An introduction to **SURFEX**

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METEO FRANCE
Toujours un temps d'avance

The SURFEX Course

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Toujours un temps d'avance

Ecole Nationale de la Météorologie

Formation Permanente

<u>Stage :</u> SURFEX

du 14/10/2009 au 16/10/2009 **salle : E058 / C059**

	09h00	10h15	10h15 – 12h00	12h00 – 12h15	12h15 – 14h00	14h00	15h00	15h15 – 17h00
MERCREDI 14/10/2009	Introduction to SURFEX E. Martin	Break	Present use of SURFEX in various applications (AROME, ARPEGE/ALADIN, climate applications, mesoclae applications …) Y. Seity, B. Decharme, F. Bouyssel, E. Martin		PAUSE REPAS	ECOCLIMAP S. Faroux	Break	ISBA B. Decharme,A. Boone, J.Calvet
JEUDI 15/10/2009	TP 1 Introduction P. Le Moigne		TP1 : introduction to the software, physiography P. Le Moigne, S. Faroux, L. Rontu		PAUSE REPAS	FLAKE R. Salgado OCEAN (ECUME) S. Belamari	Break	TEB, surface boundary layer V. Masson Chemistry, aerosols P. Tulet
VENDREDI 16/10/2009	TP 2 Introduction P. Le Moigne		TP2 : running SURFEX offline P. Le Moigne, S. Faroux, L. Rontu		PAUSE REPAS	Surface assimilation J.-F. Mahfouf	Break	Discussion, conclusion of the course,Evaluation E. Martin, P. Le Moigne, S. Faroux, L. Audonnet-Falga

<u>Responsable de la session :</u> Lydie Audonnet-Falga, P. Le Moigne, E. Martin

Semaine du 12/10/2009 au 16/10/2009

Practical informations for people attending the training course (20 people)

- Theoritical courses : E058
- Practical courses : C059
- Take your paper name with you !

- Please sign the attendance list every half day !

- Restaurant card :
- Be prepared to give money with the card at the cashier (20 Euros?)
- The last day give the card at the restaurant, they will give your money back if not used

- Any problem ? Lydie Audonnet (C052), E. Martin, P. Le Moigne

Documentation related to SURFEX :

Available at www.cnrm.meteo.fr/surfex/

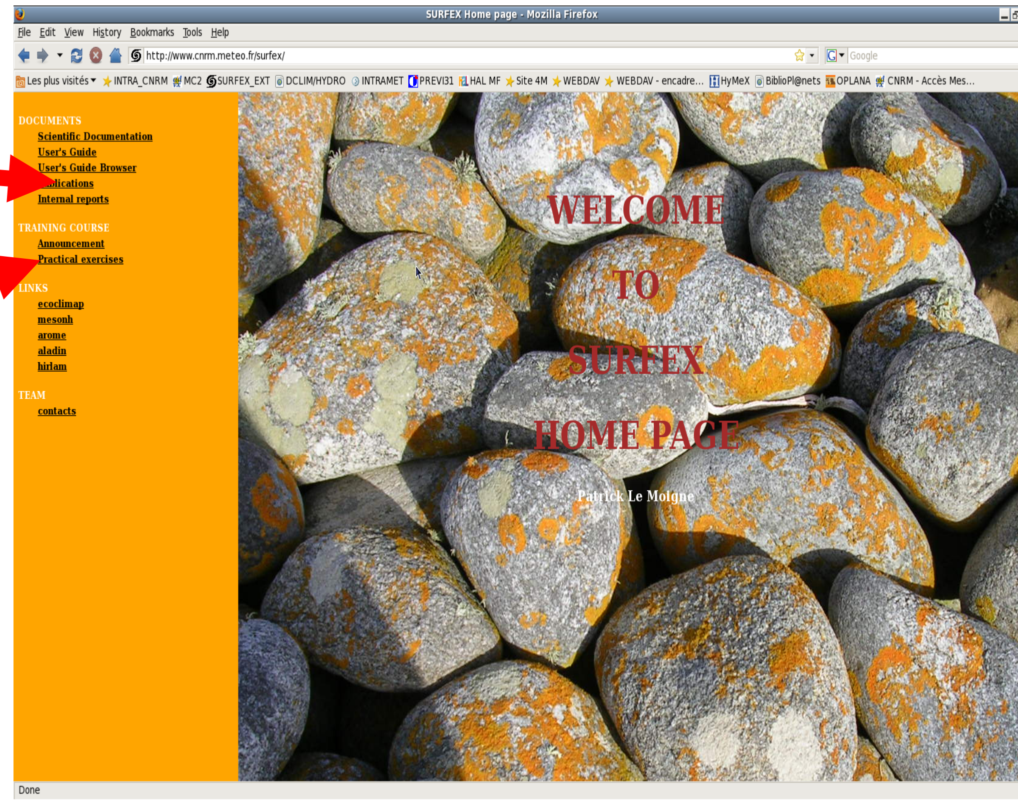
Scientific documentation

User's guide

Announcement

Practical course

Copy of the slides *(ASAP !)*



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Main principles

Let's begin : What is SURFEX ?

