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DENDROCLIMATIC STUDY IN URAL – SIBERIAN SUBARCTIC

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CONCLUSION

This book deals with the problem of obtaining of reliable climate information during the last 400-600 years within the Ural-Siberian Subarctic region on the base of tree-ring width variability of trees growing in forest-tundra zone and in the northern part of open forest subzone. This study is a part of circumpolar Subarctic dendroclimatic project being carried out by international research groups supervised by Prof. F.Schweingruber.

Evenly spread net of test- sites from the Polar Ural in the west to Chukotka in the east was founded for the first time. It will be the part of dendroclimatic monitoring system for boreal forests of Russia. The results of study show perspectivity of this type of ecological monitoring. The long-term, absolutely dated and provided with the sufficient number of sampled trees local tree-ring width chronologies of the main conifers, especially, of different larch species (Larix sibirica, L. Gmelinii and L.Cajanderi) and at least of Siberian spruce and Scots pine are obtained for these test-sites.

Extraction of the strong climatic signal both in tree-ring width chronologies and in cell dimension ones can be considered as the important part of this study. Multiple regression and simulation models of conifer tree growth showed that in most cases only summer temperatures (June and July) are of the main and positive importance for tree-ring width variation along the Ural-Siberian Subarctic region. Up to 60% of tree-ring width variability is explained by summer temperature changes. There is the most strong climatic signal in larch chronologies. In continental region (the downstream of the rivers Yana, Indigirka, Alazeya and Kolyma) this signal is maximum from the mentioned ones in literature till now. Its nature can be explained by the very strong and short-term influence (up to two months) of one limiting factor (temperature) on the radial growth of trees. Therewith the following regularity is clearly observed: moving towards from the west to the east and from the north to the south the influence of July temperatures on radial growth decreases and the influence of June temperatures increases relatively. It is evidently connected with the more early beginning of tree vegetation in southern regions. Significantly negative effect on the tree-ring width has moisture deficit in the thin layer of thawing soil in more continental and poor with precipitation regions. In connection with this the June-July precipitation promotes the increase of radial growth rate. Simulation model shows the high influence of solar radiation and of soil thermic regime on tree growth during summer in high latitudes and permafrost soils, too.

Existance of strong climatic signal in obtained tree-ring chronologies allowed to make for the first time the local quantity reconstructions of the average June-July temperatures for the 300-600 years within the subarctic region. Point reconstructions were made for 47 sites (28 base meteostations posessing the most reliable and long rows of instrumental observations and 19 dendroclimatic test-sites where tree-ring chronologies with strong climatic signal have been obtained). The sites where the reconstructions were made are evenly spread within the studied area.The analysis of reconstructed summer temperatures demonstrated that during the last centuries the amplitude of extreme variations as well as standard deviations in average summer temperatures within different regions remained high and more or less constant. However, moving from the west to the east we can see the gradual decrease of amplitude of temperature changeability both of year-to-year temperatures and long-term temperatures changes. For example, the range of extreme year-to-year June-July temperatures in the West-Siberian Subarctic is 10-11^{o} C , in the Middle Siberian Subarctic it is 7-8^{o} C and in the Eastern

Siberian Subarctic it makes 6-7° C. High similarity of tree-ring width chronologies within the vast areas that stretch from the west to the east up to 600-800 km is revealed as well. More long variations (intracentury- and century-long ones) have synchronous course within more vast areas but the differences are the most often observed in the change of variation amplitude. However, at certain periods the reverse course of such variations between the far removed from each other regions is observed. It shows that in subarctic regions of the Urals and Siberia the macrosynoptical processes effect strongly on the variability of temperature regime of summer months and that dendroclimatic reconstructions contain, mainly, the information on variability of the large-scale climatic conditions.

Based on synchrony analysis in the year-to-year variability of tree-ring chronologies the studied area was divided into six dendroclimatic regions: the West-Siberian, Taimyrski, Anabarski the northern, Anabarski the southern, Yano-Kolymski and Anyuiski. The borders of these regions coincide well with the borders of large physical and geographical as well as of climatic regioning. Large differences in larch tree-ring width variability in the riverside continental regions between the rivers Khatanga and Lena are observed. Obviously, summer temperatures in the riverside regions are greatly effected by the arctic air masses what come from the Arctic Ocean while in more southern regions they are effected by the continental air masses formed on the continent.

The spatial-temporal reconstruction of anomalies of June-July average temperatures for the years 1611- 1990 for the whole Ural- Siberian Subarctic is the most important result of this work. Maps of summer temperature anomalies show that during the last 380 years the year-to-year anomalies of summer temperature course of different directions (more than 60% from total number of years) dominated in large Subarctic sectors (Appendix 1). The spatial-temporal reconstruction of summer temperature anomalies is of great importance both for decision of the problem concerning modern tendencies in changing of regional and global climate and to forecast possible climatic changes in high latitudes of the Northern Hemisphere.

