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How forests change transit times of transpiration, evaporation and streamflow – a modeling approach

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In a recent paper we investigated how different catchment and climate properties influence transit time distributions. This was done by employing a physically-based spatially explicit 3D model in a virtual catchment running many different scenarios with different combinations of catchment and climate properties. We found that the velocity distribution of water fluxes through a catchment is more sensitive to certain properties while other factors appear less relevant. Now we expanded the approach by adding vegetation to the model and thus introducing new hydrologic processes (transpiration and evaporation) to the simulated water cycle. On the one hand we wanted to know how these new processes would influence transit times of the water fluxes to the stream, on the other hand we were interested in how exactly differences in the vegetation itself (e.g. rooting depth and leaf area index) would alter the various flux velocities (including transit times of transpiration and evaporation). It was very interesting to observe that streamflow in forested areas appeared to become older on average. We also found that transpiration was generally younger if the vegetation had shallower roots and/or a larger leaf area index. The biggest difference in the age of evaporation was detected for different amounts of subsequent precipitation (evaporation was generally younger in a wetter climate). In conclusion, we found that forests influence the age of the different water fluxes within a catchment. According to our results the overall hydrologic cycle is decelerated when adding vegetation to a model that otherwise only simulates evaporation.

Still, in order to make meaningful predictions on the age of hydrologic fluxes, it is not constructive to single out specific catchment and climate properties. The multitude of influences from different parameters makes it very challenging to find rules and underlying principles in the integrated catchment response. Therefore it is necessary to look at the individual parameters and their potential interactions and interdependencies in a bottom-up approach.