On the possibility of using CO_2 content in wood for dendroclimatic investigations

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Measurements of the CO_2 content in the annual rings of scots pine and Siberian spruce have been carried out by the method of laser photoacoustic gas analysis. The observations are analyzed from the viewpoint of connection of annual ring features with the climatic parameters (mean temperature, precipitation). Some recommendations are given concerning the use of the information obtained.

Introduction

Dendroclimatic investigations are now used quite widely for solution of climatic and ecological problems on both regional and global scale (see, for example, Ref. 1). Methodically, such investigations are based on the principles of dendroclimatic analysis developed by Russian and foreign scientists, namely, on obtaining and analysis of annual ring chronology. The main informative parameter in this analysis is the width of the annual ring in wood samples. The comparison of this parameter with the monthly mean indices of the air temperature or precipitation amount allows revealing the correlation between the yearly annual ring growth and these climatic characteristics. Using this approach, one can, in particular, reconstruct the summer temperature dated back to several centuries.[2]

Recently, some papers concerning the use of wood density characteristics in dendroclimatic investigations have been published.[3] The density characteristics complement the information about the ambient conditions contained in the yearly growth of the annual rings. In Ref. 4, for example, it is shown that the total ozone content can be reconstructed from the changes in the wood density of annual rings of conifers in the vegetation period.

Earlier in Ref. 5 we showed that the annual ring wood contains the air with the increased CO_2 content, which varies with variation of the ring width caused by the vital conditions of a tree in one or another period. This paper presents a tentative analysis of the correlation between the annual ring characteristics (width, CO_2 content) obtained by us and the climatic parameters (mean temperature and precipitation amount) observed in the corresponding periods.

Material and measurement technique

Wood of annual rings of two age groups: scots pine of the 1970s and 1980s and Siberian spruce of the 1980s and 1990s sampled from dried disks of the trees was used as a material for our investigations. The width of annual rings was measured with an MBS-1 microscope accurate to ±0.025 mm.

Gas samples were obtained using vacuum extraction. Gas analysis of extracted gas samples was carried out by the method of photoacoustic spectroscopy with the use of a discretely tunable CO_2 laser.[5]

Results and discussion

Figures 1 and 2 depict the results of measurements of the annual ring characteristics, as well as climatic characteristics according to the data of the Tomsk weather station. The background value of the concentration corresponds to atmospheric CO_2 (~ 613 mg/m^3). Climatic characteristics are calculated for the vegetation period, which lasts since May until October in the Siberian region.

Operation with long series of annual rings usually involves standardization of individual series of the tree-ring width values. This standardization includes some operations, which largely remove the age trend and exclude the variability of non-climatic origin. Since the annual ring chronology under study in our case are short, the standardization procedure was not carried out.

To assess the correlation of dendrochronological, gas-analytical, and climatic data, we have determined the correlation coefficient r of the series obtained.

The obtained absolute values of r are summarized in Table, where W stands for the annual ring width, G is for gas-analytical data, T denotes temperature, and P is for precipitation.

Wood	W–G	W–P	W–G	G–T	G–P
Pine	0.25	0.18	0.31	0.28	0.24
Spruce	0.47	0.46	0.14	0.10	0.40

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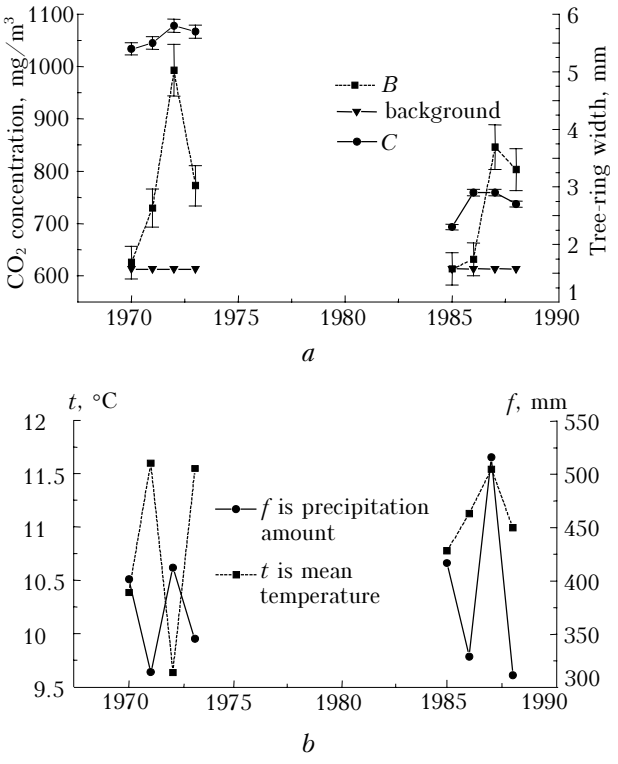

Fig. 1. Data on CO_2 emission (B) and tree-ring width (C) for pine wood (a); mean temperature and precipitation amount during the vegetation period (b).

The results presented show, first, that even with short data series the studied characteristics has some, not negligibly small, correlation and, second, variation of the CO_2 content in wood correlates with variation of climatic parameters approximately in the same way as the annual ring width does. This gives some optimism concerning the possibility of using gas analysis of the annual ring wood in dendrochronology. To obtain statistically confident quantitative results, it is necessary to use longer chronology (more than 50 years long) with all the set of dendrochronological techniques applied to processing the data.[2]

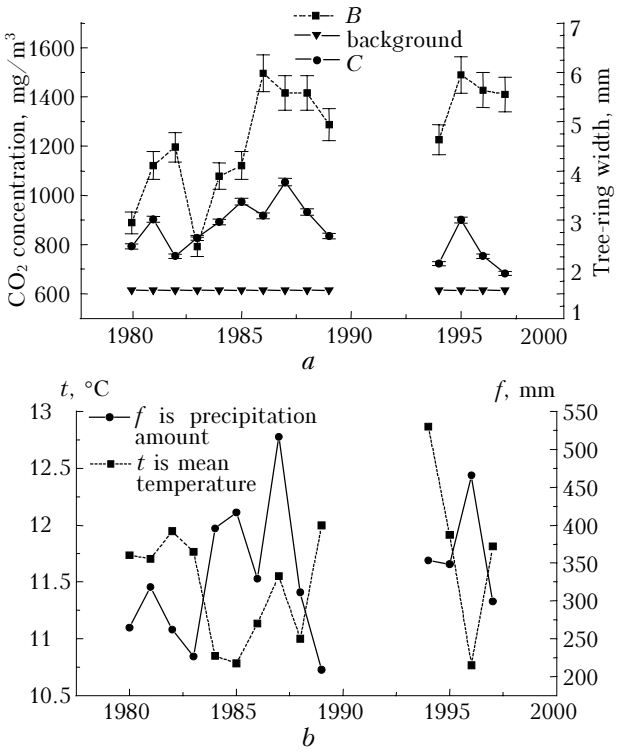

Fig. 2. Data on CO_2 emission (B) and tree-ring width (C) for spruce wood (a); mean temperature and precipitation amount during the vegetation period (b).

Acknowledgments

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