Quantifying evapotranspiration in Nepal using multiple constraints

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Formulation of energy components in SEBAL

Net radiation can be calculated as below empirical function:

$$R_n = (1-\alpha)K_{in} + (L_{in} - L_{out}) - (1-\varepsilon_a)L_{in} \tag{1}$$

where α is the surface albedo; K_{in} is the incoming short-wave radiation ($W \cdot m^{-2}$); L_{in} is the incoming long-wave radiation ($W \cdot m^{-2}$); L_{out} is the outgoing long-wave radiation ($W \cdot m^{-2}$); ε_a is the surface thermal emissivity computed by the normalized difference vegetation index (NDVI).

The K_{in} can separated into three parts in mountain area (Wang et al 2000): solar direct radiation to the ground surface (E_s); diffuse sky radiation to the ground surface (E_d) and radiation from visible adjacent terrain (E_r). The detailed formulation can be founded in (Wang et al 2000).

Soil heat flux (G) can be calculated by the empirical formula:

$$\frac{G}{R_n} = \frac{T_s - 273.15}{\alpha}(0.0038\alpha + 0.0074\alpha^2)(1 - 0.98NDVI^4) \tag{2}$$

For water bodies, G is simplified as $0.41R_n$–51 (Burba et al 1999). More details about modeling R_n and G in SEBAL can be found in numerous literature (Bastiaanssen et al 1998a; Li and Zhao, 2010; Mkhwanazi et al 2015). NDVI and T_s are Normalized Differential Vegetation Index and land surface temperature (K), respectively. Both NDVI and T_s were derived from remote sensing data.

Sensible heat flux (H) can be calculated as below function:

$$H = \frac{\rho_a C_p dT}{r_{ah}} \tag{3}$$

where ρ_a is the air density ($kg \cdot m^{-3}$); C_p is the air specific at constant pressure (1004 $J \cdot kg^{-1} \cdot K^{-1}$); r_{ah} is the aerodynamic resistance to heat transport ($s \cdot m^{-1}$). We need to calculate the first H for iterating with Monin-Obukhov similarity. So, in the first approximation, r_{ah} can be calculated as below function:

$$r_{ah} = \frac{\ln\frac{Z_1}{Z_2}}{u_* k} \tag{4}$$

where u_* represents the friction velocity estimated using the Logarithmic wind law for atmospheric conditions (Equation 5) and k is the von Karman constant by 0.41.

$$u_* = \frac{u_{200} k}{\ln\left(\frac{200}{Z_{om}}\right)} \tag{5}$$

where u_{200} is the wind speed at a blending height of 200m and Z_{om} is the surface roughness (Bastiaanssen et al 1998a).

