An introduction to SURFEX externalized surface scheme

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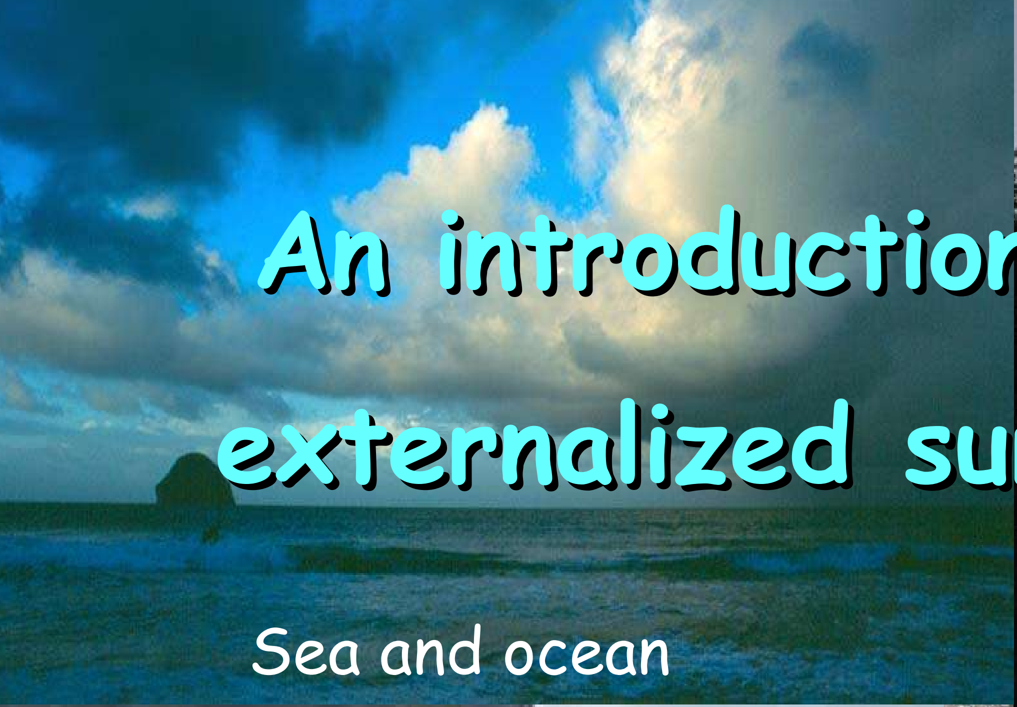


Objectives

→ **Simulate Exchanges between surface and atmosphere**

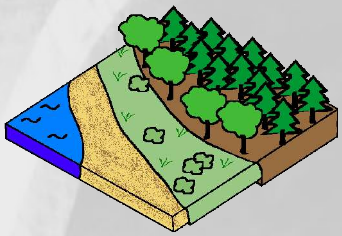
(momentum, heat, water, CO2, chemical species)

→ **Separate the surface schemes from the atmospheric model**

- allows to use **the same** surface code for several atmospheric models and Offline runs

(AROME, MESONH, ALADIN, ARPEGE, …)

- easy switch between surface schemes and options



→ **Both simple schemes and up-to-date ones,** including:

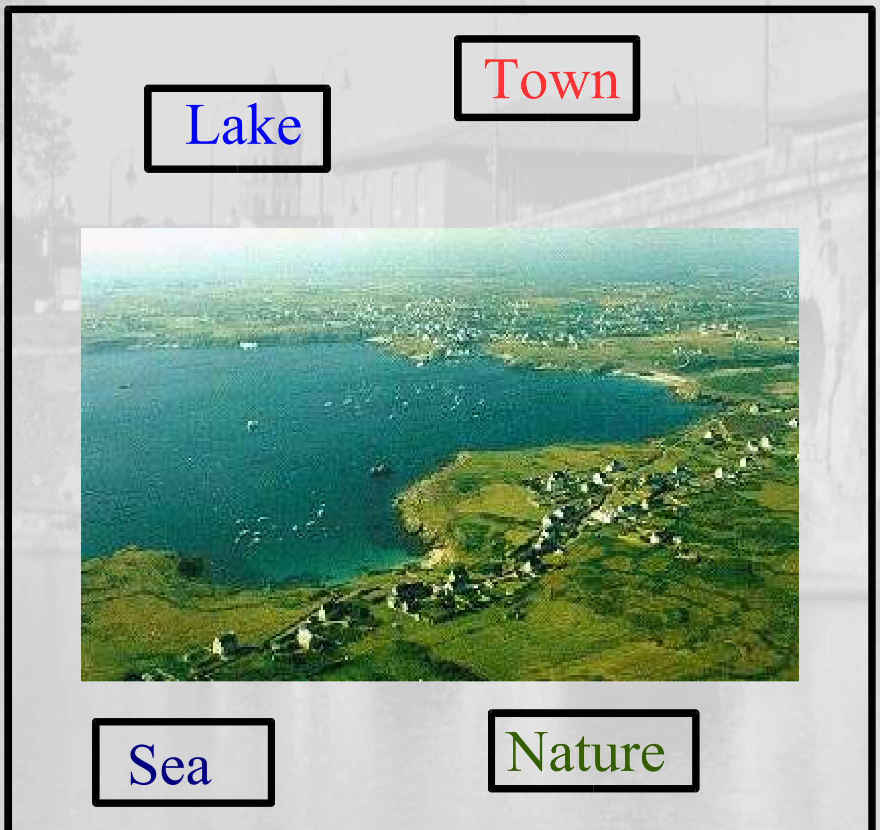
- imposed fluxes for « ideal » cases
- tiling : 4 surfaces (sea, lakes, town, vegetation) in the grid mesh
- tiling (patches) in the vegetation scheme itself : forest, grass, etc.

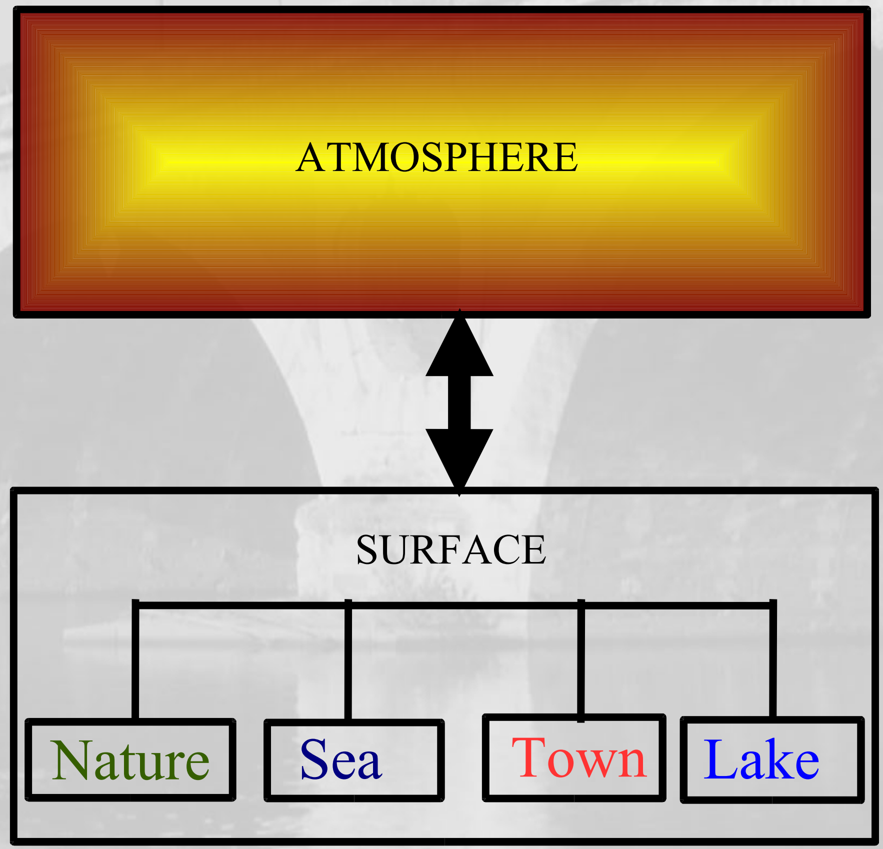
SURFEX : the externalized surface

- Initialisation or physiographic fields
  - Ecoclimap
  - Prescribed by user (**soon**)
- Initialisation of variables
  - From several file format
- Run
- Diagnostics

