The SURFEX project

- the coupling interface between the surface and atmospheric models
- a summary of the physics in Surfex
- perspectives: developments, collaboration,…

Objectives …

- **To develop an ‘externalized’ surface model independent of the atmospheric model**: initialization (parameters and surface variables), time evolution, diagnostics, IO, assimilation

- **To use a ‘general’ coupling interface between the atmosphere and the surface** following the *Best et al*. (2004) concept, but completed during the development of Surfex: the atmosphere only sees the surface fluxes, the coupling can be fully implicite with a ‘tile (d)’ surface scheme

- **To use the ‘tile ‘ concept for ocean, lake, urban and vegetated areas**: Surfex includes the surface physics developed at CNRM since 20 years

- **To be included in regional and global NWP and research models**

- **In principle, the interface should achieve a plug compatibility for surface parameterizations** ! A good test bed for Arome/Aladin-Arpege/Hirlam collaborations ???

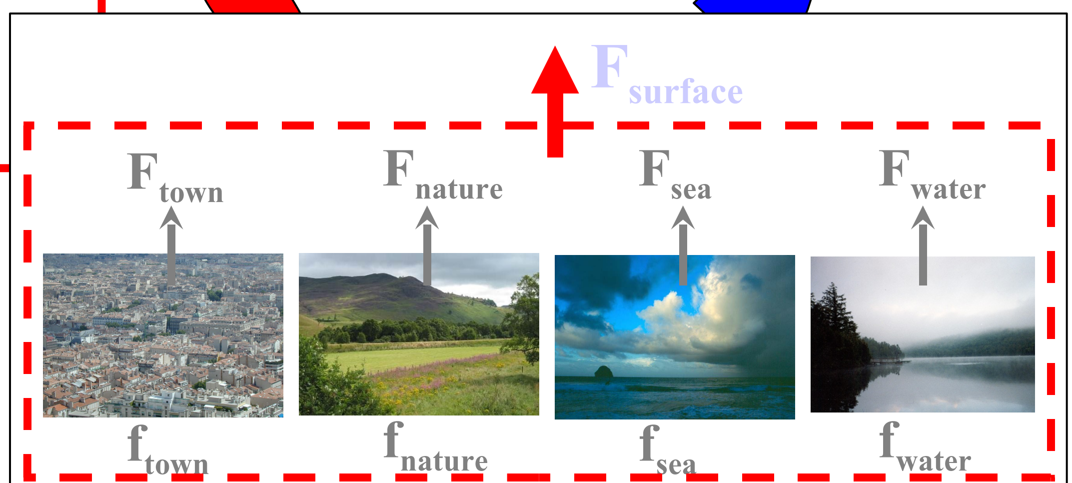
Exchanges of flux and atmospheric forcing at each time step

