BULLETIN d'EUROTALENT-FIDJIP

2015, N 8

Editions du JIPTO

Bulletin d'EUROTALENT-FIDJIP, 2015, N 8

BULLETIN d'EUROTALENT-FIDJIP

2015, N 8

Editions du JIPTO

Bulletin d'EUROTALENT-FIDJIP, 2015, N 8

11, rue de la Concorde
10100 Romilly sur Seine

Directeur de la publication : Grigori Tomski

http://academie-concorde.blogspot.fr

ISSN 2101-5317

Ce volume contient des travaux du Séminaire de l'Académie Internationale CONCORDE (Paris, du 1 au 10 juillet 2015) avec la participation des professeurs du Kazakhstan. C'est pourquoi la majorité des articles sont en russe.

Данный номер журнала содержит статьи участников семинара Международной академии КОНКОРД (Париж, с 1 по 10 июля 2015 года) и других мероприятий академии.

УДК 551.577.38

THE LARGE-SCALE ATMOSPHERIC PROCESSES AND DROUGHT IN KAZAKHSTAN

Prof. Vitaly Salnikov[a], Dr. Galina Turulina[a], Prof. Yevgeniy Talanov[a], Dr. Svetlana Polyakova[a], Dr. Tamara Tazhibayeva[a], Dr. Svetlana Dolgikh[b], Dr. Aizhan Skakova[c]

[a]Al-Farabi Kazakh National University, Almaty, Kazakhstan; [b]Kazhydromet, Almaty, Kazakhstan
[c]Institute of Ecology, Al-Farabi Kazakh National University, Almaty, Kazakhstan
Vitali.Salnikov@kaznu.kz, g_turulina@mail.ru, teage@mail.ru, Svetlana.Polyakova@kaznu.kz, Tamara.Tazhibayeva@kaznu.kz, svetlana_dolgikh@mail.ru, Aizhan.Skakova@kaznu.kz

Drought is one of the potentially hazardous natural processes for Kazakhstan. Drought is damaging the most threat to agriculture, causing a sharp decline, and sometimes total loss of crops. In this regard, a serious problem for Kazakhstan is to create an early warning system based on atmospheric aridity use features large-scale circulation and distant relations.

As well-known that a single universal index to characterize the conditions of aridity/moisture does not exist, a review of the main methods of parameterization. For revealing prognostic patterns studied the effect of large-scale dynamic processes in the atmosphere on the formation of precipitation regimes over Kazakhstan on the basis of teleconnection. It is shown that the phenomena of planetary scale occurring in the atmosphere - ocean North-Atlantic Oscillation (NAO) and South Oscillation (SOI) play an important role as the mechanisms of atmospheric circulation of the North hemisphere. Drought in Kazakhstan arise in the positive phase NAO and negative phase SOI in overwhelming majority. Also conducted a study of El-Nino influence on the formation of precipitation regimes over Kazakhstan. For selected years El-Nino built composite field anomalies of precipitation in the central months of the season on the considered territory. During El-Nino characteristics of rainfall distribution on the territory of Kazakhstan are undergoing significant changes. Concluded that the results obtained can be used in the warning system on droughts in Kazakhstan.

Keywords: *Drought, El-Nino, NAO, Indexes of drought, precipitation.*

1. Introduction. The drought is the dominating natural disaster among the other natural disasters by territory coverage and scale of the negative impact on the population in Kazakhstan. It is estimated that (Conception, 2003.) the most vulnerable sector of economy is the agricultural sector as for draughts. Allowing for immensity and increasing severeness of the droughts, and taking into account the damage that the droughts make, allows us to infer that the droughts represent a real danger to the food safety of Kazakhstan. The most important problem for Kazakhstan is the lack of the water resources. The climate change can lead to the imbalance of the system as climate – water resources – agricultural production that will inevitably affect the provision of the food safety to the population.

2. Material and methods. There is no unified common and general-purpose index for characterization of draught/humidification conditions in Kazakhstan at this time.

