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Variability of sap flow on forest hillslopes: patterns and controls

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Sap flow in trees is an essential variable in integrated studies of hydrologic fluxes. It gives indication of transpiration rates for single trees and, with a suitable method of upscaling, for whole stands. This information is relevant for hydrologic and climate models, especially for the prediction of change in water fluxes in the soil-plant-atmosphere continuum under climate change. To this end, we do not only need knowledge concerning the response of sapflow to atmospheric forcing but also an understanding of the main controls on its spatial variability.
Our study site consists of several subcatchments of the Attert basin in Luxembourg underlain by schists of the Ardennes massif. Within these subcatchments we measure sap flow in more than 20 trees on a range of forested hillslopes covered by a variety of temperate deciduous tree species such as beech, oak, hornbeam and maple as well as conifers such as firs. Our sap flow sensors are based on the heat pulse velocity method and consist of three needles, one needle acting as the heating device and the other two holding three thermistors each, enabling us to simultaneously measure sap flow velocity at three different depths within the tree. In close proximity to the trees we collect additional data on soil moisture, matric potential and groundwater levels.
First results show that the sensor design seems promising for an upscaling of the measured sap flow velocities to sap flow at the tree level. The maximum depth of actively used sapwood as well as the decrease in sap flow velocity with increasing depth in the tree can be determined by way of the three thermistors. Marked differences in sap flow velocity profiles are visible between the different species, resulting in differences in sap flow for trees of similar diameter. We examine the range of tree sap flow values and variation due to species, size class, slope position and exposition and finally relate them to the dynamics of soil moisture conditions with the goal to identify the most important controls of sap flow at our study site.