a row. On 1 October, it was 19,57 million km^2, 2,7 per cent higher than the 1981…2010 average. September Antarctic sea-ice extent has increased at an average rate of 1,1 per cent per decade. Scientists believe that changes in atmospheric circulation over the past three decades, which have weakened the prevailing winds that circle Antarctica, may be a factor. The increasing extent of the ice may also be linked to changing ocean circulation and a build-up of cold freshwater on the surface of the Southern Ocean due to increasing precipitation and melting land-based ice shelves.

Melting at the surface of the Greenland ice sheet was much less dramatic in 2013 than in the record year of 2012. It peaked in late July, when satellites detected melting over 44 per cent of the surface. This coincided with record warmth in south-western Greenland (30 July saw a temperature of 25,9 °C in Maniitsoq, the highest temperature ever recorded in Greenland).The last decade has experienced accelerated melting of the sea-ice cover and mass loss of the Greenland ice sheet.

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).

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…2013. 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. The first place in the ranked annual average temperature anomalies was 2013 year; it was the warmest year in the last 73 years. The annual average temperature anomalies in 2013 equal to 1,69 °C, which is 0,13 °C above the previous peak, observed in 1983 (Table 2.1).

Synoptic conditions over the territory of Kazakhstan in 2013 contributed to the formation of very high air temperature anomalies in separate months. So, in March, November and December 2013 air temperature anomalies in average over the country were above normal (1971…2000) at 5,53, 4.43 and 2,57 °C, respectively (the fourth, the second, the eighth largest positive anomaly from 1941). For these months, the probability of non-exceedance of the anomalies amounted to 95, 98 and 90 %, respectively. The extreme hottest were: January - anomaly was plus 1,90 °C (probability of non-exceedance is 83%), April - anomaly was plus 2,0 °C (probability of non-exceedance is 88%), October - anomaly was plus 1,38 °C (probability of non-exceedance is 86 %). A more detailed analysis of the temperature distribution on the territory of Kazakhstan in 2013 is presented in subsection 2.2.

Table 2.1 – The ranked 10 warmest years for the globe (1850...2013) and for Kazakhstan (1940…2013) and corresponding annual average temperature anomalies for Kazakhstan

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

9	2009	2006	0,99
10	2012	2005	0,88

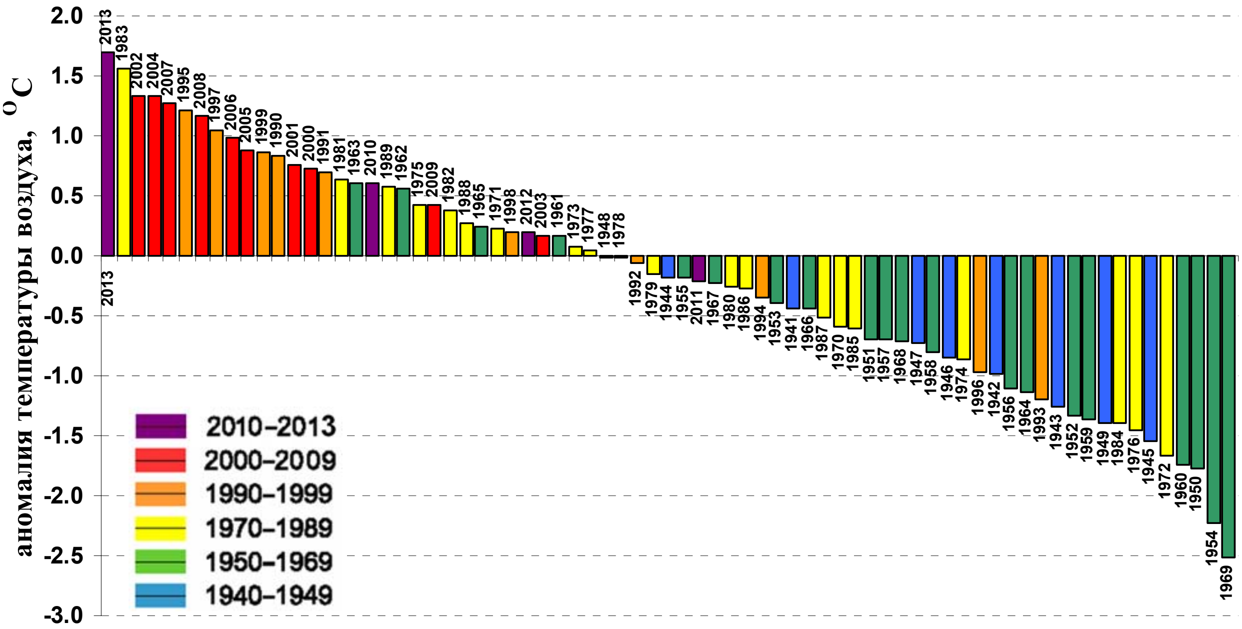


Figure 2.1 – Ranked average annual air temperature anomalies for Kazakhstan for 1940…2012 (data of 118 weather stations). Anomalies estimated relative to 1971…2000 baseline

Figures 2.2-2.4 and table 2.2 present the air temperature change for 1941…2013 for Kazakhstan and by 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 2013. Country average annual temperature has been rising by 0,28 ºC every 10 years. The highest warming was in autumn by 0,33 ºC every 10 years. Winter and spring temperatures have been increasing a little slower by 0,28 ºC and 0,30 ºC every 10 years respectively. The slowest warming was in summer – 0,19 ºC every 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 39 %, for seasons contribution varies from 2 to 37 % (Table 1.2). 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 reason of the negative winter temperatures anomalies from 2008 to 2013 are the coldest winters in the central, northern, eastern regions of the country (in most cases due to the prolonged stationing Asian anticyclone).

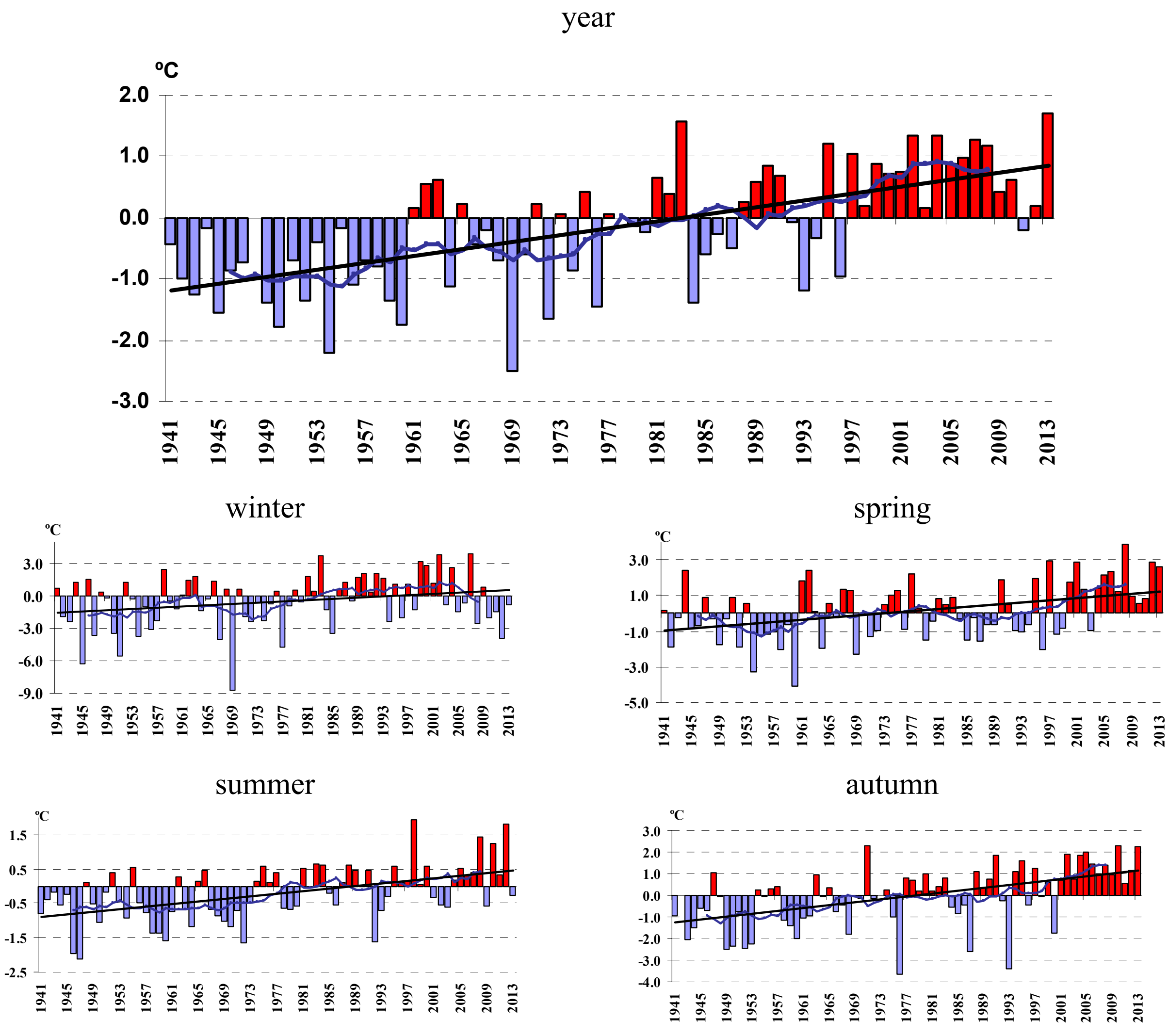
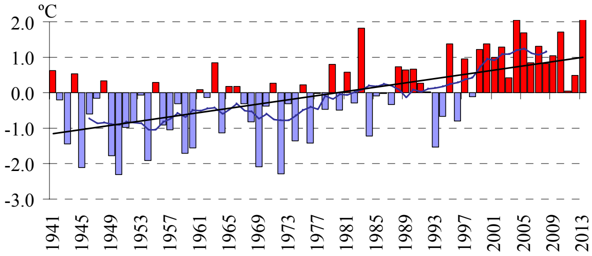


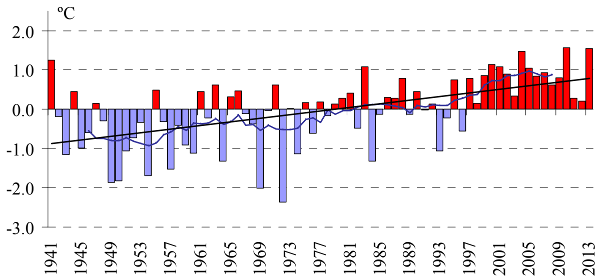
Figure 2.2 – Time series and linear trends of the annual and seasonal air temperatures anomalies (relative to 1971…2000) for 1941...2013 for Kazakhstan. The smooth curve represents the 11-year moving average

The fastest increase in the average annual temperature was in West Kazakhstan oblast equal to 0,39 ^{0}C every 10 years. The lowest warming rates were in South-Kazakhstan Oblast, East Kazakhstan Oblast, Almaty Oblast and Mangistau Oblast amounting to 0,22...0,26 ºC every 10 years. In other oblasts the temperature increase rates were within 0,27...0,32 ºC every 10 years (Table 2.2, Figure 2.3).

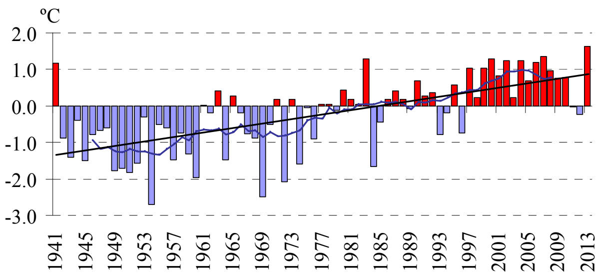
Kyzylorda oblast



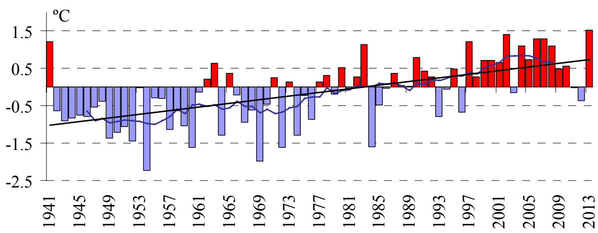
South Kazakhstan oblast



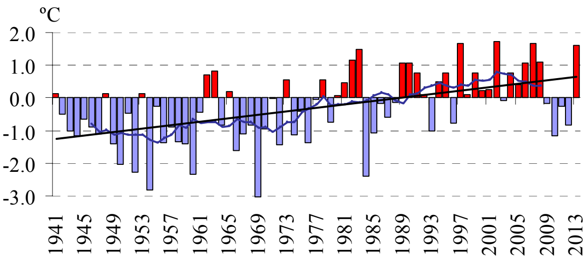
Zhambyl oblast



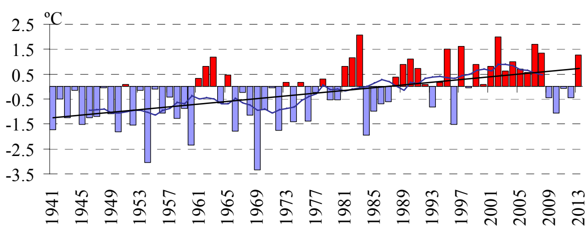
Almaty oblast



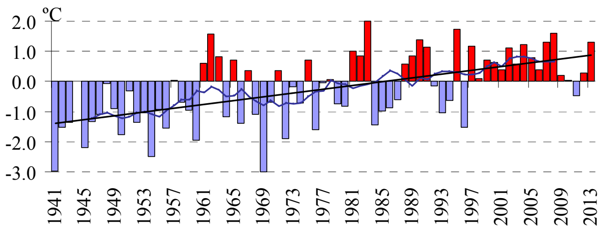
East Kazakhstan oblast



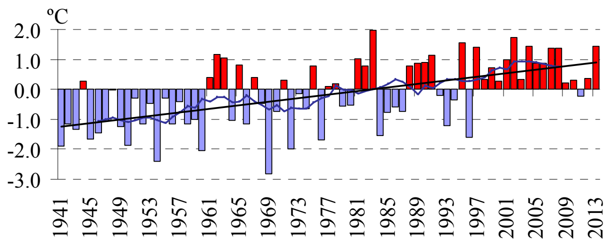
Pavlodar oblast



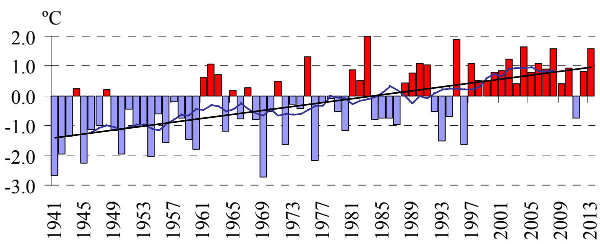
North Kazakhstan oblast



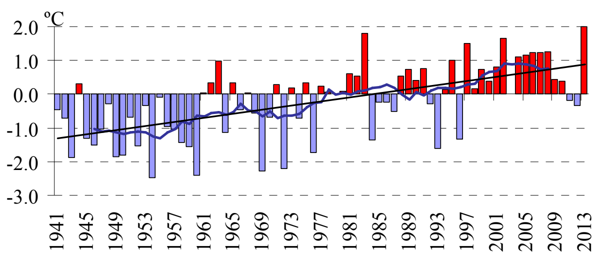
Akmola oblast



Kostanay oblast



Karaganda oblast



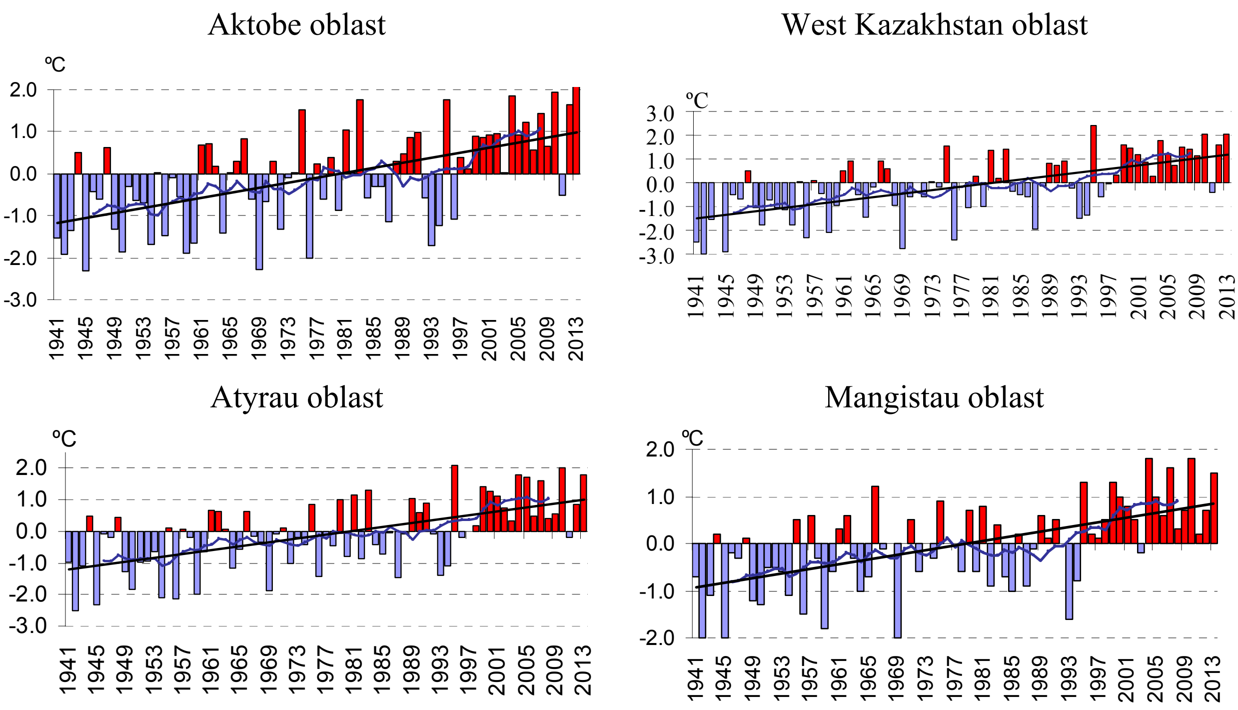


Figure 2.3 – Time series and linear trends of the annual average air temperatures anomalies (relative to 1971…2000) for 1941...2013 for Kazakhstan (^{0}C). The smooth curve represents the 11-year moving average

The biggest temperature increase was observed in southern and eastern oblasts in autumn (0,30…0,40 ºC every 10 years), in northern, Aktobe, Karaganda oblasts in spring (0,36…0,37 ºC every 10 years) and in western oblasts in winter (0,39…0,47 ºC/10 лет). In summer almost everywhere in Kazakhstan the temperature increase linear trend factor was within 0,13 and 0,27 ^{0}C per 10 years. However determination factor is rather high, especially in southern oblasts equal to 17…36 %. This means that air temperature increasing trend is stable. The warming rate in autumn and spring is also stable with determination factor of 12…37 % (Table 2.2).