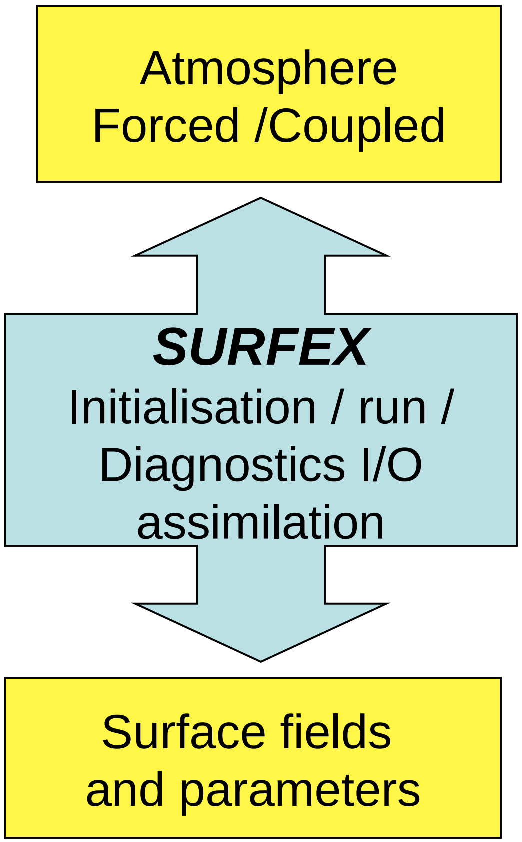
SURFEX is a « **surf**ace **ex**ternalisée » (in French).

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

SURFEX is designed as a modular scheme that can incorporate various parameterisations

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

Why do we need externalised 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 climatilogical communities.
- The use of the same code for coupled and offline application is mandatory in order to ensure the coherency between the two applications.
- Need to externalise 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

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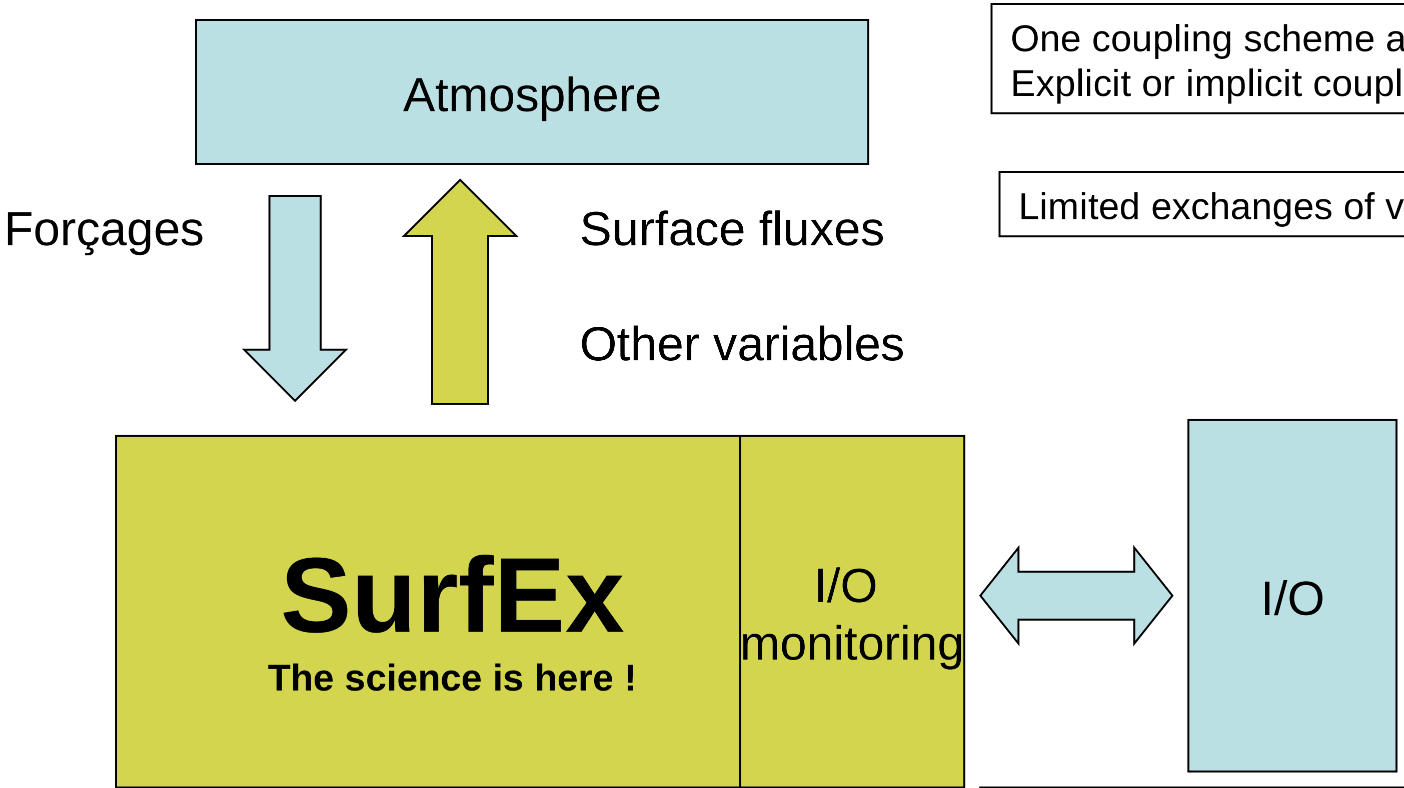
Couping and interfaces



