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The influence of soil temperature on radial increments of larch and pine stems in Central Yakutia

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ABSTRACT: Core samples were taken from various types of larch and pine forests at "Spasskaya Pad" station located 24 km north-west of Yakutsk city, in order to study in detail the role of microclimatic conditions in stem radial increment of the main forest-forming species. The forests of "Spasskaya Pad" station reflect to some degree the key features peculiar to the forests of Central Yakutia. Larch and pine need different ecological and hydrothermal soil conditions to grow in the zone of permafrost distribution where they are the main forest-forming species. The larch, more tolerant to cryogenic processes, grows on most parts of Yakutia's territory. This is promoted by the root system, which lays at a depth of only 50 cm. The pine is less resistant to frost conditions and occupies dry soils with deep permafrost thawing.

1 INTRODUCTION

Climate plays the leading role in spatial differentiation of forest cover. Forests occupy a considerable portion of the territory of Yakutia and are integral parts of permafrost ecosystems. The response of forest-forming species to climatic conditions on the territory of Yakutia, situated in the zone of permafrost distribution, is of great interest. We have studied relationships between tree-ring chronologies of Cajanderi larch (*Larix Cajanderi Mayr*) and Scotch pine (*Pinus sylvestris L.*) and permafrost ground temperature at various depths on the basis of data from Pokrovsk meteostation in Central Yakutia. It is well known that climate changes are clearly recorded in radial increments of trees in the form of annual rings with different thickness (Douglass, 1919, 1936; Fritts, 1976; Bitvinkas, 1974; Vaganov et al., 1996; Schweingruber, 1996). In dendroclimatology, the intensity of the influence from various climatic conditions on radial increment is usually estimated by the response function (Fritts, 1976, 1991; Briffa K.R. & Cook E.R., 1990). Thereby, the characteristics of local growth conditions is of considerable importance. Depending on species and place of growing, woods react differently to changes in climatic conditions. The procedures of related data collection and processing are developed in detail in dendroclimatology. Yakutia occupyies territories with sharply different climatic zones and, hence, has important potentials for the development of permafrost dendroclimatology. First, the forests of Yakutia situated in the taiga zone are represented by coniferous tree species, basically by larch, among which it is possible to meet trees with ages of 400 to 600 or even more years (Pozdnyakov, 1985; Vaganov et al., 1999; Nikolaev et al., 2001). Secondly, annual rings of coniferous trees are well defined, and their increment is quite sensitive to changes in environmental conditions. Thirdly, the territory of Yakutia is within the zone of continuous permafrost distribution with its specific peculiarities.

2 DATA COLLECTION AND ANALYSIS

Measurements of annual ring widths were done by using the semi-automatic plant Lintab V-3.0 (Rinn, 1996). The relative or absolute dates of individual series, as well as false and missing rings, were determined by means of a combination of cross-correlation analyses (Holmes, 1983) and graphic cross-dating (Douglass, 1919; Schweingruber, 1988). The cross-correlation analysis is realized in a specialized package of dendrochronological investigations dpl-98 (Holmes, 1998), and the graphic cross-dating in the software package tsap-v3.5 (Rinn, 1996). Derived tree-ring chronologies fully meet the standard requirements for dendrochronological analyses (Shiyatov, 1986; Cook & Kairiukstis, 1990).

The relative contribution of each initial climatic variable to radial increments of trees was estimated with the help of regression coefficients. Thereby, the timing was counted since the end of the growing period, i.e. from September of the last year to the end of August of the current one (Cook & Kairiukstis, 1990; Fritts, 1991).

The correlation analysis of tree-ring chronologies from larch and pine, growing in different forest types, showed a dependence of the radial increment from hydrothermal soil regime in specific forest types. High correlations are indeed found between radial increments and mean monthly ground temperatures.

The correlation analysis of larch tree-ring chronologies at the station "Spasskaya Pad" with soil temperature conditions at various depths (Fig. 1) indicates that

