SURFEX

Meso-NH
mesoscale non-hydrostatic model

Tutorial

Stéphanie Faroux &
Patrick Le Moigne

METEO FRANCE
cnrs dépasser les frontières

Universidade de Évora
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Compiled and Presented by:
Rui Salgado

ICT Instituto de Ciências da Terra
Institute of Earth Sciences

UNIVERSIDADE DE ÉVORA
ESCOLA DE CIÊNCIAS E TECNOLOGIA

ALOP
Alentejo Observation and Prediction systems

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An introduction to **SURFEX**

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METEO FRANCE
Toujours un temps d'avance

Outline

- Introduction – main principles
- Physics
- Description of the surface (tiles – patches – databases)
- Interface with the atmosphere
- Running SURFEX

Main Principles

Let's begin, what is SURFEX ?

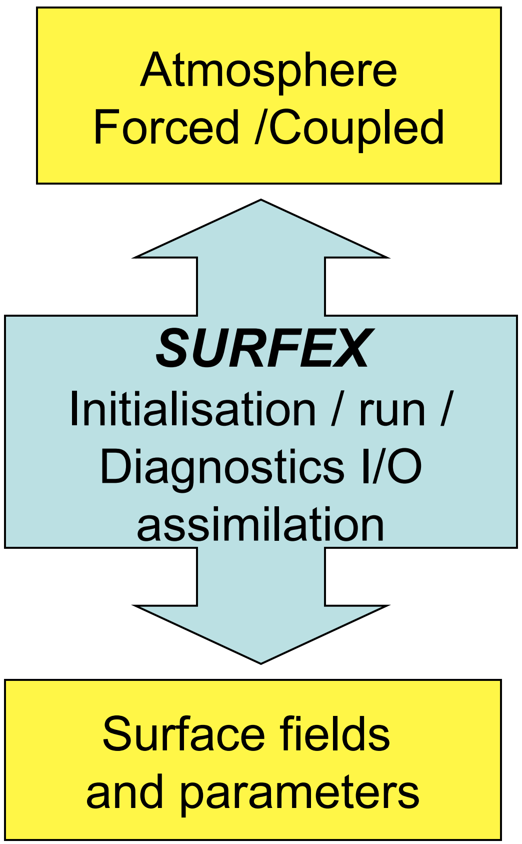
SURFEX means « surface externalisée »

SURFEX is a code that represents the surface processes.

SURFEX is « externalized », this means that the code can be used inside a meteorological or climate model, or in stand alone (offline) mode.

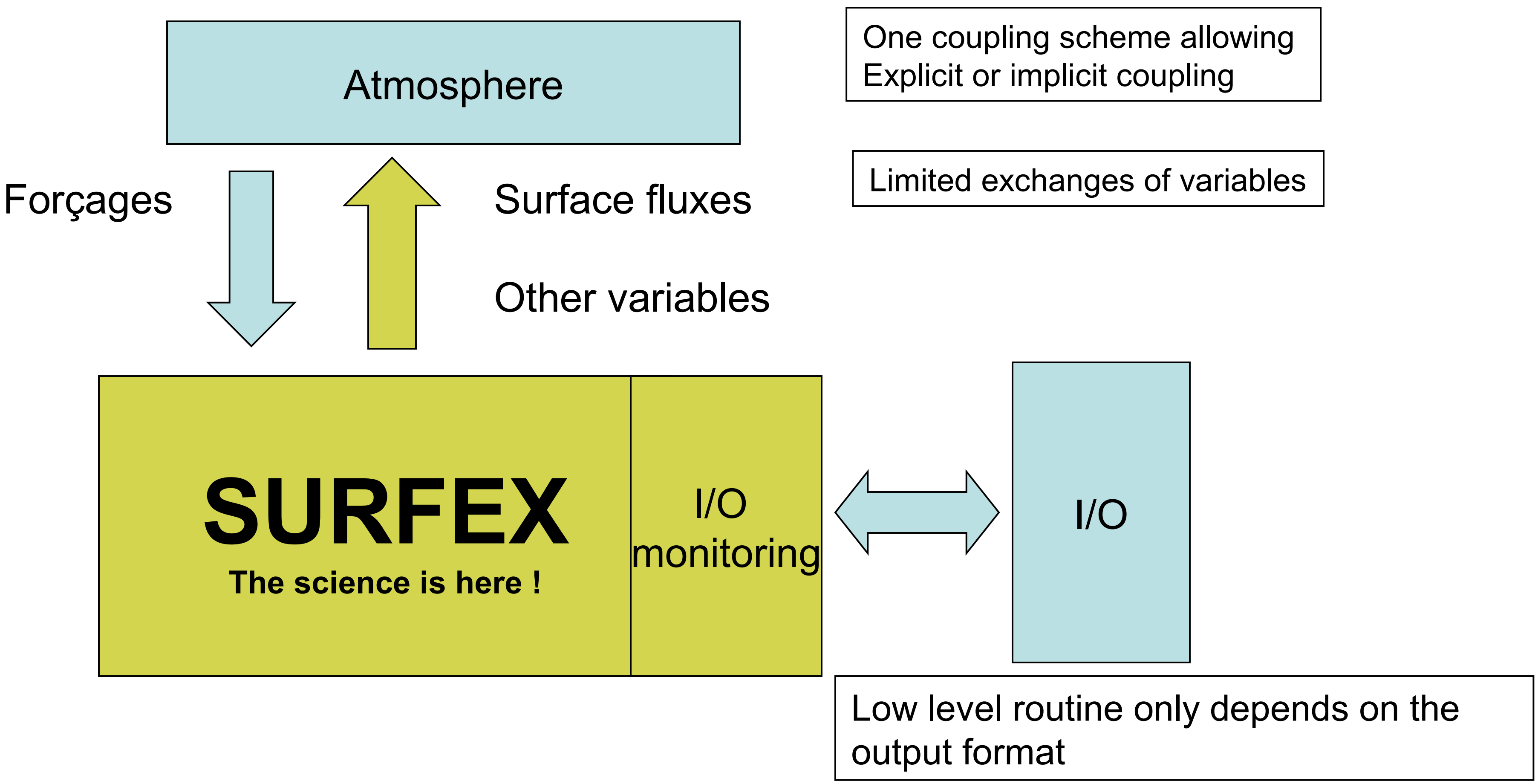
SURFEX has a modular structure and can include new parameterizations or schemes.

Why do we need externalized surface codes ?



- **The aim of a surface code is to simulate the fluxes between the surface and the atmosphere : energy, water, carbon, dust, snow, chemical species…**
- **The surface code needs to simulate processes « below » or « inside » the surface to provide this fluxes.**
- **Surface codes are improved and validated offline, many works on surface processes are done by people not belonging to the meteorological or climatological communities.**
- **The use of the same code for coupled and offline application is mandatory in order to ensure the consistency between the two applications.**
- **Need to <u>externalize</u> the surface code of the atmospheric model. I.e. clearly separate them from other part of the code in order to run them in stand alone mode**

Coupling and interfaces



Versions and correspondence with atmospheric models versions

SFX	release	NWP	MNH	CNRM-CM
V1	2005			
V4.8	2008	CY35t2	V4.8	
V5.8	2009	CY36t1		CM5 (CY32+V5.8)
V6	2010	CY37t1		
V7.1	2011		V4.9	
V7.2	Feb 2012	CY38t1		
V7.2.1	Jan 2013	CY39t1		
V7.3	Feb. 2013	CY40t1	V4.10	
V8	2016			CM6(CY37t2+V8 or V7.3**)

- v6+ (V6.0+ GMAP optimisations)
- ** CY40t1 and CNRM-CM6 contains additional developments

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Coupled and operational applications based on SURFEX

Atmospheric models :

Mesoscale model Meso-nh

Climate research : ARPEGE – ALADIN

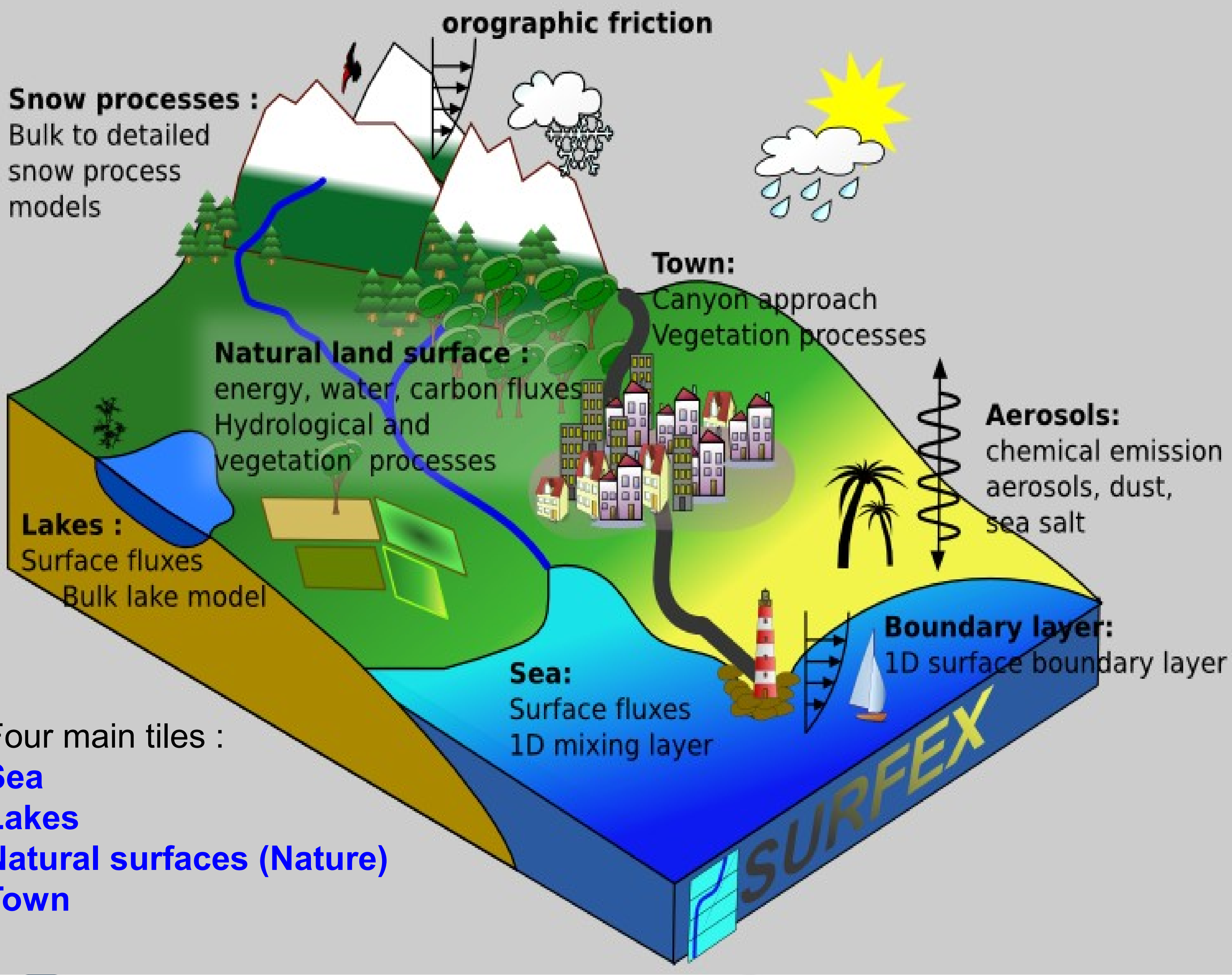
Numerical weather prediction :

- AROME (2008)
- ALADIN (2010)
- Soil analysis (OI_MAIN) 2011
- ALARO
- HARMONIE
- ARPEGE (2015/2016)

Offline operational applications

Snow and avalanches : Safran-Surfex-Mepra (2014)

Hydrology : Safran-Surfex-Modcou (2015/2016)



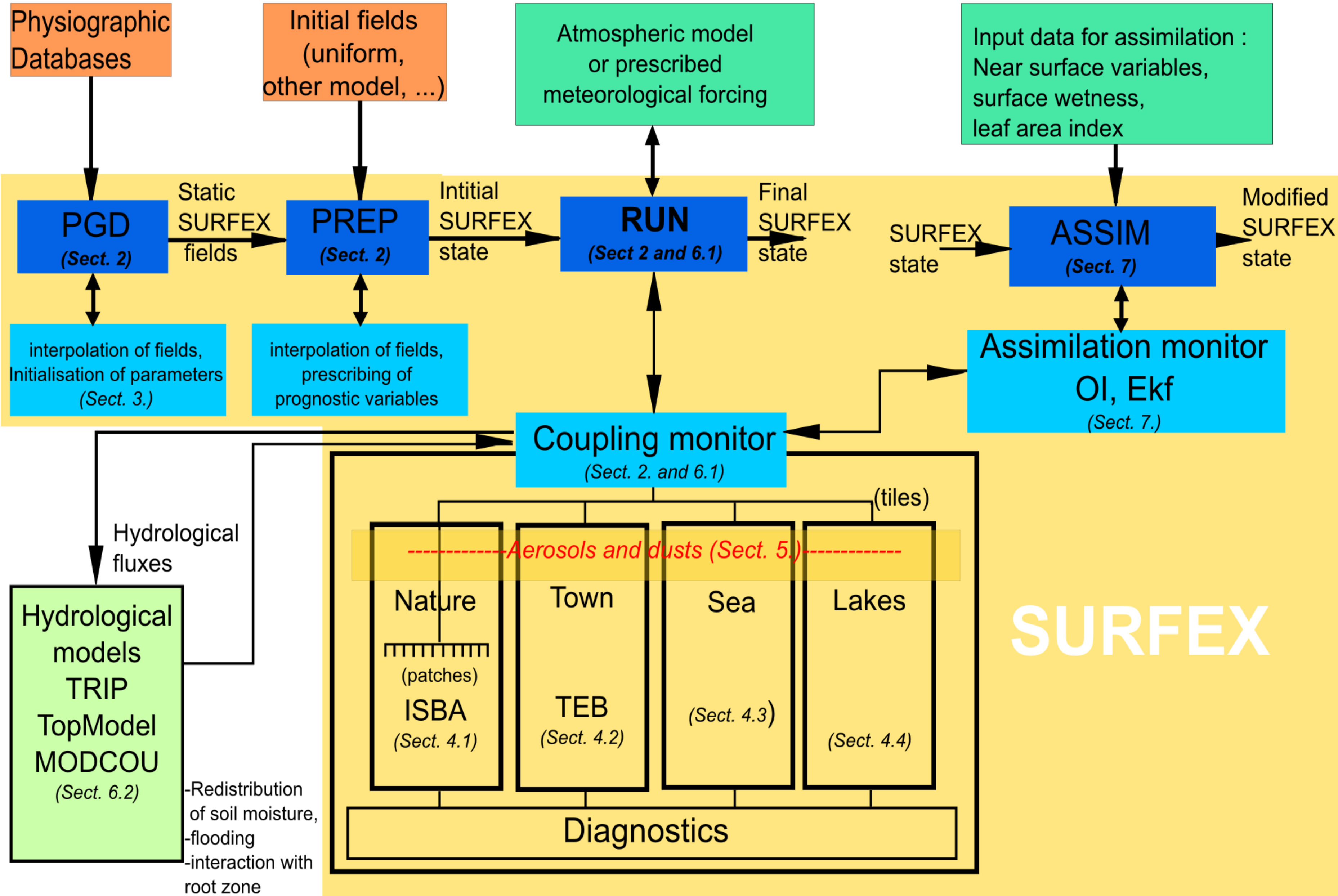
Four main tiles :

