

**CLIMATE CONDITIONS OF LAND USE IN MIDDLE AGE  
IN MOSCOW REGION**

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It is impossible to find out the ways and directions of landscape natural development and man-made evolution without reconstruction of climate fluctuations. Investigations of climate changing for historical period are the most productive ones, because not only proxy-data, but documented records on climate fluctuation and extreme phenomena. For Central Russia documented period is the latest millennium, when the first records on climate have been appeared in chronicles. So, since, the history of instrumental meteorological observation has continued nearly one and half hundred years, the main method of past climate and landscape investigation is all-round analysis of chronicle data, data of tree-ring studies and carbon-data, spores and pollen analysis data and other is the important method. Registration of unusual natural phenomena, such as storm, sun eclipse, drought, flood, became regular since second half of tenth century, one has systematic character from eleventh century. All important climate events (intensity and recurrence) were written in chronicles, because of they strongly influence on functioning, rhythmic and dynamics of landscapes and determine both, economy and historical development of Russia.

So the registration of unusual natural phenomena have been regular already in the first Russian chronicle, as it have been marked by K.S. Veselovskiy (1857), M.A. Bogolepov (1908), I.E. Buchinskiy (1957), S.I. Kostin (1965), U.I. Vozovik (1977) and others. More over, in last generalising papers on climate change during historical period have been made (Borisikov, Paseckiy 1988; *Fluctuation of climate for last millennium*, 1988; Barash, 1989; *Fluctuations of climate of Europe in historical past*, 1995). This investigation has been carried out on the base of conjugate analysis of historical documents (chronicle sources, published in the *Full collection of Russian chronicle* in 37 volumes, which includes 35 chronicles) with published data on lakes level fluctuation, amount of water in the rivers, data of tree-ring studies and carbon-data, spores and pollen analysis data. We use not only direct climate and meteorological remarks and characteristics (hot or cold, wet or dry and so on), but also mentions

about unusual natural events and indirect data (on water-floods, bad harvest, hunger years, epidemics and others). The result of our investigation is board classification in form of table of annual records of uncommon weather events in second millennium or the table of extreme natural phenomena (fig. 1).

