SURFEX

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With material from
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What is SURFEX?

SURFEX is a « **surf**ace **ex**ternalisée » (in French).

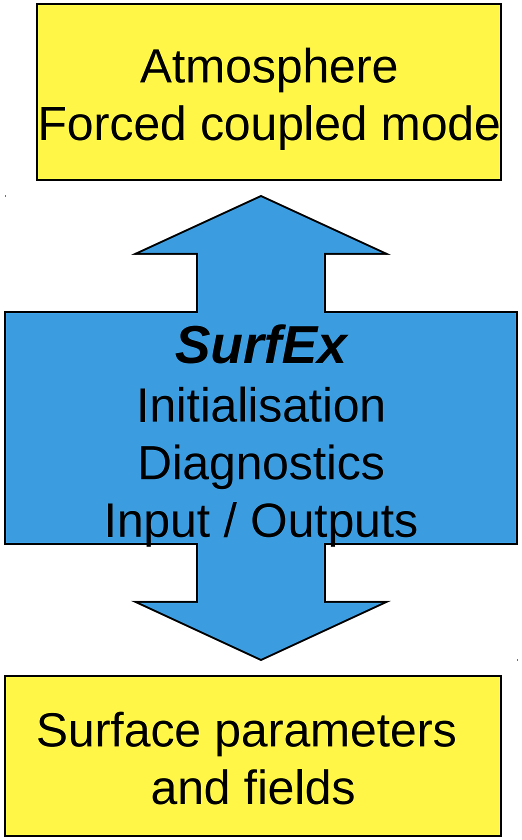
SURFEX is a surface code as stand-alone as possible, which can be run in a coupled mode with a meteorological model, or in an offline mode

SURFEX is designed as a modular scheme that can incorporate various parameterisations (via namelist options)

SURFEX is expected to be used in various applications, through existing and future collaborations on operational numerical weather predictions, climate research … and improve for the benefit of all.

SURFEX home:
http://www.cnrm.meteo.fr/surfex/

SURFEX purpose



- The aim of a surface code is to simulate fluxes between the surface and the atmosphere : energy, water, carbon, dust, snow, chemical species…
- The surface code needs to simulate near-surface and sub-surface processes to provide these fluxes.
- SURFEX is improved and validated offline, much work on surface processes are done by people not belonging to the meteorological or climate communities.
- The use of the same code for coupled and offline application is mandatory in order to ensure the coherency between the two applications.
- Externalization (separation from the atmosphere) of the surface code is needed in order to run SURFEX in stand-alone mode

SURFEX versions

36h1.4	contains SURFEX	v5.1	935 f90-files
37h1		v6.0	1045
38t1	will be	v7.x	1141

As Ulf pointed out yesterday SURFEX is not yet under version control and lives its own life besides any atmospheric code. Discussions have been initiated how SURFEX development should be governed in the future…

SURFEX namelists

See example of full SURFEX namelists in harmonie-36h1.4/nam/OPTIONS.nam_VARASSIM

BUT the actual SURFEX namelists are written from scr/ Prepare_pgd, Prep_ini_surfex, Forecast, …

```
&NAM_IO_OFFLINE
CSURF_FILETYPE      ='LFI   ',
:
/
&NAM_FRAC
LECOCLIMAP = T,
/
:
&NAM_PGD_SCHEMES
CNATURE =   'ISBA  '    ,

CSEA    =       'SEAFLX'    ,

CTOWN   =    'TEB   '    ,

CWATER  =   'WATFLX'
/
&NAM_PGD_ARRANGE_COVER
LTOWN_TO_ROCK=T
/
&NAM_COVER
YCOVER  = 'ecoclimats_v2',

/
&NAM_ZS
YZS           = 'gtopo30'       ,
/
&NAM_ISBA
CISBA         =        '2-L'         ,
```

```
&NAM_PREP_SURF_ATM
CFILE        = 'aladin.AN.20060701.00',

CFILETYPE    = 'GRIB'
/
&NAM_PREP_SEAFLUX
CFILE_SEAFLX = 'aladin.AN.20060701.00',
/
&NAM_PREP_WATFLUX
CFILE_WATFLX =
'aladin.AN.20060701.00',
/
&NAM_PREP_ISBA_SNOW
CSNOW = 'EBA'
/
&NAM_DIAG_SURFn
LSURF_BUDGET = T      ,
N2M          = 2      ,
LCOEF        = T      ,
LSURF_VARS   = T
/
&NAM_DIAG_SURF_ATMn
LFRAC        = T
/
&NAM_DIAG_ISBAn
LPGD             = T ,
LSURF_EVAP_BUDGET = T ,

LSURF_MISC_BUDGET = F ,
```

```
&NAM_DIAG_TEBn
LSURF_MISC_BUDGET = T
/
&NAM_SGH_ISBAn
CRUNOFF    = "WSAT"
/
&NAM_ISBAn
CROUGH      = "Z01D"     ,

CSCOND      = "NP89"     ,

CALBEDO     = "DRY"      ,

CC1DRY      = 'DEF '     ,
CSOILFRZ    = 'DEF'      ,
CDIFSFCOND = 'DEF '     ,

CSNOWRES   = 'DEF'      ,

CCPSURF    = 'DRY'
/
&NAM_SURF_ATM
LALDTHRES      = .FALSE. ,

LALDZ0H        = .FALSE. ,

LDRAG_COEF_ARP = .FALSE. ,
/
&NAM_SEAFLUXn
```

SURFEX steps

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)

Explicit (offline) or implicit (coupled to atmosphere) mode

SURFEX physiography

- **Orography**: GTOPO30 (USGS, U.S. Geological Survey) or user defined

  Can be imposed by the atmospheric code for coupled run.
- **Vegetation**: ECOCLIMAP or user defined
- **clay fraction**: FAO (Food and Agriculture Organization) or user defined
- **sand fraction**: FAO or user defined

