water.surf-uz.runoff-infiltration.mseytoux

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Name : *Morel-Seytoux production function on surface units*
Version : *19.06*
Domain : *hydrology*
Description : *Production function computing infiltration and runoff at the top of surface unit using the Morel-Seytoux method, based on the Green and Ampt assumptions.*

Parameters

`CoeffMultiKs`	used	global coefficient for multiplying ks parameter (default value is 1)	$-$
`CoeffMultiThetaIni`	used	Multiplication coefficient of soil moisture initial condition at the surface	$-$
`resstep`	used	numerical resolution step for cumulative infiltration height	m

Attributes

`Hc`	required	SU	capillary suction height	m
`Ks`	used	SU	saturated hydraulic conductivity	m/s
`area`	required	SU	area of the SU	$m2$
`betaMS`	required	SU	viscous correction parameter	$-$
`thetaini`	required	SU	initial soil surface water content	$m3/m3$
`thetares`	required	SU	residual soil water content	$m3/m3$
`thetasat`	required	SU	saturated soil water content	$m3/m3$

Variables

`soil.surf.hydraulic-conductivity-Ks`	used	SU	saturated hydraulic conductivity (Ks) of the plot	m/s
`water.atm-surf.H.rain`	required	SU	rainfall height on the SU	m
`water.surf.Q.downstream-su`	used	SU	output volume at the outlet of the upstream SUs	$m3/s$
`water.surf.H.infiltration`	produced	SU	water infiltration height through the surface of SU	m
`water.surf.H.runoff`	produced	SU	water runoff height on surface of SU	m

Résumé

The rain is separated by the “Morel-Seytoux production function” into infiltration and runoff on each SU. The function computes the time before all the rain is infiltrated. This caracteristic time is called “ponding time” t_p. When the ponding time is reached, the function calculates the soil infiltrability using the hydraulic conductivity and the initial soil water content and deduces the runoff. This model is adapted to the **simulation at the event scale**.

1 Scientific concepts

1.1 Calculation of water height

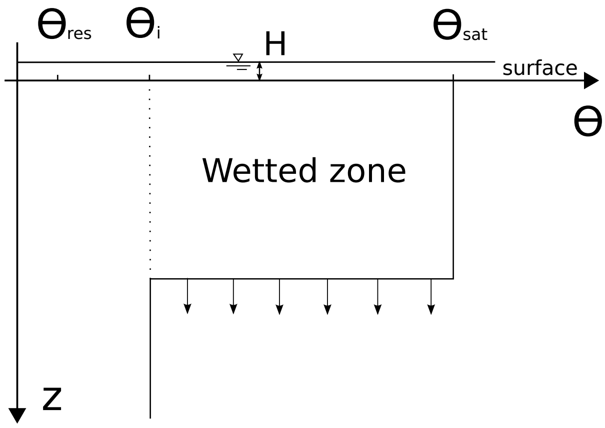
First, the function computes the water height present at the top of the surface unit. This value is composed with rainfall height P (in m) and runoff output discharge $Q_{SU}(t-1)$ (in m^3/s) from potential upper connected SUs calculated at the previous simulation time step.

$$H = P + \sum_{SU_{up}} \left(\frac{Q_{SU}(t-1) \times \Delta t}{A_{SU}} \right) \tag{1}$$

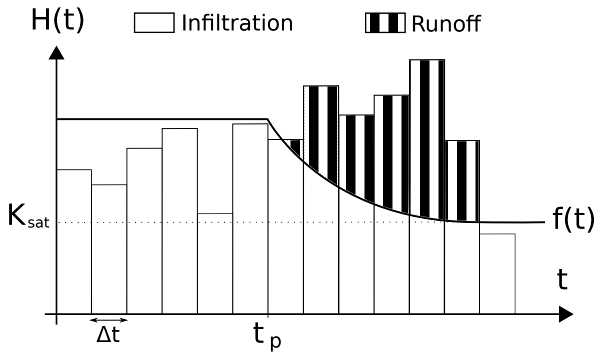
where H is the water height present at the surface of the SU (m), Δt is the simulation time step (s), and A_{SU} is the area of the unit on which the calculation is done (m^2).

1.2 Calculation of infiltrability

The "Morel-Seytoux production function" [?] is a modification of Green and Ampt's [?] equation. The main assumption is the rectangular form of the wetting front trough the soil, as schematized hereafter. Then, the model was adapted to the MHYDAS structure by Moussa and al. [?].



