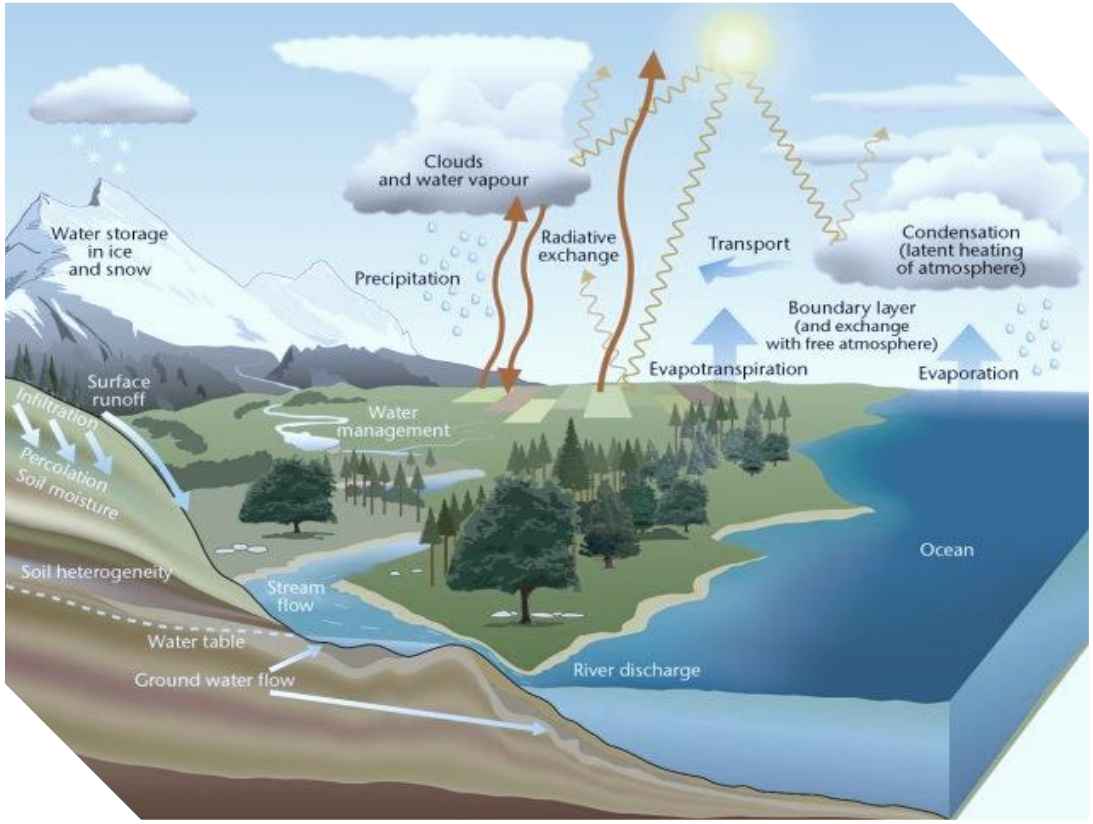
A 2-PARAMETER BUDYKO EQUATION THAT DESCRIBES THE LAND-ATMOSPHERE FEEDBACKS



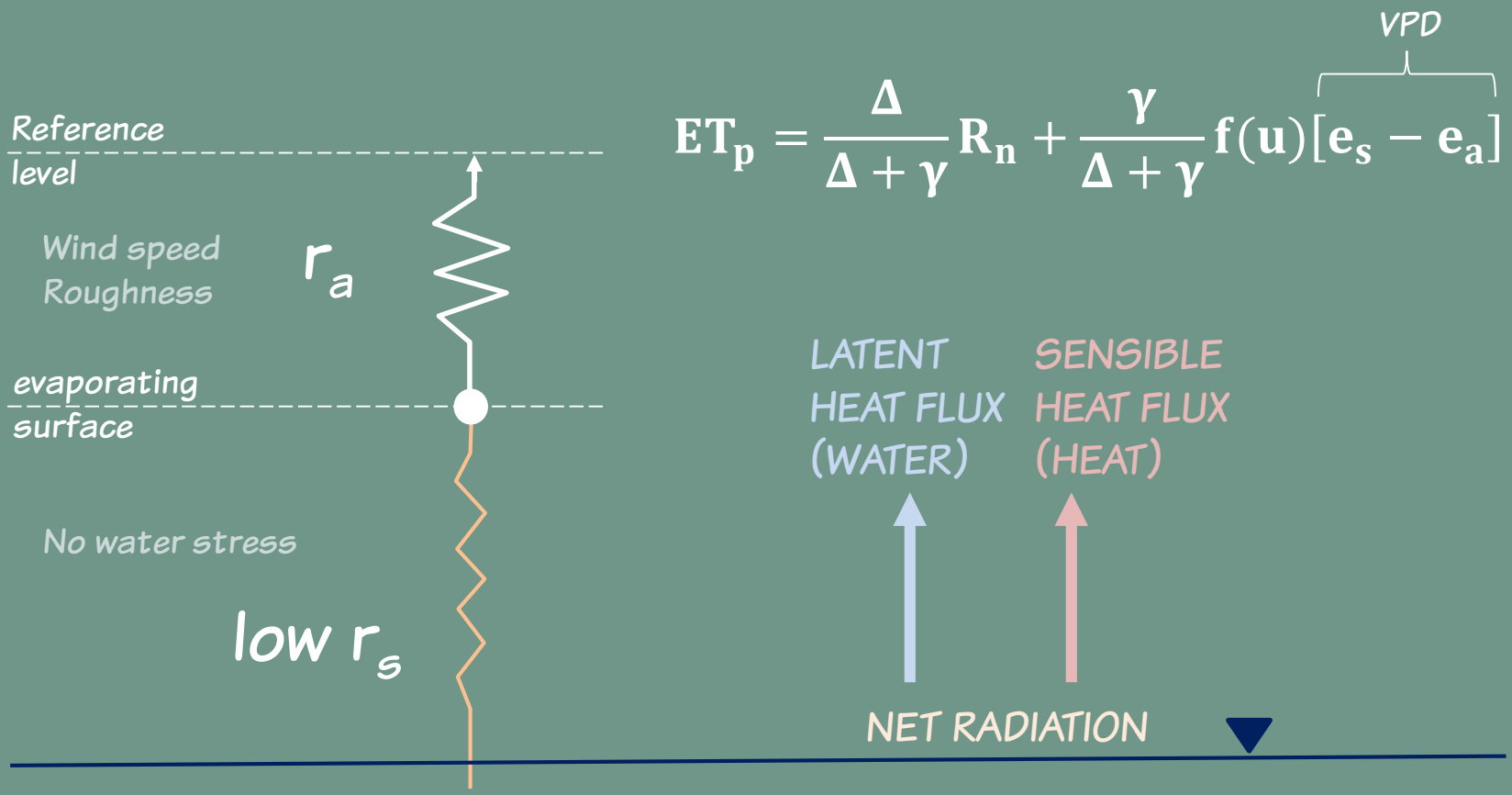
Daeha Kim
(daeha.kim@jbnu.ac.kr)
&
Jong Ahn Chun
(jachun@apcc21.org)

APCC
APEC CLIMATE CENTER

