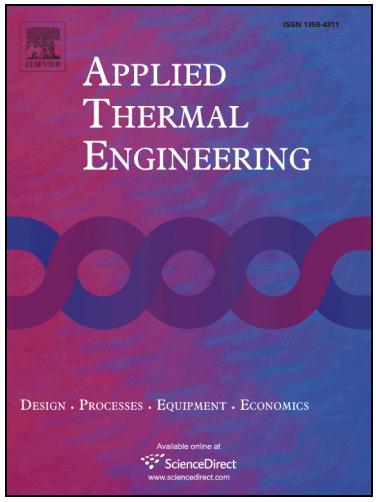

A new heat balance equation for sap flow calculation during continuous linear heating in tree sapwood

M. Trcala, J. Čermák

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A new heat balance equation for sap flow calculation during continuous linear heating in tree sapwood

Trcala M.[1], Čermák J.[2]

[1]Department of Wood Science, [2]Department of Forest Botany, Dendrology and Geobiocenology, Mendel University in Brno, Brno, Czech Republic

miroslavtrcala@seznam.cz; cermak@mendelu.cz

Abstract

This article introduces a new "linear heat balance (LHB) method" that is based on exact (physically correct) equation analytically derived from fundamental conduction-convection heat transfer equation. Therefore, the aim of this paper is to derive and analyze a new heat balance equation for sap flow calculation from measured temperature differences around continuously heated needle. The formula is derived from the steady-state conduction and convection heat transfer equation with linear source of heat power. This paper deals with the theoretical (analytical and numerical) and experimental analysis of heat and water transfer in the conductive xylem (sapwood) of trees. The analysis and verification of the new formula is based on numerical simulation (using finite element method) and the new LHB method is demonstrated on experimentally measured data. This new approach is important not only because of more exact sap flow calculation but also for information about thermal conductivity that can be used for water content estimation.

Keywords: linear heat balance method; sap flow; thermal conductivity; conduction-convection heat transfer; finite element analysis; experimental measurement

Introduction

Plant-water relations are closely connected with the flow of energy in ecosystems. Water is the most frequent limiting factor for growth, and it provides the necessary background for other physiological processes. Current technology makes it possible to measure quantitative parameters of water relations [1]. The water flow represents the biggest energy flow in vegetation which also causes its magnificent climatic effect. The biggest amounts of water just go on cooling (associated with the heat of vaporization) and only minor amounts of water go on in all other processes (such as photosynthesis transport of assimilates, growth, etc.). Water redistribution in trees is a rapid developing topic of plant physiology, highly dependent