Table 2.2 – Parameters of the air temperature anomaly linear trend for Kazakhstan and its administrative oblasts for 1941...2013

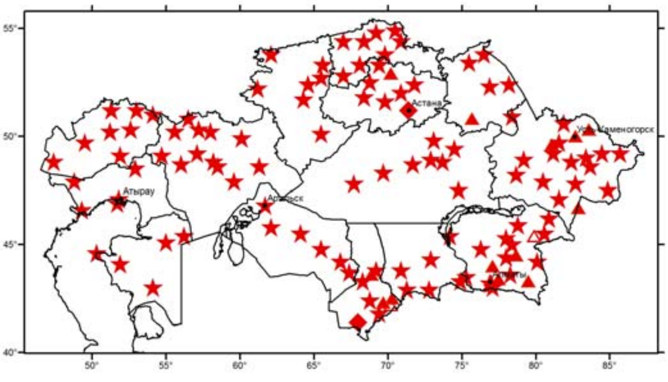
Oblast	Year		Winter		Spring		Summer		Autumn	
	*a	**R^2	a	R^2	a	R^2	a	R^2	a	R^2
Kazakhstan	0,28	39	0,28	6	0,30	16	0,19	24	0,33	27
Kyzylorda	0,30	35	0,25	3	0,33	16	0,26	32	0,33	26
South Kazakhstan	0,22	28	0,18	2	0,21	11	0,16	17	0,34	30
Zhambyl	0,31	41	0,29	5	0,24	12	0,27	36	0,40	37
Almaty	0,24	33	0,28	7	0,22	12	0,13	12	0,30	26
East Kazakhstan	0,26	25	0,26	5	0,27	11	0,14	10	0,32	18
Pavlodar	0,27	25	0,26	3	0,36	16	0,14	8	0,30	15
North Kazakhstan	0,31	32	0,30	5	0,36	15	0,21	13	0,35	18

Oblast	Year		Winter		Spring		Summer		Autumn	
	*a	**R^2	a	R^2	a	R^2	a	R^2	a	R^2
Akmola	0,30	32	0,27	4	0,37	15	0,18	11	0,35	19
Kostanay	0,32	33	0,31	5	0,36	13	0,24	15	0,35	19
Karaganda	0,29	32	0,25	4	0,36	16	0,20	17	0,35	22
Aktobe	0,30	31	0,32	6	0,33	11	0,21	13	0,32	18
West Kazakhstan	0,39	40	0,47	11	0,43	19	0,26	16	0,37	24
Atyrau	0,29	34	0,39	9	0,31	15	0,19	18	0,30	21
Mangistau	0,24	31	0,27	8	0,21	9	0,21	18	0,28	17

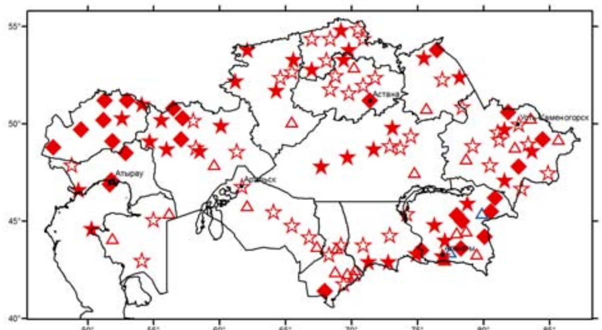
* a – linear trend factor. ºC per 10 years
** R^2 – determination factor. %
Mangistau oblast - parameters calculations were performed only on stations Fort Shevchenko

Figure 2.4 provides more detailed information about changes in seasonal and monthly air temperatures (ºC/10 years) for 1941...2012 in Kazakhstan. Positive trend of average monthly air temperatures is observed almost everywhere in Kazakhstan. Several weather stations recorded negative trends which are statistically insignificant. In February-March, and November-December the air temperature increase was most significant from 0,41 to 0,80 ºC/10 years. In April, June and October the warming rate was slower 0,21...0,40 ºC/10 years. In all other months temperature increased from 0,01 to 0,20 ºC every 10 years. Thus, temperature increase was higher in cold season (November-March) than in warm (April-October). Basing on the spatial distribution of the linear trend factor it is evident that characteristics of circulation processes have changed.

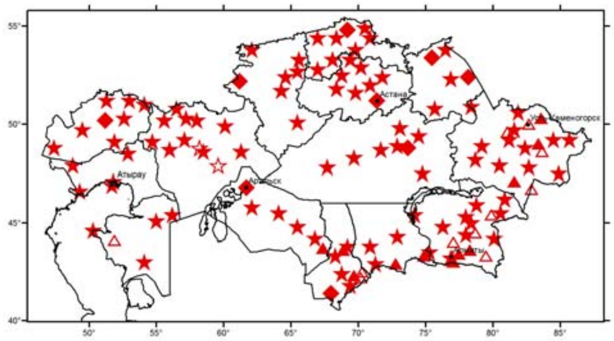
year



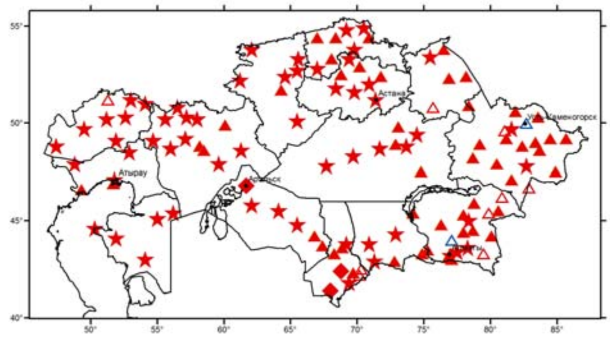
winter



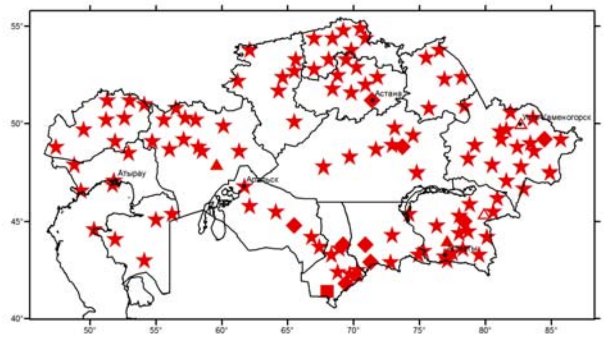
spring



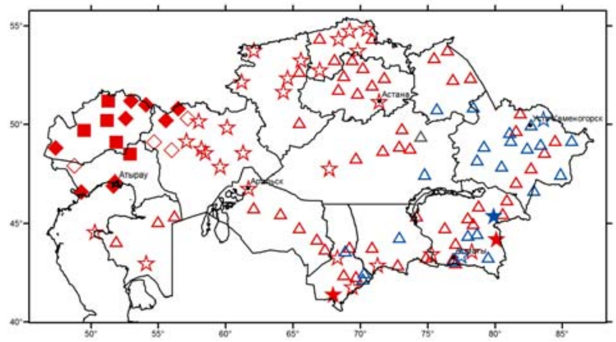
summer



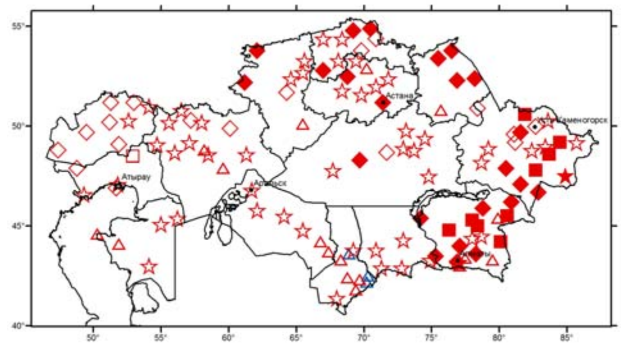
autumn



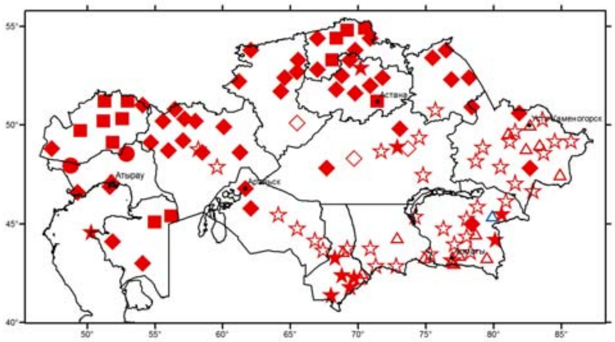
January



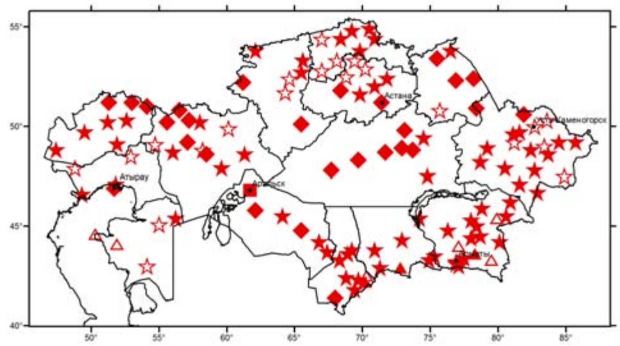
February



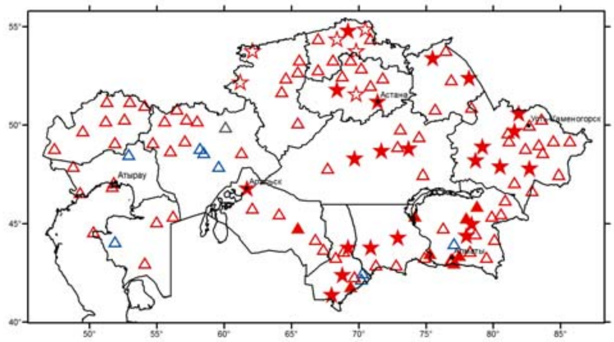
March



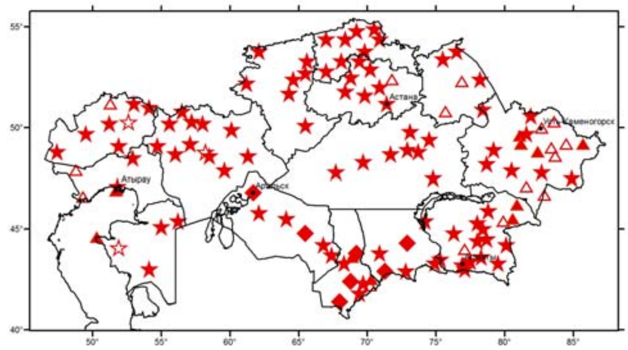
April



May



June



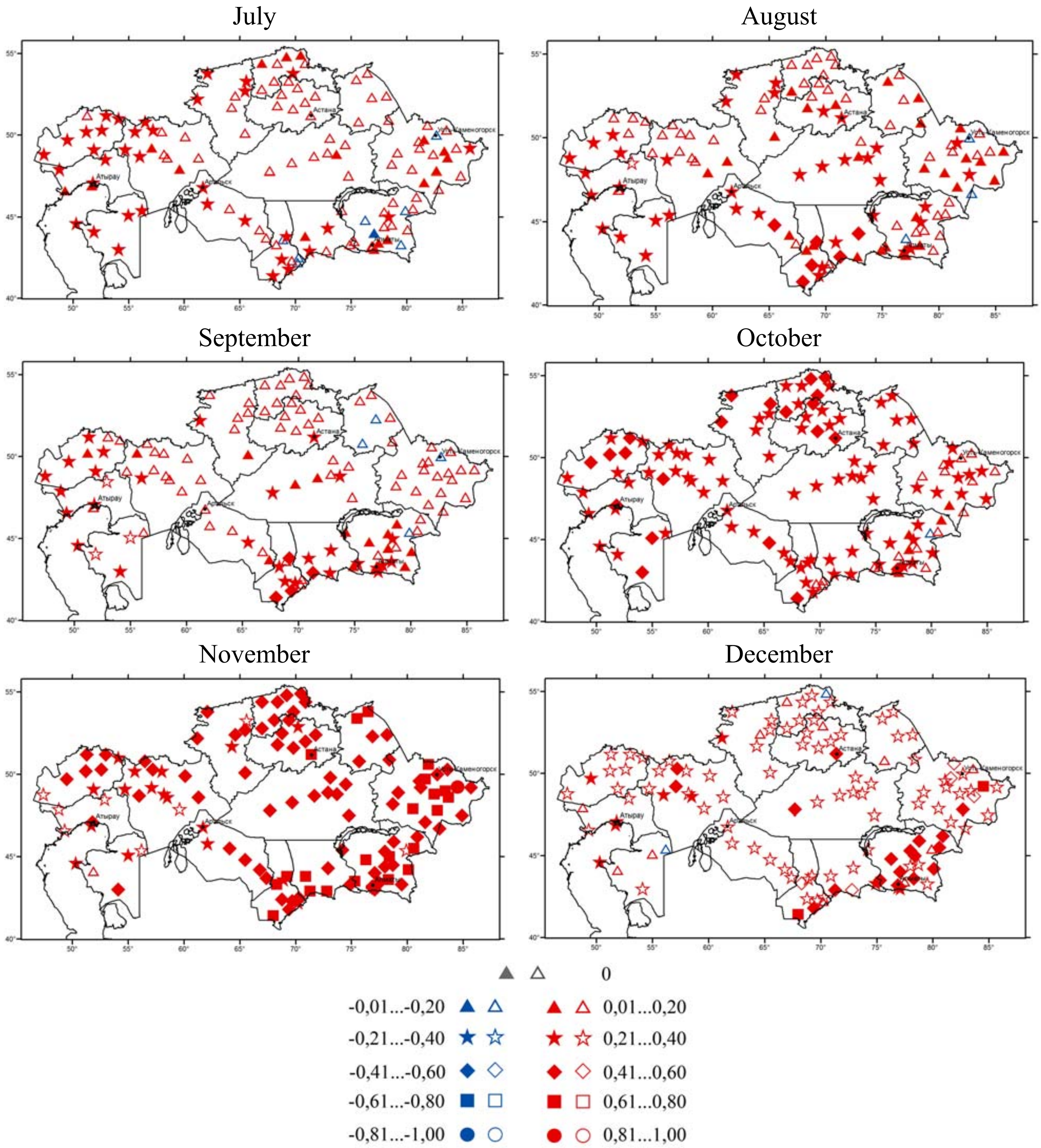


Figure 2.4 – The spatial distribution of the surface air temperature linear trend factors (ºC/10 years) in Kazakhstan for 1941...2012. Legend keys shaded for statistically significant trend

2.2 Temperature anomalies in Kazakhstan in 2013

Annual average temperature anomalies (December 2012-November 2013) were 1-2 ^{0}C higher than the norm in the west, south and the central of Kazakhstan. In this regions 2013 appeared within 10 % of the extremely warm years. In all other regions temperature anomalies were within ±1 °C (Figure 2.5a).

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

Winter

The winter of 2013 (December 2012 - February 2013) was cold in North and East Kazakhstan as well as Pavlodar, Karaganda and Almaty regions. Temperature anomalies in these regions varied from minus 1,0 ºC to minus 3,0 ºC. Temperature anomalies were 1,0…2,0°C above the norm in West Kazakhstan and in Kyzylorda oblast and were within ±1,0 °C in the rest part of Kazakhstan (Figure 2.5b). Figure 2.5b shows the distribution of the average annual temperature anomalies for three winter months. Winter temperature conditions was very contrasting, however seasonal average temperature anomalies was smoother. Thus, in December was cold and extremely cold. Air temperature anomaly in the West reached from minus 2,0 to minus 4,0 ºC and in north-east from minus 8,0 to minus 10,0 ºC. In January and February air temperature in the most part of territory of Kazakhstan was 1,0…5,0 ºC above the norm and another part within norm.

Spring

Spring was warm or extremely warm everywhere in Kazakhstan. Air temperatures were 1,0…4,0 ^{0}C above the norm. The highest anomalies of 3,0 to 4,0 ^{0}C were recorded on the vast area of the western, central and partly southern regions of Kazakhstan. In these regions the 2013 spring added to the 10 % of the extremely warm seasons. In the rest of the territory temperature anomalies were 1,0…3,0 ^{0}C within the norm, only the last northern anomalies were within norm (±1 °C, Figure 2.5 c). The hottest month was March and its anomaly was 1,0…9,0 ºC. The centre of heat was in region of Balkhash Lake.

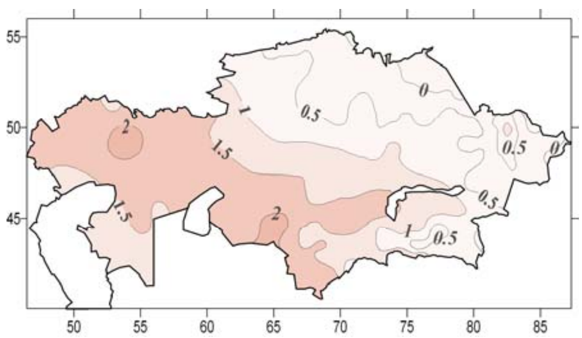
Summer

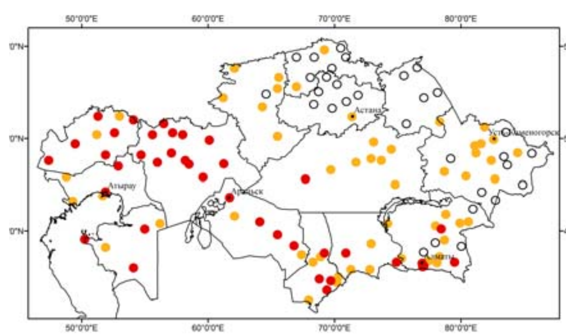
Summer of 2013 was not warm and in the east, north-east of Kazakhstan it was even cool. In the most part of territory of Kazakhstan air temperature was within means average value (Appendix 1), but in east of republic occurred negative anomalies 1,0…1,5 ºC (Figure 2.5d).

Autumn

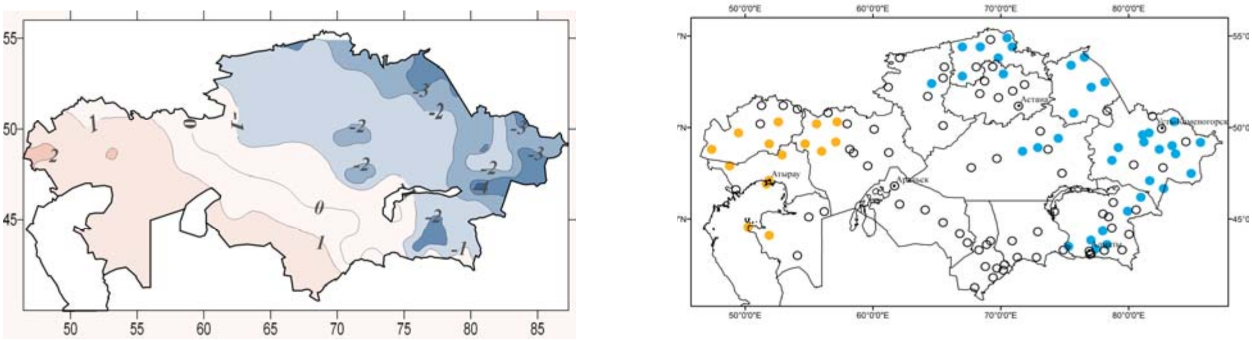
Autumn was warm or extremely warm everywhere in Kazakhstan. The greatest temperature anomalies 2,5…3,0 ºC occurred in the North Kazakhstan and in Kostanay oblast, in the rest of republic – within 1,0…2,5 ºC. Most weather stations of Kazakhstan reported that the 2013 autumn was within 10 % of the warmest autumns (Figure 2.5e). In November air temperature anomalies were positive and increased from 2,0 to 8,0 on the vast area of Kazakhstan.

year

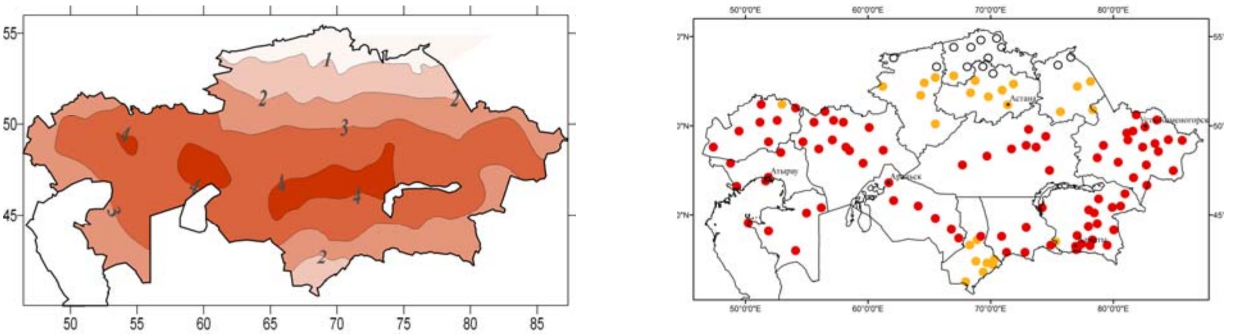




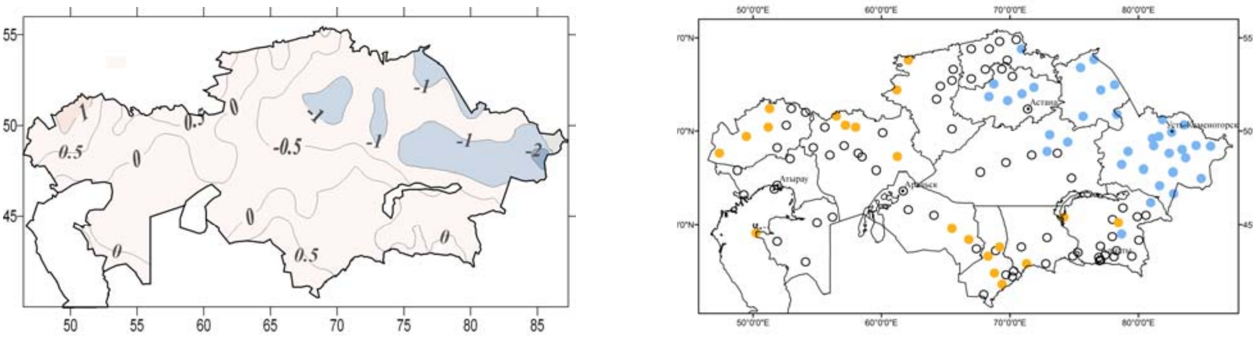
winter



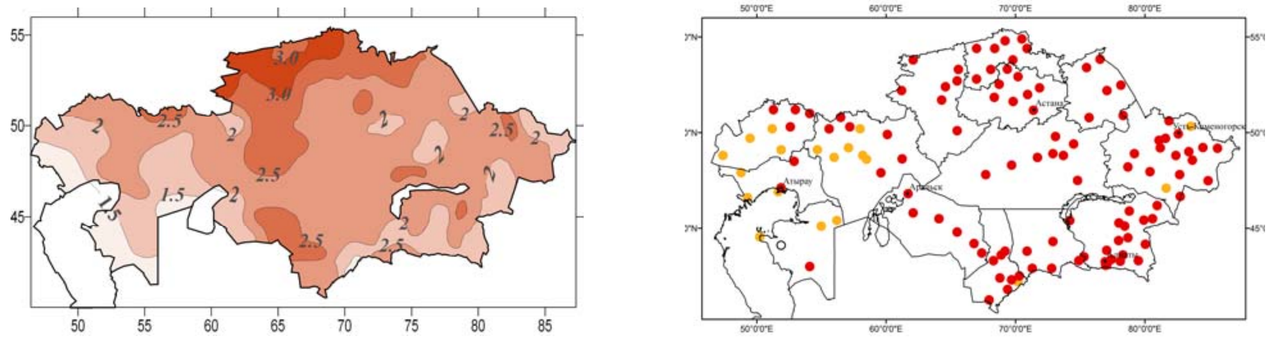
spring



summer



autumn



a) year (Dec 2012 – Nov 2013)
b) winter
c) spring
d) summer
e) autumn

- (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 2013 relative to the 1971…2000 baseline (^{0}C) and nonexceedance probabilities for 2013 air temperatures calculated over 1941…2013

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 2013 is considered below.

