ORCHIDEE Training course – January 2022

# Land surface hydrology in ORCHIDEE

**Agnès Ducharne**
UMR METIS, UPMC
agnes.ducharne@upmc.fr

# Outline

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

**How to parameterize your simulations**

**More details on the Wiki**

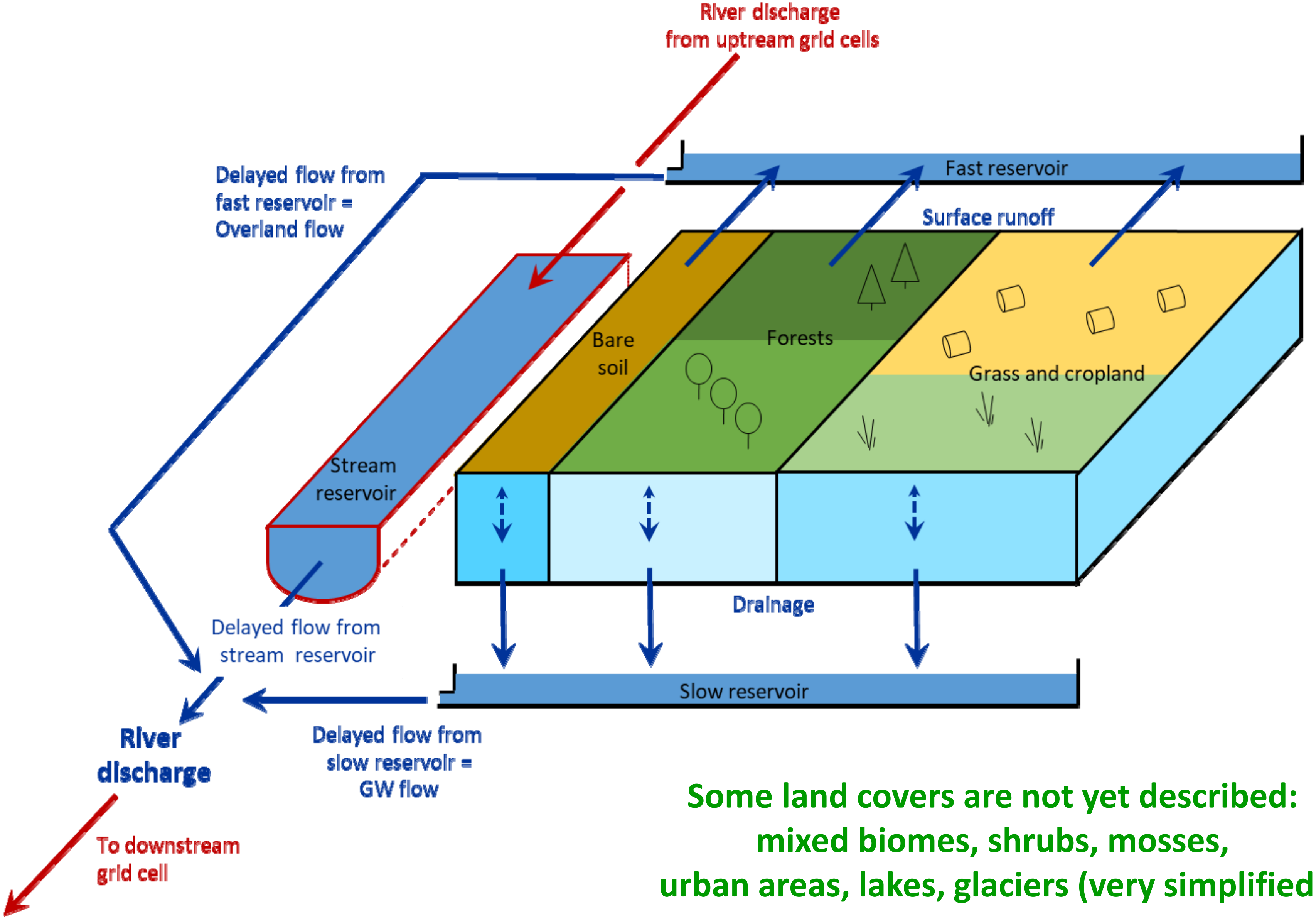
http://forge.ipsl.jussieu.fr/orchidee/attachment/wiki/Documentation/eqs_hydrol.pdf

Reference papers: de Rosnay et al., 2000; de Rosnay et al., 2002; d'Orgeval et al., 2008; Campoy et al., 2013 ; Tafasca et al., 2020

PhD theses : de Rosnay, 1999; d'Orgeval, 2006; Campoy, 2013; Tafasca, 2020

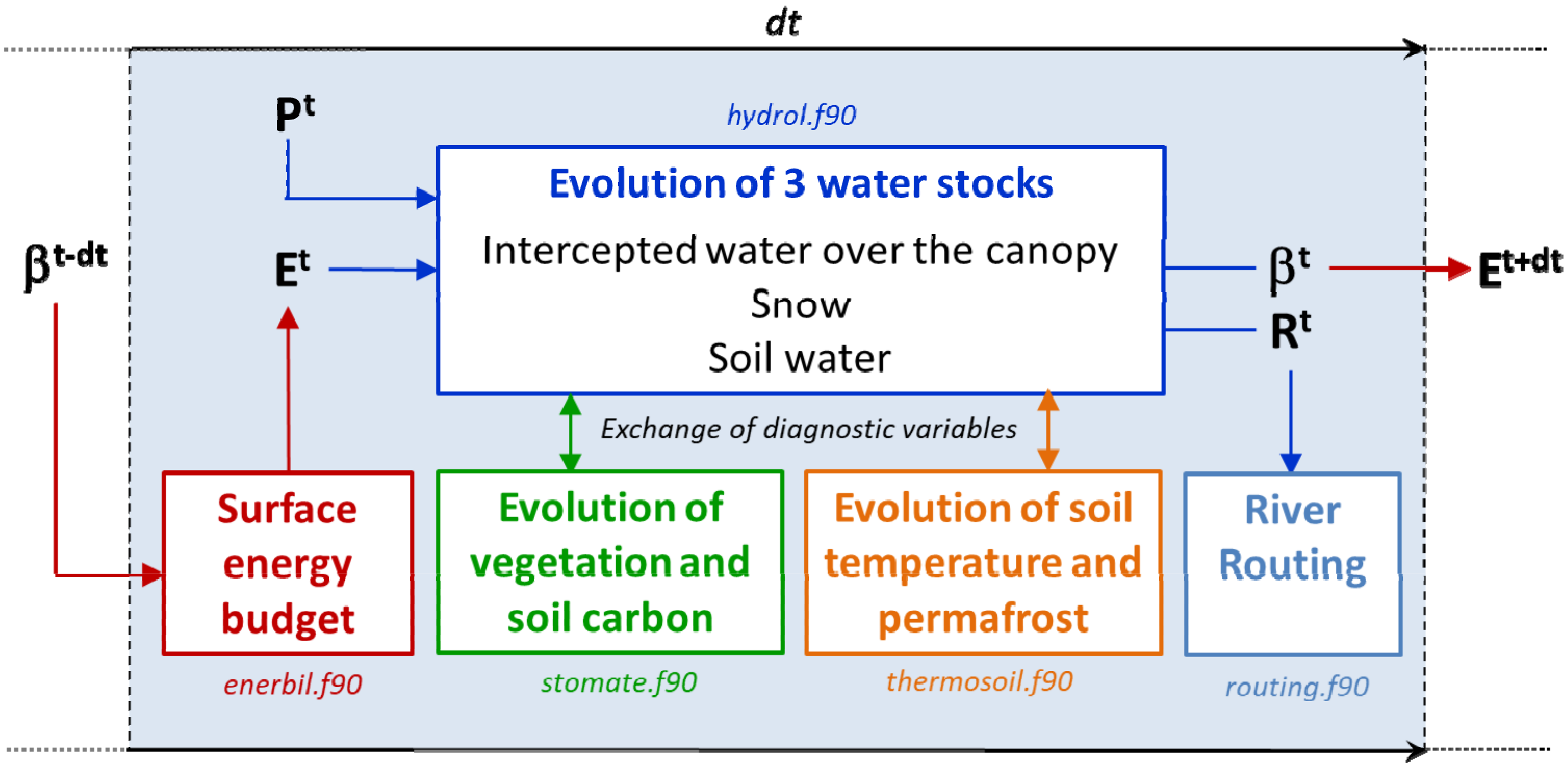
4. **A glance at the routing scheme**

# Land surface hydrology



Some land covers are not yet described:
mixed biomes, shrubs, mosses,
urban areas, lakes, glaciers (very simplified)

# Soil hydrology and water budget



*dt*

$P^t$

*hydrol.f90*

**Evolution of 3 water stocks**

Intercepted water over the canopy

Snow

Soil water

$\beta^{t-dt}$

$E^t$

$\beta^t$

$R^t$

$E^{t+dt}$

*Exchange of diagnostic variables*

**Surface energy budget**

*enerbil.f90*

**Evolution of vegetation and soil carbon**

*stomate.f90*

**Evolution of soil temperature and permafrost**

*thermosoil.f90*

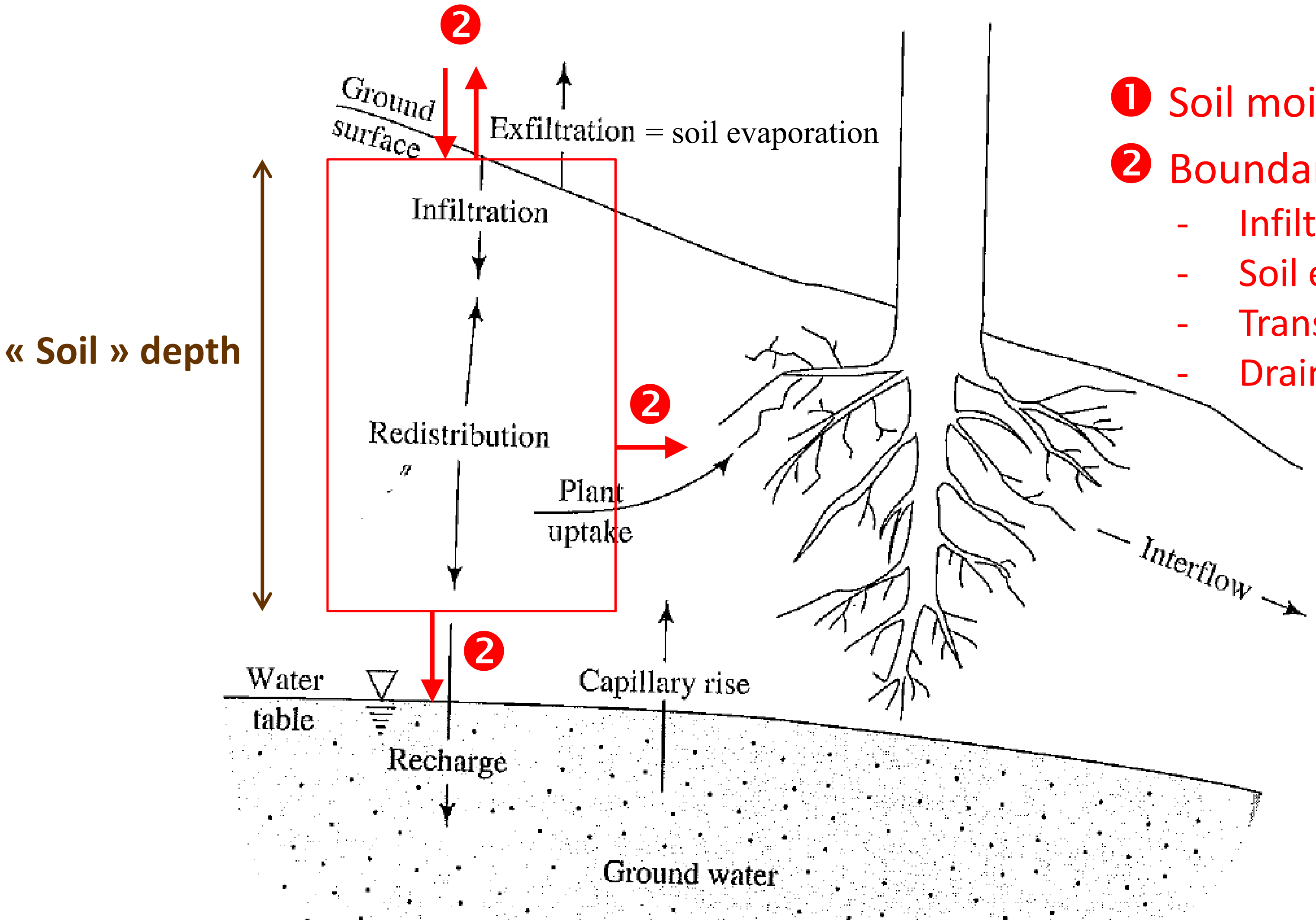
**River Routing**

*routing.f90*

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

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

# What is modeled ?



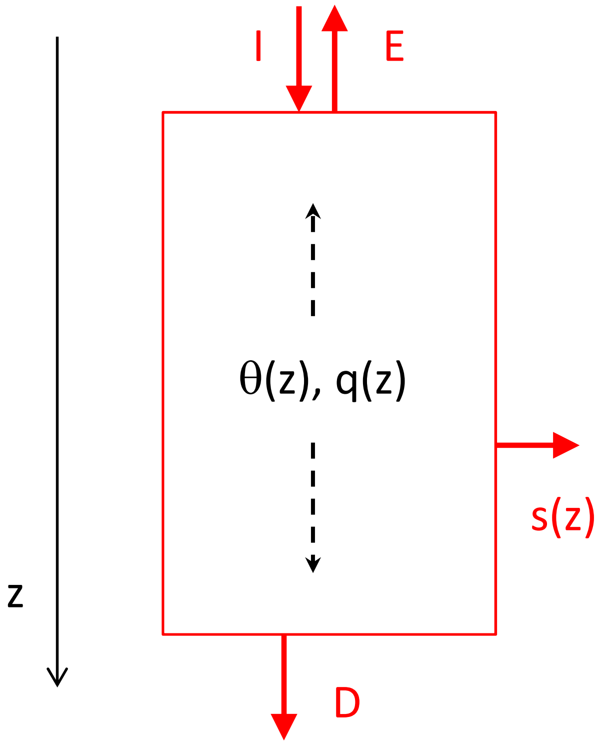
❶ Soil moisture diffusion

❷ Boundary fluxes

- Infiltration
- Soil evaporation
- Transpiration sink
- Drainage

# How is SM diffusion modeled ?

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



**2. Continuity :**

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

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

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

**Richards equation**

**4. Hydraulic head h quantifies the gravity and pressure potentials**

$$h = -z + \psi$$

**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. $s^{-1}$**
**s : transpiration sink in $m^3.m^{-3}.s^{-1}$**
**K : hydraulic conductivity in $m.s^{-1}$**
**h : hydraulic potential in m**

