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EXTREME CLIMATIC PHENOMENA OVER THE RUSSIAN PLAIN DURING THE MEDIEVAL WARMING AND THE LITTLE ICE AGE ACCORDING TO DOCUMENTARY RECORDS

Abstract: More than 1300 evidences on extreme climatic phenomena mentioned in the narrative sources over the Russian plain for the period 970-1850 have been analysed. Classification of these phenomena with the evaluation of the spatial and temporal scales has been made. Changes in frequency of extremes between the Medieval Warm Epoch and the Little Ice Age as well as the interconnection of different phenomena extremes has been studied. A hypothesis on extremes frequency changes under the possible climate warming is suggested.

Key words: climate, extreme, frequency, hazard, secular epochs, Russian plain.

1. Introduction

The instrumental observation data covering for the most of regions the period not more than 100-150 years are not sufficient to have reliable statistical descriptions and prognostic assessments of climate changes. Indirect indicators of climate, in particular historical ones derived from narrative sources (chronicles, diaries, official documents) are promising for extrapolation of climatic series deep into centuries. It is known that the extremes have the best probability to be included in the historical documents. Information carried by historical records is mostly descriptive and discrete and related to different time spans – years, seasons, months, days. Historical data for Eastern Europe are given and analysed elsewhere (Borisenkov, Pasetsky 1988; Krenke 1995; Krenke, Chernavskaya 1998). This paper deals with some statistical evaluations of changes in frequency of different extremes between the Medieval Warm Epoch (MWE) and the Little Ice Age (LIA).

2. Data and Methods

About 1200 extreme climatic and about 250 non climatic events were totally analysed. The existence of the information on victims and material damage was

considered as an indication of climatic extremes reliability. Most of the data were selected from the Russian chronicles (Complete Collection ... 1841-1982) and also from official documents (Ministry... 1830-1855; Chamber-Fourier... 1853-1856), travellers notes (Daily Travel ... 1771; Olearіy 1906; Travel through... 1873; Strais 1935) and the daily records of the late of the 17th century (Belokurov 1908). The catalogue of data (Borisenkov, Pasetsky 1988) provided a valuable help for the authors.

Data were analysed for the whole Russian plain for the periods 970-1380 and 1381-1850 which approximately correspond to the MWE (Hughes, Diaz 1994; Lamb 1987) and the LIA (Bradley, Jones 1995). The differences in the information completeness were compensated by evaluation of frequency ratios between the different climatic extremes. These ratios were presented as the share of each extreme in their total sum.

The significant practical importance has the spatial and temporal interrelation and coincidence of different extreme events, which leads to the increase of loss and damage (Krenke et al. 1991). In case of independence of events the probability of their coincidence is equal to multiplied probabilities both of them. In case of mutual attraction the probability of events coincidence is more than their probabilities multiplied by each other.

3. Classification of Extreme Climatic Phenomena and Hazards

Extreme climatic phenomena have been divided into separate groups. The first one is formed by extremes connected with the thermal conditions: severe winters, spring late frosts, summer frosts and early autumn frosts. Another group depends on the long period precipitation conditions: droughts (spring, summer and autumn), autumn and summer rotting. The next group consists from floods - unusually high in spring, and thaw winter and high shower floods, as well as raising and lowering of water level by the effect of winds and reverse river flow. Atmospheric phenomena such as thunderstorms, storms in the sea, lake or river, hail, exclusively strong winds, snow storms are included in a separate group. At last, hazards induced by plant diseases, epidemics, epizootics form the special group.

Extremes and hazards differ according to the spatial scale as well as to the duration of action. These differences depend on the circulation causes. The largest area (up to 2.5 mln. sq. km) and duration (up to 2.5 months) have the events connected with the stationary Highs. They are followed by the extremes caused by the frontal processes (up to 0.3 mln. sq. km and up to one week) and at last the local perturbation (less than 50 thousands sq. km, and about one day).

4. Changes of Climatic Extremes Frequency between the Medieval Warm Epoch and the Little Ice Age

The extremes frequency based on climatic phenomena and non climatic disasters selected in the North and the Central regions of the Russian plain has been compared to estimate the temporal changes between the MWE and the LIA. Incidentally the

period 1751-1850 belonging to the LIA was considered separately because of its high density of information.

