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SEASONAL CHANGES IN PRECIPITATION EXTREMES IN RUSSIA FOR THE LAST SEVERAL DECADES AND THEIR IMPACT ON VITAL ACTIVITIES OF THE HUMAN POPULATION

ABSTRACT. Seasonal regional features of the daily precipitation extremes were studied based on Russian meteorological stations datasets for the period of 1991-2013 compared to the 1961-1990 climate baseline conditions. Precipitation extreme changes were assessed for the most vulnerable regions of Russia with high population density, where precipitation extremes result in negative impacts on the environment and human activities. It was found that the frequency of precipitation extremes in winter and in spring for the period 1991-2013 significantly increased, by 20-40% at the average, in most parts of the case study area. Due to positive trends in daily precipitation extremes changes which was revealed for the winter and spring periods (not exceeding on average 0.2 mm/day/decade), the risks of catastrophic spring floods have been analysed, especially in the areas with a higher recurrence rate of dangerous floods, i.e. - the South Urals region and the Altai region. Strong positive trends of extreme precipitation changes were observed in the Russian Far East region. It indicates higher risk of summer rain floods in the Amur River basin. A significant impact on human activities and in particular population health is associated with revealed trends in hydrological cycle changes that are not relevant to typical meteorological and hydrological regimes. The significant increase of the frequency of extreme summer precipitation events in the Central Chernozem region of European Russia in the period of 1961-2013 was accompanied by the leptospirosis disease incidences.

KEY WORDS: precipitation extremes; climate change; flood; waterborne disease; health consequences; Russia

CITATION: Alexander Zolotokrylin, Elena Cherenkova (2017) Seasonal changes in precipitation extremes in Russia for the last several decades and their impact on vital activities of the human population. Geography, Environment, Sustainability,
Vol.10, No 4, p. 69-82
DOI-10.24057/2071-9388-2017-10-4-69-82

INTRODUCTION

Continued Global Warming affects all sides of Russian population vital activities. Its consequences may be both positive and negative. The term Vital Activity refers to the population ability to act vigorously and to rest, as well as to preserve the health in the course of creating conditions for existence and development that are closely interrelated with the environment and social realities.

A frequency and an intensity of precipitation extremes is the one among many factors, affecting on the population vital activity. Winter precipitation extremes increase snow storage and provide conditions for dangerous spring floods. Precipitation extremes in off-season and summer periods often cause catastrophic floods in some areas increasing the risks for life and for industrial and social infrastructure operation. They critically affect water supply, waste water, and storm water drain facilities. Moreover, this effect acts stronger for aging infrastructure.

Water supply and sewage systems become not able to perform their functions during heavy precipitation, and begin to pose a threat for environment and human health because they turn to sources of significant chemical and biological contamination for ecosystems, water bodies and soils due to discharges and overloads. Sometimes such a contamination can be irreversible and can affect nearby areas.

On numerous occasions, precipitation extremes lead to injuries and loss of life, i.e. can directly affect human health. Health effects may also occur after extreme events: a person may be engaged in health risk activities, both during infrastructure recovery and territory cleaning after floods.

Annual average number of destructive weather and climate events in Europe for the period from 1998 to 2007 increased by about 65% (EEA 2008). According to the same source, the total amount of losses caused by weather and climate events, for the period 1980-2007 increased from less than 7.2 billion Euros at an average for the decade (1980-1989) to about 13.7 billion Euros (1998-2007).

With regard to social consequences, according to the information from the database of emergencies CRED (EM-DAT 2009) (Center for Research on the Epidemiology of Disasters) and in terms of the Epidemiology of Disasters, it was shown that about 40 million people needed health services and satisfaction of basic needs related to survival, such as safe shelter, medical care, safe water supply and sanitary measures for the past 20 years. This number of persons exceeds eight million persons who suffered for the past two decades (1970-1990) by about 400%.

Limited data on floods resulting from several epidemiological studies showed that the highest mortality is associated with drowning, heart attacks, hypothermia, injuries and traffic accidents (Meusel et al. 2004). Studies on long-term flood impacts on health were not conducted (WHO Regional Office for Europe 2005).

Heavy rainfalls often precede waterborne disease outbreaks in Europe (Miettinen et al. 2001). However, it is not possible to extrapolate the consequences of these phenomena in terms of climate (McMichael et al. 2004).

Targeted studies on extreme precipitation and floods influences on population health were conducted in the USA (USGCRP 2016). It was proved that extreme precipitations and runoff cause waterborne disease outbreaks (Curriero et al. 2001). Therefore, a forecast of long-term trends in precipitation is important to assess the expected risks of disease outbreaks. Precipitation extremes cause disease outbreaks due to contamination of surface and underground waters. A time lag of outbreaks is about a month for contaminated surface water, and two months for groundwater.