# Finite difference integration

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

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

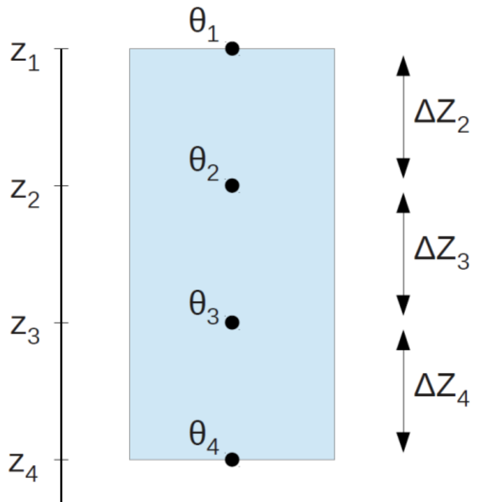
$$\frac{Q_i}{A} = -\frac{D(\theta_{i-1})+D(\theta_i)}{2}\boxed{\frac{\theta_i-\theta_{i-1}}{\Delta Z_i}} + \frac{K(\theta_{i-1})+K(\theta_i)}{2}$$

Si = transpiration sink

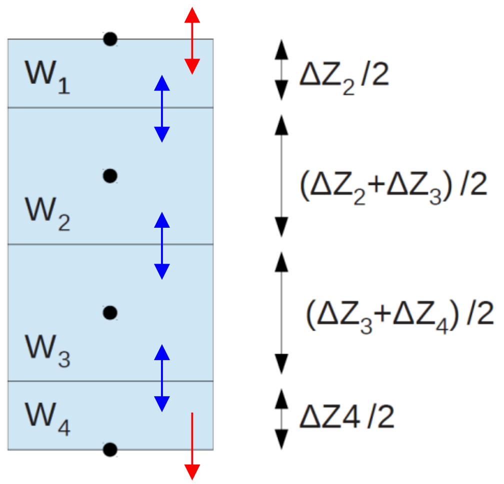
A: grid-cell area

- 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 $\theta_i$
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

$$W_i = [\Delta Z_i\,(3\,\theta_i+\theta_{i-1}) + \Delta Z_{i+1}\,(3\,\theta_i+\theta_{i+1})\,]/8$$
$$W_1 = [\Delta Z_2\,(3\,\theta_1+\theta_2)\,]/8$$
$$W_N = [\Delta Z_N\,(3\,\theta_N+\theta_{N-1})\,]/8$$

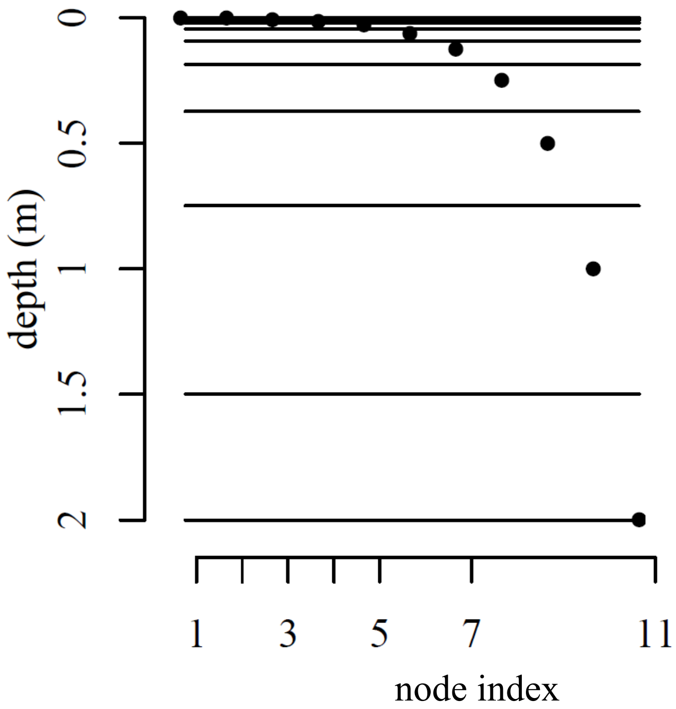
# Vertical discretization

- 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

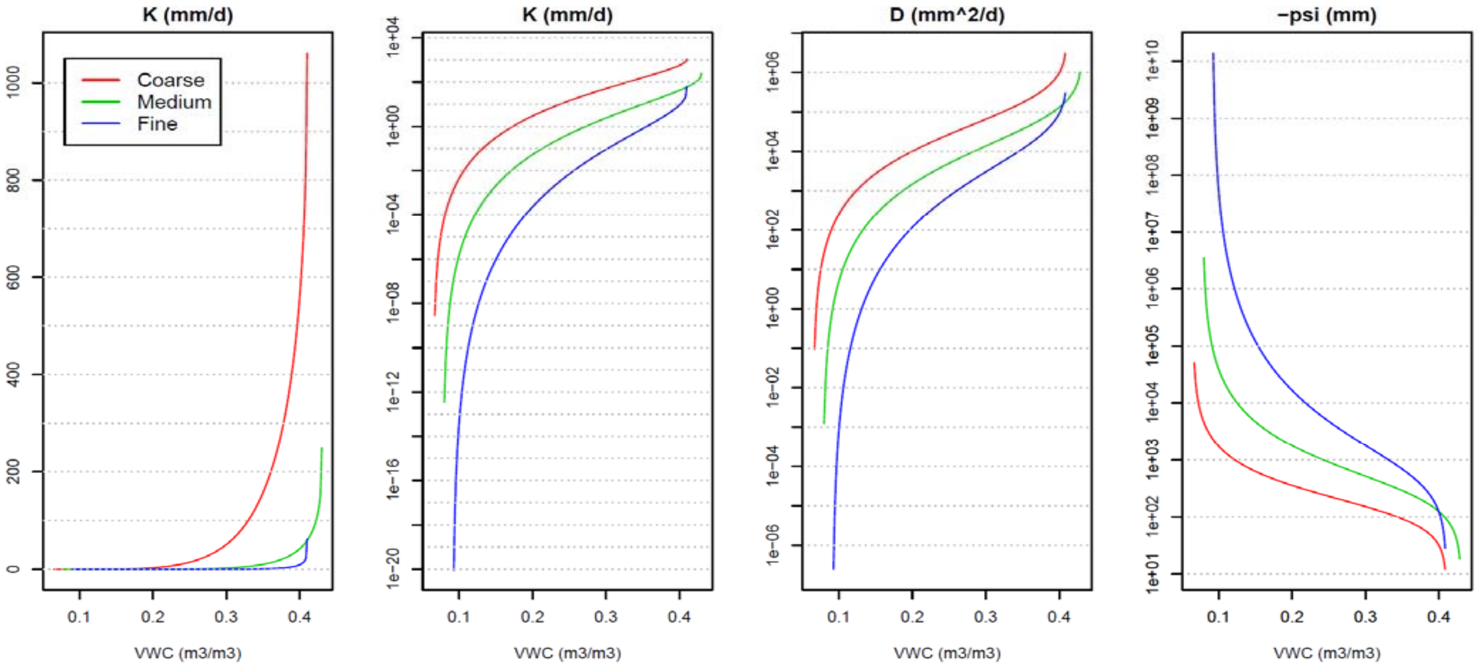
- The vertical discretization must permit an accurate calculation of $\theta i$ and the related water fluxes Qi
- We need thin layers where $\theta$ is likely to exhibit sharp vertical gradients
  (to better approximate the local derivative)
- Vertical discretization and boundary conditions must be decided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

**Alternative discretizations can be defined by externalized parameters (run.def)**

| | | | | |
|---|---|---|---|---|
| **DEPTH_MAX_H** | 2.0 | 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 $\theta$**
- Their dependance on $\theta$ is very non linear
- In ORCHIDEE, this is decribed by the so-called **Van Genuchten-Mualem relationships**:



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

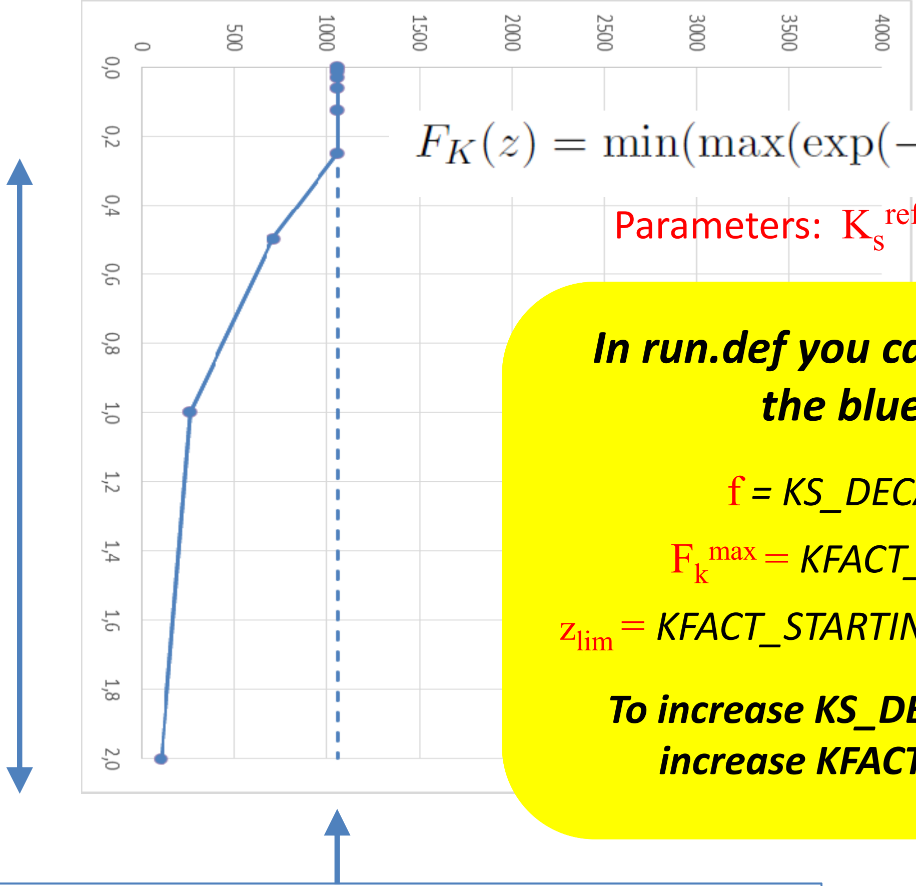
$$\psi(\theta) = -\frac{1}{\alpha}\left(\theta_f^{-1/m}-1\right)^{1/n} \qquad m = 1-1/n$$

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

**The parameters**
$\theta_s$ $\theta_r$ $K_s$ $n$
$\alpha = -1/\psi_{ae}$
**depend on soil texture**

# Modifications of Ks with depth

Ks(z) in mm/d



$$F_K(z) = \min(\max(\exp(-f(z - z_{\text{lim}}), 1/F_K^{\max}), 1)$$

Parameters: $K_s^{ref}$ $f$ $z_{lim}$ $F_K^{max}$

***In run.def you can easily change the blue profile***

$f$ = *KS_DECAY = 2. [m]*

$F_k^{max}$ = *KFACT_MAX = 10. [-]*

$z_{lim}$ = *KFACT_STARTING_DEPTH = 0.3 [m]*

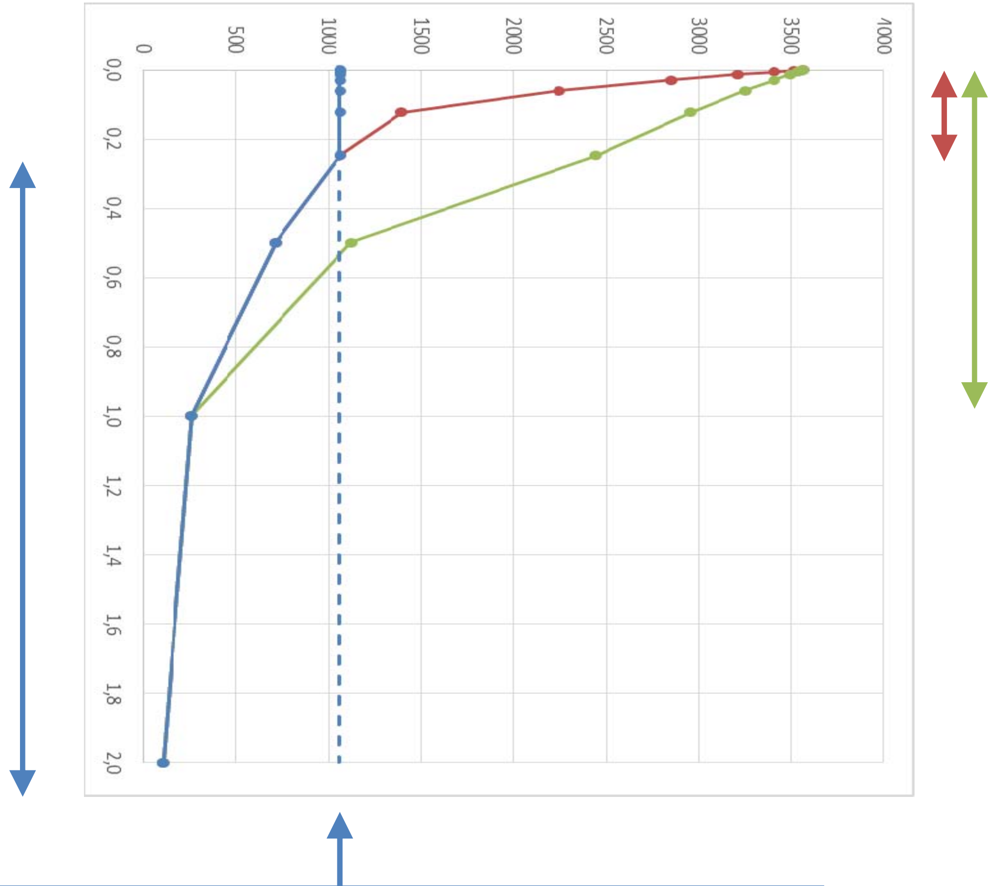
***To increase KS_DECAY, you need to increase KFACT_MAX as well***