One coupling scheme allowing
Explicit or implicit coupling

Limited exchanges of variables

Low level routine only depends on the output format

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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

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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
	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)

Lakes : Flake model

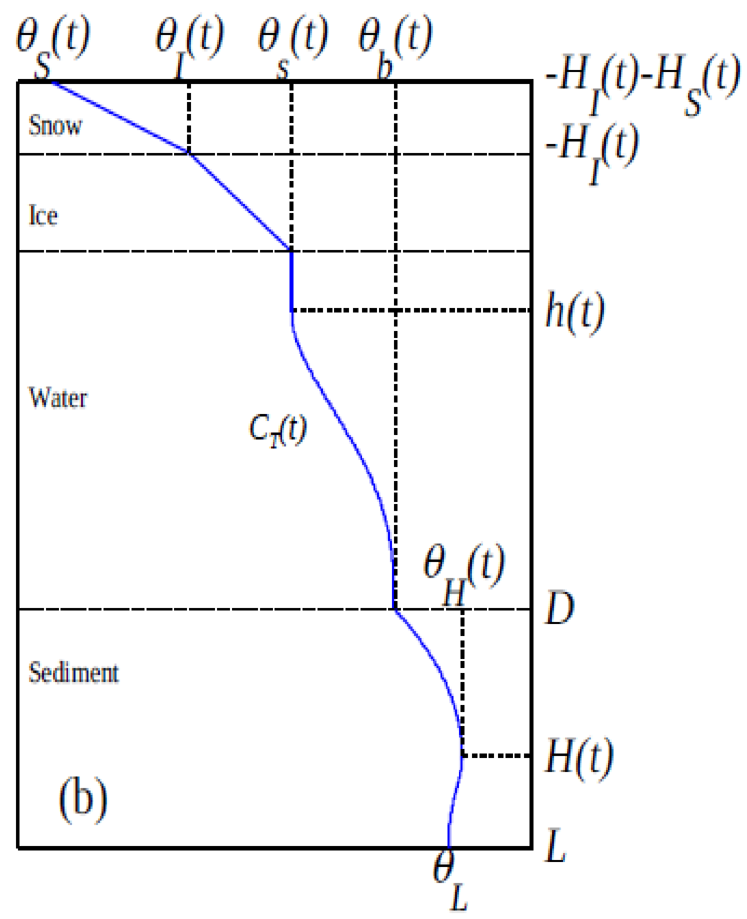
Simple model, based on assumed shape of the temperature profile