Daily maximum of air temperatures in 2013. Figure 2.6 presents in red the absolute maximum of air temperature recorded since the opening of weather station until 2012. The maximum of daily air temperature observed in 2013 is in blue. Absolute maximum temperature since the beginning of records has not been exceeded in 2013 at any considered weather stations The absolute maximum in the north republic reached 32…35 °C, in the south republic was 38…44°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).

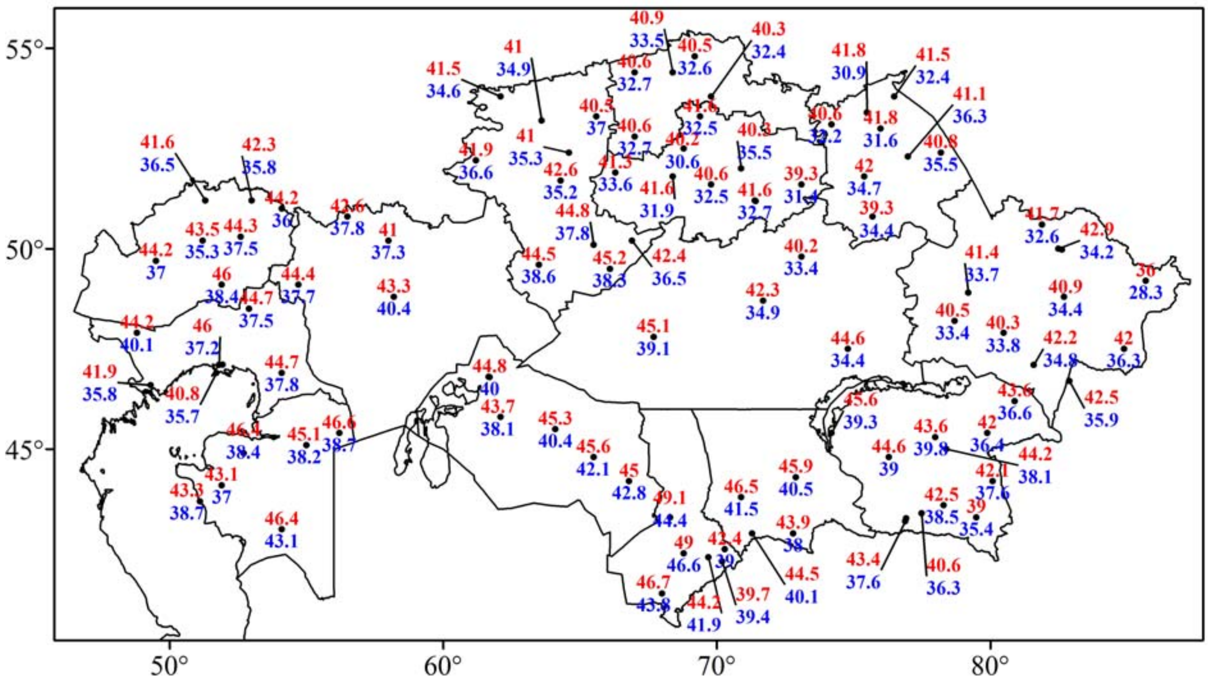


Рисунок 2.6 – Absolute maximum temperature (°C) since the beginning of records until 2012 (red) and the 2013 daily maximum temperature (°C) (blue)

Daily minimum of air temperature in 2013. Absolute minimum temperature since the beginning of records has not been exceeded in 2013 at any considered weather stations (Figure 2.7). In 2013, the lowest temperature (-37...-35 ° C) were observed at some weather stations in the east and in far west of the country. The lowest values of air temperature (absolute minimum) in Kazakhstan were recorded in January 1893 (-52 ° C, Astana) and in January 1931 (-54°C, Orlovsky Poselok).

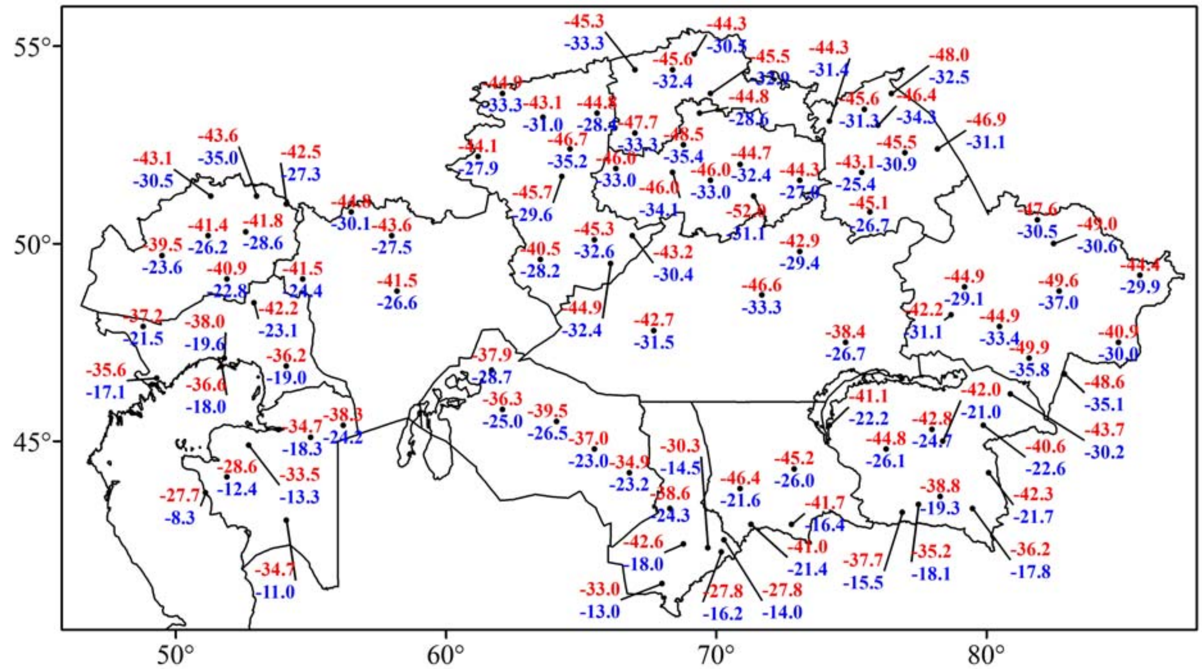


Figure 2.7 – Absolute maximum temperature (°C) since the beginning of records until 2012 (red) and the 2013 daily maximum temperature (°C) (blue)

Number of days with temperatures above 35 °C in 2013. Figure 2.8a presents spatial distribution of the number of days with temperatures above 35 °C in 2013.

Maximum number of days with high temperatures in the south region of Kazakhstan was equal to 20...60 days with 10…20 % probability of non-exceedance. In the eastern and the north-eastern Kazakhstan daily temperature seldom exceeded 35 °C (Figure 2.8b).

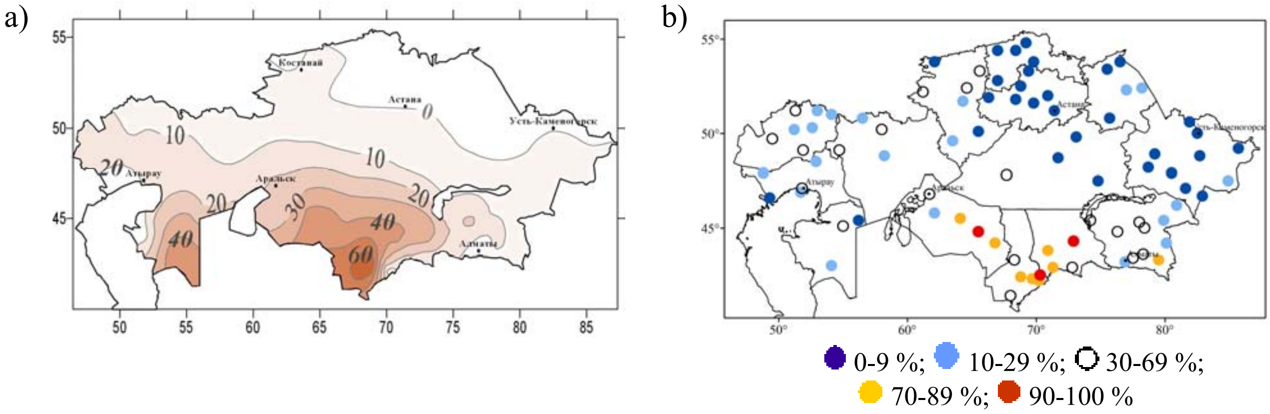


Figure 2.8 – Number of days (a) and the probability of nonexceedance of the number of days with temperatures above 35 ºC in 2013 (b) for 1941...2013

Percentage of days with the daily maximum temperatures above the 90th percentile amounted to 12…20 % in Kazakhstan in 2013 (Figure 2.9a). The most frequently maximum temperatures exceeded 90th percentile in the central region, western and south-eastern Kazakhstan.

Percentage of days with the daily minimum temperatures below the 10th percentile characterizes the frequency of extremely low temperatures. In 2013 the maximum number of such days (> 10 %) was observed in the southern part of the Balkhash Lake (Figure 2.9b).

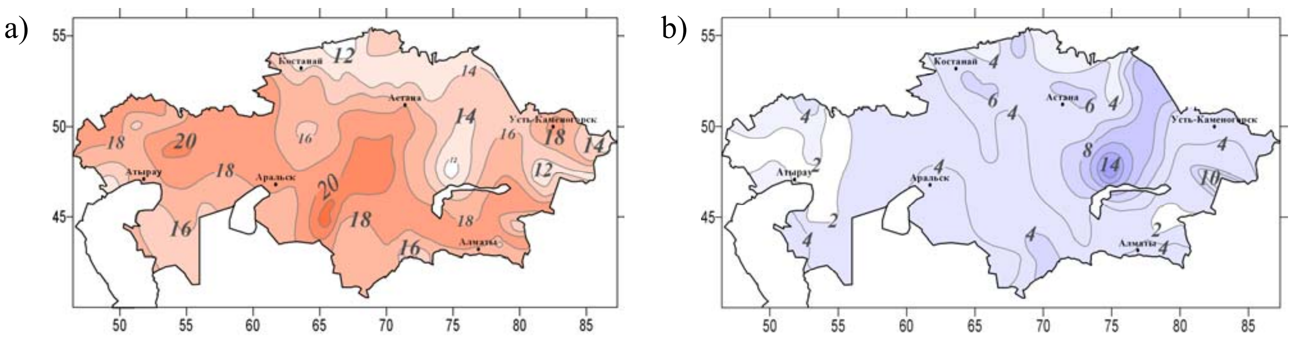


Figure 2.9 – Percentage of days with the daily maximum temperatures above the 90th percentile (a) and with the daily minimum temperatures below the 10th percentile (b) in 2013

Figure 2.10a shows the total duration of heat waves in Kazakhstan in 2013 (***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 Kazakhstan with maximum in Aktobe oblast (30…42 days) and in the central part of republic (24…30 days). Heat waves only lasted for 6…18 days in other regions.

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 2013 cold waves not observed in most part of Kazakhstan (Figure 2.10b). The exception was a small area in the far north and the area northern of Balkhash Lake, where the maximum duration of a cold wave was more than 18 days (Figure 2.10b).

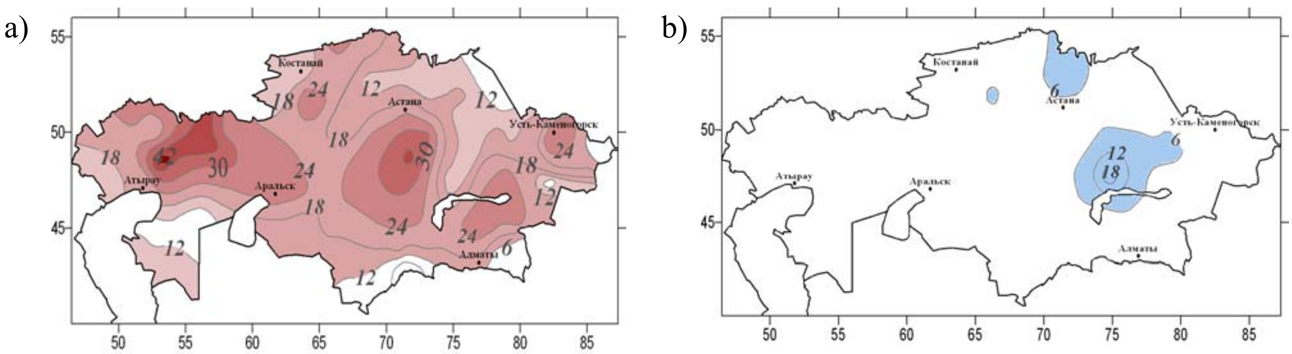


Figure 2.10 – Total sum of days with at least of 6 consecutive days the daily maximum temperature above the 90th percentile (a); and at least of 6 consecutive days the daily minimum temperature below the 10th percentile (b) in 2012

Figure 2.11 presents duration of vegetation period in 2013 (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 200 days in the north and more than 300 days in the south of Kazakhstan.

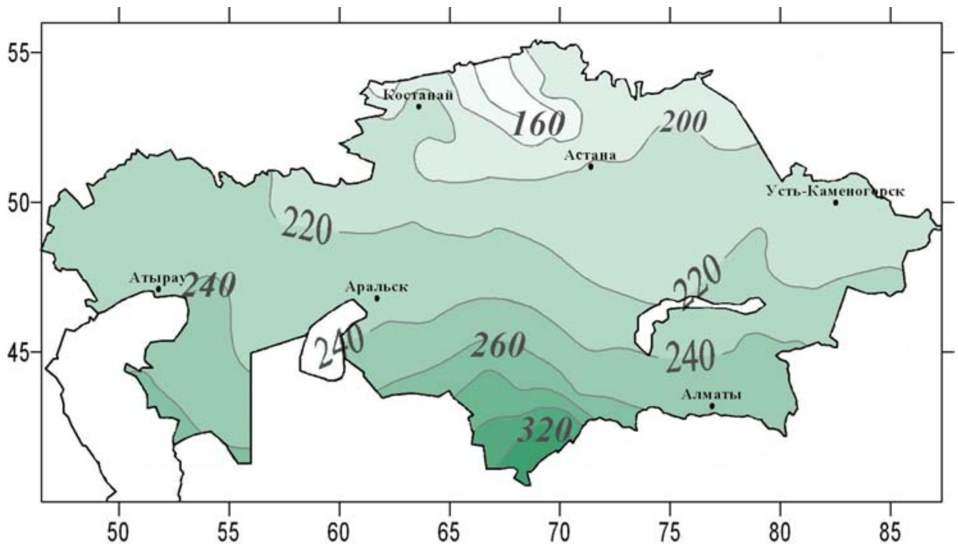


Figure 2.11 - The duration of vegetation period (days) in 2012

2.3 Trends in surface air temperature extremes

Trend analysis of the surface air temperature extremes was performed for 1941...2012.

The ***daily maximum surface air temperatures*** tend to increase at most meteorological stations of Kazakhstan. However statistically significant trends can be observed mainly in East Kazakhstan, Pavlodar, Kyzylorda Mangistau and Atyrau oblasts (Figure 2.12). Daily maximum temperatures increase by 0,01...0,40 ºC every 10 years. In some regions the increase amounts to 0,41...0,60 °C every 10 years.

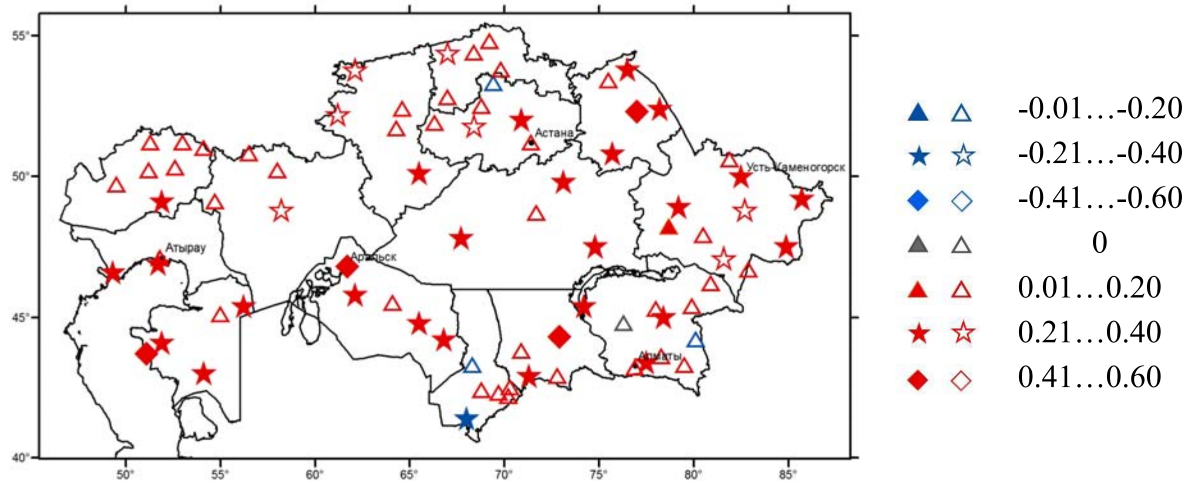


Figure 2.12 – Spatial distribution of the linear trend factors of daily maximum air temperatures (ºC/10 years) for 1941...2012. Shaded keys are for statistically significant trend

Statistically significant increase (1 to 5 days every 10 years) in the ***number of days with temperatures above 35 ºC*** appeared in western and southern regions of Kazakhstan (Figure 2.13). In the northern and eastern regions the frequency of hot days has not changed during 1941...2012.

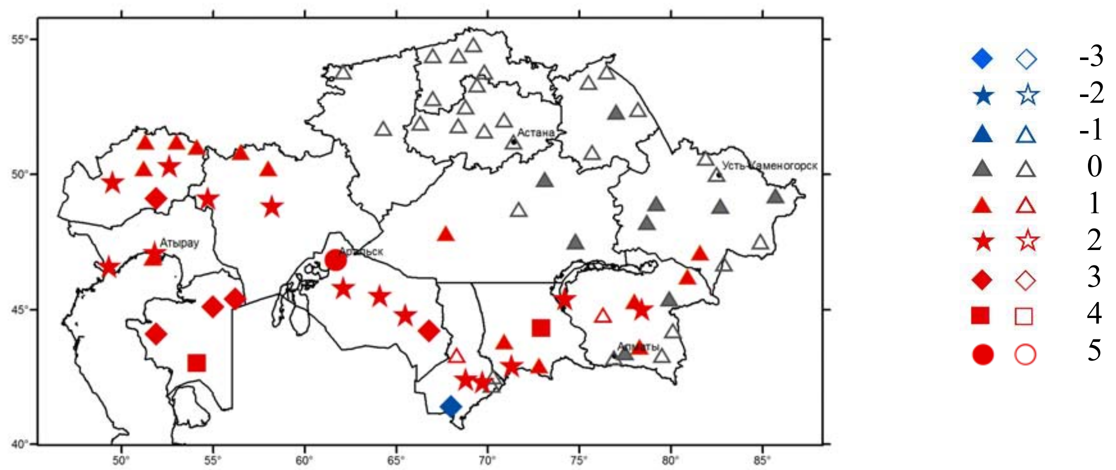


Figure 2.13 – Spatial distribution of the linear trend factors for the number of days with temperatures above 35 ºC (days/10 years) for 1941...2012. Shaded keys are for statistically significant trend

The total duration of heat waves increased throughout the country by 1 to 3 days/10 years (Figure 1.19). 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.