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

**(1) $K_s^{ref}$ is defined based on soil texture**
Here 1060 mm/d for Sandy Loam

# Modifications of Ks with depth

**Ks(z) in mm/d**



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

**(1) $K_s^{ref}$ is defined based on soil texture**
Here 1060 mm/d for Sandy Loam

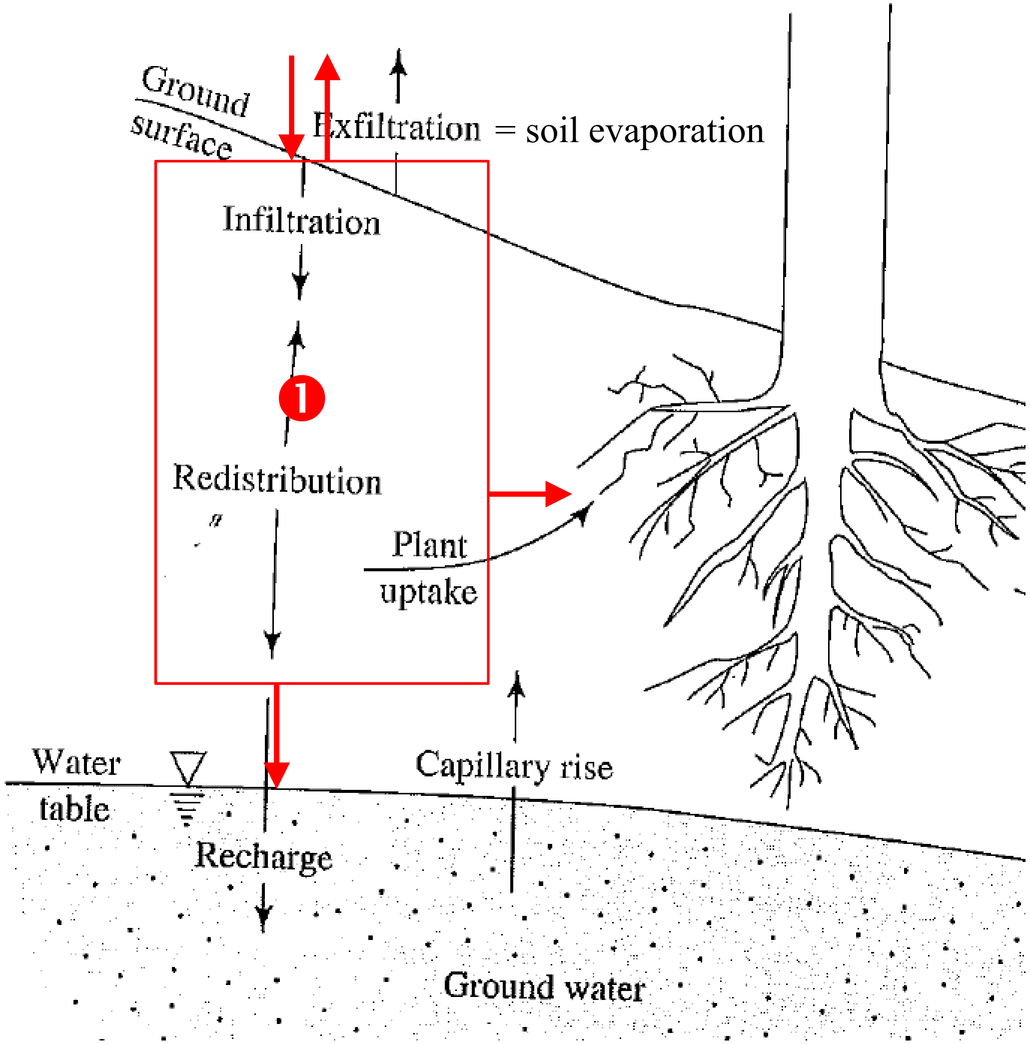
**(3) Ks also increases towards the surface because of bioturbation**
**Red: grass PFTs,**
$c_j$ = humcste = 4
**Yellow: forest PFTs,**
$c_j$ = humcste = 0.8

where $c_j$ controls the exponential decay of root density

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

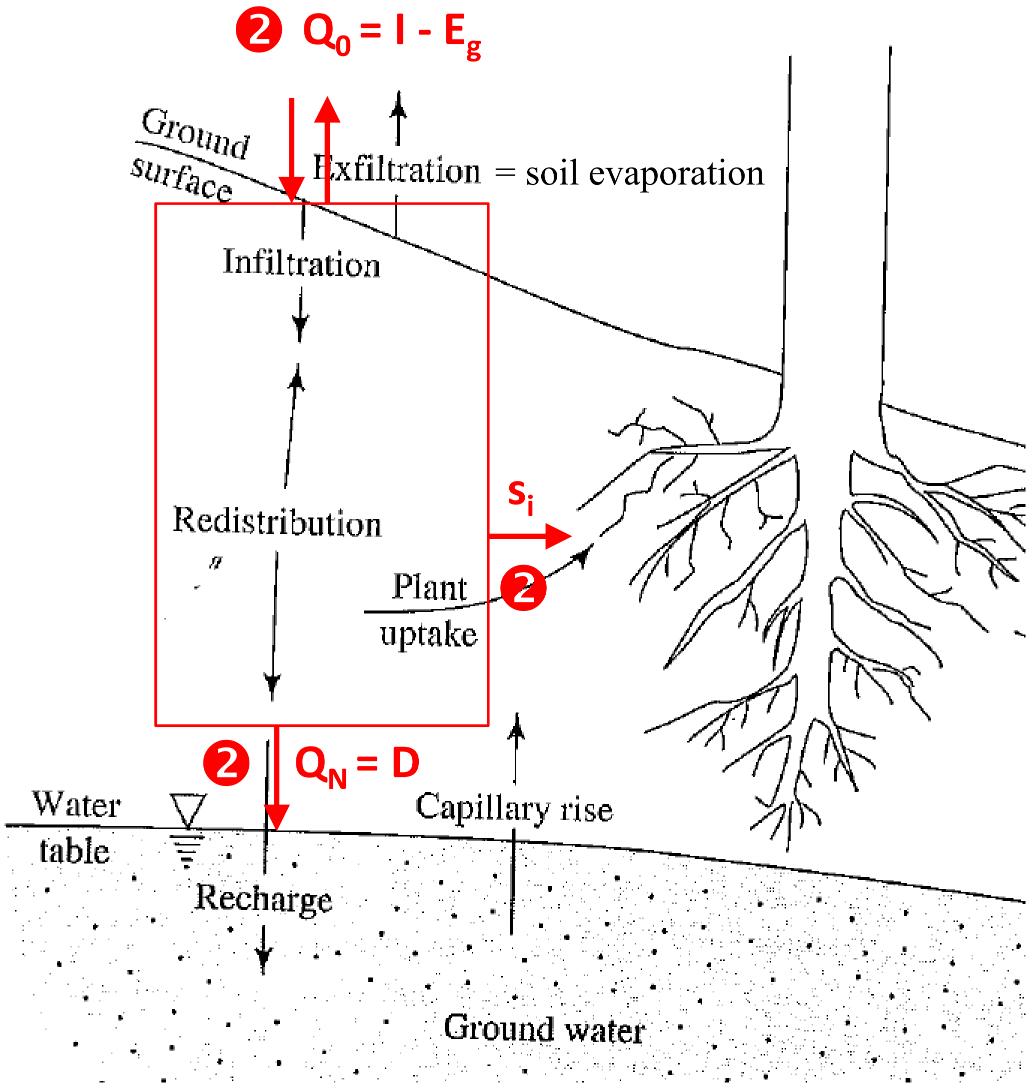
**Several externalized parameters involved, cf eqs_hydrol.pdf**

# 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 layer definition)
  - four boundary fluxes

# To sum up water diffusion



- **The soil is assumed to be unsaturated**
- **The prognostic variables are $\theta$i** (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 layer definition)
  - 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**

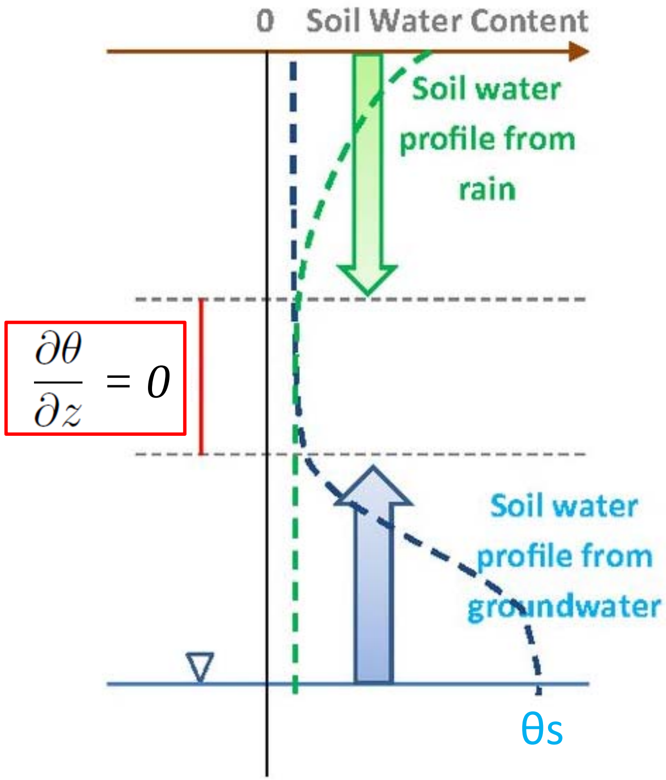
**Which all depend on soil moisture**

# 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

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



**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.**

**With F=0, you get an impermeable bottom:**

- like in a bucket scheme
- leading to build a water table

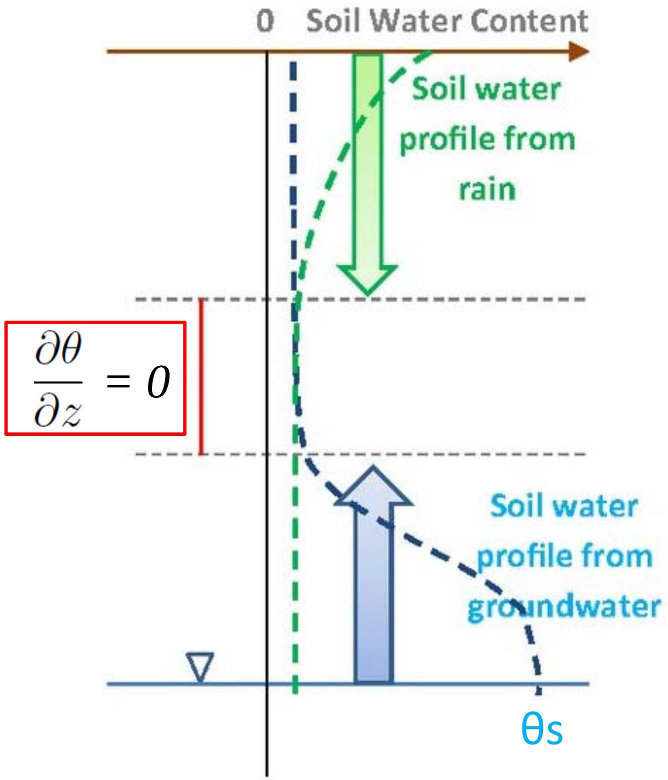
**But you need to adapt the vertical discretization!**

# Drainage

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

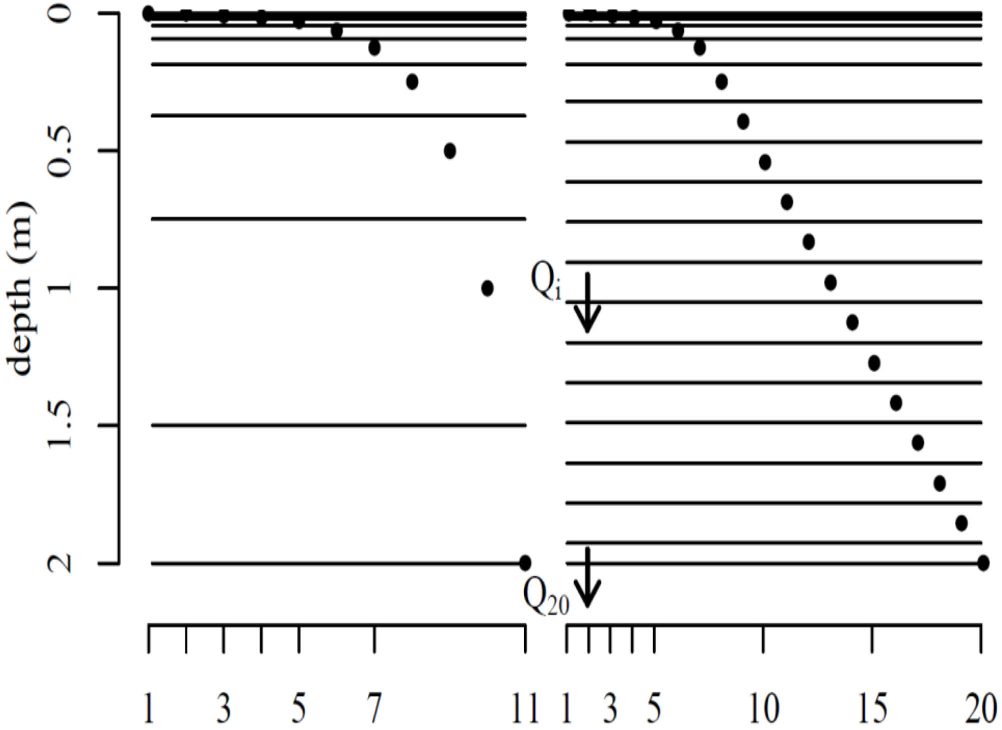
Based on the motion equation, this corresponds to a situation where θ does not show any vertical variations below the modeled soil

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



**Default discretization**

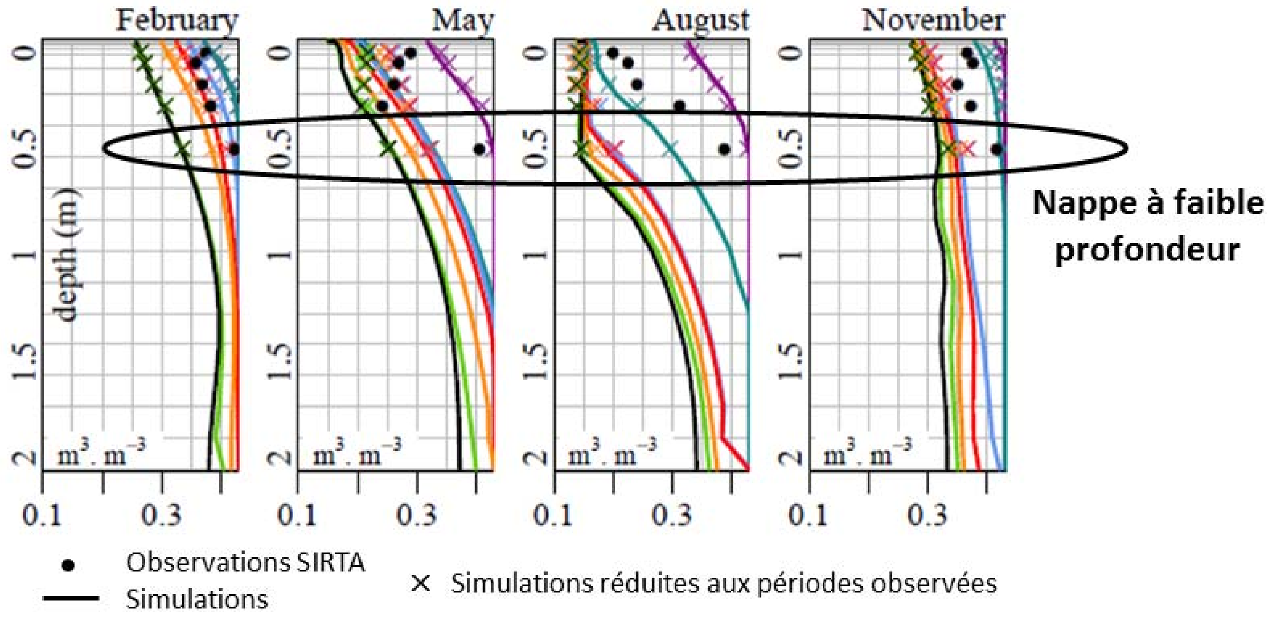
**More layers to capture deep θ gradients**