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

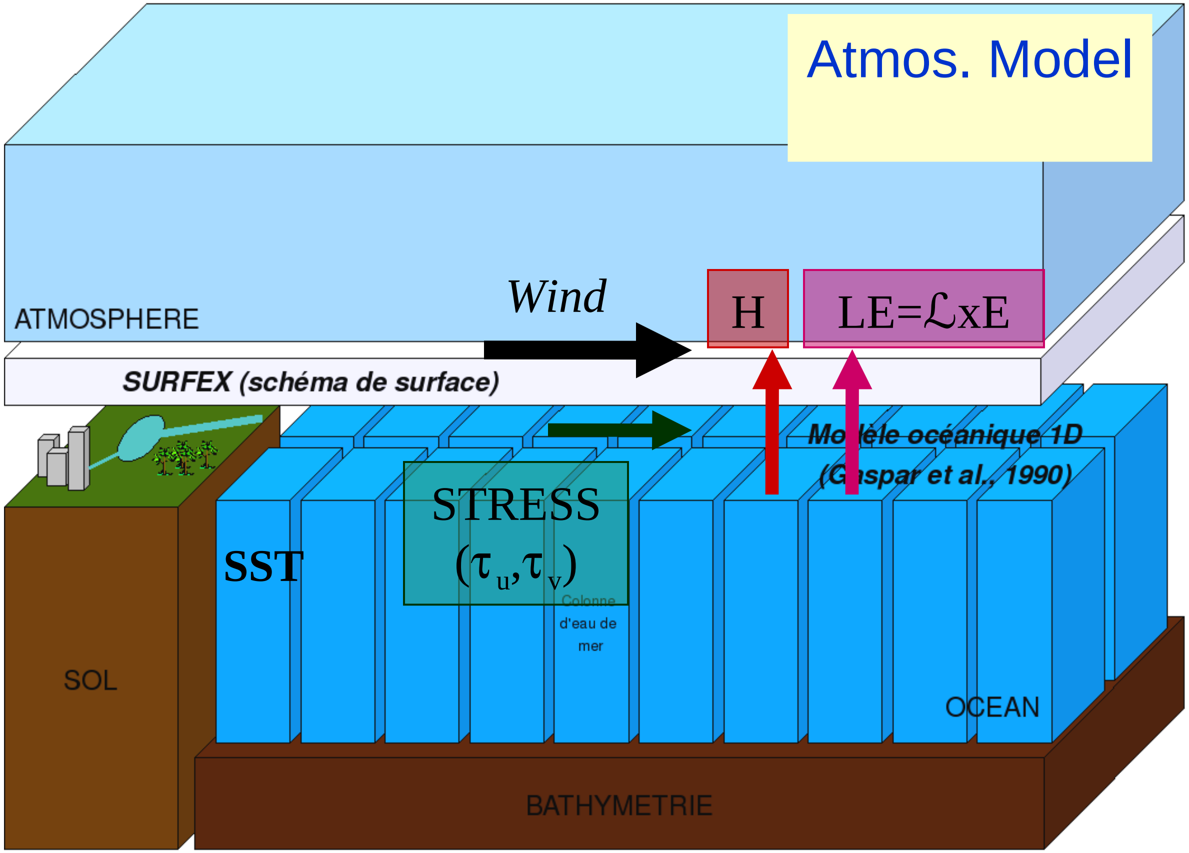
- the surface temperature,
- the bottom temperature,
- the mixed-layer depth,
- the shape factor with respect to the temperature profile in the thermocline,
- the depth within bottom sediments penetrated by the thermal wave, and
- the temperature at that depth.