Another study (Alderman et al. 2012) presents a detailed review of works of 2004-2011 analyzing quantitative relationships between floods and human health in the

USA. This work revealed short-term and long-term consequences of flood influence on human health and their dependence on flood characteristics and population vulnerability. It demonstrated that the long-term consequences cannot be fully explained yet. In the first year after the flood, mortality rates can increase essential, the risk of epidemiological disease outbreaks in the areas of population movement can increase as well.

An analysis of waterborne disease outbreaks, depending on the frequency, intensity and duration of extreme weather incidents related to precipitations for the period 1910-2010, showed that the outbreaks were preceded by heavy rainfalls and floods in 55.2 and 52.9% of extreme weather incidents (Cann et al. 2013). Most of the outbreaks were caused by Vibrio spp. (21.6%) and Leptospira spp. (12.7%) pathogens due to contamination of potable water storages.
Various aspects of the methodology to identify precipitation extremes and to enable their simulation by global climate models were discussed in many studies (for instance, (Allan and Soden 2008; Groisman et al. 1999; Leander et al. 2014; Kiktev et al. 2003; Zolina and Bulygina 2016)). Precipitation extreme changes under the Global Warming conditions were examined worldwide and locally in the numerous studies (eg, (Alexander et al. 2006; Frich et al. 2002; Groisman et al. 2005; Klein Tank and Können 2003; Zolina et al. 2009)). It was found that in general the intensity of precipitation extremes in Russia grew for the period from 1966 to 2012 what increased the risk of flood incidents (Zolina and Buligina 2016). An increasing number of days with precipitation exceeding the 95% percentile in winter was found at stations of European Russia and Western Siberiain for the 1977-2006 period (Bulygina et al. 2007). According to observations for the 1966–2010 period, the maximal snow cover depth rose in the large parts of Western and Eastern Siberia, on the coast of the Okhotsk Sea and in the southern Russian Far East and in the central and north-eastern regions of the European Russia (Bulygina et al. 2011). On the other hand, the number of medium and heavy snowfalls increased in the east of the European Russia and in the west of Siberia and reduced in the northeast of Siberia (Borzenkova and Shmakin 2012).

The objective of this exploration is to study regional peculiarities of the changes in characteristics of precipitation extremes, increasing the risk of floods and waterborne diseases for the modern warming period of 1991-2013 compared to the 1961-1990 climate norms. The peculiarity of the study is that in addition to general assessments for the whole territory of Russia, analysis of the changes was conducted in the most sensitive areas with high population density, where precipitation extremes lead to negative consequences for the environment and human vital activities.

DATA AND METHODOLOGY

The objective of the study is in assessment of changes in seasonal characteristics of precipitation extremes in Russia for the modern warming period of 1991-2013 compared to the 1961-1990 climate norms and the evaluation of their trends for the 1961-2013 period. It is suggested to analyze characteristics of precipitation extremes in the regions with increased incidents of floods and waterborne diseases.

In this paper, we analyze total daily precipitation extremes in the territory of Russia allocated by daily observations on the base of 95% percentile value and calculated for each meteorological station per season for the period 1961-1990 (threshold value). The following seasonal characteristics of precipitation extremes were calculated for each year from 1961 to 2013 based on climate records of daily precipitation totals from 527 meteorological stations in Russia (http://meteo.ru/): (1) average daily precipitation totals exceeding the threshold value (mm/day); (2) frequency of daily precipitation total exceeding the threshold value. These annual characteristics were averaged for the climate periods of 1961-1990 and 1991-2013. Time series with gaps not exceeding 10% were accepted for consideration. The significance of changes was estimated at 95% (Student's t-test). In addition, climatic trends of the same characteristics were estimated for the 1961-2013 period. As for the linear trend coefficients, we refer to the time regression. The statistical significance of trends was evaluated according to the method described in the study (Seber 1977). Our study was focused on detection of number of stations: (1) with significant linear trend coefficients for the 1961-2013 period; (2) with significant changes of precipitation extreme characteristics, where significant increase of frequency and intensity of seasonal precipitation extremes was observed in the period between 1991 and 2013 compared to the climate norm. In spring and summer, the population of Russia is more vulnerable to waterborne diseases. In addition to spring and summer seasons the changes in precipitation extreme characteristics were studied for winter, because spring floods in regions with a stable snow cover are dependent essential on quantities of winter precipitations.