The droughts are presented the most completely in the documentary sources. In the average between the North and Central regions they were mentioned once in 20 years for the period of 880 years. Ones in 28 years in the LIA, ones in 16 years in the MWE in spite of more sparse total information on the last period. In the century 1751-1850 the droughts frequency increased up to ones in 8 years, which coincided with increase of climate continentality, and the increasing of information.

Catastrophic abundance of rains during the summer or autumn seasons, usually accompanied with rain-induced floods was mentioned once in 29 years in the same area. These events as well as anomalously high spring floods during the LIA were mentioned several times more often than during the MWE. Unusual summer surplus of rains was mentioned once in 33 years, in the autumn once in 48 years, high rainy floods once in 29 years and unusually high spring floods once in 18 years during the LIA. Corresponding frequencies for the MWE were once in 143, in 102, in 102 and in 68 years. Of course, the frequencies depend on the changes of the information density, however the opposite site of ratio for the droughts indicates the real differences, too.

The frequency of notes about the severe winters in the average for the area of investigation was equal once in 16 years for the whole period, and has increased from the single case in 33 years for the Medieval Optimum to once in 20 years in the LIA and to once in 5 years at the end of the LIA (1756-1850). This latter might be mostly explained by the increase of information. Spring late frosts occurred once in 20 years during the LIA, and only once in almost 60 years during the MWE.

During the MWE the droughts were mentioned more often (53% of the total number of extremes), than the others events with their share as a rule no more than 11%. During the LIA the share of droughts decreased to only 10-19%. The share of severe winters (16%) in the LIA is far more than in the MWE, when it was equal only to 6%.

In the LIA the share of snowstorms, unusually early frosts, summer frosts is more than in the MWE. There is a tendency to the increasing share of unusually humid summer and autumn seasons. The share of storms was by 2 times, of thunderstorms - by 1.5 times higher in the MWE than in the LIA. In the century 1751-1850, which has the most representative information, the share of severe winters (24%) is on the first place, and droughts (16%) are only on the second. This reflected position of this century in the Little Ice Age. Of course, non uniformity of information during the last millennia has an impact on this example, too.

As a whole the share of extremes connected with the northern cold air intrusions, its stationaring and additional local cooling increased during all seasons of the year in the LIA. In the MWE the most often registered extremes were droughts and epidemic connected with the hot weather.

5. Interrelations between Extreme Events

Severe winters were mentioned in the North 54 times (i.e. in 6.1% of years), droughts 71 times (8.1% of the years). In the Centre correspondingly 65 and 96 times

(7.4% and 10.9% of the years). Both events were mentioned in the same year 10 times in the both regions. That corresponds to the 1.1%. The theoretical coincidence for the independent events has to be equal to 0.49% for the North and 0.80% for the Centre. Some excess of the real coincidence over the theoretical ones reveals weak attraction of these events to each other and hence to a little bit greater probability of years with high range of continentality comparing with the random set of them.

Extreme climatic events, especially droughts worsen the ecological situation and promote the development of biological hazards. For the 880 years in the Central and the Northern regions (in one of them or in the both simultaneously) the epidemics were mentioned 81 times, i.e. in 9.2% of the years, and the droughts 123 times, i.e. in 14% of the years. In case of their independence the probability of both events in the same year has to be equal to 1.3%. Meanwhile the epidemics were mentioned during 21% of the droughts and the droughts during 31% of the epidemics. Both events were mentioned in more than 2.8% of the years with the probability 2.5 higher than the random one.

6. Conclusions

The above analysis has confirmed the spreading over the Russian plain of main climatic epochs, revealed earlier in the North and the Centre of the Western Europe - the MWE and the LIA. On the other hand it has supported the representativity of documentary evidences which could be used for climate reconstruction.

The share of droughts among the extremes is higher in the MWE. Even the absolute number of its notes in the documents is higher in spite of twice less dense information from this period, more remote from our time. The shares of severe winters, early frosts and late spring frosts are the greatest during the LIA. In general the frequency of extremes increases over the LIA not only because of less information loss, but due to prevailing of meridional type of circulation which promotes the appearance of the extremes.

One can found the examples of mutual attraction of the different extreme events, like between the droughts and the epidemics and even between the severe winters and dry summers, as well as mutual antagonised events like the summer droughts and rotting.

In case of possible anthropogenic climate warming (Budyko 1972) one could suppose in all the regions the more frequent droughts and connected epidemics and less frequent snow-rich winters and high spring floods. The zonal circulation will prevail. But the picture will be changed to more complex in case of simultaneously growing precipitation which was found in the last warm decades.

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