The implications of differences in stomatal conductance model parameters on estimates of ecosystem-atmosphere energy exchange

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Energy balance and light dissipation

Farquhar von Caemerrer ($A_n$)

Ball-Berry-Leuning ($g_s$)

Penman-Monteith (evapotranspiration)

Background on models
Sensitivity analyses
Understanding $g_0$
Understanding $g_1$
Conclusions

Sub-model \( (g_s) \)

\[
g_s = g_0 + \frac{g_1 A_n}{(C_s - \Gamma) \left(1 + \frac{D_s}{D_0}\right)}
\]

e.g. Ball-Berry \( g_s \) model as modified by Leuning (1995)
Transpiration estimate parameter sensitivity

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$g_0 = \text{minimum stomatal conductance}$

$g_1 = \text{marginal water cost per unit carbon gain}$

$\alpha = \text{quantum yield of electron transport}$

$V_{cmax} = \text{the maximum carboxylation rate of Rubisco}$

Barnard & Bauerle, in review
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Intraspecific $C_3$

Bauerle et al., in review
Parameter interactions with environment

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Bauerle et al., in review
Parameter importance changes with environment

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Bauerle et al., in review
Parameter effect increases with canopy depth

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Barnard & Bauerle, in review
Sub-models \( (g_s) \)

\[ \sum g_s = g_0 + g_1 A_n \left( C_s - \Gamma \right) \left( 1 + \frac{D_s}{D_0} \right) \]

Ball-Berry \( g_s \) model as modified by Leuning (1995)
Light dependence of $g_0$

Absorbed PAR (μmol m$^{-2}$ s$^{-1}$)

Contribution to $\Sigma g_s$ (%)
Error propagation of $g_0$ parameter fit

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Barnard & Bauerle, in review
g_0 estimate error

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Measured transpiration (kg m\(^{-2}\) s\(^{-1}\))

Modeled transpiration (kg m\(^{-2}\) s\(^{-1}\))

- Obs. g_0
- LSF g_0

Barnard & Bauerle, in review
$g_1$ – differences among index

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Ball
Coefficients
$b[0]$ -0.0159
$b[1]$ 7.92
$r^2$ 0.97

Leuning
Coefficients
$b[0]$ -0.0310
$b[1]$ 8.96
$r^2$ 0.97

Medlyn
Coefficients
$b[0]$ -0.0299
$b[1]$ 5.53
$r^2$ 0.97

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Lloyd et al., in review
Water stress response

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Lloyd et al., in review
$g_1$ – Time and water stress response

Lloyd et al., in review
Water stress response

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- $g_0$ is the parameter with highest influence on transpiration estimates (in 3-dimensions)
- The $g_0$ parameters importance changes with environmental conditions
- The magnitude of the $g_0$ parameter is indirectly proportional to absorbed light
- Using measured $g_0$ gave better model estimates than linear estimates
Conclusions

- $g_1$ is the parameter with second highest influence on transpiration estimates (in 3-dimensions)

- $g_1$ values can be different among calculation indices

- The $g_1$ parameter changes over time and in response to water stress

- We are revisiting the methods of “measuring” the $g_1$ parameter