Determining Potential Evapotranspiration (PET) for a Remote, Alpine Basin in the Sierra Nevada, California

BrianHuggett ~ Department of Forestry & Wildland Resources, Humboldt State University, Arcata, California

ABSTRACT
The distribution of water across the globe is in constant flux, driven by the sun. Water moves through this complex cycle as atmospheric water vapor, precipitation, runoff, or may be stored in reservoirs such as biomass, groundwater, and glacial or polar ice. Evapotranspiration (ET) is a component of the water balance in which liquid water is returned to the atmosphere via evaporation, as from surface water, soil, or ice, or transpiration, as from plant material. The Priestly – Taylor method for determining potential evapotranspiration (PET) is modeled for a remote, Sierra Nevada basin. Total PET values will be utilized in conjunction with ongoing surface water investigations to place an upper bound on total precipitation delivered to the basin.

INTRODUCTION / OBJECTIVES
The hydrologic cycle is an idea that describes the movement of water on global, regional and local scales through its various phases as a gas, solid or liquid. Dingman (2002) describes the hydrologic cycle as a complex web of interactions between the atmosphere, ocean, land, and the sun. These fluxes of water and energy are in a continuous movement around the globe, and can enter storage in reservoirs such as glaciers, lakes, or biomass. The main driver in this system of global water distribution is the sun. Radiation energy that reaches the earth drives the evaporation of water from the oceans and mixes this water vapor with the atmosphere. Equation (1) represents a simplified equation of the water balance.

$$P - (Q + ET) = \Delta S \quad (1)$$

Where:
- P = Precipitation
- Q = Runoff
- ET = Evaporation & Transpiration
- ΔS = Change in Storage

Studies by Fisher et al. (2006) at the Blodgett Forest Research Station in California's Sierra Nevada compared 5 methods to derive evaporation and transpiration at the forest canopy scale. The current framework for measuring ET is to calculate the total potential evapotranspiration (defined as having unlimited water to evaporate or transpire) and to scale this estimate down by placing a limitation on the available water (soil moisture) to derive the actual evapotranspiration (Fisher, 2006). Of the five models, the Priestley – Taylor method closely approximated ET measured on site (Equation 2).

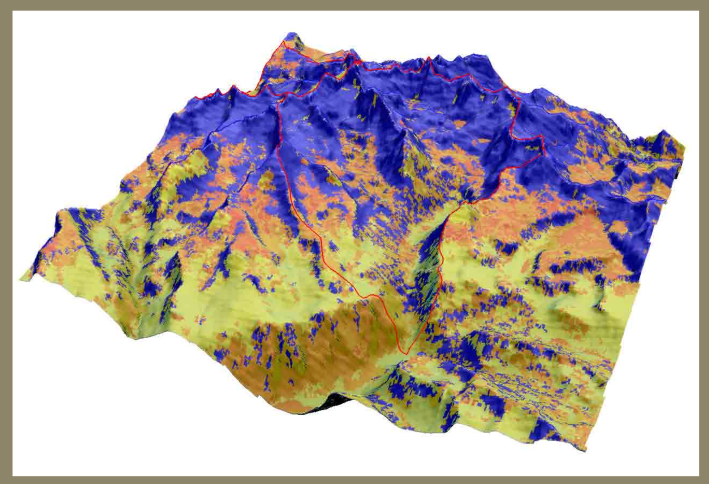
$$\lambda E = \alpha \Delta A / (\Delta + \gamma) \quad (2)$$

Where:
- λE = total potential evaporation in flux units W/m2
- α = empirical land cover parameter
- Δ = derivative saturation vapor pressure / air temp
- A = total available solar radiation
- γ = psychometric constant

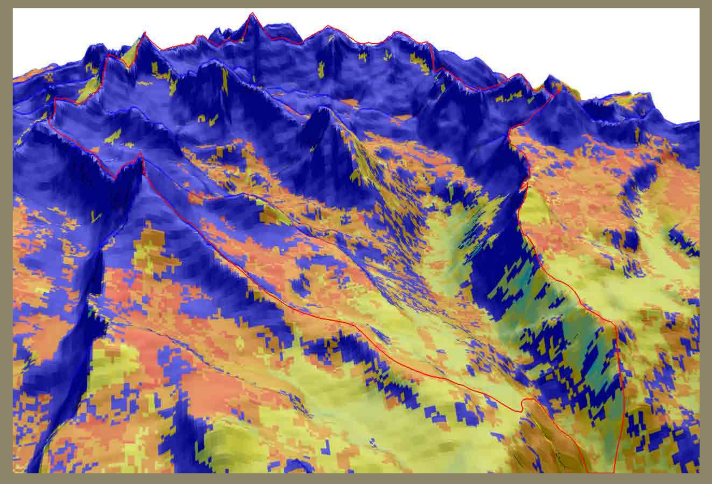
Study Site within California's Sierra Nevada

Basin of Study within Yosemite National Park

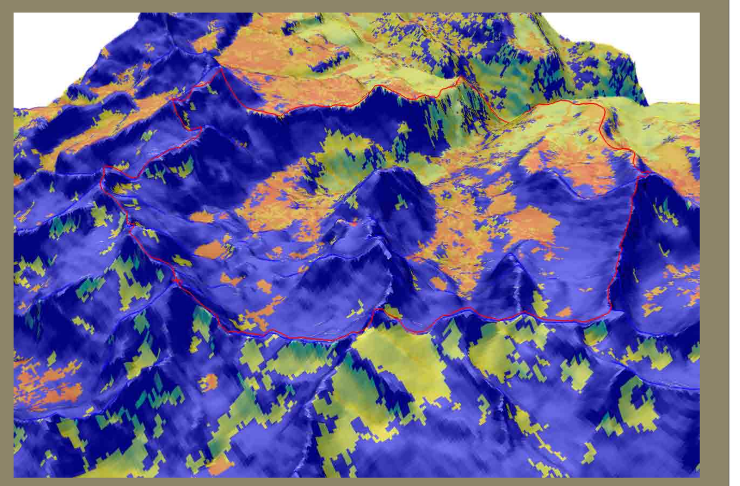
METHODS
The study site is the Upper Lyell Basin of the Merced River in Yosemite National Park and was chosen to complement ongoing, continuous hydrometeorologic investigations by the USGS and the National Park Service. The National Landcover Dataset 2001 served as the primary source of land cover characteristics. Parameters that drive the Priestley ~ Taylor method (incoming solar radiation, vapor pressure air temperature, and the psychometric constant) were derived from empirical data collected on-site, and applied to the study area on a 10-meter grid. The resulting raster datasets were then combined according to Equation 2.



Lyell Basin outlined in red, view to the East. PET values increase from 0 (blue) to ~1030 W/m2 (red).



Lyell Basin view to the southeast. Note relative lower values on northfacing slopes. PET values 0 (blue) to ~1030 W/m2 (red).



View to southwest of basin. Note perennial ice features of Lyell and Maclure glaciers in foreground, shown in yellowish color.

DISCUSSION & FUTURE DIRECTIONS
The final potential evapotranspiration model returned values from 68 to 1030 Watts / m2. Masks for each cover type were overlaid with the PET raster to produce estimates by cover type. The resulting estimates of potential evapotranspiration will provide an upper bound on our estimates of the total amount of water returned to the atmosphere via these processes. Future efforts will model factors as time series data rather than the static variable for this analysis. Incorporation of near real-time data could provide water resource managers with estimates of upper bound evapotranspiration in complex terrain to further refine existing water supply models.