Precipitation extreme changes were analyzed throughout the country territory, which includes the main settlement and economic development area of Russia with the highest population density of 10-100 person per square km, as well as with lightly and low populated areas with a density of 1-10 person/km^2 and below 1 person/km^2 respectively. The most densely populated Russian territory occupies only 1/5 of the whole area of the country, however more than 4/5 of the population is living there. The major part of this territory is located in the European area of Russia. The natural conditions of population vital activities in the most populous parts are comfortable (favorable) for living and are divided into three zones depending on the degree of comfort (Zolotokrylin et al. 2012). The rest of the area, including mountain landscapes is inhabited very poorly and some places are unsettled at all. Four most uncomfortable areas for living are located there. The discomfort increases towards the North (Zolotokrylin et al. 2012).

Zoonotic diseases are infectious and helminthic diseases that exist in natural ecosystems due to persistent pockets of infection and invasion, supported by wild animals. Waterborne diseases include the following bacterial infections: (1) tularemia (disease agent – Francisella tilarensis); (2) leptospirosis (disease agent – leptospira from Spirochaetaceae family). Parasitic helminthic infections hold a specific place, they include: (3) diphyllobothriasis (disease agent is a parasitic warm tapewarm, of the Genus Diphllbothrium, intermediate hosts are fresh-water maxillopods of the Genus Cyclops and Diaptoms, and fishes; (4) opisthorchiasis (disease agent is a parasitic trematode Opisthorchisfelineus, intermediate hosts are fresh-water shell fish Bithynia Leachi and fishes; (5) clonorchiasis (disease agent is a trematode Clonorchis sinensis, intermediate hosts are shell fishes); (6) paragonimosis (disease agent – tape fluke Paragonimus westermani, intermediate hosts are shell fishes and crawfishes). Infectious human diseases, including transmission ones (i.e., transmitted by vectors), are distributed throughout the whole territory of Russia (Medico-geographical Atlas 2015). Pathogens and vectors of zoonotic diseases are the part of natural ecosystems. They circulate within the systems, regardless of human species, and pose a serious threat to a human health. Current climate changes lead to transformation of their distribution conditions and growing of the numbers of risk factors (Second Assessment Report 2014). In this connection in the paper we present the results of studies for regions with frequent incidents of spring and summer rain floods in the densely populated part of Russia as well as for the regions with high number of incidents of waterborne zoonotic infectious and helminthic diseases. Note that due to latent disease progression the impact of the observed extremes on the incidents of the discussed diseases can be evaluated only indirectly. The characteristics of precipitation extreme changes were considered, taking into account a spatial distribution of incidents of dangerous floods throughout the territory of Russia (Map: Incidents of dangerous river floods and snow-melt floods 2008). Also, the selected characteristics were analyzed using information on the spatial distribution of water-borne zoonotic diseases throughout the territory of Russia (Map: Sanitary and environmental assessment of the territory of Russia 2008; Medico-geographical Atlas 2015).

RESULTS AND DISCUSSION

The analysis of the spatial distribution of the daily precipitation extreme frequency for the 1991-2013 period compared to the 1961-1990 period showed that the winter precipitation extreme frequency increased in most parts of Russia. The number of meteorological stations with significant changes of the winter precipitation extreme frequency is 33.3% out of the total quantity of the examined stations (Fig. 1 a). The growth of precipitation extremes prevailed in the areas with the highest population density. Widespread areas of most homogenous changes in the daily precipitation extremes in winter were detected in the West and the East of Russia. Statistically significant increase by 20-40% compared to the norm was observed in the central part of European Russia. Note that the same increase of precipitation extremes was recorded by the meteorological stations located on the banks of the great Siberian Rivers Yenisei and Lena. At the same time, a significant loss in the precipitation extreme frequency, by 40% in average was observed on the coast of the Arctic and the North-East of Russia (including the Chukotski Peninsula).

As well as in winter, increased daily precipitation extremes prevailed in spring throughout the territory of Russia for the 1991-2013 period compared to 1961-1990 (Fig. 1 b). The number of meteorological stations with significant changes of the winter precipitation extreme frequency is 31.1% out of the total quantity of the examined stations. A spatial structure and values of precipitation extreme frequency in winter and in spring are well correlated (Fig. 1a and 1b respectively). The spatial distribution of precipitation extreme frequency in spring outstands with the shift in the area of significant frequency increase from the center of European Russia to its eastern part. At the same time, the most significant growth by 20-40% (as in winter) was observed in the eastern part of European Russia. Perhaps the most significant difference between the winter and the spring situations is that the loss in frequency of precipitation extremes in the north east of Russia (including the Chukotka Peninsula) in the 1991-2013 winter period gave a way to a slight increase in the spring. The obtained results show not only the dynamic of changes in precipitation extreme frequency but also indicate that the peaks of snow water equivalent throughout the Russia territory were achieved in the 1991-2010 period (see Fig. 5a in the paper by Bulygina with co-authors (Bulygina et al. 2011) for the 1966-2010 period).