- **Topographic index statistics:** min, max, mean, std and skewness (Hydro1K)
- **subgrid runoff coefficient**: user defined
- **subgrid drainage coefficient**: user defined

Namelists to define associated data files are **NAM_ZS** and **NAM_ISBA**

ECOCLIMAP grouping of tiles

ecoclimats_v2 1km resolution:

243 covers:

1 Sea
2 Lakes
3 Rivers
4 Bare land
5 Rocks
6 Permanent snow
7 Urban
8 Tropical undefined
:
184 East Europe pastures
:
243 Coastal lagoons

Sea

Lakes and rivers

Nature

Town

ECOCLIMAP grouping of tiles

SMHI

The Nature tile is divided into 12 patches

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

ECOCLIMAP grouping of tiles

NPATCH = 1-12

The Nature tile is divided into 12 patches

	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

ECOCLIMAP parameters

Primary parameters defined for each cover:
•LAI (each 10 day)
•Root and ground depths
•height of trees
•Town parameters

Secondary parameters defined for each patch:
•fraction of vegetation
•emissivity
•roughness length
•albedo
•minimal stomatal resistance
•coefficient of thermal inertia of vegetation
•height of vegetation
:

Namelists related to ECOCLIMAP in SURFEX

&NAM_FRAC LECOCLIMAP=T / F
⇒Flag to use ECOCLIMAP. Otherwise fractions of tiles are prescribed by user.

&NAM_COVER
YCOVER= name of the file containing the ECOCLIMAP land cover map (ecoclimats_v2)
YFILETYPE= DIRECT / BINLLV / BINLLF / ASCLLV => type of file.
XRM_COVER= threshold fraction before which a cover is removed from a grid point (1E-6)
XRM_COAST= limit of coast coverage under which the coast is replaced by sea or inland water in grid points. (1)
XRM_LAKE= limit of inland lake coverage under which the water is removed from grid points (0)
XUNIF_COVER= fractions of covers prescribed by user. If set, YCOVER file isn't used.

&NAM_PGD_ARRANGE_COVER
LWATER_TO_NATURE = T / F
If T, all WATER fractions in covers become NATURE fractions (F)
LTOWN_TO_ROCK = T / F
If T, all TOWN fractions in covers become ROCK fractions in tile NATURE (F)

Namelists related to ECOCLIMAP in SURFEX

&NAM_DIAG_SURF_ATMn
LFRAC = T / F Flag to save in the output file the sea, inland water, town and nature fractions.

&NAM_WRITE_SURF_ATM
LNOWRITE_COVERS = T / F If true, do not write covers fractions in initial/restart files.

&NAM_IO_OFFLINE
LWRITE_COORD = T / F If true, latlon coordinates of grid points are written in output files.

&NAM_DIAG_ISBAn
LPGD = T / F flag to save in the output file the physiographic fields of ISBA scheme computed
from ECOCLIMAP data.
LPGD_FIX = T / F flag to save in the output file the physiographic fields of ISBA scheme computed from ECOCLIMAP data and that don’t vary in time.

ECOCLIMAP steps in SURFEX

PGD step :

- Reading of ECOCLIMAP map
- For each Surfex grid point, definition of fractions of present covers => definition of Land / Sea mask
- Writing of fractions of covers by grid point in PGD output file

PREP step:

- Reading of PGD output file to get fractions of covers by grid point
- Writing of fractions of covers by grid point in PREP output file
  (+ calculation and writing of surface parameters values if asked by user)

Model Run step:

- Reading of PREP output file to get fractions of covers by grid point
- Calculation of surface parameters values at initial time
- Update of surface parameters values at each time step
- Writing of surface parameters values if asked by user

SURFEX tiles

Sea:
•Prescribed SST
•1D ocean model

Lakes:
•Prescribed LST
•FLake

Nature:
•ISBA

Town:
•TEB (Town Energy Balance)

SURFEX tiles: Sea

&NAM_PGD_SCHEMES
CSEA = 'SEAFLX'

SST from CFILE_SEAFLX in &NAM_PREP_SEAFLUX

Namelist NAM_SEAFLUXn

Fortran name	Fortran type	values	default value
CSEA_FLUX	string of 6 characters	'DIRECT', 'ITERAT', 'COARE3', 'ECUME '	'ECUME '
CSEA_ALB	string of 4 characters	'UNIF', 'TA96'	'TA96'
LPWG	logical	**Correction fluxes due to gustiness**	F
LPRECIP	logical	**Correction fluxes due to precipitation**	F
LPWEBB	logical	**Correction fluxes due to convection**	F
LPROGSST	logical		F
NTIME_COUPLING	integer		

•"ECUME " : takes into account effect of atmospheric convection, precipitation and gustiness on fluxes : improvement of surface exchange coefficients representation.

•"TA96" : Taylor et al (1996) formula for water direct albedo, depending on solar zenith Angle

•LPWG=.T.

•LPROGSST : set it to .TRUE. to make SST evolve with tendency when using the 1d oceanic model (Gaspar et al., 1990): A simple eddy kinetic energy model for simulations of the oceanic vertical mixing