Different methods of parameterization are used by the scientists from the list of indices that is fairly broad (Klimenko, 2011; Palmer, 1965; Ped, 1975; Gringof et al., 1987; Salnikov et al., 2013), several drought/humidification change indicators can be used. They are measured according to figures from the ground hydrometeorological surveys: the precipitation ratio (ratio of rainfall to evaporation) that allows measuring the humidification by using the ratio of heat and humidity on this part of land; the hydrothermal index of G.T. Selyaninov (HTI) is the integral indicator of hydrothermal regime that includes heat and humidity. It is used as the indicator of humidification of the vegetative cover; standardized precipitation index (SPI). It is developed on the basis of the case that the deficit of precipitation causes the different effect on the ground and underground natural water runoff, snow cover and soil humidity (McKee et al., 1993); index of D.A. Ped.

Humidity index of N.N. Ivanov. It indicates the ratio of the annual precipitation to the annual evaporation. Hydrothermal index of G.T. Selyaninov (HTI) is the most widespread among the indicators listed above. According to the Lincoln Declaration on Drought Indices SPI was recommended for using as the unified index for the national hydrometeorological services. The standardized precipitation index is calculated by using of the precipitation data. The standardized precipitation index (SPI) was developed by McKee and

specifies the quantitative precipitation deficit for different periods of time with the help of SPI. The probability distribution of the precipitation values is transformed to the standard form with the help of gamma-function
(McKee et al., 1993). SPI is calculated by the precipitation data only and requires calculation of two parameters of gamma distribution. D.A. Ped offered to use the Si index as the draught criterion. It includes the main (decisive) factors that are essential for forming of the studied event: air temperature, precipitation and humidity of the active soil.

3. Results. One of the indices of precipitation ratio of N.N. Ivanov (K) was used in the article for the studying of draughts on the territory of Kazakhstan in the form of K standardized deviation that is calculated as relation of K abnormality to the mean square deviation: x > 0 – no drought; -0,5 ≤ x ≤ 0 – mild drought; -1,0 < x < -0,5 – moderate draught; x ≤ -1,0 – strong draught (wherexis the standardized deviation of ratio of N.N. Ivanov.

The index map of the distribution of the precipitation zones can be seen in the figure 1. This index map is produced according to data for the period from 1971 to 2011. Kazakhstan has almost all zones, ranging from arid to humid (from high-mountain zone). Most part of Kazakhstan that is 94 % of its territory lies in two zones: arid and semi-arid. The arid zone expands in the southern half of Kazakhstan, including Atyrau, Mangystau, the southern half of Aktobe, Jambyl, Karagandy and Almaty provinces. The semi-arid zone extends along the northern half of Kazakhstan and in south-east of Kazakhstan as well. The conditions are slightly milder (arid subhumid zone) on even land of North Kazakhstan and Akmola province, on the territory of Tarbagatay ridge, in low-mountain and medium-altitude mountain regions of East Kazakhstan, South Kazakhstan, Almaty, Jambyl provinces.

The time variation of the precipitation ratio of N.N. Ivanov and crop yield for the period from 1971 to 2011 for Kostanay province is illustrated in the figure 2.

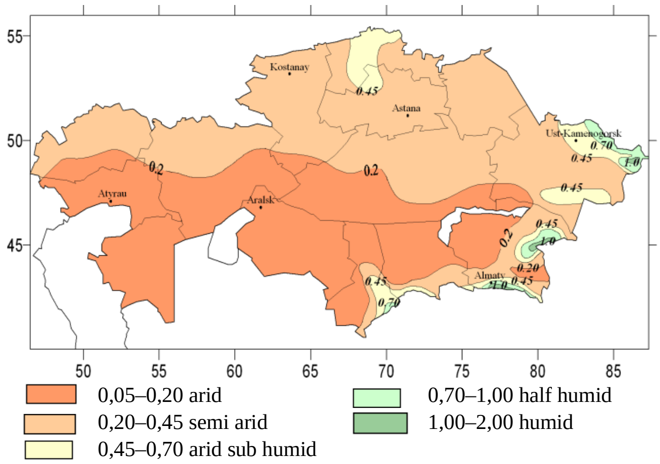

Fig. 1. The map of the distribution of the humidity index of N.N. Ivanov on the territory of Kazakhstan, produced according to data for the period from 1971 to 2011