Sea

Lakes

Natural surfaces (Nature)

Town



Physiographic Databases
Initial fields (uniform, other model, ...)
Atmospheric model or prescribed meteorological forcing
Input data for assimilation : Near surface variables, surface wetness, leaf area index
PGD (Sect. 2)
Static SURFEX fields
PREP (Sect. 2)
Intitial SURFEX state
RUN (Sect 2 and 6.1)
Final SURFEX state
SURFEX state
ASSIM (Sect. 7)
Modified SURFEX state
interpolation of fields, Initialisation of parameters (Sect. 3.)
interpolation of fields, prescribing of prognostic variables
Assimilation monitor OI, Ekf (Sect. 7.)
Coupling monitor (Sect. 2. and 6.1)
(tiles)
Hydrological fluxes
------------Aerosols and dusts (Sect. 5.)------------
Nature
(patches)
ISBA (Sect. 4.1)
Town
TEB (Sect. 4.2)
Sea
(Sect. 4.3)
Lakes
(Sect. 4.4)
SURFEX
Hydrological models TRIP TopModel MODCOU (Sect. 6.2)
-Redistribution of soil moisture,
-flooding
-interaction with root zone
Diagnostics

Physics

Physical schemes




Sea and oceans :
Prescribed SST, Charnock formula
Mondon and Redelsperger
ECUME (multicampaign parametrisation)
1D ocean model

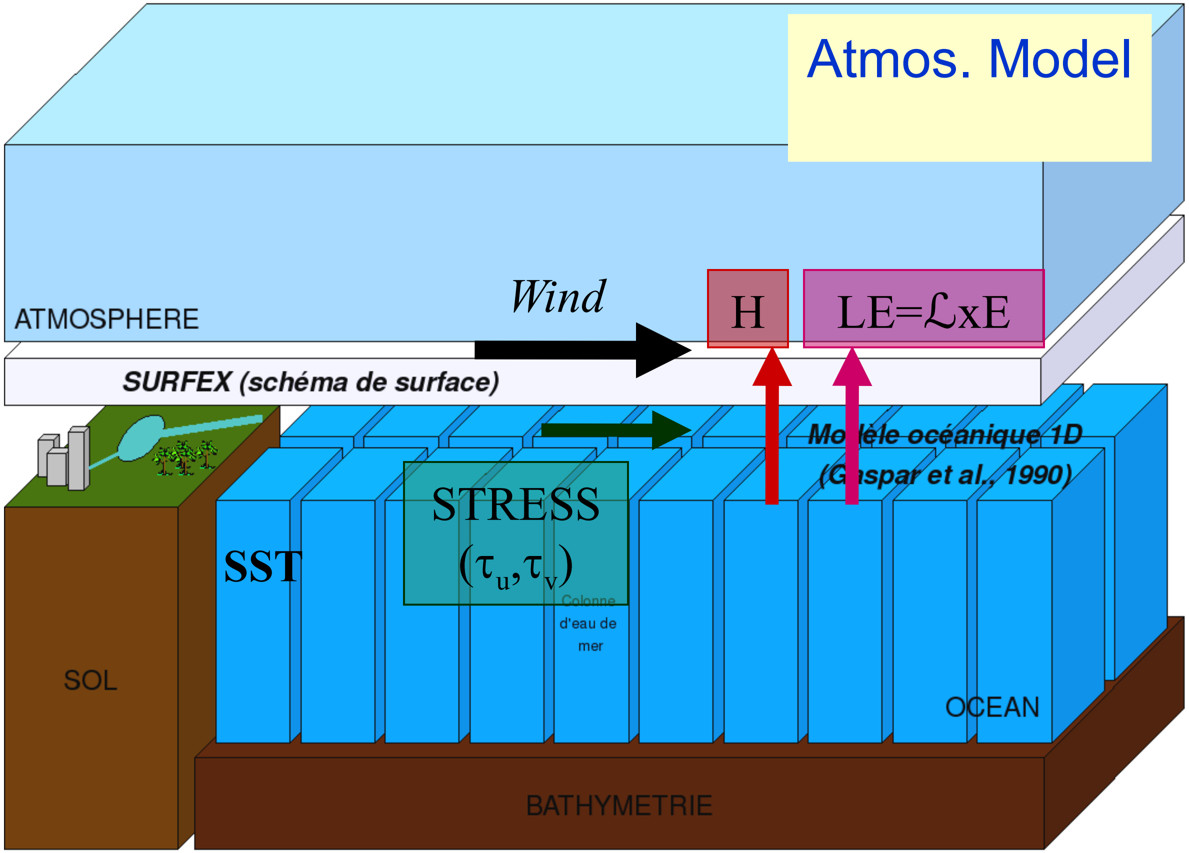
Lakes :
Prescribed surface temperatures, Charnock formula
FLake

Sol/Vegetation : ISBA
(Interaction Soil Biosphere Atmosphere)

Town : TEB (Town Energy Balance)
Canyon Approach,
Detailed radiatif scheme
Heat storage in buildings

SEA / OCEAN

- **ECUME multi-campaign parametrisation (prescribed SST)**
- **1D ocean mixing layer model Gaspar et al., 1990**



Flake model

Flake model is able to predict :

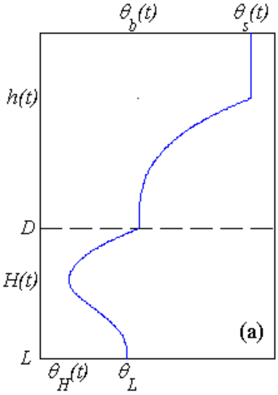
- vertical temperature structure
- mixing conditions in lakes of various depth
- for various time scales (few hours to several years)

- bulk model based on M.O. similarity theory : structure of turbulence in boundary layer entirely defined with turbulent scales u_* and θ_*
- includes a parameterization of sediments
- includes also a snow scheme since part of lake can freeze

variables

- $\theta_s(t)$ surface temperature
- $h(t)$ height of mixed layer
- $\theta_b(t)$ deep temperature
- $H(t)$ depth penetrated by thermal wave
- $\theta_H(t)$ temperature at depth $H(t)$

summer profile



Lakes : Flake model

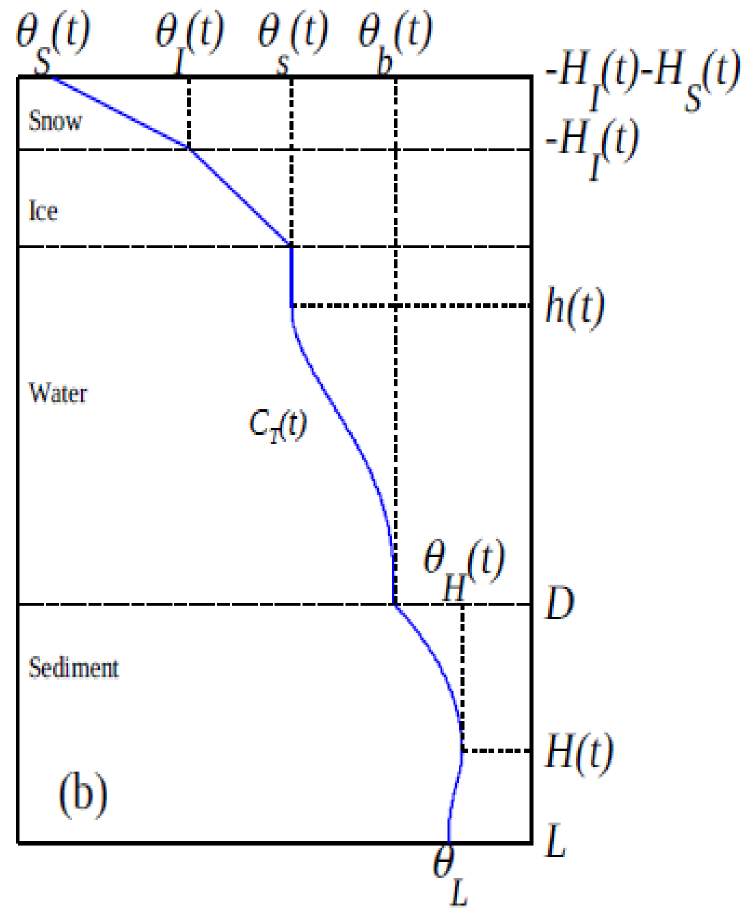
Simple model, based on assumed shape of the temperature profile

Snow/Ice :

- **the ice depth,**
- **the temperature at the ice upper surface,**
- **the snow depth, and the temperature at the snow upper surface.**

Water / Sediments

- **the surface temperature,**
- **the bottom temperature,**
- **the mixed-layer depth,**
- **the shape factor with respect to the temperature profile in the thermocline,**
- **the depth within bottom sediments penetrated by the thermal wave, and**
- **the temperature at that depth.**



ISBA

the model for **natural continental surfaces**

ISBA

Model of the « nature » part of SURFEX

Exchanges of energy, water, carbon, (dust, snow) with the atmosphere and the hydrology

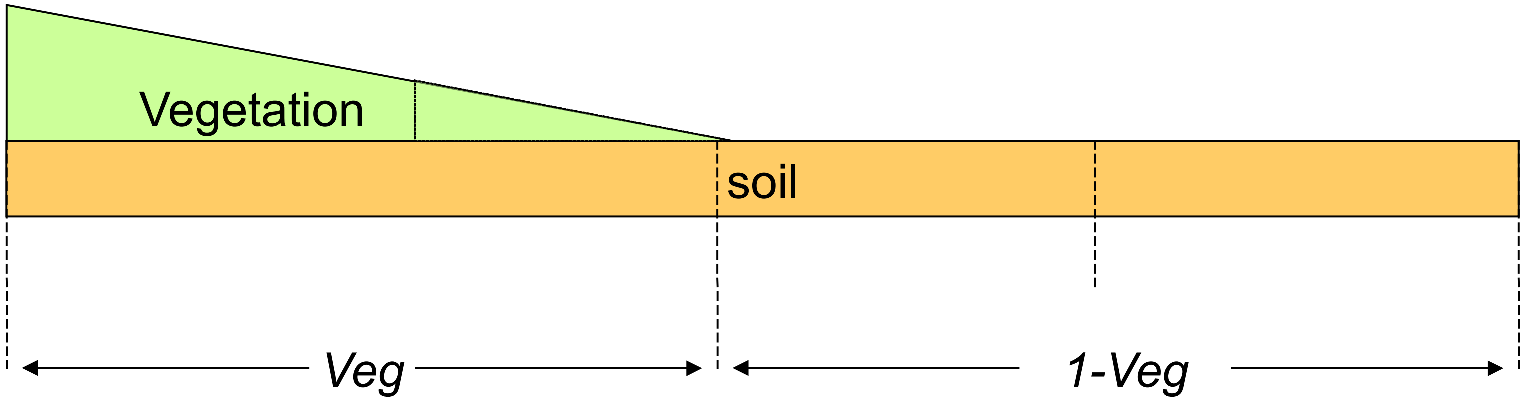
Work with the « mean » properties of the mesh (aggregation rules, or on a number of patches (1 to 12, according to the user's choice). In the case of patches, each models are independent (no lateral transfers).

- The parameters and the surface description.
- Force restore model : energy and water
- Multilayer model « diffusion »
- Snow
- Phosynthesis and carbon cycle

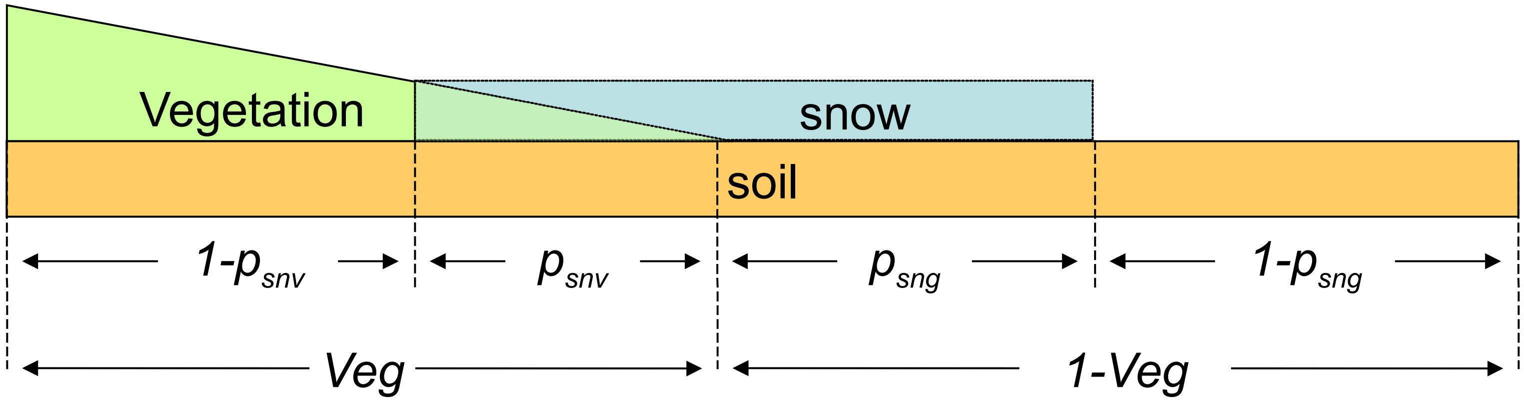
Introduction : main parameters

Primary parameters	Secondary parameters
Soil	
Clay fraction (X_{clay})	
Sand fraction (Y_{sand})	
	Saturation (or porosity) (W_{sat})
	Field capacity (W_{fc})
	Wilting point (W_{wilt})
Vegetation	
Type of cover	
	Minimal surface resistance (R_{smin})
	Leaf area index (LAI)
	Roughness lenght for momentum and heat z_0 and z_{0h}
	Fraction of vegetation (veg)
Both	
Soil depth (d_i) i =1,2,...	
Albedo (α)	
Emissivity(β)	

