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:

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

And we adopt a simple linear conductance attenuation parameterization:

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

Such that equation (1) can be rewritten as:

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

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

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

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.

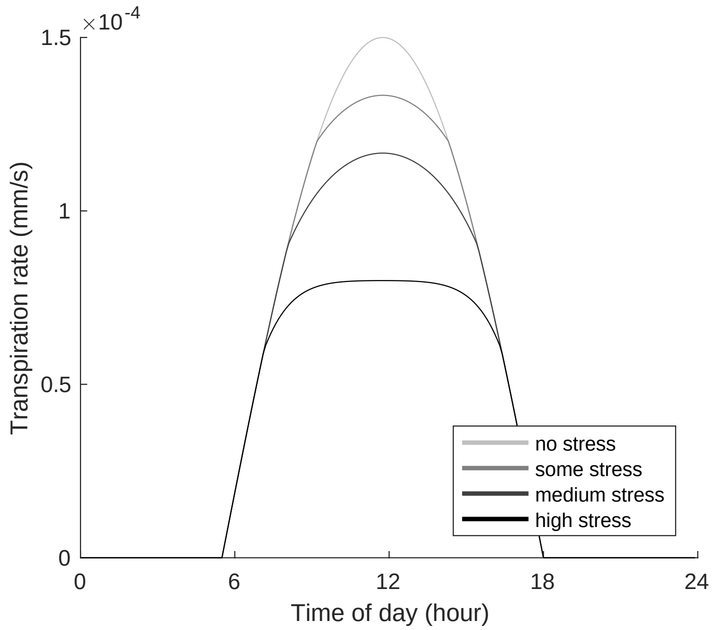

Figure 1: We are forcing the model with the lightest gray curve. And then based on Ψ_L, we attenuate the transpiration accordingly. In this case, I am varying Ψ_s to achieve different levels of stress.

2.3 Solution

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

$$T = q \tag{7}$$

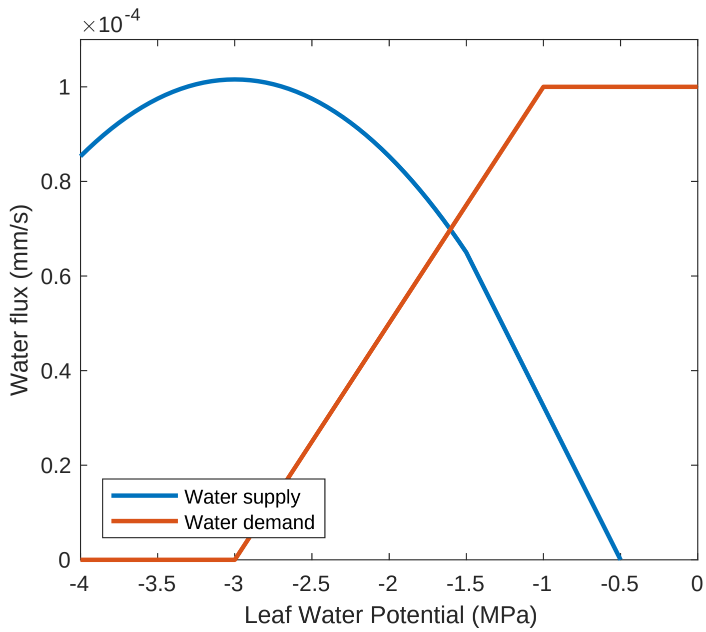

Figure 2: The solution for Ψ_L occurs where the two curves intersect.

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.

$$\theta_1 = \theta_0 - \frac{q\Delta t}{Z_r} \tag{8}$$

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

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 diurnal course $T_{\max}$, which with no stress produces approximately 4.3 mm/d of transpiration. All five runs use the same $k_{\max}$ = 6e-5 mm/s/MPa; Z_r varies from 0.5 to 2.5m.

