Soil hydrology

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ORCHIDEE
LAND SURFACE MODEL

Outline

1. **Introduction**
   – Scope of this specific training
2. **The multi-layer « CWRR » scheme**
   – Processes (soil moisture diffusion, boundary fluxes)
   – Parameters and options
3. **Forcing conditions**
   – Vegetation/LC, soil texture, slope

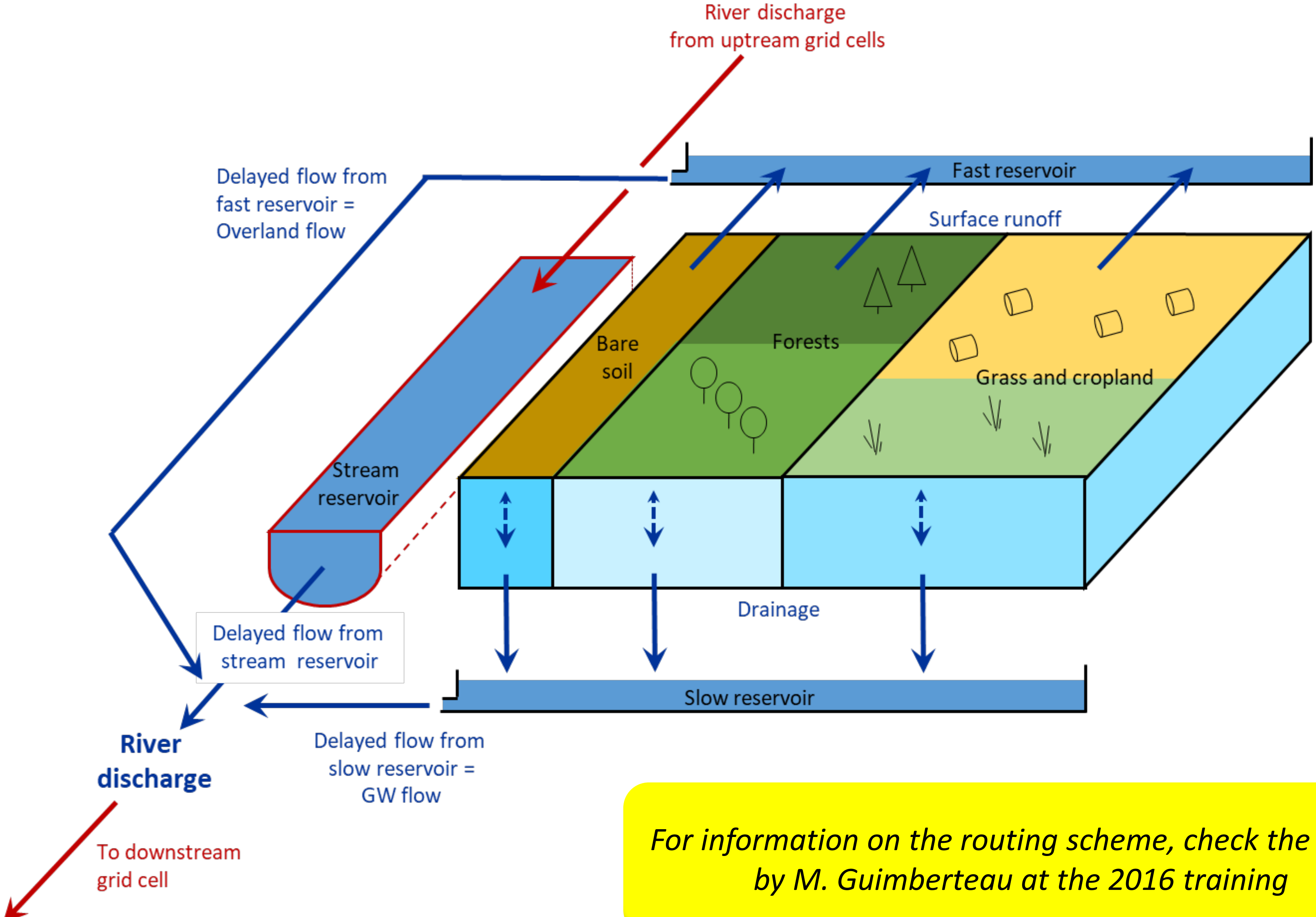
More details on the Wiki

http://forge.ipsl.jussieu.fr/orchidee/attachment/wiki/Documentation/eqs_hydrol.pdf

Reference papers: de Rosnay et al., 2000; de Rosnay et al., 2002; d'Orgeval et al., 2008; Campoy et al., 2013 ; Tafasca et al., 2019 ; Ducharne et al. in prep

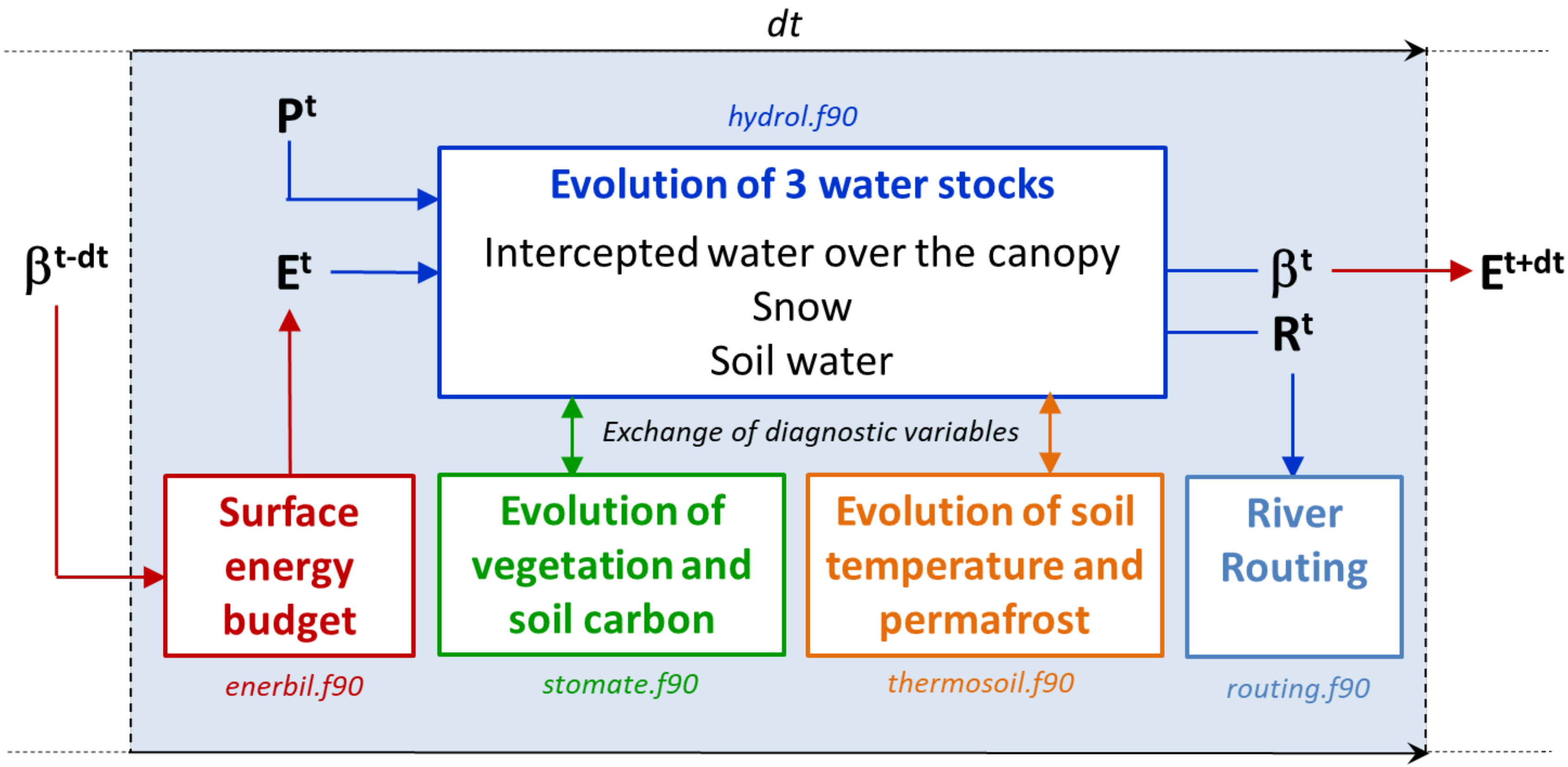
PhD theses : de Rosnay, 1999; d'Orgeval, 2006; Campoy, 2013

Land surface hydrology



For information on the routing scheme, check the slides by M. Guimberteau at the 2016 training

Soil hydrology and water budget



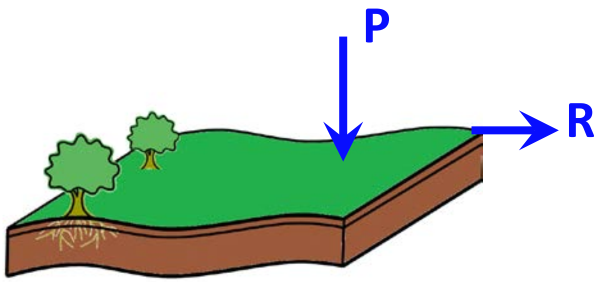
$$dS/dt = P - E - R$$

We will focus on soil water and the related water fluxes (soil hydrology)
No interception, no snow, no soil water freezing today

Two versions of soil hydrology

Two-layer = Choisnel = ORC2

Ducoudré et al., 1993; Ducharne et al., 1998; de Rosnay et al. 1998

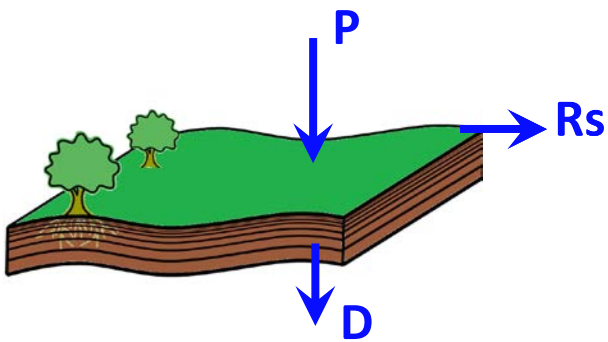


- **Conceptual description of soil moisture storage**
- **2-m soil and 2-layers**
- Top layer can vanish
- Constant available water holding capacity (between FC and WP)
- Runoff when saturation
- No drainage from the soil

  We just diagnose a drainage as 95% of runoff for the routing scheme

Multi-layer = CWRR = ORC11

de Rosnay et al., 2002; d'Orgeval et al., 2008; Campoy et al., 2013



- **Physically-based description of soil water fluxes using Richards equation**
- **2-m soil and 11-layers**
- Formulation of Fokker-Planck
- Hydraulic properties based on van Genuchten-Mualem formulation
- Related parameter based on texture
- Surface runoff = P – Esol – Infiltration
- Free drainage at the bottom

Two versions of soil hydrology

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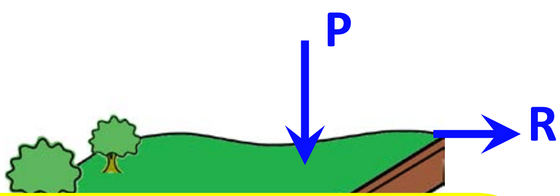

It has been abandoned in the trunk and in branch ORCHIDEE_2_2

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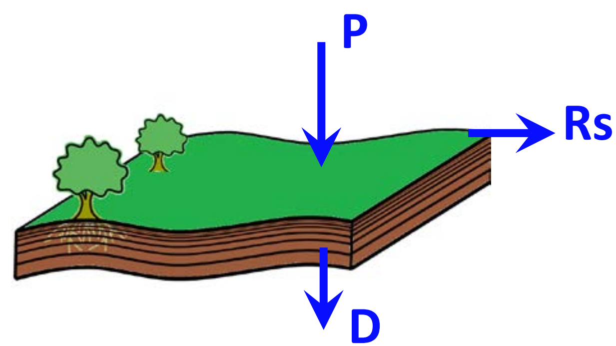