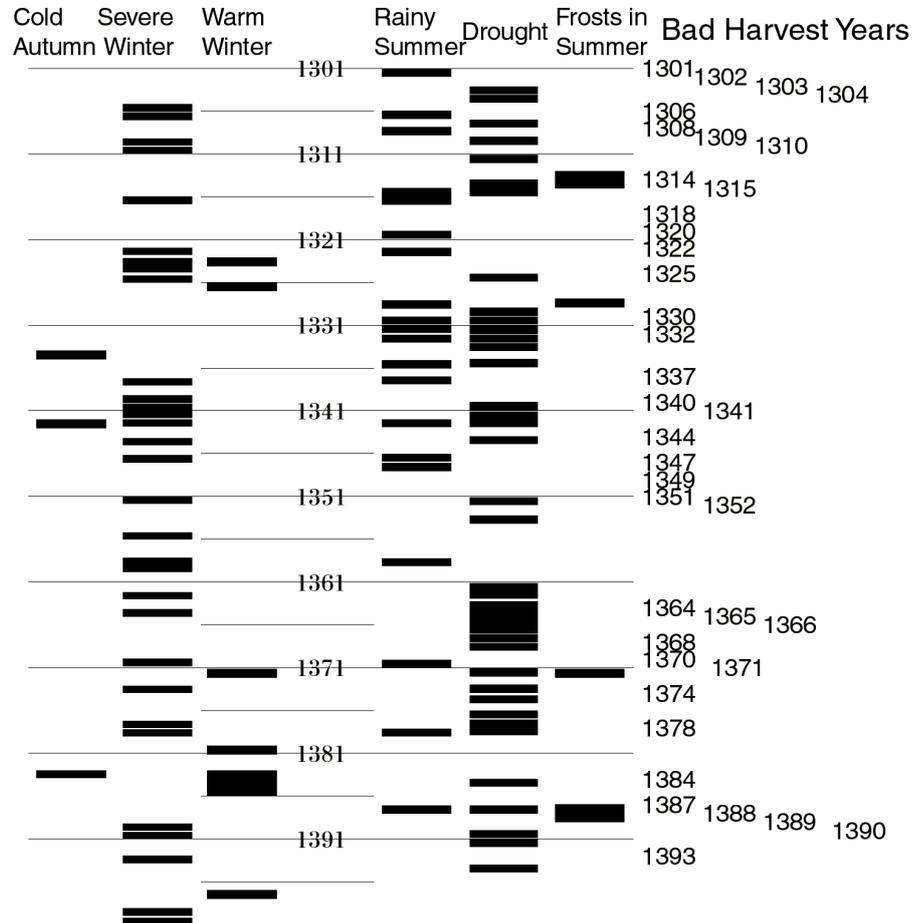


Fig. 1. Extreme natural phenomena during XIV-XVI century

The common scheme of climate dynamics in Moscow can be perform in such manner. The climate of last millennium has one distinguish feature. This is existing of two main periods: the climate optimum in eighth-thirteenth century (VIII-XIII), and the second periods is little ice age from XIV till the middle of XIX. In the first half of XIX century the modern warming of climate has began, which continue till now. Reconstruction by authors of *Changing of Climate of Europe...* (1995) and investigation by V.A.Klimanov

(1984) has realised that amplitude of climate fluctuation during the first millennium was small, and from VIII century till first part of XII century the air temperature was high and climate was dry. So in small climate optimum climate was warmer and drier than now (X and XI centuries were the warmest). Besides high temperature (1-3°C warmer than modern), there were no severe winters then (with temperature below -40°C). The sums of effective temperature above 10°C were 200-500° higher than now. Little summer precipitation led to decreasing of small basin quantity, swamp areas and reducing of flood. We can judge about it when we find Slavs settlements on the flood-plain of Moscow rivers as Moscow river, Pahra and others. There were much more broad-leaved forest, especially oak in west sectors, in the zone of coniferous and coniferous broad-leaved forest. So summer conditions were warmer (1987). Obviously, climate of the beginning of II millennium A.D. on Russian plain was the same as now in dry steppe zone of south-east of European part of Russia. In this favourable climate sense time, the famous way from Varangians to Greeks has been found out (Barash 1989).

As chronicles show us, frequency of catastrophic natural events was minimal. In X-XII centuries old Russian agriculture suffered mainly from drought. However, severe droughts, cold winters, rainy summers led to hunger not so often (987-991, 1092-1096, 1124-1128, 1145-1146). In XI century and first quarter of XII century frequency of catastrophic natural events was minimal too. 41 extreme natural phenomena have been registered for X century in Russian chronicles, for XIII century – 102 (Borisenkov, Pasetzkiy 1988).

In X century AD winter crop and spring wheat and rye, barley and oats were the main agricultural species. Millet was the next crop, but then its role was decreasing. As you know millet is the species of dry climate, and in that time millet was less effective. The rye (winter and spring) was the most economical and effective in Russian agriculture during millennium (Kiryanova 1992). Rye was the main bread till the middle of XX century. We can read about price on rye in chronicle description of starvation (Barash 1989).

In the main, climate conditions of little climate optimum were favorable for farmers and ensured good harvest and social-economic prosperity of Slavonic tribes.

From XIII century extreme phenomena became more frequent, both severe and soft winters, and dry summers. Such change for the worse of climate conditions led to bad harvest and starvation during 17 years. Chronicles give us clear idea about increasing of unsuitability of atmosphere processes and cyclone activity intensification. That led to increasing of frequency of flood, more mustering and to falling the temperature, the records in chronicles about frost in summer, which killed the crops (Borisenkov, Pasetzkiy 1988).

The transitional period of thirteenth – fourteenth century was the period of contrasts, as it was the forerunner of little ice age. It had the next characteristic features – increasing of intrayear variability of weather, increasing of moistening, harsh fluctuation wetting and

warming from year to year. We can see in the table very often warm and severe winter, rainy and dry summer. The summer temperature decreased on one-two degrees, and summa of effective temperature in forest zone reduced on 800-1000°C (Borisenkov, Pasetzkiy 1988; *Fluctuations of climate...* 1995). The duration of vegetation period of crops reduced almost on tree weeks (Бараш, 1989),

According to Lyahov's data (1995), in the centre of European Russia the average year temperature for 30-years 1201-1230, 1231-1260 and 1261-1290, were 3,4°, 3,8° and 3,0°C respectively; winter -9,5°, -9,4° and -9,8°C; summer 17,2°, 16,7° and 17,2°C, spring – for all these periods 3,8°C.