It was revealed that the spatial pattern of daily precipitation extreme frequency in summer was different than winter and spring one. The number of stations where significant changes of precipitation extreme frequency were observed in summer reduced to 19.6% as compared to the winter period (Fig. 1 c). In contrast to winter and spring, when positive changes of precipitation extreme frequency were substantially prevailed, 47% of significant changes were positive in summer time, but 53% of the ones were negative. On the other hand, the positive frequency changes in the most densely populated territory of Russia prevailed at most stations in summer as well as in winter. However, these changes were not statistically significant in general. The number of stations with significant positive changes of the frequency decreased on the Arctic coast and in the north eastern part of Russia, with the exception of the Chukotski Peninsula.

Thus, the frequency of precipitation extremes for the period of 1991-2013 compared to 1961-1990 significantly increased in winter and spring. This occurred both in sparsely and in densely populated regions of Russia. The revealed changes affected the growth of snow cover (Bulygina et al. 2011) and led to increasing of spring flooding risks especially in the regions with higher than usual frequency of dangerous floods. However, an uncertainty is remaining on the territory of European Russia, as the higher winter temperatures have led to a reduction in the depth of soil freezing and have improved its draining properties. In some areas in the west and in the south of European Russia the number and duration of winter thaws, during which snowmelt occurred, increased in the first decade of 21-st century compared to 1961-1990 (Krenke et al. 2012). In turn, the