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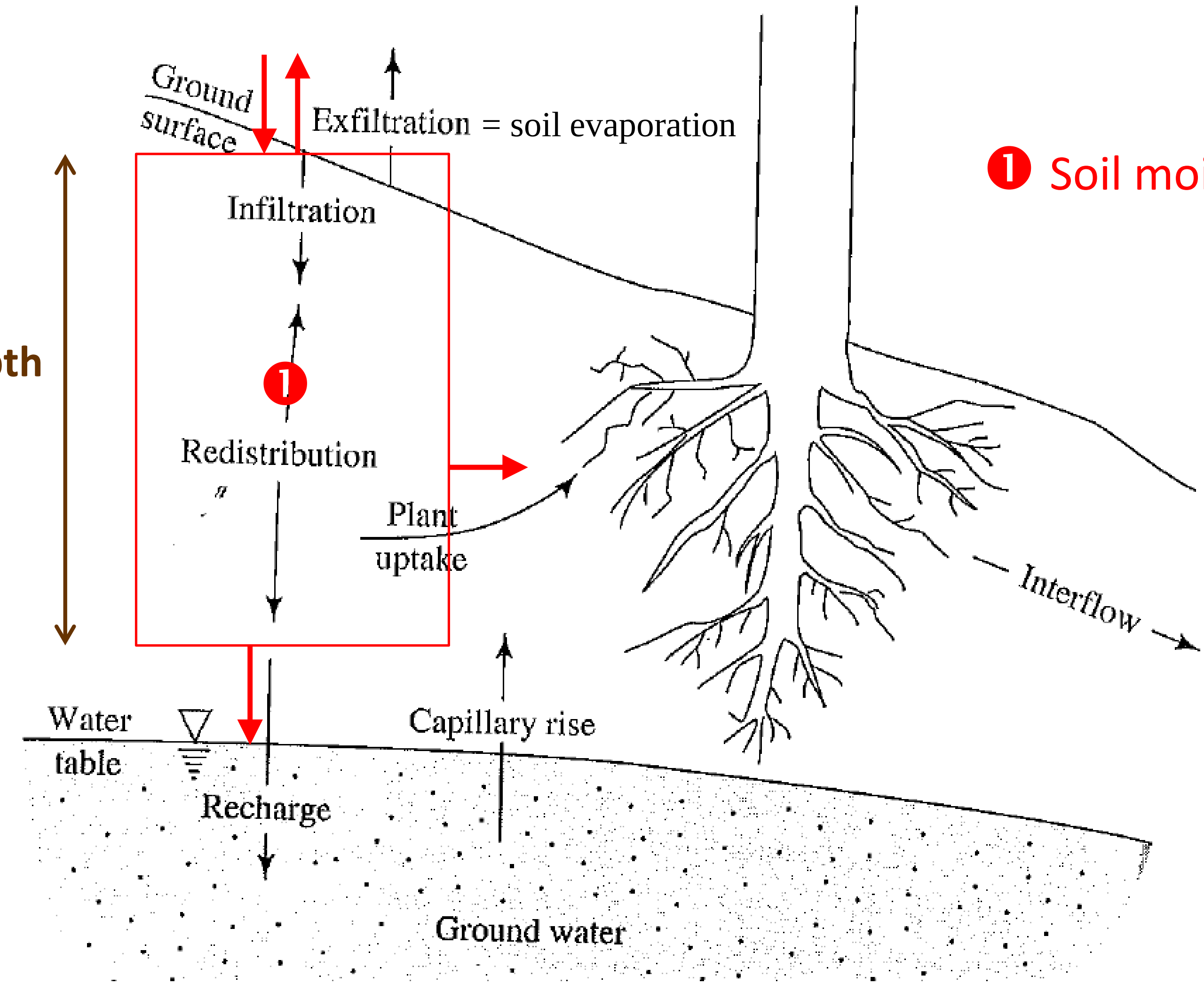
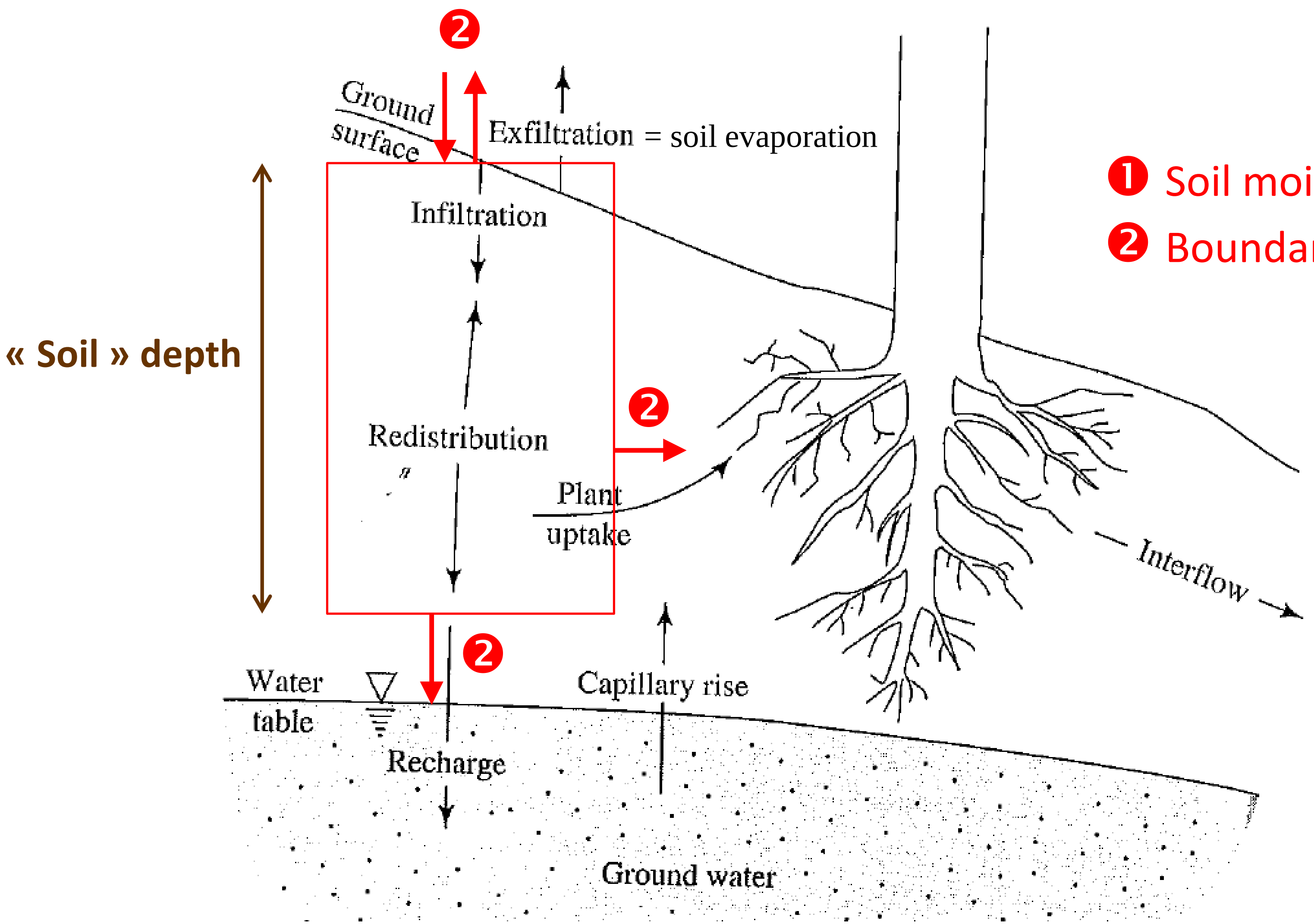
What is modeled ?

« Soil » depth



❶ Soil moisture diffusion

What is modeled ?

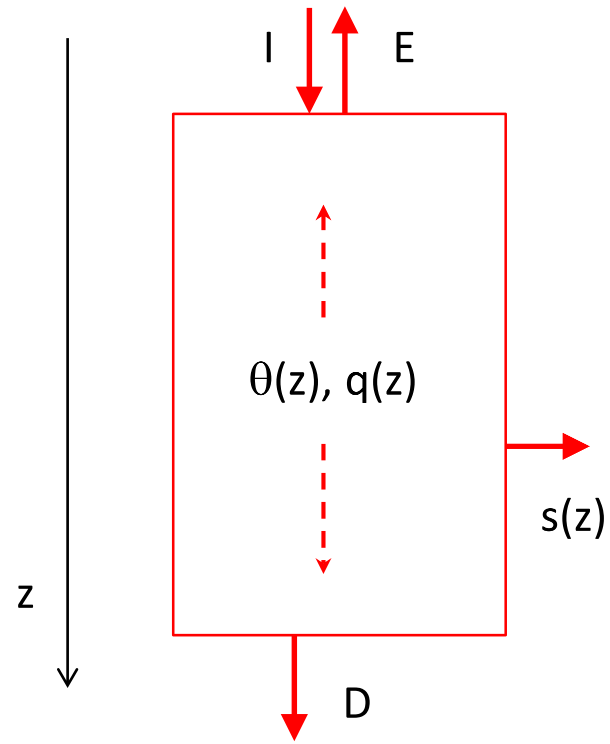


❶ Soil moisture diffusion

❷ Boundary fluxes

How is SM diffusion modeled ?

1. We assume 1D vertical water flow below a flat surface



θ : volumetric water content in $m^3.m^{-3}$
q : flux density in $m. s^{-1}$
h : hydraulic potential in m
K : hydraulic conductivity in $m.s^{-1}$
s : transpiration sink in $m^3.m^{-3}.s^{-1}$

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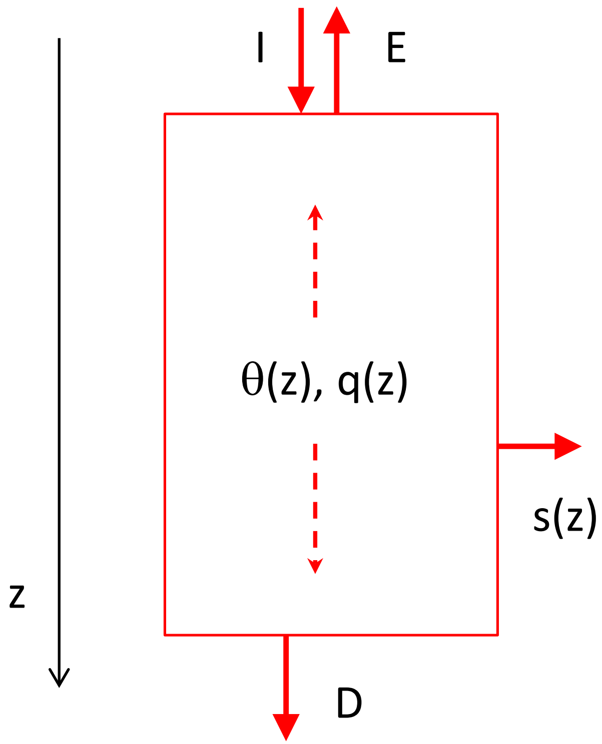

2. Continuity :

$$\boxed{\frac{\partial \theta}{\partial t} + \frac{\partial q}{\partial z} = -s}$$

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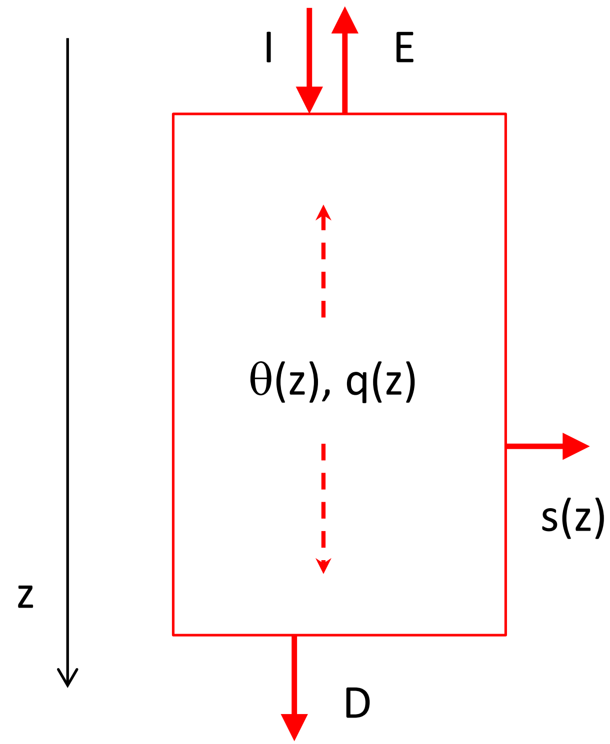

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$$\boxed{\frac{\partial \theta}{\partial t} + \frac{\partial q}{\partial z} = -s}$$

3. Motion = diffusion equation because of low velocities in porous medium

$$q(z) = -K(z)\frac{\partial h}{\partial z}$$

Richards equation

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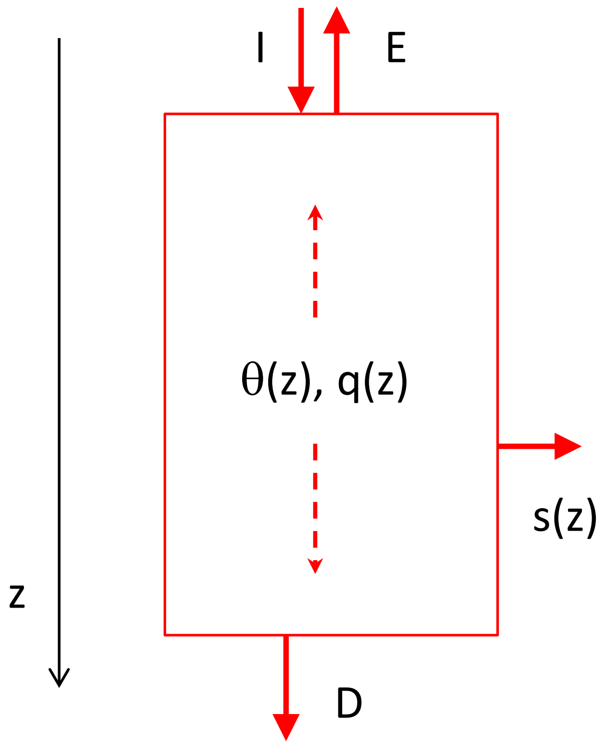

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4. Hydraulic head h quantifies the gravity and pressure potentials

$$h = - z + \psi$$

ψ is the matric potential (in m, <0)

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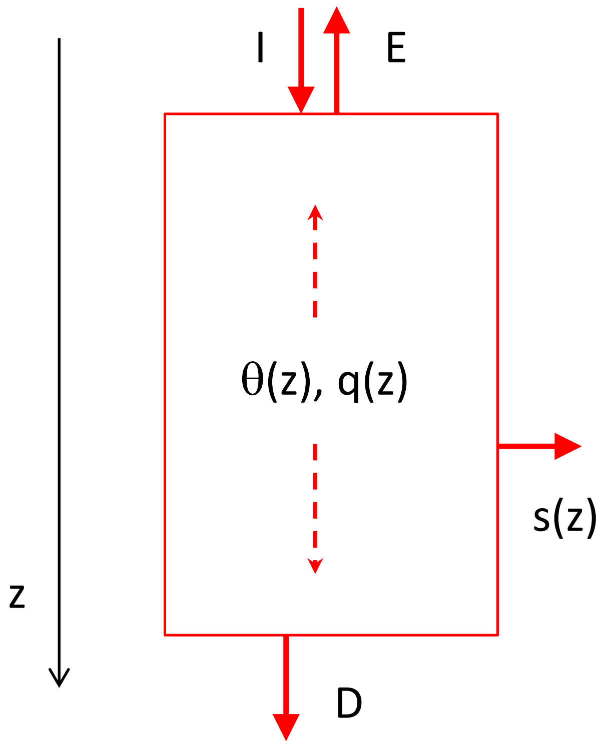

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$$h = -z + \psi$$

ψ is the matric potential (in m, <0)

5. K and ψ depend on θ (unsaturated soils)

$$q(z) = -K(\theta)\left[\frac{\partial \psi}{\partial z} - 1\right]$$

$$\boxed{q(z) = -D(\theta)\frac{\partial \theta}{\partial z} + K(\theta)}$$

$$D(\theta) = K(\theta)\frac{\partial \psi}{\partial \theta}$$

D is the diffusivity (in $m^2.s^{-1}$)

θ : volumetric water content in $m^3.m^{-3}$
q : flux density in $m.\ s^{-1}$
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Finite difference integration