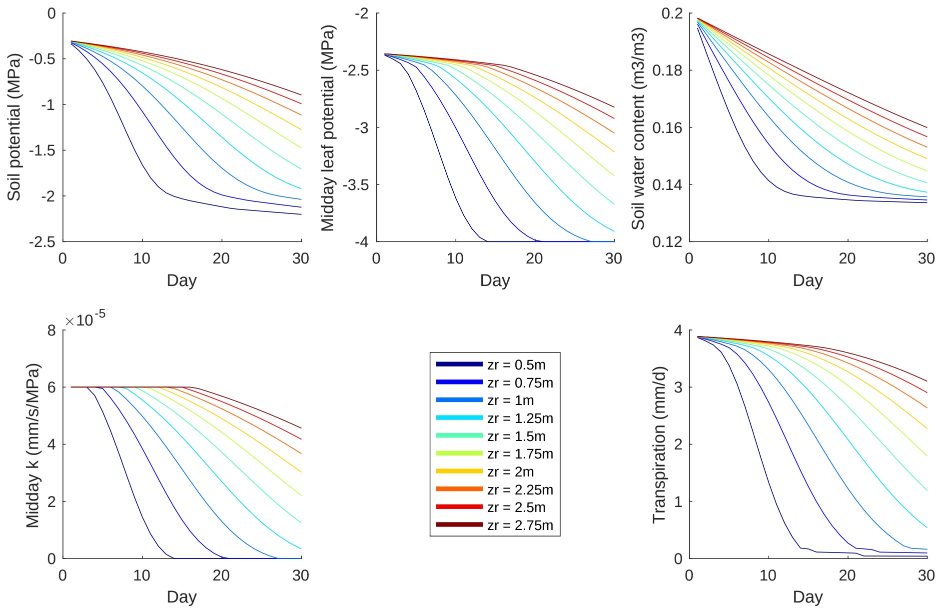

Figure 3: Varying Z_r.

3.2 Experiment 2

No drainage, no rain. Looking at a 30-day drydown. I'm forcing the model with a diurnal course $T_{\max}$, which with no stress produces approximately 4.3 mm/d of transpiration. All five runs use the same $Z_r = 1$m; $k_{\max}$ varies from 4 to 8e-5.

- We should consider whether any other traits should be coordinated with $k_{\max}$ (e.g. p_{50}).
- Here a drydown doesn't seem as appropriate...
- Maybe it's better to have some rain?

3.3 Experiment 3

Factorial approach mixing the various Z_r and $k_{\max}$.