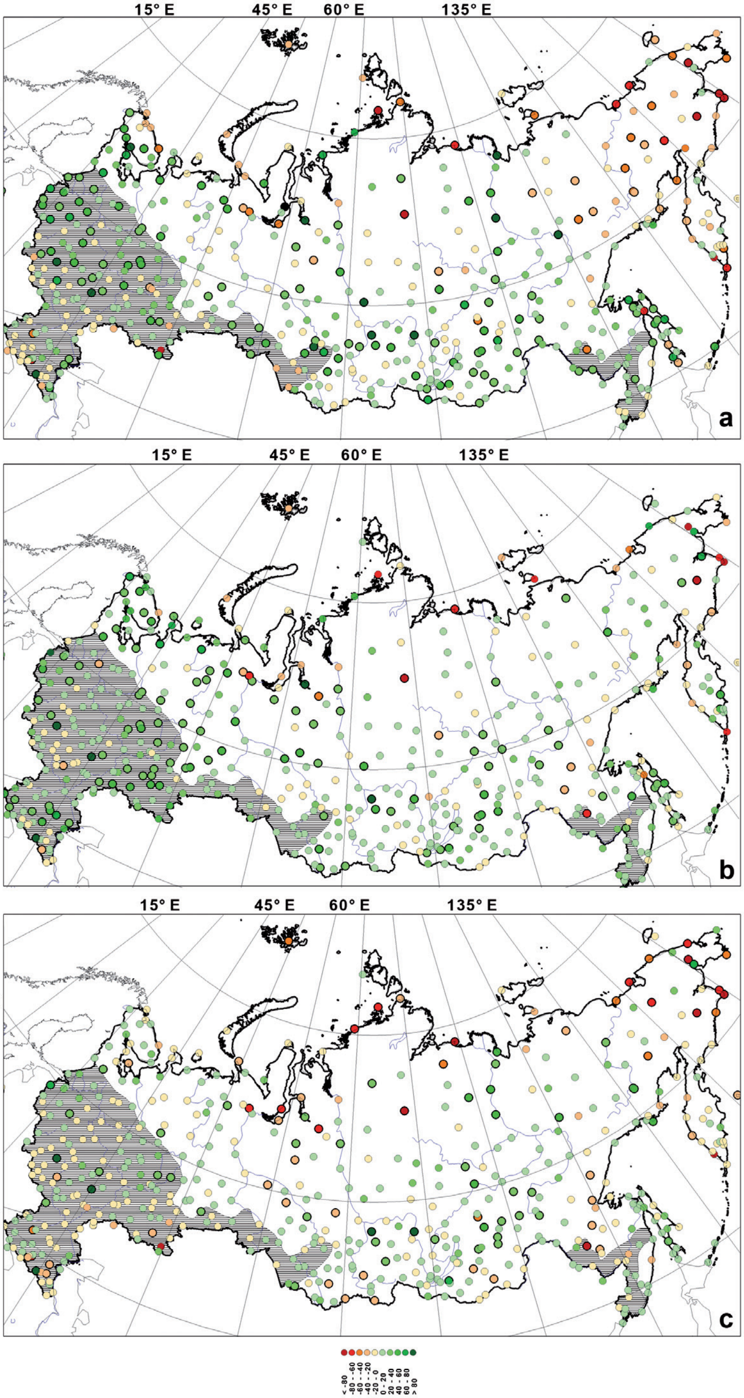

Fig. 1. Difference of daily total precipitation extreme frequency (%) in winter (a), in spring (b) and in summer (c) for the period of 1991-2013 compared to 1961-1990. Conditionally favorable area with the highest population density (4/5 of the Russia's population) is shaded (source: National Atlas of Russia 2008c). Significant differences are denoted with the black border of colored symbols

loss of water storages in the snow cover in early spring enables reducing of spring flood runoff (Roshydromet second assessment report 2014).

The peculiarity of the spatial distribution of significant trend coefficients for daily precipitation extremes on the territory of Russia for the 1961-2013 period is that a positive trends were detected at two third of meteorological stations in all seasons. Thus, the number of stations with significant positive trend coefficients for daily precipitation extremes (59.4% in winter, 65% in spring, 64.4% in summer and 66.7% in autumn) exceeds the corresponding number of stations with negative trend coefficients (41.2% in winter, 35% in spring, 35.6% in summer and 33.3% in autumn). For all seasons, in most parts of the study area the steady tendency of increasing in precipitation extreme changes, not exceeding 1.2 mm/day/decade in winter, 1.5 mm/day/decade in spring, 2.7 mm/day/decade in summer and 2.4 mm/day/decade in autumn, was observed.

As shown in Fig. 2a, the negative trends of changes in winter precipitation extremes were observed mainly on the sparsely populated Arctic coast of the country, including the Chukotski Peninsula. Conspicuous is the fact that negative significant trends (from 0.2 to 0.6 mm/ day in a decade) prevail in the densely populated southern part of European Russia (especially in the basin of the Don River), affected by spring floods of mixed sources (snow and rain). According to an analysis described in the study (Roshydromet second assessment report 2014), the spring runoff of the Don River decreased to 30% for the past few decades. Reduced runoff is caused by lower water storage in snow cover by early spring thaw that is a result of not only reducing of precipitations, but also increasing number and duration of winter thaws. In summary, the full-flowing spring floods on the Don were not occurred for almost 16 years. In the other area of dangerous spring floods - the Kuban River basin - negative trends also prevailed in winter (Fig. 2a), but they were statistically non-significant.

In winter, in the area of spring snowmelt floods, located in the South Urals region, the number of stations with positive (0.1-0.2 mm/day per decade) trends and negative (0.2 mm/day per decade) trends was approximately equal (Fig. 2a). However, the positive trends (0.2 mm/day per decade) were observed mainly in the Altai region with frequent dangerous river floods on tributaries of the Ob River (once in 3 years) and in the middle reach of the Yenisei (once in 6 years). The last biggest catastrophic flood over past half of century occurred in the spring of 2014 in the Altai region, due to the simultaneous combination of rapid snowmelt and heavy precipitation fall. This resulted in an increasing risk of chemical and biological contamination of water intended for human consumption, changes in the distribution of disease vectors and rodents throughout the territory. Loss of raw water supply and its quality degradation in turn affected the efficiency of water treatment processes and the stability of distributed potable water. Increased turbidity of surface water and growth of the number of pathogens (and their indicators) resulted in additional loads for wastewater treatment plants, especially for the facilities of surface water treatment. The damage caused by the destructive floods happened in spring, 2014 in the Altai region was estimated at almost five billion Rubles. Less destructive flood compared to 2014 happened again in some areas of the Altai region in 2016.