- The differential equations of continuity and motion are solved using finite differences :

$$\frac{W_i(t+dt)-W_i(t)}{dt} = Q_{i-1}(t+dt) - Q_i(t+dt) - S_i$$

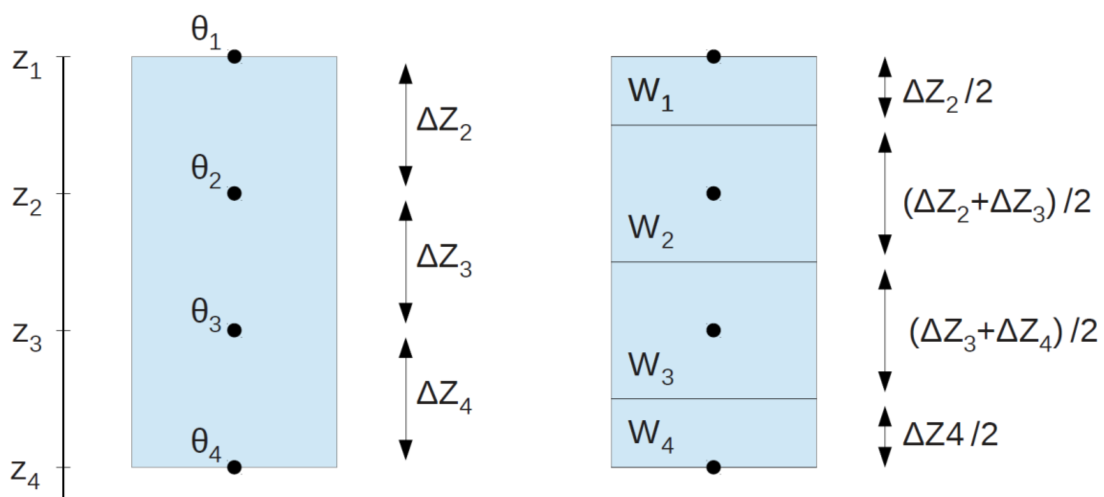
$$\frac{Q_i}{A} = -\frac{D(\theta_{i-1})+D(\theta_i)}{2}\frac{\theta_i-\theta_{i-1}}{\Delta Z_i} + \frac{K(\theta_{i-1})+K(\theta_i)}{2}$$

Si = transpiration sink

A: grid-cell area

- The soil column is discretized using N **nodes,** where we calculate **θi**
- Each node is contained in one **layer**, with a total water content **Wi**
- The fluxes **Qi** are calculated at the **interface** between two layers

tridiagonal matrix



N=4 nodes with θ_i
3 internode heights

N=4 layers with W_i
5 interfaces

Wi is obtained by vertical integration of θ(z) in layer i, assuming a linear variation of θ(z) between 2 nodes

$$W_i = [\Delta Z_i\,(3\,\theta_i+\theta_{i-1}) + \Delta Z_{i+1}\,(3\,\theta_i+\theta_{i+1})]/8$$

$$W_1 = [\Delta Z_2\,(3\,\theta_1+\theta_2)]/8$$

$$W_N = [\Delta Z_N\,(3\,\theta_N+\theta_{N-1})]/8$$

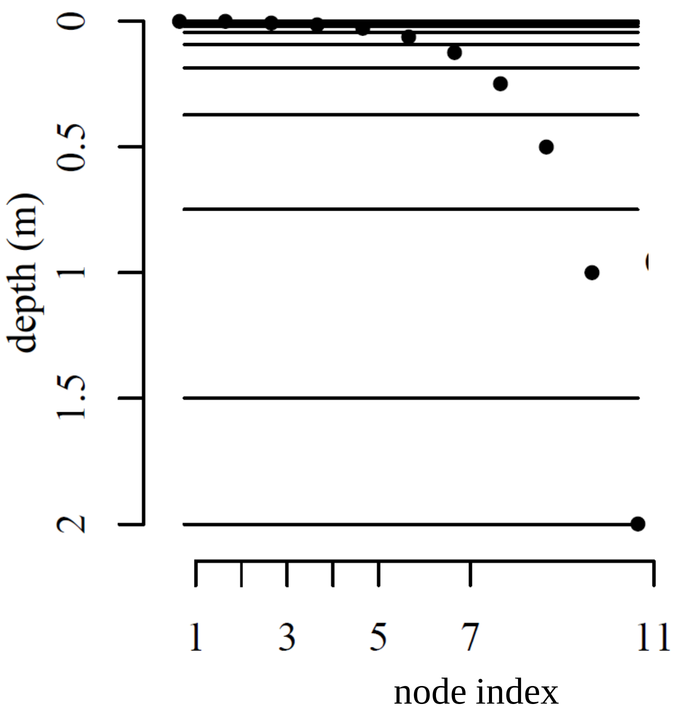
Vertical discretization

- The vertical discretization must permit an accurate calculation of θi and the related water fluxes Qi
- We need thin layers where θ is likely to exhibit sharp vertical gradients
(to better approximate the local derivative)
- Vertical discretization and boundary conditions must be decided together !

By default, in hydrol, we use :

- 2-m soil
- 11 nodes (layers) with geometric increase of internode distance

(cf. de Rosnay et al., 2000)



i	≈ hi (mm)
1	1
2	3
3	6
4	12
5	23,5
6	47
7	94
8	188
9	375
10	751
11	500

Vertical discretization

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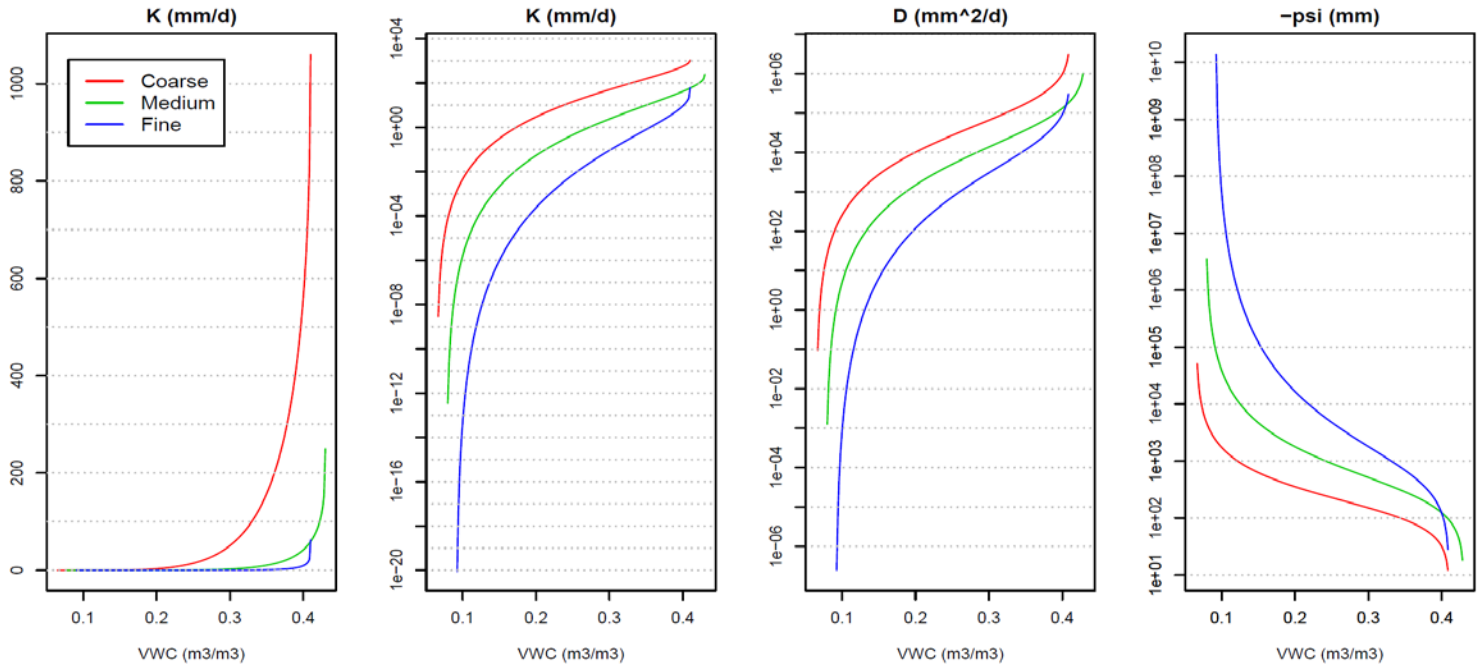
- We need thin layers where θ is likely to exhibit sharp vertical gradients (to better approximate the local derivative)
- Vertical discretization and boundary conditions must be decided together !

- **Alternative discretizations can be defined by externalized parameters**

DEPTH_MAX_H	2.0 or 4.0 depending on hydrol_cwrr	m	Maximum depth of soil moisture	Maximum depth of soil for soil moisture (CWRR).
DEPTH_MAX_T	10.0	m	Maximum depth of the soil thermodynamics	Maximum depth of soil for temperature.
DEPTH_TOPTHICK	9.77517107e-04	m	Thickness of upper most Layer	Thickness of top hydrology layer for soil moisture (CWRR).
DEPTH_CSTTHICK	DEPTH_MAX_H	m	Depth at which constant layer thickness start	Depth at which constant layer thickness start (smaller than zmaxh/2)
DEPTH_GEOM	DEPTH_MAX_H	m	Depth at which we resume geometrical increases for temperature	Depth at which the thickness increases again for temperature.

The hydrodynamic parameters

- **K and D depend on saturated properties (measured on saturated soils) and on θ**
- Their dependance on θ is very non linear
- In ORCHIDEE, this is decribed by the so-called **Van Genuchten-Mualem relationships**:



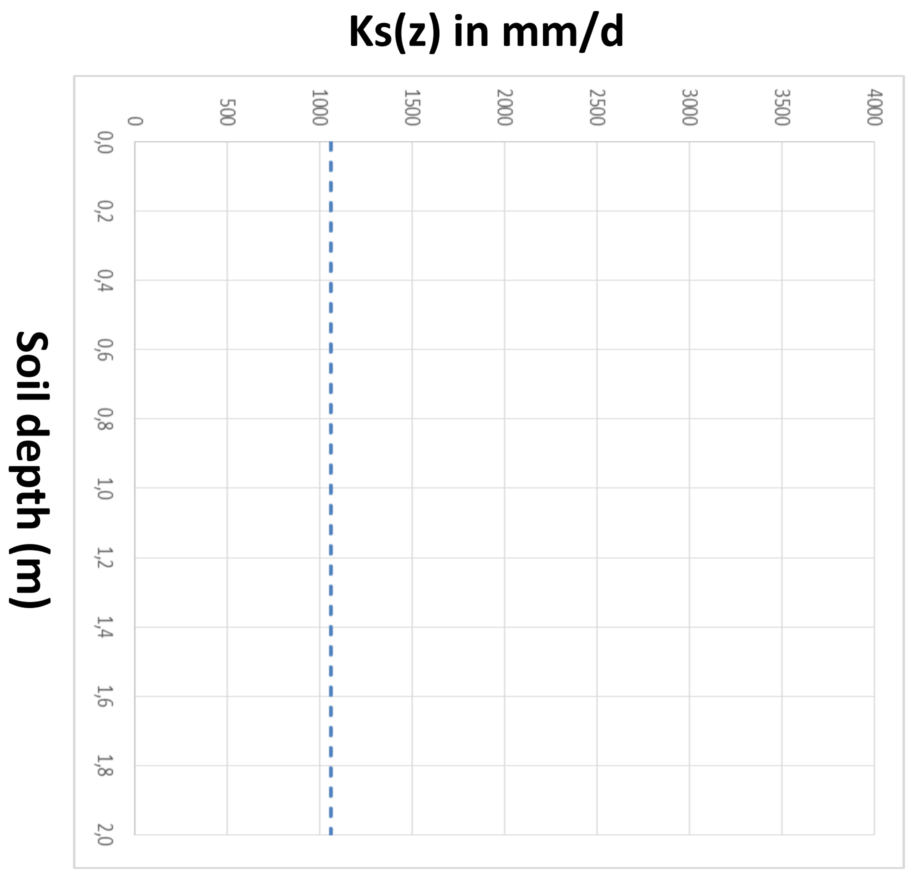
$$K(\theta) = K_s\sqrt{\theta_f}\left(1-\left(1-\theta_f^{1/m}\right)^m\right)^2 \qquad \theta_f = (\theta-\theta_r)/(\theta_s-\theta_r)$$

$$\psi(\theta) = -\frac{1}{\alpha}\left(\theta_f^{-1/m}-1\right)^{1/n} \qquad m = 1-1/n$$

$$D(\theta) = \frac{(1-m)K(\theta)}{\alpha m}\frac{1}{\theta-\theta_r}\theta_f^{-1/m}.\left(\theta_f^{-1/m}-1\right)^{-m}$$

The parameters
θ_s θ_r K_s n
$\alpha = -1/\psi_{ae}$
depend on soil texture

Modifications of Ks with depth

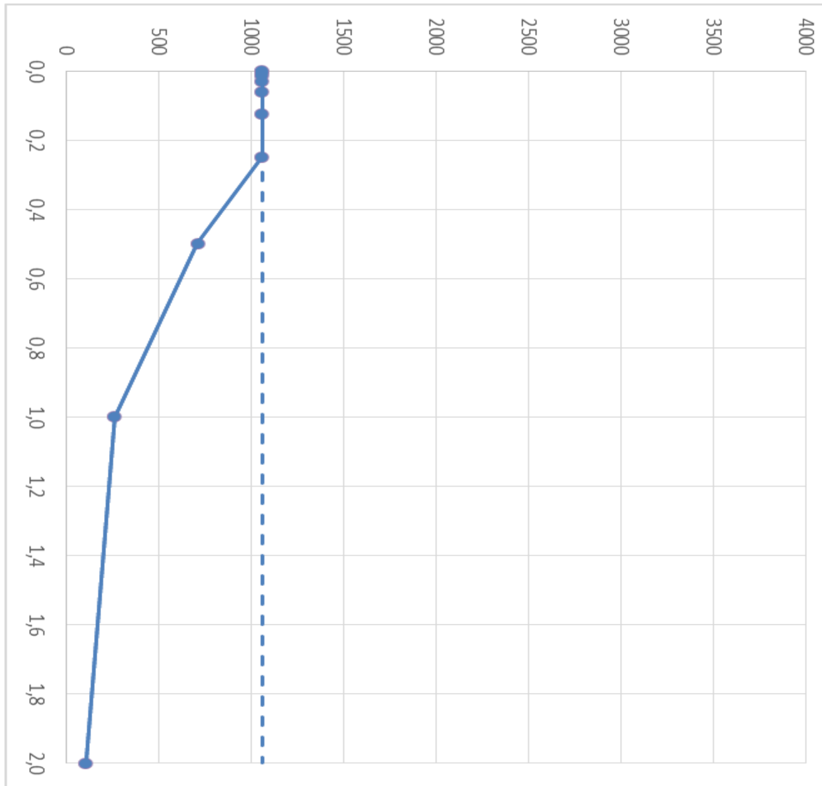


(1) K_s^{ref} is defined based on soil texture

Here 1060 mm/d for Sandy Loam [Zobler class Coarse]

Modifications of Ks with depth

Ks(z) in mm/d



(2) Ks decreases exponentially with depth below 30 cm (Compaction)