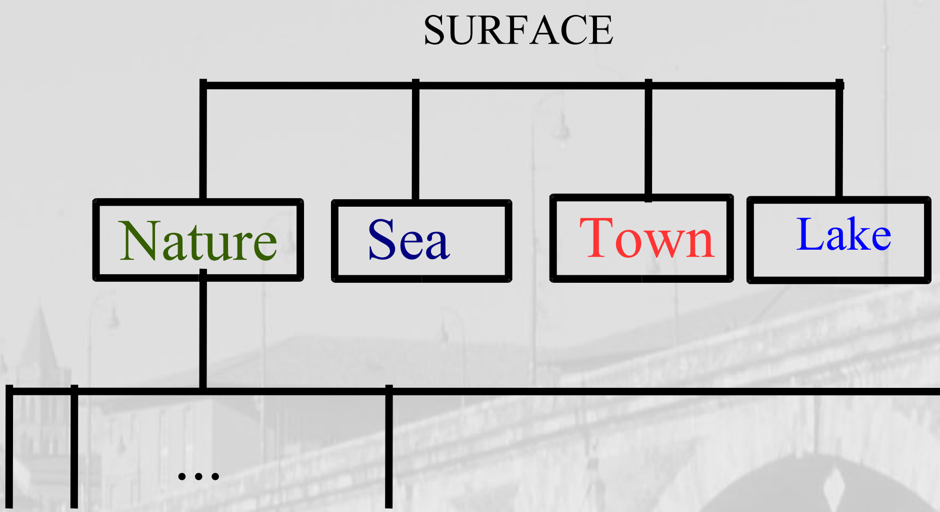
The externalized surface

- 4 surface types : **the tiles**





The Nature surface is divided in patches



1: bare ground
2: rocks
3: permanent snow
4: needle leaf trees
5: evergreen broadleaf trees
6: deciduous broadleaf trees

7: C3 crops
8: C4 crops
9: irrigated crops
10: herbaceous
11: natural herbaceous (tropics)
12: gardens

The Physical schemes




Sea and ocean :
prescribed SST, Charnock formula
→ will soon include a better bulk formulation
→ project to implement a 1D oceanic mixing layer

Lakes :
prescribed temperature, Charnock formula

Vegetation and soil : ISBA
(Interface Soil Biosphere Atmosphere)

Town : TEB
(Town Energy Balance)

ISBA : general

Simulates: exchanges of heat , water, and CO_2
soil and vegetation temperature,
soil liquid water and ice
snow

1 to 12 patches (number of patches is user's choice)

Exemples:
1 patch = **classical aggregated scheme**
3 patches = 1 patch bare soils
+ 1 patch low vegetation
+ 1 patch trees
12 patches = flat bare soil + rocks + perm. snow
+ C3, C4 and irrigated crops, C3, C4 and irrigated grass
+ evergreen and deciduous broadleaf trees, needleaf trees

ISBA : physics

ISBA:

Soil options: Force restore, 2 layers , temp, water, ice
Force restore, 3 layers , temp, water, ice
Diffusion, N layers , temp, water, ice

Vegetation options:
Noilhan and Planton 89 (~Jarvis)
AGS (photsynthesis and CO2 exchanges)
AGS and interactive vegetation

Hydrology options:
no subgrid process
subgrid runoff, subgrid drainage

Snow options:
1 layer, varying albedo, varying density (Douville 95)
3 layers, albedo, density, liquid water in snow pack (Boone and Etchevers 2000)
operational ARPEGE scheme (soon)

TEB:

Canyon approach:
detailed radiation scheme (trapping – shadow effect)
heat storage in buildings

ISBA FR 2L : Force Restore / 2 soil layers

The original version (Noilhan and Planton,1989, Noilhan and Mahfouf,1996)

- Five prognostic variables for soil+vegetation

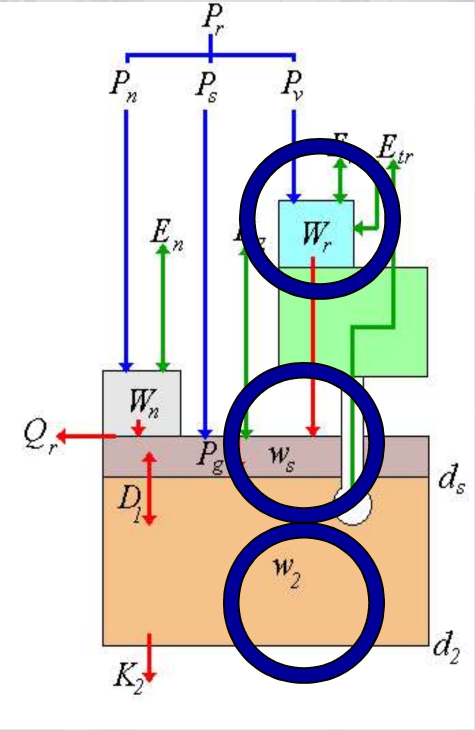
$$\frac{\partial T_s}{\partial t} = C_T(R_n - H - LE) - \frac{2\pi}{\tau}(T_s - T_2)$$

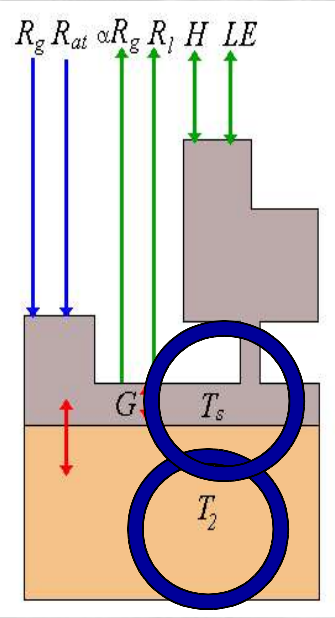
$$\frac{\partial T_2}{\partial t} = \frac{1}{\tau}(T_s - T_2)$$

$$\frac{\partial w_g}{\partial t} = \frac{C_1}{\rho_w d_1}(P_g - E_g) - \frac{C_2}{\tau}(w_g - w_{geq})$$

$$\frac{\partial w_2}{\partial t} = \frac{1}{\rho_w d_2}(P_g - E_g - E_{tr}) - \frac{C_3}{d_2\tau}\max\left[0.,(w_2 - w_{fc})\right]$$