Description of the surface : fraction of vegetation and snow per patch



Description of the surface : fraction of vegetation and snow per patch



Snow fraction : $p_{sn} = p_{snv} + p_{sng}$

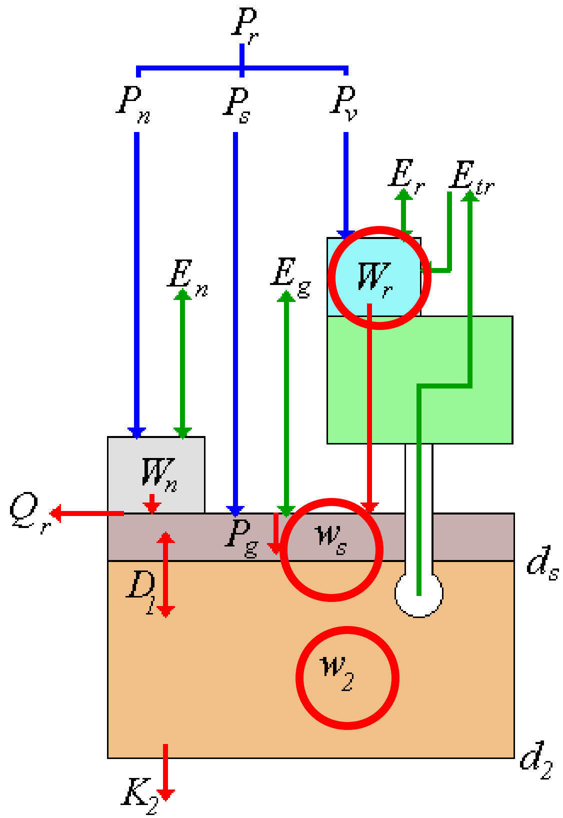
Albedo : $\alpha_{total} = (1-p_{snv})\,\alpha_{veg} + p_{sn}\,\alpha_{snow} + (1-p_{sng})\,\alpha_{soil}$

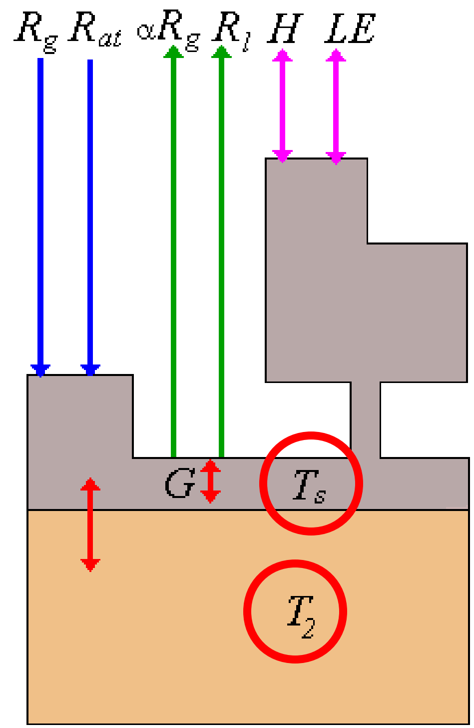
Emissivity : $\varepsilon_{total} = (1-p_{snv})\,\varepsilon_{veg} + p_{sn}\,\varepsilon_{snow} + (1-p_{sng})\,\varepsilon_{soil}$

ISBA : soil description

Option Namelist : CISBA	Temperature profile	Hydrology profile
2-L	Ts : surface temperature T2 : deep temperature	Surface layer (1cm) Root zone
3L		Surface layer (1cm) Root zone Sub-root zone
DIF	N temperature	N soil layers (default = 14 layers) root zone depends on vegetation (Richard's equations)

ISBA : the basic version : CISBA=2-L





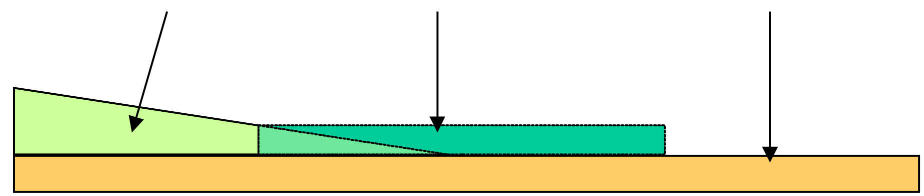
5 prognostic variables (except snow) : Ts, T_2, Wr, Wg, W_2

Surface energy budget : temperature

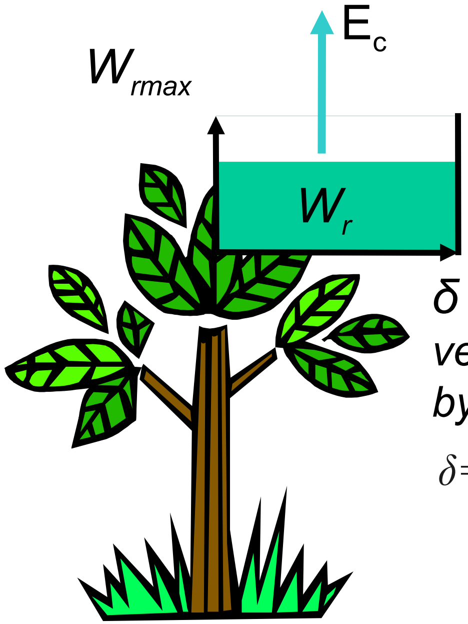
$$\frac{\partial T_s}{dt} = C_T\left(R_n - H - LE\right) - \frac{2\pi}{\tau}\left(T_s - T_2\right)$$

$$\frac{\partial T_2}{dt} = \frac{1}{\tau}\left(T_s - T_2\right)$$

Inertia coefficent : $C_T = 1 / \left[\frac{veg\left(1 - p_{snv}\right)}{C_v} + \frac{p_{sn}}{C_n} + \frac{\left(1 - veg\right)\left(1 - p_{sng}\right)}{C_g} \right]$



Surface hydrologic budget : interception reservoir

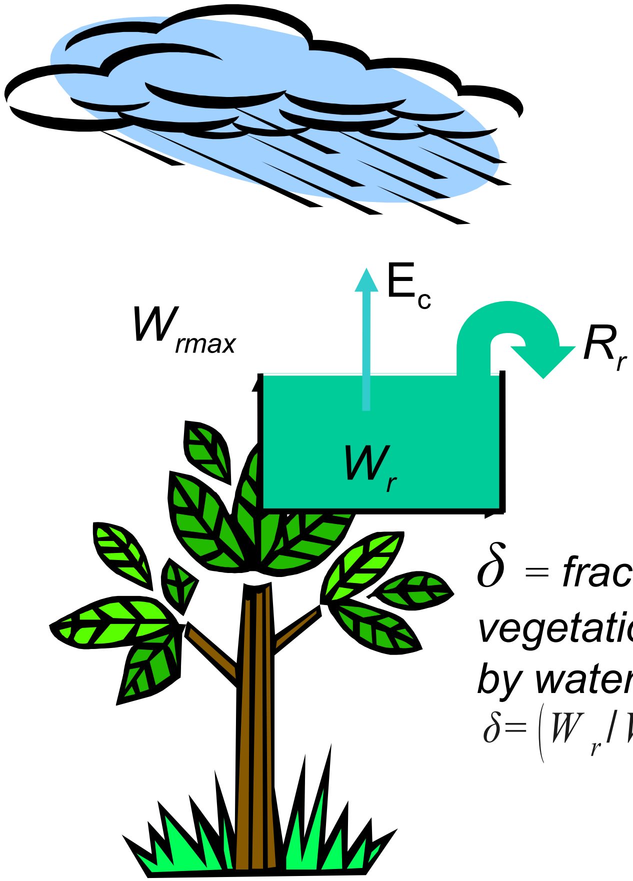


δ = fraction of vegetation covered by water

$$\delta = \left(W_r / W_{r\max}\right)^{2/3}$$

Deardorff, 1978.

Surface hydrologic budget : interception reservoir



δ = *fraction of vegetation covered by water*

$$\delta = \left(W_r / W_{r\max} \right)^{2/3}$$

$$\frac{\partial W_r}{\partial t} = \left(1 - p_{nv}\right) vegP - E_c - R_r$$

$$R_r = \max\left(0, \frac{W_r - W_{r\max}}{\Delta t}\right)$$

$$W_{r\max} = 0.2\, vegLAI$$

Deardorff, 1978.

Hydrological budget : evapotranspiration (in the absence of snow)

$$E = E_g + E_{veg}$$

$$E_{veg} = E_c + E_{ETR}$$

$$E_{veg} = \underbrace{veg\left(1 - p_{nv}\right)}_{\text{Snow free vegetation fraction}} \underbrace{\rho_a C_H V_a h_v \left[q_{sat}\left(T_s\right) - q_a\right]}_{\text{Surface – Atmosphere exchange}}$$

Hydrology : transfers in the soil (FR)

$$\frac{\partial w_1}{\partial t} = \frac{C_1}{\rho_w d_1}\left[I_r - E_g\right] - D_1 \qquad w_{min} \le w_1 \le w_{sat}$$

$$\frac{\partial w_2}{\partial t} = \frac{1}{\rho_w d_2}\left(I_r - E_g - E_{tr}\right) - K_2 \qquad w_{min} \le w_2 \le w_{sat}$$

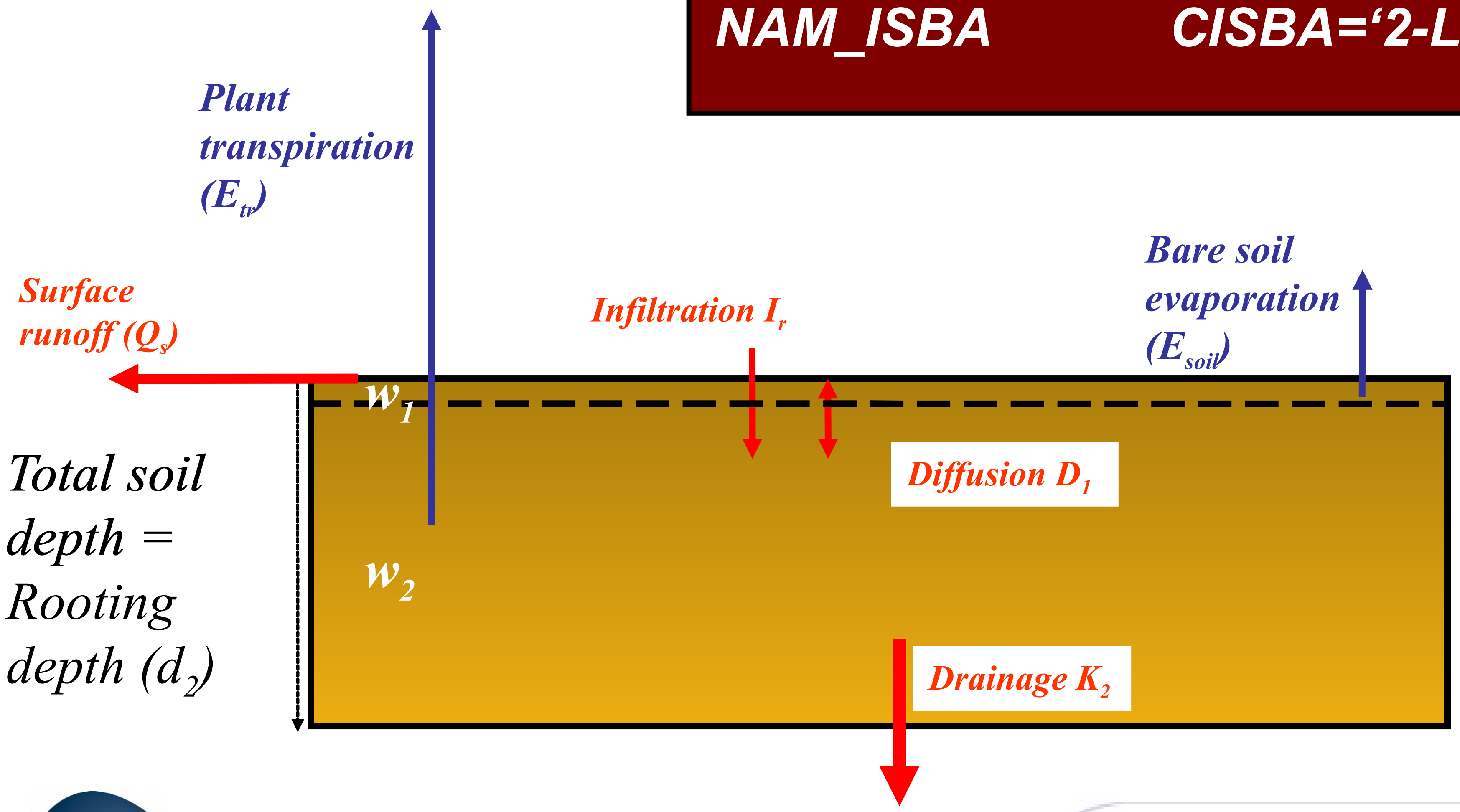
w2 : total water content, w1 : fraction of tw2 near thhe surface

Infiltration : $I_r = (1 - veg)P + R_r + S_m - Q_s$

Surface runoff : $Q_s = \frac{d_2 \rho_w}{\Delta t}\max\left(0, w_2 - w_{sat}\right)$

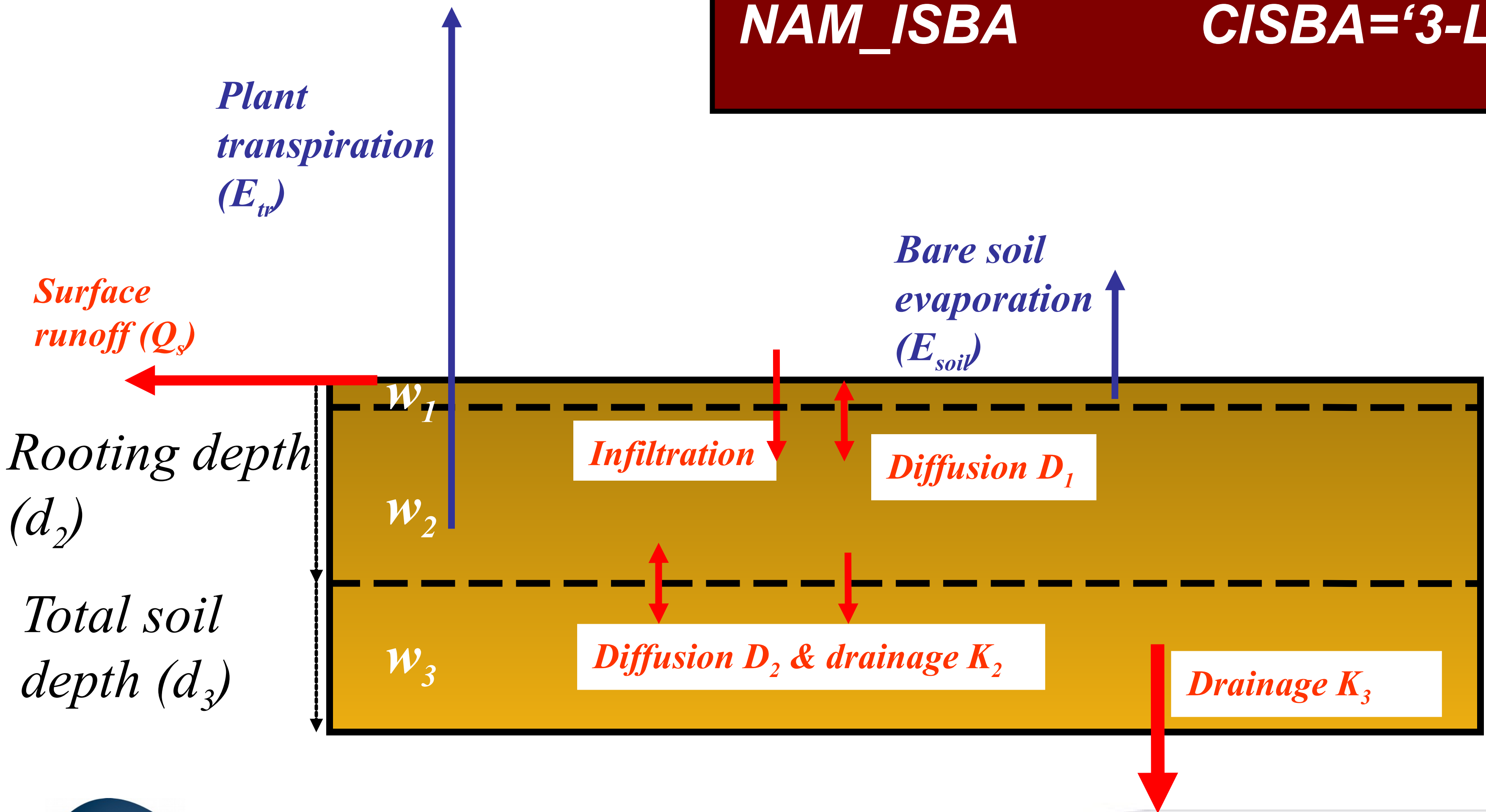
Water Budget : Soil moisture

NAM_ISBA CISBA='2-L'



Water Budget : Soil moisture

NAM_ISBA CISBA='3-L'



Model « Diffusion » N layers CISBA=DIF

Explicit soil DIFfusion Option: Downgradient thermal transfer and Richard's Eq.