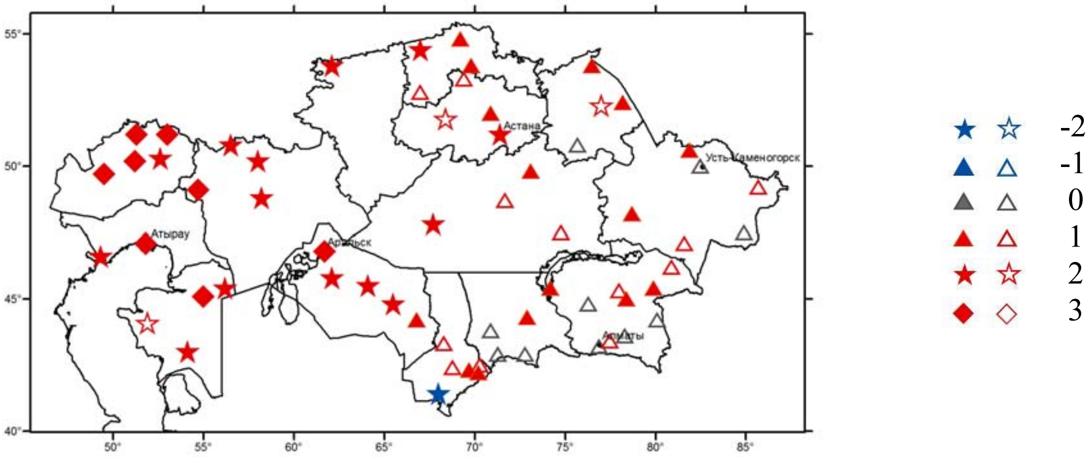


Figure 2.14 – Spatial distribution of the linear trend factors of the total duration of heat waves (day/10 years) during 1941...2012. Shaded keys stand for statistically significant trend

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 the mountain regions of the southern Kazakhstan (5...6 days every 10 years). In other regions the number of frost days reduces by 1...4 days every 10 years.

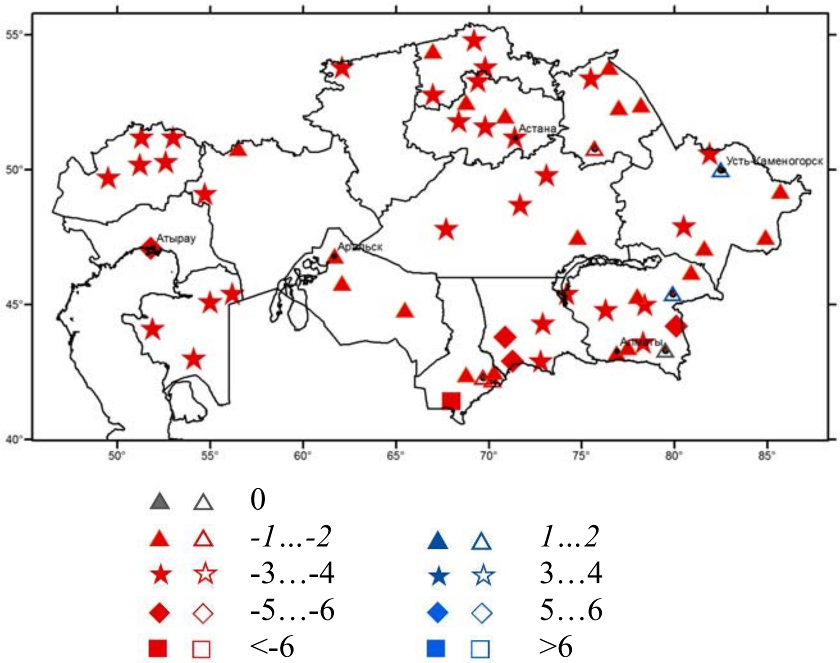


Figure 2.15 – Spatial distribution of the linear trend factors of the number of days with daily minimum temperature below 0 °C (day/10 years) for 1941...2012. Shaded keys stand for statistically significant trend

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.

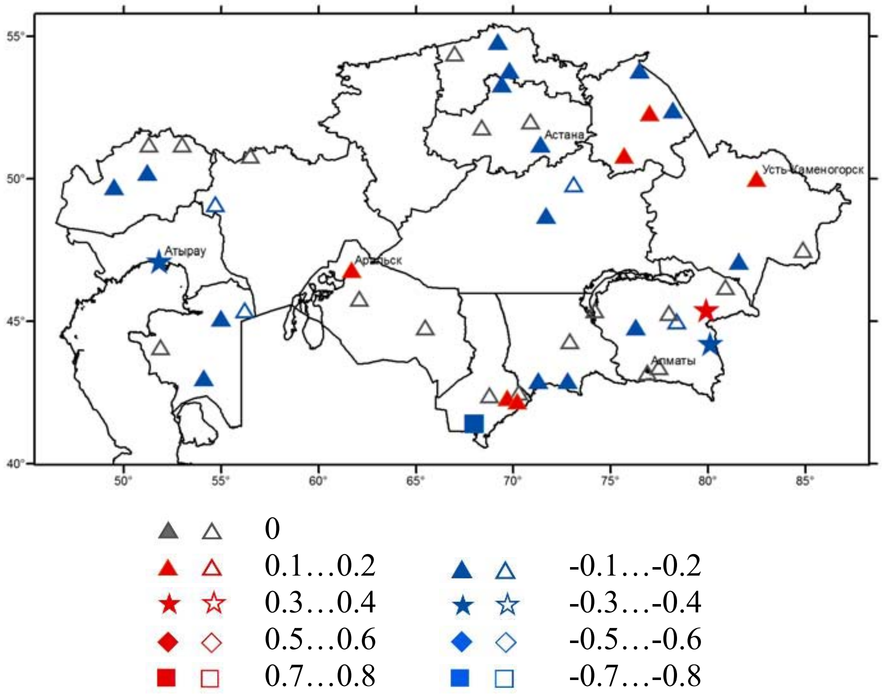


Figure 2.16 – Spatial distribution of the linear trend factors of the daily air temperature amplitude (°C/10 years) for 1941 ... 2012. Shaded keys stand for statistically significant trend

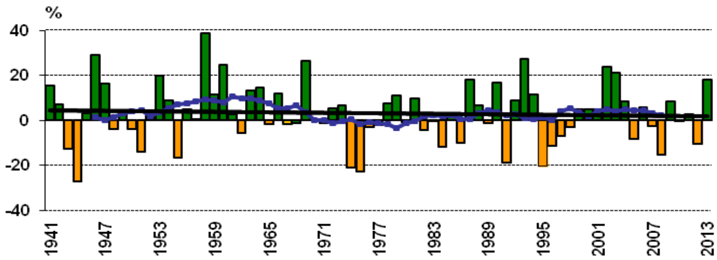
3 PRECIPITATION

3.1 Observed changes in precipitation in Kazakhstan for 1941-2013

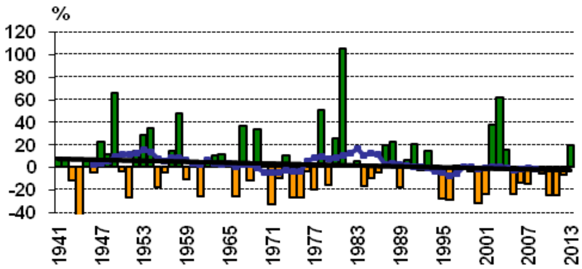
In contrast to the air temperature, changes in precipitation in Kazakhstan are more diverse. Experts estimated linear trends of the monthly, seasonal and annual precipitation time series for 121 weather stations. In some regions of Kazakhstan precipitation increased slightly, whereas in other regions they decreased.

Figure 3.1 shows the time series of annual precipitation anomalies for 1941...2013, calculated relative to the 1971...2000 baseline and spatially averaged for Kazakhstan and oblasts. On average annual precipitation has been decreasing slightly by 0,6 mm every 10 years, or about by 0,4 % of normal per 10 years (table 3.1). A slight increase in annual precipitation (by 0,4...4,0 mm/10 years) was observed in Karaganda, Aktobe, Mangistau, Pavlodar, Akmola, North Kazakhstan and Almaty oblasts. In other oblasts –Zhambyl, Kyzylorda, Kostanay, South-Kazakhstan, West-Kazakhstan, Atyray and East-Kazakhstan – precipitation has been decreasing by 1,6…4,2 mm per 10 years. All annual trends are statistically insignificant.

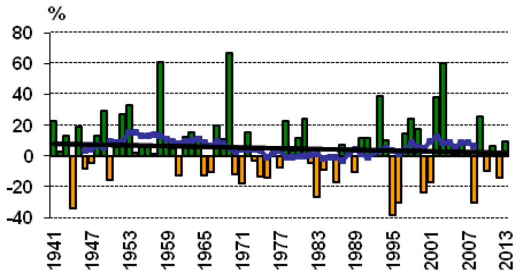
Kazakhstan



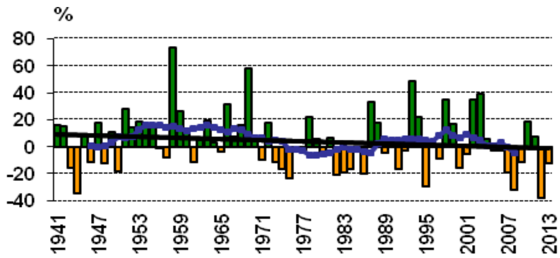
Kyzylorda oblast



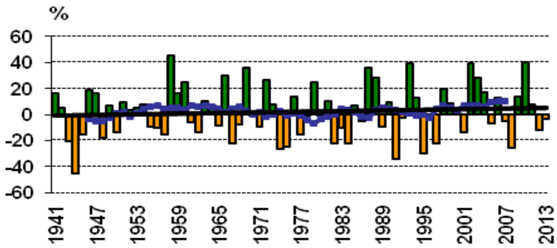
South Kazakhstan oblast



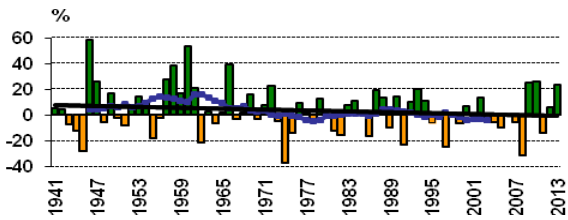
Zhambyl oblast



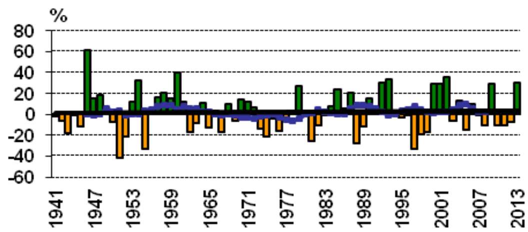
Almaty oblast



East Kazakhstan oblast



Pavlodar oblast



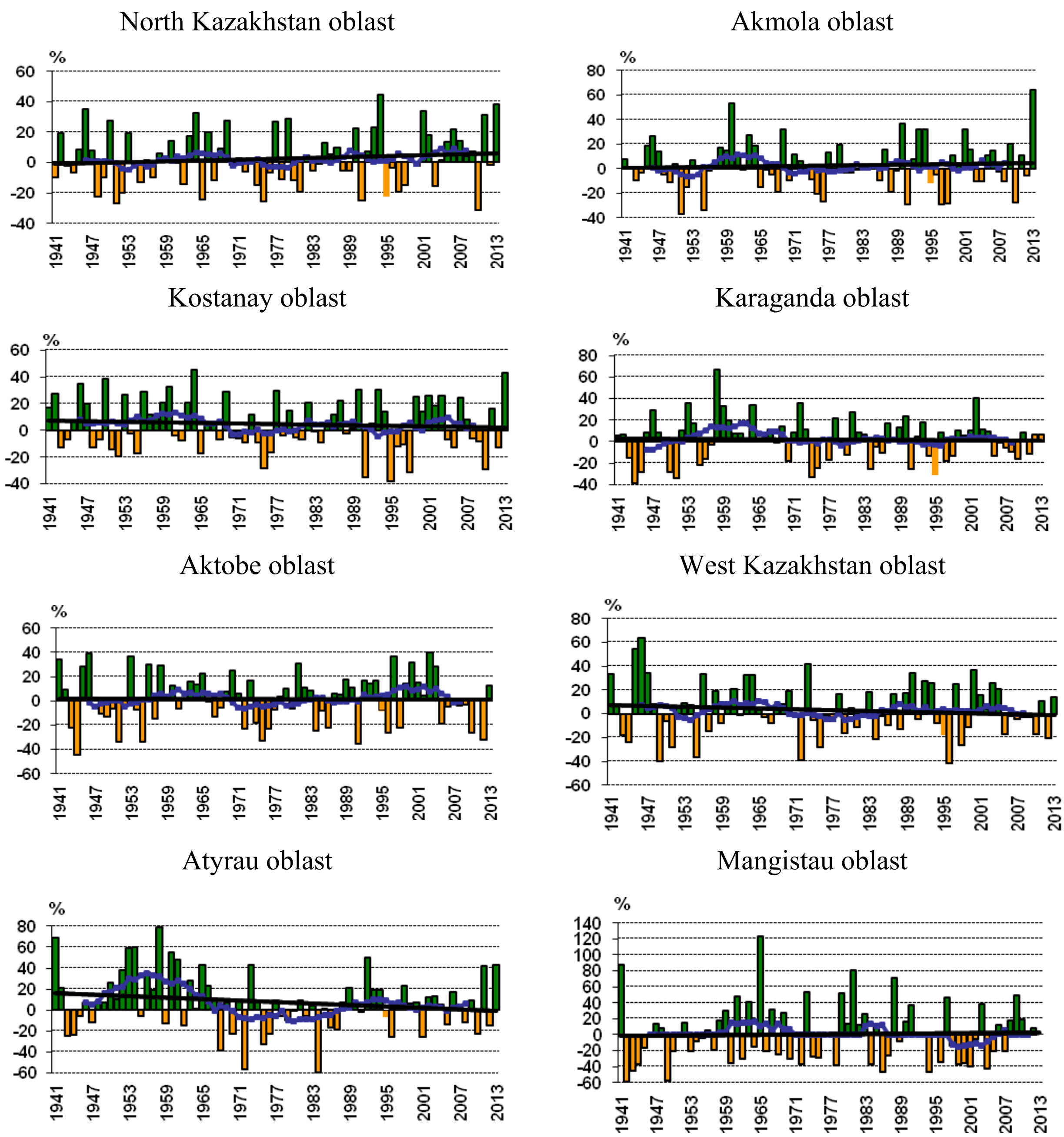


Figure 3.1 – Time series and linear trends of annual and seasonal precipitation anomalies (%) for 1941...2013 calculated relative to the 1971...2000 baseline. *The smooth curve shows the 11-year moving average*

Table 3.1 – Linear trend parameters of the seasonal and annual precipitation anomalies (mm/10 years, %/ 10 years) for Kazakhstan and oblasts for 1941...2013

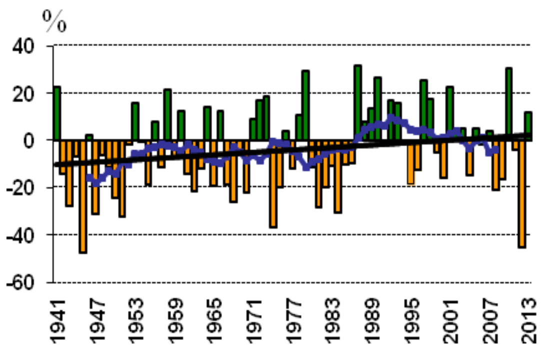
Region/oblast	Unit	Year		Winter		Spring		Summer		Autumn	
		*a	**R^2	a	R^2	a	R^2	a	R^2	a	R^2
Kazakhstan	mm	-0,6	1	1,4	5	-0,6	0	-0,6	0	-0,9	2
	%	-0,4		1,8		-0,2		-0,8		-1,4	
Kyzylorda	mm	-1,8	1	-0,6	1	-0,6	0	-0,2	0	-0,7	1
	%	-1,4		-1,4		-1,1		-1		-2,1	

Region/oblast	Unit	Year		Winter		Spring		Summer		Autumn	
		*a	**R^2	a	R^2	a	R^2	a	R^2	a	R^2
South Kazakhstan	mm	-3,3	1	0,5	0	-4,3	2	0,6	0	-0,2	0
	%	-0,8		0		-2,7		0,3		0,6	
Zhambyl	mm	-2,6	2	0,9	1	-3,3	4	0,2	0	-0,3	0
	%	-1,4		0,4		-3,4		-0,1		-0,8	
Almaty	mm	3,6	1	3,2	9	-2,3	1	2,1	2	0,3	0
	%	0,9		4,1		-1,6		1,9		0,6	
East Kazakhstan	mm	-4,2	2	0,8	1	-1,2	2	-2,5	2	-1,2	1
	%	-1,2		1,2		-2,0		-2,0		-1,4	
Pavlodar	mm	0,9	0	1,3	6	1,2	2	0,4	0	-2,4	6
	%	0,3		2,5		2,2		0,4		-3,6	
North Kazakhstan	mm	3,2	1	3,2	16	2,1	4	-2,4	1	0,4	0
	%	0,9		5,8		3,5		-1,6		0,4	
Akmola	mm	1,7	0	1,8	6	1,2	2	0,1	0	-1,9	3
	%	0,5		3,3		1,5		0,1		-2,7	
Kostanay	mm	-1,6	1	0,3	0	1,2	1	-1,2	1	-2,5	5
	%	-0,8		0,7		1,7		-1,5		-3,4	
Karaganda	mm	0,6	0	1,8	5	0	0	-0,7	0	-0,7	2
	%	-0,2		1,7		-0,2		-1,3		-1,9	
Aktobe	mm	0,8	0	1,7	4	2,2	3	-1,3	1	-2,1	4
	%	0		1,9		3,3		-1,9		-3,5	
West Kazakhstan	mm	-2,9	1	1,3	2	-0,2	0	-2,1	2	-1,6	2
	%	-1,1		2,0		-0,9		-2,9		-2,5	
Atyrau	mm	-3,7	3	-2,3	10	-0,1	0	-1,1	1	-0,4	0
	%	-2,4		-7,7		-0,4		-2,4		-1,1	
Mangistau	mm	0,9	0	0,5	1	1,9	2	-1,5	1	0	0
	%	0,7		2,3		3,9		-5,5		-0,1	

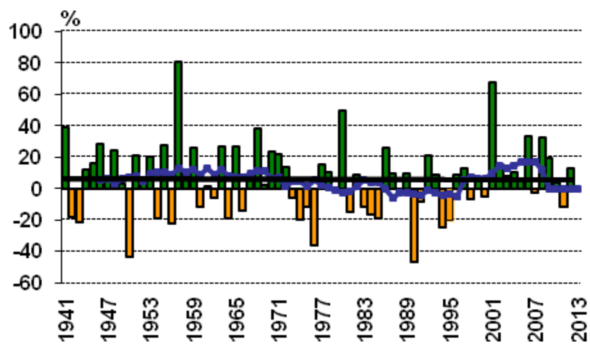
* a – linear trend factor, %/10years, mm/10 years;
** R^2 – determination factor,%

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 1,4 mm every 10 years (statistically significant trend) (table 3.1).