JEONBUK NATIONAL UNIVERSITY 1947 KOREA

ATMOSPHERIC RESPONSES TO WATER STRESS

$E_p = E_w = E_a$ under no water stress:

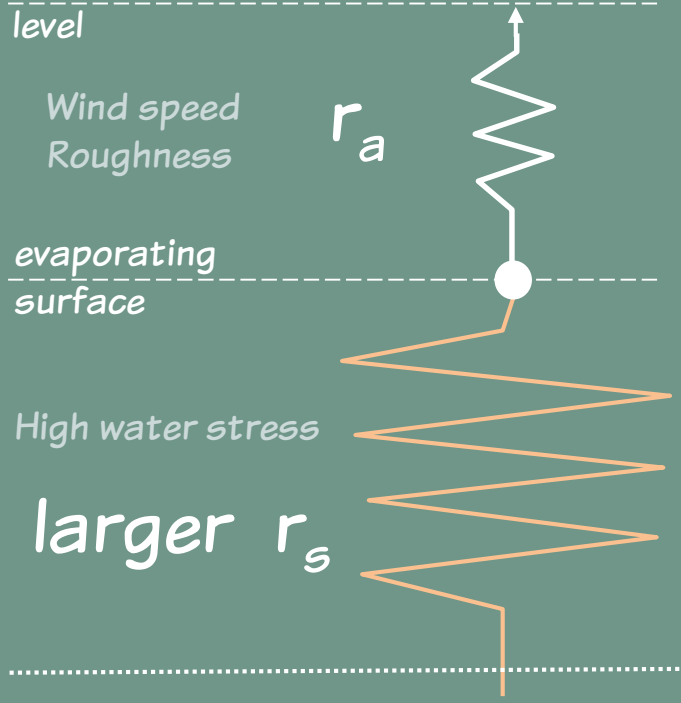


$$ET_p = \frac{\Delta}{\Delta + \gamma} R_n + \frac{\gamma}{\Delta + \gamma} f(u)\overbrace{[e_s - e_a]}^{VPD}$$

