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Investigating Sub-daily Responses of Water Flow of Trees in Tropical Successional Forests in Thailand

Authors : Pantana Tor-Ngern

Abstract : In the global water cycle, tree water use (Tr) largely contributes to evapotranspiration which is the total amount of water evaporated from terrestrial ecosystems to the atmosphere, regulating climates. Tree water use responds to environmental factors, including atmospheric humidity and sunlight (represented by vapor pressure deficit or VPD and photosynthetically active radiation or PAR, respectively) and soil moisture. In forests, Tr responses to such factors depend on species and their spatial and temporal variations. Tropical forests in Southeast Asia (SEA) have experienced land-use conversion from abandoned agricultural practices, resulting in patches of forests at different stages including old-growth and secondary forests. Because the inherent structures, such as canopy height and tree density, significantly vary among forests at different stages and can strongly affect their respective microclimate, Tr and its responses to changing environmental conditions in successional forests may differ. Daily and seasonal variations in the environmental factors may exert significant impacts on the respective Tr patterns. Extrapolating Tr data from short periods of days to longer periods of seasons or years can be complex and is important for estimating long-term ecosystem water use which often includes normal and abnormal climatic conditions. Thus, this study aims to investigate the diurnal variation of Tr, using measured sap flux density (JS) data, with changes in VPD in eight evergreen tree species in an old-growth forest (hereafter OF; >200 years old) and a young forest (hereafter YF, <10 years old) in Khao Yai National Park, Thailand. The studied species included Sysygium syzygoides, Aquilaria crassna, Cinnamomum subavenium, Nephelium melliferum, Altingia excelsa in OF, and Syzygium nervosum and Adinandra integerrima in YF. Only Sysygium antisepticum was found in both forest stages. Specifically, hysteresis, which indicates the asymmetrical changes of JS in response to changing VPD across daily timescale, was examined in these species. Results showed no hysteresis in all species in OF, except Altingia excelsa which exhibited a 3-hour delayed JS response to VPD. In contrast, JS of all species in YF displayed one-hour delayed responses to VPD. The OF species that showed no hysteresis indicated their well-coupling of their canopies with the atmosphere, facilitating the gas exchange which is essential for tree growth. The delayed responses in Altingia excelsa in OF and all species in YF were associated with higher JS in the morning than that in the afternoon. This implies that these species were sensitive to drying air, closing stomata relatively rapidly compared to the decreasing atmospheric humidity (VPD). Such behavior is often observed in trees growing in dry environments. This study suggests that detailed investigation of JS at sub-daily timescales is imperative for better understanding of mechanistic responses of trees to the changing climate, which will benefit the improvement of earth system models.

Keywords : sap flow, tropical forest, forest succession, thermal dissipcation probe
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