Winter



Spring



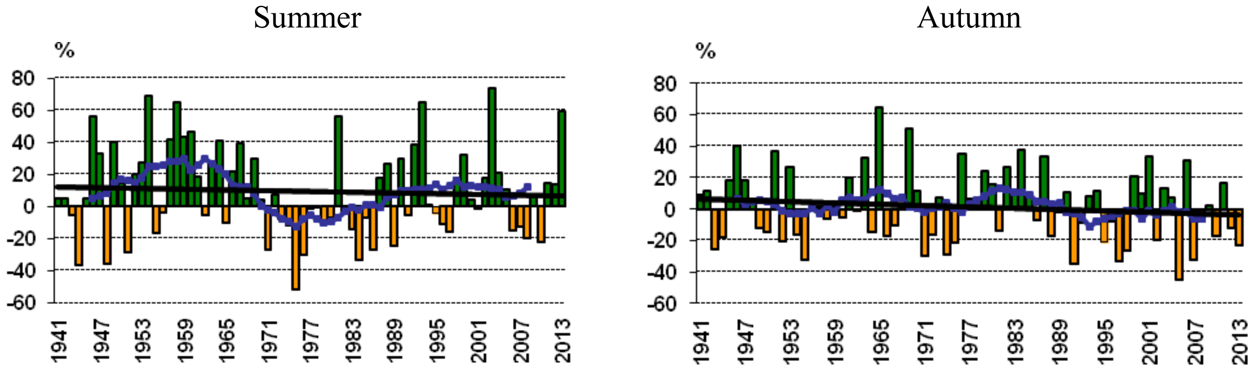


Figure 3.2 – Time series and linear trends of seasonal precipitation anomalies (%) for 1941...2013 relative to the 1971...2000 baseline. *The smooth curve represents the 11-year moving average*

Figure 3.3 and 3.4 provide more detailed information about changes in seasonal and monthly air temperatures (ºC/10 years) for 1941...2012 in Kazakhstan. Changes in the seasonal precipitation are diverse.

Figure 3.3 shows the change in annual and seasonal precipitation in Kazakhstan for 1941-2012 (% of norm/10 years). Changes in the seasonal precipitation are diverse. In summer and autumn in most parts of Kazakhstan except mountain south-eastern regions precipitation decreased by 1...7% of norm every 10 years. In winter precipitation mostly increased. Continuous positive trends were observed in the northern and central regions, mountains and foothills north-western, eastern, south-eastern regions by 1...9 % of normal every 10 years. In spring, a positive trend was observed in the north-western part of Kazakhstan, whereas in other regions precipitation decreased. It should be noted that almost all seasonal trends are statistically insignificant, except winter precipitation.

In January and February precipitation increased everywhere in Kazakhstan by 0.1...9 % per 10 years. In Almaty, Pavlodar, North Kazakhstan, and Akmola oblasts the increase was statistically significant whereas in Atyrau oblast precipitation decreased by about 13 % every 10 years. In spring and summer change in precipitation both negative and positive was negligible all over Kazakhstan, except North Kazakhstan oblast where precipitation increased by 9.2 % every 10 years in March. In September and October precipitation decreased in most of Kazakhstan. In September precipitation reduction was statistically significant in northern half of Kazakhstan and in Karaganda and Kyzylorda oblasts (by 7...14 %/10 years). In November and December, change in precipitation was mostly positive. In North-Kazakhstan and Karaganda oblasts precipitation increase was statistically significant and amounted to 8...9 % every 10 years.

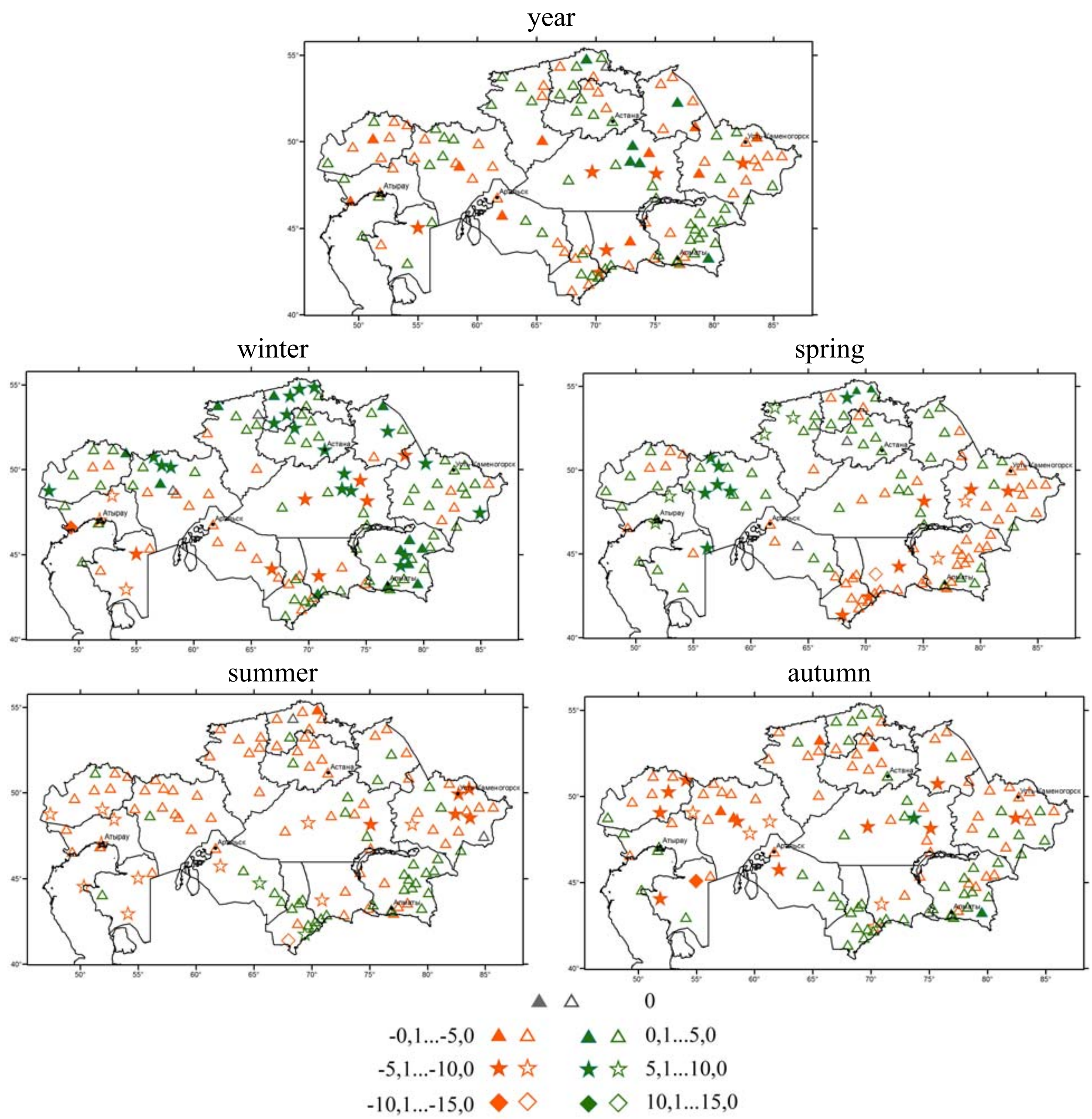
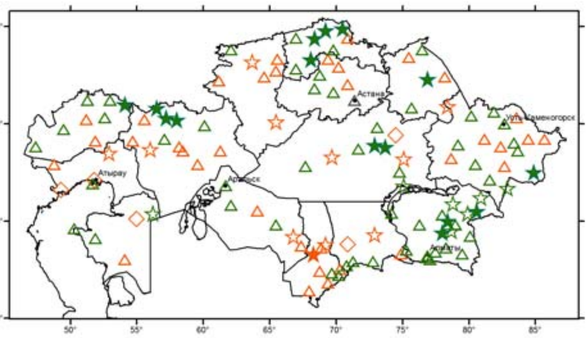
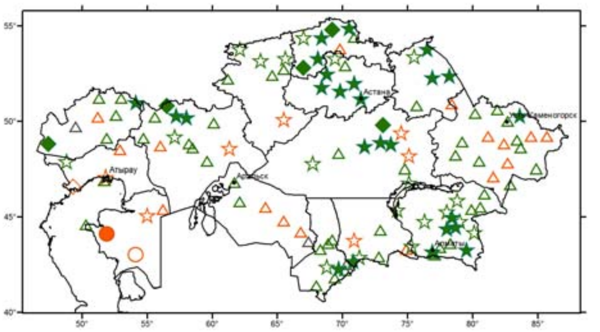
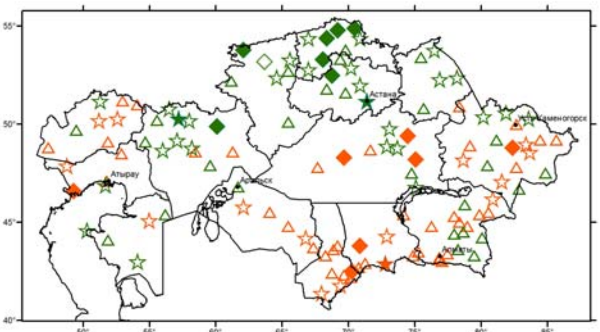
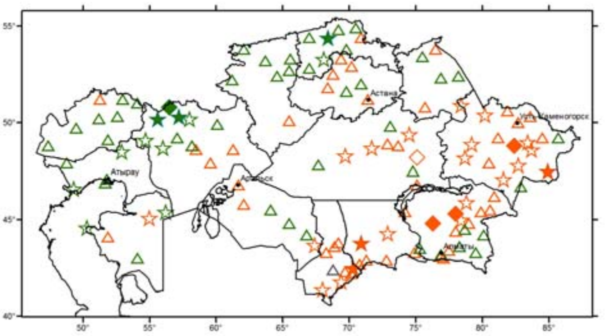
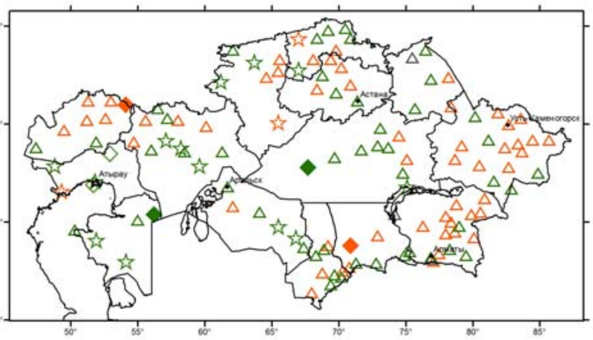
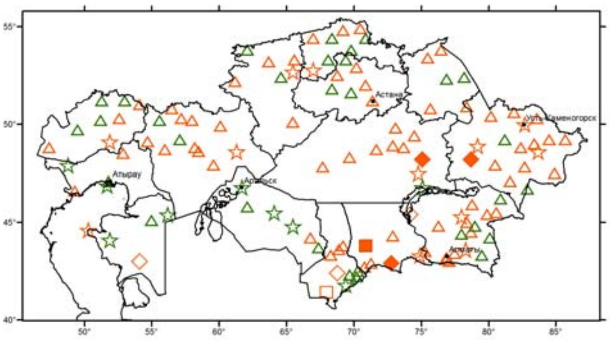
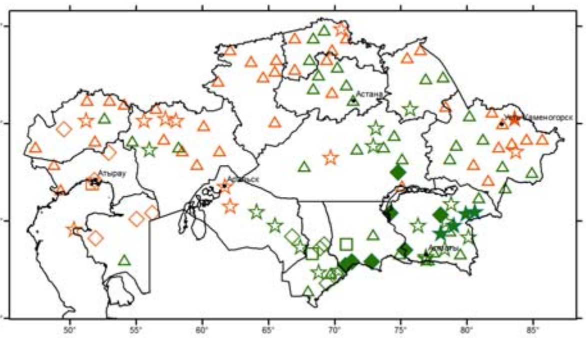
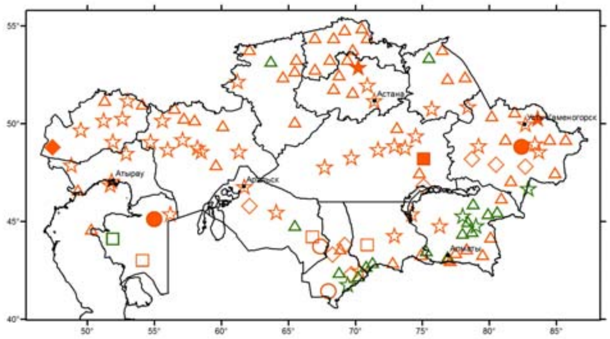


Figure 3.3 – Spatial distribution of the linear trend factor of seasonal and annual precipitation anomalies (%/10 years), over 1941...2012, relative to the 1971…2000 baseline. Shaded keys stand for statistically significant trend

January	February
	
March	April
	
May	June
	
July	August
	

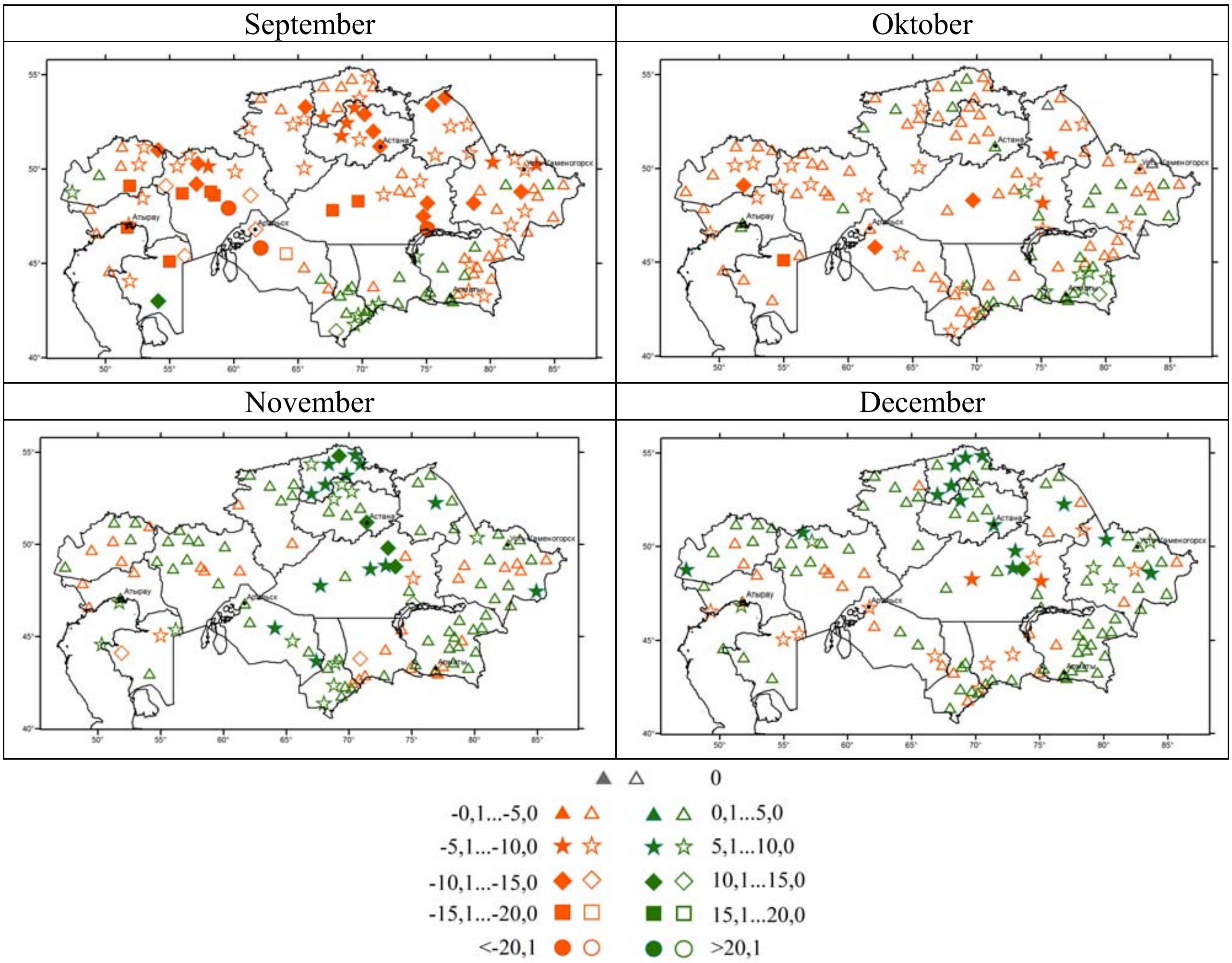


Figure 3.4 – Spatial distribution of the precipitation linear trend factor (% of normal/10 years), over 1941...2012, relative to the 1971-2000 baseline. Shaded keys stand for statistically significant trend

3.2 Precipitation anomalies in Kazakhstan in 2013

Figure 3.5 shows the spatial distribution of annual and seasonal precipitation in 2012, expressed as percentage of normal over 1971...2000 and nonexceedance probability of annual and seasonal precipitation in 2013. The nonexceedance probability means the frequency of the corresponding anomaly in the observational records.

In 2013 (December 2012 through November 2013) the annual precipitation were observed within norm (80…120 %, Figure 3.5a) almost everywhere in Kazakhstan. In North Kazakhstan, and in Far East Kazakhstan annual precipitation (20…60 %) were higher than normal. These regions in 2013 were within 10 % of extremely wet years since 1941. Deficit of annual precipitation (20…40 %) occurred in Mangistau, Kyzylorda, Zhambyl and Karaganda oblasts.

Winter (December 2012 through November 2013).

In winter, the positive rainfall anomalies - 20 ... 100 % above normal were in southern, eastern and north-eastern regions of Kazakhstan, as well as locally in some western and north-western regions of Kazakhstan. In central and south-western parts of Kazakhstan precipitation was 20…60 % below the norm (Figure 3.5b). In other regions precipitation was within norm.

Spring.

In spring, precipitation exceeded the norm by 20 ... 80 % in northern and north-eastern of the country, as well as places in the central and southern Kazakhstan (Figure 3.5c). Precipitation exceeded the norm by 100 % (Appendix 2) in far north of Kazakhstan. According to results of twenty meteorological stations of these regions spring of 2013 was within 10 % of the extremely wet seasons. Precipitation deficit of 20 ... 60 % was observed in most part of western and in some parts of southern and central Kazakhstan. In other regions precipitation was within norm (80…120 %).

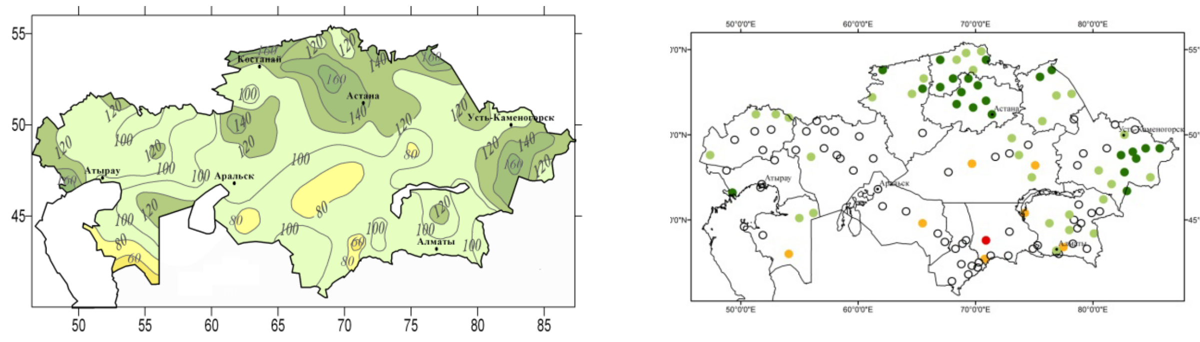
Summer.

Summer 2013 was wet and extremely wet in the most part of the territory of Kazakhstan. Extreme precipitation exceeds the norm in 2 ... 2,5 times, was recorded in Kostanay, North Kazakhstan, Akmola, Pavlodar, East Kazakhstan and Almaty regions. The rest of the territory precipitation exceeded the norm by 20…80 %. In western and locally of Kazakhstan precipitation was within the norm. Small hearths of precipitation deficit (<20 %) was observed in southern and western Kazakhstan. (Figure 3.5d).

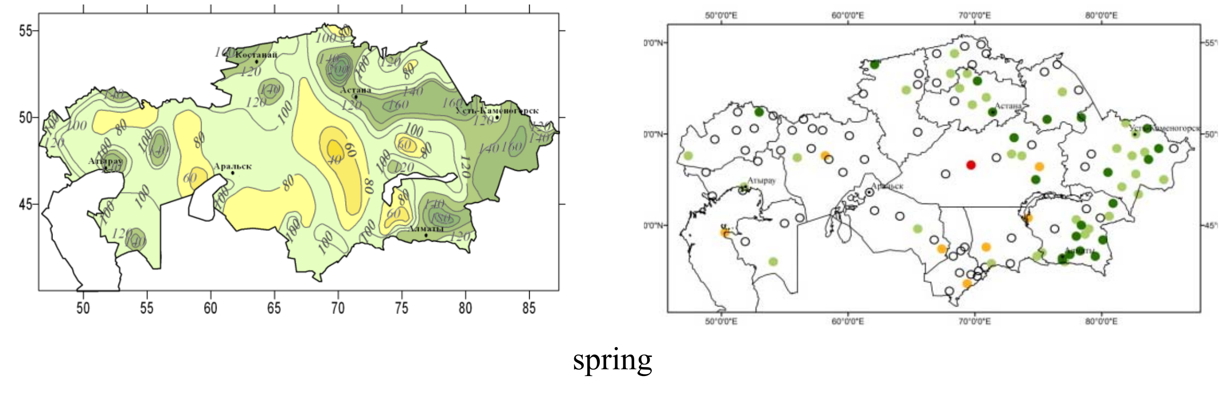
Autumn.