3 Prognostic equations: N-layers for temperature, liquid water and soil ice:

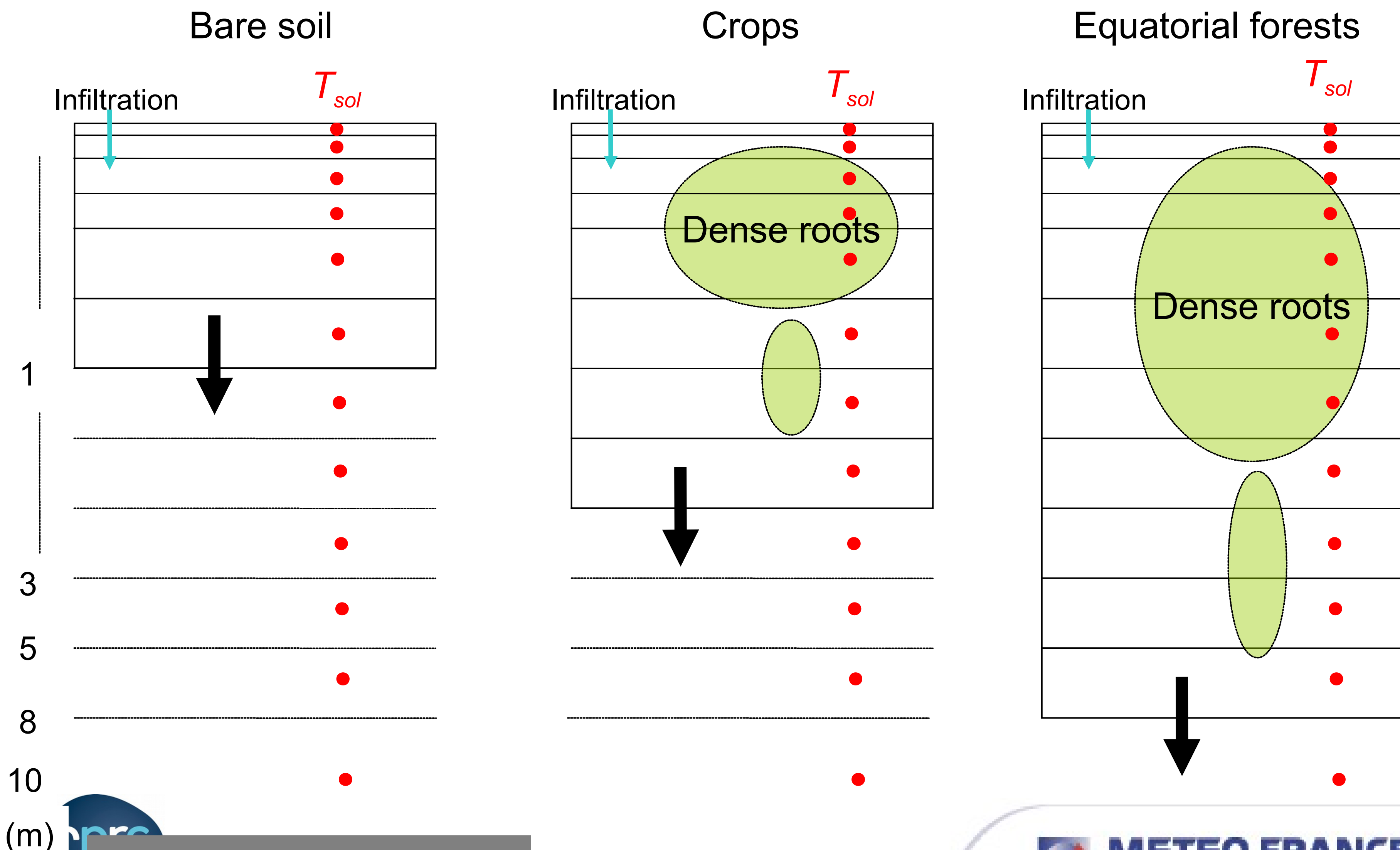
$$c_h \frac{\partial T_g}{\partial t} = \frac{\partial G}{\partial z} + \Phi_g$$

$$\frac{\partial w_l}{\partial t} = -\frac{\partial F}{\partial z} - \frac{\Phi_g}{L_f \rho_w} - \frac{S_l}{\rho_w} \qquad (w_{min} \leq w_l \leq w_{sat} - w_i)$$

$$\frac{\partial w_i}{\partial t} = \frac{\Phi_g}{L_f \rho_w} - \frac{S_i}{\rho_w} \qquad (0 \leq w_i \leq w_{sat} - w_{min})$$

$$w = w_l + w_i$$ Total soil water

Default configuration for ISBA-DF (14L)



Source : B. Decharme, CNRM

The snow models of ISBA

EBA	1 reservoir, 2 prognostic variables (Wn, albédo) model : ARPEGE/PN, ALADIN/PN (Bazile)
D95 (default)	1 reservoir, 3 prognostic variables (Wn, albedo, density) (climate model, AROME, offline) (Douville, 1995)
3-L CRO	ISBA-ES (explicit snow) multi-layer, 4 prognostic variables offline (chaîne SIM, …) and climate applications CROCUS/SURFEX : multilayer model based on ISBA-ES and the the snow model CROCUS (description of snow grains, incresed number of layers) (Brun et al., Vionnet et al.)

Carbon options (ISBA-A-gs, ISBA-CC)

Carbon fluxes:

Photosynthesis, ecosystem respiration, net exchanges with the ecosystem

Biomass (including LAI : leaf area index)

Evolution of the above-ground and below-groude biomass

Carbon stock

Organic matters, mulch, wood

Better representation of plant behaviours (C3 vs C4), LAI consistent with water and carbon fluxes, assimilation of vegetation data

NPATCH = 12 mandatory

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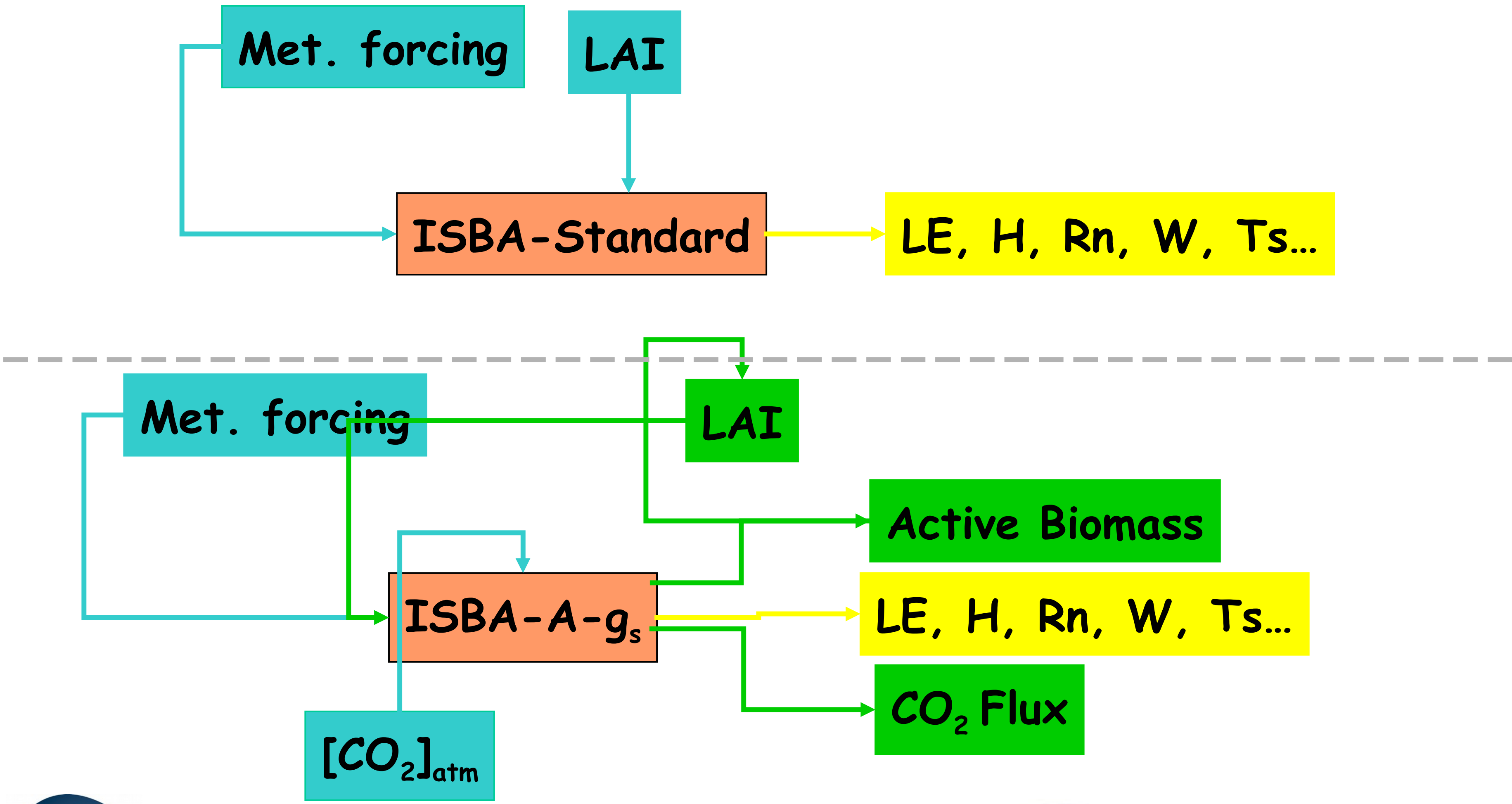
ISBA standard vs A-gs



(Calvet et al, 1998)

ISBA : options and namelists

NAM_ISBA	NPATCH, CISBA, CPHOTO, NGROUND_LAYER,SAND,CLAY,WDRAIN,CTI
NAM_DATA_ISBA	Init PGD ISBA (ECOCLIMAP=.F.) : NTIME, VEGTYPE, VEG,LAI, Z0, EMIS, DG,ROOTFRAC,RSMIN, …
NAM_PREP_ISBA	Initial field for ISBA + date
NAM_PREP_ISBA_SNOW	CSNOW, initial field for SNOW, +date
NAM_PREP_ISBA_CARBON	RESPL
NAM_ISBAn	**XTSEP**, Options of calculation for some parameters (conduction, Z0)
NAM_SGH_ISBAn	**Options subgrid hydrology** (KSAT, WDRAIN, …
NAM_DIAG_ISBA	Diagnostics for ISBA
NAM_SOIL_TEMP_ARP	LTEMP_ARP (4 temperatures FR climat)

See the user's guide for output variables

ISBA main physical options

ISBA	Soil	Force restore : 2 temperature, 2 or 3 layers for water, icing Diffusion : multilayer (temperature, water, icing)
	Vegetation	Noilhan et Planton 89 (~Jarvis) A-gs (photosynthesis and CO2 fluxes) A-gs and interactive vegetation Slow carbon processes (wood and roots)
	Hydrology	No subgrid process Subgrid surface runoff Subgrid drainage Flooding and coupling with TRIP
	Snow	1 layer, albedo, density variable (ARP/Climat, Douville 95) 1 layer, albedo, density variable (ARP/ALD, Bazile) Multilayer (3, or…) albedo, density, liquid water content (Boone and Etchevers 2000)

