

Notes on this SPAC implementation

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1 Introduction

2 Model description

2.1 Plant Water Supply Equations

The basic Darcy flux is described by:

$$q = - \int_{\psi_{soil}}^{\psi_{leaf}} k(\psi) d\psi \quad (1)$$

And we adopt a simple linear conductance attenuation parameterization:

$$k(\psi) = \frac{\psi - p_2}{p_1 - p_2} \cdot k_{\max} \quad (2)$$

Such that equation (1) can be rewritten as:

$$q = -k_{\max} \cdot f_k(\Psi_L, \Psi_s) \cdot (\psi_L - \psi_s) \quad (3)$$

Where f_k is the fraction of maximal soil-to-leaf hydraulic conductance, and is a function of both Ψ_s and Ψ_L :

$$f_k = \frac{\frac{1}{2}(\psi_L + \psi_s) - p_2}{p_1 - p_2} \in [0, 1] \quad (4)$$

2.2 Plant Water Demand Equations

Here we implement hydraulic limitations to transpiration. As Ψ_L becomes more negative, transpiration is reduced relative to some maximal value, using a simple linear attenuation function. This function uses p_3 and p_4 as parameters to define the onset of transpiration reduction p_3 and the point at which there is no transpiration p_4 .

$$T = T_{\max} \cdot f_T \tag{5}$$

$$f_T = \frac{\psi_L - p_4}{p_3 - p_4} \in [0, 1] \tag{6}$$

Right now we have to produce some reasonable values for T_{\max} and force the model with that data, directly. Instead we could implement a stomatal conductance model, if we would rather force with micro-met.

2.3 Solution

We solve for leaf water potential and transpiration by requiring that:

$$T = q \quad (7)$$

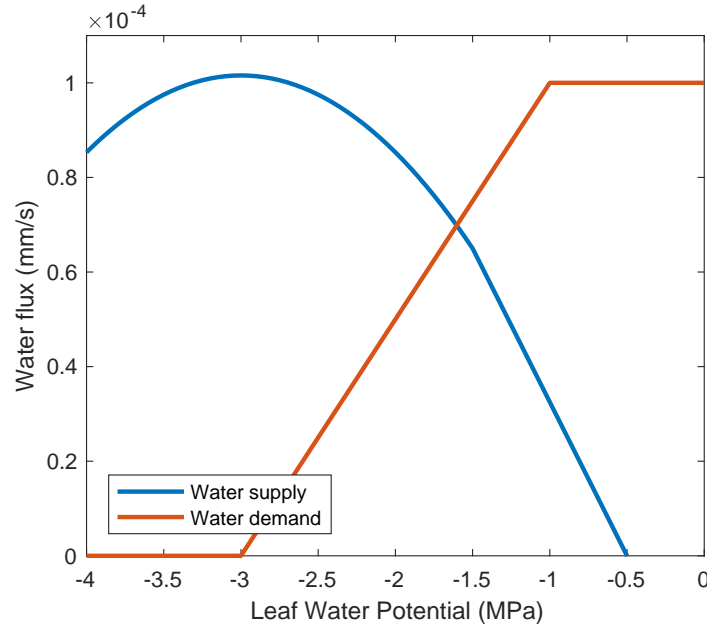


Figure 1: The solution for Ψ_L occurs where the two curves intersect.

Because transpiration decreases with decreasing Ψ_L and sap flux increases, we can usually find a satisfactory solution.

2.4 Bucket

Right now the bucket is the simplest it can be. Remove the transpiration each timestep. The bucket is sized according to the effective rooting depth Z_r .

$$\theta_1 = \theta_0 - \frac{q\Delta t}{Z_r} \quad (8)$$

$$\psi_{soil}(\theta) = \psi_{soil,sat} \left(\frac{\theta}{\theta_{sat}} \right)^{-b} \quad (9)$$

Do not currently have implementations of:

- Rain
- Runoff
- Drainage

3 Experiments

3.1 Experiment 1

No drainage, no rain. Looking at a 30-day drydown. I'm forcing the model with a constant T_{\max} of $1\text{e-}4$ mm/s, which is approximately 4.3 mm/d.

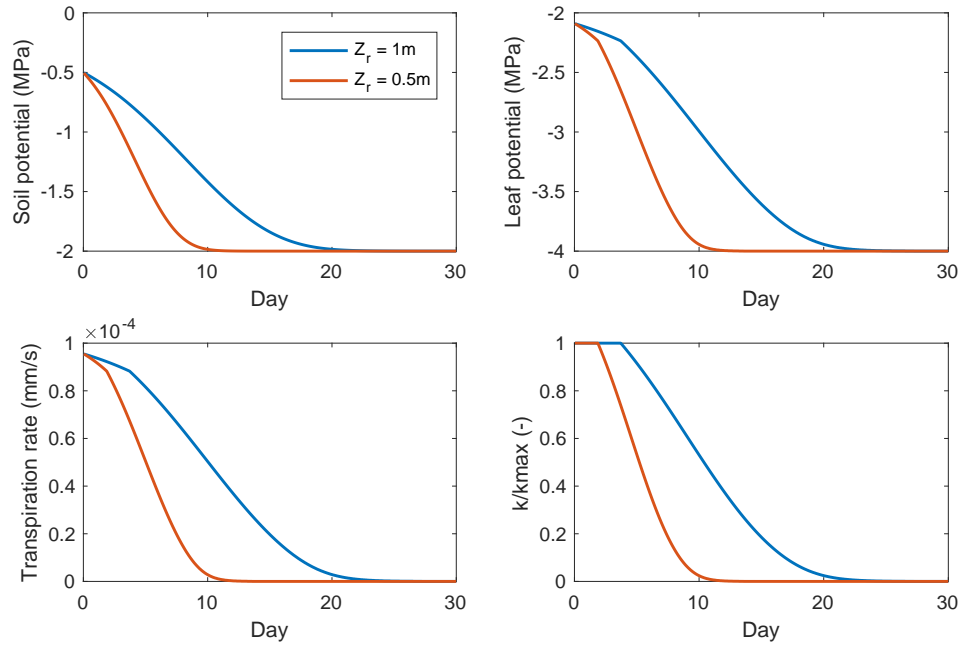


Figure 2: As expected, deeper rooting leads to a longer decay period.

References

- J. S. Sperry, F. R. Adler, G. S. Campbell, and J. P. Comstock. Limitation of plant water use by rhizosphere and xylem conductance: results from a model. *Plant Cell Environment*, 21(4):347–359, 1998. ISSN 1365-3040. doi: 10.1046/j.1365-3040.1998.00287.x. URL <http://dx.doi.org/10.1046/j.1365-3040.1998.00287.x>.