

Module

root_solute_uptake_Michaelis

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1 Introduction

The module calculates the rates of solute uptake by the roots based on a Michaelis-Menten kinetic.

2 Assumptions

- An instantaneous demand is available.
- All the roots are equally able to take up solutes.

3 Equations

Let R_{\max} be the instantaneous demand for a given solute species. R_{\max} is a mass of solute per unit surface of soil per unit of time : ($kg.m^{-2}.s^{-1}$). A maximum uptake rate per unit length of root r_{\max} is calculated dividing R_{\max} by the total root length. The rate of solute uptake per unit volume of soil and unit of time $R(z, t)$ is calculated according to :

$$R(z, t) = r_{\max}(t)\rho(z)\frac{C(z, t)}{C(z, t) + K} \quad (1)$$

where $\rho(z)$ is the root length density ($m_{root}.m^{-3}$), $C(z, t)$ is the concentration of the solute species ($kg.m^{-3}$) and K is the Michaelis-Menten constant with unit of a concentration.

The module is able to handle iterations with a module providing the transport and the mass balance for the solute species. When iterations are allowed, the module checks that the following condition is satisfied before accepting the solution :

$$\frac{\max_{i=1,N} |R_i^{j+1} - R_i^j|}{\max_{i=1,N} |R_i^{j+1}|} \leq \epsilon \quad (2)$$

where N is the number of nodes of the grid, j is the iteration index and ϵ is the convergence criteria. If convergence is not obtained with a maximum number of iterations (parameter *nitermax*) the module returns control to the main with an error flag. The time increment is then reduced and the module is called again.

The module returns uptake rates expressed in mass of solutes and also in moles of solutes.

4 Inputs

- **crop maximum solutes uptake mass flux density** Instantaneous demand of the crop. [$kg.m^{-2}.s^{-1}$].
- **crop root length** Total root length of the root system. [$m.m^{-2}$].
- **crop root length density** Root length density. [$m.m^{-3}$].
- **soil solution solutes concentration** Concentration of the solute species in the soil water [$kg.m^{-3}$].
- **soil water volumetric content**. Volumetric water content of the soil. [$m^3.m^{-3}$].

5 Outputs

The module produces the following outputs. None of these require an initial value. They are initialized to 0 and calculated at the first call of the compute. All the informations listed below are also available in the VSOIL-MODULES application.

- **crop root solutes mass uptake rate** Solute mass uptake rates by roots at grid nodes. [$kg.m^{-3}.s^{-1}$] [*tagged*]
- **crop root solutes mass uptake rate profile cumulated** Solute species mass uptake rates by roots integrated on the soil profile. [$kg.m^{-2}.s^{-1}$] [*tagged*]
- **crop root solutes mass uptake rate profile cumulated daily** Solute species mass uptake rates by roots integrated on the soil profile and cumulated for the day. [$kg.m^{-2}$] [*tagged*]
- **crop root solutes mass uptake rate profile time cumulated** Solute species mass uptake rates by roots integrated on the soil profile and cumulated since the beginning of the simulation. [$kg.m^{-2}$] [*tagged*]
- **crop root solutes molar uptake rate** Solute species molar uptake rates by roots at grid nodes. [$mol.m^{-3}.s^{-1}$] [*tagged*]
- **crop root solutes molar uptake rate profile cumulated** Solute species molar uptake rates by roots integrated on the soil profile. [$mol.m^{-2}.s^{-1}$] [*tagged*]

- **crop root solutes molar uptake rate profile cumulated daily** Solute species molar uptake rates by roots integrated on the soil profile and cumulated for the day. [$mol.m^{-2}$] [*tagged*]
- **crop root solutes molar uptake rate profile time cumulated** Solute species molar uptake rates by roots integrated on the soil profile and cumulated since the beginning of the simulation. [$mol.m^{-2}$] [*tagged*]

6 Parameters

Parameters description is available in the VSOIL-MODULES application when editing the module. When possible, default values are available in the GUI to ease the utilisation of the module. **Default values are given to facilitate the utilisation of the module, but there is no warranty that they are adapted to your specific case. The user MUST check them before using.**

- **cmichael**, [$kg.m^{-3}$]. Michaelis-Menten constant for all the solute species for which uptake by the root system is simulated. Parameter K in eq: 1
- **epsiter**, [-]. Convergence criteria. Parameter ϵ in eq: 2
- **nitermax**, [-]. Maximum number of iterations allowed before reducing the time increment.