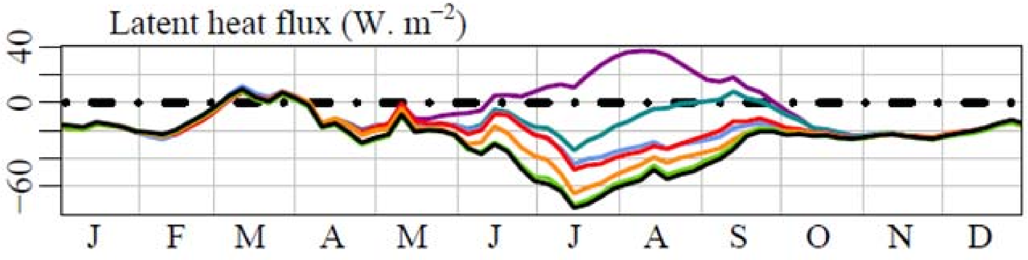


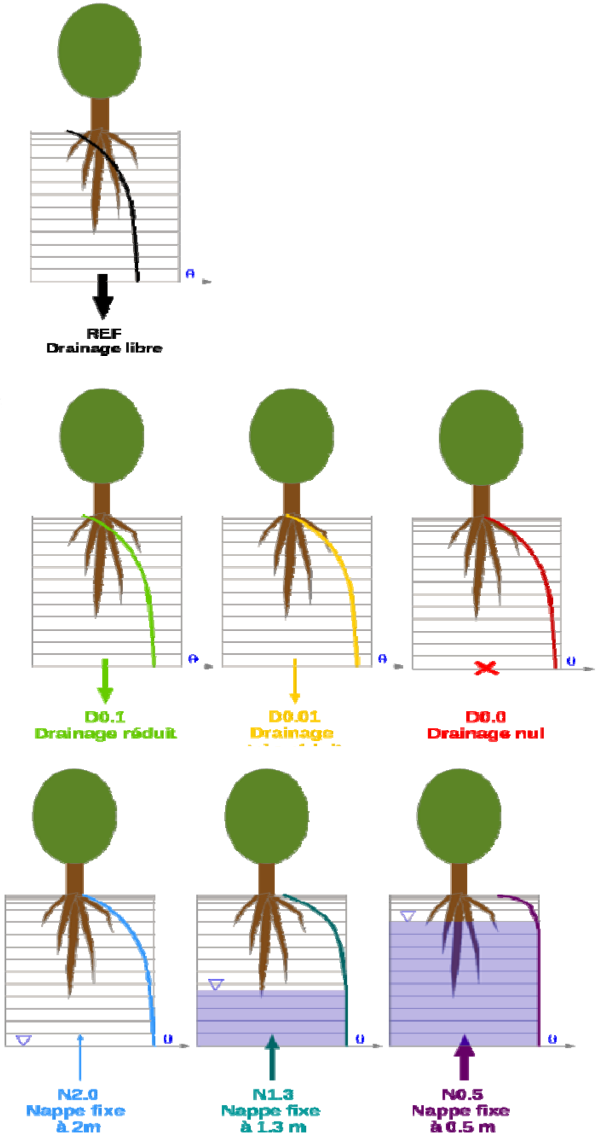
# Drainage

Simulations ORCHIDEE-LMDZ en zoomé-guidé au SIRTA

Comparaison à des mesures locales







Campoy et al., 2013

# Infiltration (and surface runoff)

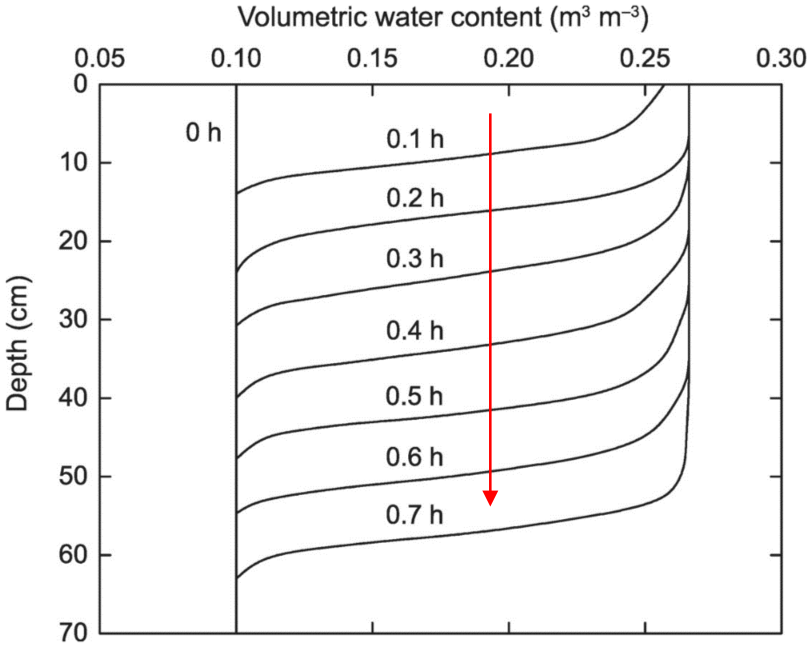
- At the soil surface, throughfall can either infiltrate or run off (surface runoff)
- The routing scheme can also produce water to infiltrate (return flow, irrigation, etc.)

} $P_0$

- The modeling of infiltration relies on gravitational fluxes: $q(z) = K(\theta)$

Soil absorption is neglected

- With **wetting front propagation based on time splitting procedure** and **sub-grid-variability of K** (because the grid-cells are large)



Idealized result from some field experiment

Iterative saturation of the layers from top to bottom

The infiltration rate in layer i depends $K(\theta_i)$ but it is reduced to account for subgrid variability

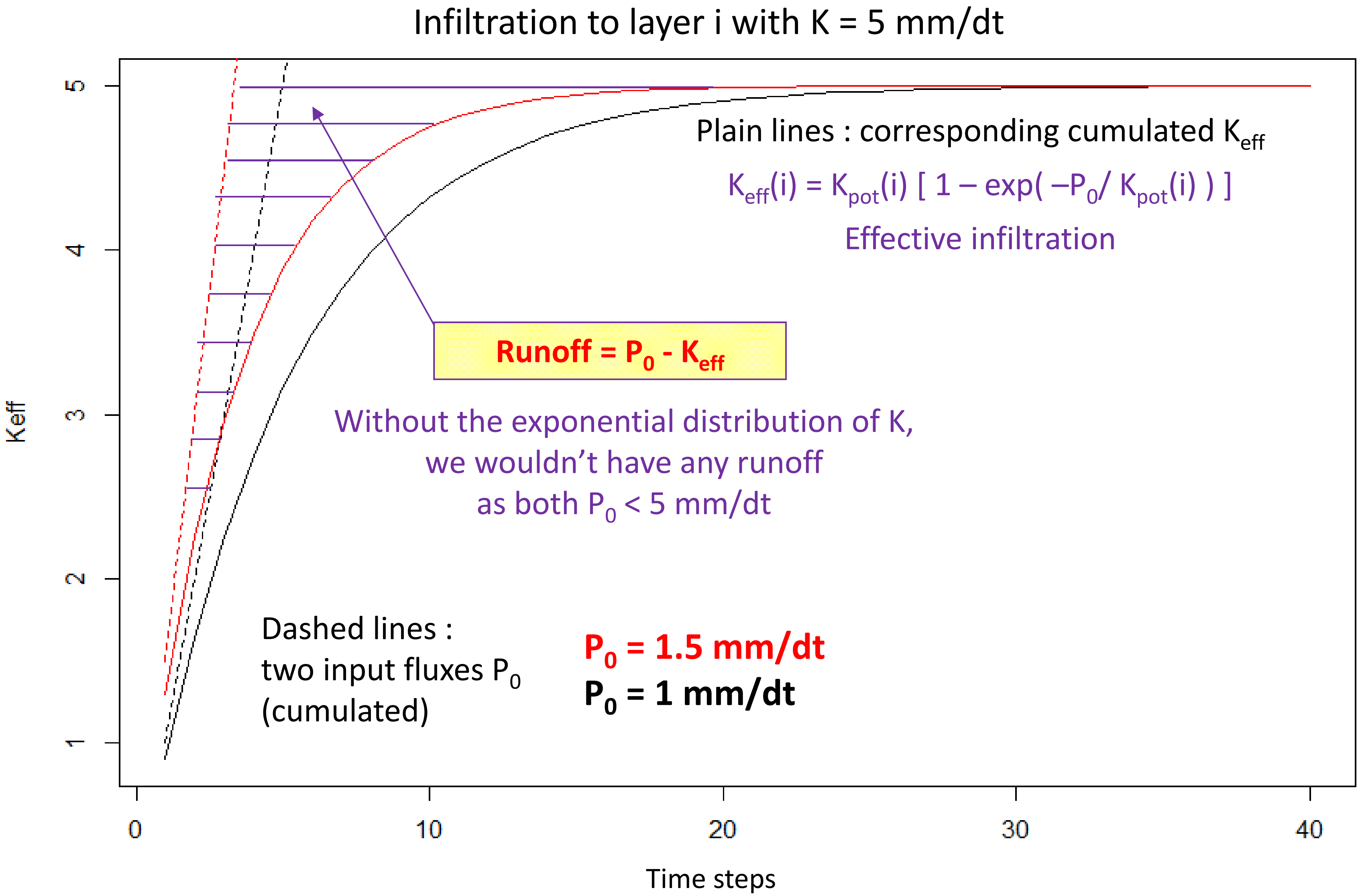
We consider an exponential distribution of K with a mean of $K(\theta_i)$

- $K_{eff}$ is the mean of K values < $P_0$
- Runoff production where $P_0 > K$

The time to saturate a layer depends on $K_{eff}$ and soil moisture deficit ($W_{sat} - W$)

Stop when $P_0$ fully infiltrated or time step is over

# Infiltration (and surface runoff)



Plain lines : corresponding cumulated $K_{eff}$

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

Effective infiltration

**Runoff = $P_0$ - $K_{eff}$**

Without the exponential distribution of K, we wouldn't have any runoff as both $P_0 < 5$ mm/dt

Dashed lines :
two input fluxes $P_0$
(cumulated)

**$P_0$ = 1.5 mm/dt**
**$P_0$ = 1 mm/dt**

# Infiltration (and surface runoff)

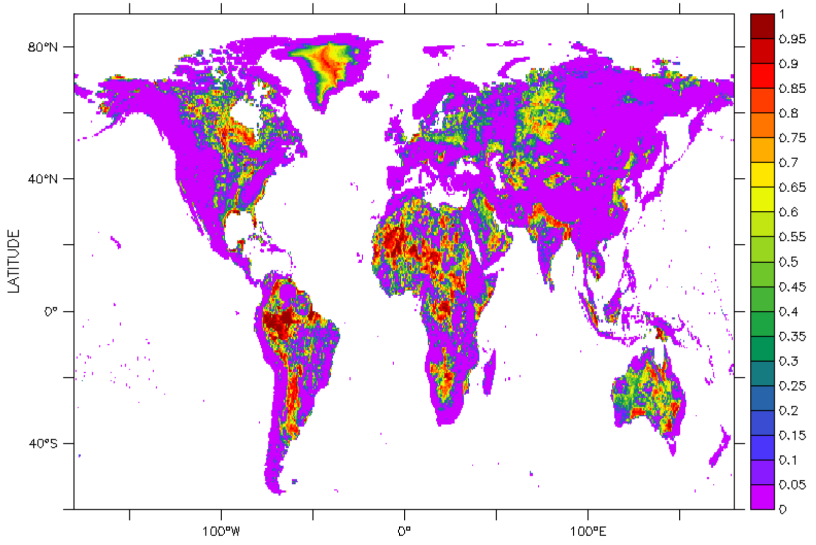
- At the soil surface, throughfall can either infiltrate or run off (surface runoff)
- The routing scheme can also produce water to infiltrate (return flow, irrigation, etc.)

$P_0$

- The modeling of infiltration relies on gravitational fluxes: $q(z) = K(\theta)$

Soil absorption is neglected

- With **wetting front propagation based on time splitting procedure and sub-grid-variability of K** (because the grid-cells are large)
- Surface runoff $R_s^{pot}$ can **reinfiltrate** in flat areas (ponding)



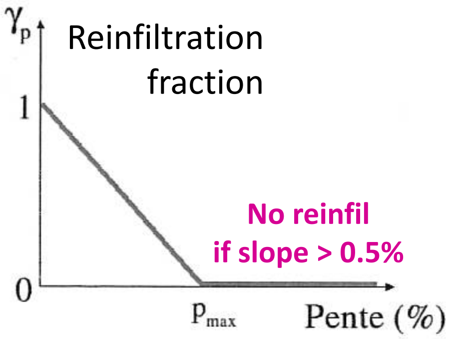
Reinfiltration fraction

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

**Ponding fraction for future reinfiltration**

$\gamma_p R_s^{pot}$

**Effective surface runoff** $R_s = (1-\gamma_p) R_s^{pot}$



**A lot of reinfil in flat areas**

**No reinfil if slope > 0.5%**

# Infiltration (and surface runoff)

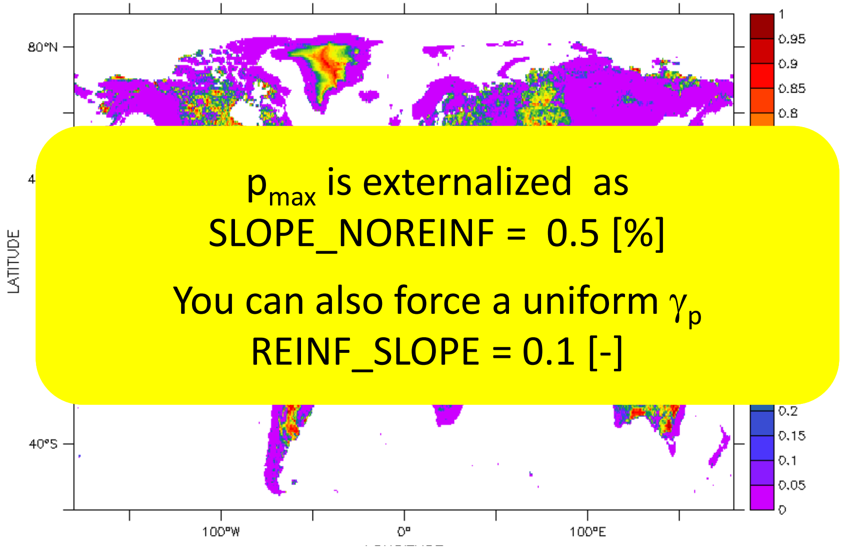
- At the soil surface, throughfall can either infiltrate or run off (surface runoff)
- The routing scheme can also produce water to infiltrate (return flow, irrigation, etc.)