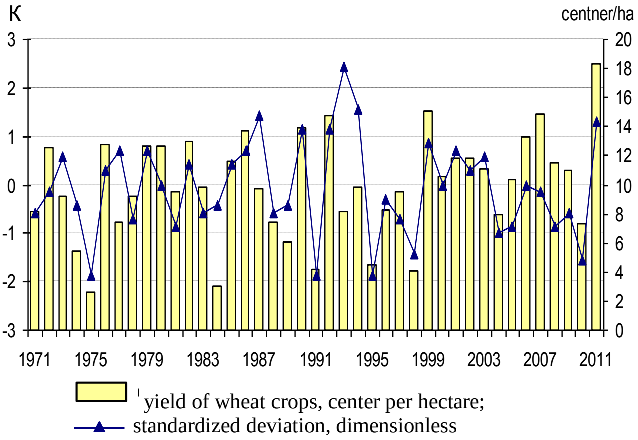

Fig. 2. Time variation of the standardized deviation of the humidity index of N.N. Ivanov (curve) and yield of the wheat crops (bar graph) for the period from 1971 to 2011 for Kostanay province of the Republic of Kazakhstan

The analysis showed fair compatibility between time variation of K ratio and crop variation, i.e., the positive values of K standardized deviation correspond to the high crop values, and the negative values correspond to the years with the low yield (Salnikov et al., 2013). Obviously that one of the decisive factors of draught creation is the atmospheric circulation. The different diagnostic studies that use archival meteorological data jointly showed that prevailing versatility modes (variation types) in the open atmosphere of Earth are characterized by the proper common spatial structure. The series of works (Gray, 1984; Rasmusson et al., 1983) show that many of the most noticeable of the year to year variations of the meteorological characteristics of the atmosphere of the northern hemisphere and hydrological values in the ocean are connected with ENSO.

The detailed review of El Nino – Southern oscillation is given in the works (Gruza et al., 2002; Petrosyants et al., 2002; Volkov et al., 1990; Perevedentsev et al., 2012). The Southern oscillation index from 1971 to 2012 is characterized by the considerable variability in time and the prevailing of the negative values can be observed for last decades. The negative values of SOI mean the warm phase of ENSO, i.e. the development of El Nino; the positive values of index mean the cold phase, i.e. development of La Nina. It should be noted that the role of the large scale dynamic processes and its abnormalities in the atmosphere of the northern hemisphere in forming of weather and climatic regimes in Kazakhstan is not studied in full.

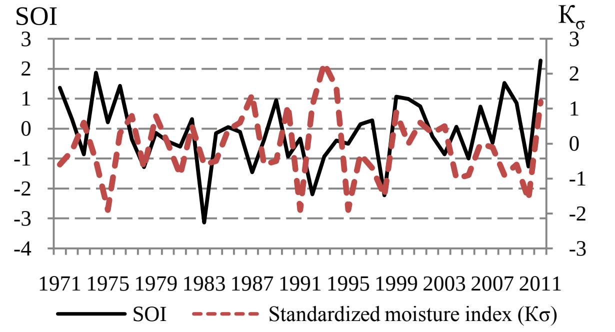

Fig.3. The time series of the Southern oscillation index (SOI)

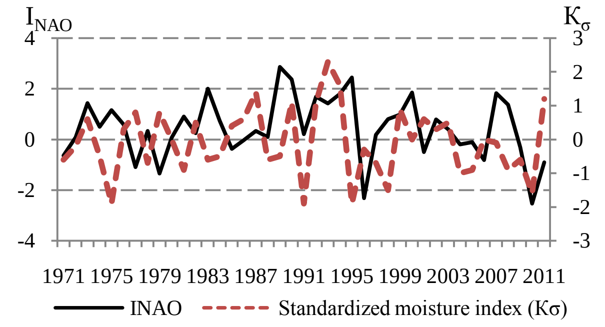

Fig.4. The time series of the North Atlantic oscillation index (NAO)