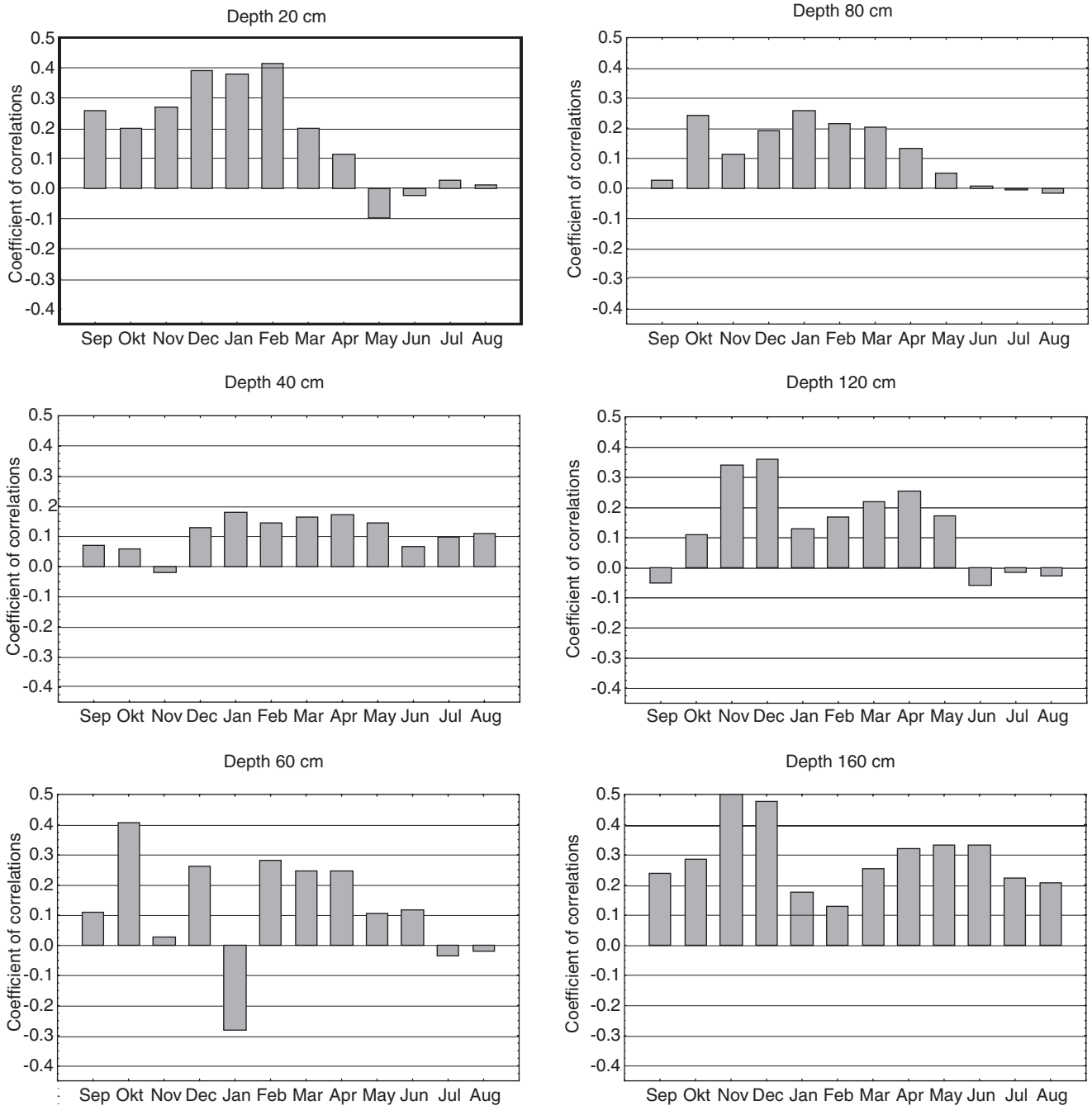

Figure 1. Response function of tree-ring chronologies depending on soil temperature (cluster-berry larch forest, "Spasskaya Pad" station).

the strongest correlation is observed in winter time. The higher soil temperature, the quicker soil heating, which favours early onset of active tree growth at the beginning of the vegetation period.

Summer temperatures do not limit the radial increment of trees – in this period the amount of heat necessary for successful growth is abudant for trees. However, there is a significant link of radial increment with the temperature at a depth of 160 cm. Obviously, ground condition at this depth has indirect effects on the radial increment. The lesser heat flowing into the forest soil will be used for permafrost thawing, the quicker and earlier will be ground thawing; accelerated ground thawing, in turn assists in earlier growth processes.

The response function of pine radial increment is shown in Fig. 2. At the upper and lower limits of the active layer, at 20 and 120 cm depth respectively, the winter soil temperatures untill the end of May have positive effects on the radial increment of tree growth. In the soil layer at 40–80 cm depth, the positive temperature influence is observed during spring months. This leads to earlier ground thawing and to the beginning of pine growth processes.