In autumn precipitation deficit of 20…80 % was observed in almost everywhere in Kazakhstan. Extremely dry (non-exceedance probability 90…100 %) was in southern and south-eastern Kazakhstan and same regions of Akmobe, Kostanay, Karaganda and Pavlodar regions. Only in western Kazakhstan precipitation was by 20…100 % above the norm. According to results of five meteorological stations of these regions autumn of 2013 was within 10 % of the extremely wet seasons (Figure 3.5e).

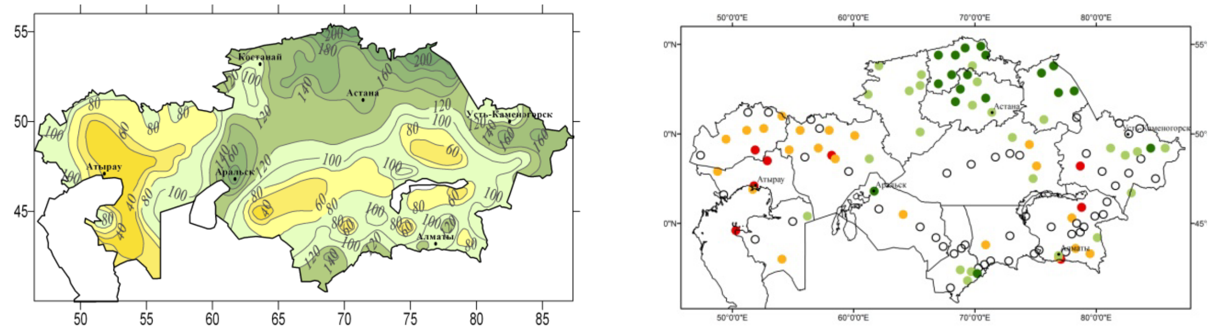
year



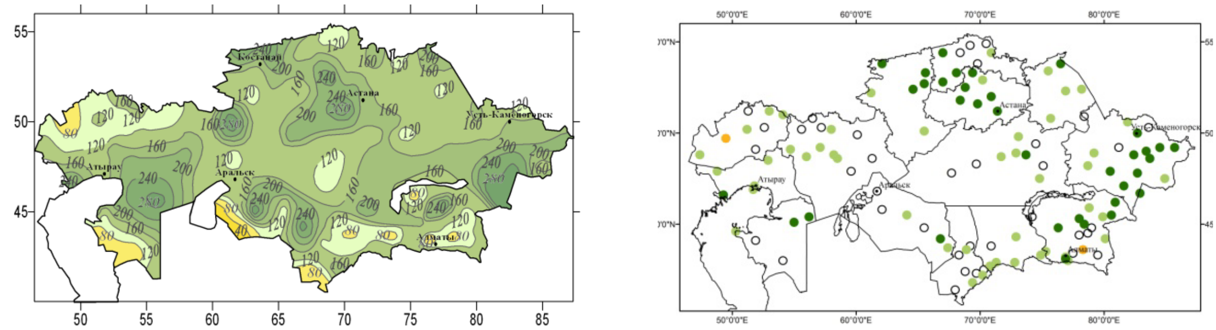
winter



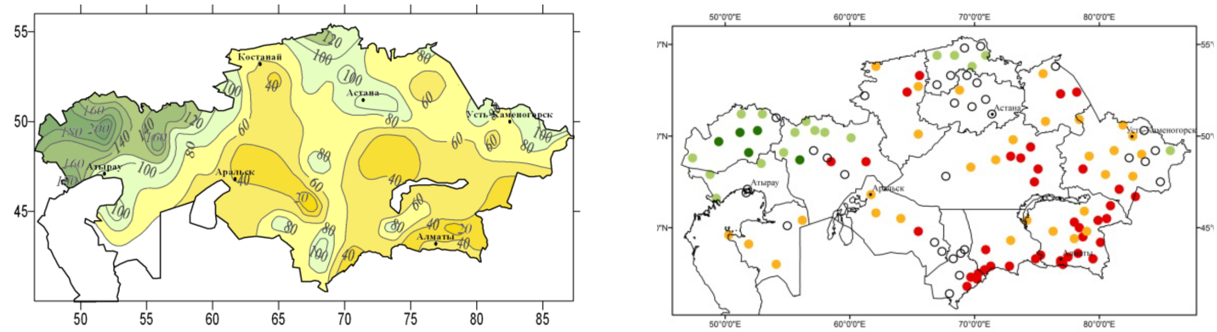
spring



summer



autumn



a) year (Dec 2012 – Nov 2013)
b) winter
c) spring
d) summer
e) autumn

– extremely dry (non-exceedance probability 0-9 %);
– dry (non-exceedance probability 10-29 %);
–about norm (non-exceedance probability 30-69 %);
– wet (non-exceedance probability 70-89 %);
– extremely wet (non-exceedance probability 90-100 %).

Figure 3.5 – Precipitation in 2013 as % of the norm (over 1971…2000) and non - exceedance probabilities in 2013 calculated according to the period 1941 ... 2013

To assess precipitation extremes in 2013 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 2013 are presented below.

Maximum of daily precipitation in 2013. Figure 3.6 shows absolute maximum daily precipitation, since the beginning of records to 2012 in red. Daily maximum observed in 2013 are in blue. In 2013 the absolute maximum of daily precipitation was exceeded at Ganjushkino (Atyrau region) weather station where precipitation amounted to 50 mm.

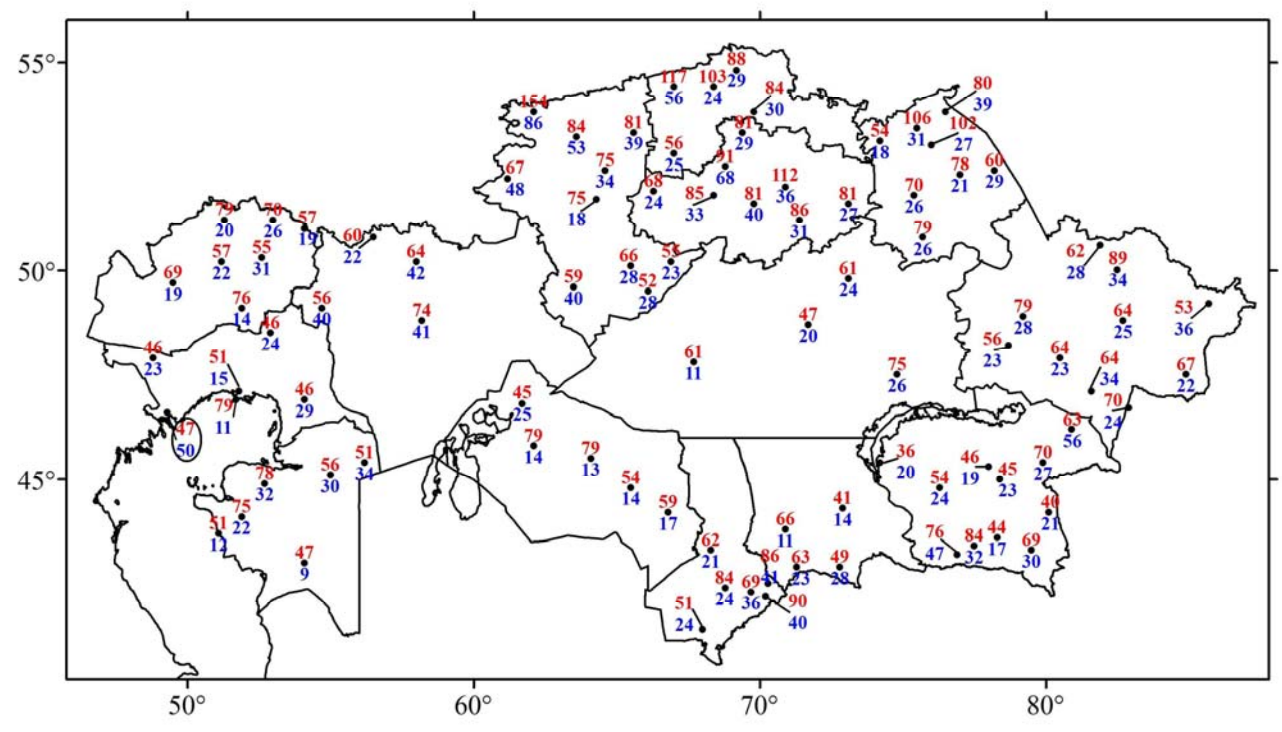


Figure 3.6 – Absolute maximum of daily precipitation, since the beginning of records until 2012 (in red) and the daily maximum in 2013 (in blue), mm

Figure 3.7 shows the share of extreme precipitation (above 95th percentile) in the total precipitation of 2013. 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 Ganjushkino station (56 %) and Karabalik (53 %). At Zhaltir, Mihaylovka, Blagoveschenka, Aral sea, Kushmurun, Karabay, Balkashino, Zhetigora stations also recorded rather high share of extreme precipitation – 40...44 %.

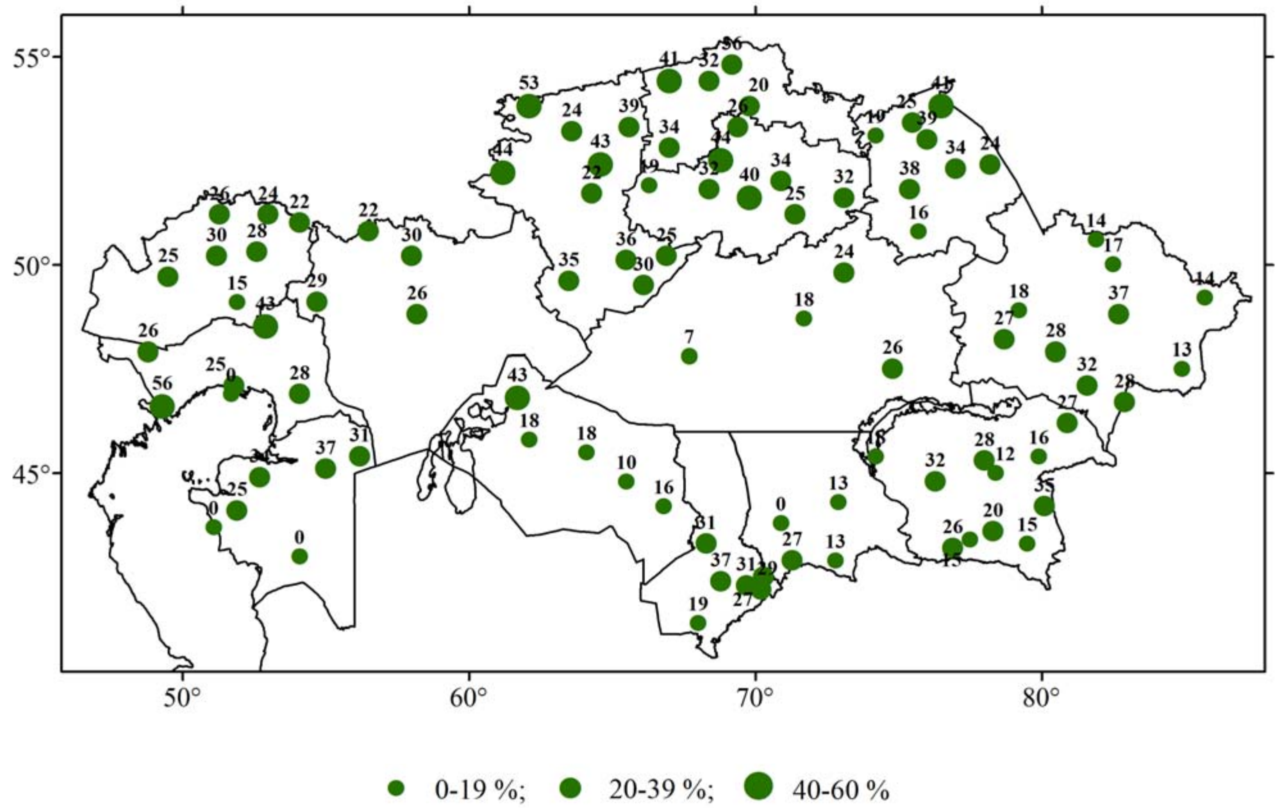


Figure 3.7 – Percentage share of extreme precipitation in the annual total in 2013. Extreme precipitation is the sum of daily precipitation exceeding 95th percentile

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 2013 the dry period lasted for about a month at almost all weather stations. The longest dry periods from 61 to 89 days were in Mangistau, Kyzylorda oblasts and in the southern Kazakhstan. The longest dry periods from 90 to 142 days were in Zhambyl oblast (Uyuk), South Kazakhstan oblast (Shardara, Arys).

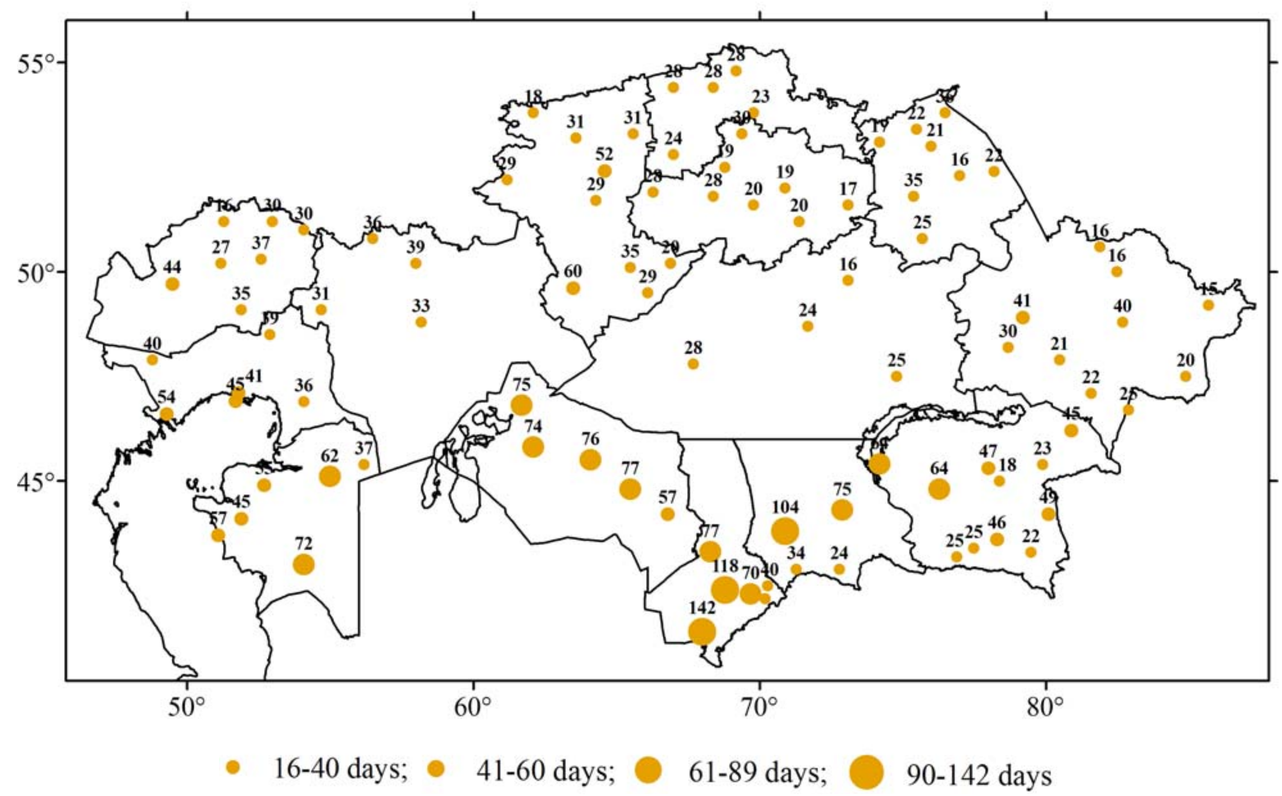


Figure 3.8 – Maximum duration (in days) of dry period in 2013

Figure 3.9 shows the maximum duration of the period in 2013 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 10 days. The longest wet periods of 8…10 days were observed in Katon-Karagay (VKO), Martuk (Aktobe oblast), Kokshetay (Akmola oblast), Ruzaevka (NKO) appropriately. At some stations of North Kazakhstan, Akmola, Kostanai regions, as well as in the south of Kazakhstan. Precipitation is within 6 ... 7 consecutive days. На некоторых станциях Северо-Казахстанской. Акмолинской. Костанайской областях. а также на юге Казахстана. осадки выпадали в течение 6…7 дней подряд.

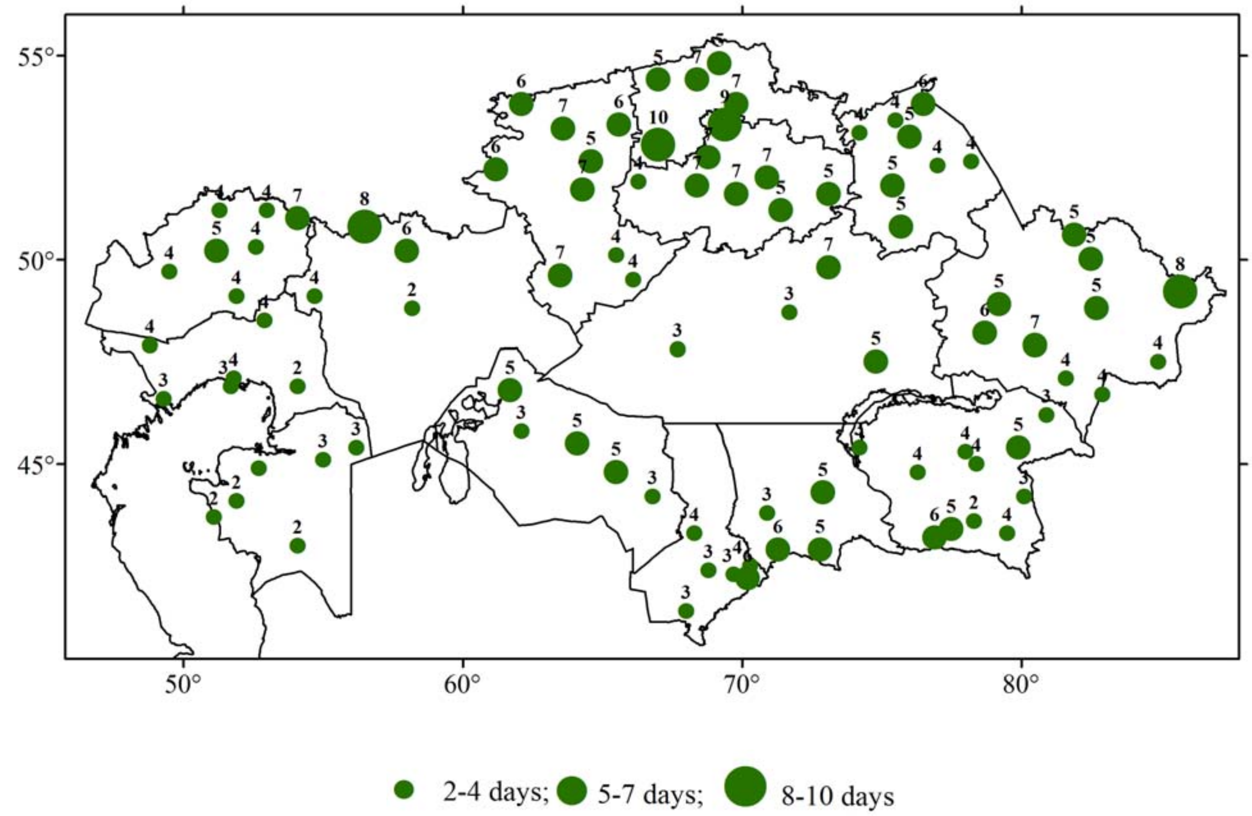


Figure 3.9 – Maximum duration (in days) of wet period in 2013

3.3 Trends in precipitation extremes

Trend analysis of precipitation extremes was prepared over 1941…2012.

The maximum daily precipitation (Rx1day) in Kazakhstan remained almost unchanged (figure 3.10). Both increasing and decreasing trends were weak – around 0,1…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 3,2 mm per 10 years at Bayanaul station, whereas at Bektauata and Turar Ryskulov stations maximum daily precipitation increased by 1,5…1,6 mm per 10 years, respectively.