In summer, the number of stations with a significant negative trend of changes in daily precipitation extremes for the period of 1961-2013 on the Arctic coast, including the Chukotski Peninsula, decreased in comparison with winter (Fig. 2b). However, in the same time, the number of meteorological stations with a significant negative trend (up to 0.6-1.1 mm/day per decade) increased in the south-eastern part of European Russia. There was revealed essential increase in the frequency of droughts in this region for the past few decades (Cherenkova 2013). It is important to stress that non-significant trends prevailed in the areas of most frequently repeated rainfall floods (Amur River region, Transbaikalia). Strong positive trends of

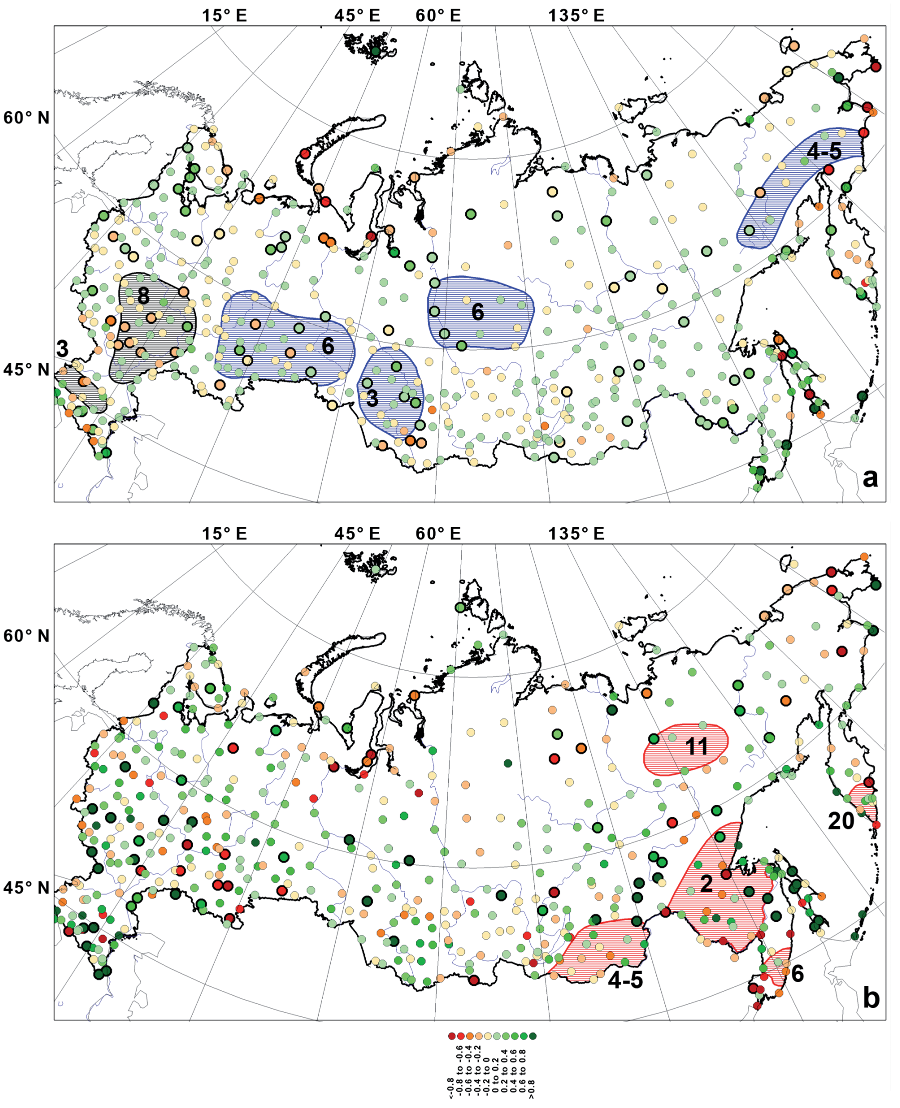

Fig. 2. Decade trends of changes in daily precipitation extremes in winter (a) and in summer (b) for the 1961-2013 period (mm/day/decade). Significant trends are denoted with the black border of colored symbols. Areas of increased frequency of dangerous floods originated by snow (marked with Blue), originated by snow and rain (mixed origin) (marked with Black). Areas of increased frequency of dangerous floods originated by rainfall are indicated with Red (source: National Atlas of Russia 2008a). A number of incidents per year are shown within or near areas

changes in precipitation extremes (increase up to 1.5-1.7 mm/day per decade) were observed in the southern part of the Russian Far Eastern of the Amur River Basin (Fig. 2b). It indicates the growing risk of floods in the region. The summer floods of 2013 spilled over vast areas of the Russian Far East and China's northeast has become one of the biggest natural disasters of the last decade - in view of duration, distribution area, casualties and economic losses (527 billion Rubles) (Danilov-Danilyan and Gelfan 2014). The abovementioned results obtained correspond to conclusions of the study (Zolina and Bulygina 2016).