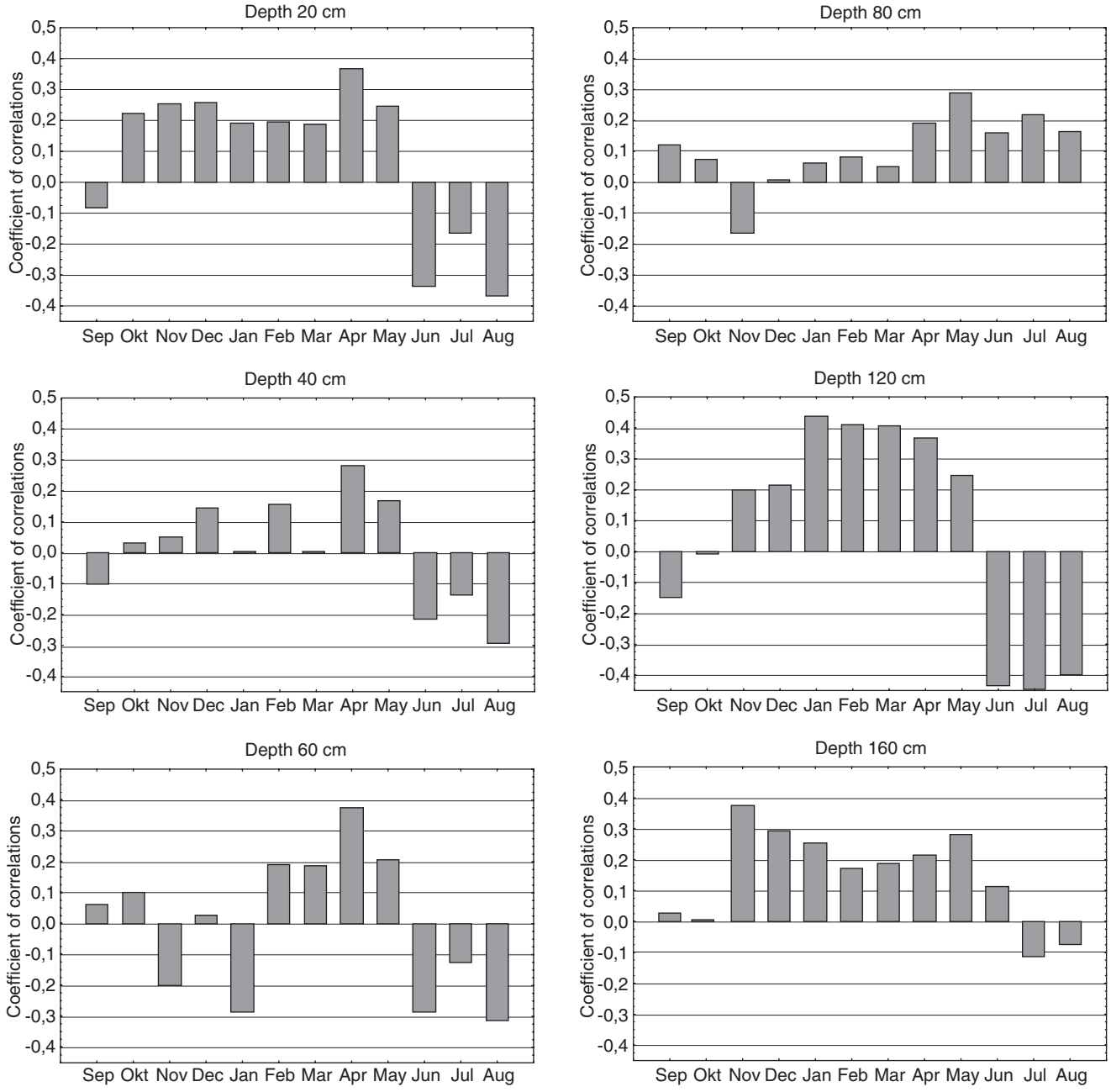

Figure 2. Response function of tree-ring chronologies depending on soil temperature (bearberry pine forest, "Spasskaya Pad" station.

However, unlike larch, the pine growth is subject to the influence from substantially negative summer temperatures at some depths. It may possibly be explained by more soil moisture deficit in dry soils, where high temperatures cause drying effects.

3 CONCLUSION

Radial increments of wood species in permafrost soils are closely connected with the active-layer temperature during the whole season. Larch and pine grow in the zone of permafrost distribution, where they are the main forest-forming species, Different responses to changes in soil temperature at various depths of the seasonally-thawing layer suggest that they need different ecological and hydrothermal soil conditions.

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