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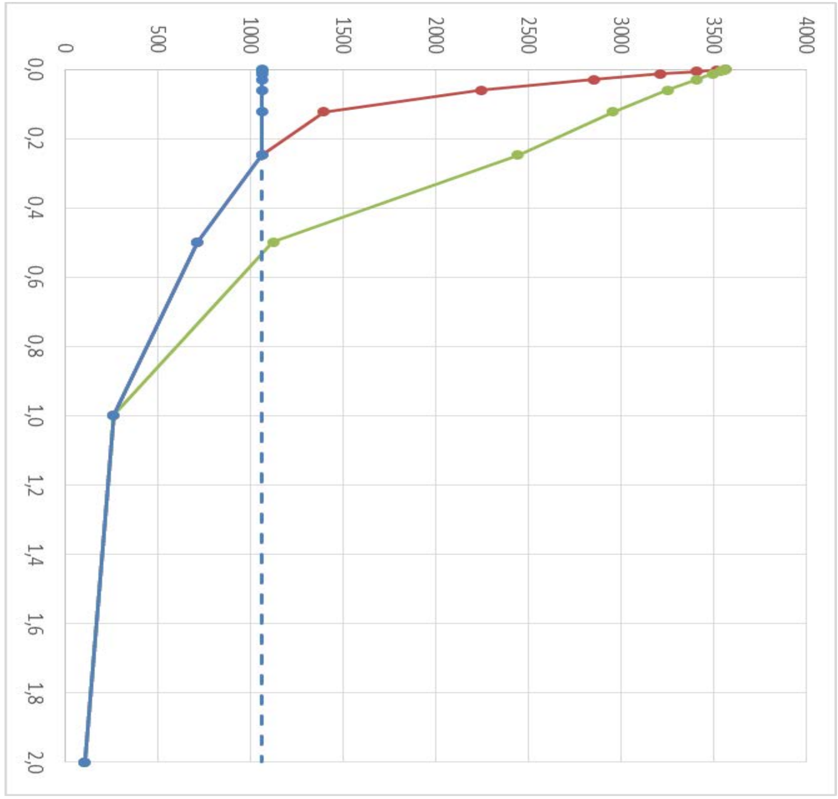

(3) Ks also increases towards the surface because of bioturbation
Orange: grass PFTs,
cj = humcste = 4
Yellow: forest PFTs,
cj = humcste = 0.8

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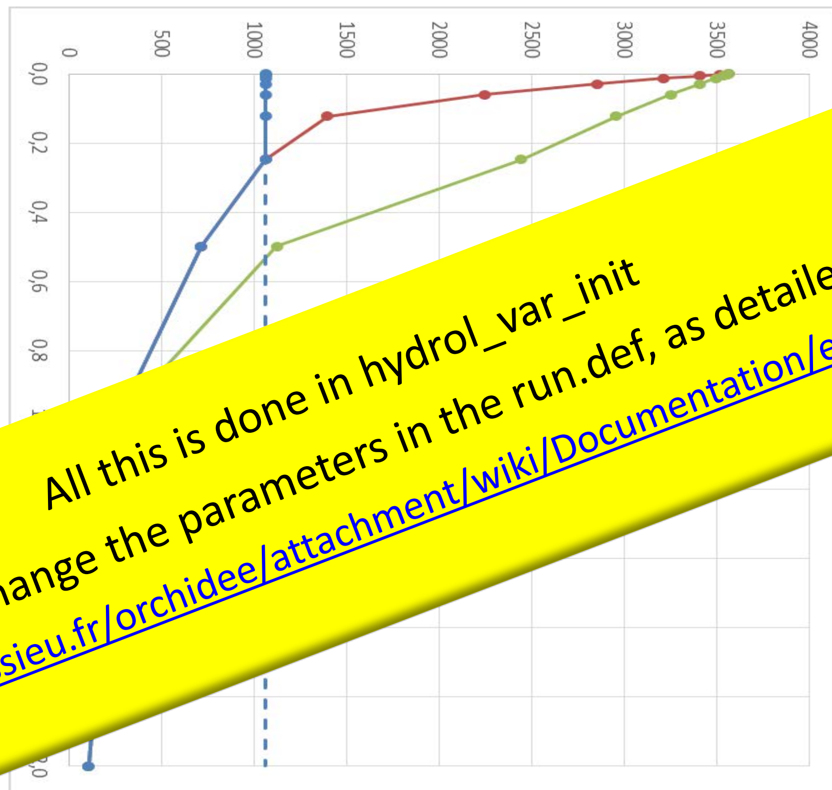
Modifications of Ks with depth

Ks(z) in mm/d



...increases
...surface
...urbation
...PFTs,
... = 4
...rest PFTs,
...j = humcste = 0.8

(2) Ks decreases exponentially with depth belo...

All this is done in hydrol_var_init

You can change the parameters in the run.def, as detailed in

http://forge.ipsl.jussieu.fr/orchidee/attachment/wiki/Documentation/eqs_hydrol.pdf

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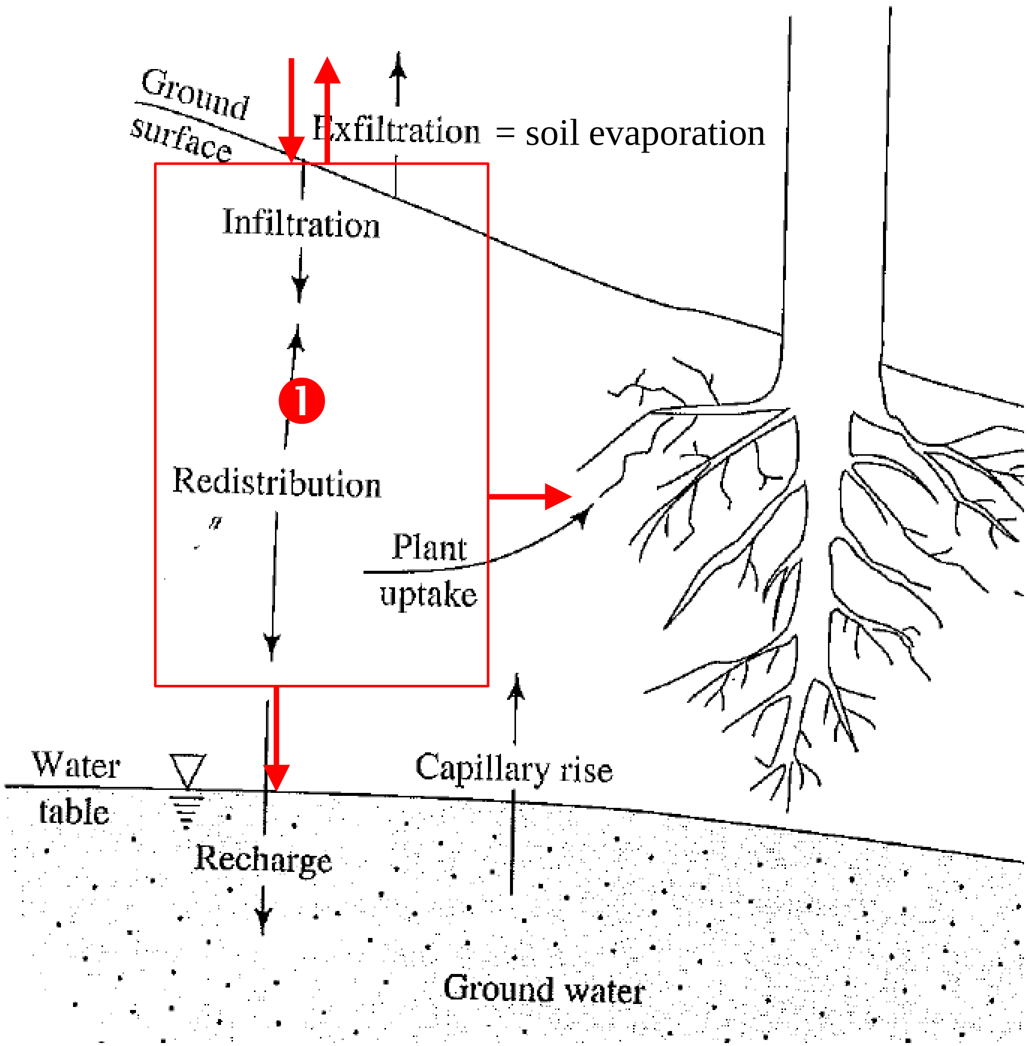
To sum up water diffusion



- **The soil is assumed to be unsaturated**
- **The prognostic variables are θi** (at the nodes)
- They are updated **simultaneously** (by solving a tridiagonal matrix)
- **Their evolution is driven by**
  - the soil properties K(z) and D(z)
  - the vertical discretization (soil depth and node position Zi)
  - four boundary fluxes

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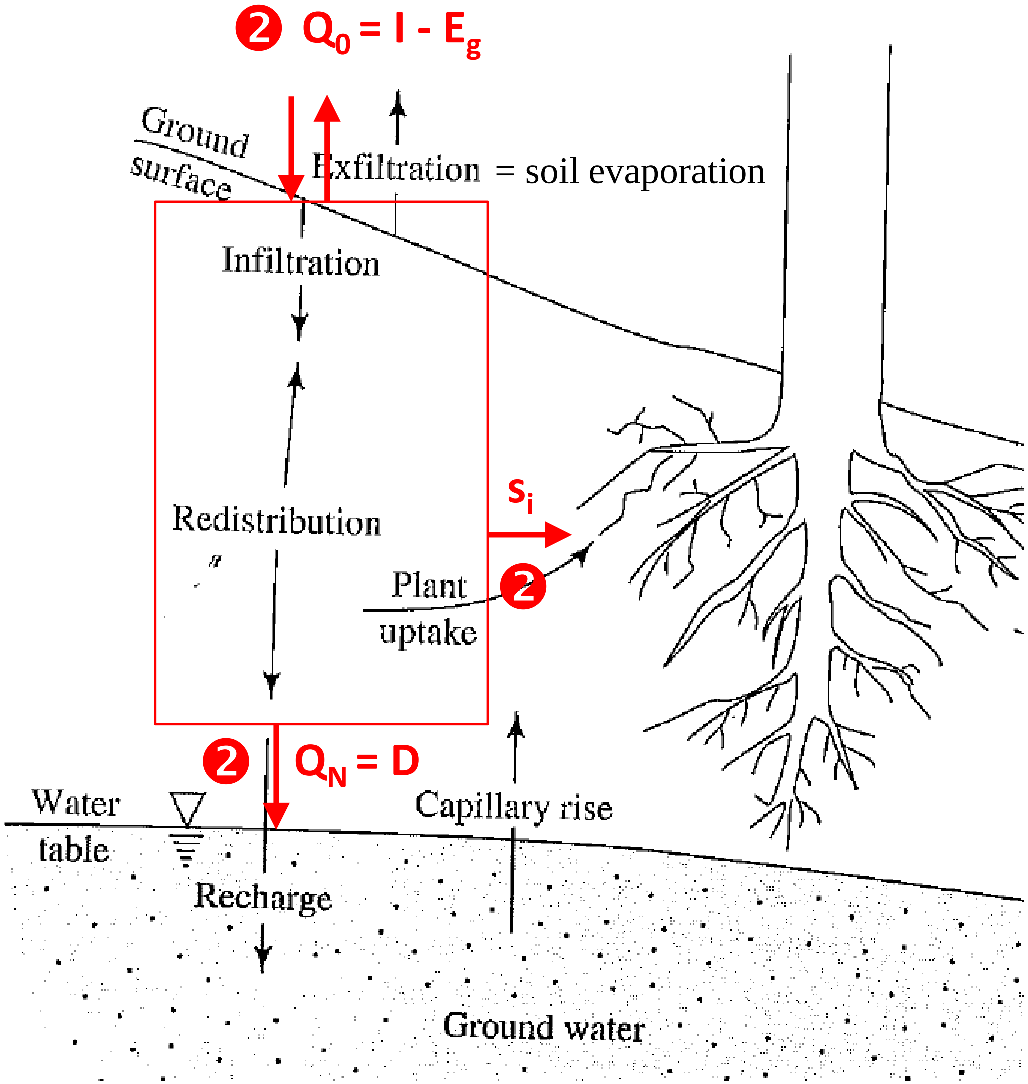

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  - the vertical discretization (soil depth and node position Zi)
  - four boundary fluxes ❷
    - **transpiration sink s_i**
    - top and bottom boundary conditions:

      $Q_0 = I - E_g$ and **$Q_N = D$**

      I: infiltration

      E_g : soil evaporation

      D: drainage

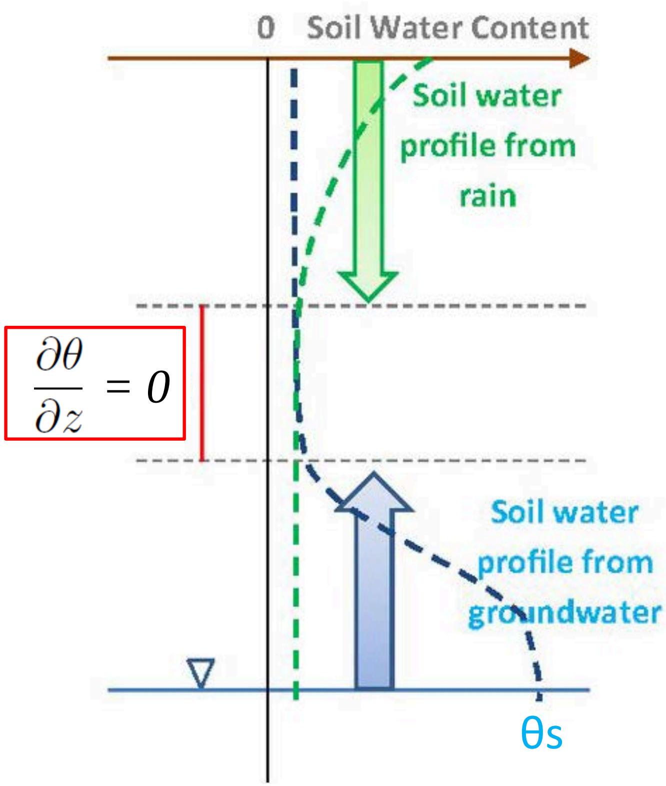
Which all depend on soil moisture

Drainage

By default : $\boxed{Q_N = K(\theta_N)}$

Based on the motion equation, this corresponds to a situation where θ does not show any vertical variations below the modeled soil

$$q(z) = -D(\theta)\frac{\partial \theta}{\partial z} + K(\theta)$$



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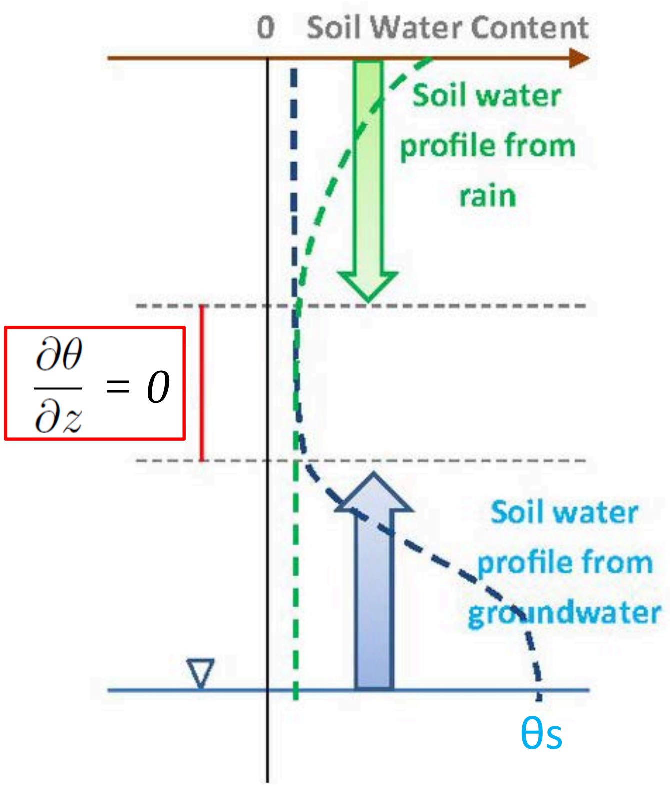