The XIII century began from heavy rains and severe frosts. In 1211 there was great drought, which lead to very hungry years since 1211 till 1216. The period from 1211 till 1233 is one of the longest periods, in which extreme natural phenomena concentrated. The population of Russia reduced sharply, just before mongolo-tatar invasion.

For XIV century, we can see enlargement of quantity of severe winters and at the same time warm winters, rainy and dry summer, seasonal contrast increased, on the background of cooling. It was the time of contrasts and sharp cooling. Especially cold winters were in 1309/10, 1340/41, 1389/90 and 1393 years. We can find 30 noted about very severe winter and also about very often rainy summers. That led to very bad harvest and famine during 37 years.

We can trace increasing of quantity of extreme natural events in XIII-XIV (by S.I. Barash's calculation, 1989): there were 252 extreme events in VIII-XII, but there were 330 such years in XIII-XVI century. Correspondingly, there were – 109 and 181 hungry years, 182 and 291 years of extremely bad harvest, including for reason of destruction of winter crops in severe winters – 67 and 185.

Period since XV till XIX century are called little ice age. But getting chill was not gradual, it expressed in increasing of quantity of unusual natural phenomena, forcing of intrayear fluctuations. Vegetative period reduced on tree weeks. Cyclone activity forced sharply and pluvial period alternated with dry years. But bad harvests and famines in general were caused by severe winters and long heavy rains.

But little ice age were wet only in its second part, after XVI (Lyahov 1995). In the first part of little ice age precipitations were the same as now, but more than in the climate optimum VIII-XII centuries. The greatest variability of climate was at the end of XIV – the beginning XV and at XVI-XVII centuries, when there were years with especially cold winters and high humidity due to winter precipitations (Barash 1989). As a result, fir-tree had become a dominant in coniferous-broad leaved forests and co-dominant – in broad leaved (Turmanina 1987).

In agro-climate sense all XIV centuries was not so good: frequent thunderstorms, heavy downpours, floods due to cyclone activity (Barash 1989). There were such disasters

as epidemic reasons, because of natural and socials (wars, starvation). Such a painful plague epidemic was in 1654-1657 – the strongest in XVI-XIX centuries. 35 central Russian town and 30 thousand square km had been embraced by plague at its first stage, more than 100 thousand people have died. It was 30-85% of population (Dulov 1983). In Europe the same conditions led to decreasing of birth rate, increasing of death rate and reducing of population.

E.P.Borisenkov and V.M.Paseckiy (1988) mark the warming of climate at the beginning of XVI centuries. There were 9 soft winter in XV, 20 – in XVI and 7 – in XVII, but summers were cold (also coldest in Central Europe). Russian chroniclers wrote about sharp cooling in last third of XVI centuries. That led to serious economical shocks. The end of XVI was the period of strong political and economical crisis in Russian State (oprichnina and Livon Wars by Ivan IV), with the bad climate conditions (high humidity, low temperature). Many Russian villages have died, and large villages became small. The area as with forests and bushes, meadow and bogs became larger (Kolbowiski 1995).

Little ice age was not entirely cold, it was the set of shorter cold and normal periods. We can see that small ice period was broken into two parts by warm time of XVI century. The XV century – very cold time. There were 150 extreme natural events. The weather was unstable – dry periods changed by wet and cold. So snow cover in Moscow in 1445 was more than two meters and there were great frosts. Bad harvests due to severe winter were in 1408, 1417, 1420, 1443, 1467, 1468, 1481 and 1496 (Barah 1989). Heavy rains were in 1404-1405, 1424, 1430, 1445, 1453-1456, 1484, greatest droughts – in 1408, 1412, 1414, 1422, 1424, 1442-1443, 1448, 1471-1472, 1485, 1493 and severe winters – in 1407-1408, 1420-1423, 1445-1447, 1461-1462, 1471. All these events caused more than 40 hungry years.

The XVI century was characterised by high humidity, which expressed also in enlarging of lake quantity. The tale about Moscow as marshy and swampy region and about navigable small rivers concern to this time. Many villages, located near rivers, disappeared in XVII century.