**$P_0$**

- The modeling of infiltration relies on gravitational fluxes: $q(z) = K(\theta)$

Soil absorption
is neglected

- With **wetting front propagation based on time splitting procedure and sub-grid-variability of K** (because the grid-cells are large)
- Surface runoff $R_s^{pot}$ can **reinfiltrate** in flat areas (ponding)



$p_{max}$ is externalized as
SLOPE_NOREINF = 0.5 [%]

You can also force a uniform $\gamma_p$
REINF_SLOPE = 0.1 [-]

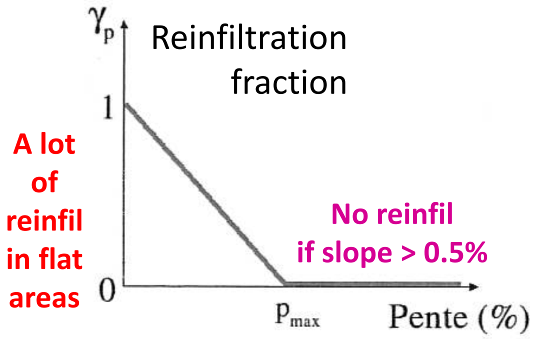
Reinfiltration fraction

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

**Ponding fraction for future reinfiltration**

$\gamma_p R_s^{pot}$

**Effective surface runoff** $R_s = (1-\gamma_p) R_s^{pot}$



# 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, given water stress from previous time step
2. **Another issue is to calculate the stress function $\beta_g$** to calculate soil evaporation at the next time step
3. **This is done in hydrol by a supply/demand approach** based on the soil moisture at the end of the time step

**$E_g$ can proceed at potential rate unless the soil cannot supply it**

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

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

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

**$Q_{up}$ 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 $\theta_i$ remains above $\theta_r$*

*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 $Q_{up}$*

# 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. **Another issue is to calculate the stress function $\beta_g$** to calculate soil evaporation at the next time step
3. **This is done in hydrol by a supply/demand approach** based on the soil moisture at the end of the time step

**$E_g$ can proceed at potential rate unless cannot supply it**

4. **We can reduce the demand using a soil resistance (Sellers et al., 1992)**

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

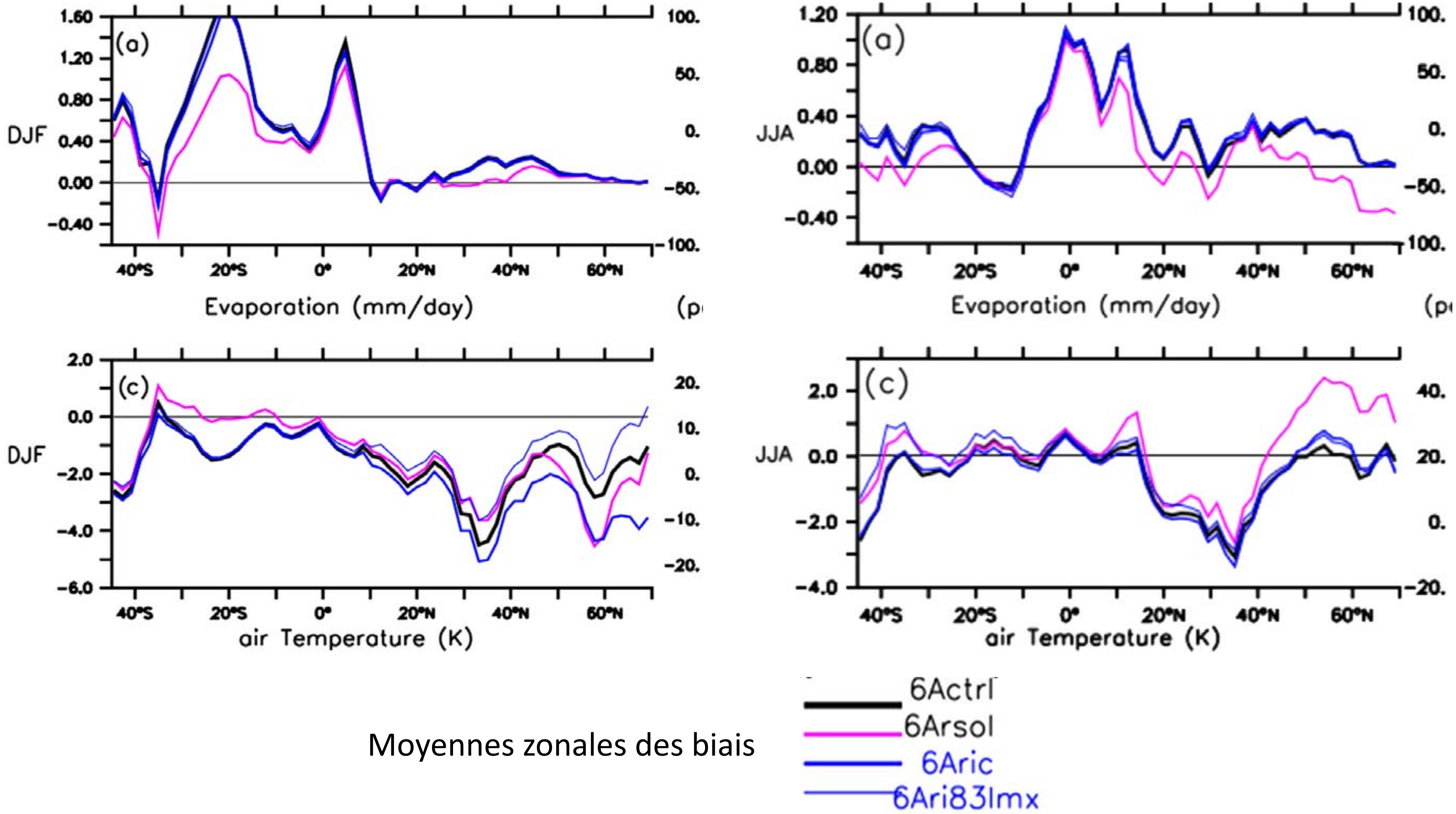
L is the soil moisture in the 4 top layers
Ls is the equivalent at saturation

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

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

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

# Soil evaporation ($E_g$)



Moyennes zonales des biais

Cheruy et al., 2020 → simulations with LMDZOR to prepare CMIP6

# The transpiration sink

**The dependance of transpiration on soil moisture is conveyed by the water stress $u_s(i)$**

$u_s(1)=0$

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

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

**$n_{root}$ : 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**

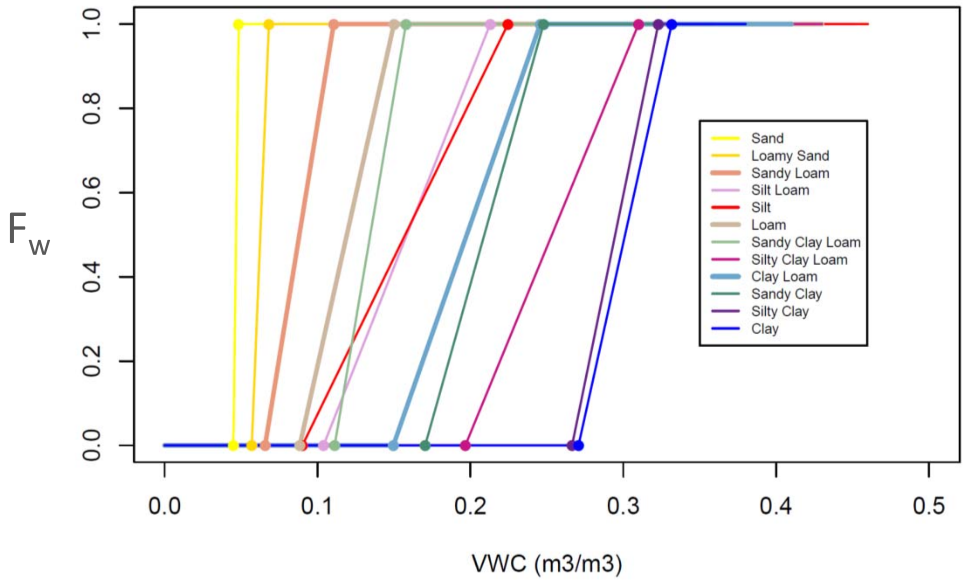
**$W_f$ = field capacity**

Calculated based on VG parameters, thus as a function of soil texture, with

$\psi_w = -150000$ m

$\psi_f = -1000$ m (-3000 m for sandy soils)

**$AWC = W_f - W_w$**



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

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

**The smaller $W_\%$, the smaller the water stress**

**$p_\%$ is externalized as WETNESS_TRANSPIR_MAX**
= 0.8, 0.8, …, 0.8
(13 times as for soil texture classes)

# 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 $r_{st}$

$r_{st}$ also depends on light, $CO_2$, LAI, air temperature and vpd, and on nitrogen limitation in the trunk (CN)

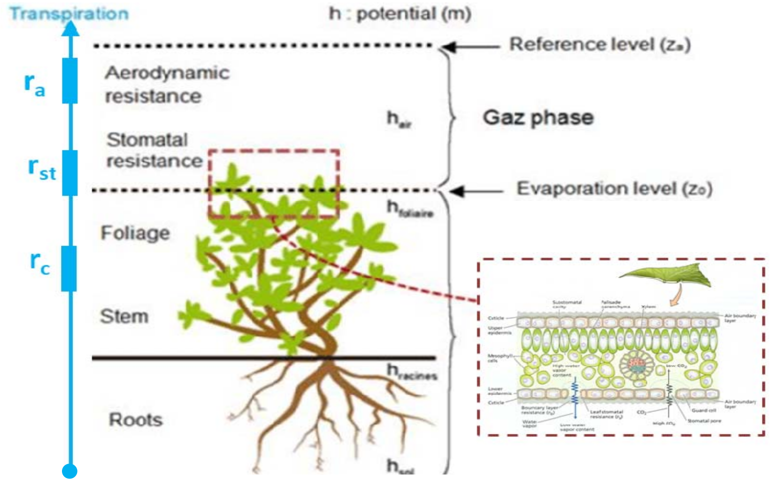
*In the code :*
$U_s$ = humrel

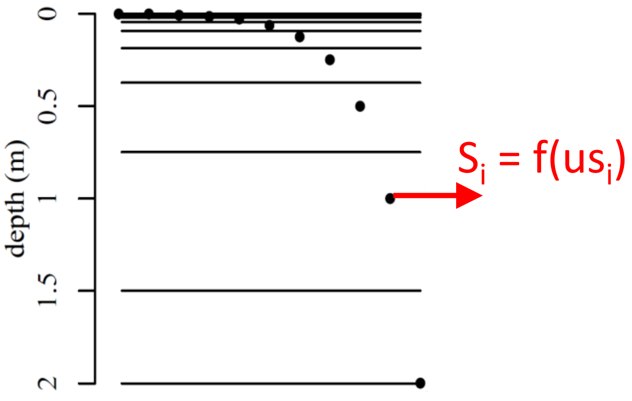
❷ $u_s$ is used to distribute Tr between the soil layers

$$T_r = \Sigma S_i$$

$$U_s = \Sigma us_i$$

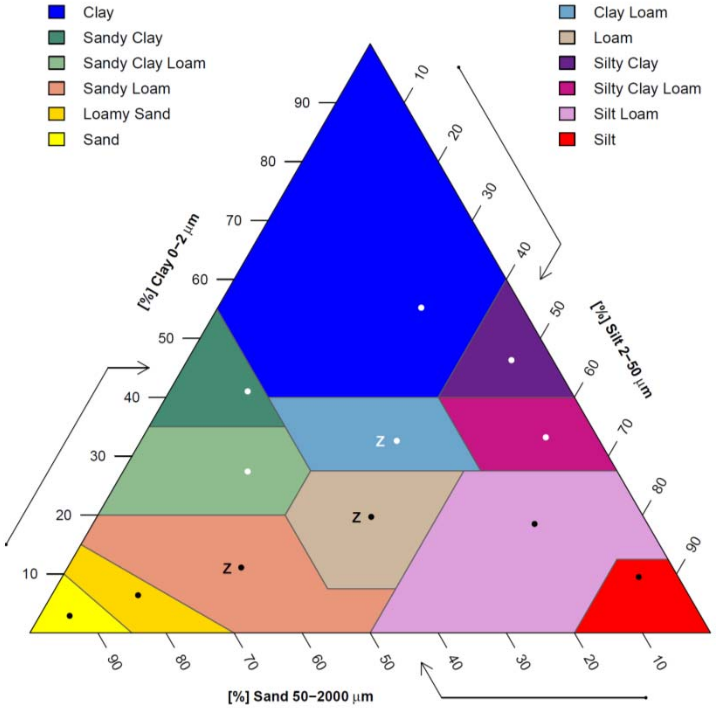
$$S_i = T_r\, us_i / U_s$$





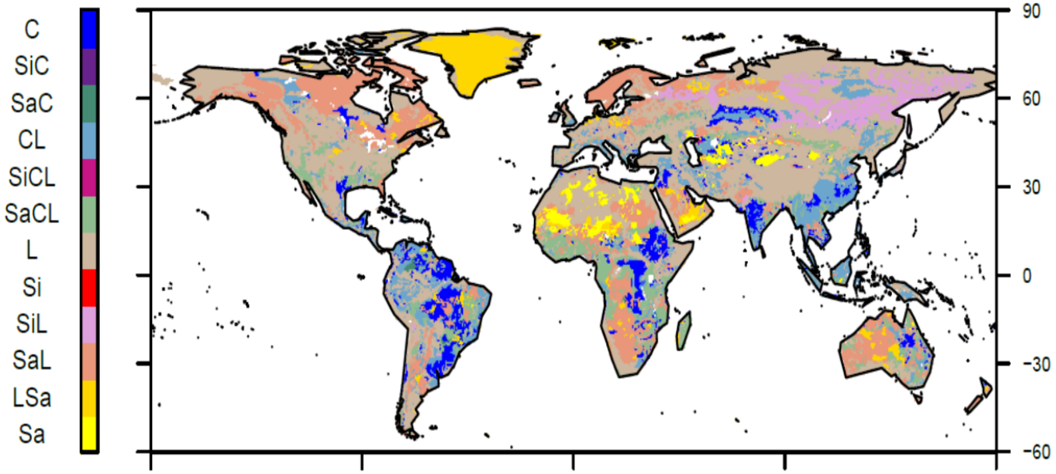
# The role of soil texture

- **In hydrol, the main soil properties are:**
  - Van Genuchten parameters: $\theta_s$ $\theta_r$ $K_s^{ref}$ $n$ $\alpha$ $(= -1/\psi_{ae})$
  - derived field capacity and wilting point: $\theta_w$ $\theta_f$
  - clay_fraction for stomate, and thermal properties for thermosoil
- **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 (granulometry)
- **It 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 maps **with 12 USDA classes**:
  - 1/12° map of Reynolds et al. (2000)
  - 0.5°map from SoilGrids (Hengl et al. 2014)
- **In each grid-cell, we use the dominant texture**