SURFEX tiles: Lakes

SMHI

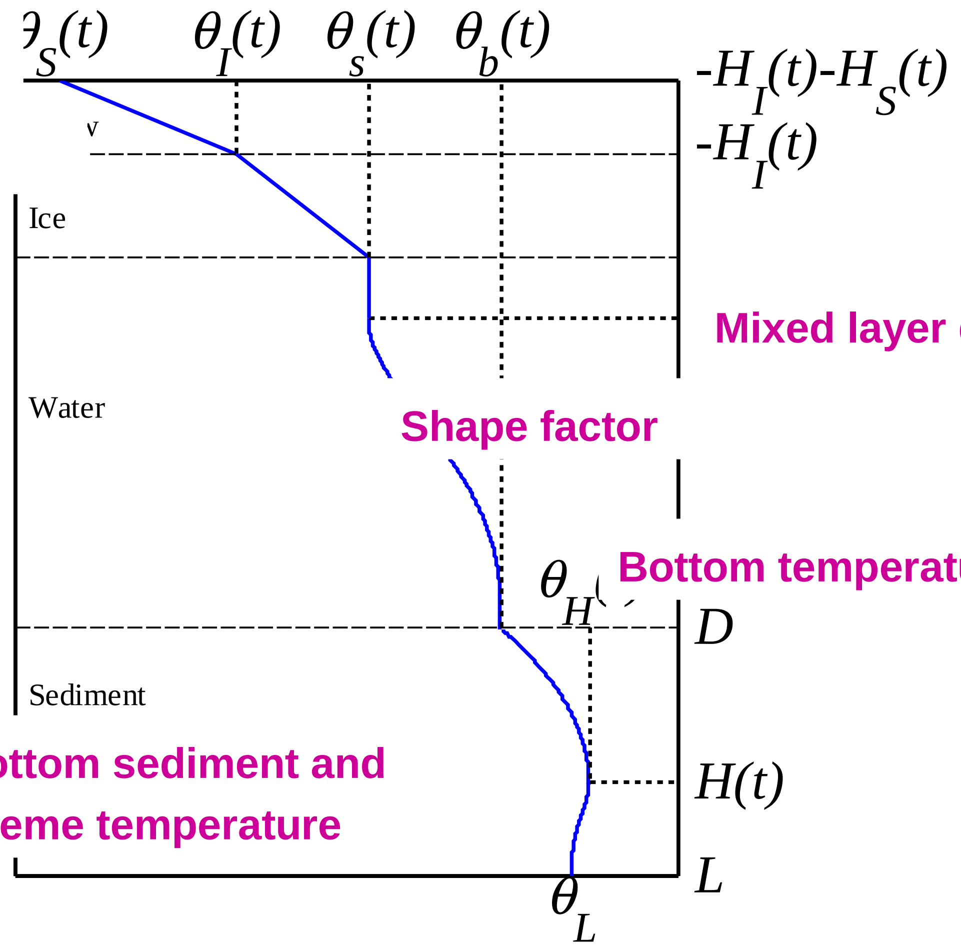
&NAM_PGD_SCHEMES
CWATER = 'WATFLX'* or 'FLAKE'

*LST from CFILE_WATFLX in &NAM_PREP_WATFLUX

FLake – http://lakemodel.net

Surface temperatures (water, ice, snow**)**

Ice (and snow) **depth**

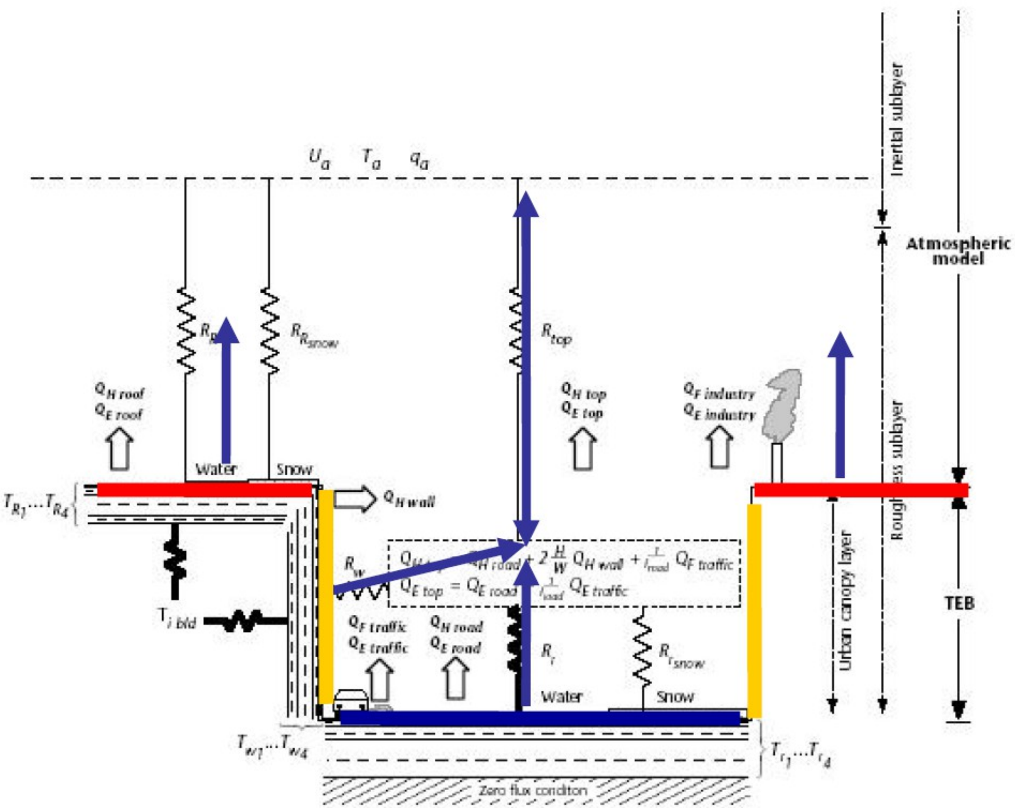


Extreme temperature of bottom sediment and depth of the sediment extreme temperature

SURFEX tiles: Town

&NAM_PGD_SCHEMES
CTOWN = 'TEB'

The town energy balance (TEB) model
(Masson 2000; Masson et al. 2002; Lemonsu et al. 2003)