It is interesting that at the beginning of little ice age the process of mastering of areas between rivers began. This process had economic and nature causes. Village had been founded on higher position.

The culmination of small ice period was the time since 1550 till 1701 year, when we can see maximal frequency of severe winter and frosts in summer. We can read that crop even could not matured in some years and farmers dry rye with help of fire. The large range of temperature fluctuation testified about great instability of climate and significant regional differentiation. That show us great importance of circulation processes in climate formation.

Climate fluctuation have been reflected by price indexes for crops and others agriculture products. After little climate optimum the prices became higher, in better conditions prices – reduced. In the second part of XVI century prices become to increase sharply and reached its maximum at the end of XVIII and begin XIX – the bloom of little ice age.

The great period XIII-XVI centuries was characterised by stabile most unfavourable climate condition and its tragic consequences: bad harvest and hunger. But there were no economical decline, moreover we can observe opposite process – inculcation of bare fallow system of agriculture and wide spreading of rye and oats instead wheat and barley (Krivosheev, 1995). Such reaction leded to agriculture revolution in Russia XIV-XVI. In the middle of XVIII century – when the weather condition was most unfavourable – the new culture, potato had been disappeared on Russian fields.

Ploughed fallow system of agriculture combined three-field and forest fallow. It delayed intensification, but it was more adapted to nature. Poor development of stock-raising, vegetable-growing and gardening have been compensated by appropriated economy (hunting, fishing, wild-hive beekeeping (Danolova 1996).

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## KLIMATYCZNE WARUNKI UŻYTKOWANIA ZIEMI W ŚREDNIOWIECZU W REGIONIE MOSKIEWSKIM

### STRESZCZENIE

W rekonstrukcji warunków klimatycznych minionych epok historycznych szczególnie przydatne są: interpretowanie zapisków pozostawionych w dawnych kronikach, badanie pierścieni przyrostów drzew oraz analiza pyłkowa. W artykule przedstawiono uzyskany w wyniku badań prowadzonych przez wielu naukowców obraz warunków klimatycznych panujących w minionym tysiącleciu w regionie moskiewskim.

Klimat rozpatrywanego okresu jest wyraźnie zróżnicowany. Pierwszy z wyraźnie zaznaczonych okresów stanowi małe optimum klimatyczne w wiekach VIII-XIII, drugi – mała epoka lodowa, utrzymująca się od XIV do połowy XIX w.

W czasie małego optimum klimatycznego klimat był cieplejszy i suchszy niż obecnie (najcieplejsze były stulecia X i XI). Temperatura powietrza była o 1-3°C wyższa niż obecnie, nie było surowych zim (z temperaturą poniżej -40°C). Rzadko występowały klęski żywiołowe. Głównymi roślinami uprawnymi w regionie moskiewskim były wówczas ozima i jara pszenica, żyto, jęczmień i owies.

W przejściowym okresie XIII-XIV w. zwiększyła się zmienność warunków pogodowych i częstość występowania niekorzystnych zjawisk, co poprzedzało nadejście małej epoki lodowej. Temperatura lata spadła o 1-2°C. Długość okresu wegetacyjnego skróciła się niemal o 3 tygodnie. Znacznie wzrosła częstość nieurodzajów i klęsk głodu.

Począwszy od XV w. okres wegetacyjny uległ dalszemu skróceniu o ok. 3 tygodnie. Mała epoka lodowa nie była jednak jednolitym okresem chłodu. Bardzo chłodny był XV w. oraz okres od XVII do połowy XIX w. W XVI w. natomiast zaznaczyło się pewne ocieplenie. Koniec tego korzystniejszego okresu pozostał w historii jako czas ostrego kryzysu gospodarczego i politycznego. W XVII w. znacznie wzrosła częstość surowych zim i nawet przypadków wystąpienia mrozu w sezonie letnim. Miejsce pszenicy i jęczmienia na polach uprawnych zajęły owies i żyto. Ceny zarówno zbóż, jak i innych produktów rolnych znacznie wzrosły. Często były lata nieurodzajów i klęsk głodu oraz związane z nimi epidemie chorób (w czasie epidemii panującej w latach 1654-1657 zmarło ponad 100 tysięcy osób).

Mała epoka lodowa zakończyła się w połowie XIX w., kiedy to rozpoczęło się współczesne ocieplenie klimatu.