ATMOSPHERIC RESPONSES TO WATER STRESS

$E_p > E_w > E_a$ under water stress:

water stress:



$$ET_p = \frac{\Delta}{\Delta + \gamma} R_n + \frac{\gamma}{\Delta + \gamma} f(u)[e_s - e_a]$$

VPD

SENSIBLE HEAT FLUX (HEAT)

LATENT HEAT FLUX (WATER)

NET RADIATION

TWO DERIVATIONS FOR THE SAME EQUATION

Yang et al. (2008) with a correction:

$$\frac{E}{P} = \frac{E_p}{\left(aP^n + bE_p^n + c\right)^{\frac{1}{n}}}$$

$E = E_w$ for $P \to \infty$

$E = P$ for $E_p \to \infty$

$E = P$ for $P \to 0$

$$F(\Phi) = \frac{E_p}{\left(\frac{E_p}{E_w}P^n + E_p^n\right)^{\frac{1}{n}}}$$

$$\mathbf{F(\Phi) = \Phi\left[\frac{x}{1 + x\Phi^n}\right]^{\frac{1}{n}}} \qquad \mathbf{x = \frac{E_w}{E_p}}$$

=

Zhou et al. (2015) :

$$\frac{E}{P} = F\left(\frac{E_p}{P}\right) = F(\Phi)$$

$$m_p = \frac{\partial E/E}{\partial P/P};\ m_e = \frac{\partial E/E}{\partial E_p/E_p}$$

$$m_p + m_e = 1,$$

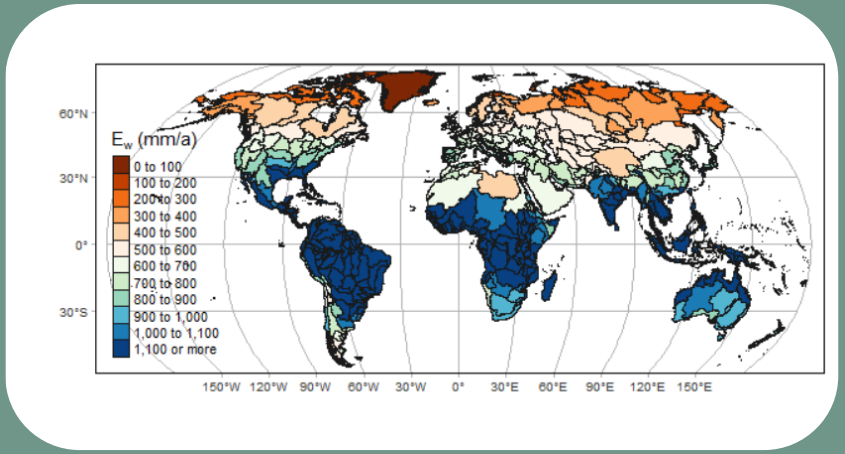
$$\frac{m_p}{m_e} = \frac{F(\Phi) - \Phi F'(\Phi)}{\Phi F'(\Phi)} = x\Phi^n$$