$$\frac{\partial W_r}{\partial t} = vegP - (E_v - E_{tr}) - R_r$$



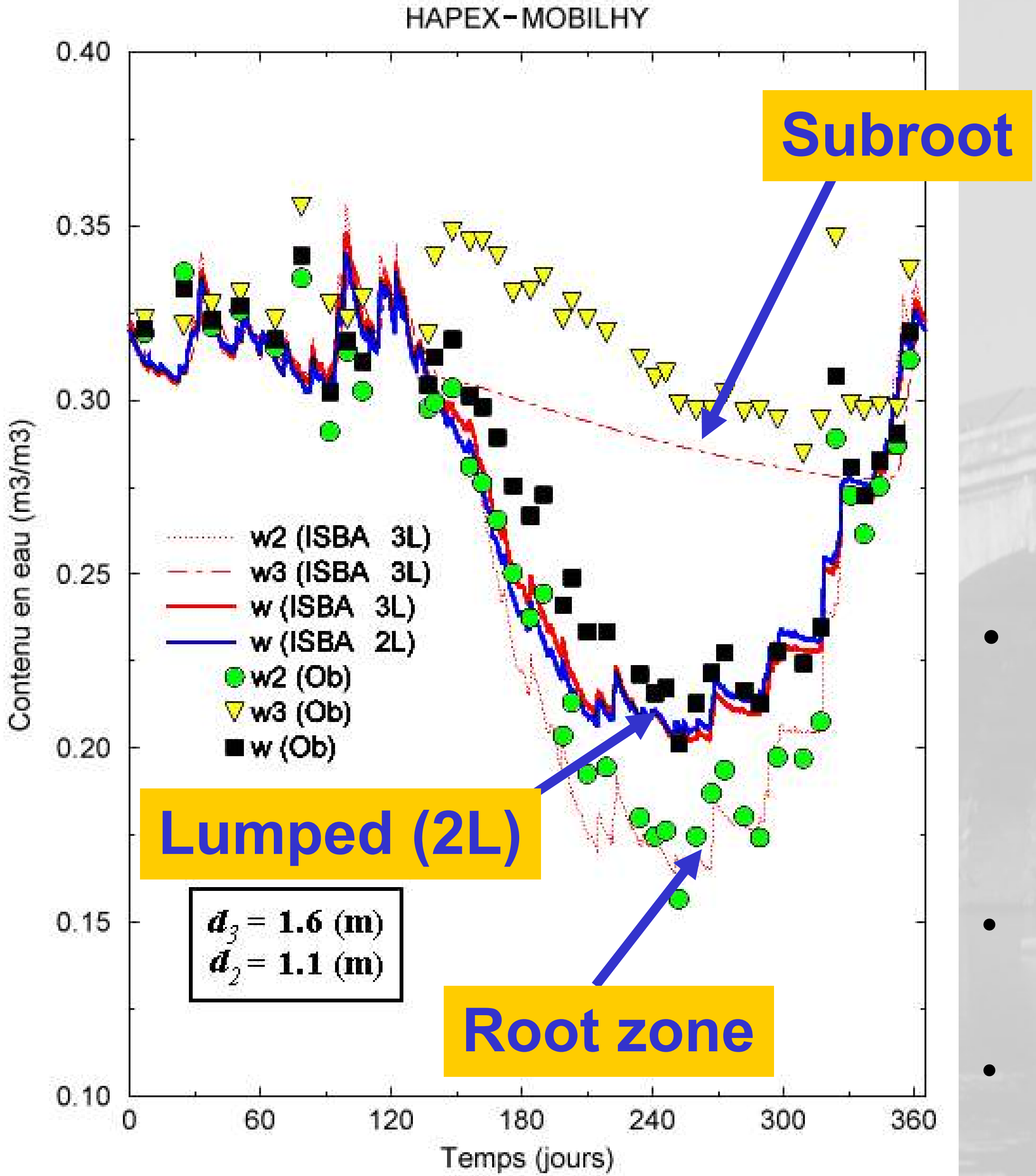


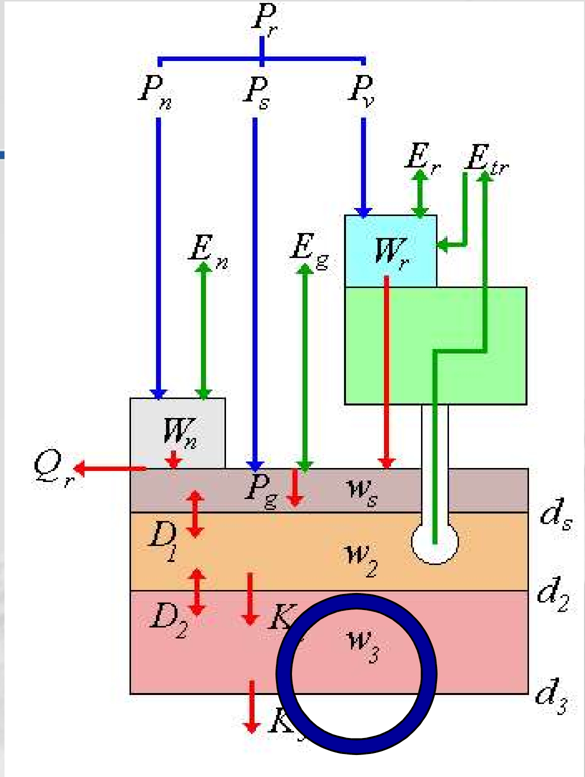
$$0 \le w_g \le w_{sat}$$

$$0 \le w_2 \le w_{sat}$$

$$0 \le W_r \le W_{rsat}$$

ISBA soil option : 3L

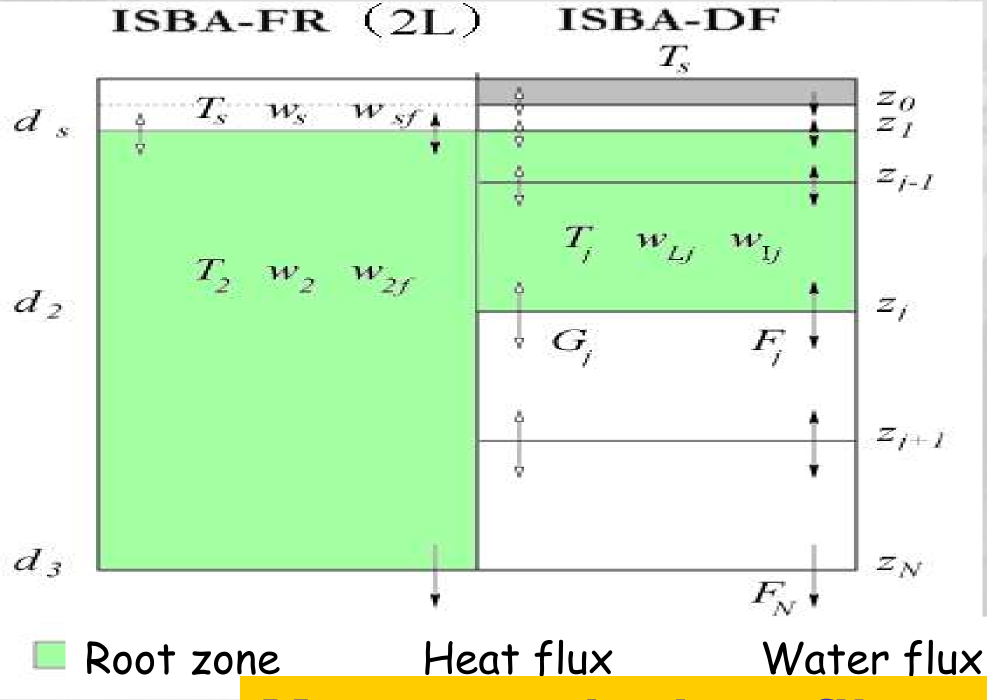


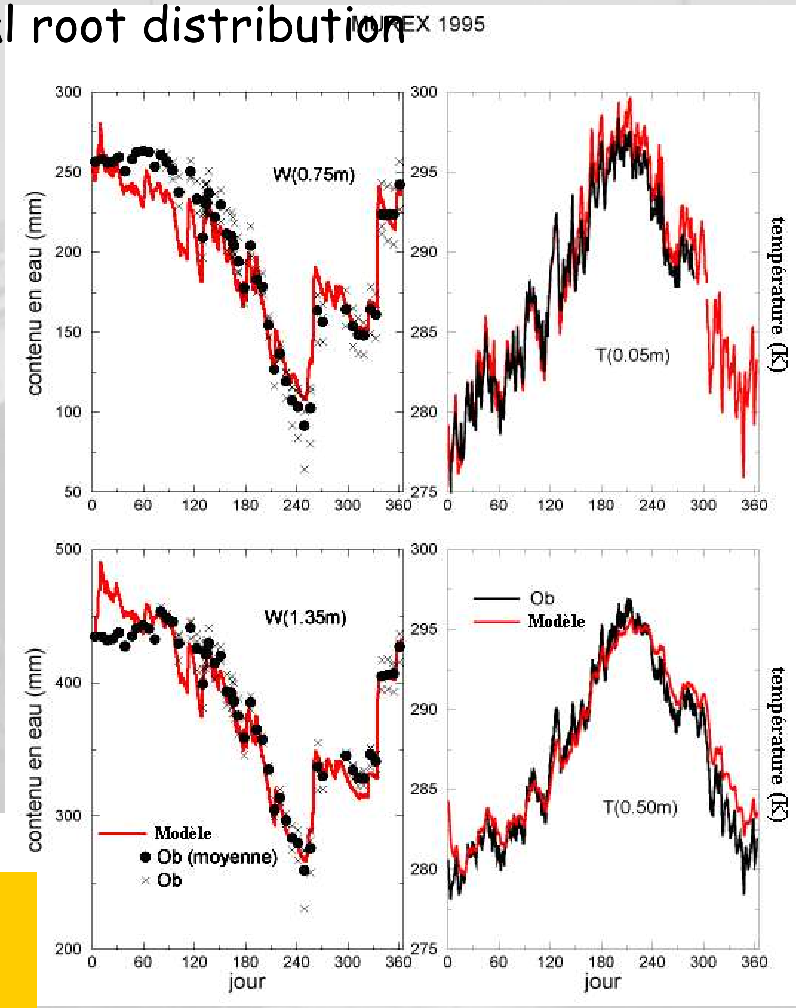


- Reservoirs :
  - Surface
  - Root zone
  - Subroot zone
- Improved simulation of soil water content
- Boone et al, 1999