The code is also apt to use reduced drainage :

$Q_N = F.K(\theta_N)$ F in [0,1]

F is externalized by **free_drain_coef (1,1,1)**

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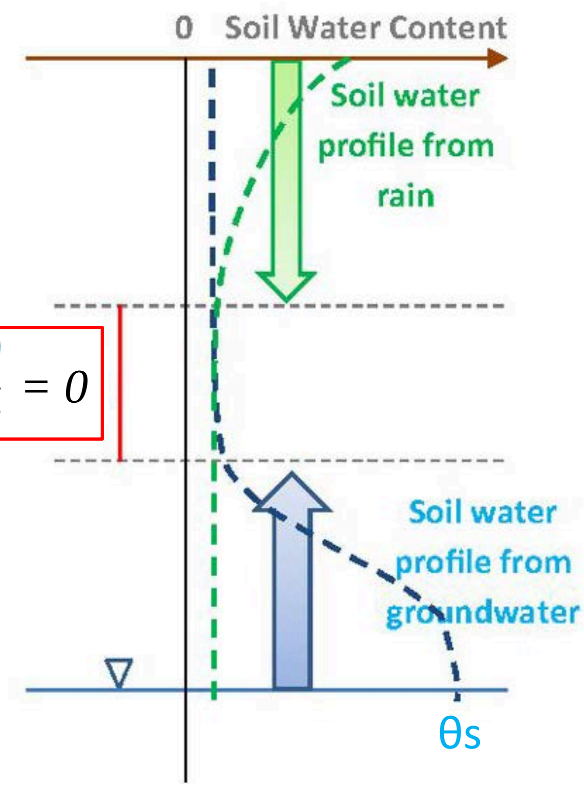

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$Q_N = F.K(\theta_N)$ F in [0,1]

F is externalized by **free_drain_coef (1,1,1)**

With F=1, you get an impermeable bottom:

- like in the Choisnel scheme
- leading to build a water table

But you need to adapt the vertical discretization!

Drainage

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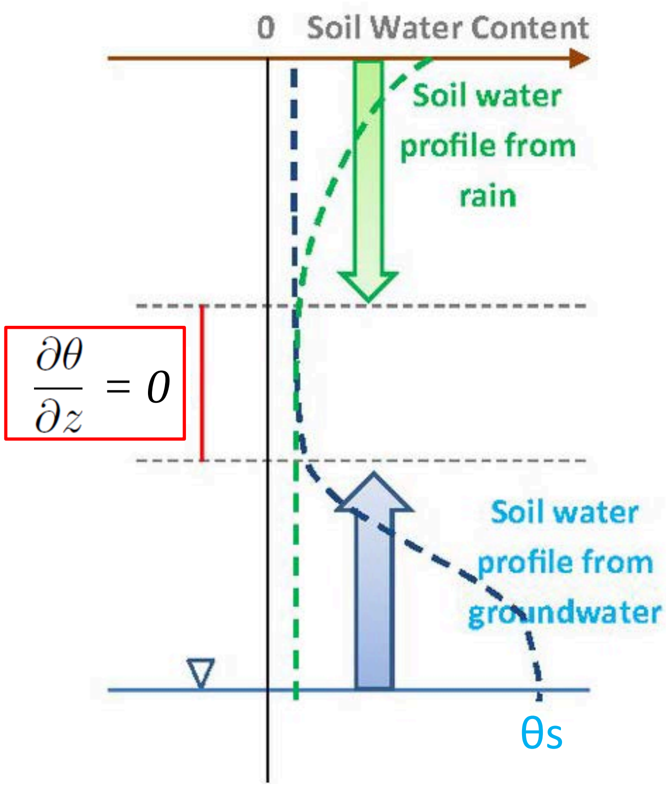
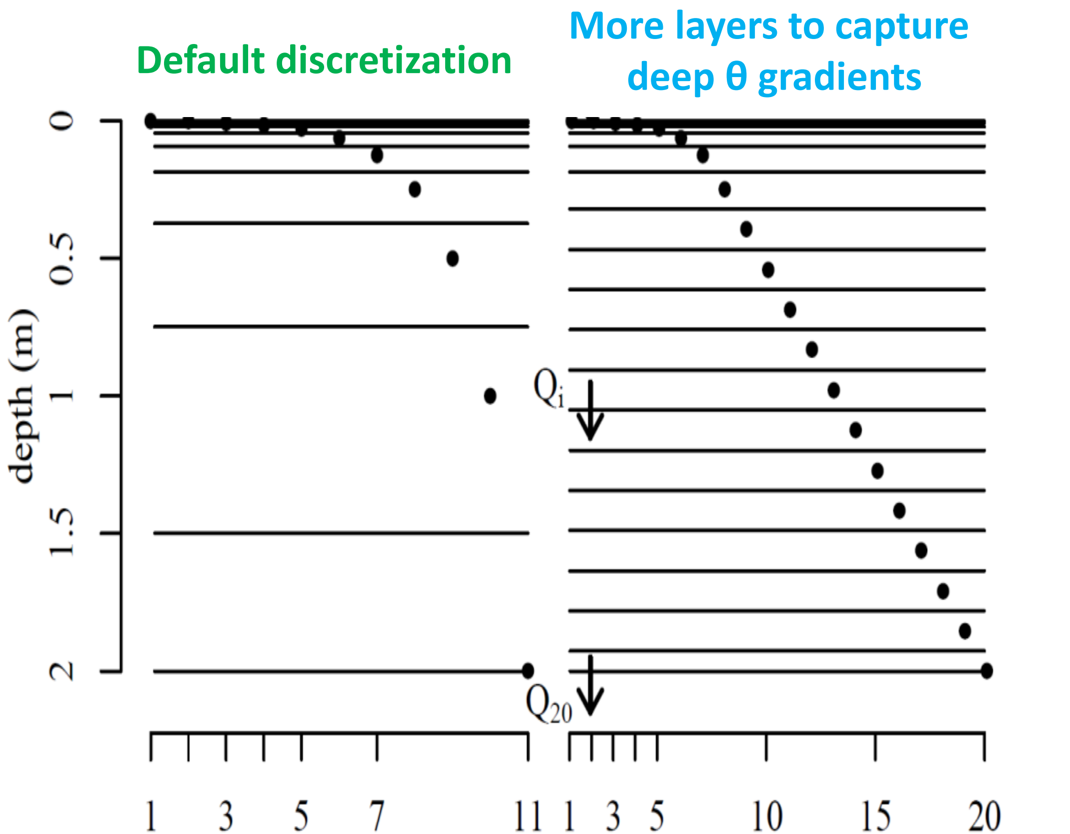




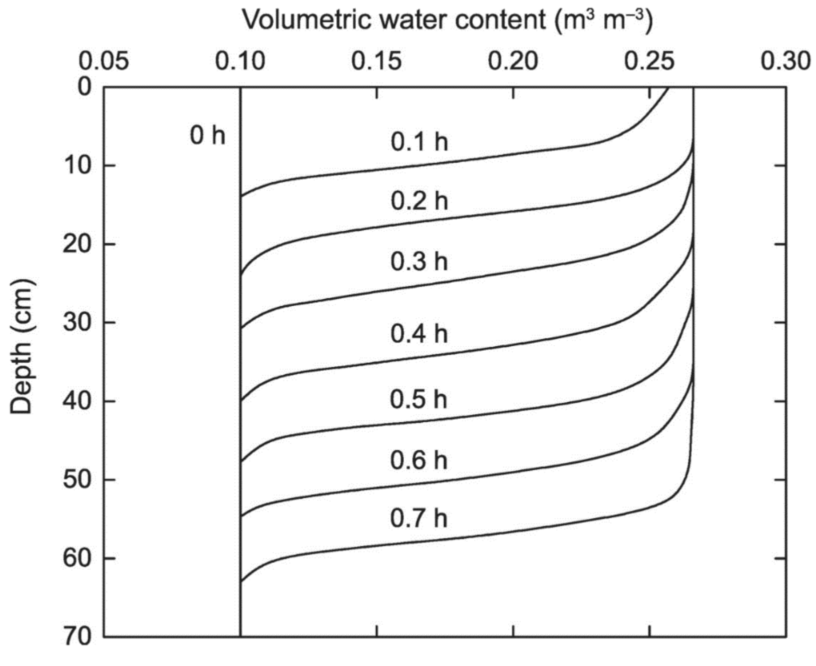
Infiltration (and surface runoff)

- At the soil surface, throughfall can either infiltrate or run off (surface runoff)
- The routing scheme can also produce water to infiltrate (return flow, irrigation, etc.)

P_0

- The modeling of infiltration relies on gravitational fluxes: $q(z) = K(\theta)$
- With **wetting front propagation based on time splitting procedure and sub-grid-variability**

Soil absorption is neglected



dt = 30 minutes in forced mode

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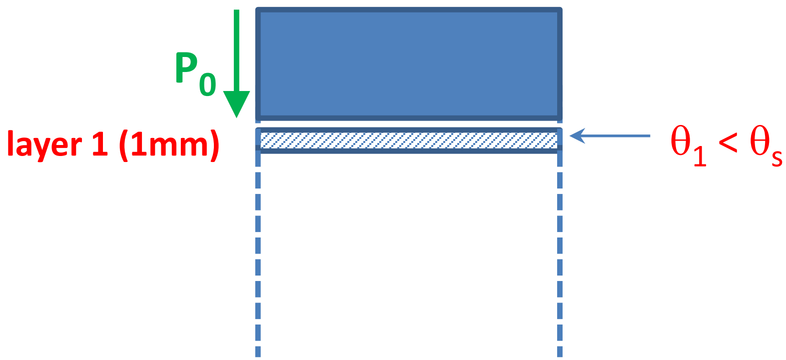
1. Direct infiltration of P_0 to the top soil layer (1-mm deep)



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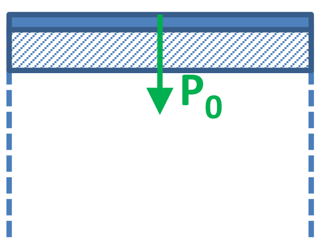
Soil absorption is neglected

1. Direct infiltration of P_0 to the top soil layer (1-mm deep)
2. If **P_0 is sufficient,** infiltration to the lowest layers

propagation to layer 2



$\theta_1 = \theta_s$; immediate saturation (t_1=0)

$\theta_2 < \theta_s$; $K_{pot}(2) = [K_s(2) + K(\theta_2)]/2$

Reduction from K_{pot} to K_{eff} because subgrid variability

$$K_{eff}(2) = K_{pot}(2)\ [\ 1 - \exp(\ -P_0/\ K_{pot}(2)\ )\ ]$$

$$R_s(2) = P_0 - K_{eff}(2)$$

θ_2 increased up to θ_s

$$t_2 = h_2\ (\theta_s - \theta_2)\ /\ K_{eff}(2)$$

We consider an exponential distribution of K with a mean of K_{pot}
- K_{eff} is the mean of K values < P_0
- Runoff production where P_0 > K

Infiltration (and surface runoff)

- At the soil surface, throughfall can either infiltrate or run off (surface runoff)
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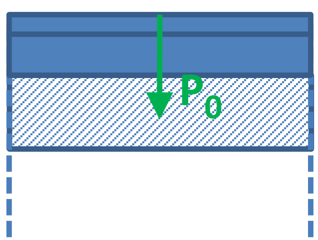
$\Big\}\ P_0$

- The modeling of infiltration relies on gravitational fluxes: $q(z) = K(\theta)$
- With **wetting front propagation based on time splitting procedure and sub-grid-variability**

Soil absorption is neglected

1. Direct infiltration of P_0 to the top soil layer (1-mm deep)
2. If **P_0 is sufficient,** infiltration to the lowest layers

propagation to layer 3



$\theta_2 = \theta_s$

$\theta_3 < \theta_s$; $K_{pot}(3) = [K_s(3) + K(\theta_3)]/2$

Reduction from K_{pot} to K_{eff} because subgrid variability

$$K_{eff}(3) = K_{pot}(3)\ [\ 1 - \exp(\ -P_0 / K_{pot}(3)\ )\ ]$$

$$R_s(3) = P_0 - K_{eff}(3)$$

θ_3 updated up to θ_s

$$t_3 = h_3\ (\theta_s - \theta_3)\ /\ K_{eff}(3)$$

We consider an exponential distribution of K with a mean of K_{pot}
- K_{eff} is the mean of K values < P_0
- Runoff production where P_0 > K

Infiltration (and surface runoff)

- At the soil surface, throughfall can either infiltrate or run off (surface runoff)
- The routing scheme can also produce water to infiltrate (return flow, irrigation, etc.)