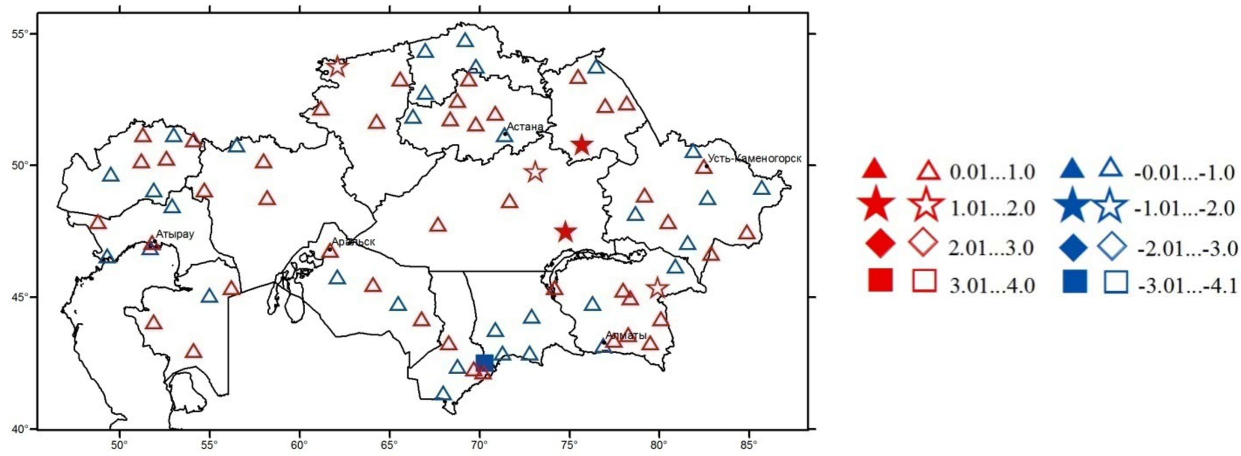


Figure 3.10 – Spatial distribution of the linear trend factor of maximum daily precipitation (mm/10 years), for 1941...2012. Shaded keys stand for statistically significant trend

Analysis of the percentage share of extreme precipitation in annual total (***R95pTOT***) showed that weak trends both decreasing and increasing by 1...2 %/10 years was observed everywhere in Kazakhstan except few stations. For example, at Karaganda and Zheskazgan stations the share of extreme precipitation increased by 1,6 and 1,7 % every 10 years, respectively. At Ayagoz, Amangeldy and Turar Ryskulov stations extreme precipitation share decreased by 1,3…2,7% 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.

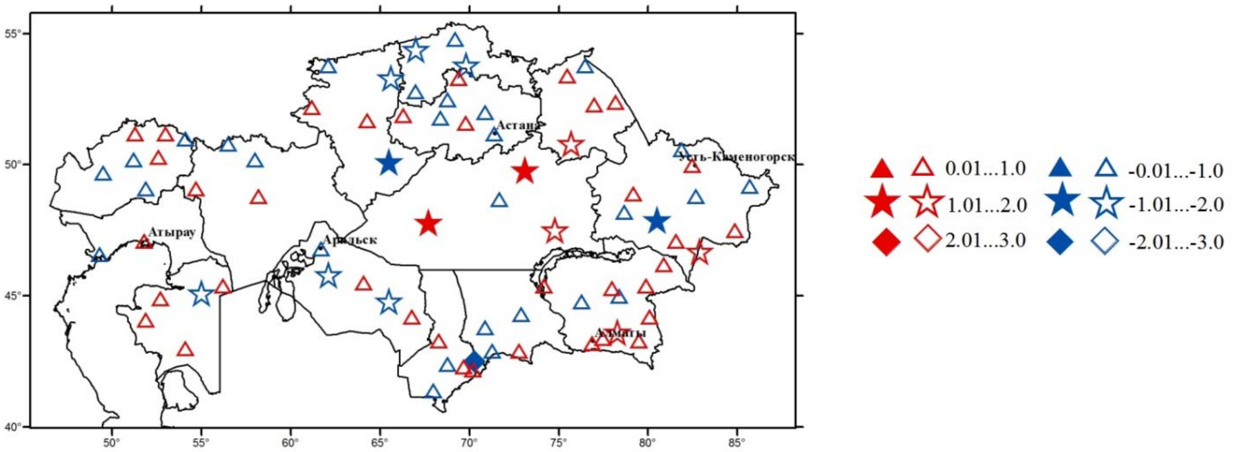


Figure 3.11 – Spatial distribution of the linear trend factor of extreme precipitation share in annual total (%/10 years) over 1941...2012. Extreme precipitation is the sum of daily precipitation above the 95th percentile. Shaded keys stand for statistically significant trend.

The maximum duration of dry period 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 station dry period reduced by 6 days per 10 years. However, at Kokpekty, Ekidyn, Kyzan and Beyneu stations duration od dry period increased by 1…4 days (figure 3.12).

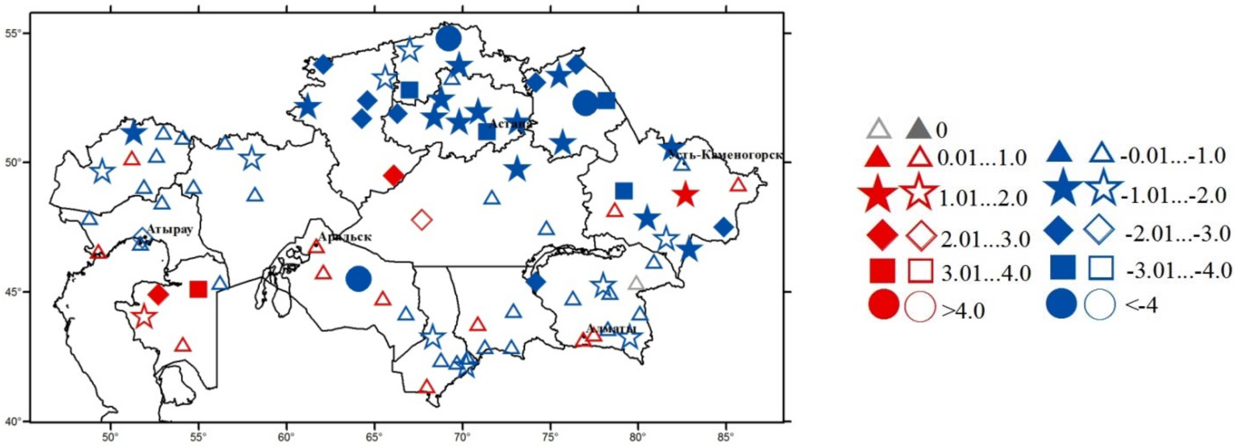


Figure 3.12 – Spatial distribution of the linear trend factor of the maximum dry period duration (day/10 years) over 1941...2012. Shaded keys stand for statistically significant trend.

CONCLUSION

Features of 2013 year. Globally, in 2013 became the sixth warmest year on record since 1850. In 2013, the average air temperature over land and ocean areas, on average around the globe was 0,50ºS ± 0,10 ° C above the baseline period (1961…1990, 14 °C).

In Kazakhstan 2013 year by the value of the average annual air temperature (January-December) was the warmest year since 1941. Country average annual temperature anomaly in 2013 amounted to 1,69 ° C which is 0,13 ° 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 1 st place among themselves warm years.

The largest average annual air temperature anomalies (1,0...2,0 °C) were observed in western, central and southern regions of Kazakhstan. In these regions 2013 year appeared to be within 10% of extremely warm years since 1941. In all other regions temperature anomalies were within ±1 °C of the norm.

The annual precipitation was 80…120 % of normal on the vast area of Kazakhstan. In the northern regions and in the far east of Kazakhstan, precipitation was above normal at 20 ... 60 %. These regions appeared within 10 % of extremely wet years since 1941.

Winter 2013 (December 2012 – February 2013). Temperature conditions of this winter have been very contrasting: December 2012 was very cold; January and February 2013 were warm. In December 2012, the air temperature anomalies were from 2...4 °C in the west of the country to 8,0... 10,0 °C in the northeast. In January and February temperatures in most part of Kazakhstan were above normal by 1,0...3,0 ° C, in some areas by 4,0 ... 5,0 ° C. In south-eastern, eastern, north-eastern and locally in western, north-western Kazakhstan winter precipitation was by 20…100 % above the norm. In central, south-western Kazakhstan precipitation was by 20…60 % below the norm. In the rest of Kazakhstan amount of precipitation was within the norm.

Spring 2013 was very warm everywhere in Kazakhstan. Except for the northern areas and the far south, air temperature anomalies were more than 2,0 °C, in some areas even higher than 4,0 °C. In these regions spring 2013 appeared within 10% extremely warm season. On the vast area the high positive anomalies of precipitation was near normal or 20...60 % less than normal. In the northern and north-eastern regions of the spring season precipitation greatly exceeded the norm - in some places up to 80 ... 100%.

Temperature conditions in summer 2013 were within the norm in the most parts of Kazakhstan, only in some areas in the north-east of the country, temperatures were below the norm by 1,0...1,5 °C. Herewith, the amount of precipitation was above normal everywhere in the Republic. Extreme annual precipitation exceeded the norm in 2...2.5 times was recorded in Kostanay, North Kazakhstan, Akmola, Pavlodar, East Kazakhstan and Almaty regions.

Autumn was extremely warm and dry almost the entire territory of Kazakhstan. In NKO and Kostanay regions seasonal temperature anomalies were 2,5...3,0 °. Temperature anomalies in North Kazakhstan amounted about 8,0 ºC (November, 2013). Precipitation deficit appeared on the vast area of territory of Kazakhstan, in some regions it was 80 %. Extremely dry autumn season was observed in south-eastern Kazakhstan. Just in West Kazakhstan precipitation was above normal at 20 ... 100%.

In 2013 absolute maximum and minimum of air temperature in Kazakhstan has not been exceeded at any considered weather stations. The percentage of days with daily maximum temperatures above the 90th percentile was 12 ... 20 % (1/5 year). The number of days with high temperatures above 35 ^{0}C exceeded 40...60 days in far south of Kazakhstan. In 2013, there was irregularity of precipitation in time. In some regions percentage share of extreme precipitation in the annual total in 2013 exceeded 20…40 % and locally 50 %. Absolute maximum was exceeded in weather station Ganjushkino (50 mm). The previous maximum (47 mm) was recorded here in May 1960. The maximum length of time when precipitation was less than 1 mm the was observed in the southern regions and amounted about 2 ... 3 months, sometimes about 4 months. In most parts of the territory of republic the duration of these periods was 3…7 weeks. The maximum duration of the wet period (6...10 days) were observed in the northern, eastern, western and southern places of Kazakhstan.

Climate Change in Kazakhstan. Average monthly, seasonal, and annual air temperature were increased practically everywhere in Kazakhstan, for the period 1941 ... 2013 (73 year). Country average annual temperature has been rising by 0,28 ºC every 10 years. The highest warming was in autumn by 0,33 ºC every 10 years. Spring and winter temperatures have been increasing a little slower by 0,30 ºC and 0,28 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 39 %, for seasons contribution varies from 2 to 37 %.

The fastest increase in the average annual temperature was in West Kazakhstan oblast equal to 0,39 ^{0}C every 10 years. The lowest warming rates were in South-Kazakhstan Oblast, East Kazakhstan Oblast, Almaty Oblast and Mangistau Oblast amounting to 0,22...0,26 ºC every 10 years. In other oblasts the temperature increase rates were within 0,27...0,32 ºC over 10 years (1941…2013).

The biggest temperature increase was observed in spring in northern and central oblasts (0,33…0,37 ºC every 10 years) and in autumn in southern and eastern oblasts (0,30…0,40 ºC every 10 years). In western oblasts the biggest temperature rise still occurred in winter (0,27…0,38 ºC every 10 years).

In February-March, and November-December the air temperature increase was most significant from 0,41 to 0,80º C/10 years. In April, June and October the warming rate was slower 0,21...0,40 ºC/10 years. In all other months temperature increased from 0,01 to 0,20 ºC every 10 years. Thus, temperature increase was higher in cold season (November-March) than in warm (April-October).

Daily maximum temperatures increase by 0,01...0,40 ºC every 10 years. In some regions the increase amounts about 0,60 °C every 10 years. The number of days with temperatures above 35 ºC increased in western and southern regions of Kazakhstan by 1 to 5 days every 10 years. The total duration of heat waves increased throughout the country by 1 to 3 days/10 years.

The annual precipitation has been decreasing slightly by 0,6 mm every 10 years, or about by 0,4 % of normal per 10 years during 1941-2013. On average in Kazakhstan precipitation tends to slightly decrease in all seasons except winter when precipitation tends several increased. All tends were statistically insignificant.

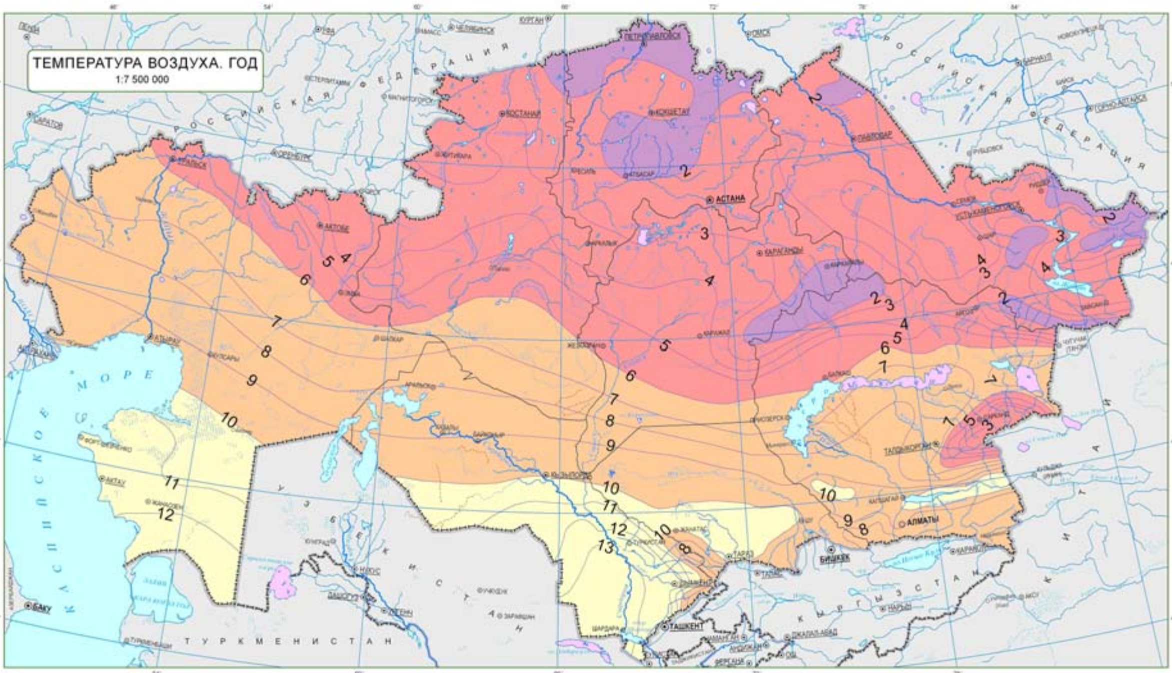
Changes in the seasonal precipitation were diverse. In summer and autumn in most parts of Kazakhstan except mountain south-eastern regions precipitation decreased by 1...7% of norm every 10 years. In winter precipitation mostly increased. Continuous positive trends were observed in the northern and central regions, mountains and foothills north-western, eastern, south-eastern regions by 1...9 % of norm every 10 years. In spring, a positive trend was observed in the north-western part of Kazakhstan, whereas in other regions precipitation decreased. It should be noted that almost all seasonal trends were statistically insignificant, except winter precipitation.

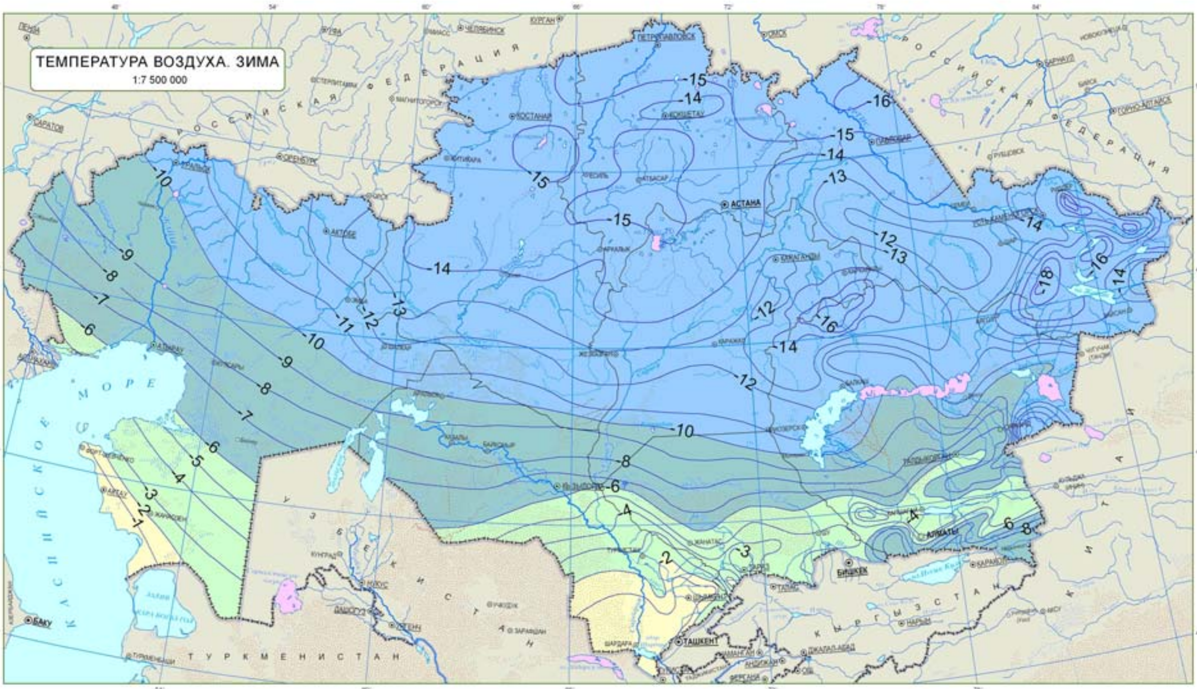
Some tends in precipitation extremes were observed. The extreme precipitation share in annual total were increased by 1…2 of norm every 10 years in the most weather stations of the south-eastern part of country.

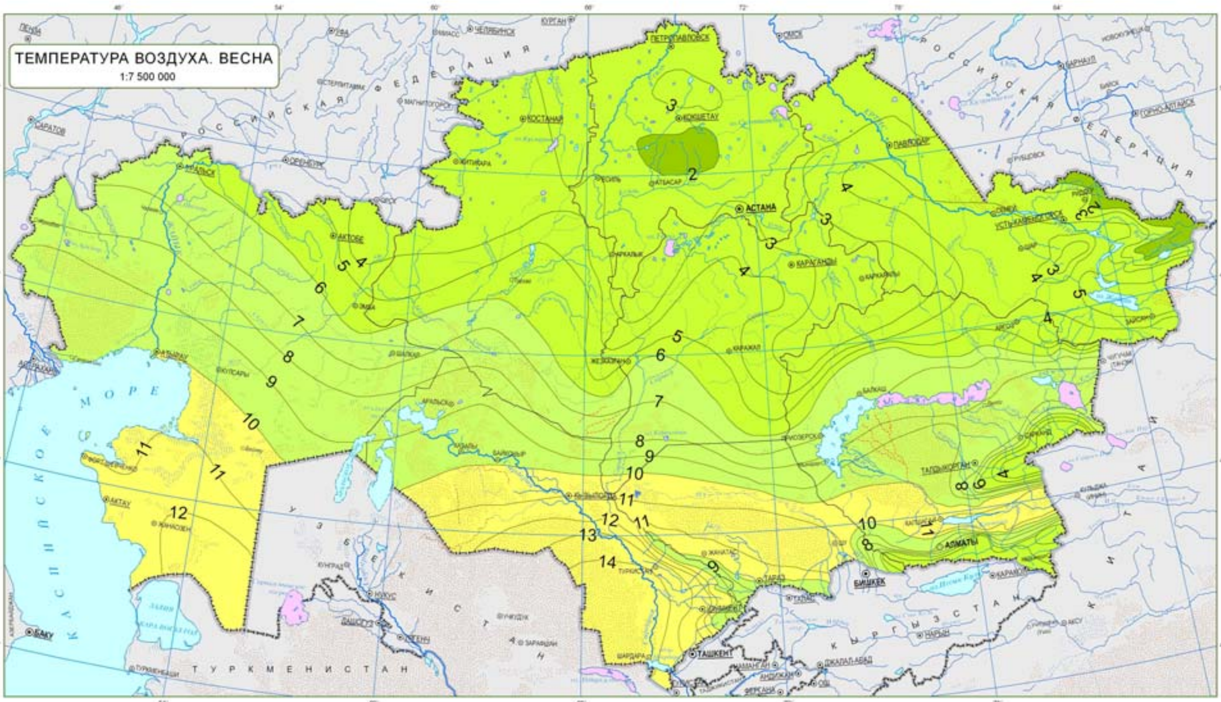
The duration (statistically significant) of dry period occurred in the northern region of Kazakhstan and amounted 1...3 days every 10 years.