ISBA soil option : diffusion : DF

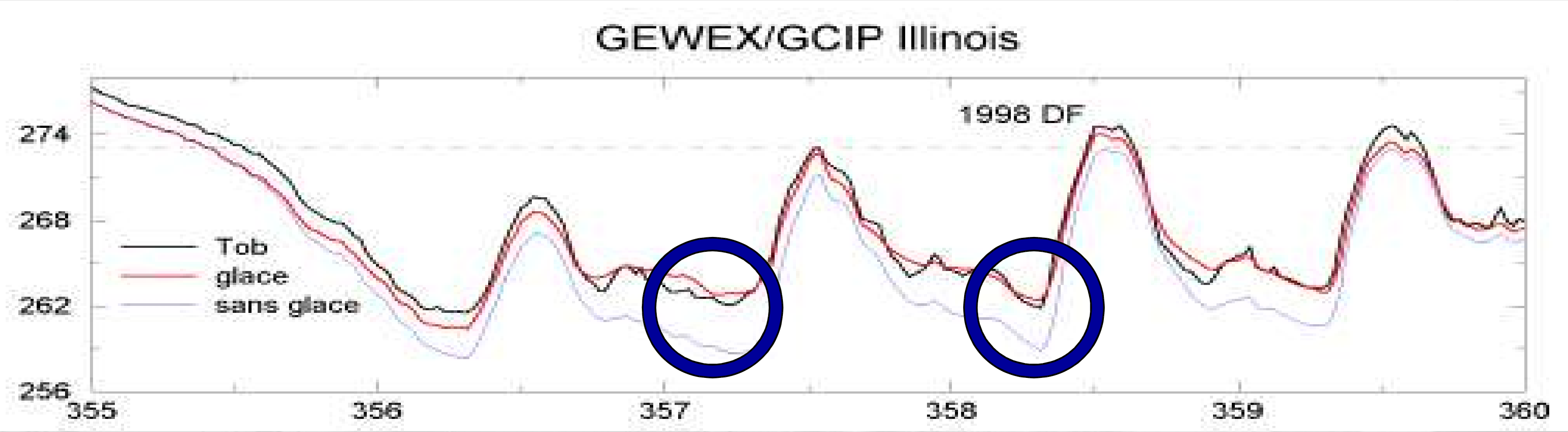
- diffusion equations for heat and water
- temperature, liquid water, ice in the same layers
- possibility of soil texture profile; vertical root distribution





Murex vertical profiles of water and temperature

ISBA soil option (DF and FR) : soil ice model



- Boone et al, 2000, as Giard and Bazile 2000 in ARPEGE/ALADIN
- Force restore coefficients modified according to icing/thawing of the soil layers
- Improved simulation of surface temperature (release of latent heat when the soil freeze)

ISBA : physics

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operational ARPEGE scheme (soon)

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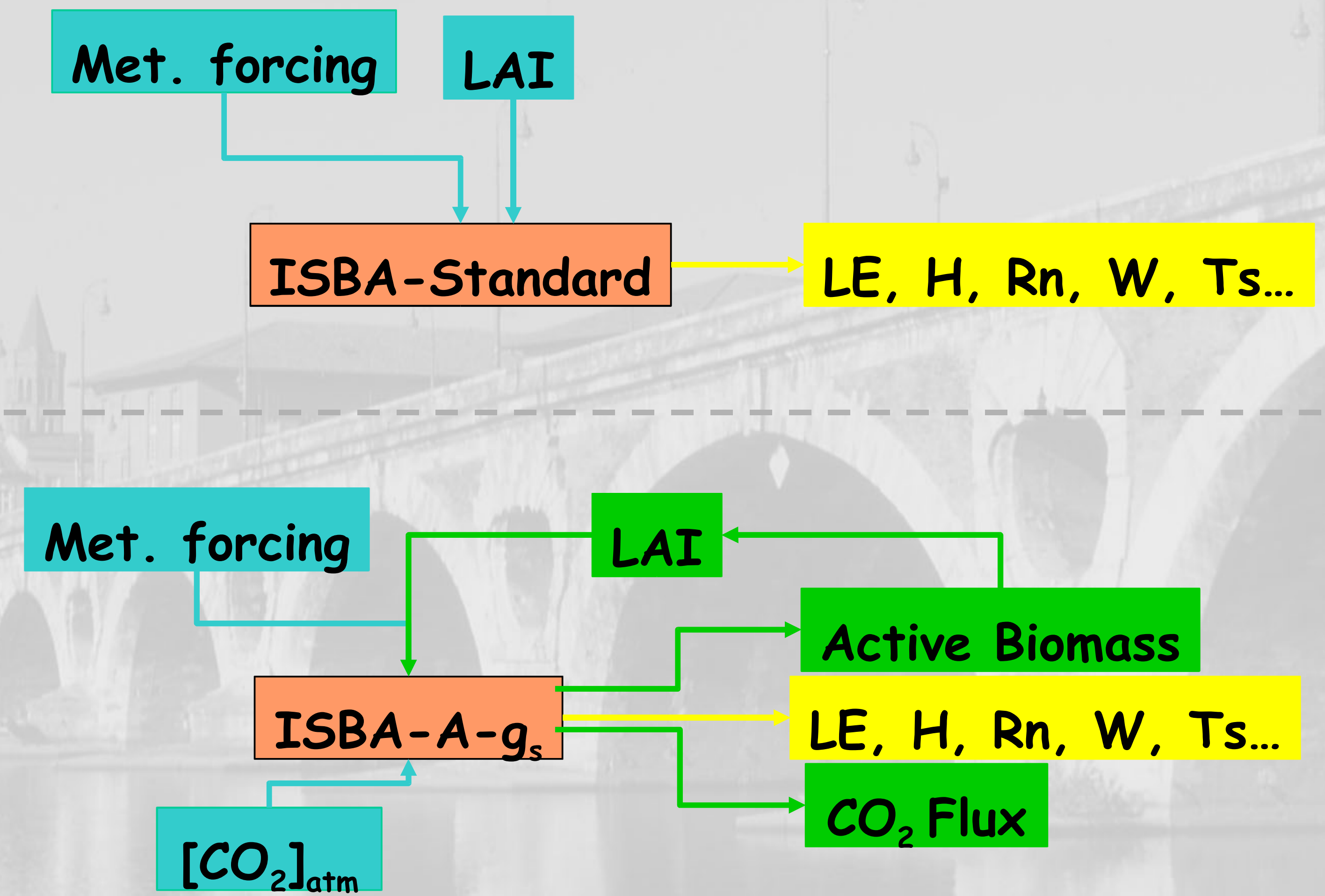
ISBA vegetation options : Jarvis, A-gs



(Calvet et al, 1998)