It should be noted that the floods in the southern part of the Primorye Territory occur frequently in late summer - early autumn (Fig. 2b). Most of them are caused by tropical typhoons passing over the Japan Sea at this time. The last destructive flood in this area occurred under the influence of typhoons Lionrock (late August 2016) and Nam Teun (early September 2016). According to the preliminary assessment of the Khabarovsk region Administration, the flood damage amounted by 1.2 billion Rubles (http://www.primorsky.ru/news/). As consequence of the flood, many inhabited localities were flooded, internal infrastructure was destroyed, including power supply facilities, transport and waterworks. The flood caused losses of the crop and a large number of livestock. Population health risks were increased significantly due to contamination of potable water by the infiltration of pathogens. The abovementioned results in increased risks of human contacts with waterborne disease agents.

Statistically significant coefficients of the trend of daily precipitation extremes frequency in the winter accounted for nearly 40% out of the trend coefficients at all considered meteorological stations in Russia. In addition, 70.7% out of them were positive. The tendency to increase the daily precipitation extreme frequency for the 1961-2013 winter periods observed almost in the entire territory of Russia. At the same time the meteorological stations of the Chukchi Peninsula were an exception: observations at these stations showed a reduced trend in daily precipitation extremes (did not exceed two days per 10 years). The number of stations with positive significant trend of daily precipitation extreme frequency (did not exceed two days per 10 years over study area) slightly decreased in summer to 63.3% in comparison with winter in the whole territory of Russia (Fig. 3a). Positive coefficients of the trends identified in winter are kept in summer as well, in most parts of East Siberia and West Siberia and in European Russia. Note that the seasonal patterns demonstrate the consistency between the trends in the daily precipitation extremes frequency in the European part of Russia for the period of 1961-2013 and monthly precipitation in the same region for the period of warm anomalies of Northern Atlantic sea surface temperature (1995-2012) relative to its cool period (1962-1994) which were analyzed in the previous study (Cherenkova 2017).

The Fig. 3a and 3b show the areas (marked by number 1) of wooded steppe and meadow-steppe plain ecosystems of the Central Chernozem region located in the center of European Russia where incidents of bacterial infectious diseases tularemia and leptospirosis were reported. As shown in Fig. 3b, the lowest number of incidents of leptospirosis (less than 1 incident/year) for the period of 1997-2010 was observed in the Kursk and Lipetsk region, as well as in the north of the Saratov region. The annual average incidents in the same period in the Tambov region amounted to 1-5 cases/year and 5-15 cases in Belgorod, Voronezh and Penza region. The highest incidents of leptospirosis were reported in the north and east of the study area: 15-40 cases/year in Orel and Ryazan regions, and 40-80 cases/year in the Tula region and in the Republic of Mordovia. It should be noted that the highest incidents were observed in the areas with significant positive trends of the precipitation extreme frequency in summer for the period of 1961-2013. Similar to the conclusion made in the work (Sann et al. 2013) using the example of the United States, the majority of above-mentioned incidents in the regions of Russia were caused by pathogens Leptospira spp. as a result of contamination of drinking water sources.

Among other waterborne infections, only the tularemia appears in sub-boreal forest and forest-steppe essentially swamped plain ecosystems of Western Siberia (Fig. 3a, area number 2). The positive significant trend of precipitation frequency (4 day per 100 years) was revealed in observations of only one meteorological station in this region, although local summer rain floods are observed almost every year.

Negative trends of precipitation extreme frequency prevailed in the regions with frequent summer floods in the Amur region