Supplementary Figures

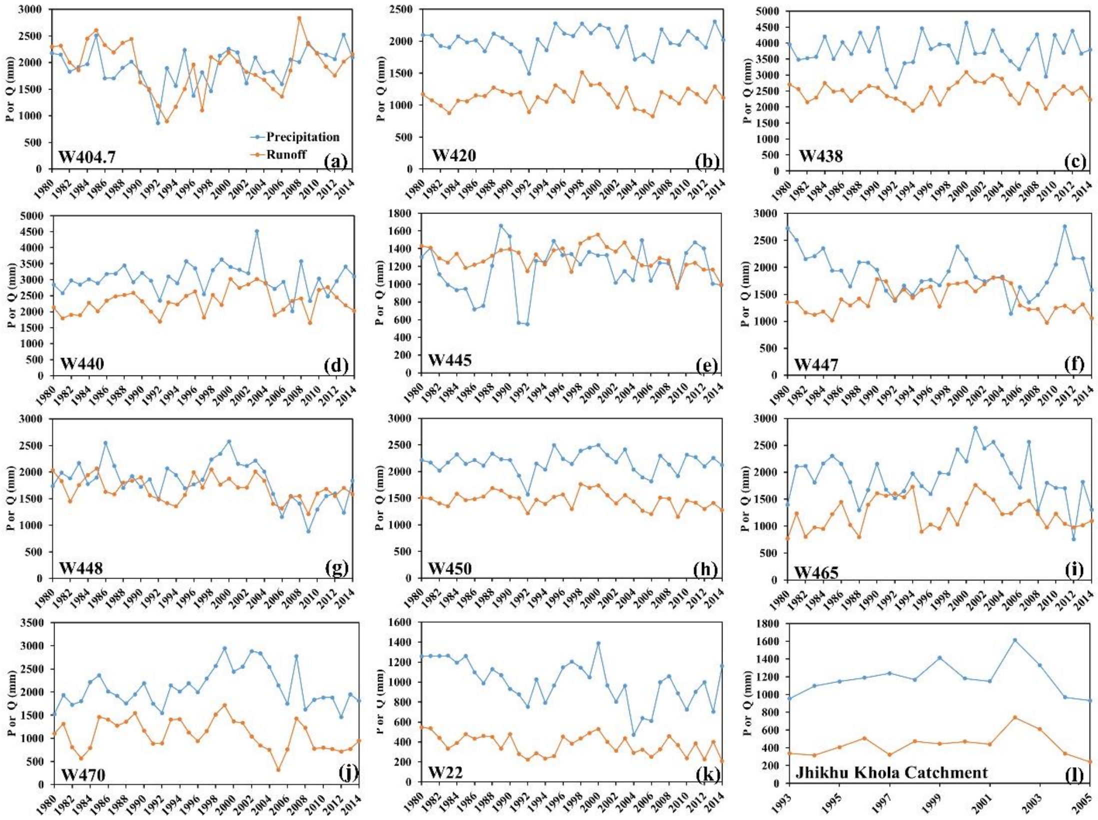

Figure S1. The comparison of multi-year precipitation and runoff for the Gandaki sub-basin, W22, and Jhikhu Khola Catchment.