However, it can be assumed that the influence of the climatic phenomena of El Nino and Southern oscillation is observed in Kazakhstan in a certain way because the changes in the global atmosphere circulation cause the changes in the regional weather conditions. Sometimes this is a positive influence, e.g., the increase of yield of cereal crops because of great amount of precipitation in the steppe area of Kazakhstan. But from the other side proper allowance must be made for possible negative weather events in other regions of Kazakhstan. The average monthly data INAO of the Climate Research Unit (CRU) of the University of East Anglia (UEA, http://www.cru.uea.ac.uk/) are used in this work for the period from 1971 to 2011. The lasting motion of NAO index from 1971 is shown in the figure 4. NAO index reached its maximum point in the beginning of 90's of the XX's century as it can be seen from the mentioned curve. Then it steadily went down till the present moment. It is specified that series of NAO index have the cycling of nearly 60-70 years and it shows the significant positive correlation with the series of the air temperature of the Northern hemisphere (Perevedentsev et al., 2012). Periods with the positive NAO indices are characterized with the intensive western shifting of the air masses and notable warming of the most part of the extratropical latitudes of the Northern hemisphere, especially expressed in the winter – spring period. The periods with the negative NAO indices differ by the weakening of the zonal circulation. The relation between NAO index for December-March with atmospheric draught in the North Kazakhstan is shown in this work (Tabl. 1). In the most events of draughts in Kazakhstan are resulted from the positive NAO phase. The Southern oscillation index during the period from 1971 to 2011 has the significant time variability. The negative values of SOI corresponds to the warm phase of ENSO with the predominance of El Nino processes over La Nina, the positive values of SOI over the cold phase of El Nino (Fig. 3). The number of the draught events in North Kazakhstan with the different phase of Southern oscillation is shown in the table 2.

Table 1
The number of draught events with (Si > 1) in the North Kazakhstan with the different phase of NAO index

NAO	Month						Total
	IV	V	VI	VII	VIII	IX	
$I_{NAO} < 0$	2	3	2	1	–	1	9
$I_{NAO} > 0$	9	4	9	9	10	7	48

Table 2
The number of draught events with (Si > 1) in North Kazakhstan with the different phase of SOI

ENSO	Month						Total
	IV	V	VI	VII	VIII	IX	
SOI < 0	7	4	6	5	5	4	31
SOI > 0	4	3	5	5	5	4	26

The draughts in Kazakhstan can be observed mainly with the predominant negative values of SO index (Salnikov et al., 2013). The precipitation is the decisive factor in the abovementioned indices for the assessment of draught conditions or moisture conditions. The precipitation was chosen as important indicator of the atmosphere circulation for studying of the impact of ENSO on the weather regime in Kazakhstan. The abnormalities of monthly amount of precipitation were used as the basic data for the period from 1971 to 2011. The events for the years of strong but early or late El Nino were analyzed separately. Student's criterion was used for assessment of statistical significance of the obtained results. 5 % and 10 % were specified as two levels of significance. The monthly amounts of precipitation over the lowland part of Kazakhstan are decreased from the North to the South in the average multiyear plan according to the different studies (Chichasov, 1991). The increase of its seasonal amount is peculiar to Kazakhstan from Ural and Aktobe provinces to Pavlodar province among latitude decrease of precipitation from the North to the South.

The defining characteristics of precipitation distribution over the territory of Kazakhstan have significant changes in the years of El Nino (Fig. 5 a, c). The amounts of precipitations change within normal limits in spring over the whole territory of the republic. The zones of positive precipitation abnormalities shift to the western and eastern districts of Kazakhstan in the summer months. However, the abnormality is expressed fairly clear. The deficit of precipitation is observed over the northern part of Kazakhstan at the same time.