http://nwpi.krc.karelia.ru/flake/

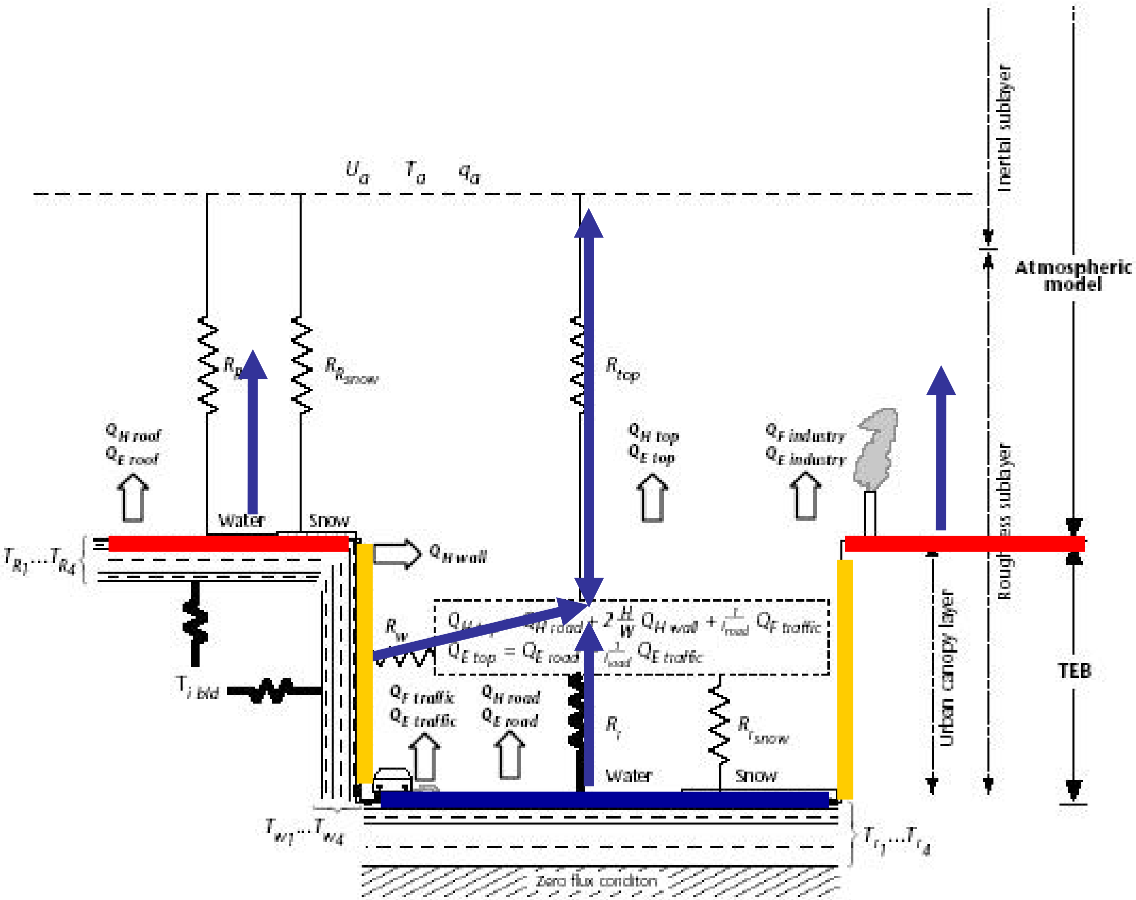
SEA / OCEAN

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



TEB : main principles

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

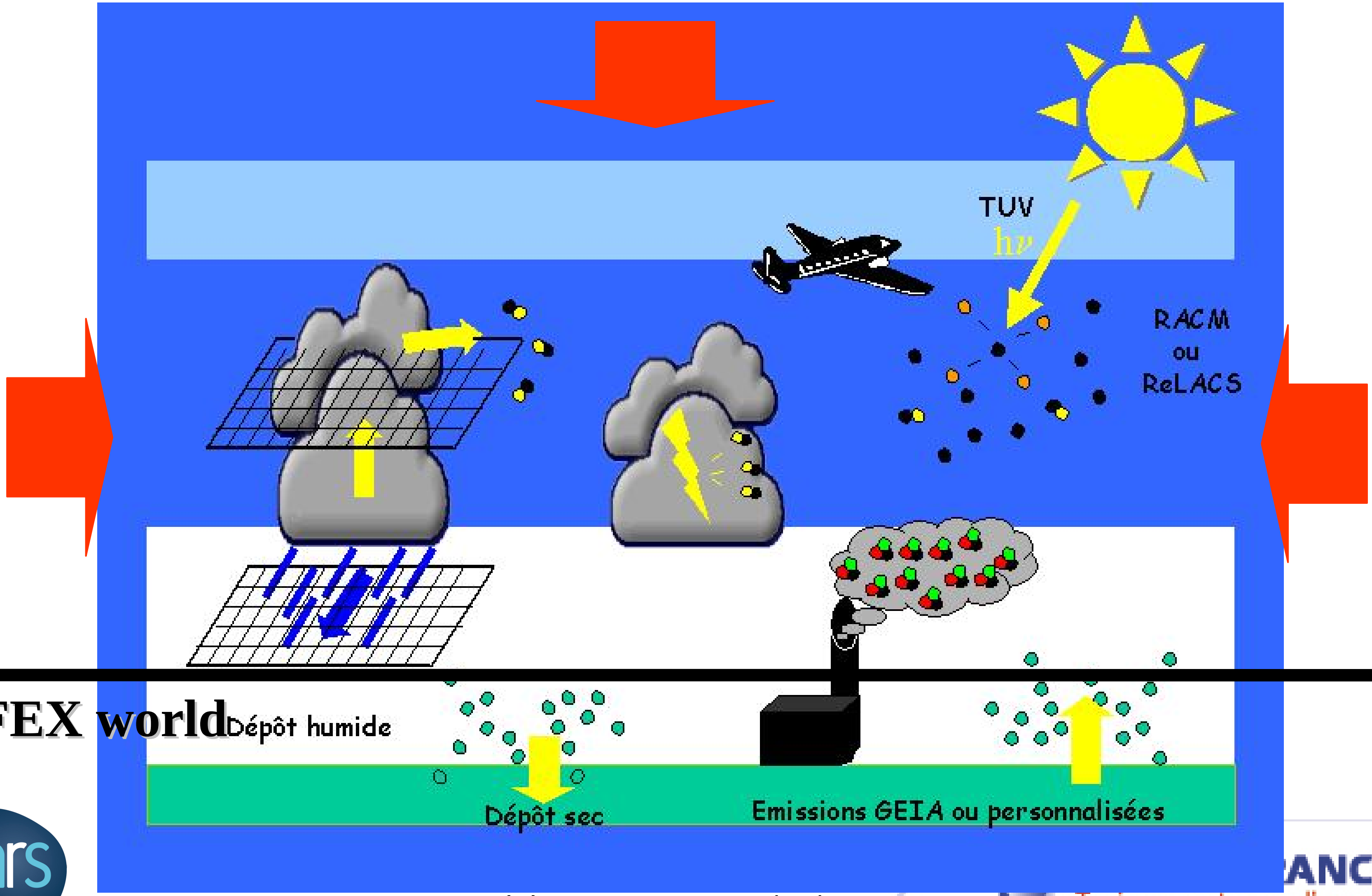


- The town is described by :
- One roof, a road, two identical walls

- Physical phenomena :
- Interception of rain and snow
- Heat storage in buildings
- Anthropic fluxes

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

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



le:
GE,
MWF, ...