The local and spatial reconstructions with such a dense net of test-sites were made for subarctic regions of the Northern Hemisphere for the first time.

Spatial reconstructions of anomalies of June- July average temperatures and the local reconstructions for the last 500 years based on tree-ring width chronologies do not show the clearly expressed positive trend of air temperature in connection with the increase of green-house gases concentration in the atmosphere within the whole studied area where, in the opinion of the most of climatologists, the most strong anthropogenic climate warming must occur. In contrast, in the late 1970s and in the first half of 1980s the decrease of radial growth due to temperature in summer months was observed in many regions of the Ural-Siberian Subarctic what was the most clearly seen within the West-Siberian and Taimyrski sectors. Occuring presently year-to-year changes of summer air temperature as well as changes of the air temperature of many years do not exceed the limits of their historical variations. Based on dendroclimatic reconstruction data it should not be uniquely stated that climate warming in high latitudes what was observed in the middle of the current century in different subarctic regions of the Ural and Siberia was extraordinary. Similar summer temperature increases with the similar amplitude were observed, for example, in different subarctic sectors of the Ural and Siberia late in the 17th as well as in the middle and late in the 18th centuries. The warm period in the middle of the 20th century what was clearly registrated by instrumental data made through the whole nothern hemisphere (Bradley, Jones, 1993) has strongly changed the spatial distribution of summer temperature anomalies in

Subarctic what just our reconstructions show. The frequency of temperate-warm and warm years during the middle of the 20th century increased within the whole studied area. Evidently, the expected warming in the first part of the 21th century will cause the increase of such years in high latitude regions of the Asian continent. At the same time the analysis of obtained data allows to state that the anthropogenic climate change will not be most probably synchronous in different large sectors of Subarctic. Growth rate of trees growing in the polar timberline of their spreading must the most quickly respond to such climate change. Other biological processes such as the change of forest ecosystem composition and structure, successions, shifting of the borders of botanical and geographical zones and belts as well as of the polar timberline of tree spreading, it means those processes which are characterized by the long-term functioning must be revealed with the great delay (for decades and hundreds years).

The results of our work greatly add the information on the past variations of tree growth and on variability of temperature in high latitude regions of the Ural and Siberia . This information is very important for understanding of mechanisms and reasons of regional and global temperature changes. We are sure that materials analysed and discussed in the book will be of great interest for different specialists and, firstly, for climatologists, ecologists, geographers, forest specialists, glaciologists, specialists of permafrost. We hope the specialists of other interests will find the possibility to consider presented materials from other viewpoints and will greatly increase the information on environment and climate changes in the high latitude regions of the Northern Hemisphere.

The most perspective tendencies of dendroclimatic research became more clear for the authors. Firstly, this is the analysis of spatial-temporal variations of summer temperatures within the whole circumpolar subarctic zone of the Northern Hemisphere. The materials that we have obtained should be combined with the data of spatial dendroclimatic reconstructions along the European, Canadian and Alaska north. The related analysis of such reconstructions is important both to reveal similarities and differencies in temperature changes at global and regional scale and to verify models of the total atmosphere circulation.

Secondly, this is the increase of dendroclimatic test-site network as well as obtaining of more great number of tree-ring chronologies based on different tree species and different sites, especially for the mountain regions. This will allow to make more reliable dendroclimatic reconstructions with many climatic parameters.

Thirdly, it means the large extension of tree-ring chronologies for several key plots of Subarctic far into centuries (thousands years ago) using the wood remained and subossil that has been preserved till the present time both on the surface and in holocene (alluvial, peat, lake, sea) deposits. There is the perspective for developing of the super-long chronologies in the Asian continent in such regions as Yamal, Taimyr, the Lower Indigirka where the well preserved subfossil wood was found.

Fourthly, not less important work is to compare data of dendroclimatic reconstructions with data on climate change obtained with the help of other indirect records with high resolution in time. Among them those are of great value which allow to reveal century and super century temperature variations. The combining of similar data allows to avoid errors at the reconstruction of the past climatic and ecological conditions, at assessment of their present state and at the long-term forecasting.

Fifthly, tree-rings contain in their cell structure the information on climate changes with the resolution what is more precise than a year or a season. Studying intraseasonal variations of growth rate and factors which are responsible for these variations the cell structure of tree-rings contains the information of more high resolution, it means the information about intraseasonal variations of conditions. Efficient use of tree-ring structure parameters in reconstruction of climate changes is one of the problems of the nearest future in dendroclimatic research.

The wide-scale research of dendroclimatic reconstructions of environment and climate can not be made by small groups of specialists. Realizing of the Siberian subarctic dendroclimatic project demonstrated that large regional and global problems can be fruitfully solved only in cooperation, at the reasonable work distribution and at combining of specialized group efforts.