Water uptake reduction

The water uptake of each cohort W^c_{upt} is proportional to its relative share of fine roots r_{Mr} and limited by the transpiration demand of each cohort D^c_{tr} and the available water W^c_{av} in every layer i

This can be formulated as follows:

$$W^c_{upt} = \min\left(D^c_{tr}\ ,\ \sum_i W^c_{av}(i)\right) \qquad (0.0.1)$$

The available water $W^c_{av}(i)$ for each cohort in every layer i is estimated from the total plant available water in the soil layer above the wilting point, the relative share of fine roots of the cohort in the actual layer and an uptake resistance f_{ru}.

flag_wred = 1 (Function fred1)

To calculate this resistance function f_{ru} it is assumed that optimal conditions for water uptake exist only when the water content does not vary by more than 10 percent from the field capacity W_s^{FC}, otherwise there is a linear reduction of the plant available water {Chen, 1993 #67}

$$f_{ru} = \begin{cases} 1 - \dfrac{0.9 \cdot W_s^{FC} - W_s}{0.9 \cdot W_s^{FC} - W_s^{WP}} & ,\ W_s < 0.9 \cdot W_s^{FC} \\ 0.3 + 0.7 \cdot \dfrac{W_s^{sat} - W_s}{W_s^{sat} - 1.1 \cdot W_s^{FC}} & ,\ W_s > 1.1 \cdot W_s^{FC} \\ 1 & ,\ \text{otherwise} \end{cases} \qquad (0.0.2)$$

whereas W_s is the actual water content and W_s^{sat} the saturated water content of the soil layer (pore volume).

flag_wred = 2 (Function fred2)

The uptake resistance expresses the fraction of plant available soil water which can be removed in one day. The value is used for all days and all sites and is set to {Aber, 1992 #1056}

$f_{ru} = 0.4$

flag_wred = 3 (Function fred3)

Resistance function f_{ru} is defined like flag_wred = 1 (Function fred1) and is modified for each soil layer by the root profile:

$$f_{ru} = \begin{cases} 1 - \dfrac{0.9 \cdot W_s^{FC} - W_s}{0.9 \cdot W_s^{FC} - W_s^{WP}} & , W_s < 0.9 \cdot W_s^{FC} \\ 0.3 + 0.7 \cdot \dfrac{W_s^{sat} - W_s}{W_s^{sat} - 1.1 \cdot W_s^{FC}} & , W_s > 1.1 \cdot W_s^{FC} \\ 1 & , \text{otherwise} \end{cases} \qquad (0.0.3)$$

fred3 = root_fr(j) * f_{ru}

flag_wred = 4 (Function fred4)

The function for calculating uptake resistance is modified by a profile defined in the array fred. The profile is given by measurements of Beerenbusch.

fred = (/ 0.0, 0.03, 0.03, 0.02, 0.02, 0.02, 0.02, 0.01, 0.01, 0.01, &

0.01, 0.01, 0.01, 0.01, 0.01 /)

f_{ru} = fred(j)

flag_wred = 5

In this case no uptake resistance is assumed:

f_{ru} = 1.0

flag_wred = 6

Only 50 % of plant available soil water can be removed in one day:

f_{ru} = 0.5

flag_wred = 7

Only 25 % of plant available soil water can be removed in one day:

f_{ru} = 0.25

flag_wred = 8 (Function fred6)

The function for calculating uptake resistance is similar to fred1. It follows an approach of Kloecking (2006) and describes an empirical relation between soil water content and resistance.

$$
f_{ru} = \begin{cases} 0 & W_s < W_s^{WP} \\ 0.1 + \dfrac{0.9 \cdot W_s^{FC} - W_s}{0.9 \cdot W_s^{FC} - W_s^{WP}} & W_s < 0.9 \cdot W_s^{FC} \\ 0.3 + 0.7 \cdot \dfrac{W_s^{sat} - W_s}{W_s^{sat} - 1.1 \cdot W_s^{FC}} & W_s > 1.1 \cdot W_s^{FC} \\ 1 & \text{, otherwise} \end{cases} \qquad (0.0.4)
$$

flag_wred = 9

This case is only a test.

flag_wred = 10 (Function fred7)

Uptake resistance is calculated by an empirical relation between soil water content and resistance following an approach by {Chen, 1993 #67}.

$$
f_{ru} = \begin{cases} 0 & W_s < W_s^{WP} \\ e^{-5 \cdot \frac{0.9 \cdot W_s^{FC} - W_s}{0.9 \cdot W_s^{FC} - W_s^{WP}}} & W_s < 0.9 \cdot W_s^{FC} \\ 0.3 + 0.7 \cdot \dfrac{W_s^{sat} - W_s}{W_s^{sat} - 1.1 \cdot W_s^{FC}} & W_s > 1.1 \cdot W_s^{FC} \\ 1 & \text{, otherwise} \end{cases} \qquad (0.0.5)
$$