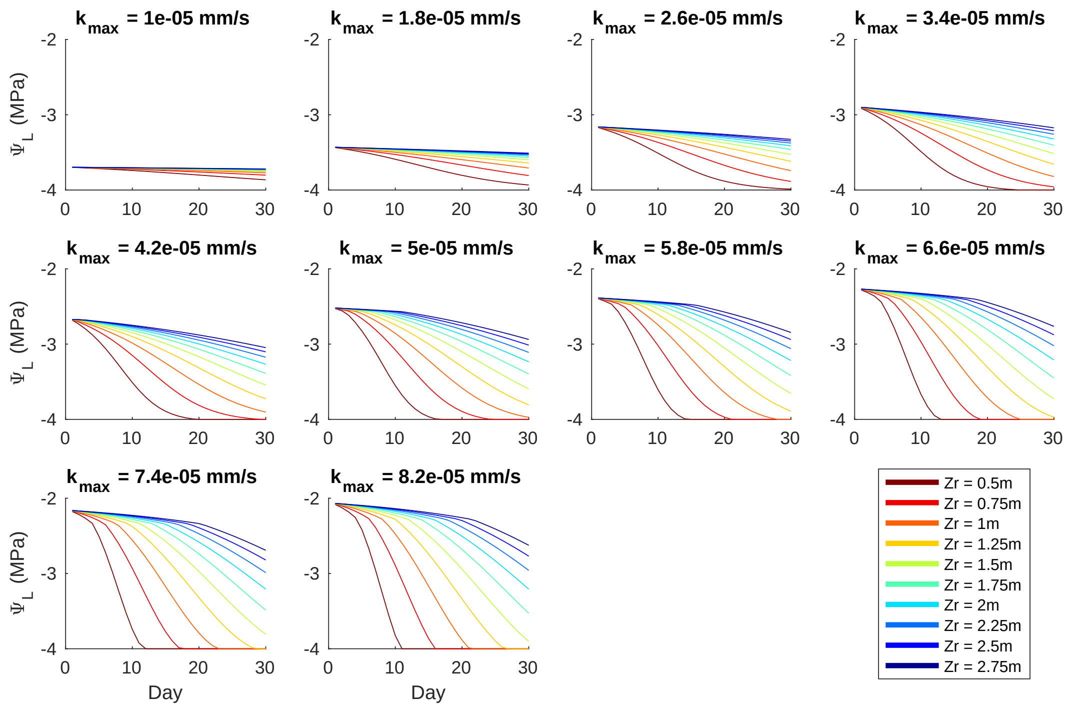

Figure 4: There are a couple of challenges here for retrieving the correct Z_r

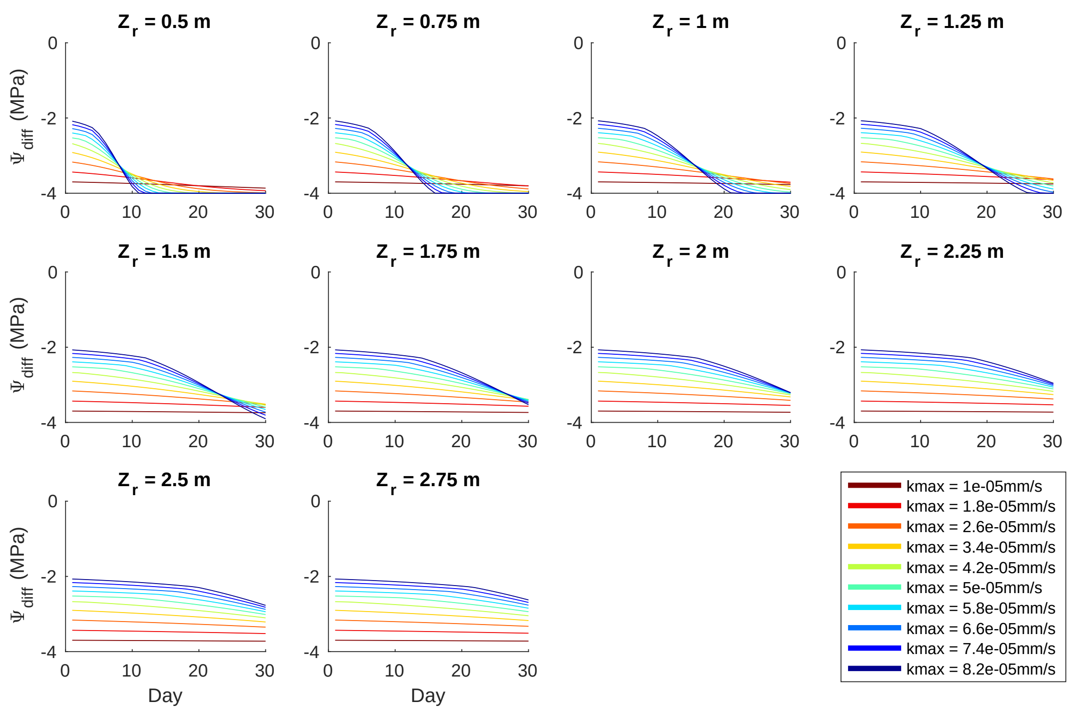

Figure 5: As Z_r gets smaller, our classification for k_{plant} becomes more challenging

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`.