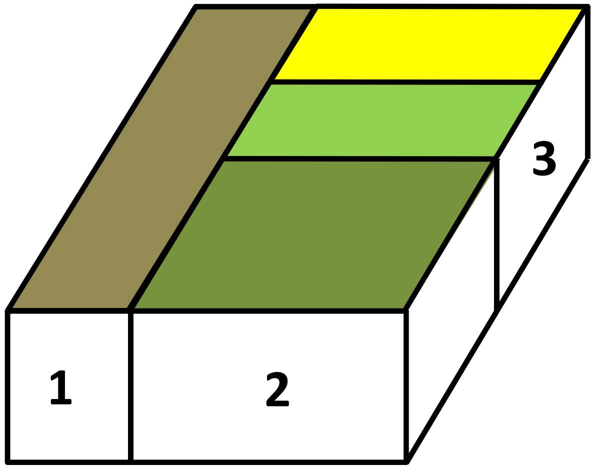
# The role of soil texture

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



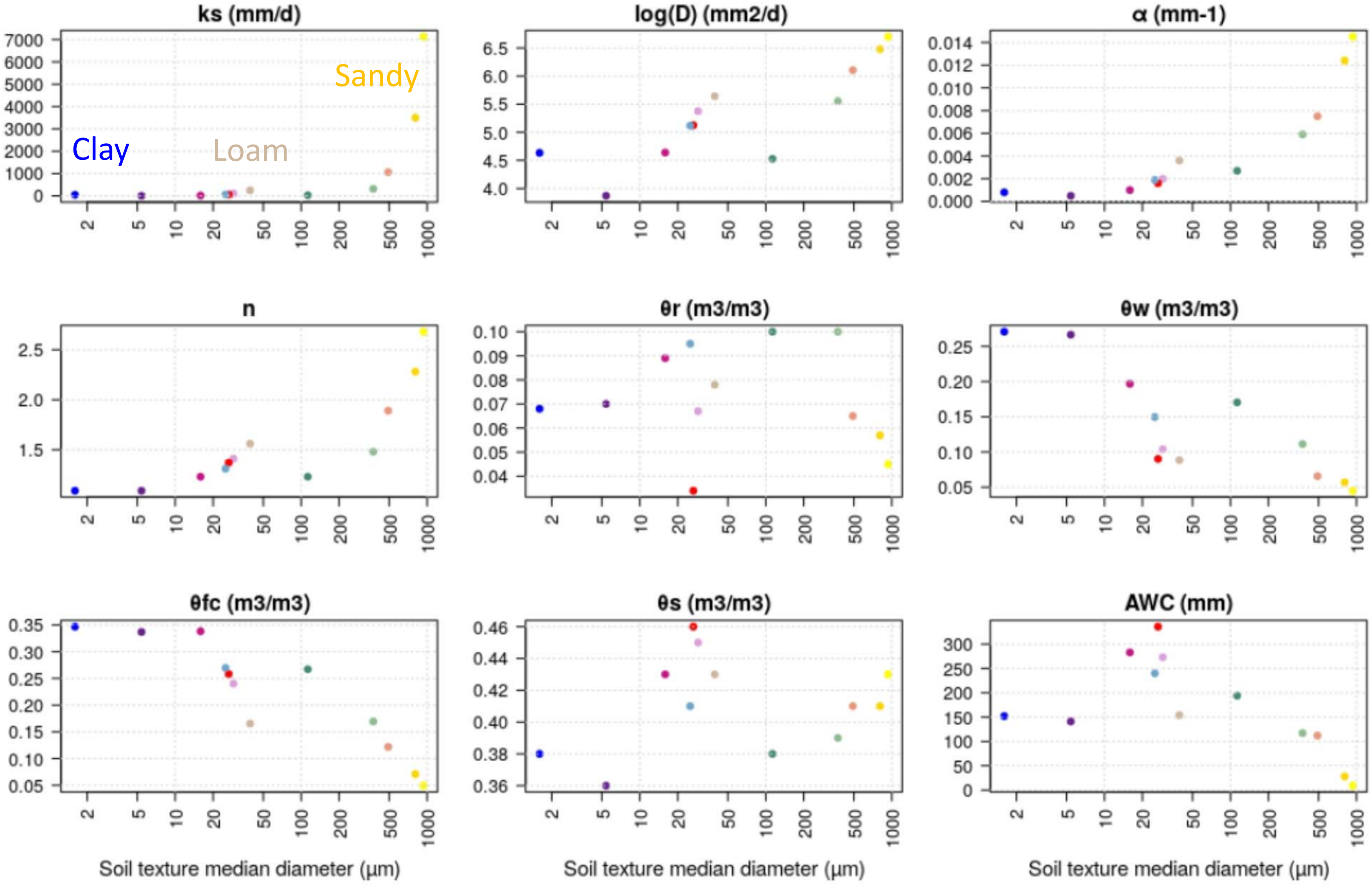
***Dominant texture in each ORCHIDEE grid-cell:***
*defining the hydraulic properties*

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



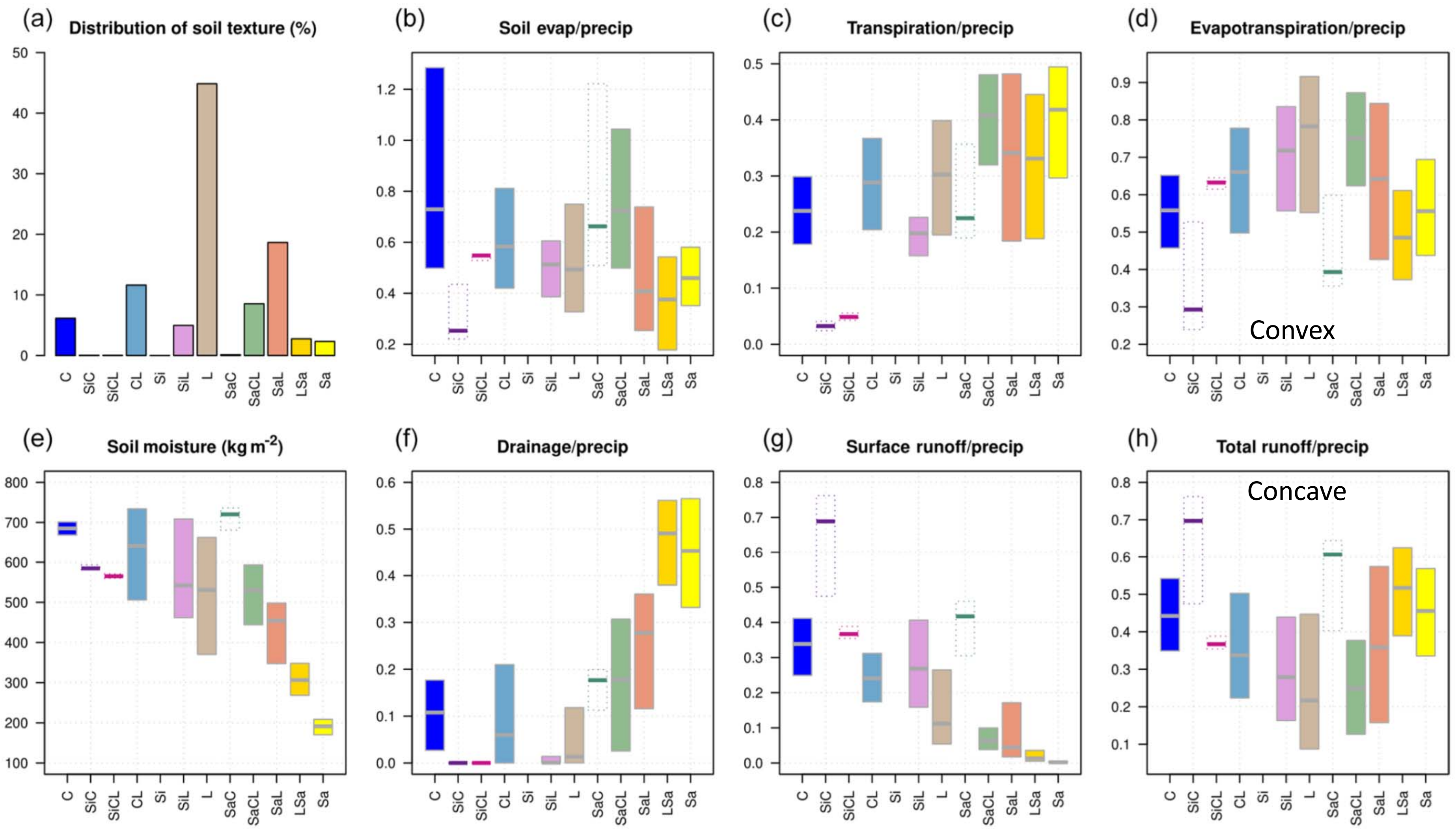
**1: Bare soil PFT**
**2: All Forest PFTs**
**3: All grassland and cropland PFTs**

# The role of soil texture



Tafasca et al., 2020

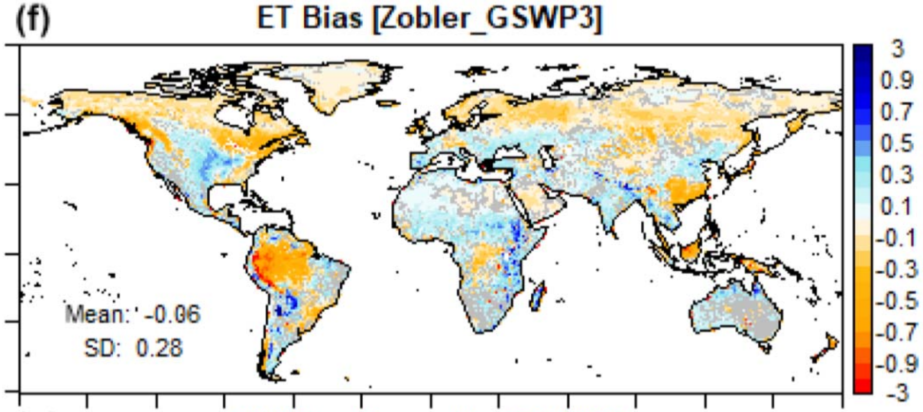
# The role of soil texture



Variability of simulated variables over land surface (excluding Antarctica and Greenland) within each soil texture class. Reynolds soil map, with GSWP3 meteorological forcing over 1980–2010.

Tafasca et al., 2020

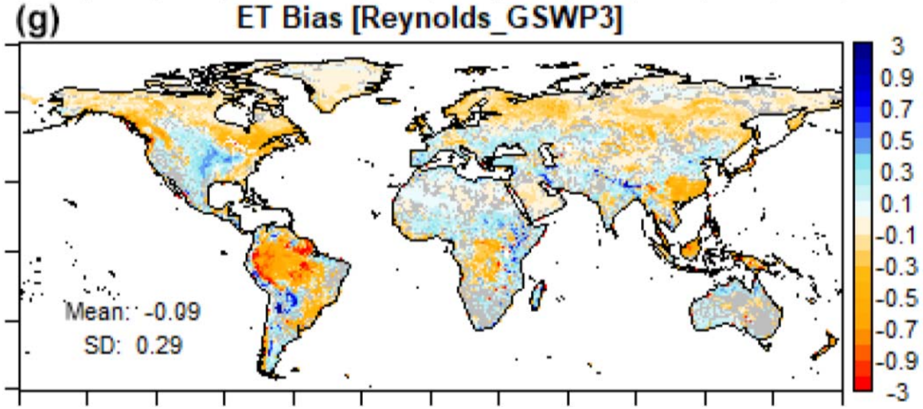
# The role of soil texture

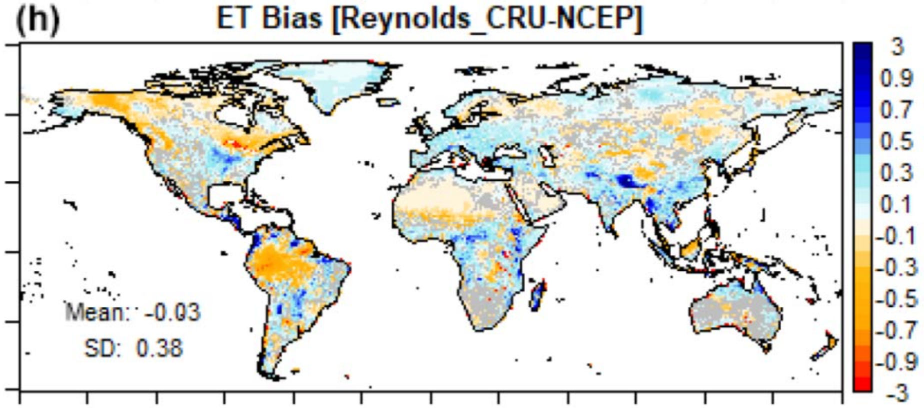


**ET bias against GLEAM3 product over 1980–2010**

- with different soil maps (vertically)
- with different meteorological datasets (horizontally)

For branch 2.2, version CMIP6.



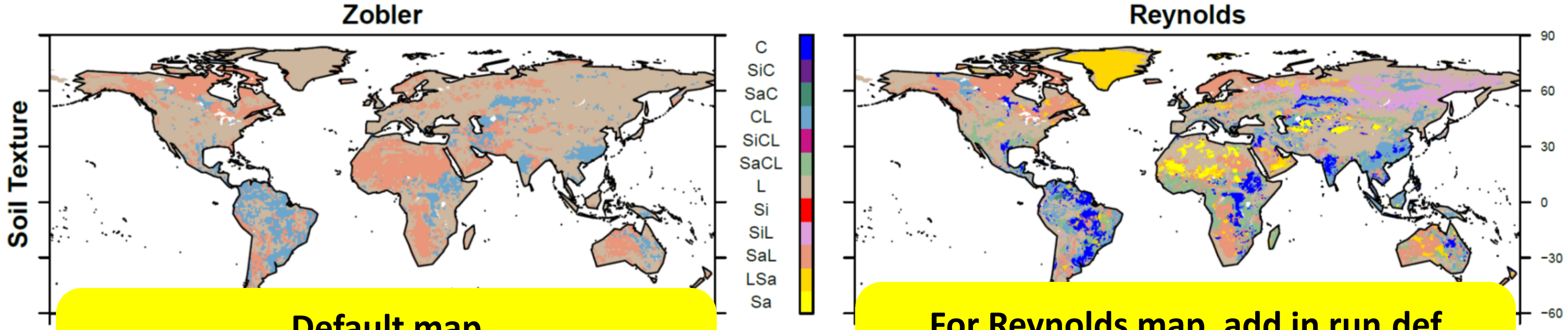


The influence of the soil texture map is much smaller than the one of the atmospheric forcing

Tafasca et al., 2020

# The role of soil texture

Soil hydraulic and thermal properties are defined from soil texture,
with 13 classes (12 USDA + Clay Oxisols)



**Default map**
SOILTYPE_CLASSIF = zobler;
SOILCLASS_FILE = soils_param.nc

**For Reynolds map, add in run.def**
SOILTYPE_CLASSIF = usda;
SOILCLASS_FILE = soils_param_usda.nc

**You can also force the value of soil properties, which will be uniform**

**Minimum setting, here to force using the 1st texture class (Sand)**
IMPOSE_SOILT = y
# SOIL_FRACTIONS = Areal fraction of the 13 soil USDA textures; the dominant one is selected
SOIL_FRACTIONS = 0.9, 0.0, 0.0, 0.0, 0.0, 0.1, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0

**You can further change the value of some / all soil hydraulic parameters**
# KS_IMP ([mm/d] ) : saturated conductivity (0-dim mode) {IMPOSE_SOILT}
KS_IMP = 1000. (instead of 7128 mm/d for Sand)
**Also possible for MCS_IMP, MCR_IMP, NVAN_IMP, AVAN_IMP, MCFC_IMP, MCW_IMP**