SURFEX world

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Describing the surface

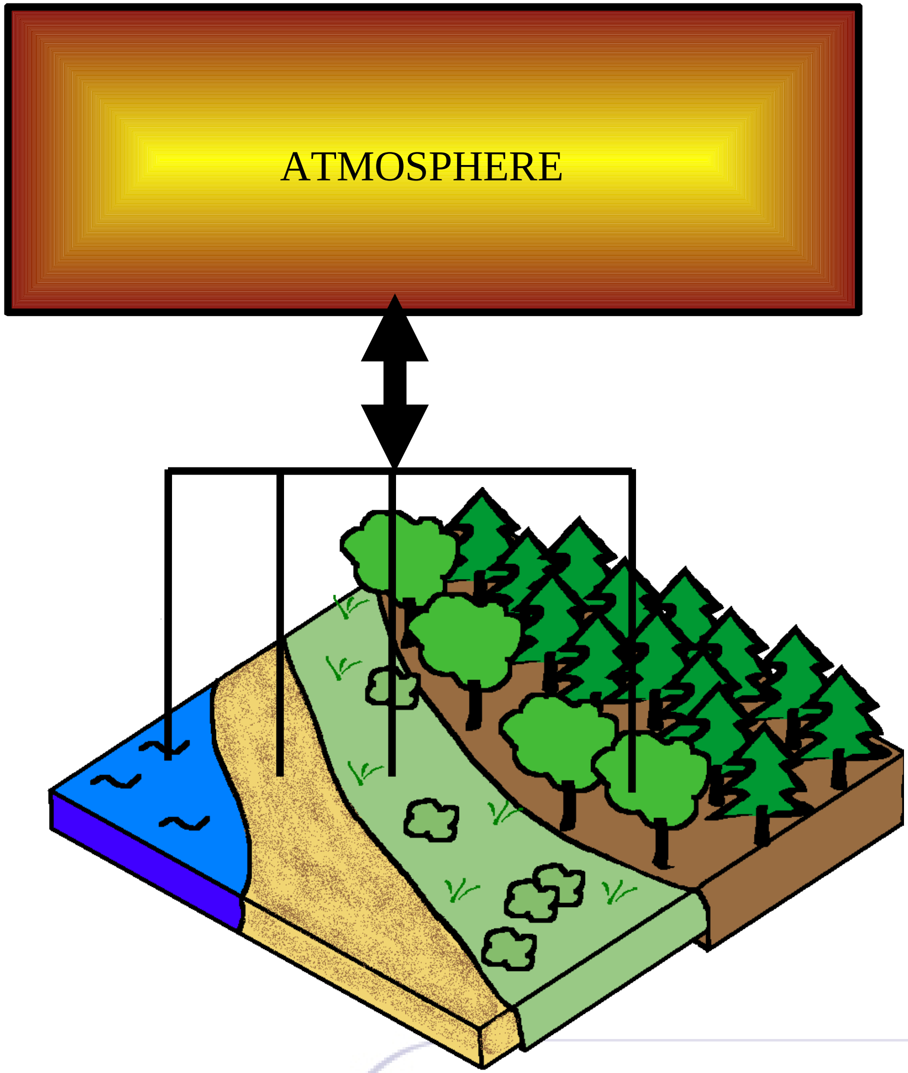
How can we represent the surface heterogeneity in a grid ?

Tiling approach :

- Within a grid mesh, the surface is divided into several homogeneous component.

1. Each component receives the same atmospheric forcing
2. Each component calculates fluxes
3. Fluxes are aggregated and returned to the atmosphere

- No horizontal transfert within the surface



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 **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)

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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

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)