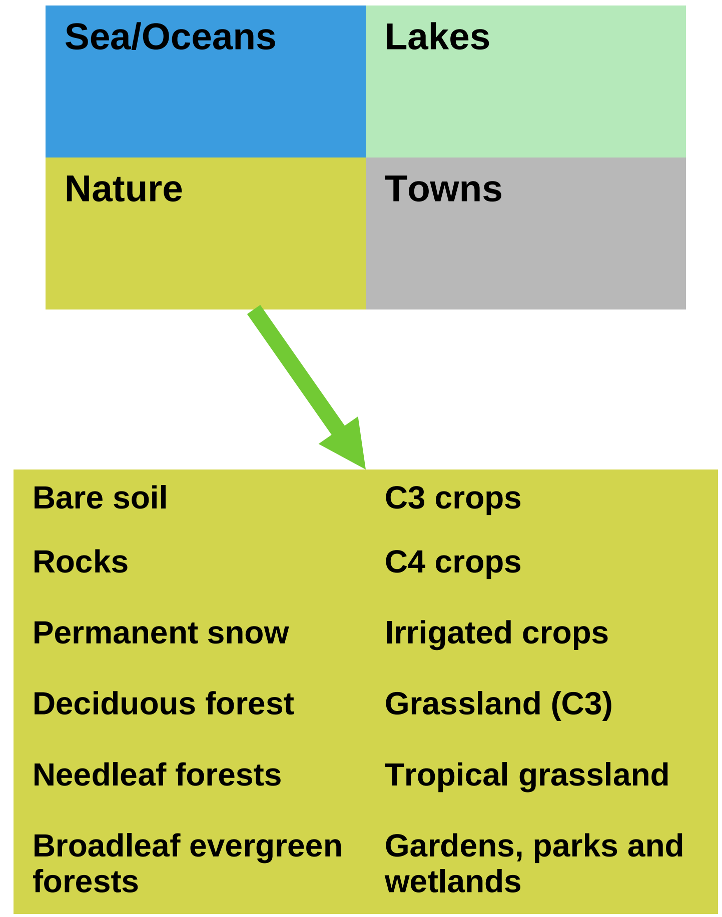
The town is described by one roof, a road and two identical walls.

Physical phenomena:

- Interception of rain and snow
- Heat storage in buildings
- Anthropogenic fluxes

SURFEX tiles: Nature

&NAM_PGD_SCHEMES
CNATURE = ’ISBA’

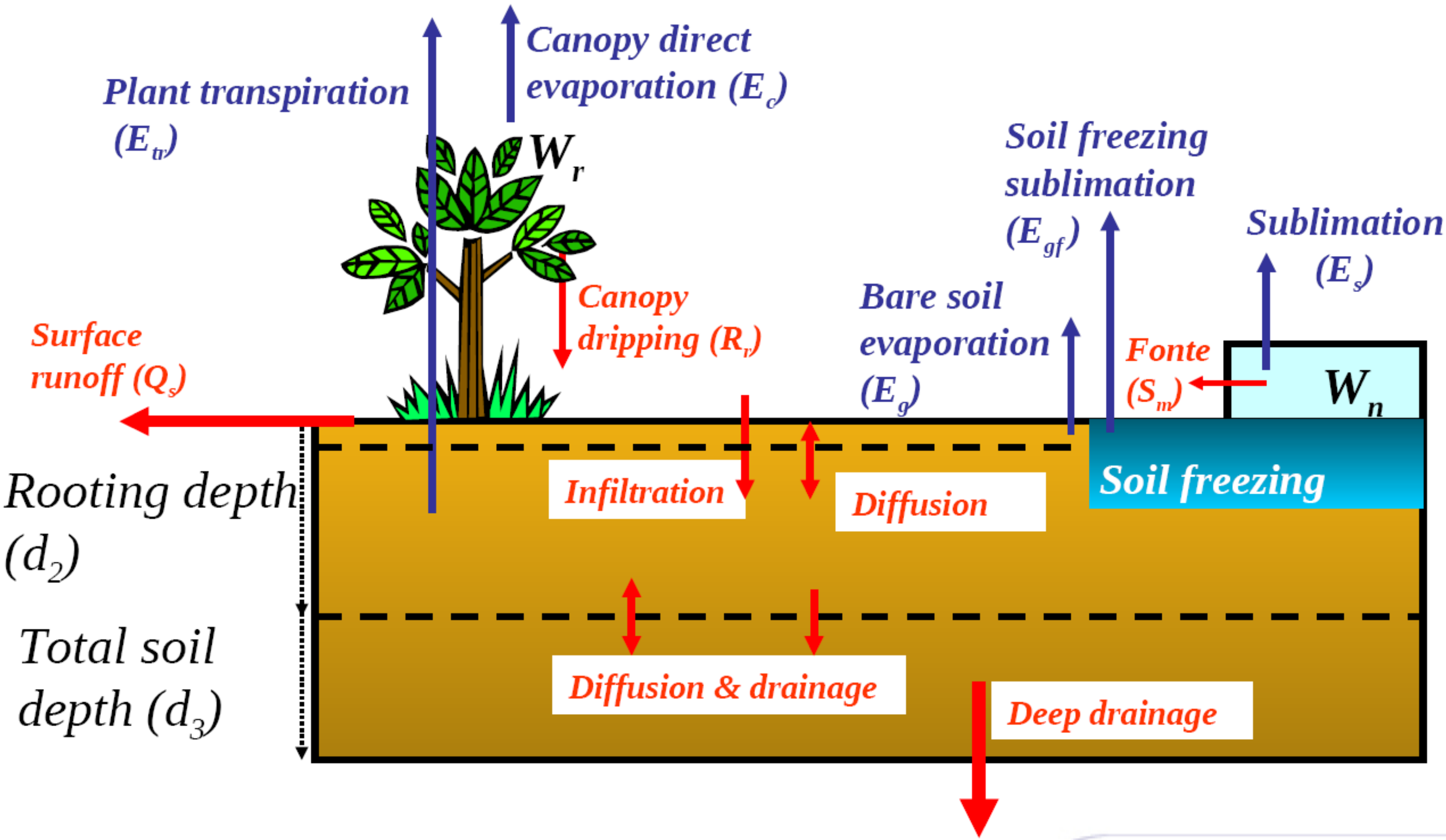


- The tile Nature is divided into 12 patches or less
- For each tile/patch, the forcing is identical, prognostic variables are independent
- Fluxes are aggregated, then returned to the atmosphere
- No specific patch for snow (except permanent snow). Snow is present in all patches if necessary.