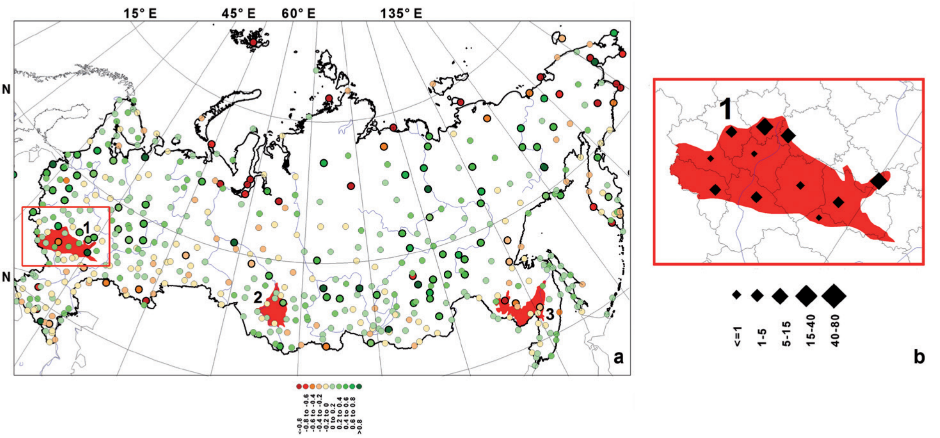

Fig. 3. Decade trends of frequency of changes in daily precipitation extremes in summer for the period of 1961-2013 (day/decade) (a). Significant trends are denoted with the black border of colored symbols. Areas with observed incidents of tularemia and leptospirosis: center of European Russia (1), south of Western Siberia (2), Russian Far East (3) are marked with Red (source: National Atlas of Russia, 2008b). The average annual number of leptospirosis incidences in European Russia for the 1997-2010 period (source: Medico-geographical Atlas 2015) is marked by rhombs (b)

(up to 3-12 day per 100 years). Lowland broad-leaved forest ecosystems of the Amur region located in Far East of Russia (Fig. 3a, area number 3), are the large center of parasitic helminthic infections, namely: (1) diphyllobothriasis; (2) opisthorchiasis; (3) clonorchiasis and (4) paragonimiasis. The agents of these diseases are parasitic worms that change two or three hosts in the process of lifecycle. In this case the last host is a human. Eating of raw, lightly salted or poor cooked fish causes human infection. Formation of the centers is caused by well warmed, low-flow shallow places, favorable for expansion of small crustaceans. That is why the negative trend of precipitation extreme frequency is not critical in these helminth centers.

CONCLUSIONS

The analysis of seasonal characteristics of the precipitation extremes for the period of 1961-2013 in Russia allocated by daily observations on the base of 95% percentile allowed to obtain the following results. The frequency of precipitation extremes in winter and spring for the period of 1991-2013 increased significantly by 20-40% on average compared to the 1961-1990 climate norms, both in sparsely and in densely populated regions of Russia. The only exception was the coast of the Arctic in winter and spring, and the north-east of Russia (including the Chukotski Peninsula) in winter. There was observed a significant decrease in the frequency of precipitation extremes in these regions, by 40% on average for the period of 1991-2013. The changes in daily precipitation extremes revealed in winter and spring in the period of 1991-2013 compared to the climate norms affected the growth of snow storages (Bulygina et al. 2011). In summer, the positive statistically insignificant changes in the frequency of precipitation extremes in the most densely populated territory of Russia prevailed at most meteorological stations.

Significant positive trends of changes in daily precipitation extremes in Russia in the period of 1961-2013 are revealed on two thirds of meteorological stations in all seasons. A steady increasing tendency of changes in daily precipitation extremes (not exceeded 3 mm/day per decade) was observed for all seasons of the year in most parts of Russia for the 1961-2013. In the same time, prevalence of essential trends to reduction of daily precipitation extremes in winter in the densely populated southern part of European Russia in the same period has resulted in lower runoff of the Don

River. Positive trends of changes in daily precipitation extremes were observed in the Altai region where dangerous river floods on tributaries of the Ob River and in the middle reach of the Yenisei River are happened frequently. In view of positive trends of changes in daily precipitation extremes revealed in winter and in spring, the risks of catastrophic spring floods (similar to the flood in the Altay region in the spring of 2014 are growing, especially in the areas with a higher recurrence rate of dangerous floods. Consequently, the risks of chemical and biological contamination of water are increased. In summer, strong positive trends of changes in precipitation extremes were observed in the southern part of the Russian Far East (in the Amur River Basin). It indicates the growing risk of floods in the region. Substantiation of the abovementioned is the summer floods of 2013, spilled over vast areas of the Russian Far East and China's northeast and caused the huge economic losses as well as the destructive flood in late August, early September 2016 in Khabarovsk region.

Increasing frequency of daily precipitation extremes in winter for the period 1961-2013 was observed almost in the entire territory of Russia. Positive coefficients of trends occurred in the winter time were kept also in the summer in the most parts of Eastern Siberia and West Siberia as well as in European Russia.

In summer the positive significant trend of the precipitation extreme frequency in the Central Chernozem region in the center of the European part of Russia in the years 1961-2013 enabled increasing of leptospirosis disease incidences. It is the result of contamination of potable water sources.

A significant threat to sustainable vital activities and in particular to the health of the Russian population is associated with return of these phenomena and with revealed trends in hydrological cycle changes that are not relevant to meteorological and hydrological regimes typical for the local area.

ACKNOWLEDGEMENTS

The study was supported by the Russian Science Foundation (project 16-17-10236 «Impact of climate changes on population vital activity in Russia («areas with specific climatic conditions»)»).

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Received on October 27th, 2017 Accepted on November 22nd, 2017

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