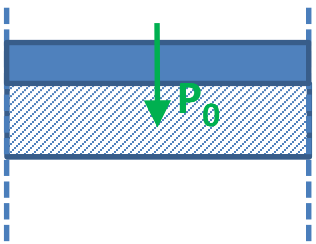
$\Big\}\ P_0$

- The modeling of infiltration relies on gravitational fluxes: $q(z) = K(\theta)$
- With **wetting front propagation based on time splitting procedure and sub-grid-variability**

Soil absorption is neglected

1. Direct infiltration of P_0 to the top soil layer (1-mm deep)
2. If **P_0 is sufficient,** infiltration to the lowest layers

propagation to layer i



$\theta_{i-1} = \theta_s$

$\theta_i < \theta_s$; $K_{pot}(i) = [K_s(i) + K(\theta_i)]/2$

$\mathbf{K_{eff}(i) = K_{pot}(i)\ [\ 1 - \exp(\ -P_0 / K_{pot}(i)\ )\ ]}$

$\mathbf{R_s(i) = P_0 - K_{eff}(i)}$

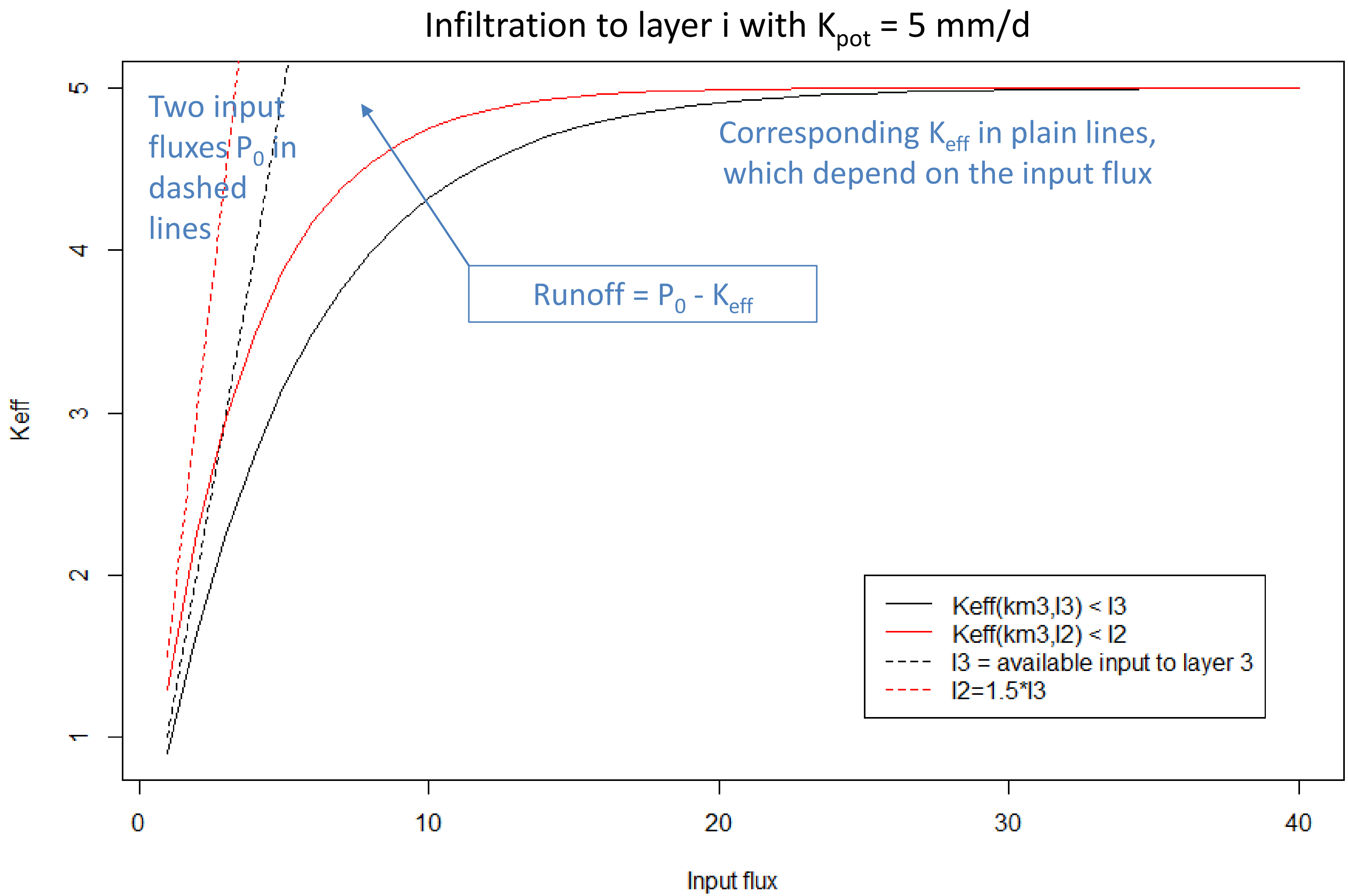
θ_3 increased up to θ_s

$t_3 = h_3\ (\theta_s - \theta_3) / K_{eff}(3)$

Loop on layers i until P_1 fully processed or $\Sigma t_i = dt$

$\mathbf{R_s^{pot} = \Sigma\ R_s(i)}$

Infiltration (and surface runoff)



Infiltration (and surface runoff)

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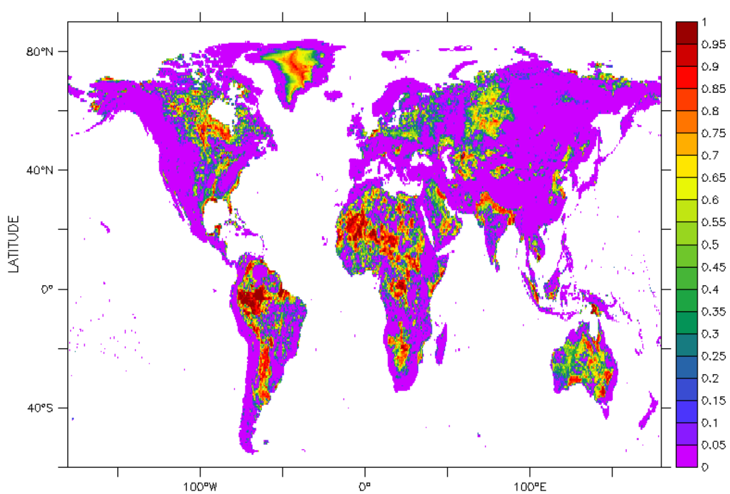
P_0

- The modeling of infiltration relies on gravitational fluxes: $q(z) = K(\theta)$
- With **wetting front propagation based on time splitting procedure and sub-grid-variability**

Soil absorption is neglected

1. Direct infiltration of P_0 to the top soil layer (1-mm deep)
2. If **P_0 is sufficient,** infiltration to the lowest layers
3. Possible **reinfiltration** of surface runoff in flat areas (ponding)

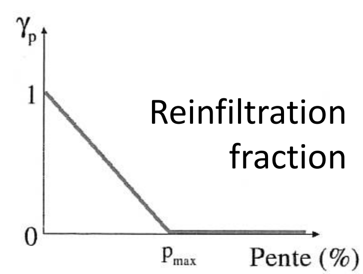


Reinfiltration fraction

$R_s^{pot} = \Sigma R_s(i) = P_0 - \Sigma I_i$

$\gamma_p R_s^{pot} \rightarrow P_0^{t+dt}$

$R_s = (1-\gamma_p) R_s^{pot}$



In the code :
γ_p = reinf_slope
p_{max} = 0.5%

Soil evaporation (E_g)

1. The soil evaporation involved in the surface boundary flux ($Q_0 = I - E_g$) is given by the energy budget
2. **The issue in hydrol is to calculate the stress function β_g** to calculate soil evaporation at the next time step
3. **This is done by a supply/demand approach** based on the soil moisture at the end of the time step
4. **Supply/demand: E_g can proceed at potential rate unless this dries the soil out**

$$\boxed{E_g = \min(E^*_{\mathrm{pot}}, Q_{\mathrm{up}})}$$

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$$\boxed{E_g = \min(E^*_{\mathrm{pot}}, Q_{\mathrm{up}})}$$

$$E^*_{\mathrm{pot}} = \frac{\rho}{r_a}\left(q_{\mathrm{sat}}(T_w) - q_{\mathrm{a}}\right) < E_{\mathrm{pot}} = \frac{\rho}{r_a}\left(q_{\mathrm{sat}}(T_s) - q_{\mathrm{a}}\right)$$

$$\beta_g = E_g / E_{\mathrm{pot}}$$

Q_{up} is calculated by 1 or 2 dummy integrations of the water diffusion,

(a) We apply E^*_{pot} as a boundary flux at the top, and test if θ_i remains above θ_r
If it does, then $Q_{up} = E^*_{pot} = E_g$

(b) Else, we force $\theta_1 = \theta_r$ and this drives an upward flux: the surface value Q_0 gives Q_{up}

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4. **Supply/demand: E_g can proceed at potential rate unless this dries the soil out**
5. **Since r3975, we can reduce the demand using a soil resistance (Sellers et al., 1992)**

In run.def :
DO_ROIL = y
(default = n)

$$r_{\text{soil}} = \exp(8.206 - 4.255 L/L_s)$$

L is the soil moisture in the 4 top layers
Ls is the equivalent at saturation

$$\boxed{E_g = \min\left(\frac{q_{sat}(T_W) - q_a}{r_a + \boldsymbol{r_{soil}}}, Q_{up}\right)}$$

The minimum is still found via 1 or 2 dummy integrations of the water diffusion

The transpiration sink

The dependance of transpiration on soil moisture is conveyed by $u_s(i)$

$u_s(1)=0$

$u_s(i>1) = n_{root}(i) \cdot F_w(i)$

$F_w(i) = \max(0,\min(1, (W_i-W_w)/(W_\%-W_w)))$

n_{root} : mean root density in layer i

$n_{root} = \int_{hi} R(z)dz \,/\, \int_{htot} R(z)dz$

$R(z) = \exp(-c_j z)$

c_j depends on the PFT

W_w = wilting point

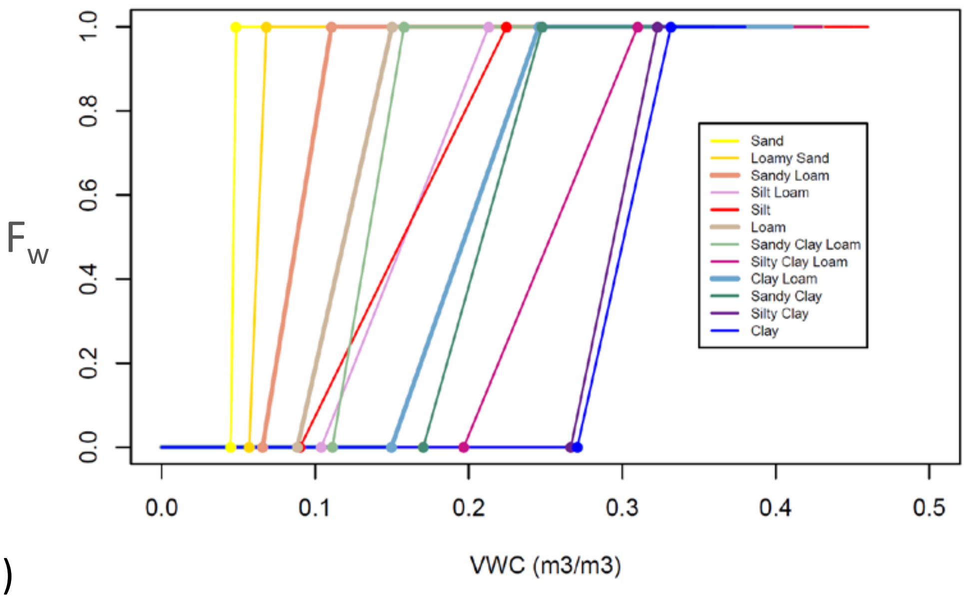
W_f = field capacity

$AWC = W_f - W_w$

$W_\%$: moisture at which us becomes 1 (no stress)

$W_\% = W_w + p_\% AWC$

In contantes_mtc.f90:
c_j = humcste
In constantes_soil.f90:
$p_\%$ = pcent = (/ 0.8, 0.8, 0.8 /)



The transpiration sink

The dependance of transpiration on soil moisture is conveyed by $u_s(i)$

$$T_r = \rho \left(1 - \frac{I}{I_{max}}\right) \frac{q_{sat}(T_s) - q_{air}}{r_a + r_c + r_{st}}$$

❶ $U_s = \Sigma_i u_s$ is used to calculate the stomatal resistance r_{st}

r_c also depends on light, CO_2, LAI, air temperature and vpd, and nitrogen limitation in the new trunk (CN)

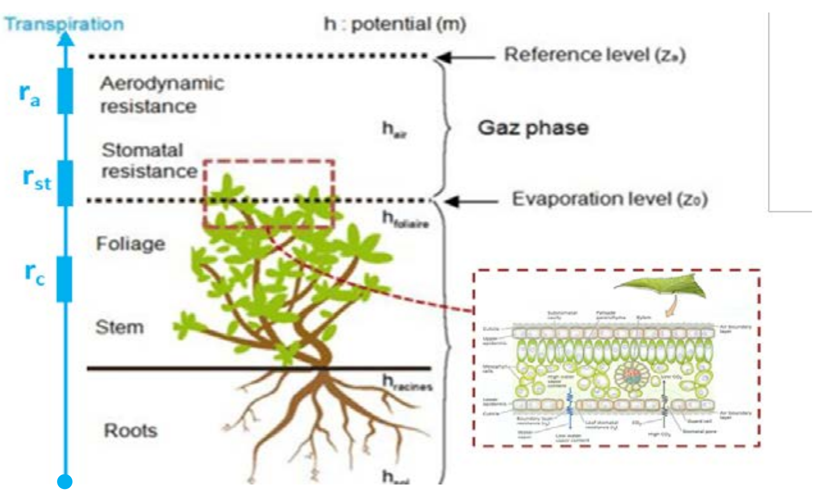
In the code :
U_s = humrel

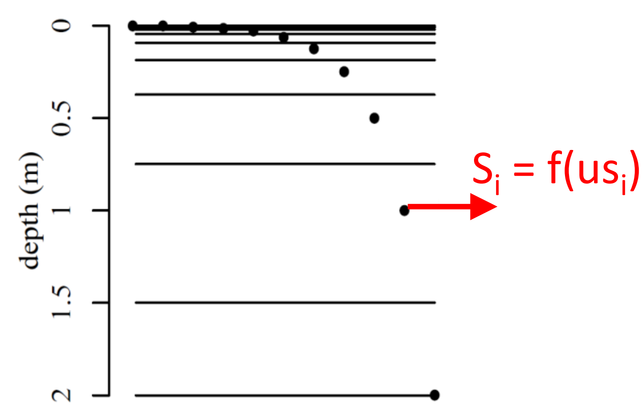
❷ u_s is used to distribute Tr between the soil layers

$$T_r = \Sigma S_i$$

$$U_s = \Sigma us_i$$

$$S_i = T_r \, us_i / U_s$$





New diagnostics

- **TWBR = Total water budget residu** (in kg/m²/s) to check water conservation

TWBR = dS/dt – (P – E – R)

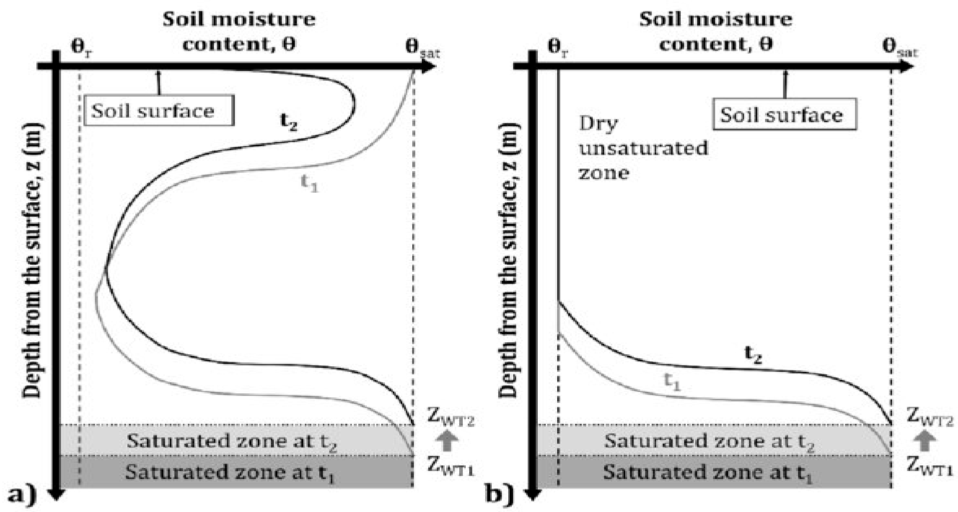
S includes intercepted water and snow

Typical values are < 10^{-5} mm/d or less

- **wtd = water table depth** (m), defined in each soiltile as the depth of deepest saturated node overlaid by an unsaturated node.