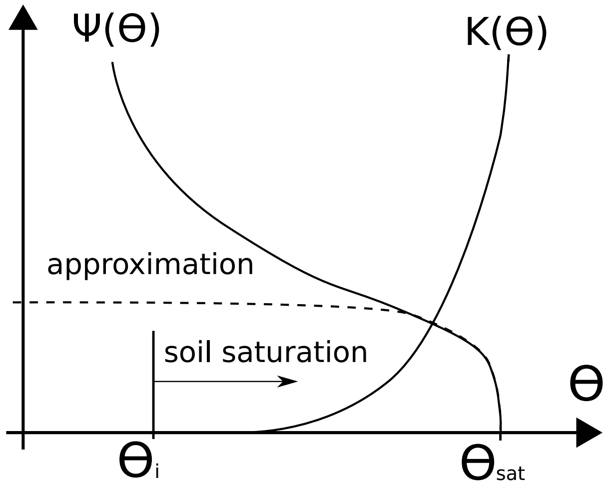
Runoff cannot occur as long as the soil surface retention potential is not reached. Therefore, at every time step, the model needs to determine whether the ponding time (t_p) has been reached. For $t < t_p$ all the rain is infiltrated and for $t > t_p$ the cumulative infiltration $F(t)$ is calculated from the equation 2. This behaviour could be represented with the infiltratbility $f(t)$ (m/s) which dicrease in time from t_p. Then, the value of $f(t)$ tends towards the saturated hydraulic conductivity K_{sat}.



$$F(t) - F_p - \left(S_f + F_p \times \left(1 - \frac{1}{\beta_{MS}}\right)\right) \times ln\left(\frac{S_f + F(t)}{S_f + F_p}\right) = \frac{K_s \times (t - t_p)}{\beta_{MS}} \quad (2)$$

where F_p is the cumulative infiltration when ponding occurs (m), β_{MS} is the viscous correction parameter $(-)$ ranged between 1 and 1,7 and usually taken equal to 1,3 [?], K_s is the saturated hydraulic conductivity (m/s). K_s is a distributed parameter on surface units but it can be time variable as a function of soil practice and rainfall.

The parameter S_f is a factor composed of storage and suction (m). This factor is calculated with the equation 3 which is an approximation of the "suction head / water content" relation curve $\phi(\theta)$, hereafter.



$$S_f = (\theta_s - \theta_i) \times H_c \times \left(1 - \frac{1}{3} \times \left(\frac{\theta_i - \theta_r}{\theta_s - \theta_r}\right)^6\right) \quad (3)$$

where Hc is the capillary height (m), θ_s is the volumetric soil water content at saturation (m^3/m^3), θ_r is the volumetric residual soil water content (m^3/m^3) and θ_i is the initial water content in the top surface layer (m^3/m^3). This calculation is done once at the beginning of the simulation.

To determine the cumulative infiltration $F(t)$ at every time step, the function realizes iterations to satisfy the equation 2. The parameter $ResStep$ (m) characterises the accuracy of calculated cumulative infiltration value. The smaller this parameter is, the more accurate the value F is. However, simulation duration is higher because of the greater number of iteration steps.

1.3 Calculation of infiltration and runoff

Then, produced variables are calculated as following :

if $t \leq t_p$:

$$\begin{cases} I = H \\ R = 0 \end{cases} \quad (4)$$

if $t > t_p$:

$$\begin{cases} I = F(t) - F(t-1) \\ R = H - (F(t) - F(t-1)) \end{cases} \quad (5)$$

where I is the infiltrated water height (m), R is the runoff water height on SU (m), F is the cumulative infiltration (m) at time t, and H is the water height at the top of the surface unit (m) calculated in equation 1.

We could note that once t_p is reached, the soil cannot be "unsaturated". Therefore, the "Morel-Seytoux production function" should be only used at the scale of a rain event.

Some examples of use are available in the paper of Morel-Seytoux [?], Chahinian [?] and in thesis of Chahinian [?] and Ghesquière [?].

2 Functional description

2.1 Function name

The name (fileID) of the simulation function is `water.surf-uz.runoff-infiltration.mseytoux`.

2.2 Function parameters

The function "Morel-Seytoux production function" must be used with the following parameter :

Symbol	*Name*	*Value range*	*Unit*
$ResStep$	`resstep`	> 0	m

Thus, the correct syntax to use in the `model.xml` file is illustrated hereafter :

```
<function fileID="water.surf-uz.runoff
          -infiltration.mseytoux">
    <param name="resstep"
           value="0.000005" />
</function>
```

2.3 Unit properties required

Some of the soil properties are required. These are described in the following table :

Symbol	*Name*	*Value range*	*Unit*
K_s	`ks`	≥ 0	m/s
θ_r	`thetares`	$0 \leq \theta_r \leq 1$	m^3/m^3
θ_s	`thetasat`	$0 \leq \theta_s \leq 1$	m^3/m^3
β_{MS}	`betaMS`	> 0	$-$
H_c	`Hc`	≥ 0	m
A_{SU}	`area`	> 0	m^2

The condition $\theta_r \leq \theta_s$ must be verified.

2.4 Initial conditions

The function "Morel-Seytoux production function" requires an initial condition which is located in the `SUini.ddata.xml` file.

Symbol	*Name*	*Value range*	*Unit*
θ_i	`thetaini`	$0 \leq \theta_i \leq 1$	m^3/m^3

The condition $\theta_r \leq \theta_i \leq \theta_s$ must be verified.

2.5 Variables

Variables produced, required and updated by this function are listed hereafter :

Symbol	*Name*	*Unit*
R	`water.surf.H.runoff`	m
I	`water.surf.H.infiltration`	m
Q_{SU}	`water.surf.Q.downstream-su`	m^3/s
K_s	`soil.surf.hydraulic-conductivity-Ks`	m/s
P	`water.atm-surf.H.rain`	m

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