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Predicting evapotranspiration change in a successionnal forest without eddy covariance measurements

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In the lifetime of terrestrial ecosystems disturbance events are a normal, reoccurring process. In forested ecosystems, landscape succession can result in long-lasting changes of the hydrological behavior, in particular changes in evapotranspiration. Evapotranspiration models used in hydrology, however, commonly assume a homogeneous forest age. Experimental data from eddy covariance measurements are scarce and rarely monitor forest successions. Therefore there is a need for alternative methods to understand differences in AET in differently aged forests and improve AET estimates in developing landscapes.

In this study we developed a minimalist conceptual model to predict actual evapotranspiration (AET) during summer from soil water depletion data. The approach was applied to three experimental sites in Western Canada which represent a forest succession (different stand ages in a similar environment). The objective was to gain insights into the role of forest stand age, interannual climate variability, and the Horton index (rate of vaporization to wetting) in controlling summer AET. We used continuous soil moisture and precipitation data over 20 years to drive the model at different temporal resolutions. The results were compared with observed AET measurements (eddy-covariance data).

The results show that easy-to-measure soil water depletion can be used to make predictions of summer AET for half-hourly and daily time scales. The approach could predict the differences from 5 to 35% of AET among the differently aged stands. The results are sensitive to the canopy architecture, active root depth and stand age. Moreover, we find that the model is reliable despite summer dry-wet transitions due to sporadic rainfall events. Finally, the interannual variability of the Horton index at each stand implies different root water uptake strategies during landscape succession. If the model should prove successful for a wider range of forest landscapes, envisioned applications include estimates at sites where eddy covariance data are inexistent or impossible (e.g. complex terrain) or for large-scale water balance assessments using remote-sensing techniques.