Geophysical Research Abstracts
Vol. 18, EGU2016-8017, 2016
EGU General Assembly 2016

Model estimation of hydraulic characteristics of conifer tree-rings by their cellular structure

Irina Sviderskaya (1), Marina Bryukhanova (2), and Aleksandr Kirdyanov (3)

(1) Siberian Federal University, Krasnoyarsk, Russian Federation (isvider@mail.ru), (2) V.N.Sukachev Institute of Forest SB RAS, Krasnoyarsk, Russian Federation (mbryukhanova@mail.ru), (3) V.N.Sukachev Institute of Forest SB RAS, Krasnoyarsk, Russian Federation (kirdyanov@ksc.krasn.ru)

Year-to-year and intra-ring variations in xylem cellular structure are considered to be a promising source of information on the ecological condition. This information can be even more valuable if it would be complemented by understanding of its functional meaning. But the relations among anatomical and functional characteristics annual rings and tracheids are not simple and linear. It is not yet possible to measure experimentally the year-to-year and intra-ring variability of water transport anatomical units to determine these relations. The only way is to use a mathematical model based on up-to-date knowledge of water transport mechanism and xylem microanatomy.
We have elaborated the model allowing us to evaluate water conductance of individual annual rings and tracheids by lumen diameter and wall thickness. In the model any annual ring is the radial file of tracheids described by its mean tracheidogram. The quantity of water transported by a ring per unit of time and pressure, conductance, is the sum of conductance values of individual tracheids. The conductance of a tracheid is the reciprocal of its hydrodynamic resistance which is the sum of lumen and pits' resistance. The lumen resistance is calculated by Hagen-Poiseuille equation by the lumen hydraulic diameter. The total resistance of pits depends on their number and individual pit resistance. Unlike in the other models we suppose the individual pit sizes and therefore individual pit resistance vary among the tracheids in relation with their lumen diameter and wall thickness. Taking into consideration literature data for Pinaceae we suppose the diameters of pit membrane, torus, aperture to be linear functions of the lumen radial size.
Model calculations indicate that intra-ring radial variation of tracheid conductance is similar to the lumen radial size variation. Conductance of latewood tracheids is 10–15 times less than conductance of early wood tracheids. Conductance of early tracheids is limited by lumen diameter while conductance of late tracheids is limited by pits. Early wood tracheids are responsible for about 90% of the total ring conductance. Pits' resistance reduces the total ring conductance by 15–25%. In general the total ring conductance correlates well with the mean cell number per radial file. However in larch trees growing in permafrost zone we found out rings having the same width or the same number of cells per radial file but significantly differing by total conductance. The difference is explained by the difference in cellular structure: more tracheids of less radial diameter or the same number of tracheids with thicker walls and smaller lumens.