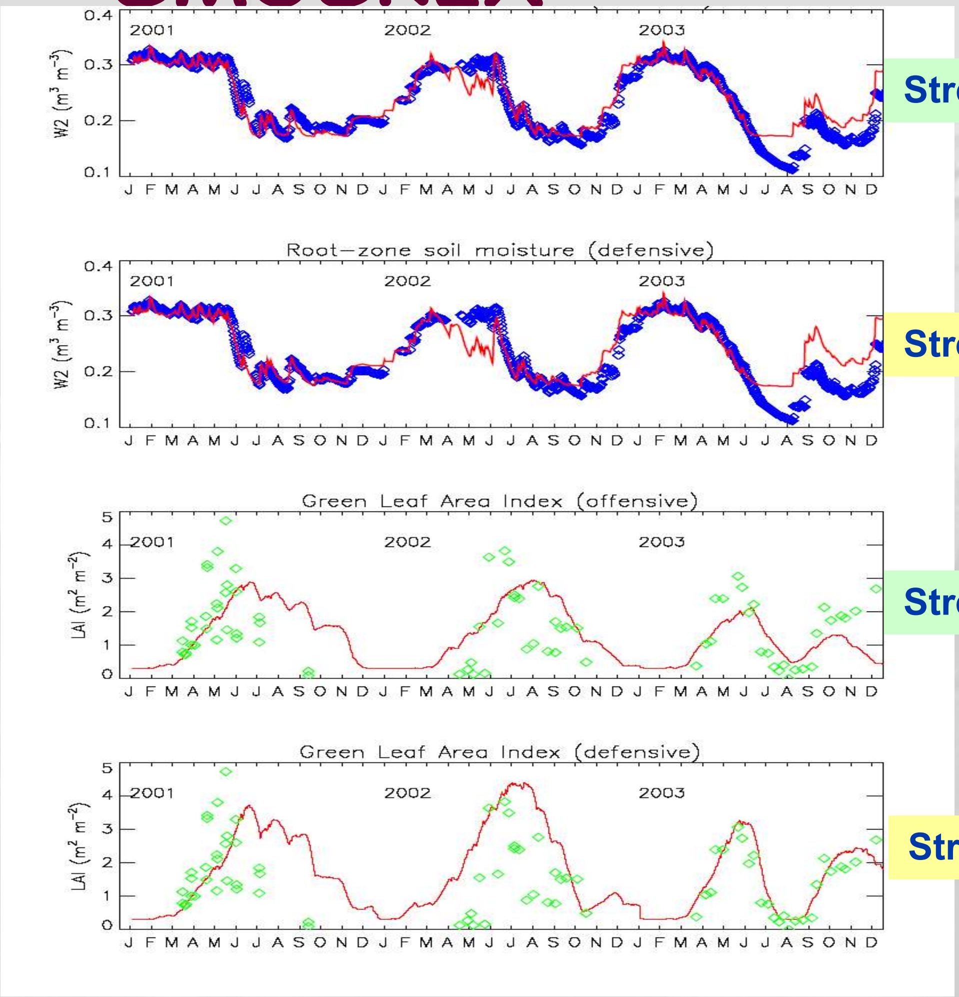
ISBA vegetation options : A-gs

SMOSREX

Root-zone soil moisture:

ISBA-A-gs simulations from 2001 to 2003

LAI:



Stress tolerant

Stress avoiding

Stress tolerant

Stress avoiding

(J. Munoz Sabater)

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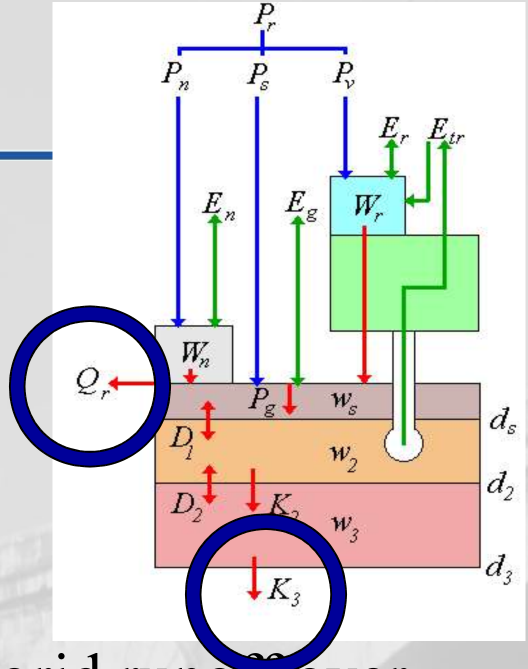
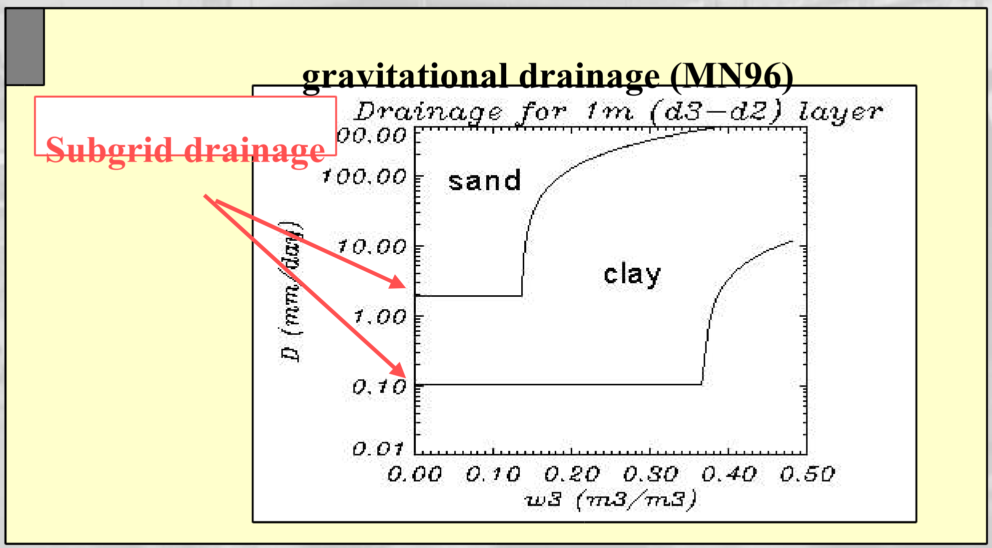
ISBA : hydrology options

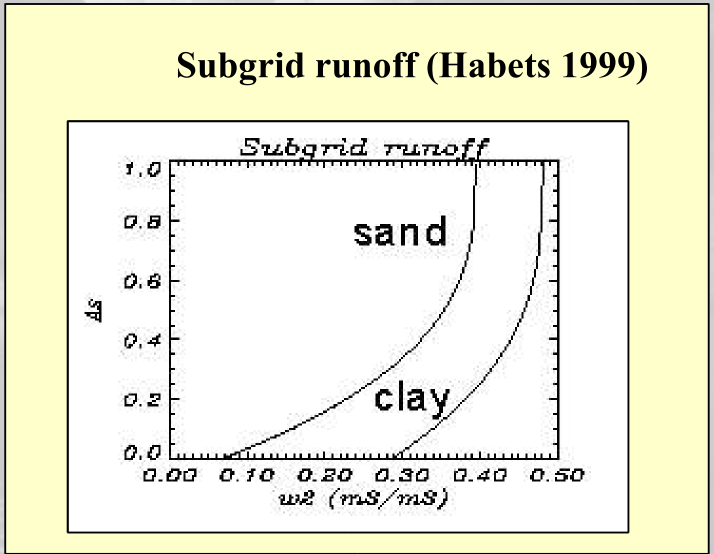
- Surface runoff
- Gravitational drainage



Subgrid gravitational drainage (Noilhan-Mahfouf 96)

Subgrid runoff over saturated areas (Habets 99)