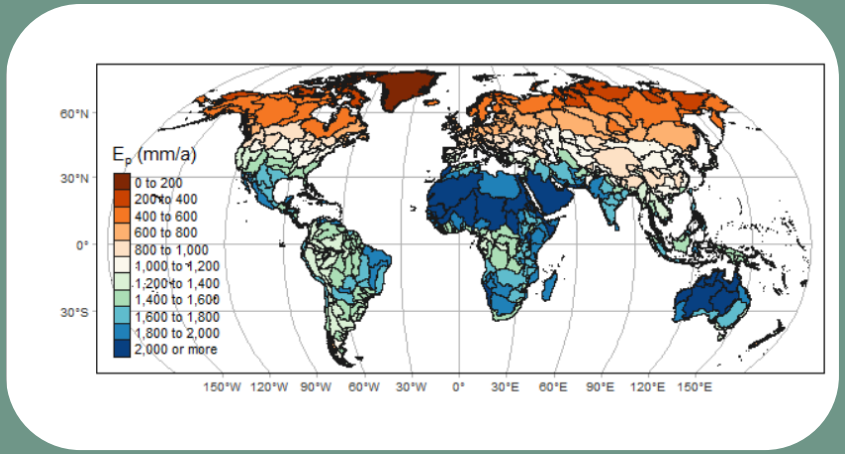
$$F(\Phi) = \Phi(1 + x\Phi^n)F'(\Phi)$$

$$\mathbf{F(\Phi) = \Phi\left[\frac{x}{1 + x\Phi^n}\right]^{\frac{1}{n}}}$$

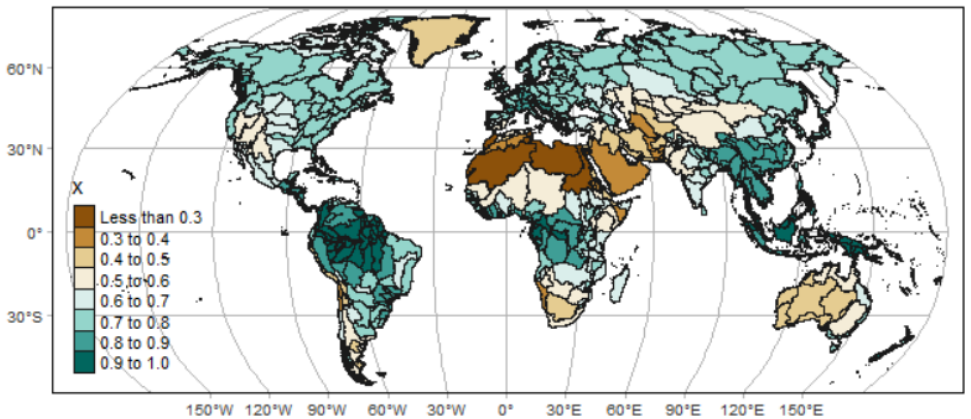
E_w REPRESENTS ENERGY AVALIABLITY

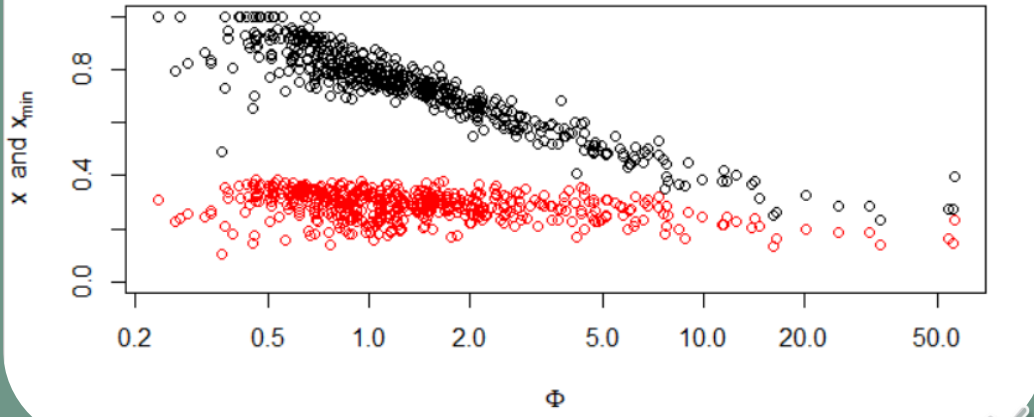
E_w can be estimated by the complementary evaporation theory of Bouchet (1963)