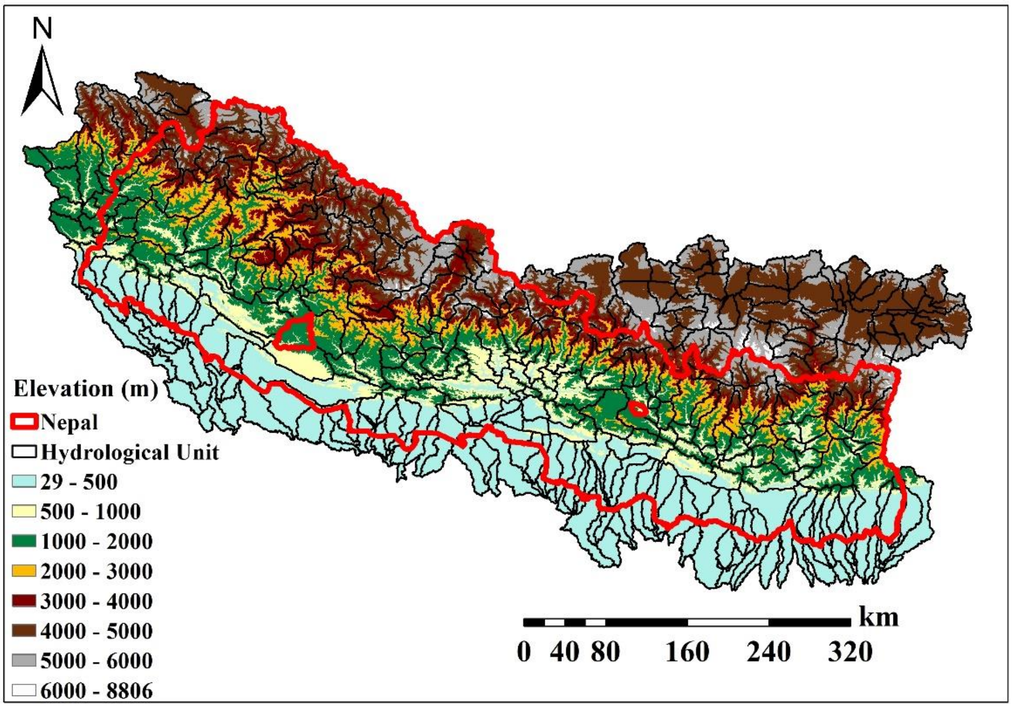

Figure S2. The delineation of hydrological units in Nepal's watersheds

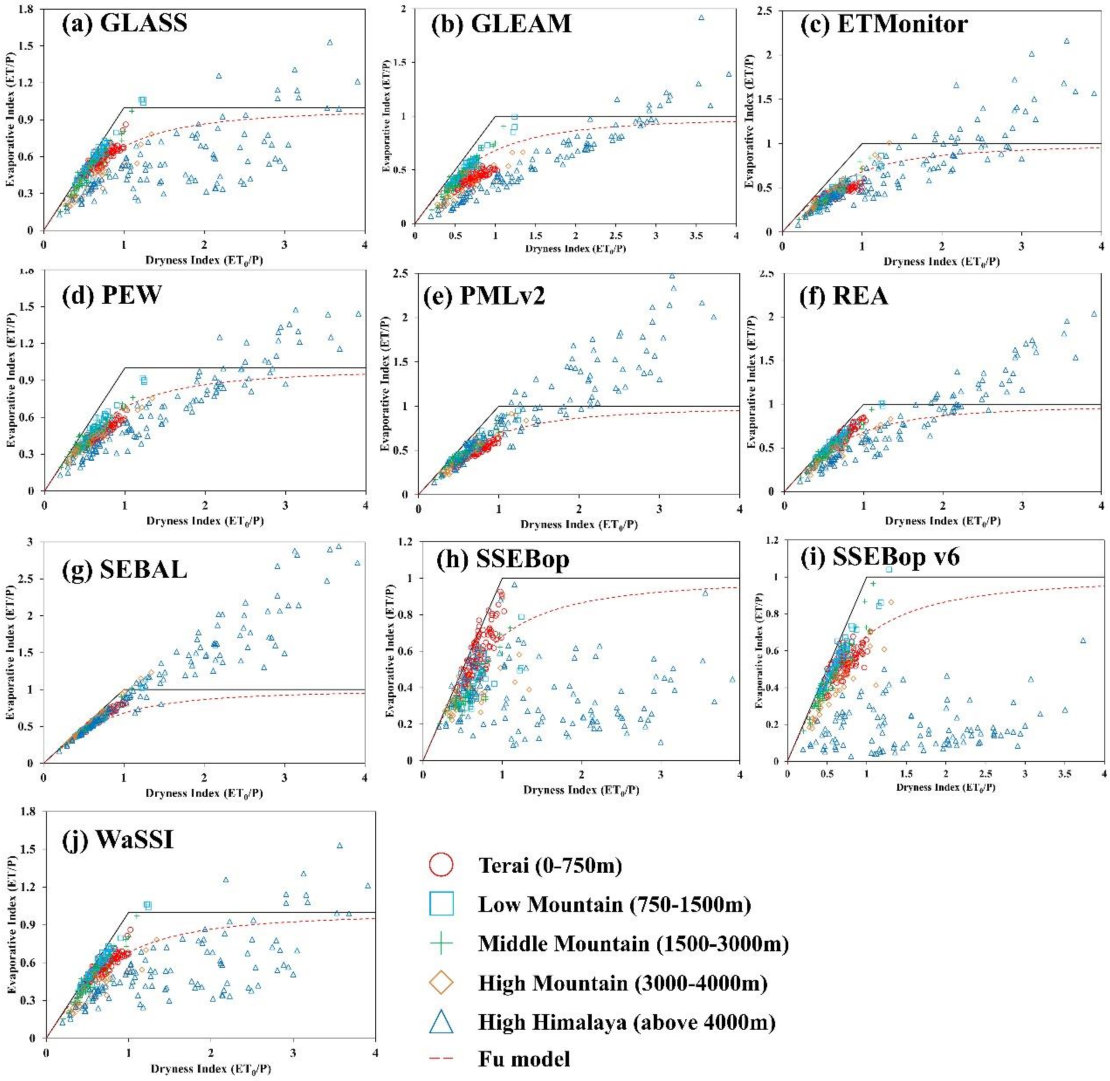

Figure S3. Distribution characteristics of ET/P − ET_0/P for various ET Products across mountain zones under the Budyko framework. In this diagram, PET is derived from P-M method.

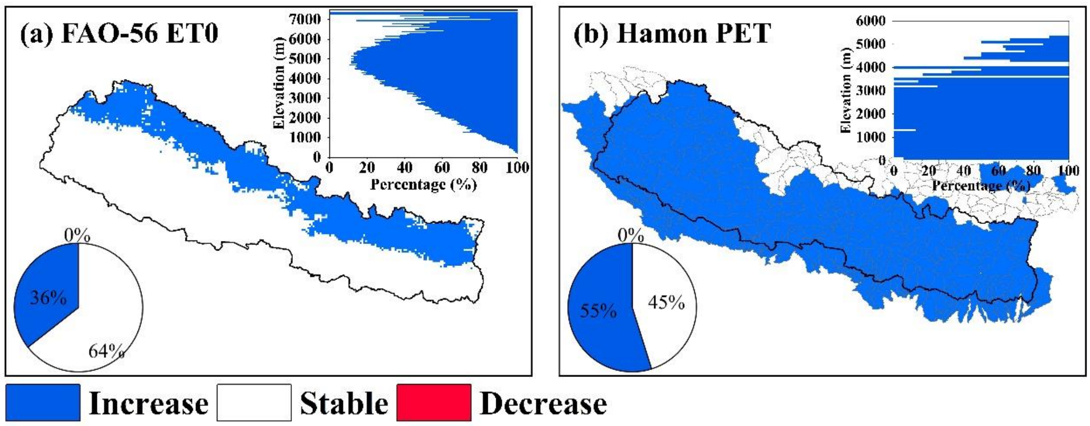

Figure S4. FAO-56 reference ET (ET_0) and Hamon PET trend pattern.