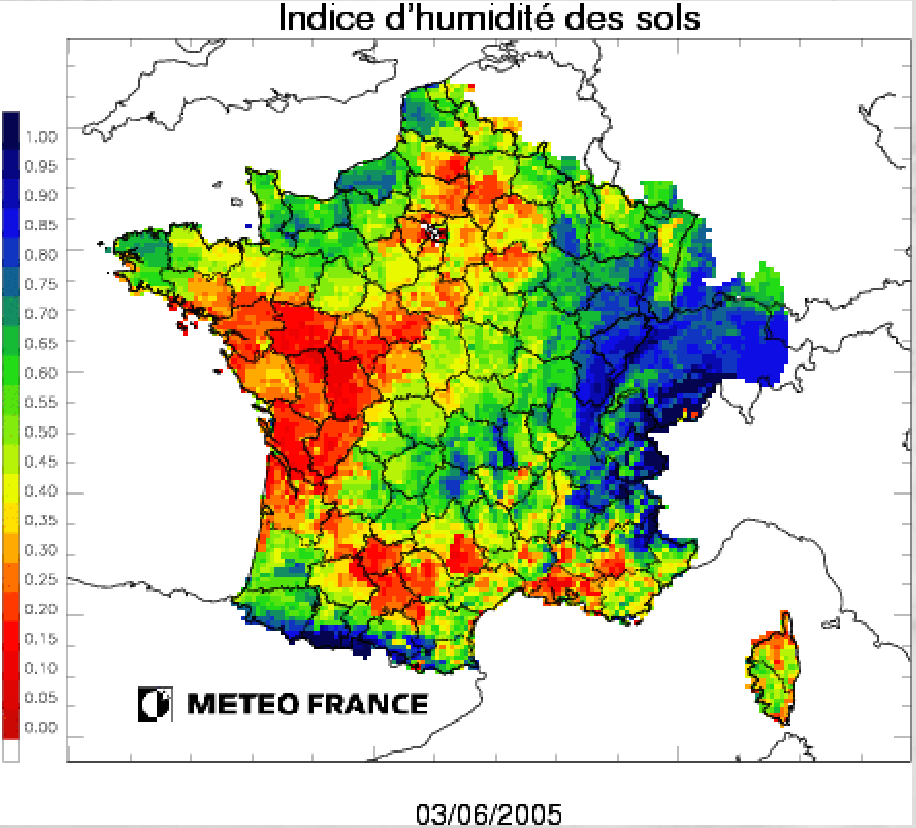
Both depend on soil texture

Results of SIM over France : Water budget monitoring

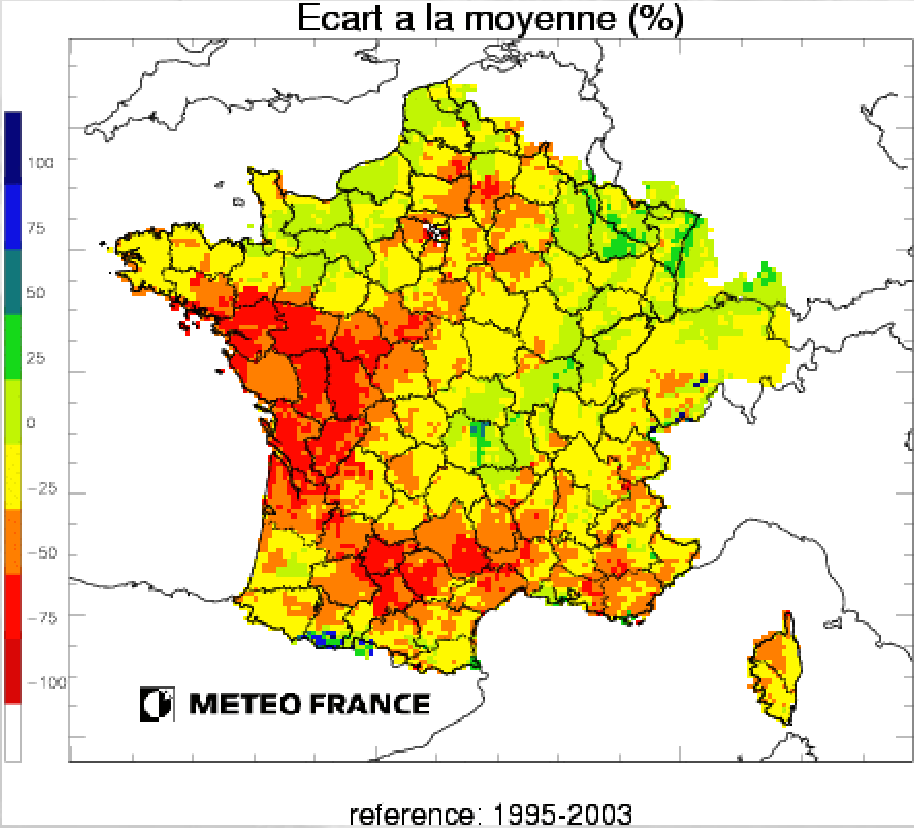
Simulation of the soil wetness index:

$$SWI = \frac{w_2 - w_{wilt}}{w_{fc} - w_{wilt}}$$

3june 2005



Deviation from 1995-2003 mean

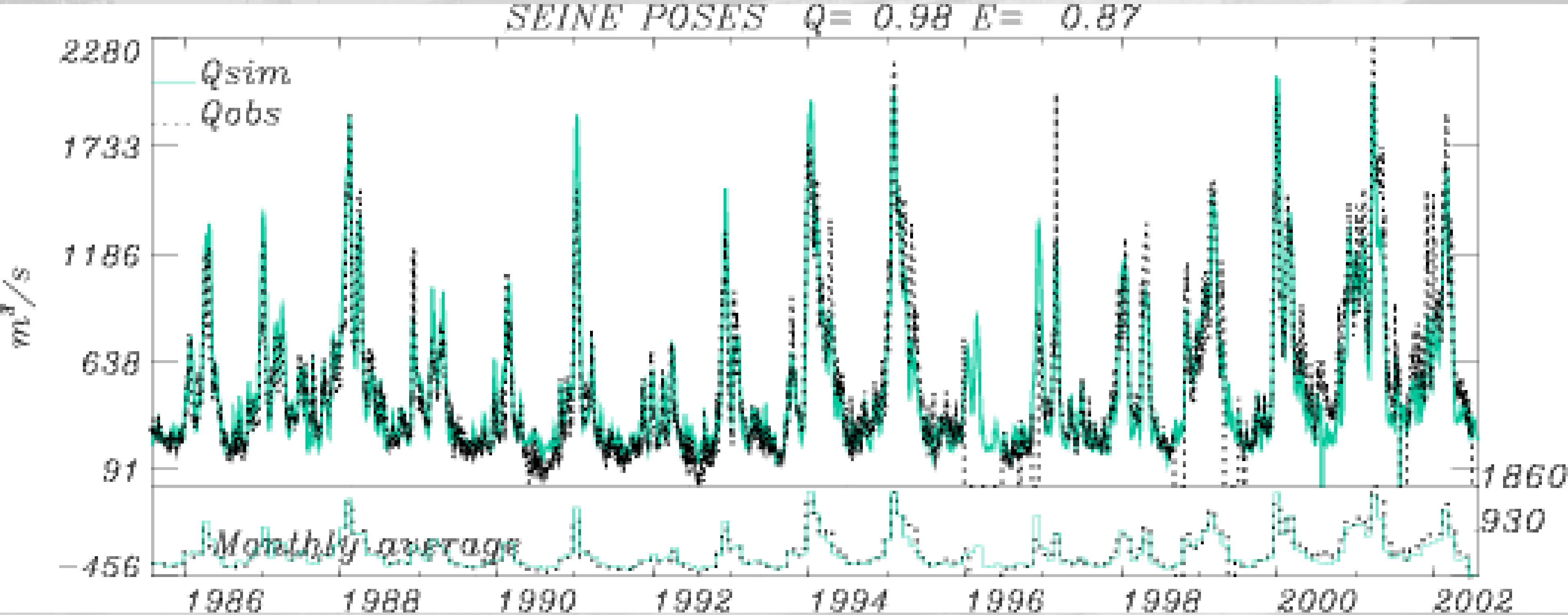


Application in hydrology : River discharge

- ISBA coupled with the hydrological model MODCOU

16 years of simulated discharge

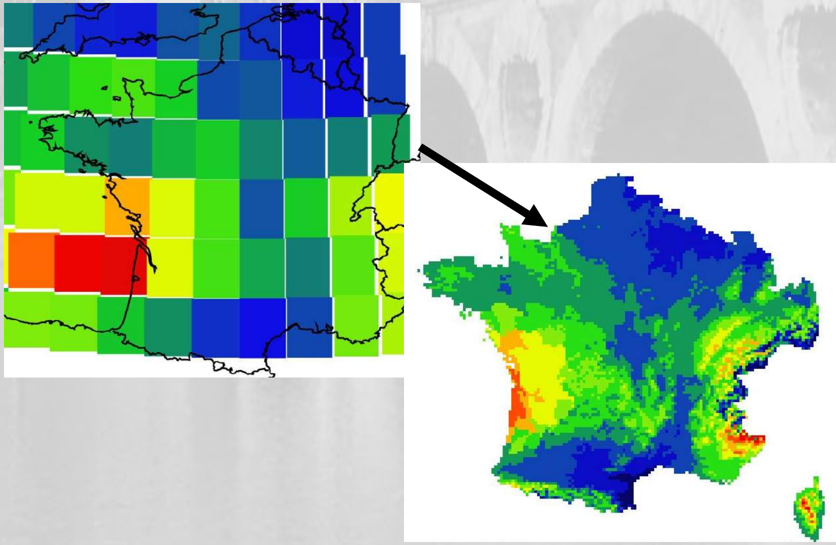
Seine at Poses (outlet)