SURFEX Nature physics options

	Force restore, 2 layers, temp, water, ice	**CISBA = 2-L**
Soil	**Force restore, 3 layers, temp, water, ice**	**3-L**
	Diffusion, N layers, temp, water, ice	**DIF**

SURFEX Nature physics options



Noilhan and Planton 1989; Douville et al. 1995; Mahfouf and Noilhan 1996; Boone et al. 1999; Boone et al. 2000

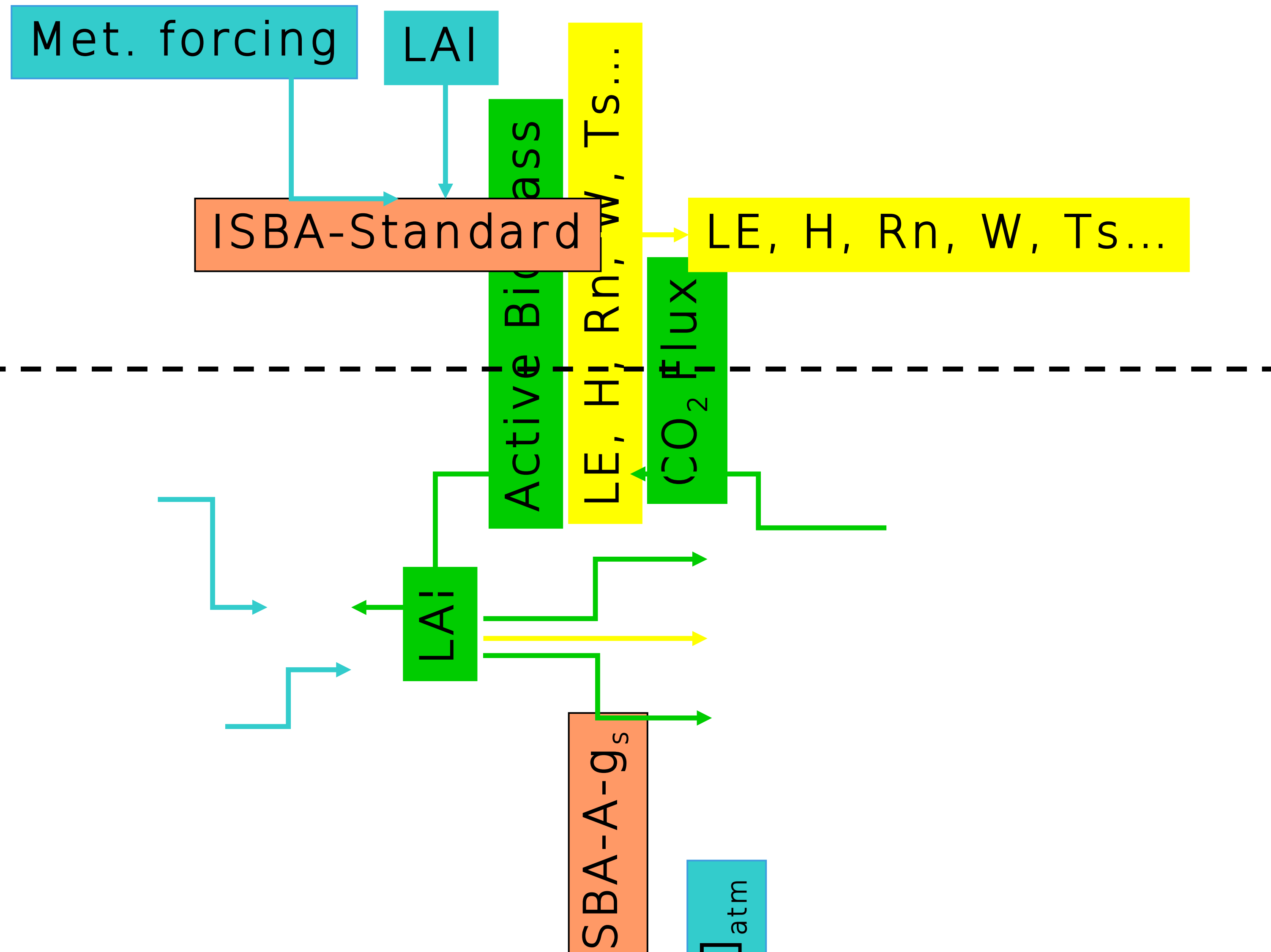
SURFEX Nature physics options

Soil	Force restore, 2 layers, temp, water, ice	CISBA = 2-L
	Force restore, 3 layers, temp, water, ice	3-L
	Diffusion, N layers, temp, water, ice	DIF
Vegetation	Noilhan & Planton 1989 (~Jarvis)	CPHOTO=NON
	A-gs (photosynthesis and CO2 fluxes)	AGS
	A-gs and interactive vegetation	LAI
	:	