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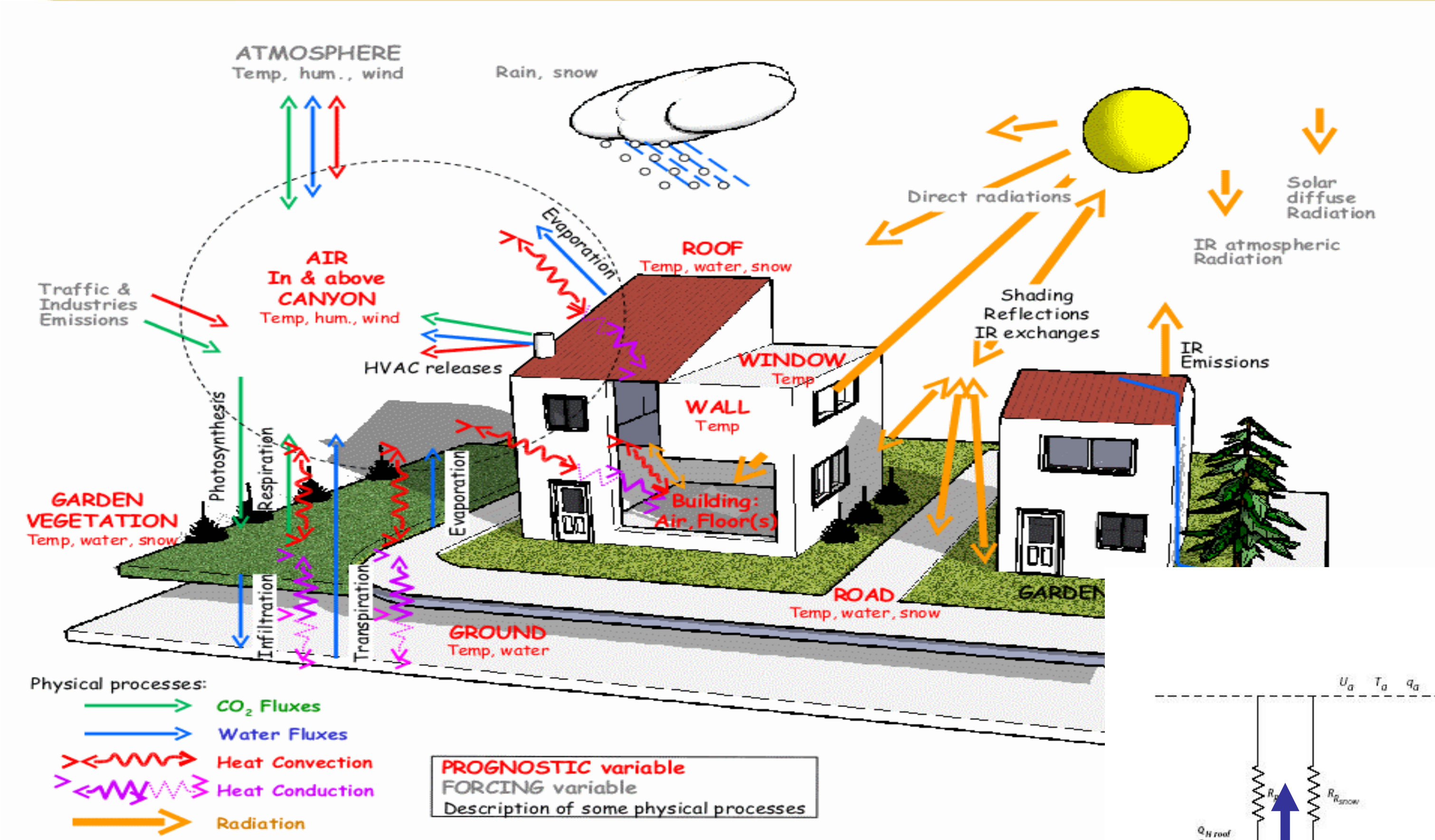
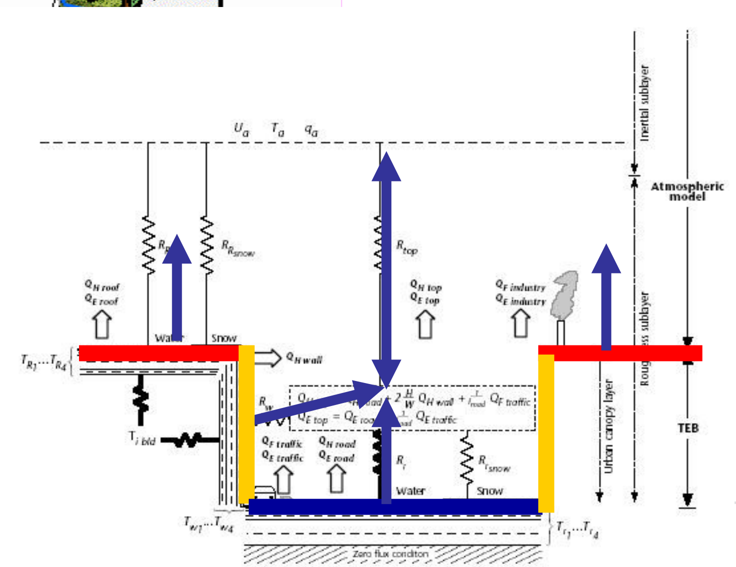
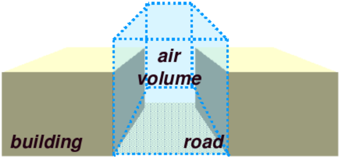
TEB


ATMOSPHERE
Temp, hum., wind
Rain, snow
Direct radiations
Solar diffuse Radiation
IR atmospheric Radiation
AIR
In & above
CANYON
Temp, hum., wind
Evaporation
ROOF
Temp, water, snow
Traffic & Industries Emissions
HVAC releases
Shading
Reflections
IR exchanges
IR Emissions
WINDOW
Temp
WALL
Temp
Photosynthesis
Respiration
Evaporation
Building:
Air, Floor(s)
GARDEN
VEGETATION
Temp, water, snow
ROAD
Temp, water, snow
GARDEN
Infiltration
Transpiration
GROUND
Temp, water
Physical processes:
CO2 Fluxes
Water Fluxes
Heat Convection
Heat Conduction
Radiation
PROGNOSTIC variable
FORCING variable
Description of some physical processes

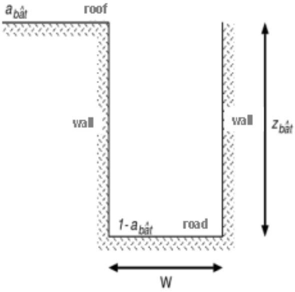

Inertial sublayer
Atmospheric model
Roughness sublayer
Urban canopy layer
TEB
Water
Snow
Zero flux condition

urban canyon concept



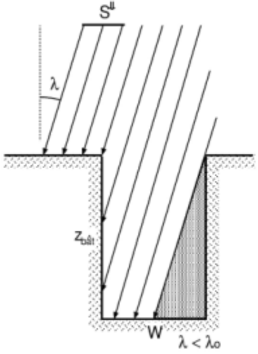
princip of TEB model

- urban canyon model : parameterization of exchanges of water and energy between canopy and atmosphere
- exclusive treatment of built surfaces
- idealized geometry
- 3 elementary surfaces

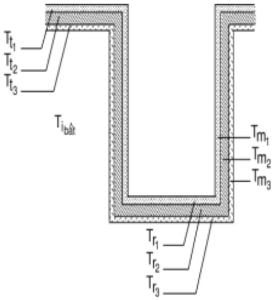


princip of TEB model

computation of energy budget of each surface

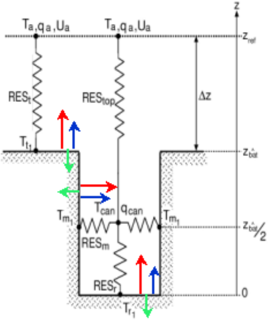


computation of temperature surface + materials

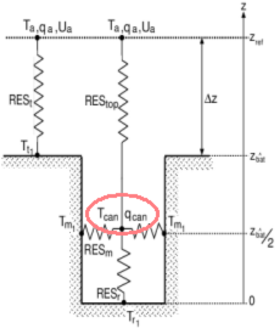


princip of TEB model

computation of exchanged energy with aerodynamical network



computation of air temperature and humidity inside the canyon



II.1. The CANYON approach in TEB

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

- TOWN is represented by 3 surfaces: 1 WALL, 1 ROOF, 1 ROAD, each composed of several layers.

- Each layer of these surfaces is characterized by:
  - An albedo
  - An emissivity
  - A depth
  - A thermal conductivity (TC)
  - A heat capacity (HC)

II.2. Geometric parameters for TOWN

- BLD: fraction of building
- BLD_HEIGHT: height of buildings.
- WALL_O_HOR: wall surface / horizontal surface *(to estimate if there is one big building or several little ones).*
- Z0_TOWN: roughness length.

II.3. Modelisation

- Rain interception and runoff, ROOF & ROAD
- Snow 1D model, ROOF & ROAD
- HEAT fluxes between the 3 surfaces and the air
- Anthropogenic fluxes (traffic, industry)
- Temperature of the 3 surfaces and in the street
- Humidity and wind in the street

III.1. TEB_GARDEN

- To represent gardens & parks in towns.

- If LGARDEN=T (NAM_PGD_SCHEMES), natural fraction in town is replaced by a garden fraction and ISBA is called inside the TOWN tile :
  - interactions between the urban and the garden parts are represented.
  - Temperature and humidity in the street are modified by the gardens.
  - Garden and urban fluxes are aggregated for the TOWN tile.

III.2. TEB_GREENROOF

- To represent greenroofs in towns.

- If LGREENROOF=T (NAM_TEB), GREENROOF fraction must be given in NAM_DATA_TEB (no greenroof in ECOCLIMAP):
  - interactions between the roofs and the greenroofs are described.
  - Temperature and humidity on the roofs are modified by the greenroofs.
  - Greenroof and urban fluxes are aggregated for the TOWN tile.

III.3. BEM

Building Energy Model, Bueno et al 2011

- Describes what happens inside buildings:
  - Heating system
  - Cooling system
  - Ventilation

=> CBEM = « BEM » in NAM_TEB

=> TI_BLD calculation is modified.

- Implies numerous new parameters (cf NAM_DATA_BEM), for example:
  - NATVENT is NONE, MANU, MECH or AUTO *(NAM_DATA_BEM)*
    - MANU: manual window opening
    - MECH: mechanical surventilation
    - AUTO: automatic window opening
  - CCOOL_COIL is IDEAL or DXCOIL *(NAM_TEB)*
    - IDEAL : ideal cooling system
    - DXCOIL: real cooling system
  - CHEAT_COIL is IDEAL or FINCAP (*NAM_TEB)*
    - IDEAL: ideal heating system
    - FINCAP: real heating system

III.6. Road, garden and greenroof watering

- Possibility to irrigate the roads, gardens or greenroofs with NAM_DATA_TEB_IRRIG:
  - Giving date and hour for beginning and end of irrigation
  - Giving total irrigation over 24h (kg/m²)

  => The water is added to rain.

III.7. Solar panels on roofs

- Panels are characterized by (can be given in namelist NAM_DATA_TEB):
  - An emissivity
  - An albedo
  - And efficiency coefficent
  - A fraction of solar panel on roofs
  - Daily integrated production of energy

- Energy budget is calculated for solar panels and panel fluxes are aggregated to calculate total urban fluxes.

IV.2. TEB use

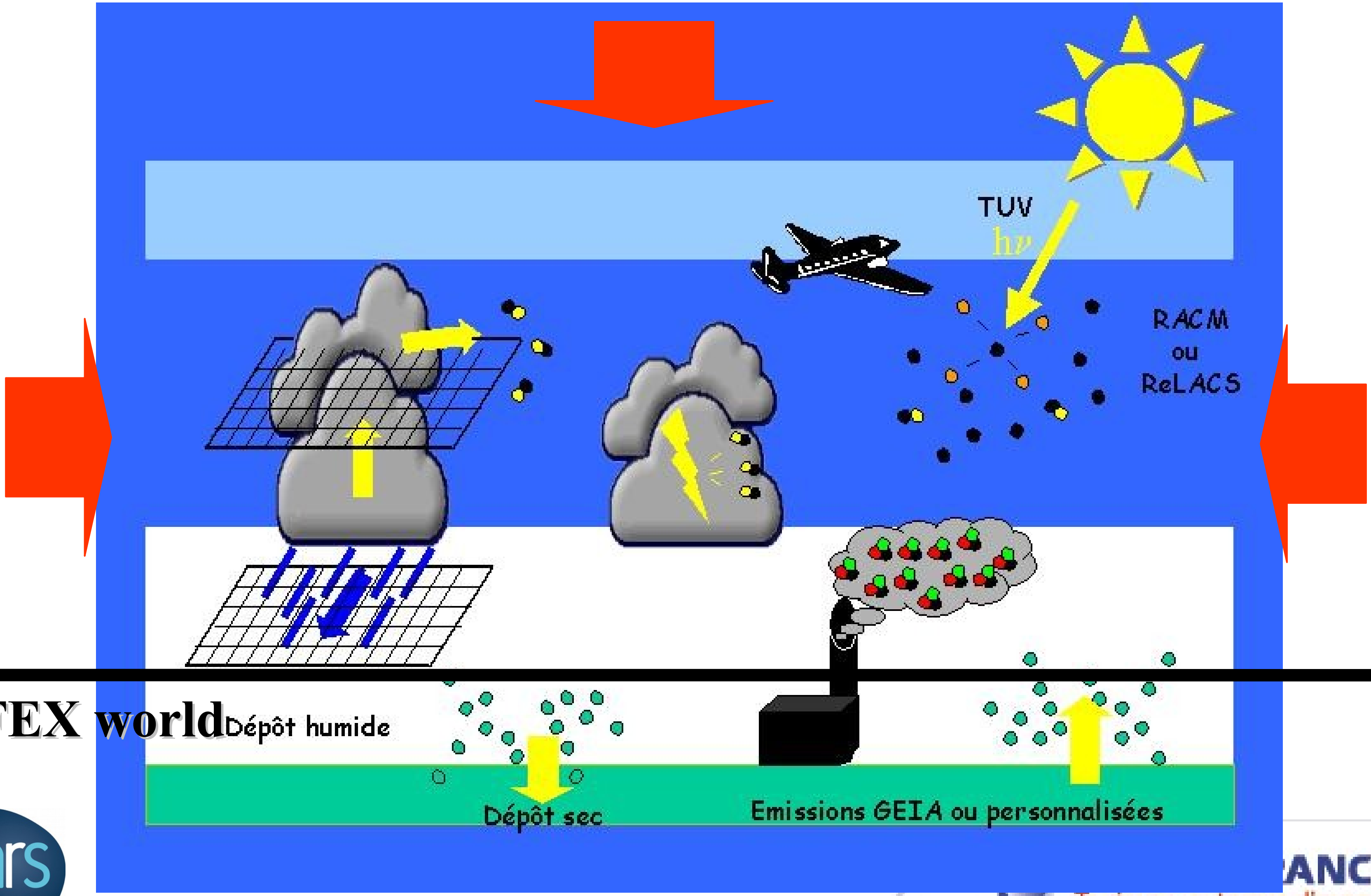
- TEB is used :
  - Alone
  - In SURFEX offline
  - In Mesonh atmospheric model
  - In AROME atmospheric model

- In the future, TEB will be used:
  - In ARPEGE-CLIMAT model

- TEB already appeared in numerous multidisciplinary projects (with architects, sociologists, urbanists) working on future cities, concerning:
  - Ecology and energy saving
  - Human comfort