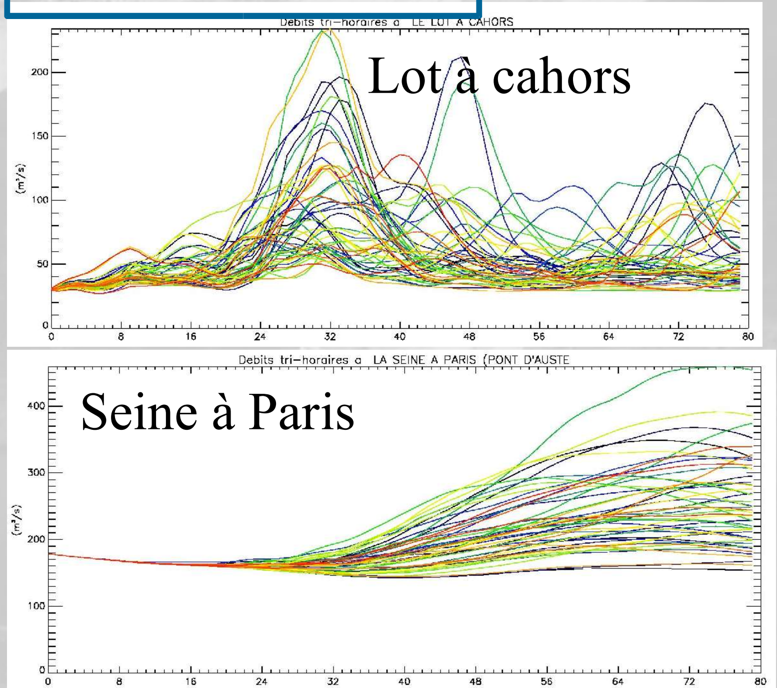
Hydrological applications : Ensemble forecast

- ECMWF ensemble forecasts (precipitation, température)
- Désagegation
- SIM runs

Spatial desaggregation



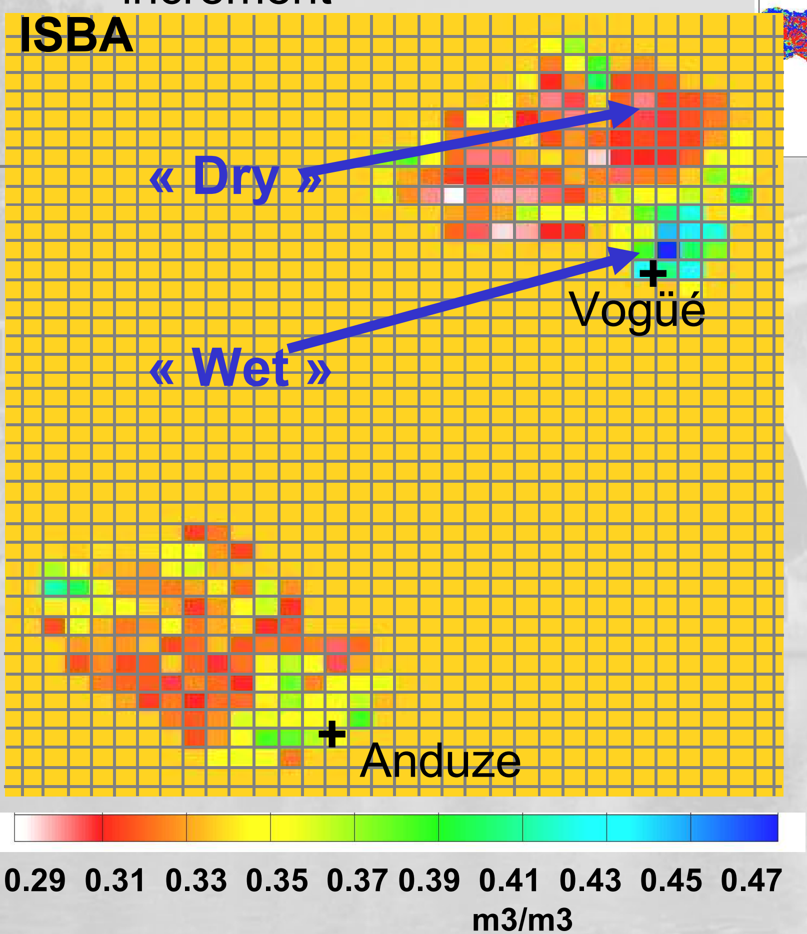
Ensemble discharge

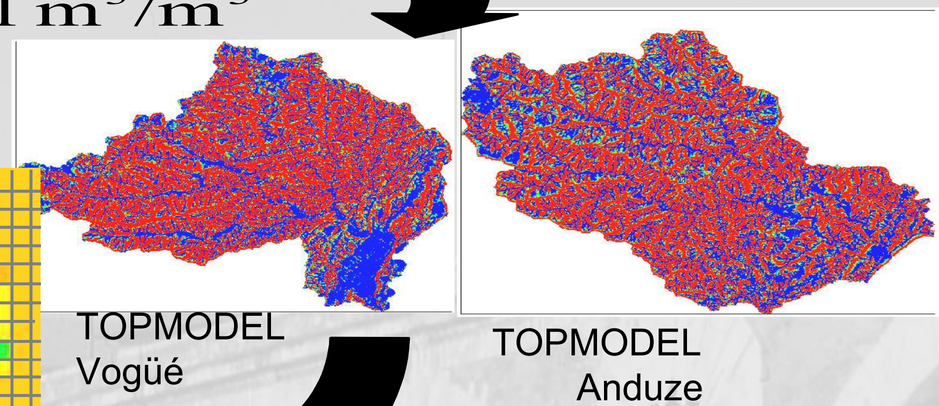


Applications in hydrology : lateral redistribution in catchments

$$Wg(t_0) = 0.25\ \mathrm{m^3/m^3}$$
$$+\Delta Wg = 0.01\ \mathrm{m^3/m^3}$$

incrément





- TOPMODEL is used to redistribute liquid water in catchments
- Will be coupled in surfex and tested in MésoNH
- Impact on convective precipitation ?

(Katia Chancibault)