SURFEX Nature physics options

CPHOTO=NON

CPHOTO=LAI

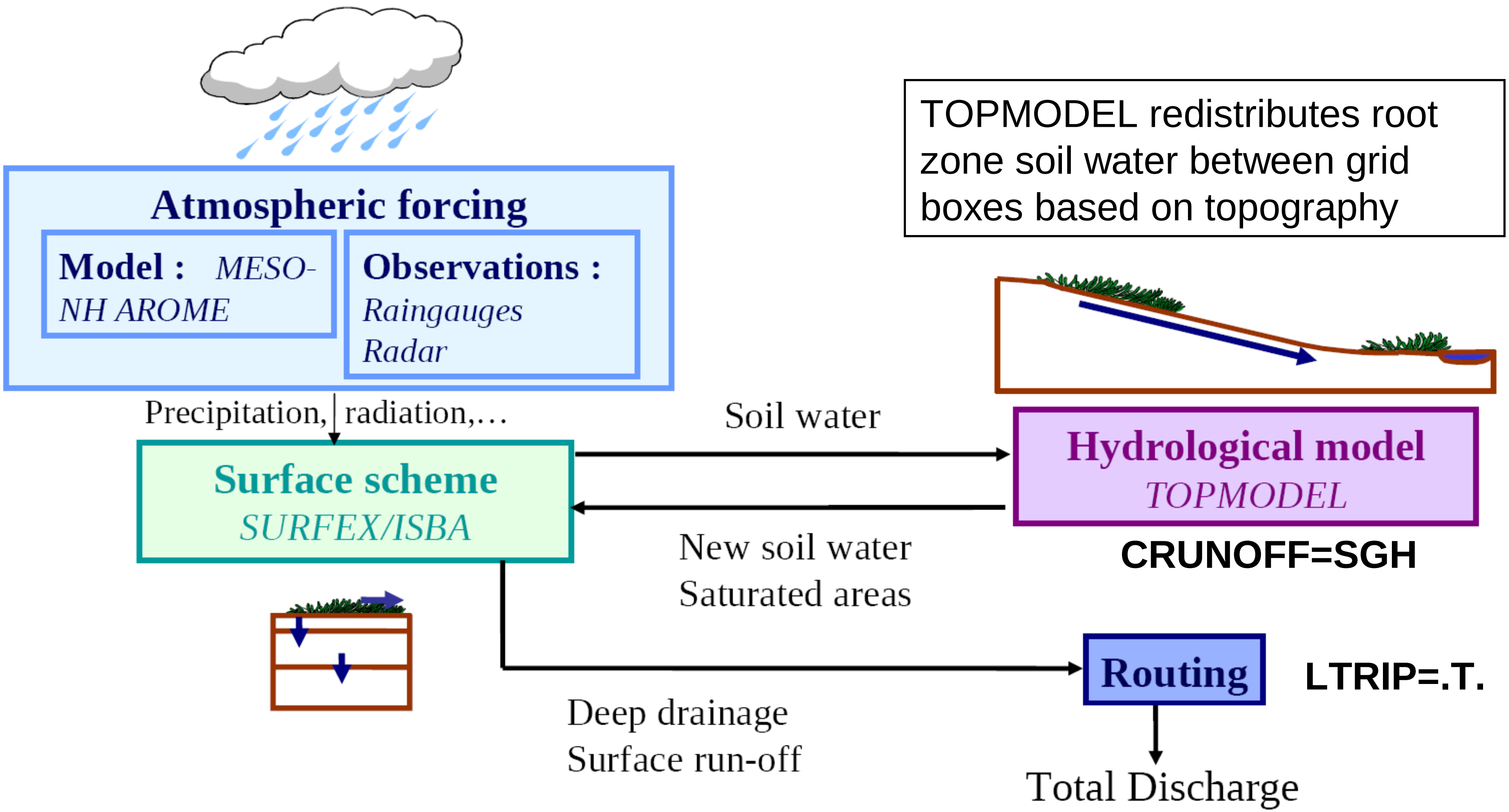


SURFEX Nature physics options

Soil	**Force restore, 2 layers, temp, water, ice**	**CISBA = 2-L**
	Force restore, 3 layers, temp, water, ice	**3-L**
	Diffusion, N layers, temp, water, ice	**DIF**
Vegetation	**Noilhan & Planton 1989 (~Jarvis)**	**CPHOTO=NON**
	A-gs (photosynthesis and CO2 fluxes)	**AGS**
	A-gs and interactive vegetation	**LAI**
	:	
Hydrology	**Standard (no subgrid processes)**	**CRUNOFF=WSAT**
	Subgrid runoff (DT92, Topmodel)	**DT92, SGH**
	:	

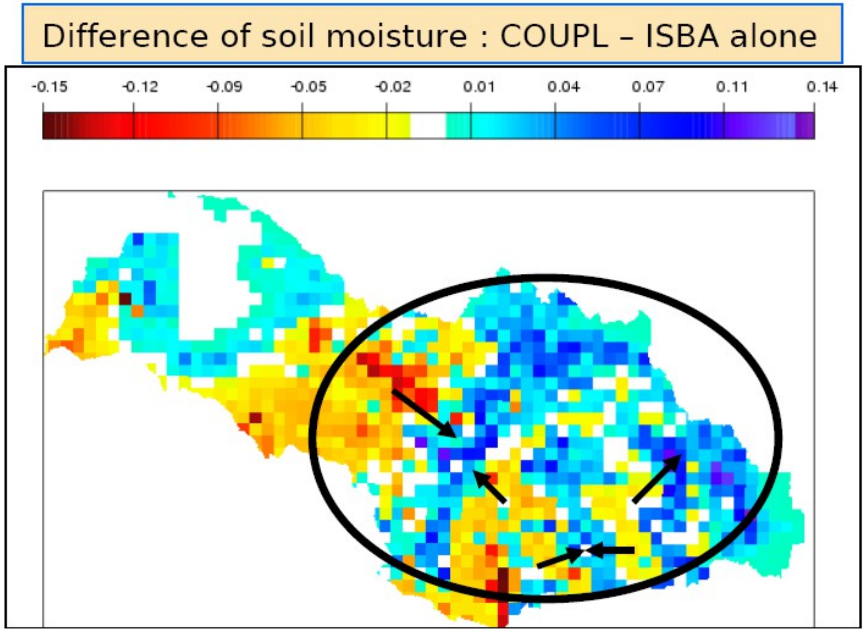
Coupling SURFEX and TOPMODEL for flash floods…