ANNEX 1

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






ТЕМПЕРАТУРА ВОЗДУХА. ВЕСНА
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АСТАНА
АЛМАТЫ
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ТАШКЕНТ
КАСПИЙСКОЕ МОРЕ
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КЫРГЫЗСТАН
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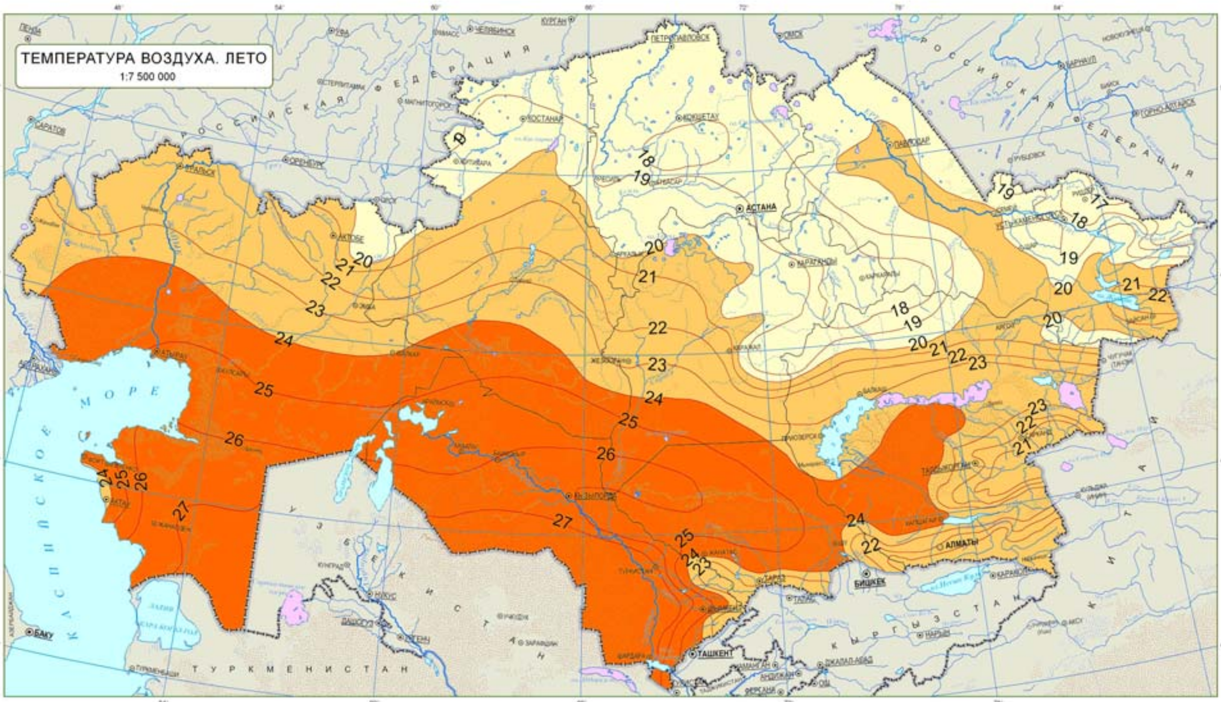
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АЛМАТЫ
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КЫРГЫЗСТАН
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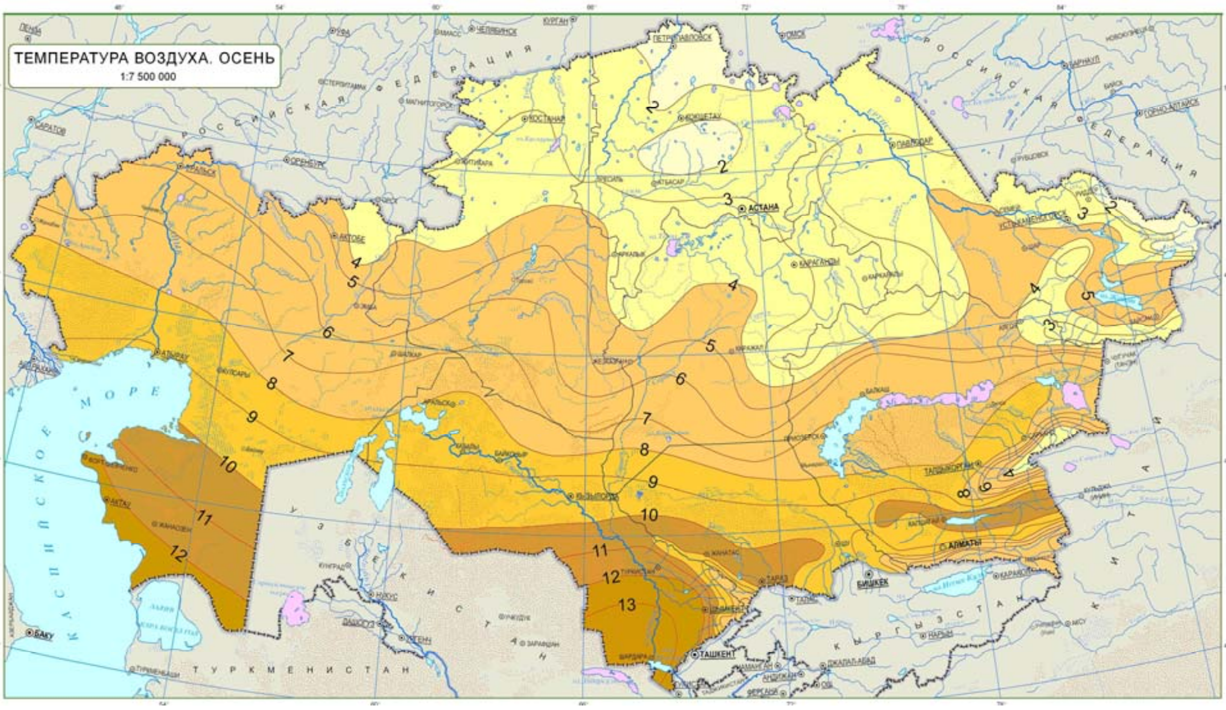
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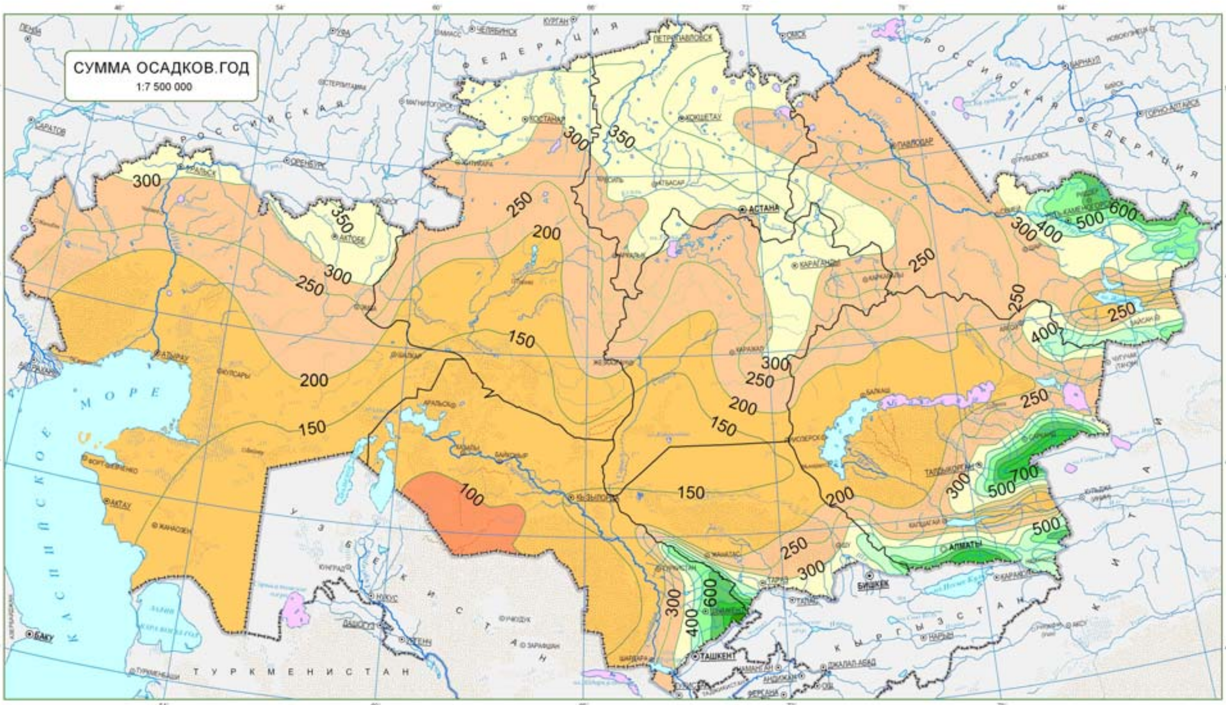
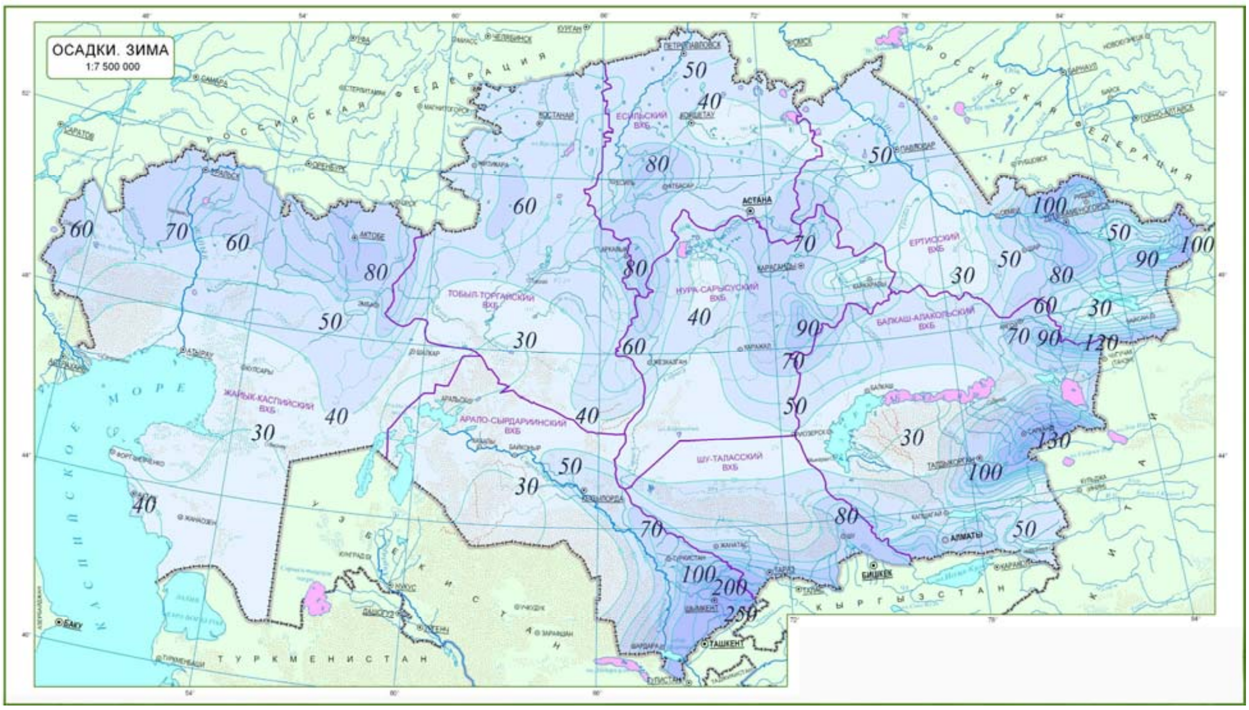
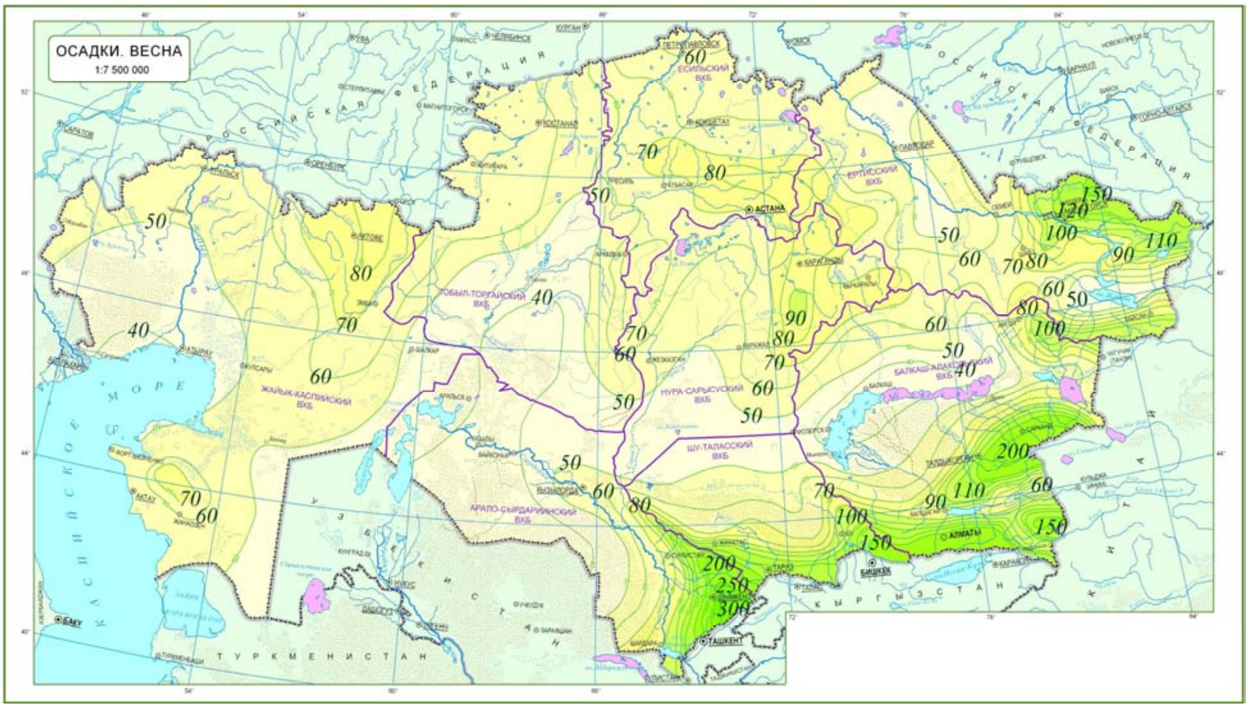
ANNEX 2

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



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ЖАЙЫК-КАСПИЙСКИЙ ВХБ
НУРА-САРЫСУСКИЙ ВХБ
ШУ-ТАЛАССКИЙ ВХБ
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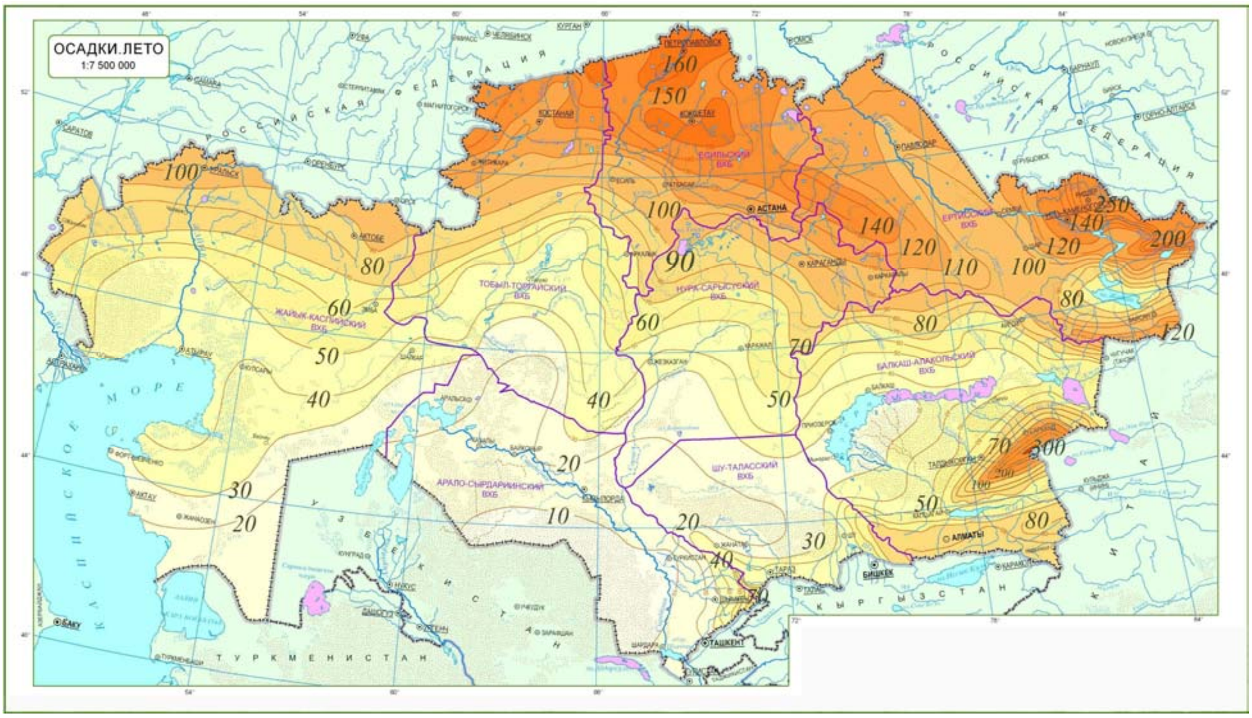
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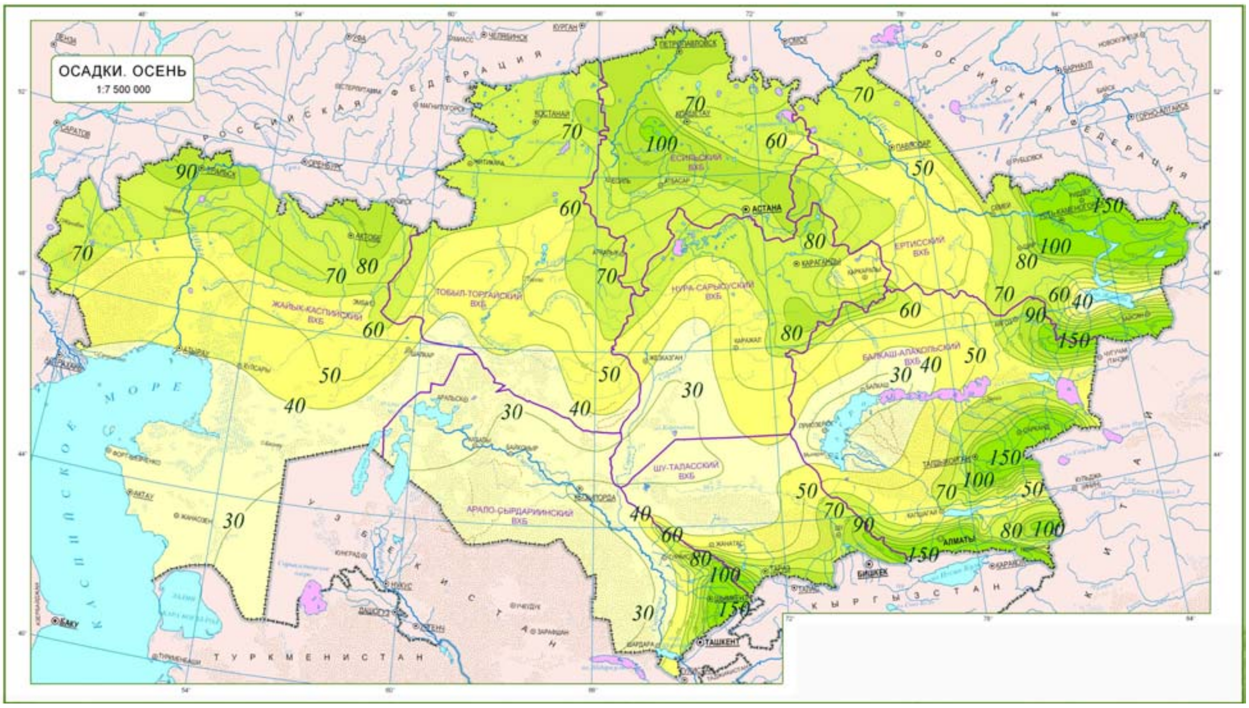
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