ISBA : physics

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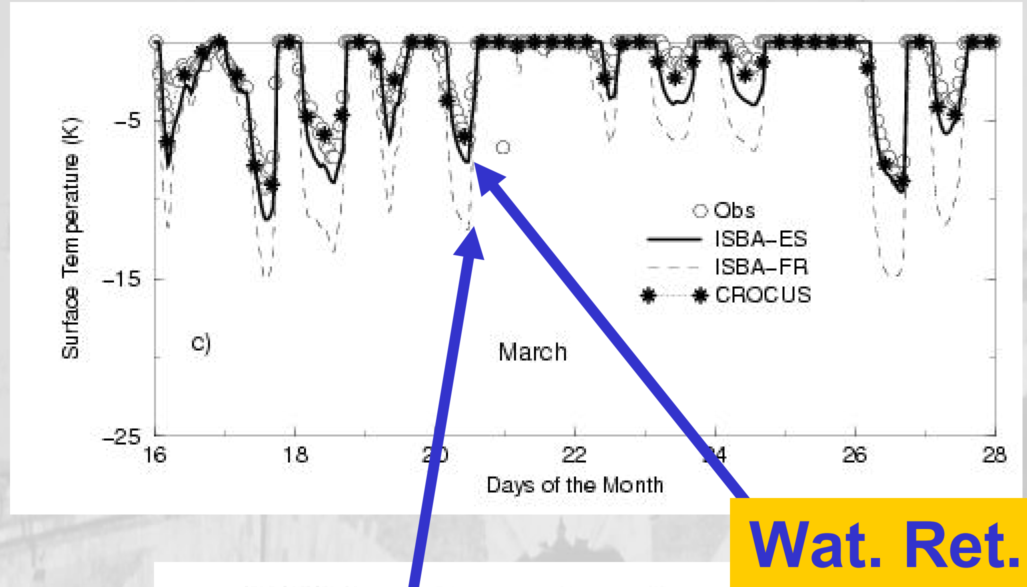
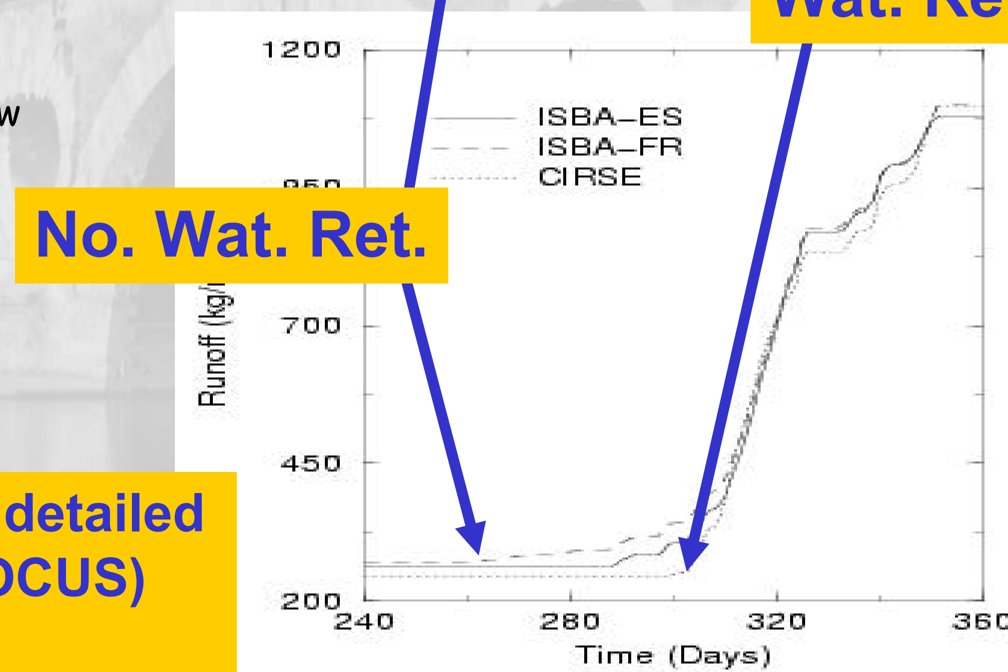
SNOW schemes

- 1 layer model :
  - 1 layer, varying albedo, varying density
  - (Douville 1995)
- 3 layer model : ES
  - 3 layers, albedo, density, snow heat and liquid water in snowpack
  - 3 prognostic variables : thickness of each layer, snow density, snowpack heat content
  - Diagnostic variables : snow water equivalent, snowpack liquid water, snow layer temperature
  - (Boone and Etchevers 2000)
- ARPEGEALADIN operational scheme **soon !**
  - Current work of Andrey Bogatchev





Comparison with detailed snow model (CROCUS) and observations

ISBA : physics

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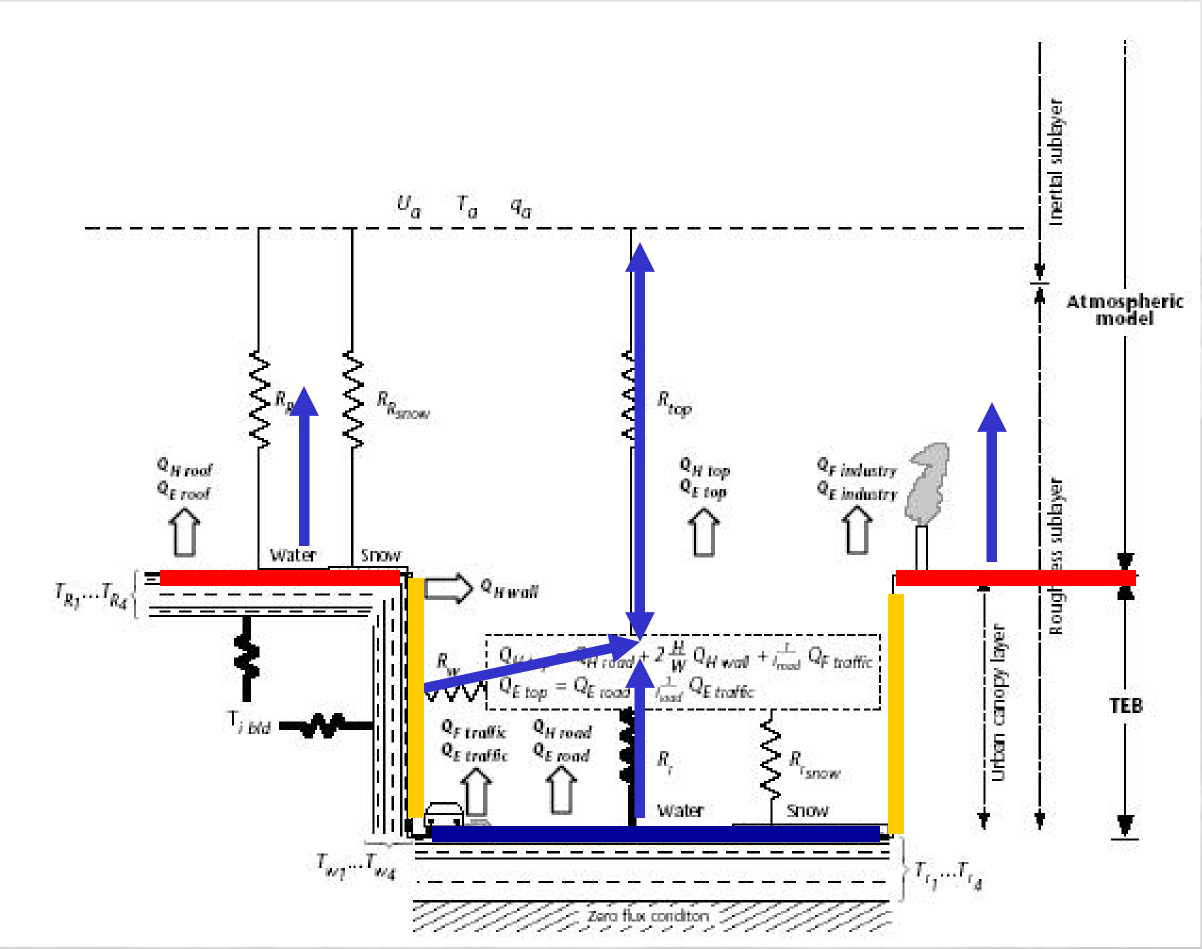
TEB : physics

Masson 2000, Masson et al 2002, Lemonsu et al 2003



- Only 1 road, 1 roof, and 2 *identical* facing walls
  → ONLY ONE WALL SEB
  → Only one wall temp.
  → Only one road temp.

- Rain and snow interception
- Latent heat fluxes
- Heat conduction in the materials
- Anthropogenic fluxes

Conclusion

- **An introduction to SURFEX**
  - Many options for soil, vegetation, hydrology, snow with extensive validations, and tested in MesoNH research model and AROME
  - Tiling / patches
  - Offline, Coupled (implicit, explicit) mode
  - Use of ECOCLIMAP data (▶ P. Le Moigne)

- **Now :**
  - Work to couple SURFEX with ALADIN/ ARPEGE in a configuration close to the present surface scheme (▶ D. Giard).
  - Implicit coupling (▶ P. Le Moigne), not all options available in implicit mode (DF , snowES, TEB)

- **In the future :** many opportunities to test the various options in the ALADIN, AROME and ARPEGE configurations and improve the physics