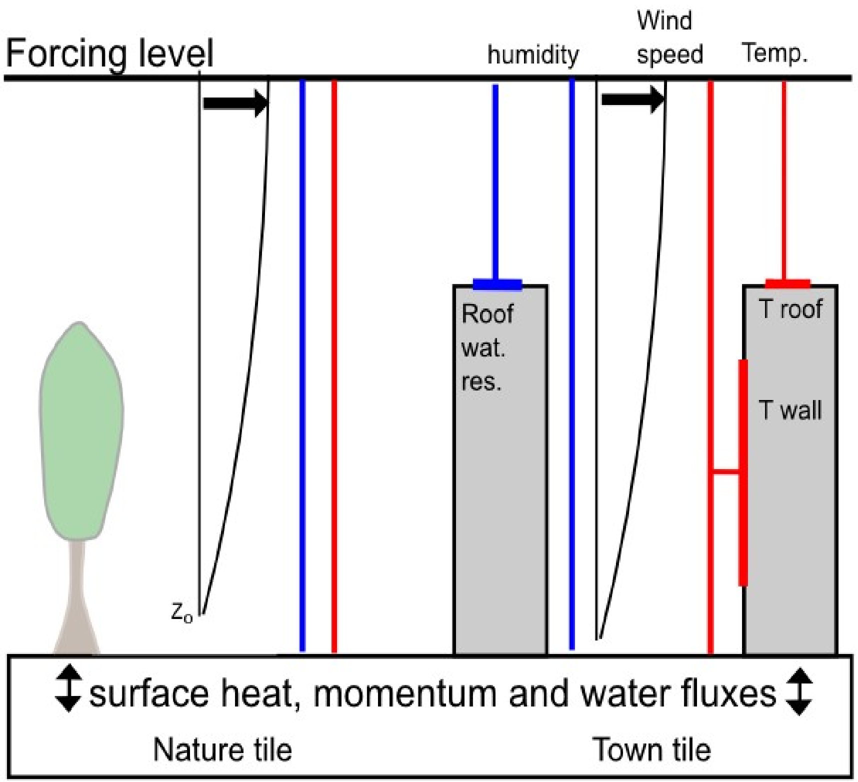
Chemical scheme
From local (dx=1 km) to synoptic scale (dx=50 km)

http://www.aero.obs-mip.fr/mesonh

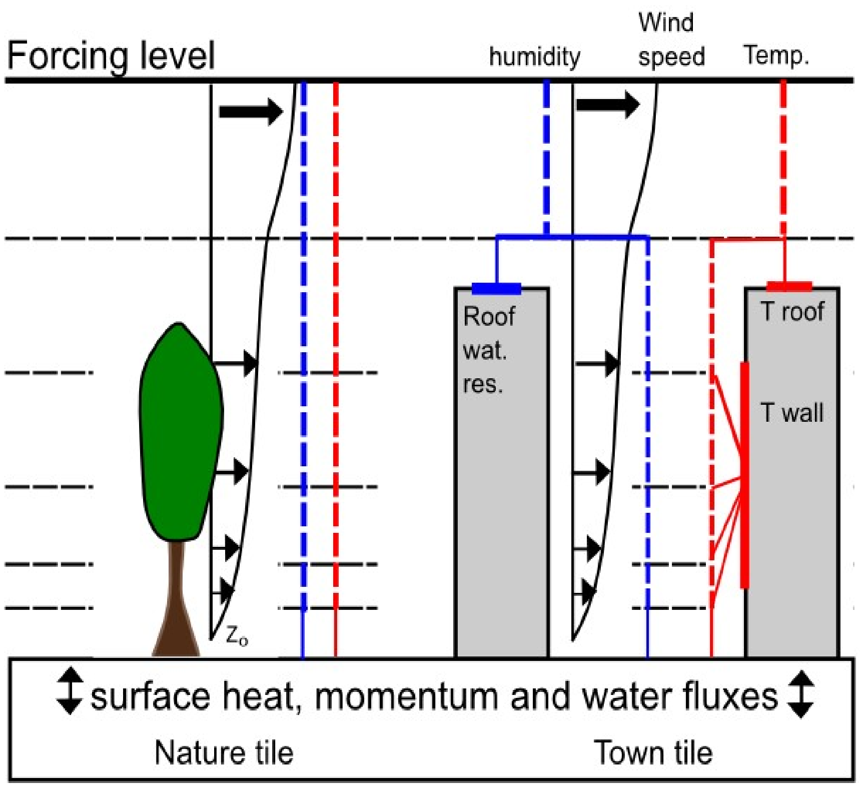


The SBL model (Canopy)

without SBL model



with SBL model

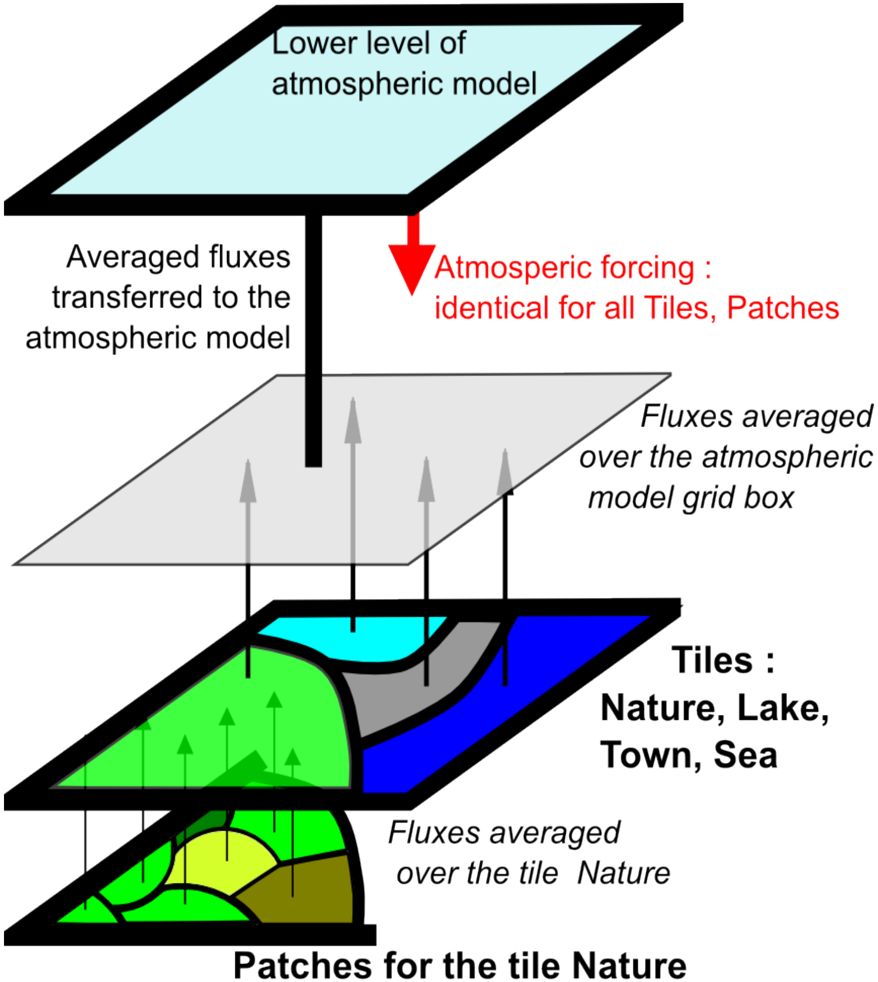


Describing the surface

How can we represent the surface heterogeneity in a grid ?

Tiling approach :

- **Within a grid mesh, the surface is divided into several homogeneous component.**
- **Each component receives the same atmospheric forcing**
- **Each component calculates fluxes**
- **Fluxes are aggregated and returned to the atmosphere**
- **No horizontal transfert within the surface**



SURFEX tiling and coupling with an atmospheric model

Tiling in SURFEX :

- **The surface is divide into**

  4 main Tiles, which are treated by different models.

Sea/Oceans	Lakes
Nature (bare soil/ vegetation)	Towns

- **The tile Nature is divided into 12 (or 19) patches or natural functional types**

NO no vegetation	C3 (C3 crops)
ROCK (bare rock)	C4 (C4 crops)
SNOW (snow and ice)	IRR (irrigated crops)
TREE (deciduous broadleaved forest)	GRAS (temperate /C3 grassland)
CONI (evergreen needleleaved forest)	TROG (tropical /C4 grassland)
EVER (evergreen broadleaved forest)	PARK (wetlands)

Aggregation of functional types is possible in ISBA

Total number of patchs chosen by user

	12	11	10	9	8	7	6	5	4	3	2	1
NO	1	1	1	1	1	1	1	1	1	1	1	1
ROCK	2	2	1	1	1	1	1	1	1	1	1	1
SNOW	3	3	2	2	2	2	1	1	1	1	1	1
TREE	4	4	3	3	3	3	2	2	2	2	2	1
CONI	5	5	4	4	3	3	2	2	2	2	2	1
EVER	6	6	5	3	3	3	2	2	2	2	2	1
C3	7	7	6	5	4	4	3	3	3	3	1	1
C4	8	8	7	6	5	4	3	3	3	3	1	1
IRR	9	9	8	7	6	5	4	4	4	3	1	1
GRAS	10	10	9	8	7	6	5	5	3	3	1	1
TROG	11	10	9	8	7	6	5	5	3	3	1	1
PARK	12	11	10	9	8	7	6	4	4	3	1	1

Physiographic parameters

The surface needs several types of parameters :

Orography

Type of the surface (tile) and vegetation types (patches) for « Nature »

- ISBA : Albedo, leaf area index, soil texture, …
- FLAKE : lake depth, extinction coefficient …
- SEA Bathymetry
- …

Solutions :

- **Prescribe the model parameters using a namelist (simple offline runs).**

Physiographic parameters

Solutions :

- **Databases :**
  - Land cover database ECOCLIMAP
  - Topography (e.g. Gtopo30 at 1 km or SRTM for higher resolution, from which the mean grid-cell altitude and sub-grid topography parameters are derived).
  - Soil properties (clay and sand proportions, organic matters) derived from FAO or HWSD databases.
  - Lake depth and optical water properties (Kourzeneva et al., 2011)
  - Ocean Bathymetry (e.g. Etopo2 from Smith and Sandwell (1997))
- **Ad hoc parameter list (specific cases)**

ECOCLIMAP :
A global database of surface parameters

A land cover map at 1 km resolution in latlon projection

Fully coupled to SURFEX, or available separately)

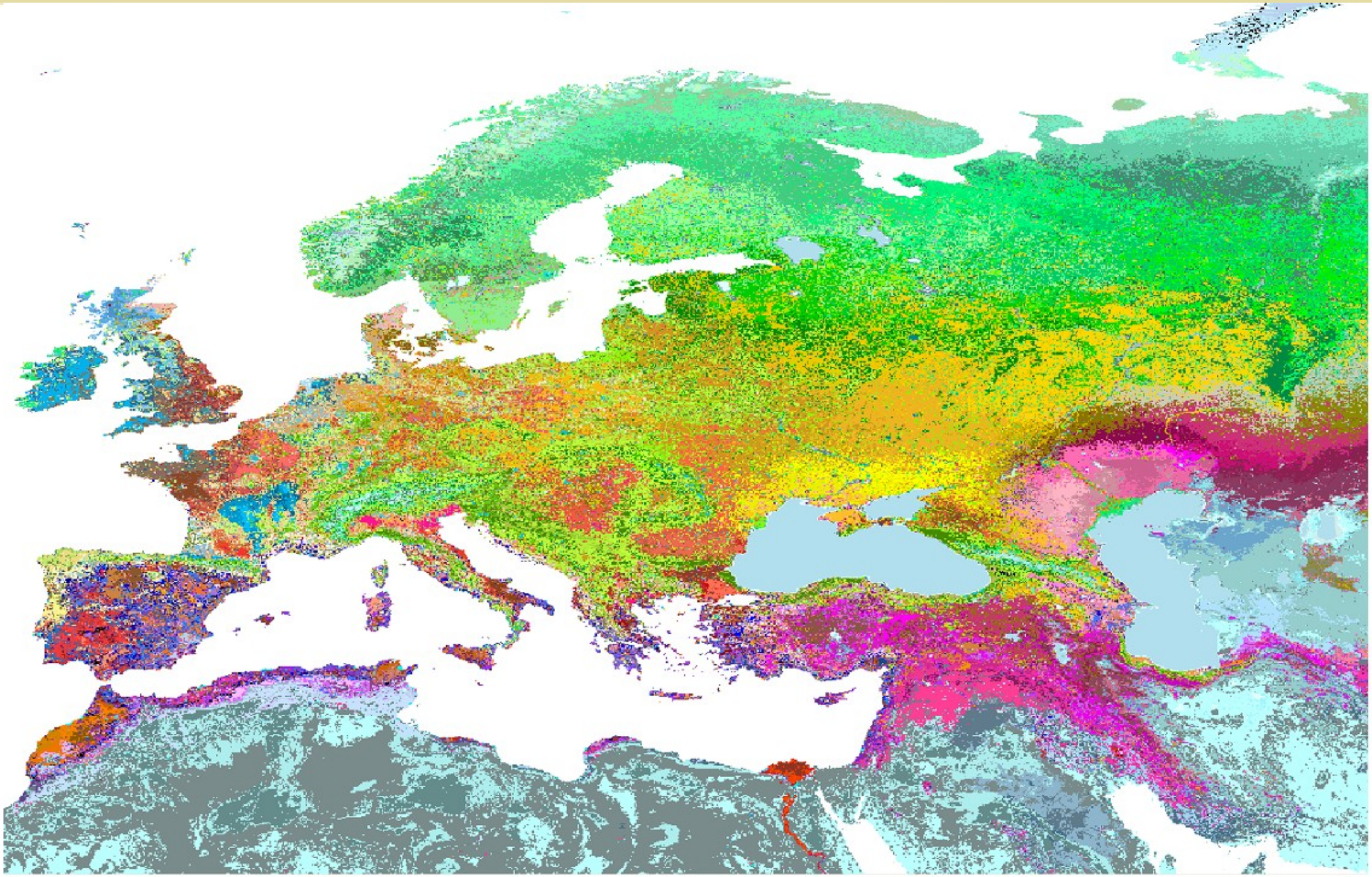
ECOCLIMAP I : global (215 covers)

ECOCLIMAP II Europe (273 covers)

10-day period surface parameters: LAI, fraction of vegetation veg, roughness length, emissivity, fraction of greeness.

Constant surface parameters: visible / nir / uv albedos, minimum stomatal resistance…

ECOCLIMAP-II Europe



ECOCLIMAPII domain

II.2. ECOCLIMAP files in SURFEX namelist

```
&NAM_COVER
YCOVER = « ECOCLIMAP_I_GLOBAL »
YCOVERFILETYPE = « DIRECT »
/
```

DIRECT means that *YCOVER* is composed of 2 files:

- **ECOCLIMAP_I_GLOBAL.*dir*** is **BINARY** and contains the rough grid of covers numbers.
- **ECOCLIMAP_I_GLOBAL.*hdr*** is **ASCII** and contains the metadata for the upper binary file.

II.3. ECOCLIMAP_I_GLOBAL.hdr contents

215 ecosystems from UDM/IGBP/PELCOM/CORINE cover, climate maps and NDVI profiles. CNRM, Meteo-France

nodata: 0

north: 90.

south: -90.

west: -180.

east: 180.

rows: 21600

cols: 43200

recordtype: integer 8 bytes

II.4. Files ECOCLIMAP*.dir / .hdr (1)

Several versions available at
http://www.cnrm.meteo.fr/surfex-lab/

- Physiography download
- > Land use

ECOCLIMAP-II is an update of ECOCLIMAP-I (more recent input data, automatic NDVI classification) on Europe.