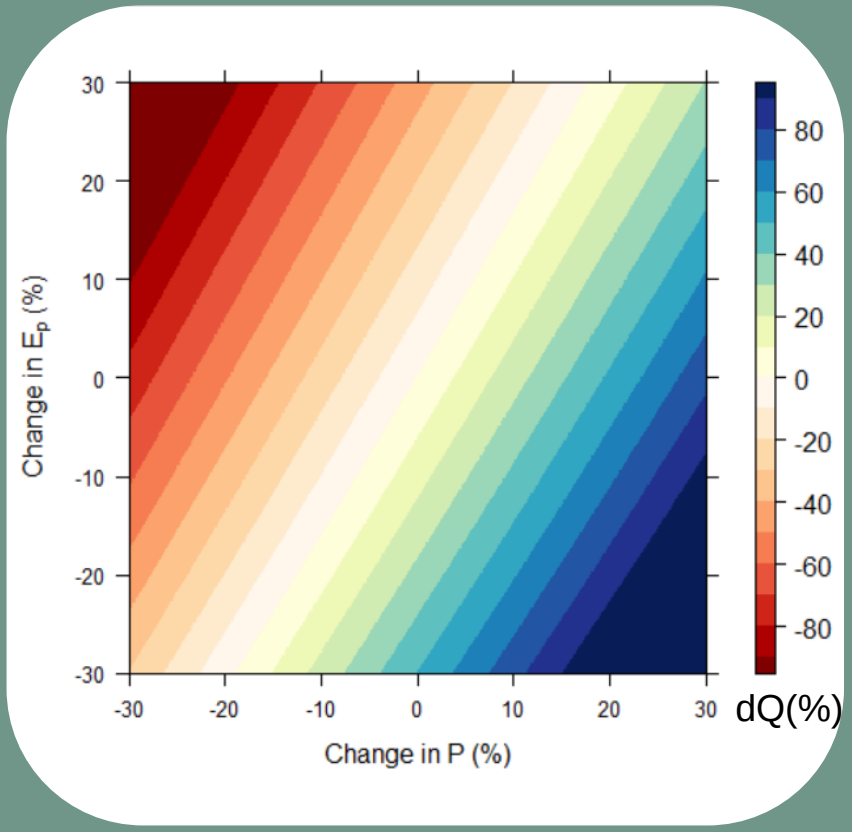
The new parameter x is tightly related with climatological aridity!



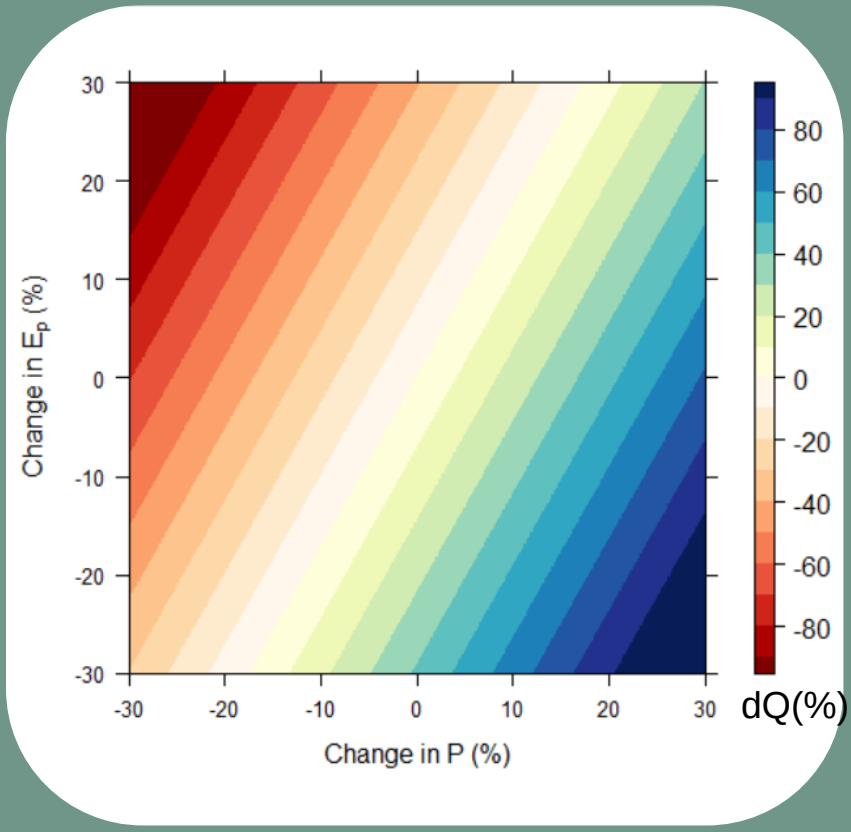


RUNOFF SENSITIVITY COULD MATTER

2-parameter Budyko equation



Turc-Mezentsev equation



CONCLUSIONS

- ✓ Land-atmosphere interaction requires two parameters for a Budyko function
- ✓ The wet-environment evaporation is better suited to represent surface energy availability
- ✓ While the sinlge-parameter function works well, it could lead to biased sensitivities of Q to changing climates

Questions?

daeha.kim@jbnu.ac.kr