Title: A Unified Approach to Estimate Potential Evapotranspiration of Forest Ecosystems

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Outlines

Why this study?

Hydrologic modeling at a large scale often uses potential (PET) to derive actual ET (AET) as a function of PET and soil moisture status. However, PET is a confusing concept in modern hydrologic science. For example, forests with a large leaf area will use more water than crops with a small leaf area when both types of ecosystem are under the same unrestricted soil water conditions. It is obvious that forests should have a much higher PET than crops. Few studies have addressed this problem due to limited measurements of forest ET. Perhaps, ET is the least measured component of the hydrologic balances of forested watersheds.

Most literature especially in agriculture uses Reference ET (ETr) to replace the ill-defined PET as initially proposed by Penman half a century ago. Now, the so called FAO56 PET method, is widely used as the standard approach to estimate PET for various reasons, such as estimating irrigation water needs of golf courses, wetland water loss, and regional estimates of water budgets. This unified method calculates ET for a short grass with a fixed canopy conductance and boundary layer aerodynamic conductance under unlimited soil water conditions.

Field data suggest measured actual forest ET can be higher than the reference grass ET (PETr). So, the FAO PET method must be modified so it can be applied to estimate potential ET for forests. Two key factors must be considered: 1) forests have tall trees resulting in a different aerodynamic conductance than grasses; and 2) the canopy conductance is extremely variable at multiple temporal scales.

There is a need in the general hydrological community to develop a method to model actual ET as a function of potential ET for forested conditions at large scales.

We define forest PET (PETf) as the maximum ET under optimum soil water conditions. For practical modeling applications, such soil water conditions mean that soil moisture content is equal or above soil field capacity.

Objectives

1. Understand the environmental control on maximum ET and actual ET for various forest ecosystems under optimum soil moisture conditions.

2. Modeling PET for such optimum conditions. Forest PET = f (LAI, Canopy Conductance, Grass reference ET). The model should be applicable to large scale such as watershed and regional. Conductance = f(Forest Age, Type, VPD, Radiation)

3. Modeling actual ET as function of potential ET and soil moisture content.

Methods

Data needs: all forest ecosystems.
We will use measured eddy flux and micrometeorology data at the daily time scale, such as daily average of LE, canopy conductance, soil moisture content etc. We will evaluate a few simplified ET models such as FAO56 PET, Priestley-Tyler Equation, and the newly developed model for several forest ecosystems.

Co-authorship Rules

I'd like to list all co-authors from each site who will be responsible for raw data contribution, interpretation, site description writing, and participating discussion section of the manuscript. I expect site PIs to recommend the names who would contribute substantial scientific knowledge.