# Other controls of soil parameters

**All that has been said before about texture is for MINERAL soils (no organic matter)**

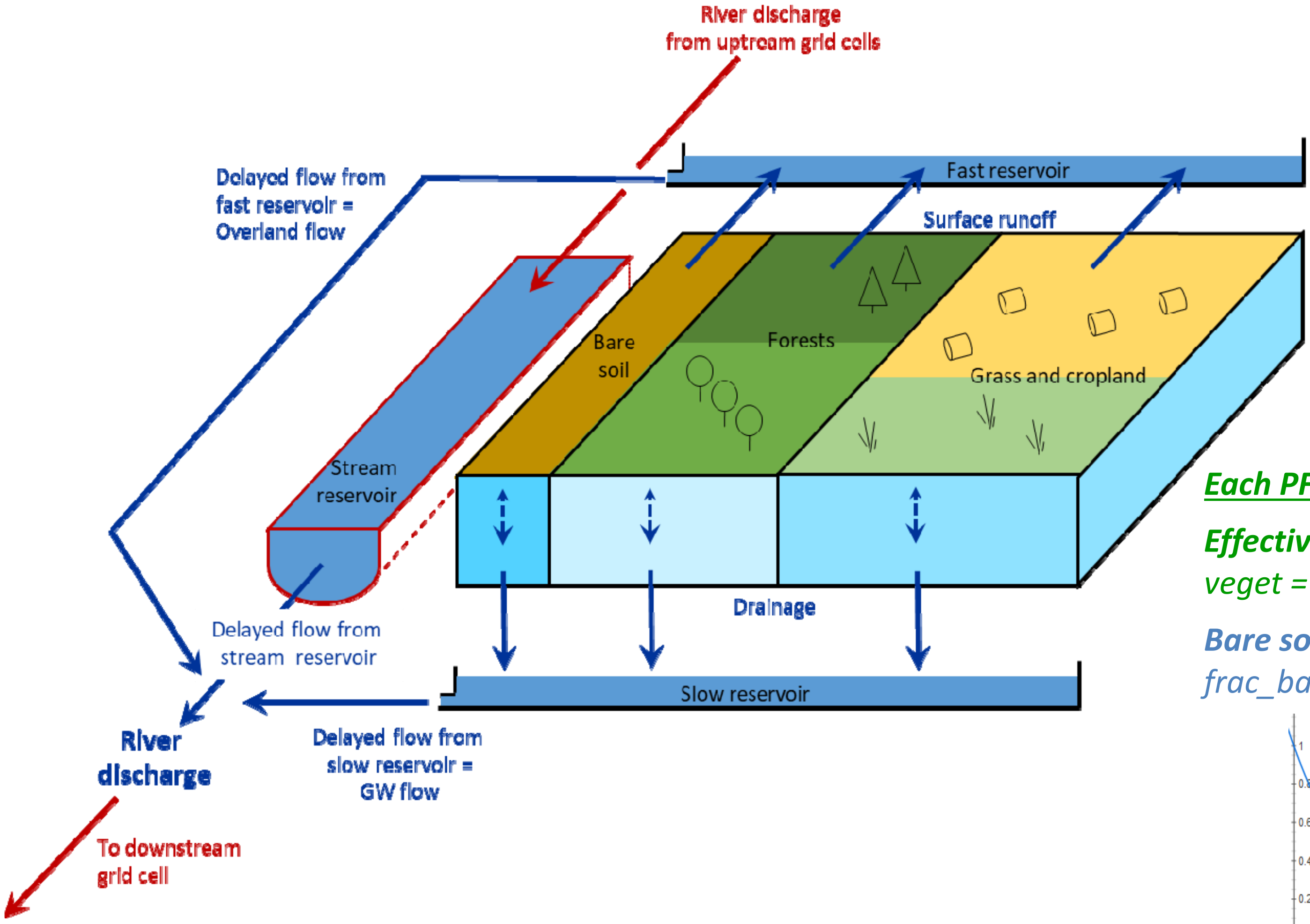
- This is the default in the trunk
- If you set OK_SOIL_CARBON_DISCRETIZATION = y then
  - $\theta_s$ and $K_s^{ref}$ will depend on soil organic carbon but only for thermosoil (not for hydrol) → This is a bug and it is being corrected
  - The other soil parameters ($\theta_r$ , $n$, $\alpha = -1/\psi_{ae}$ ) do not depend on soil organic carbon as in MICT (Guimberteau, Zhu, et al., 2018)

**Soil freezing also impacts soil hydraulic and thermic parameters** (accounted for in trunk)

- Reduced $\theta_s$ and $K_s^{ref}$
- Impacts on infiltration, water redistrinution, and all water fluxes

# Interactions with the vegetation/LC

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



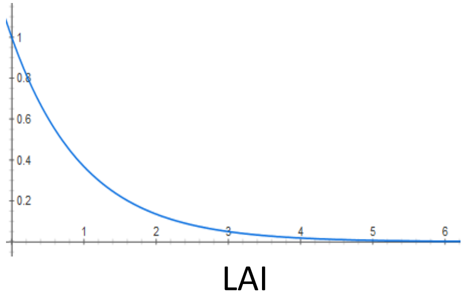
***Each PFT with***

***Effective vegetation fraction (Tr & IL)***

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

***Bare soil fraction (Eg)***

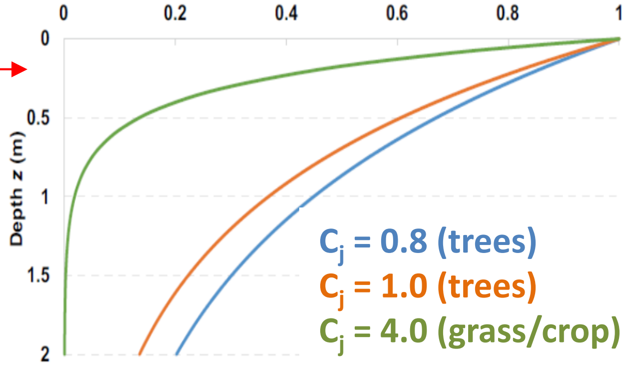
*frac_bare = veget_max * exp(- LAI)*



# 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 us on transpiration in each soil layer i**

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

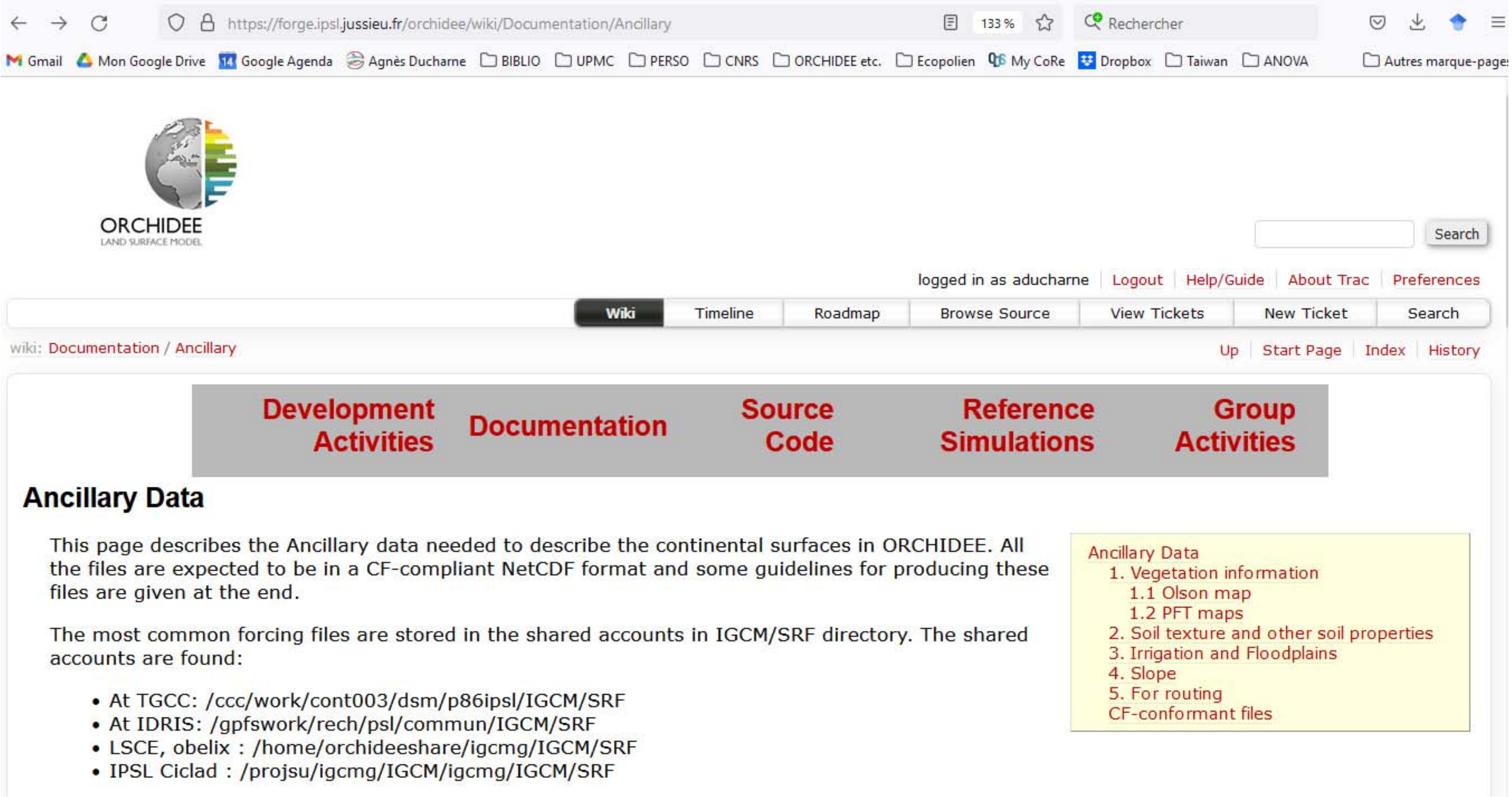
**(2) the increase of Ks towards the surface**

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

**It is externalized as HYDROL_HUMCSTE**

= 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
(for 13 MTCs)

# Which maps are used for hydrology?



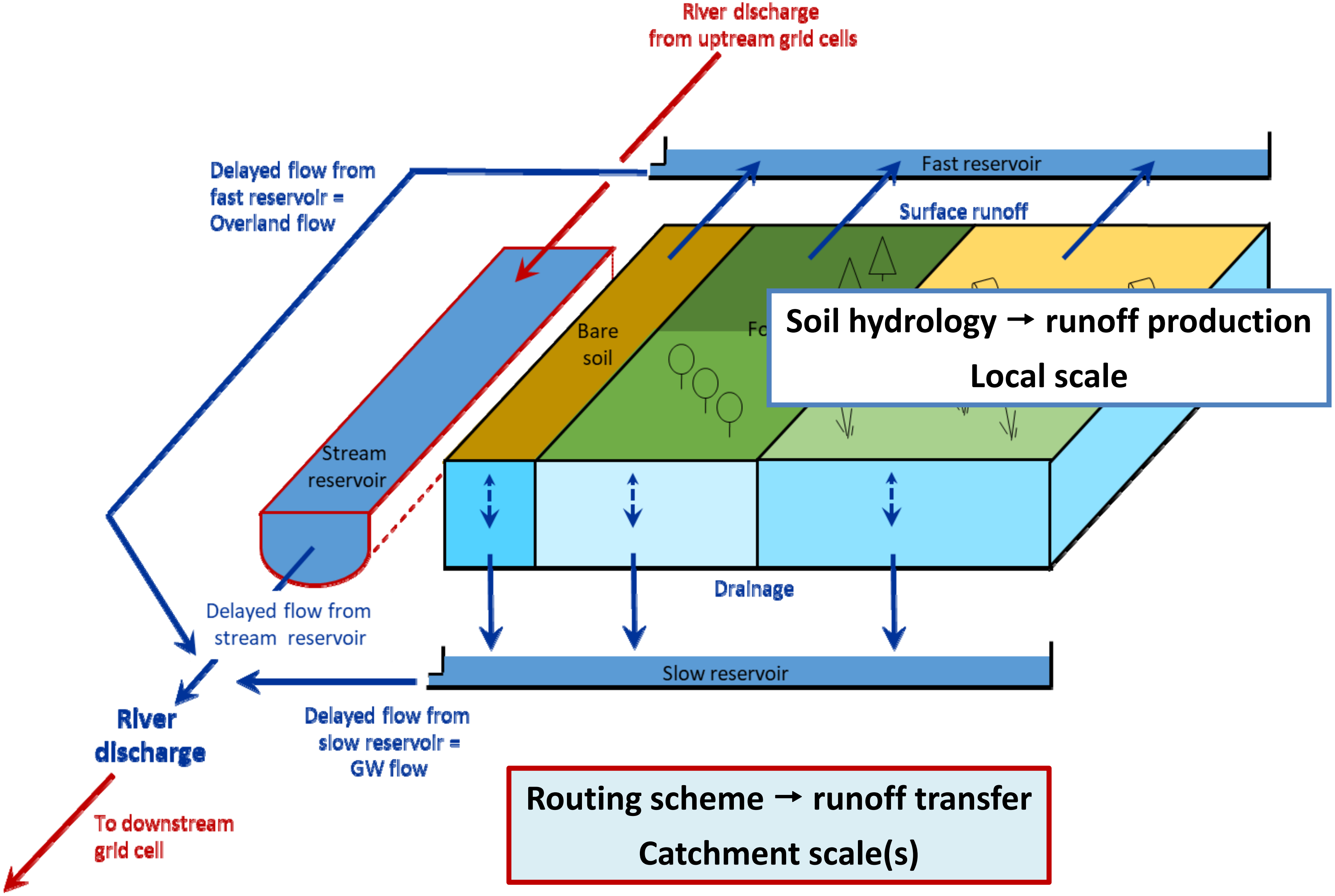
## Ancillary Data

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/SRF
- At IDRIS: /gpfswork/rech/psl/commun/IGCM/SRF
- LSCE, obelix : /home/orchideeshare/igcmg/IGCM/SRF
- IPSL Ciclad : /projsu/igcmg/IGCM/igcmg/IGCM/SRF