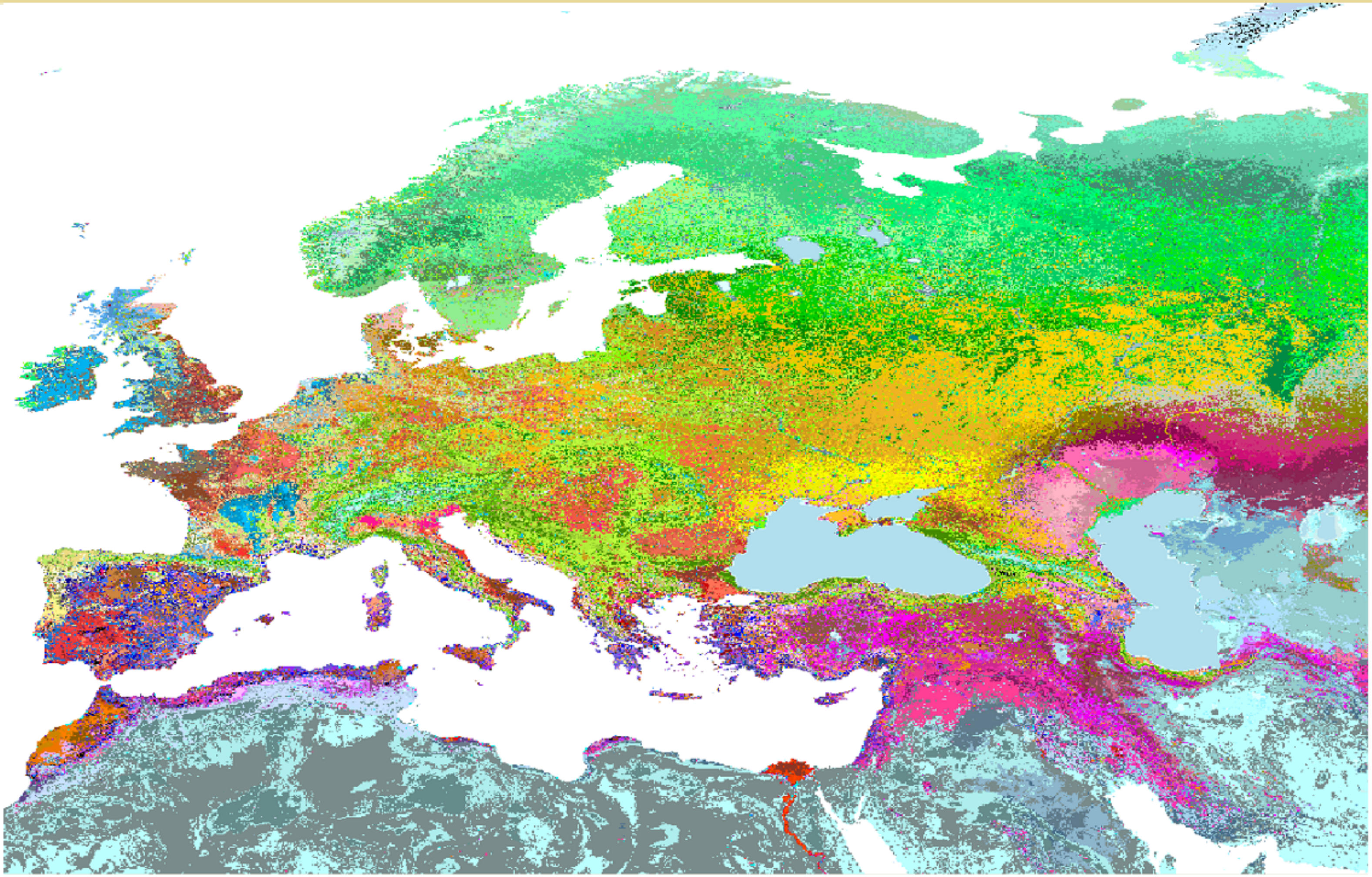
ECOCLIMAP II Europe (273 covers)

ECOCLIMAP II Africa (in progress)

