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Evaluation of an instrumental method to reduce error in canopy water storage estimates via mechanical displacement

Jan Friesen (1), John Van Stan (2), Kael Martin (3), Matthew Jarvis (4), Jessica Lundquist (3), and Delphis Levia (5)

(1) Helmholtz Centre for Environmental Research - UFZ, Leipzig, Germany (jan.friesen@ufz.de, +49 341 235-1939), (2) Department of Geology & Geography, Georgia Southern University, Statesboro, GA, USA, (3) Department of Civil & Environmental Engineering, University of Washington, Seattle, WA, USA, (4) Independent Scholar, Newark, DE, USA, (5) Departments of Geography and Plant & Soil Sciences, University of Delaware, Newark, DE, USA

To improve water budgeting of forested catchments and inform relevant hydrologic theory regarding forest water cycling, the scientific community has been seeking simple, inexpensive, direct methods for determining rainwater storage on in-situ tree canopies. This paper evaluates an installation arrangement/routine for one such method: mechanical displacement sensors placed on the trunk to directly monitor compression under canopy water loading from rainfall. The evaluated installation routine aligns mechanical displacement sensors along orthogonal axes passing through the trunk's mechanical center to reduce wind-induced noise. Experimental attainment of neutral bending axes for a subject hard- and softwood tree suggest the routine is precise and approximates the trunk's mechanical center well regardless of differences in cellular axial stiffness between heart and sapwood. When installed in this precise sensor arrangement, bending tests of different direction produced consistent signal ratios between sensor pairs about -1 (1 unit compression/1 unit elongation), allowing the identification and removal of bending strains from raw strain signals to isolate the compression component attributable to canopy water storage. The same experiments performed on sensors 5cm off the computed mechanical center were unable to produce neutral bending axes or consistent signal ratios during directional bending. Results from the method evaluation were translated into a data processing technique that is applied to strain data from 2 sample storms (1 each for the hard- and softwood trees). Processed strain data showed clear synchronicities between rainfall and canopy loading, and periods of maximized canopy water loading (capacity). Our results indicate the evaluated arrangement/installation procedure for mechanical displacement sensors may provide scientists with simple, direct canopy water storage estimates at high temporal resolution and sensitivity.