Supplement of

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

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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.

\[
E_{PM}^* = 2E_{PT}^* - E
\]

(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,

\[
\frac{E}{E_{PM}^*} = \frac{E}{2E_{PT}^* - E}
\]

(S2)

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

\[
\frac{E}{E_{PM}^*} = \frac{E}{2 - \frac{E_{PT}^*}{E_{PT}^*}}
\]

(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.

\[
E_{PM}^* = \frac{s\phi + \rho c_p g_A D_A}{s + \gamma \left( 1 + \frac{g_A}{g_{Cmax}} \right)}
\]

(S4)
\[
\frac{s \phi}{s + \gamma \left( 1 + \frac{g_A}{g_{C_{\max}}} \right)} \left( 1 + \frac{\rho c_p g_A D_A}{s \phi} \right) = \frac{\alpha s \phi}{s + \gamma \left( 1 + \frac{g_A}{g_{C_{\max}}} \right)}
\]

(S5)

Here \( \gamma \) is the psychrometric constant (hPa K\(^{-1}\)), \( s \) is the slope of the saturation vapor pressure versus air temperature (hPa K\(^{-1}\)), \( \alpha \) is the Priestley-Taylor parameter (\( \alpha = 1.26 \) under non-limiting moisture conditions), \( D_A \) is the vapor pressure deficit of air (hPa). \( g_{C_{\max}} \) 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 \( g_{C_{\max}} = g_c / M \) (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 \( g_{C_{\max}} \) over the water surface is very high (Monteith, 1965; 1981), \( g_A/g_{C_{\max}} \) was assumed to be negligible.

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

\[
\frac{E}{E_{PT}^*} = \frac{\Lambda \left[ s + \gamma \left( 1 + \frac{g_A}{g_{C_{\max}}} \right) \right]}{\alpha s}
\]

(S6)

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

\[
\frac{E}{E_{PM}^*} = \frac{\Lambda \left[ s + \gamma \left( 1 + \frac{g_A}{g_{C_{\max}}} \right) \right]}{2\alpha s - \Lambda \left[ s + \gamma \left( 1 + \frac{g_A}{g_{C_{\max}}} \right) \right]}
\]

(S7)
According to the PM equation (Monteith, 1965) of actual and potential evapotranspiration,

\[
\frac{E}{E_{PM}^*} = \frac{s\phi + \rho c_p g_A D_A}{s + \gamma \left(1 + \frac{g_A}{g_c}\right)}
\]

(S8)

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

\[
\frac{s + \gamma \left(1 + \frac{M g_A}{g_c}\right)}{s + \gamma \left(1 + \frac{g_A}{g_c}\right)} = \frac{\Lambda \left[ s + \gamma \left(1 + \frac{M g_A}{g_c}\right) \right]}{2\alpha s - \Lambda \left[ s + \gamma \left(1 + \frac{M g_A}{g_c}\right) \right]}
\]

(S9)

After some algebra the final expression of \(\Lambda\) is as follows.

\[
\Lambda = \frac{2\alpha s}{2s + 2\gamma + \gamma \frac{g_A}{g_c} (1 + M)}
\]

(S10)