**Resistance bulk soil-to-soil-root interface**

We will use the same formulation as in v-SPAC (Deng et al 2017) with some modifications. The root water uptake (RWU) is taken as a sink term for the Richards equation. The RWU, as originally formulated by Nimah and Hanks (1973), is modified so that the bulk soil-to-soil-root interface resistance and the plant resistance are described separately.

The Resistance from the bulk soil to the soil-root interface is given by:

R\_{sr} (z,t)= frac{\Delta x}{RDF(z)\*K(\Theta)} (eq Rsr)

Where $\Delta x$ is the equivalent length of water transfer from soil to root, RDF(z) is a root distribution function and $ K(\Theta)}$ is the soil hydraulic conductivity.

RDF is an exponential function that allows root density to decrease with depth (Deng et al 2017, Hentschel et al 2013). We modified the exponent to make a less steep decrease in root density within a profile of 30 cm, which is consistent with root presence in the cliff (field observations and sampling, for other species: Matthes-Sears and Larson 1995):

RDF(z) = \lambda \* \beta ^{{(z/L)}^{1/3}} (eq RDF)

Here $\lambda$ is the normalization factor $\lambda = frac{1}{\sum\_{z=0}^{L} \beta ^{{(z/L)}^{1/3}}$ and $\beta$ is a shape parameter ranging from 0 to 1.

The figure (rdf\_dx a)) shows a 30 cm depth profile and how the root density would behave with different shape parameters. We notice that across 5 orders of magnitude, the root density is very similar for the first 15 cm and that it only changes by ~6% between parameters at the bottom of the profile. Consequently, we will set $\beta$ to 1 as suggested by Deng et al (2017).

The equivalent length of water transfer from soil to root, $\Delta x$, can be constant throughout the model (Hutson, 2003), it can be calibrated (Deng et al. 2017), or it can be set depending on each soil layer's RDF (Verburg et al., 1996). Here, we use a mixed approach where we solve a system of equations of the form $\Delta x (RDF)=a\*{b}^{RDF}$, using the calibrated values from Deng et al (2017) as boundary conditions, i.e $\Delta x (0.1) = 10$ mm and $\Delta x (1) = 0.0001$. Solving this system sets the equation to be:

\Delta x (RDF)= 35.94\*{2.79e-6}^{RDF} (eq dx)

Note that parameter a has units of mm, and parameter b is a shape factor. In figure (rdf\_dx b)), we can see that this fit predicts a $\Delta x = 10\pm3$ mm for all but the smallest shape parameter. This will allow us to use this function to determine the resistance for each depth.

A graph of a line

Description automatically generated with medium confidence

b)

a)

A graph of different colored lines

Description automatically generated

Figure RDF\_dx. Panel a) shows the behavior of the RDF with different soil depths and different orders of magnitude for the shape parameter $\beta$. b) shows how the equivalent length of water transfer from soil to root ($\Delta x$) changes as depth increases (and root density decreases).

The last term to be specified for equation (eq R\_sr) is the soil hydraulic conductivity. Now we’re going to use the Mualem relationship but note that K changes for fractures and it’s mostly empirical and varies over 8 orders of magnitude (Chen et al 2022). Maybe consider having it fixed when modeling?

**Resistance in the plant**

The v-SPAC model uses an “integrated vulnerability curve” (IVC) derived from the whole plant measurements instead of just measuring the hydraulic conductivity loss (HCL) in a segment. By doing this, they relate the total plant resistance (Rp), to the hydraulic state of the plant given by the xylem water potential ($\Psy\_x$) through:

$R\_p=R\_min\*exp[(frac{-\Psy\_x}{d})^b]$

-Rmin is the minimum plant resistance that happens when hydraulic conductance is max at full hydration.

-Rp is technically the sum of the total root resistance and the stem xylem resistance and each should be determine by a VC to determine Rmin, d and b. They approximate the total plant resistance to the total root resistance, because other studies show that the root system is much

Nightime sapflow

//besides Deng how many studies have attempted to get the HCL through field studies

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| --- | --- |
| Richards | Box model |
| moisture in different layers is just due to gravity- vertical infiltration (we can have an argument) | We can set interactions between boxes, right now surface and deep work through infiltration but we can set a flow in either direction or with other boxes that are filled independently. |
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