Supplement of Hydrol. Earth Syst. Sci., 20, 4237–4264, 2016
http://www.hydrol-earth-syst-sci.net/20/4237/2016/
doi:10.5194/hess-20-4237-2016-supplement

Hydrology and Earth System Sciences
Open Access

Supplement of

Canopy-scale biophysical controls of transpiration and evaporation in the Amazon Basin

Kaniska Mallick et al.

Correspondence to: Kaniska Mallick (kaniska.mallick@gmail.com) and Ivonne Trebs (ivonne.trebs@list.lu)

S1. Derivations of evaporative fraction (Λ) 'state equation' in STIC1.2

In order to express Λ in terms of g_A and g_C, we had adopted the Advection–Aridity (AA) hypothesis (Brutsaert and Stricker, 1979) with a modification introduced by Mallick et al. (2015). Although the AA hypothesis leads to an assumed link between g_A and T_0, the effects of surface moisture (or water stress) were not explicit in the AA equation. Mallick et al. (2015) implemented a moisture constraint in the original AA hypothesis for deriving an expression of Λ. A modified form of the original advection-aridity hypothesis is written as follows.

$$E^*_{PM} = 2E^*_{PT} - E \tag{S1}$$

Here E^*_{PM} is the potential evapotranspiration according to Penman-Monteith (Monteith, 1965) for any surface, and E^*_{PT} is the potential evapotranspiration according to Priestley-Taylor (Priestley and Taylor, 1972). Dividing both sides by E we get,

$$\frac{E}{E^*_{PM}} = \frac{E}{2E^*_{PT} - E} \tag{S2}$$

and dividing the numerator and denominator of the right hand side of eqn. (S2) by E^*_{PT} we get,

$$\frac{E}{E^*_{PM}} = \frac{\frac{E}{E^*_{PT}}}{2 - \frac{E}{E^*_{PT}}} \tag{S3}$$

Again assuming the Priestley-Taylor equation for any surface is a variant of the PM potential evapotranspiration equation, we will derive an expression of E^*_{PT} for any surface.

$$E^*_{PM} = \frac{s\phi + \rho c_P g_A D_A}{s + \gamma\left(1 + \frac{g_A}{g_{Cmax}}\right)} \tag{S4}$$

$$= \frac{s\phi}{s + \gamma\left(1 + \frac{g_A}{g_{Cmax}}\right)}\left(1 + \frac{\rho c_P g_A D_A}{s\phi}\right)$$

$$= \frac{\alpha s\phi}{s + \gamma\left(1 + \frac{g_A}{g_{Cmax}}\right)} \qquad \text{(S5)}$$

$$= E_{PT}^{*}$$

Here γ is the psychrometric constant (hPa K^{-1}), s is the slope of the saturation vapor pressure versus air temperature (hPa K^{-1}), α is the Priestley-Taylor parameter (α =1.26 under non-limiting moisture conditions), D_A is the vapor pressure deficit of air (hPa). g_{Cmax} is defined as the maximum possible g_C under the prevailing atmospheric conditions whereas g_C is limited due to the moisture availability (M) and hence g_{Cmax} = g_C/M (Monteith, 1995; Raupach, 1998). We assume that M is a significant controlling factor for the ratio of actual and potential evapotranspiration (or transpiration for a dry canopy), and the interactions between the land and environmental factors are substantially reflected in M. Since, Penman (1948) derived his equation over the open water surface and g_{Cmax} over the water surface is very high (Monteith, 1965; 1981), g_A/g_{Cmax} was assumed to be negligible.

Expressing ϕ as ϕ = E/Λ and expressing E_{PT}^{*} according to eqn. (S5) gives the following expression of E/E_{PT}^{*}.

$$\frac{E}{E_{PT}^{*}} = \frac{\Lambda\left[s + \gamma\left(1 + \frac{g_A}{g_{Cmax}}\right)\right]}{\alpha s} \qquad \text{(S6)}$$

Now substituting E/E_{PT}^{*} from eqn. (S6) into eqn. (S3) and after some algebra we obtain the following expression.

$$\frac{E}{E_{PM}^{*}} = \frac{\Lambda\left[s + \gamma\left(1 + \frac{g_A}{g_{Cmax}}\right)\right]}{2\alpha s - \Lambda\left[s + \gamma\left(1 + \frac{g_A}{g_{Cmax}}\right)\right]} \qquad \text{(S7)}$$

According to the PM equation (Monteith, 1965) of actual and potential evapotranspiration,

$$\frac{E}{E_{PM}^{*}} = \frac{\dfrac{s\phi + \rho c_p g_A D_A}{s + \gamma\left(1 + \dfrac{g_A}{g_C}\right)}}{\dfrac{s\phi + \rho c_p g_A D_A}{s + \gamma\left(1 + \dfrac{g_A}{g_{Cmax}}\right)}} \tag{S8}$$

Combining eqn. (S7) and (S8) (eliminating E/E_{PM}^{*}) gives an expression for Λ in terms of the conductances.

$$\frac{s + \gamma\left(1 + \dfrac{Mg_A}{g_C}\right)}{s + \gamma\left(1 + \dfrac{g_A}{g_C}\right)} = \frac{\Lambda\left[s + \gamma\left(1 + \dfrac{Mg_A}{g_C}\right)\right]}{2\alpha s - \Lambda\left[s + \gamma\left(1 + \dfrac{Mg_A}{g_C}\right)\right]} \tag{S9}$$

After some algebra the final expression of Λ is as follows.

$$\Lambda = \frac{2\alpha s}{2s + 2\gamma + \gamma\dfrac{g_A}{g_C}(1 + M)} \tag{S10}$$