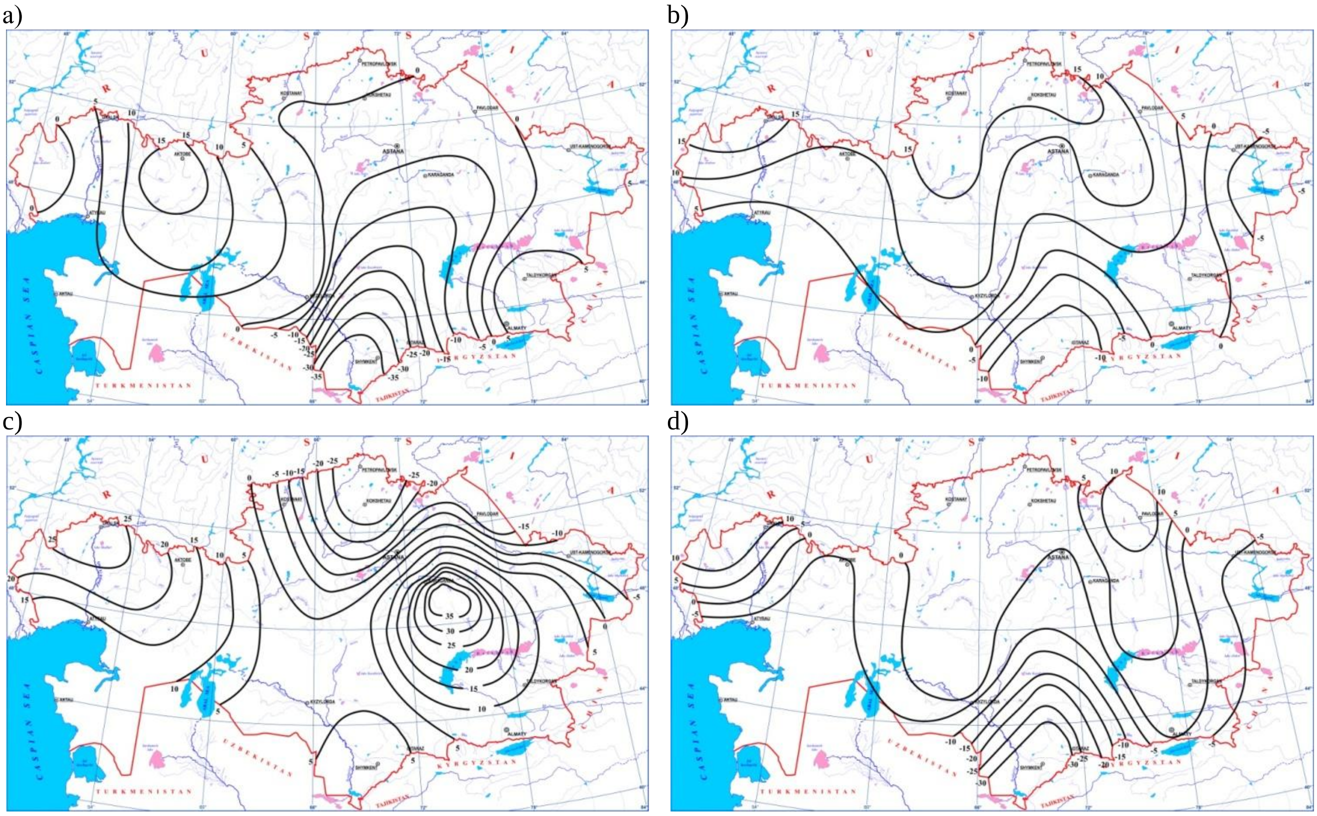

Fig. 5. Composition fields of precipitation abnormalities in the middle months of the seasons in the years of El Nino (a – spring; c – summer) and following the year of El Nino (b – spring; d – summer)

For the spring seasons of years that follow after El Nino year (Fig. 5 b, d) are characterized by the positive precipitation abnormalities almost over the whole territory of the republic. The zone of its small deficit is observed only at the far south. The pattern of precipitation stay the same in summer. The decrease of variations of precipitation distribution is observed that is presumably connected with El Nino.

The increase of value of abnormalities of the monthly amount of precipitation is characterizing feature for the years of strong, early and late El Nino. However, the necessary checking of the received results with large scale material must be done for the final conclusions.

4. Conclusion. Therefore, as a result of the conducted studies it was shown that the draught problem in Kazakhstan grows not only in view of change of the air temperature and precipitation regime, in connection with a poorness and unequal distribution of the water resources but due to the geographical location and remoteness from the oceans in the continent.

Different approaches to the parameterization of draughts are analyzed. One of the indices, i.e., the precipitation ratio of N.N. Ivanov was used in the work for studying of the features of the spatial distribution of the draughts in the territory of Kazakhstan. The conclusion is made that one of the most important part of all indices of draughts is the amount of the precipitation. The zoning of the territory of Kazakhstan is done according to precipitation degree. It is shown that for the mentioned region all the zones are typical to mentioned region, from arid to humid (beginning from high-mountain zone). The most part of Kazakhstan that is 94% lies in two zones: arid and semi-arid. It is also shown that there is a fair compatibility between time variation of K ratio and crop variation, i.e., the positive values of K standardized deviation correspond to the high crop values, and the negative values correspond to the years with the low yield