For further details on these maps, see:

ECOCLIMAP-I: Masson et al, 2003
ECOCLIMAP-II : Faroux et al, 2013

Download ECOCLIMAP_I_GLOBAL.hdr.gz and ECOCLIMAP_I_GLOBAL_V1.5.dir.gz

- **ECOCLIMAP v1.6**, a sea point into Corsica is removed and replaced by land.
  Download ECOCLIMAP_I_GLOBAL.hdr.gz and ECOCLIMAP_I_GLOBAL_V1.6.dir.gz
- **ECOCLIMAP v1.7**, Separation of lakes (cover2) and rivers (cover3). Sea estuaries from water to sea (Decharme-LeMoigne). Lakes depths from GLDB (http://www.flake.igb-berlin.de/ep-data_old.shtml) database, collocated with ecoclimap 1.7 lake position
  Download ECOCLIMAP_I_GLOBAL_V1.7.hdr.gz and LAKE_DEPTH_ECO_I_V1.7.hdr.gz and ECOCLIMAP_I_GLOBAL_V1.7.dir.gz and LAKE_DEPTH_ECO_I_V1.7.dir.gz

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Serie ECOCLIMAP 2 : 215 cover on the globe + 273 over Europe

- **ECOCLIMAP v2.0**, a 1 km global database with improved land use data over Europe
  Download ECOCLIMAP_II_EUROP.hdr.gz and ECOCLIMAP_II_EUROP_V2.0.dir.gz
- **ECOCLIMAP v2.1**, a 1 km global database, Norway permanent snow update, referring to the glacier mask file from 'Norway Water Resources and Energy Directorate' . File provided by Dagrun Vikhamar Schuler & Mariken Homleid
  Download ECOCLIMAP_II_EUROP.hdr.gz and ECOCLIMAP_II_EUROP_V2.1.dir.gz
- **ECOCLIMAP v2.2**, a ghostly sand island near the New Caledonia is removed, 2 ghostly lakes in Surinam are removed (following indications from Ghislain Faure).
  Download ECOCLIMAP_II_EUROP.hdr.gz and ECOCLIMAP_II_EUROP_V2.2.dir.gz
- **ECOCLIMAP v2.3**, Separation of lakes (cover2) and rivers (cover3). Sea estuaries from water to sea (Decharme-LeMoigne). Lakes depths from GLDB (http://www.flake.igb-berlin.de/ep-data_old.shtml) database, collocated with ecoclimap 2.3 lake position
  Download ECOCLIMAP_II_EUROP_V2.3.hdr.gz and LAKE_DEPTH_ECO_II_V2.3.hdr.gz and ECOCLIMAP_II_EUROP_V2.3.dir.gz and LAKE_DEPTH_ECO_II_V2.3.dir.gz

---

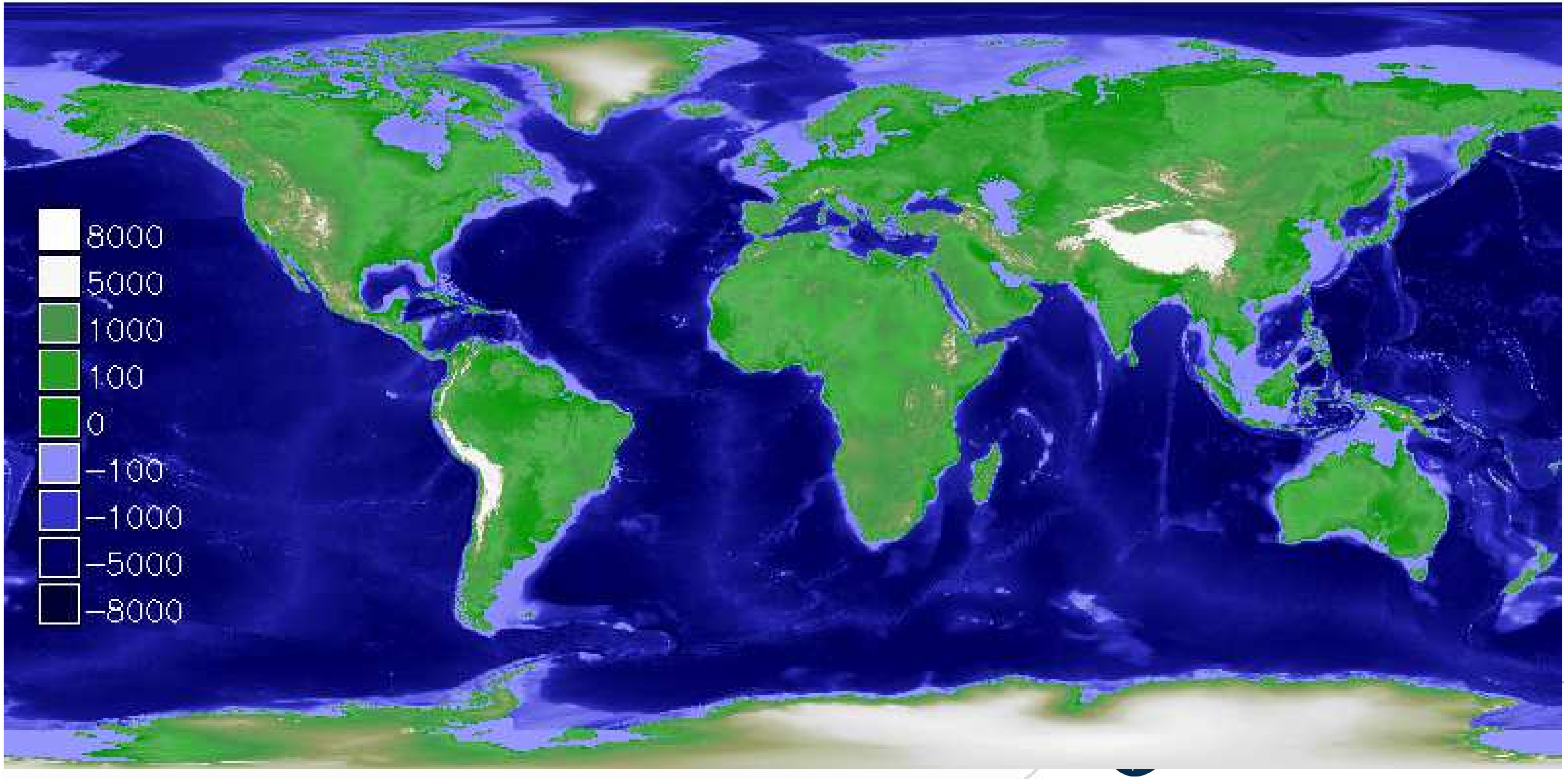
* Global potential permafrost area at 10km resolution from 0.5deg resolution:
Download
perm_glo_10km.dir.gz and perm_glo_10km.hdr.gz

---

* Global grounwater map at 10km resolution from 0.5deg resolution:
Download
groundwater_10km.dir.gz and groundwater_10km.hdr.gz

V.1. Other physiographic databases available on Surfex-lab website

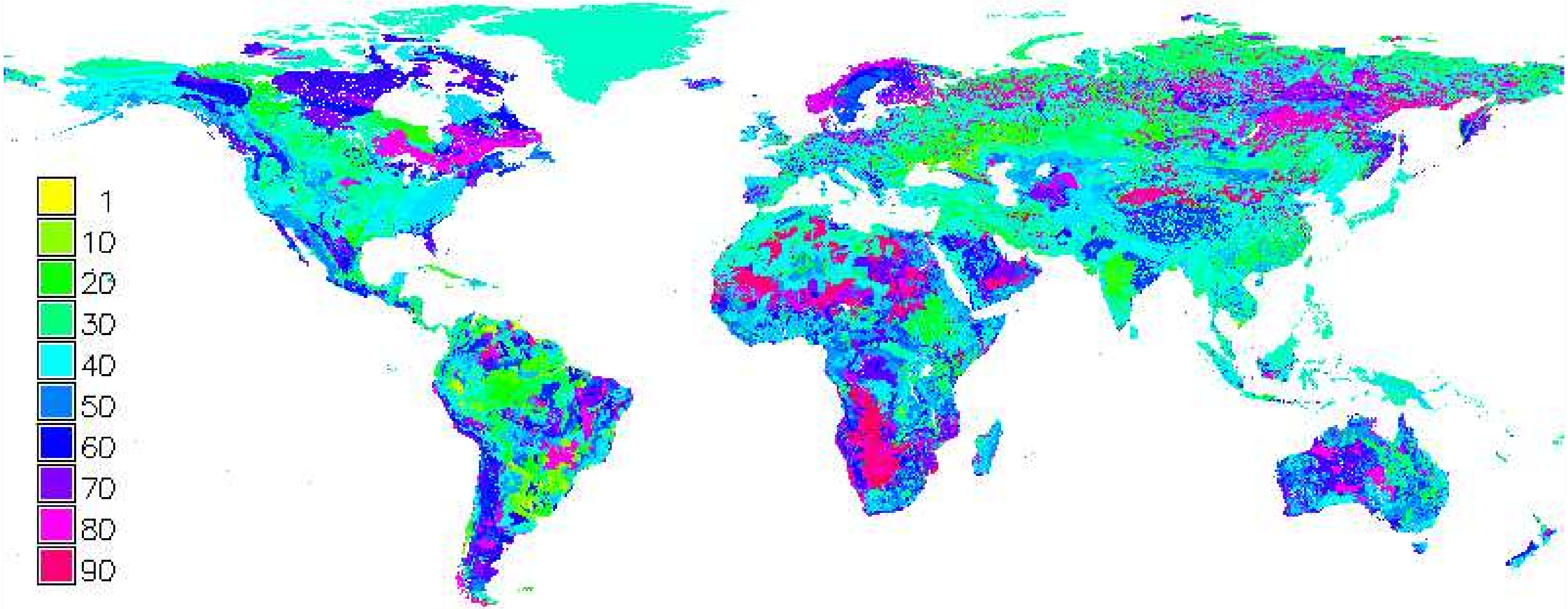
- Bathymetry :etopo2 from NOAA (4km resolution)



V.2. Other physiographic databases available on Surfex-lab website

- Lake depth: database from E. Kurzeneva (1km resolution)
- Permanent snow: global permanent snow at 10km resolution
- Soil texture (CLAY and SAND fractions):
  - FAO at 10km resolution
  - HWSD à 1km resolution

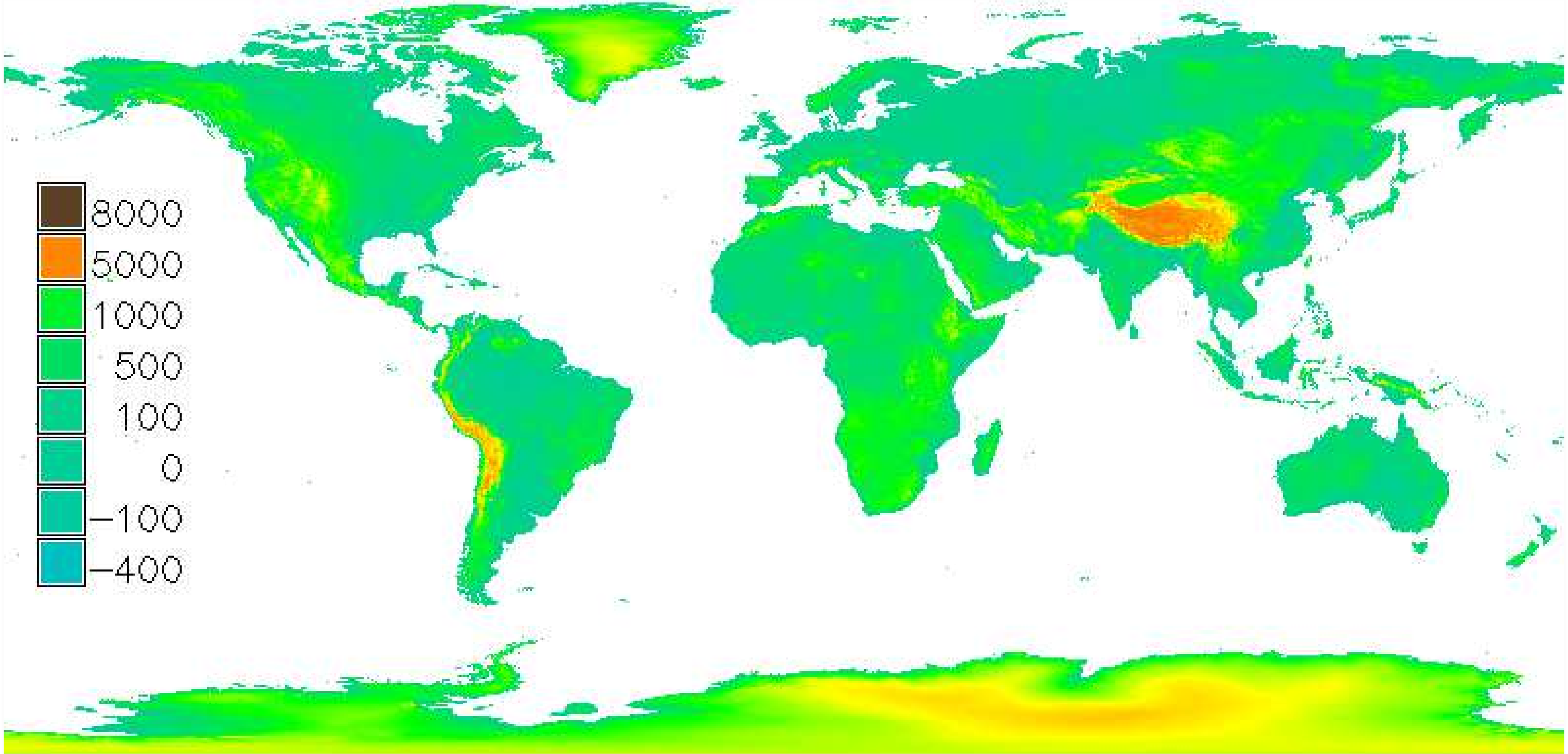
SAND fraction from HWSD (1km resolution)



V.3. Other physiographic databases available on Surfex-lab website

- Topography:
  - GTOPO30 from USGS at 1km resolution
  - Inline: srtm90 at 90m resolution (http://srtm.csi.cgiar.org/SELECTION/inputCoord.asp)
  - GMTED30 (not yet available on surfex-lab)
- Topographic index: HYDRO1K, derived from GTOPO30.