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

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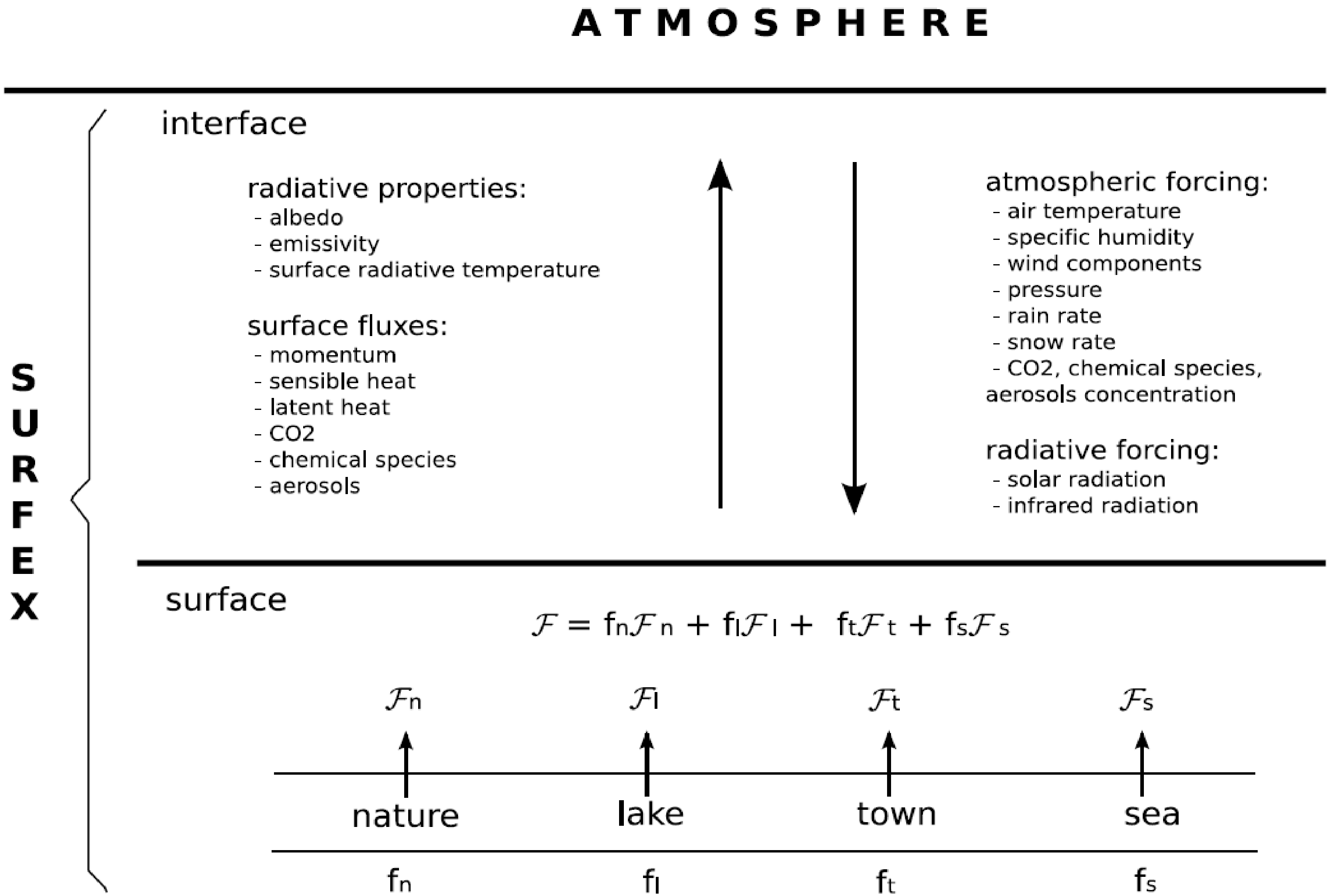
Interface with the atmosphere

Interface with the atmosphere



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Coupling with the atmosphere :

Explicit coupling (general case) :

variables are provided at T

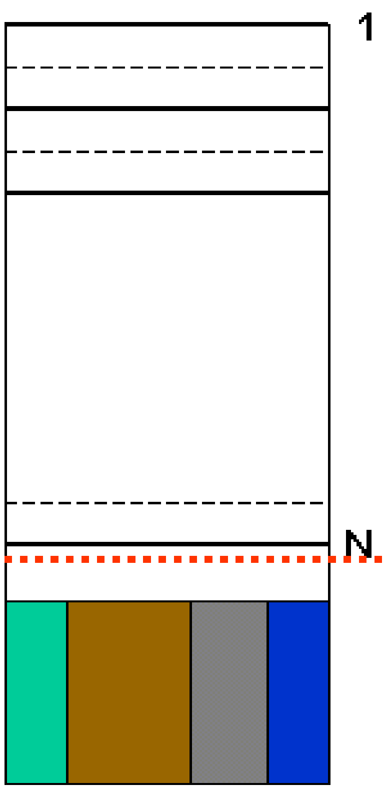
Fluxes are returned averaged over T / T+DT

Offline : ASCII, binary, lfi, FA,
netcdf standardised 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

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

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

Interface routines

coupling_surf_atm : packing and call 4 main tiles

coupling_naturen : call of the chosen scheme for the tile
coupling_isba_svatn : choice of method of coupling
coupling_isba_orographyn : subgrid_orography
coupling_isba_canopy : boundary layer
coupling_isban : divide in patches, interactive vegetation , dusts

Isba : energy and water fluxes

All coupling_xxx have the same arguments

More practical …
Running SURFEX

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)

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PREP

Date of all surface schemes

File to read, or uniform variables (namelist)

RUN (prognostic)

OPTIONS for RUN :

General : general options for surface atmosphere

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

Run : need a PREP file and an atmospheric forcing

DIAG

Inside « RUN » or autonomously using a surface file and an « instantaneous » forcing.

Defined by namelist (various options)

diagnostics aggregated over all the surface, or by tiles, or by patches (nature)

ASSIM

OI_MAIN :

Soil analysis based on Optimal interpolation (Giard and Bazile, 2000, Monthly weather review)

Input : T2m, RH2m

VARASSIM :

Soil analysis based on EKF (Mahfouf et al., 2009, JGR)

Input : T2m, RH2m, wg (satellite) and/or LAI (ISBA-A-gs)