  Sought from the soil bottom: if a part of the soil is saturated but underlaid with unsaturated nodes, it is not considered as a water table.

  If the bottom node is not saturated, the water table depth is set to undef.



Which maps are used for soil hydrology?

ORCHIDEE
LAND SURFACE MODEL

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wiki: Documentation / Ancillary

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Development Activities | Documentation | Source Code | Reference Simulations | Group Activities

Ancillary Data

This page describes the Ancillary data needed to describe the continental surfaces in ORCHIDEE. All the files are expected to be in a CF-compliant NetCDF format and some guidelines for producing these files are given at the end.

The most common forcing files are stored in the shared accounts in IGCM/SRF directory. The shared accounts are found:

- At TGCC: /ccc/work/cont003/dsm/p86ipsl/IGCM
- At IDRIS:
  - On the ada machine: /workgpfs/rech/psl/rpsl035/IGCM
  - On the ergon machine: /u/rech/psl/rpsl035/IGCM
- LSCE, obelix : /home/orchideeshare/igcmg/IGCM
- IPSL Ciclad : /prodigfs/ipslfs/igcmg/IGCM
- At the web by DODS : http://dods.ipsl.jussieu.fr/igcmg/IGCM

1. Vegetation information

ORCHIDEE model can read vegetation map based on Olson categories or on PFT categories. When a PFT map is used as an input, the parameter **land_use** in the .def file should be set to TRUE, else to FALSE.

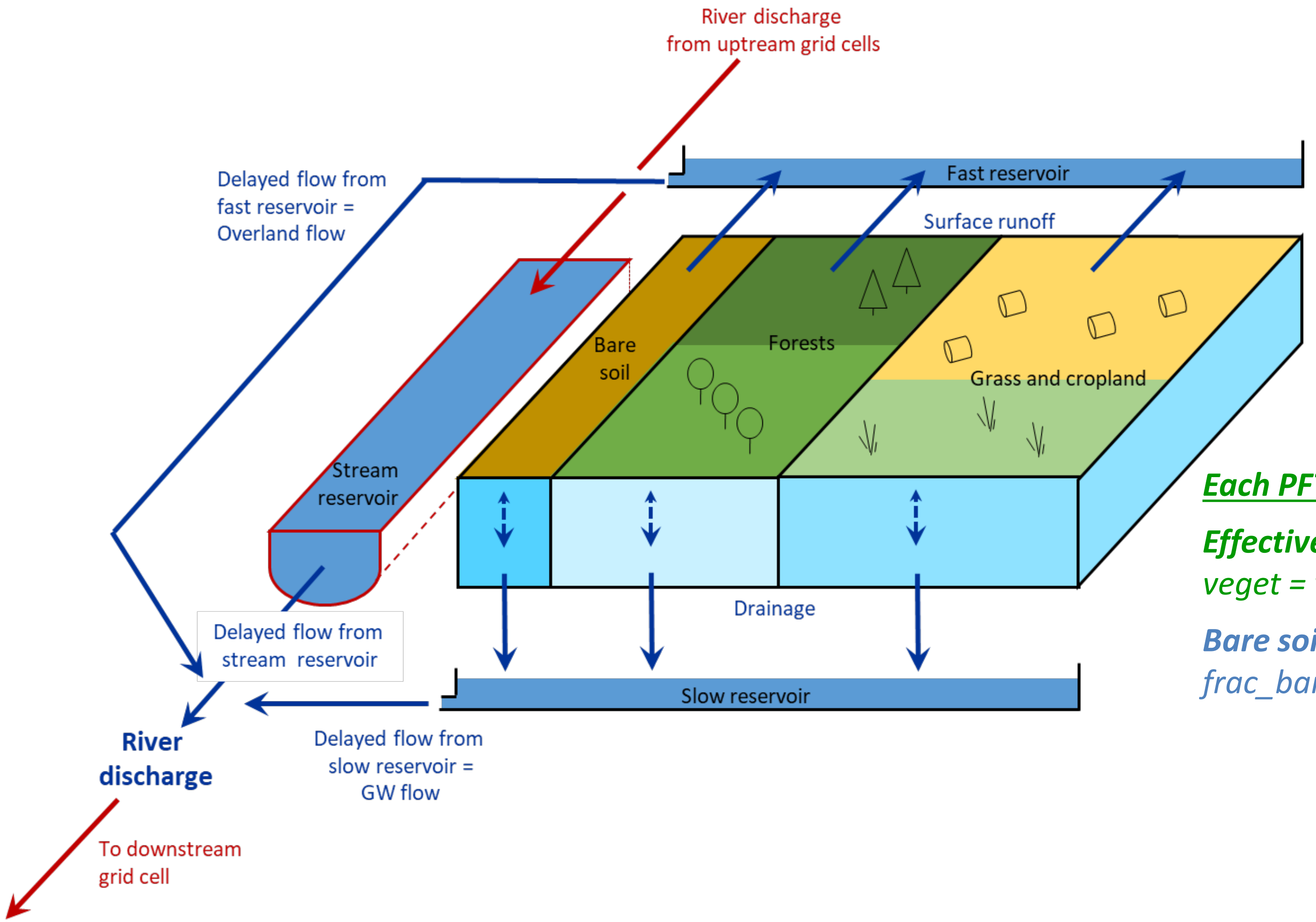
1.1 Olson map

A map at 5km resolution on a Goode homolosine projection with the dominant Olson class has been generated by Nicolas Viovy based on a 1km IGBP map. The map is available on the common repository of ORCHIDEE forcing files on CCRT, IDRIS and other platforms. It is also available here. This map contains 94 land categories. The conversion from Olson to PFT categories is done within the code of ORCHIDEE. Up to the version 1.9.5.2, there was a bug when converting Olson category 79 (warm C4 woody savanna). It was distributed into tropical broad-leaved raingreen (40%) and C3 grass (40%) while it should have been tropical broad-leaved raingreen (40%) and **C4** grass (40%). This bug has been fixed in the version 1.9.6.

1.2 PFT maps

Interactions with the vegetation/LC

1. Horizontally, PFTs define soil tiles with independent water budget (below ground tiling)



Each PFT with

Effective vegetation fraction (Tr & IL)

veget = veget_max (1 - exp(- LAI))

Bare soil fraction (Eg)

*frac_bare = veget_max * exp(- LAI)*

LAI

Interactions with the vegetation/LC

2. Vertically, ORCHIDEE defines a root density profile

In each PFT j $R_j(z) = \exp(-c_j\, z)$

In each soil layer i $n_{root}(i)$ is the mean root density with $\Sigma_i n_{root}(i) = 1$

↓

It controls:

(1) the water stress on transpiration in each soil layer i

$$u_i = n_{\mathrm{root}}(i)\max(0, \min(1, (W_i - W_w)/(W_\% - W_w)))$$

(2) the increase of Ks towards the surface

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It controls:

(1) the water stress on transpiration in each soil layer i

$$u_i = n_{\mathrm{root}}(i)\max(0,\min(1,(W_i - W_w)/(W_\% - W_w)))$$

(2) the increase of Ks towards the surface

In the code, c_j is called humcste and defined in constantes_mtc.f90

It can be « externalized », with default values depending on soil hydrology/depth

```
REAL(r_std), PARAMETER, DIMENSION(nvmc) :: humcste_cwrr  = &
 & (/ 5.0,   0.8,   0.8,   1.0,   0.8,   0.8,   1.0, &
 &    1.0,   0.8,   4.0,   4.0,   4.0,   4.0 /)
!! Values for dpu_max = 2.0
```

The role of soil texture

- **In hydrol, the main soil properties are:** θ_s θ_r K_s^{ref} n α $(= -1/\psi_{ae})$ θ_w θ_f
- clay_fraction is a parameter for stomate
- They are defined based on soil texture

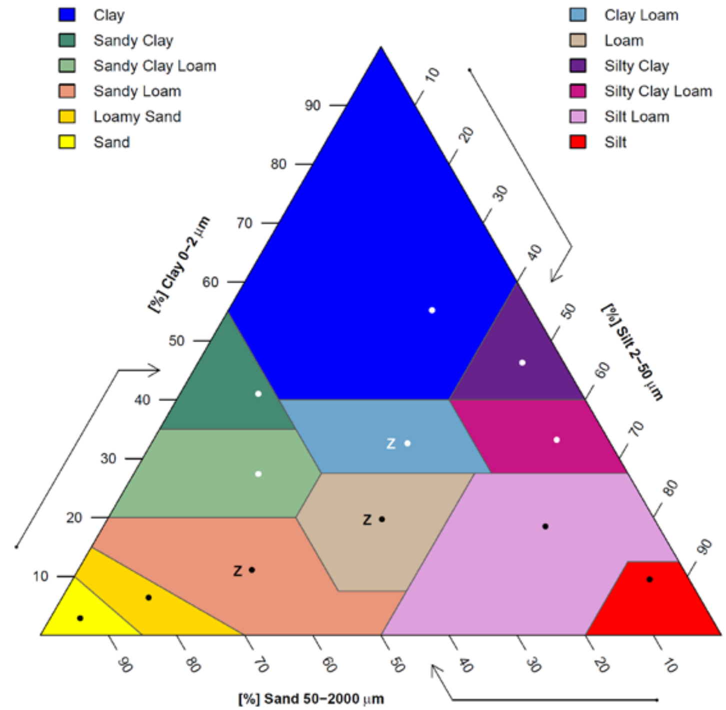
(in the real world, they can depend on other factors, as soil structure, OMC, etc.)

- **Soil texture is defined by the % of sand, silt, clay particles in a soil sample** (granulometric composition)
- **Soil texture can be summarized by soil textural classes**

- By default, ORCHIDEE reads texture from the 1°x1° map of Zobler (1986) **with 3 USDA classes:** Sandy Loam , Loam , Clay Loam

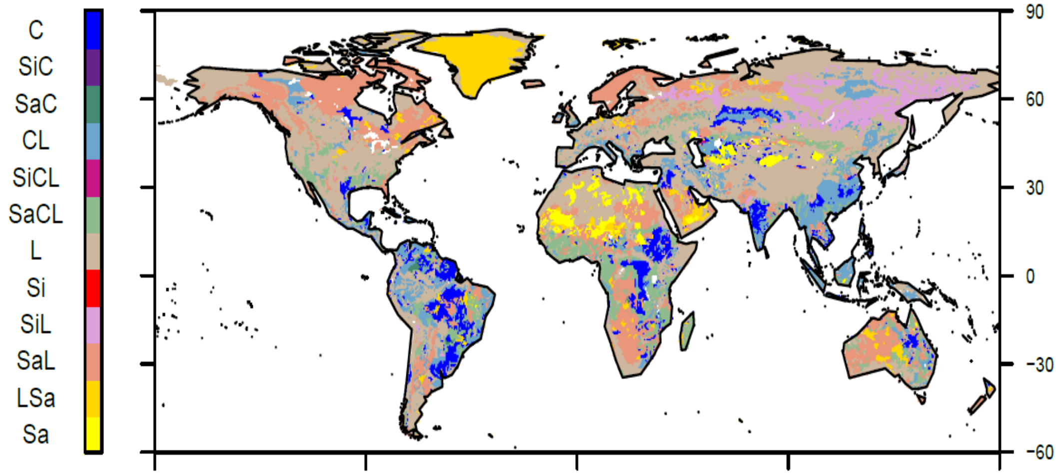
- Alternative soil map: 1/12° USDA map of Reynolds et al. (2000) **with 12 USDA classes**

- **In each grid-cell, we use the dominant texture**

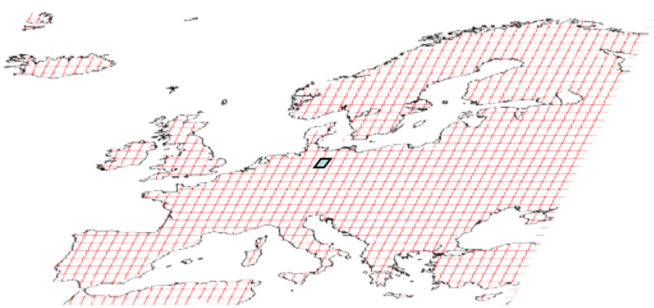


The role of soil texture

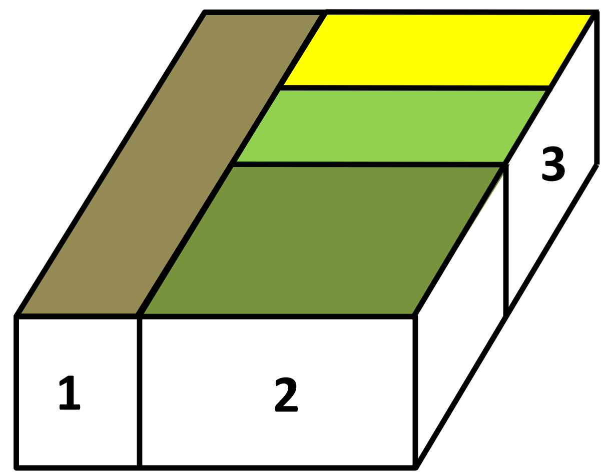
5’ soil texture map of Reynolds et al. (2000)



