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Factors impacting stemflow generation in a European beech forest: Individual tree versus neighborhood properties

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The redistribution of precipitation by canopies changes the water flow dynamics to the forest floor. The spatial pattern of throughfall has been researched in a number of studies in different ecosystems. Yet, also stemflow substantially influences water input patterns, constituting a mean of 12% of gross precipitation for European beech as one of the most abundant tree species in Central Europe.
While the initiation of stemflow depends mostly on precipitation event properties, stemflow amounts are strongly shaped by canopy structure. Stemflow research has mainly addressed the impact of single tree morphological variables. In previous studies, the impact of forest structure on area-based stemflow was studied comparing plots with different properties using few exemplary stemflow measurements. In non-homogeneous stands, this approach might not be accurate, as the variation of stand properties like tree density could change tree individual stemflow fluxes. To investigate this, a total measurement of all trees per plot is required. We hypothesize, that in addition to individual tree metrics, tree neighborhood relations have a significant impact on stemflow generation in a heterogeneous beech forest.
Our study site is located in the pristine forest of the National Park Hainich, central Germany. It is heterogeneous in respect to tree density, species composition and tree age. We measured stemflow in an areal approach, for all trees on 11 subplots (each 10 m x 10 m) spaced evenly throughout a 1 ha plot. This involved overall 65 trees, which is 11% of the plot's trees. 27 precipitation events were recorded in spring and early summer of 2015 and 2016. Stand properties were surveyed, including diameter at breast height, height, position and species of a tree. From this data, we calculated neighborhood properties for each tree, as number, basal area, and relative height of neighboring trees within a radius of the plot's mean tree distance. Using linear mixed effects models, we identified the different factors, individual and neighborhood, which significantly explain stemflow amount per tree.
Preliminary results show, that the main impact on stemflow in our heterogeneous beech forest is due to individual tree diameter at breast height, while neighborhood factors have a smaller influence.
This work defines the most important factors for stemflow fluxes, using easy-to-acquire tree and stand information, which allows the robust extrapolation of stemflow measurements and the generation of a spatially discrete pattern of stemflow input to the soil. Because of the high local and temporal concentration of precipitation, stemflow fluxes could be a key factor in forest soil water dynamics. On the long run, the results shall enable us to directly link soil water content measurements with estimated stemflow volumes for individual trees to trace stemflow fluxes into and through the soil.