# Soil vs « catchment » hydrology



**Soil hydrology → runoff production**

**Local scale**

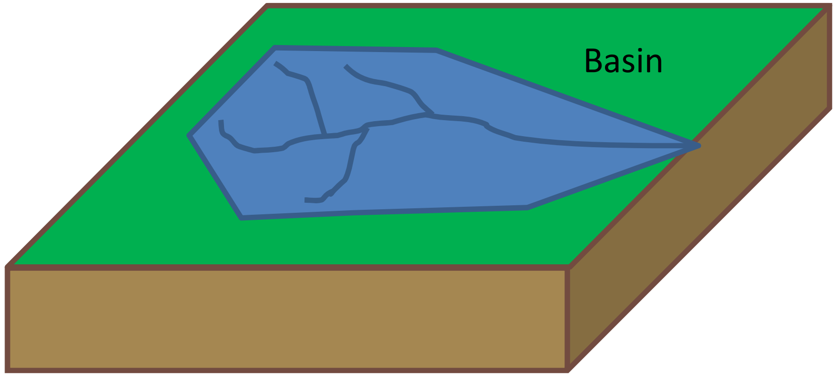
**Routing scheme → runoff transfer**

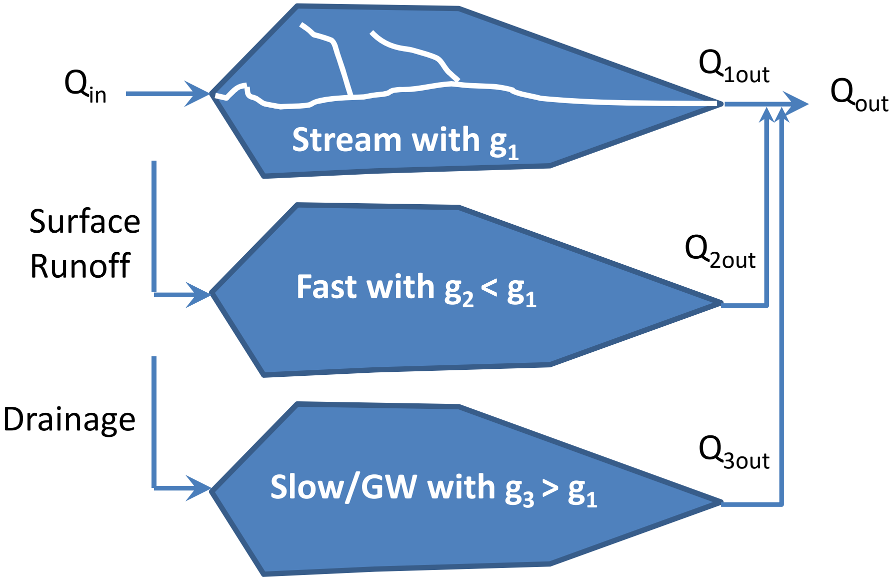
**Catchment scale(s)**

# Overview of the standard version

## Separate basins/HTUs in each grid-cell

### with 3 reservoirs for streams, hillslopes and GW

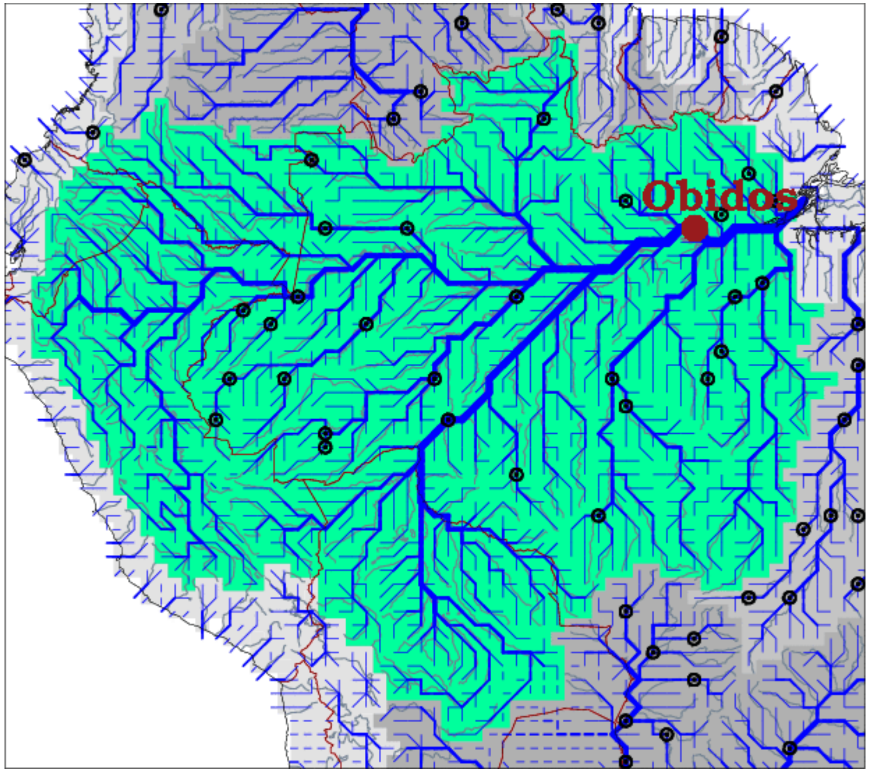




**Residence times $\tau_i = g_i \Delta x / \sqrt{slope}$**

## Cascade of stream reservoirs

### along the river network

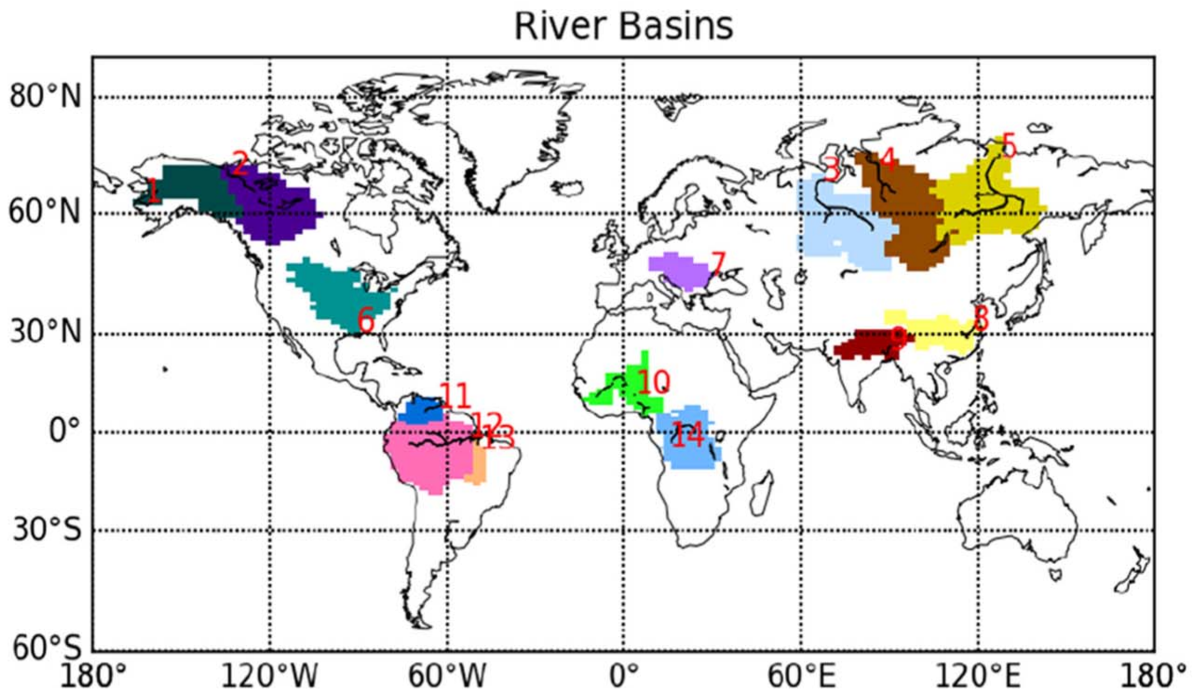


River network based on 0.5° topography

Polcher 2003 ; Ngo-Duc et al. 2007 ; Guimberteau et al., 2012

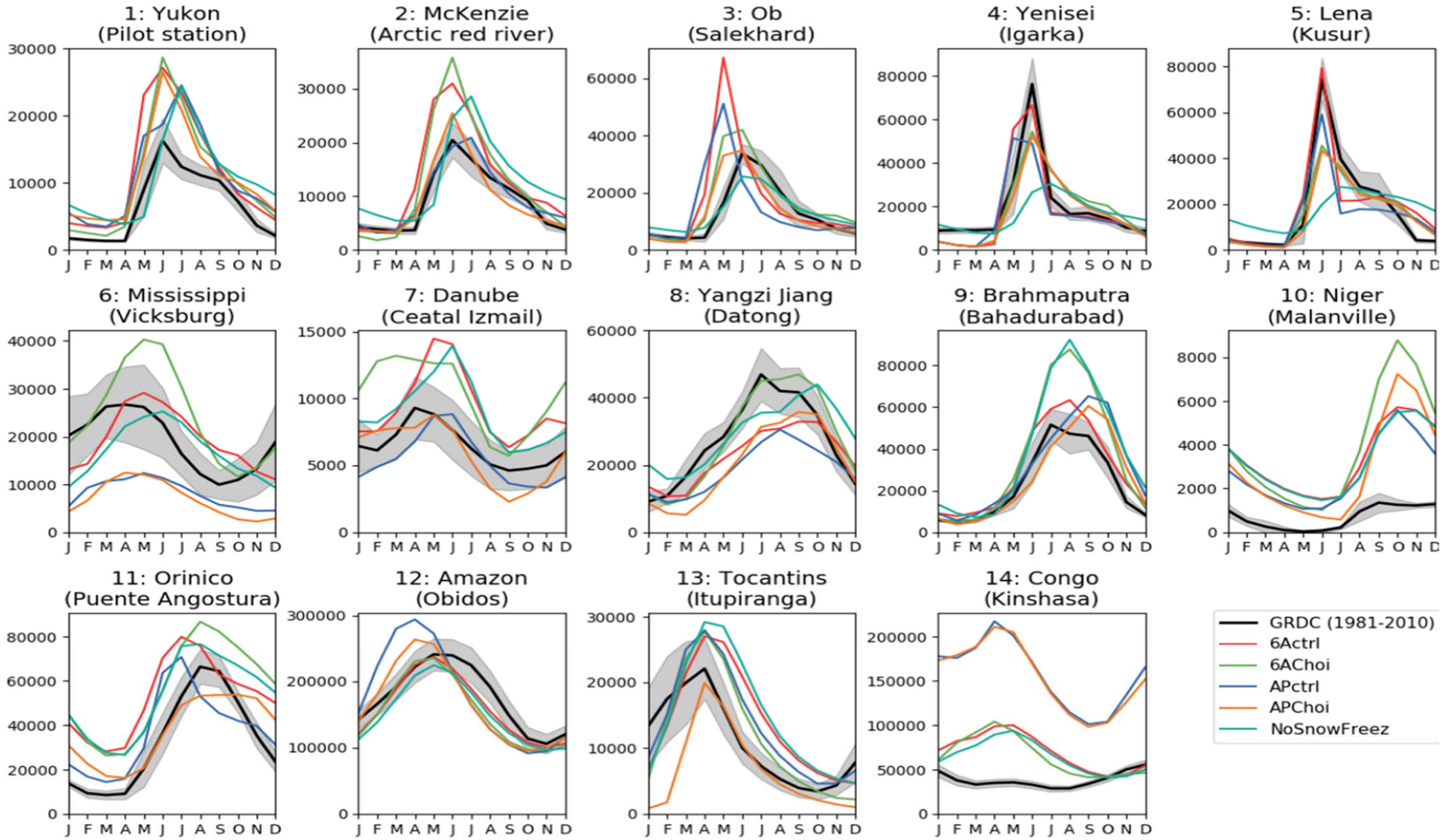
# Results for CMIP6

- Land-atmosphere simulations over 1981-2010 with prescribed SST from AMIP
- Resolution 144 x 143 (2.5x1.25°) x 79
- Comparison of IPSL-CM6A (6Actrl) to IPSL-CM5 (APchoi) and other configurations
- River discharge at the outlet of 14 major river basins against observed record (GRDC)



Cheruy et al., 2020

# 4. A glance at the routing scheme



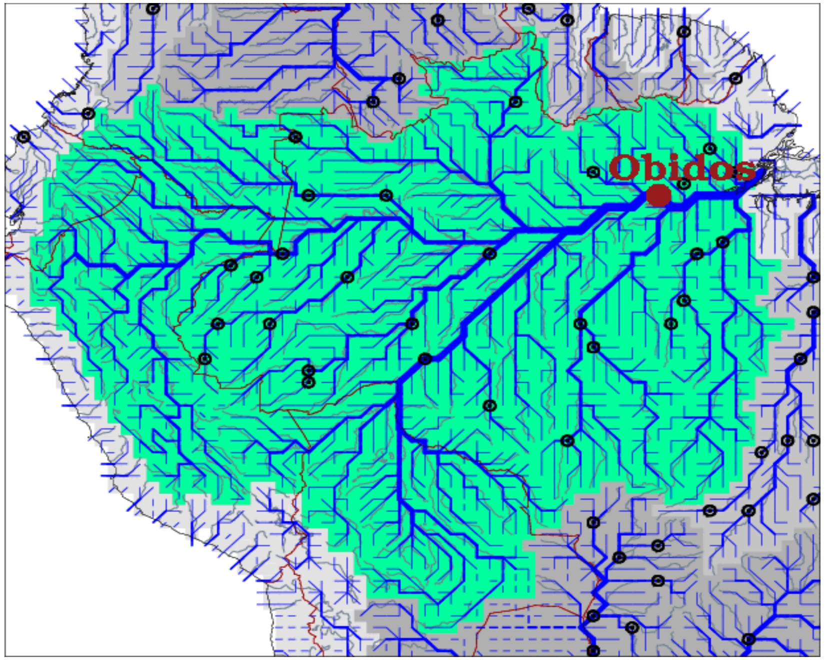
Improvement of **simulated discharge** from IPSL-CM6A (6Actrl) to IPSL-CM5 (APchoi) in most river basins

Mostly related to improvements of simulated precipitation

+ Freezing in Yenisei and Lena

# Work in progress for a higher resolution routing

River network based on
**0.5° topography**



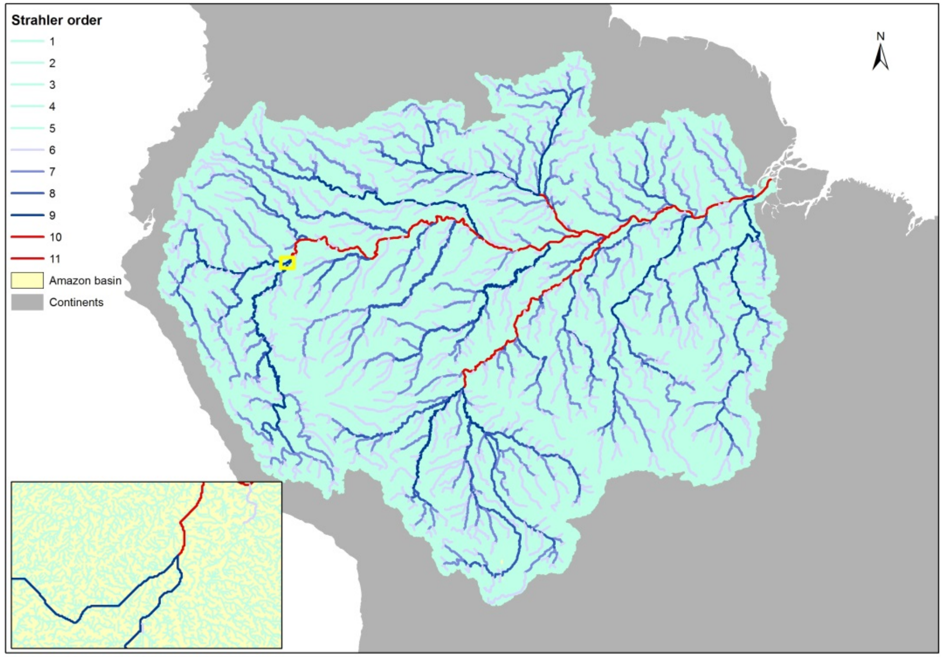
**Trunk or Branch 2.2**

Only valid if ORCHIDEE resolution ≥ 0.5°

**Residence times in the three reservoirs**
By default, independent from ORCHIDEE resolution
But can be defined in run.def

**Options for irrigation and flooding**

Higher resolution river network based on
**HydroSHEDS (1 km) or MERIT-Hydro (2km)**



**Branch 2.2**

2 different versions of the routing scheme able to deal with the high resolution topography

EVALUATION WORK IN PROGRESS
before merge in the trunk

# Soil hydrology in a nutshell

- **During a time step, the soil hydrology scheme :**
  - Updates the soil moisture as a function of precipitation and evapotranspiration
  - 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
  - Lots of debugging over the past years
- **You can adapt the behavior of the soil hydrology 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!)
- **Routing scheme OK for resolutions ⩾ 0.5°**
  - More infos on the slides of M. Guimberteau, Training of 2016