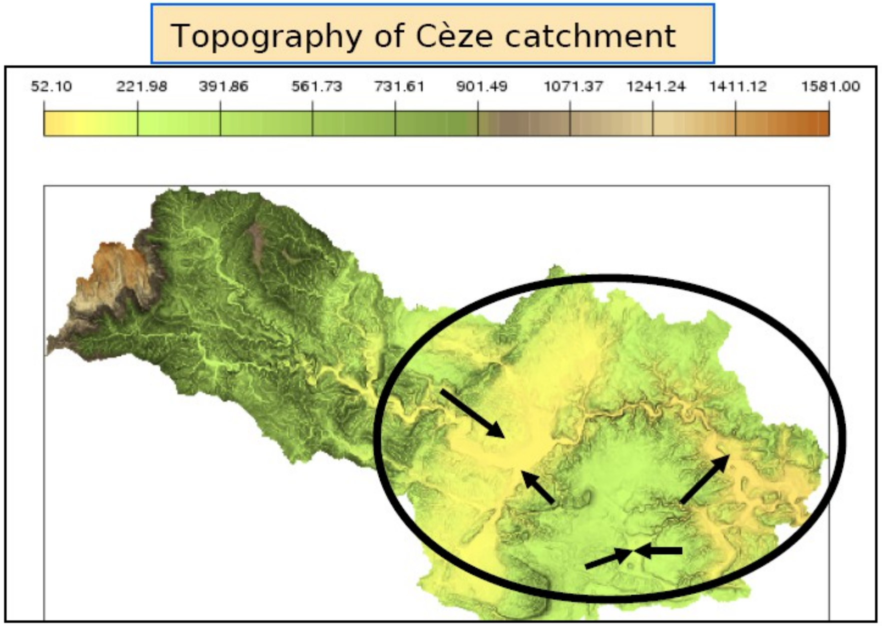
SMHI



Contact : B. Vincendon, CNRM-GAME

…with and without coupling





More realistic soil water contents

High sensitivity to input rain rate

SURFEX Nature physics options

SMHI

Soil	Force restore, 2 layers, temp, water, ice	CISBA = 2-L
	Force restore, 3 layers, temp, water, ice	3-L
	Diffusion, N layers, temp, water, ice	DIF
Vegetation	Noilhan & Planton 1989 (~Jarvis)	CPHOTO=NON
	A-gs (photosynthesis and CO2 fluxes)	AGS
	A-gs and interactive vegetation	LAI
	:	
Hydrology	Standard (no subgrid processes)	CRUNOFF=WSAT
	Subgrid runoff (DT92, Topmodel)	DT92, SGH
	:	
Snow	1 layer, prog. SWE, albedo	CSNOW=EBA
	1 layer, prog. SWE, albedo, density	D95
	3-(N) layers, prog. SWE, albedo, density, temp	3-L
	Multilayer Crocus model (snow avalanche)	CRO

SURFEX Nature physics options

3-L snow scheme:

- an N-layer scheme (default 3)
- explicit compaction (and melt densification)
- radiative transfer
- explicit energy budget: prognostic variables = albedo, density, SWE and ***H***
- liquid water content (using enthalpy concept)

$$H_{s\,i} = c_{s\,i}\, D_{s\,i}\, (T_{s\,i} - T_f) - L_f\, (W_{s\,i} - W_{l\,i})$$

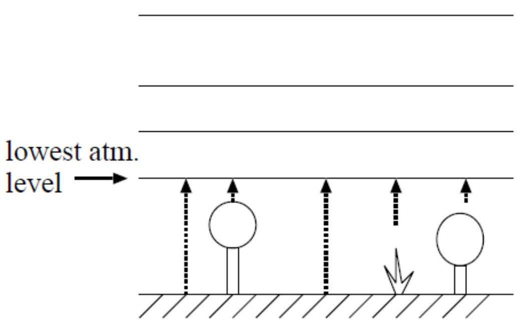
New prog. variable

2 prognostic variables "for the price of one"...

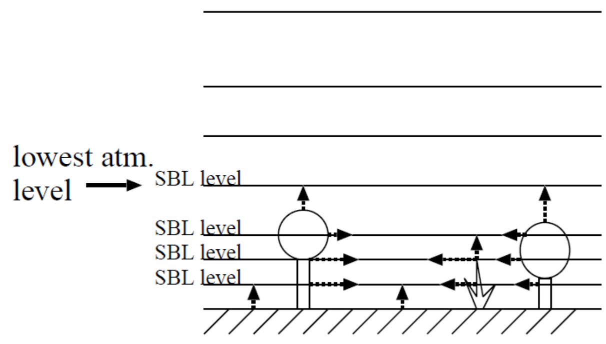
$$T_{s\,i} = T_f + (H_{s\,i} + L_f\, W_{s\,i}) \,/\, (c_{s\,i}\, D_{s\,i}) \qquad (W_{l\,i} = 0)$$

$$W_{l\,i} = W_{s\,i} + (H_{s\,i}/L_f) \qquad (T_{s\,i} = T_f)$$

SURFEX Surface BL scheme (canopy model)



"single-layer" surface scheme
coupled to an atmospheric model



"single-layer" surface scheme
+ Surface Boundary Layer scheme
coupled to an atmospheric model

&NAM_PREP_ISBA
LISBA_CANOPY = .T.