Dominant texture in each ORCHIDEE grid-cell:
defining the hydraulic properties



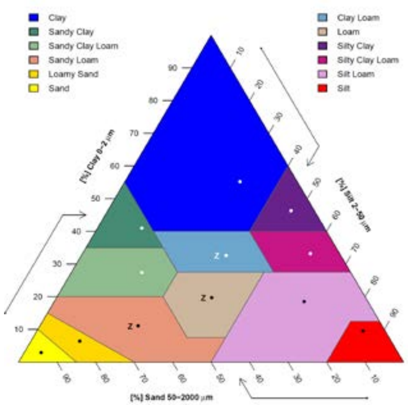
Sub-grid scale heterogenity:
3 soil columns based on PFTs
with independent water budget
but same texture

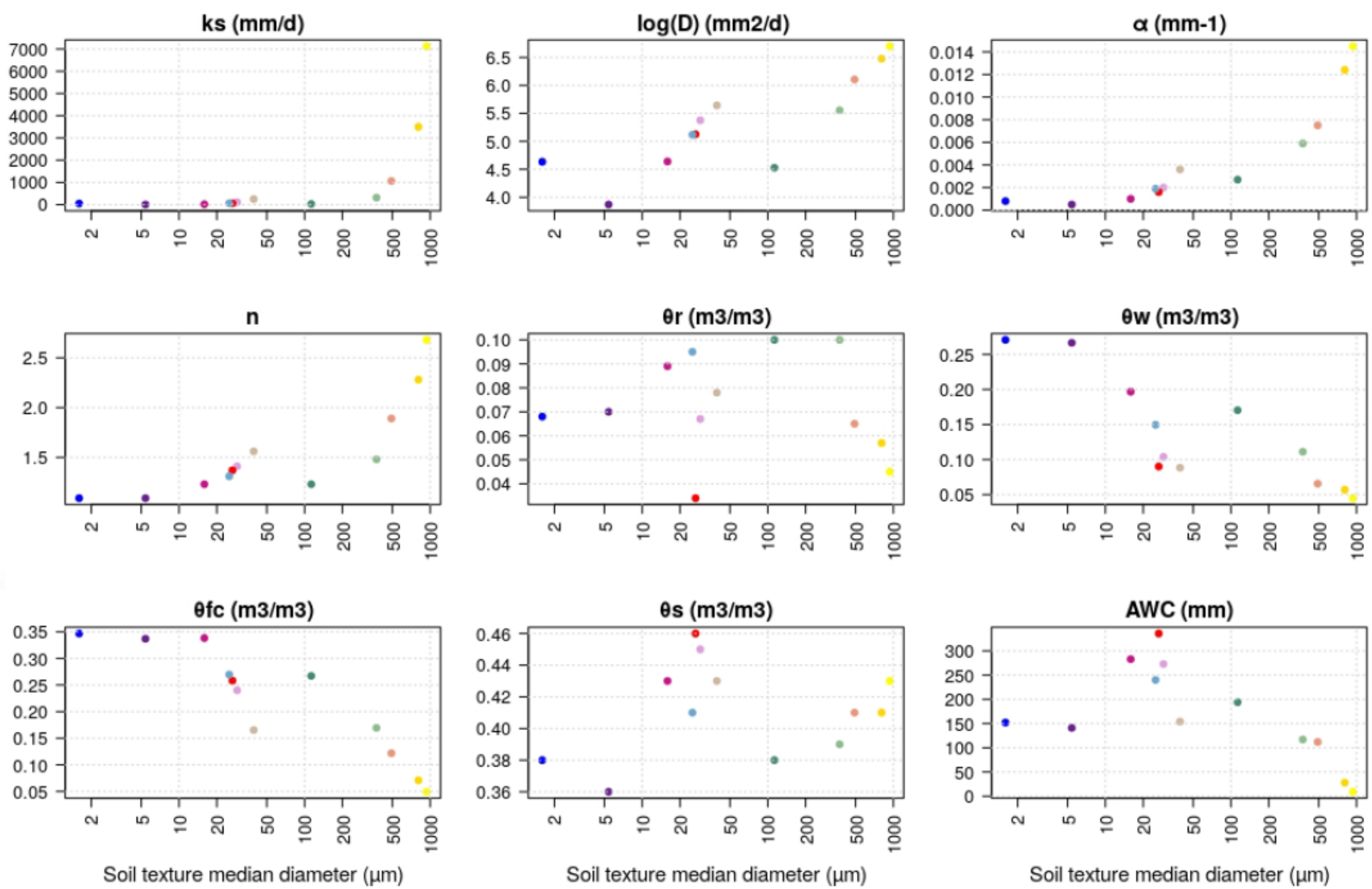


1: Bare soil PFT
2: All Forest PFTs
3: All grassland and cropland PFTs

The role of soil texture

- **In hydrol, the main soil properties are:** θ_s θ_r K_s^{ref} m $\alpha=1/\psi_{ae}$ θ_w θ_f
- **They are defined based on soil texture**





The role of soil texture

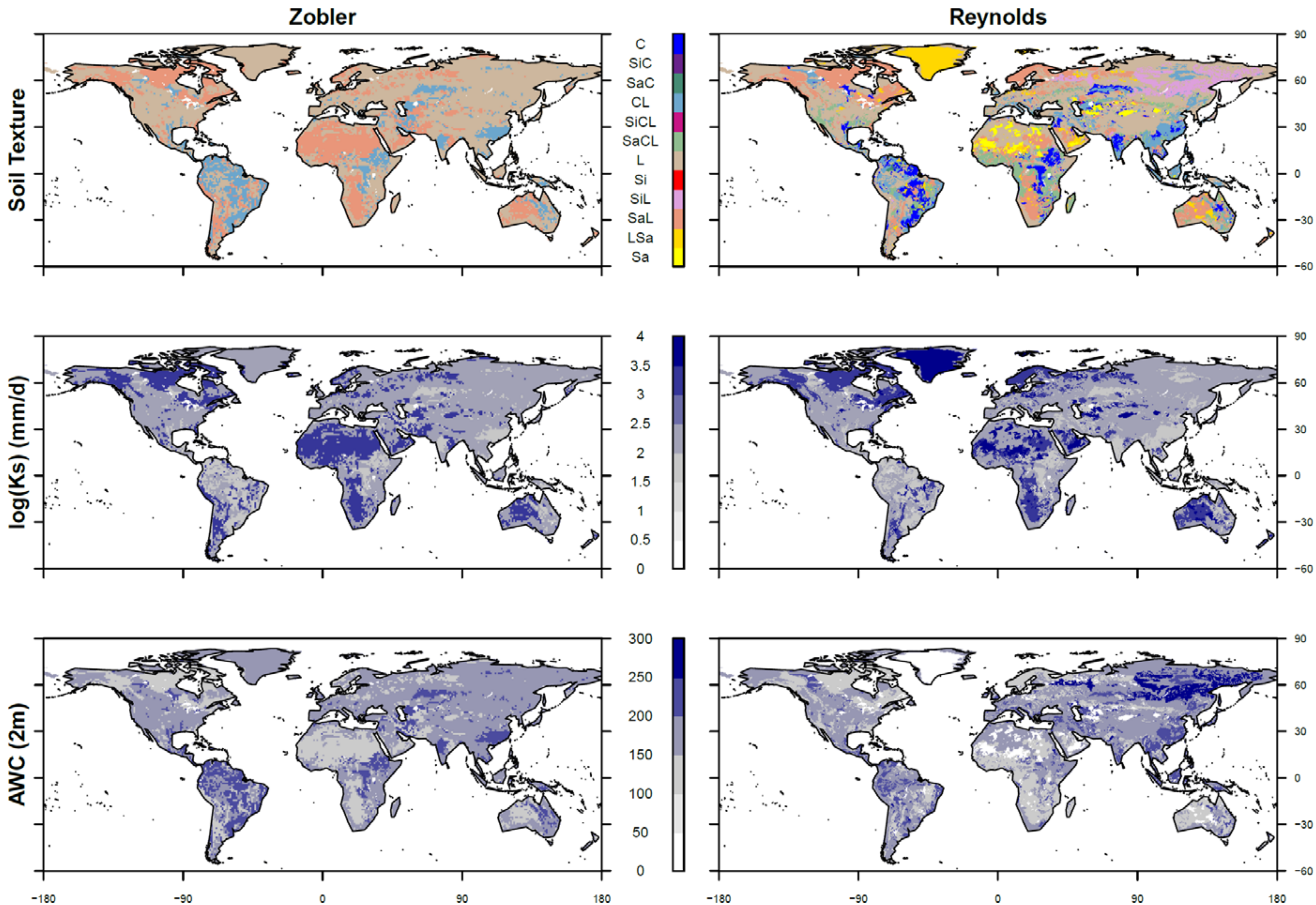
- **In hydrol, the main soil properties are:** θ_s θ_r K_s^{ref} m $\alpha=1/\psi_{ae}$ θ_w θ_f
- **They are defined based on soil texture**

Three ways of defining soil texture in run.def

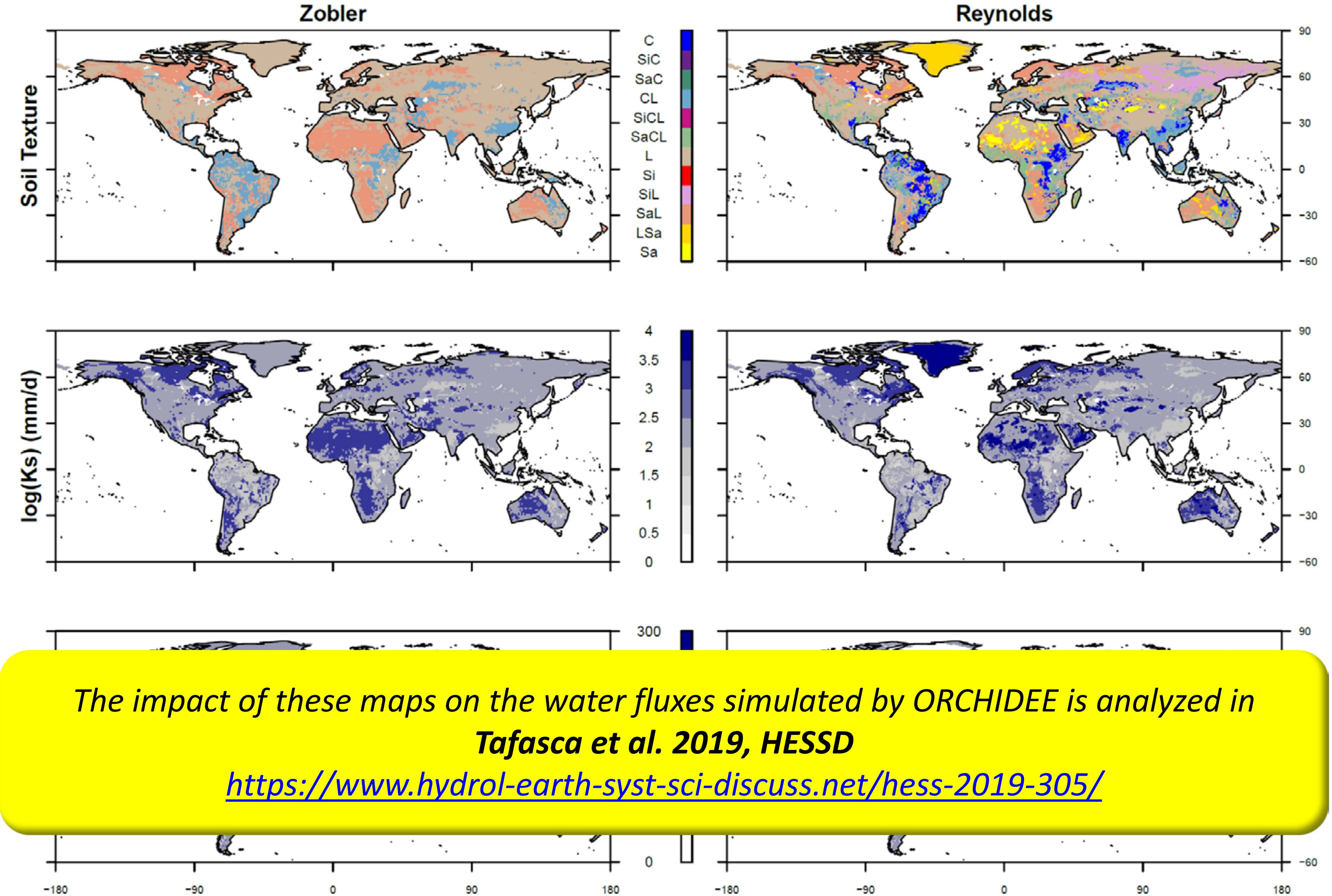
1. **Default keywords: SOILTYPE_CLASSIF = zobler; SOILCLASS_FILE = soils_param.nc**
2. **For Reynolds : SOILTYPE_CLASSIF = usda ; SOILCLASS_FILE = soils_param_usda.nc**
3. IMPVEG=y, IMPSOIL=y, SOIL_FRACTION = (x,y,z, etc.)

→ x,y,z <u>are</u> areal fraction allocated to the soil textural classes defined by your selected map
→ x,y,z <u>are not</u> % sand, silt, clay defining your soil's texture, despite the fact that this option is primarily intended for 0D simulations
→ to get the soil properties of one texture class, set SOIL_FRACTION = (1,0,0, …0…), and use the externalization to redefine the 1st value of the vectors defining soil properties

The role of soil texture



The role of soil texture



The impact of these maps on the water fluxes simulated by ORCHIDEE is analyzed in
Tafasca et al. 2019, HESSD
[*https://www.hydrol-earth-syst-sci-discuss.net/hess-2019-305/*](https://www.hydrol-earth-syst-sci-discuss.net/hess-2019-305/)

Soil hydrology in a nutshell

- **During a time step, the soil hydrology scheme :**
  - Updates the soil moisture
  - Calculates the related fluxes (infiltration, surface runoff, drainage)
  - Calculates the water stresses for transpiration and soil evaporation of the next time step
  - Calculates some soil moisture metrics for thermosoil and stomate

- **The equations can be complex, but the parametrization is intended to work without intervention**
  - Default input maps are defined in COMP/sechiba.card
  - Defaults parameters are defined in PARAM/run.def and code
  - Lot of debugging over the past years

- **You can adapt the behavior of the scheme:**
  - Easy : change externalised parameters in PARAM/run.def
  - A bit less easy: use different input maps (you need to comply to the format)
  - More difficult: change the code (welcome to orchidee-dev!)

Thank you for your attention
Questions ?

ORCHIDEE
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