The possible mechanisms of impact of teleconnection in the atmosphere on Kazakhstan were studied with the purpose of note the role of the large scale dynamic processes and its abnormalities in the atmosphere of the northern hemisphere in forming of weather and climatic regimes in Kazakhstan, searching for the forecast patterns of the forming of precipitation regime and therefore, draughts. It is shown that North Atlantic oscillation index (NAO) reached its maximum point in the beginning of 90’s of XX’s century, and then it steady decreased to the present time. The relation between the North Atlantic and Southern oscillations was studied with the atmosphere draught in North Kazakhstan. It is shown that the periods with the positive NAO indices are characterized with the intensive western shifting of the air masses and notable warming of the most part of the extratropical latitudes of the Northern hemisphere, especially expressed in the winter – spring period. The periods with the negative NAO indices differ by the weakening of the zonal circulation. In the most events draughts in Kazakhstan are resulted from the positive NAO phase and from the prevailing negative values of SO index. The refore, the conducted studies show that the amplification of zonal shifting in the middle latitudes of the Northern hemisphere and degree of atmosphere baroclinity in the years of El Nino leads to the significant abnormality of distribution of the monthly amount of precipitation over the territory of Kazakhstan. The most significant show of signal is marked during the period from June of the year of El Nino till March of the next year. The extreme abnormalities are observed almost on the whole territory of the republic.

References

1. Chichasov G.N., 1991. Technology of the long term weather forecasts. St. Petersburg, Hydrometeo-Publishing, 301.

2. Conception, 2003. Conception of ecological safety of the Republic of Kazakhstan for the period from 2004 to 2015. Decree of the President of the Republic of Kazakhstan No. 1241 dated December 3, 2003.

3. Gray W.M., 1984. Atlantic seasonal hurricane frequency. Part.1: El-Nino and 30 mb Quasi-Biennial Oscillation influences. Mon. Wea. Rev. 112, 1649–1667.

4. Gringof I.G., Popova V.V., Strashnyi V.I., 1987. Agrometeorology. Leningrad, Hydrometeo-Publishing, 310 .

5. Gruza G.V., RanjkovaE.Ya., Kleshchenko L.K., Aristova L.N., 2002. On relations of climatic abnormalities on the territory of Russia with El Nino event – South Oscillation. Meteorology and hydrology 5, 32-51.

6. Klimenko V.V., 2011. Why does the global warming slow down? Reports of Academy of Sciences of Russian Federation 440 (4), 536-539.

7. McKee T.B., Doesken N.J., Kleist J., 1993. The relationship of drought frequency and duration to time scales. Preprints, 8th Conference on Applied Climatology, 17-22 January. Anaheim, CA. 179–184.

8. Palmer W.C., 1965. Meteorological drought. Dep.of Commerce Weather Buerau. Washington. Reseach Paper.45, 58.

9. Ped D.A., 1975. Onindicatorof draught and excessive precipitation. Works of Hydrometcentre of USSR 156, 19-38.

10. PerevedentsevYu.P., Shattalinskiy K.M., Vazhnova N.A., Naumov E.P., Shumikhina A.V., 2012. Climate changes on the territory of Privolzhsky Federal District for the last decades and its connection with the geophysical factors. Bulletin of Udmurt University. Biology. Geosciences 4, 122-135.

11. Petrosyants M.A., Gushchina D. Yu. 2002. On definition of El Nino and La Nino events. Meteorology and hydrology 8, 24-35.

12. Rasmusson E.M., Hall J.M., 1983. El-Nino: The great equatorial Pacific Ocean warming event od 1982–83. Weatherwise. 36 (4), 313–348.

13. Salnikov V.G., 2013. Report on research work ‘Development of methods, models and geoinformation technologies of control, analysis and forecast of dynamics of desertification processes on the territory of the Republic of Kazakhstan’ (interim). Almaty, 130. (state registration number 0112PK00567, Inv. No. 0212PK00989, MNRTI 39.01.94)

14. Salnikov V.G., Turulina G.K., Polyakova S.E., Skakova A.A., 2013. Large scale atmosphere processes and drought in Kazakhstan. Bulletin of Kazakhstan State University. Ecology series 2/1 (38), 125-131.

15. Wallace J., Blackmon M., 1988. Observed low frequency atmosphere variations. M., Mir, 66-109.

SOMMAIRE