LCANOPY DRAG =.T.
drag activated in SBL scheme within the canopy

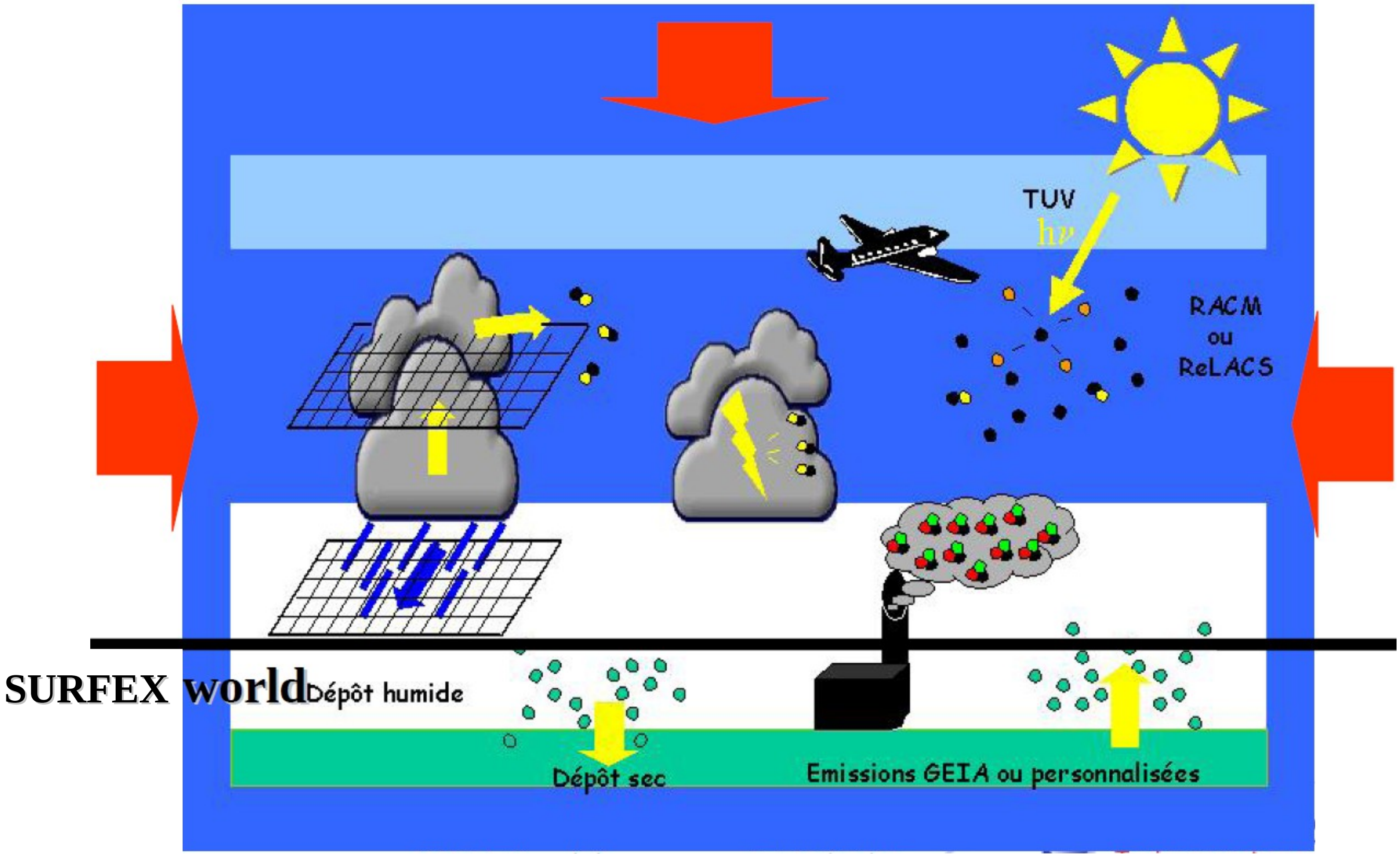
&NAM_PREP_TEB
LTEB_CANOPY = .T.

$$\begin{cases} \frac{\partial U}{\partial t} = \frac{\partial U}{\partial t}(z = z_a) + Turb(U) + \mathrm{Drag_u} \\ \frac{\partial \theta}{\partial t} = \frac{\partial \theta}{\partial t}(z = z_a) + Turb(\theta) + \frac{\partial \theta}{\partial t}_{canopy} \\ \frac{\partial q}{\partial t} = \frac{\partial q}{\partial t}(z = z_a) + Turb(q) + \frac{\partial q}{\partial t}_{canopy} \end{cases}$$

$$\frac{\partial e}{\partial t} = Dyn.Prod. + Therm.Prod. + Diss. + \frac{\partial e}{\partial t}_{canopy}$$

SURFEX chemistry and aerosols

Processes for deposition and emission of chemical species do activate only if chemical species are present as concentrations and fluxes.



SURFEX diagnostics

SMHI

Namelist NAM_DIAG_SURF_ATMn

Fortran name	Fortran type	default value
LFRAC	logical	.FALSE.
LDIAG_GRID	logical	.FALSE.

=.T. save data for sea, lake, nature, town
mean grid diagnostics

Namelist NAM_DIAG_SURFn

Fortran name	Fortran type	values	default value
N2M	integer	0, 1, 2	0
LSURF_BUDGET	logical		.FALSE.
LRAD_BUDGET	logical		.FALSE.
LCOEF	logical		.FALSE.
LSURF_VARS	logical		.FALSE.

=2 compute interpolated diag at 2m and 10m
=.T. save fluxes at grid, tile and patch levels
save radiation components for spectral bands
=.T. save exchange coeff at grid and tile levels
=.T. save qs at grid, tile and patch levels

Namelist NAM_DIAG_ISBAn

Fortran name	Fortran type	default value
LPGD	logical	.FALSE.
LPGD_FIX	logical	.FALSE.
LSURF_EVAP_BUDGET	logical	.FALSE.
LSURF_MISC_BUDGET	logical	.FALSE.
LSURF_BUDGETC	logical	.FALSE.
LRESET_BUDGETC	logical	.FALSE.

=.T. save Ecoclimap physiographic fields
also save static Ecoclimap physiographic fields
=.T. save water fluxes at Nature and patch levels
=.T. save misc fields, e.g. snow fraction
save time integrated fluxes
reset cumulative values at start of run

Drakensberg, South Africa, August 2006