GTOPO30 orography (1km resolution)



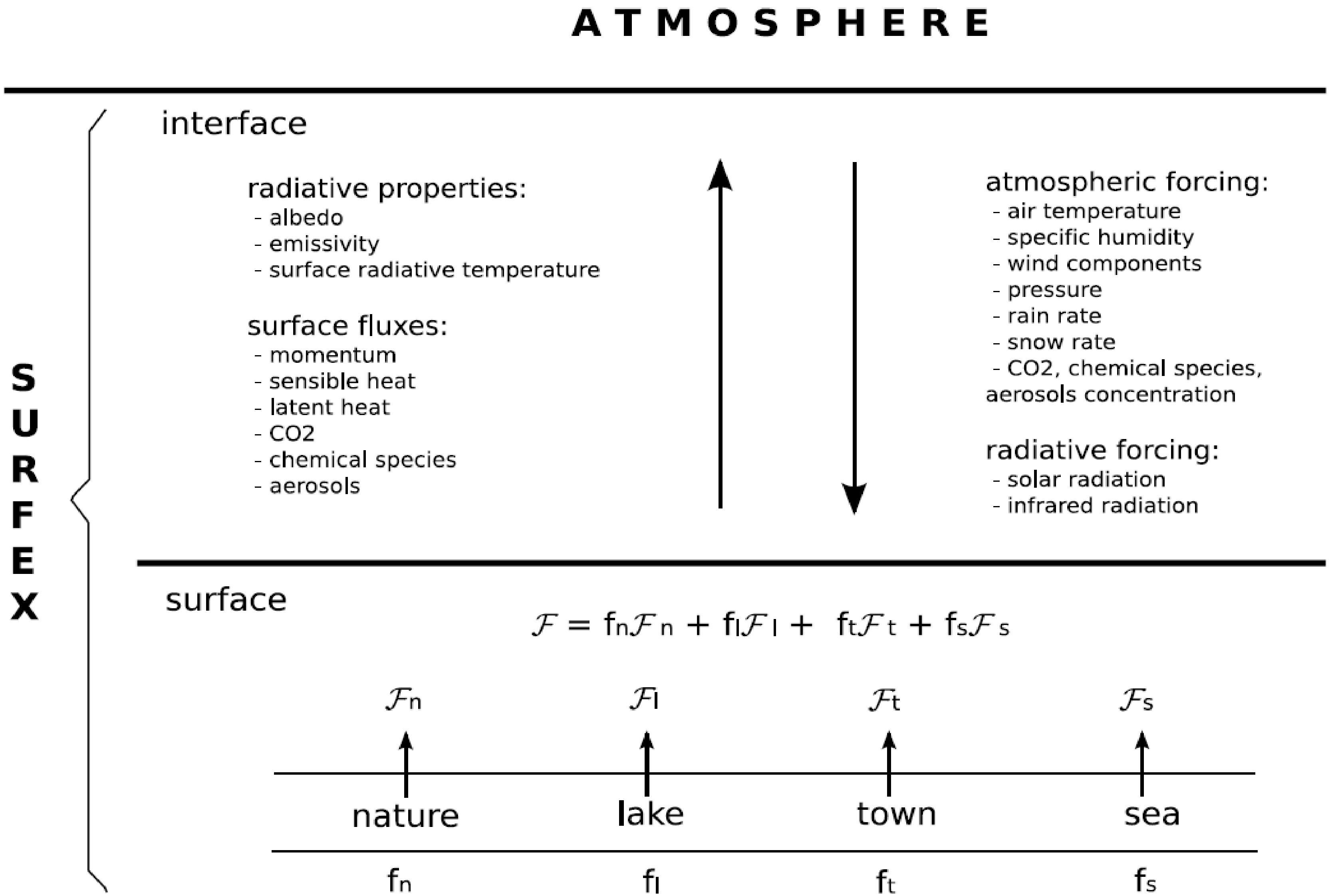
V.4. Where physiographic data are used in SURFEX (examples)?

- **CLAY** and **SAND** fractions to calculate profiles for
  - **WSAT** : water contents to reach soil saturation
  - **WWILT** : wilting point water contents
  - **WFC**: field capacity water contents

- **RSMIN** (minimum stomatal resistance) and **LAI** to calculate **Rs** : surface resistance, taking part in the calculation of evapotranspiration **Evp**.

Interface with the atmosphere

Interface with the atmosphere



Coupling with the atmosphere :

Explicit coupling (general case) :

variables are provided at T (or T → T+DT)

Fluxes are returned averaged over T / T+DT

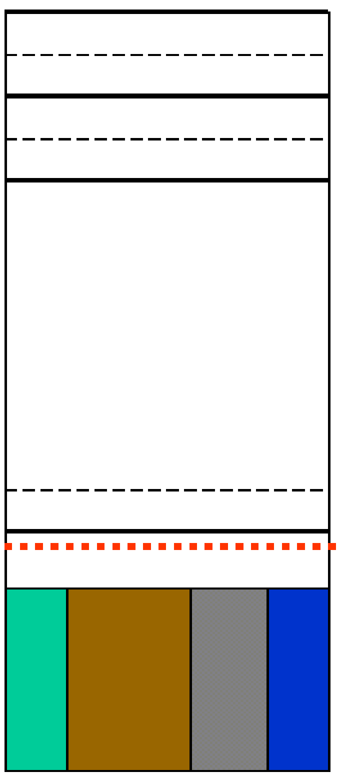
Offline : ASCII, binary, lfi, FA,
netcdf standardized interface
(ALMA, Polcher et al., 1998)

http://web.lmd.jussieu.fr/~polcher/ALMA/

Coupled mode : call coupling_surf_atm(variables…)

implicit coupling

In case of long time step to avoid instabilities in the coupling with the atmosphere. The surface is called in the middle of the vertical diffusion loop (Best et al., 2004).



Vertical diffusion

$$\begin{cases} X \equiv u, v, \theta, q \\ X_i^+ - X_i^- = -\omega_{i,j}\left(X_{i+1}^+ - X_i^+\right) + \omega_{i-1,j}\left(X_i^+ - X_{i-1}^+\right) \\ F_{X,0} = 0 \end{cases}$$

Downward sweep

$$\begin{cases} X_i^+ = A_{X,i}^- X_{i+1}^+ + B_{X,i} \\ A_{X,i} = f\left(\omega_{i-1,i}, \omega_{i,i}, A_{X,i-1}\right) \\ B_{X,i} = f\left(\omega_{i-1,i}, \omega_{i,i}, B_{X,i-1}, X_{X,i-1}\right) \end{cases}$$

Lower atmospheric level

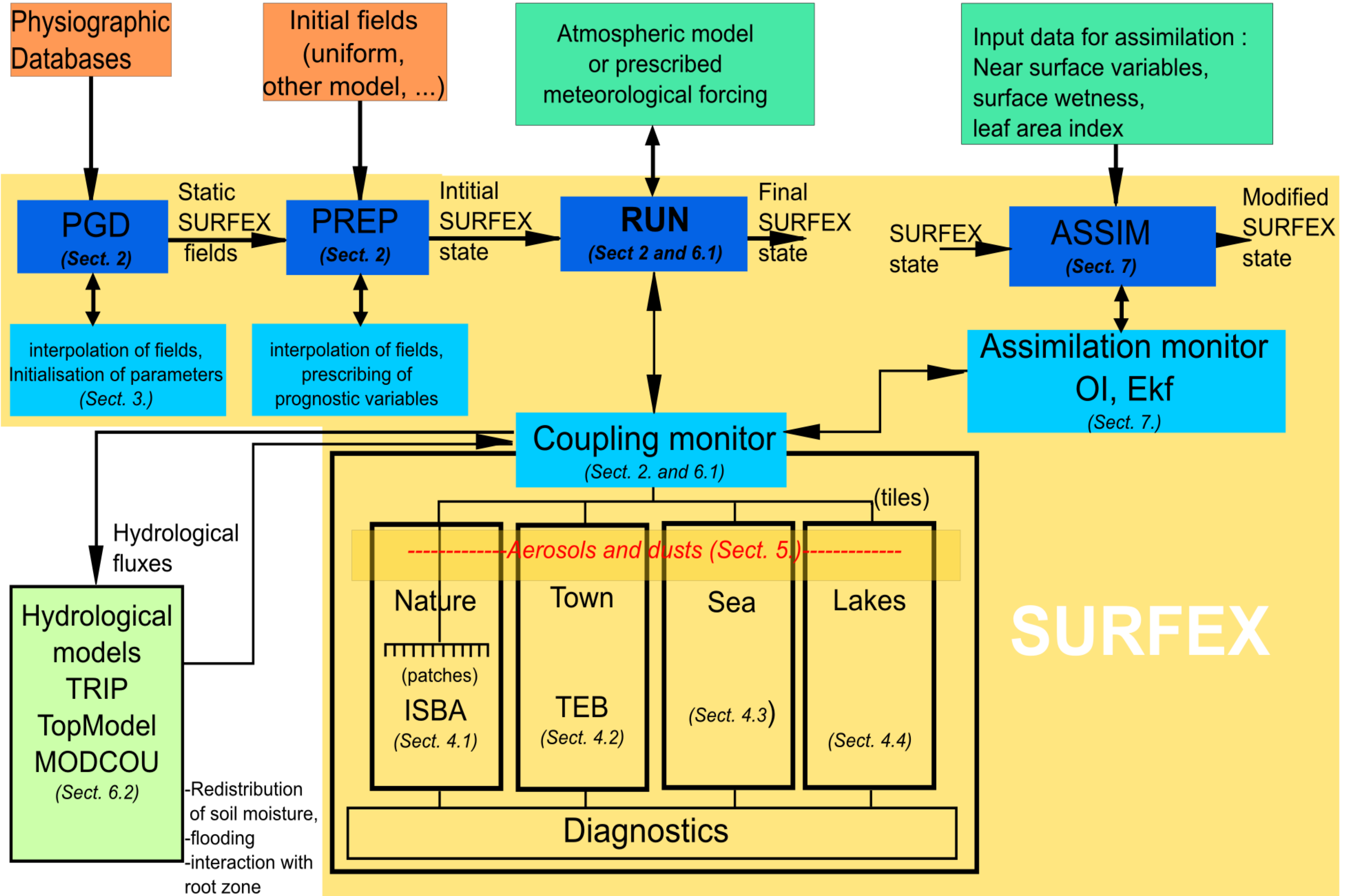
$$X_N^+ = A_{X,N}^- F_{X,S}^+ + B_{X,N}^-$$

Surface Ts + Fluxes on each tiles, Average fluxes

$$\begin{cases} H^+ = \rho C_p V_N^- C_H^- \left(\beta_S T_S^+ - \beta_N T_N^+\right) \\ \dfrac{C_s}{\Delta t}\left(T_S^+ - T_S^-\right) = R_n^+ - H^+ - LE^+ - G^+ \end{cases}$$

Upward sweep

More practical …
Running SURFEX



Physiographic Databases
Initial fields (uniform, other model, ...)
Atmospheric model or prescribed meteorological forcing
Input data for assimilation : Near surface variables, surface wetness, leaf area index
PGD (Sect. 2)
Static SURFEX fields
PREP (Sect. 2)
Intitial SURFEX state
RUN (Sect 2 and 6.1)
Final SURFEX state
SURFEX state
ASSIM (Sect. 7)
Modified SURFEX state
interpolation of fields, Initialisation of parameters (Sect. 3.)
interpolation of fields, prescribing of prognostic variables
Assimilation monitor OI, Ekf (Sect. 7.)
Coupling monitor (Sect. 2. and 6.1)
(tiles)
Hydrological fluxes
------------Aerosols and dusts (Sect. 5.)------------
Nature
(patches)
ISBA (Sect. 4.1)
Town
TEB (Sect. 4.2)
Sea
(Sect. 4.3)
Lakes
(Sect. 4.4)
Diagnostics
SURFEX
Hydrological models TRIP TopModel MODCOU (Sect. 6.2)
-Redistribution of soil moisture,
-flooding
-interaction with root zone

Running SURFEX

PGD : Physiography
•Choice of surface schemes
•Grid
•physiography

PREP : initialisation of prognostics variables

RUN mode : atmospheric model, offline, ASSIM, DIAG
run and diagnostics
(need atmospheric forcing)

PGD

Surface schemes :

Ex for NATURE : NONE, FLUX, TSZ0, ISBA (and options for ISBA)

Grid :

- **Gaussian, conformal projection, LONLAT reg, IGN (French Lambert projection), NONE (namelist)**
- **A part of the grid of an already existing file**
- **Can be given in fortran argument (ignore namelists)**

Physiography :

- **Covers : ECOLIMAP or uniform**
- **Orography (GTOPO30, other files, uniform)**
- **Sand and Clay fractions (FAO, other file, uniform)**

- For each **vegtype** with not null fraction:
  - Soil depths (root, soil, ice)
  - Height of trees (if vegtype for tree)
  - 10-day LAI (1 year for ecoclimap1 - 1992, 5 years for ecoclimap2 – 2002->2006) (Leaf Area Index)
  - Mean ALB_VEG_NIR and ALB_VEG_VIS

- For **Town** (if not null fraction):
  - Z0, BldHgt, WOHor, Bld frac, Garden frac
  - Alb & Emis for Roof, Road, Wall
  - Hc, Tc, D for each layer of Roof, Road, Wall
  - H & LE for Trafiic and Industry

III.4. Other vegetation physiographic parameters

- Depend only on surface type,ie on tile & vegtype, and not on spatial localisation (cover).
- Correspondence tables are directly written in SURFEX code (file ***ini_data_param.F90***).
- These are ALBVIS, ALBVEG, RSMIN, GAMMA, WRMAX_CF, RGL, CV, GMES, RE25, GC, BSLAI, DMAX, STRESS, SEFOLD, LAIMIN, CE_NITRO, CF_NITRO, CNA_NITRO, ROOT_EXTINCTION, ROOT_LIN, SOILRC_SO2, SOILRC_O3.

- Some parameters are calculated from other ones:
  - **VEG** (fraction of vegetation) from LAI and vegtype
  - **Z0** (roughness length) from LAI, H_TREE and vegtype
  - **EMIS** (emissivity) from VEG and vegtype

- Like LAI, these parameters deduced from LAI are 10-day defined.

III.5. Remark on ALBEDO

- To use albedos from the *.bin ECOCLIMAP files (more precise and evolving in time), and not those from ini_data_param.F90 (very rough), you need to activate:

CALBEDO = « CM13 »

In NAM_ISBAn

During the RUN step of SURFEX.

III. 6. Namelists NAM_FRAC_… & NAM_DATA_…: an alternative to ECOCLIMAP

- Namelist **NAM_FRAC** gives choice of using ECOCLIMAP (at least partially) or providing tiles fractions (sea, water, nature, town) directly here in the namelist.

- Namelists **NAM_DATA_…** (ISBA, TEB, BEM, TEB_GARDEN, TEB_GREENROOF, SEAFLUX, FLAKE) allow the user to replace one, several or all ECOCLIMAP parameters by its own data.

- For detailed descriptions, cf namelists documentation in user's guide on surfex-lab website.

  http://www.cnrm.meteo.fr/surfex-lab//spip.php?rubrique10

PREP

Date of all surface schemes

File to read, or uniform variables (namelist)

III.7. Stages for ECOCLIMAP in SURFEX (summary)

- **PGD:**
  - Reads the covers map (files .dir & .hdr)
  - Calculates the fractions of covers in each grid point
  - Reads the .bin ECOCLIMAP data files
  - Calculates the fractions of tiles (SEA, WATER, NATURE, TOWN) in each grid point
  - Writes the fractions of covers and tiles in the output PGD file
- **INIT (called during PREP and RUN steps):**
  - Reads the PGD output file
  - Reads the .bin ECOCLIMAP data files
  - Calculates the surface parameters for each grid point

RUN (offline) prognostic variables

OPTIONS for RUN :

General : general options for surface atmosphere

By scheme : options for run (e.g. : subgrid hydrology)

Run : need a PGD file, a PREP file and an atmospheric forcing