Méso-NH
AROME
Arpège / Aladin

albedo
emissivity
radiative temperature

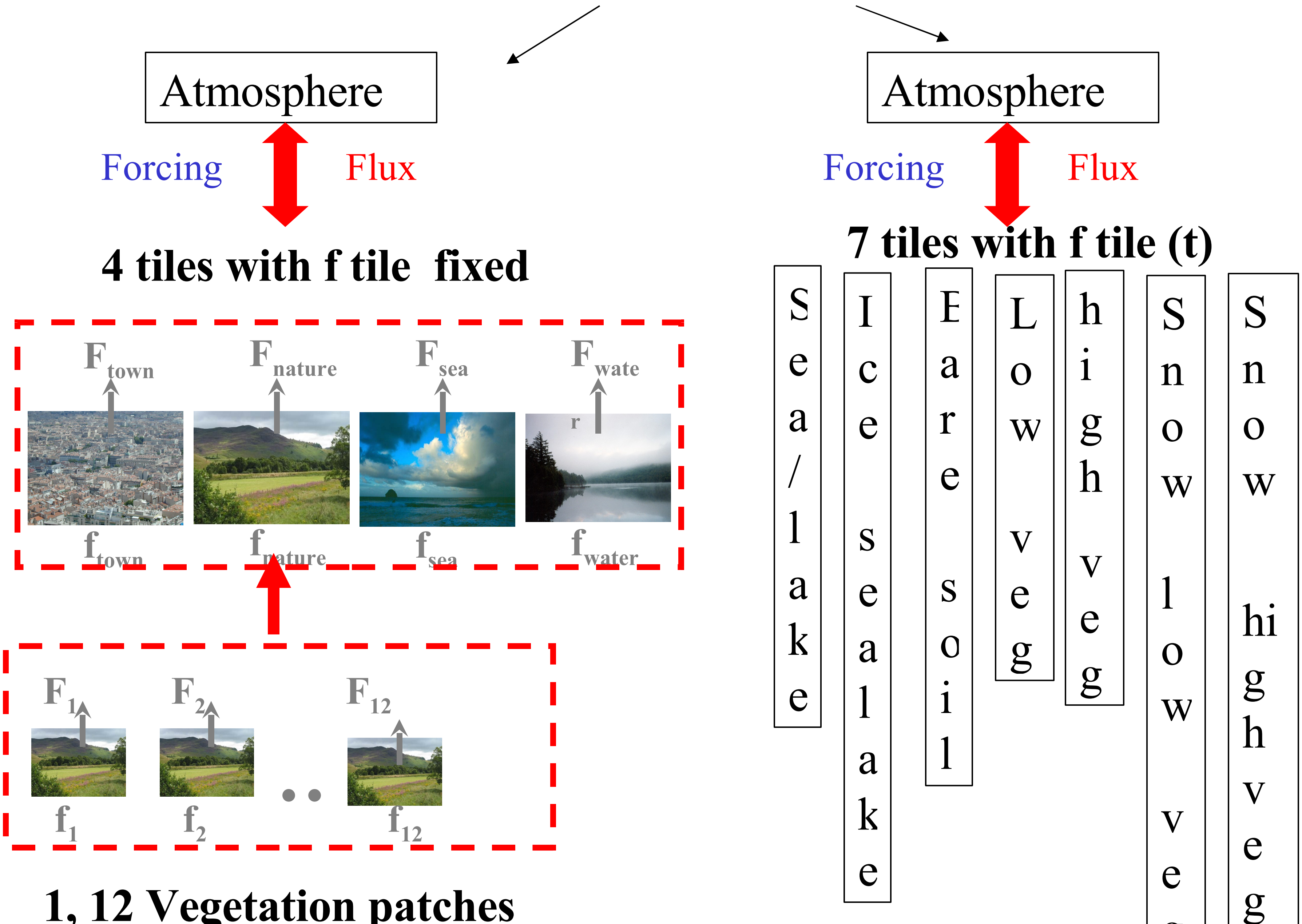
momentum flux
sensible heat
latent heat
CO2 flux
Chemical fluxes

Atmospheric forcing
Sun position
Downward radiative fluxes



Surfex output as surface boundary conditions for atmospheric radiation and turbulent scheme (additional output needed for the convection scheme)

The tiles and patches in Surfex and Hirlam surface schemes



The physical schemes to estimate the exchanges of radiation, momentum, heat, water and CO_2 fluxes

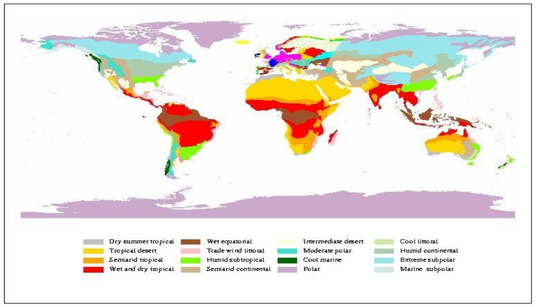
Sea and ocean :
⇒ prescribed SST, and 3 bulk formulations
⇒ development a 1D oceanic mixing layer

Lakes :
prescribed temperature, Charnock formula

Vegetation and soil : **ISBA / ISBA-A-gs**
(Interface Soil Biosphere Atmosphere)

Town : **TEB**
(Town Energy Balance)

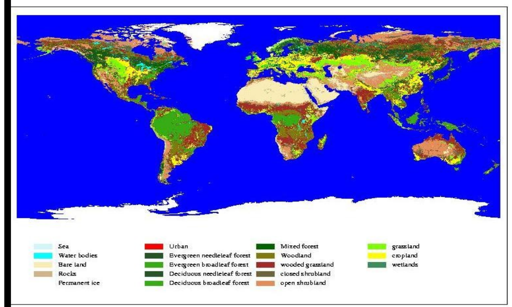
Climate map



Koeppe et de Lond 1958

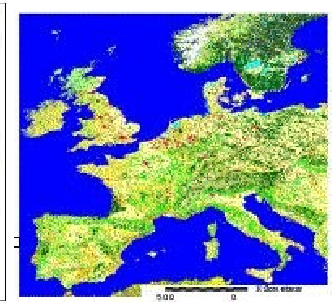
1km: 16 classes

Land cover maps



University of Maryland

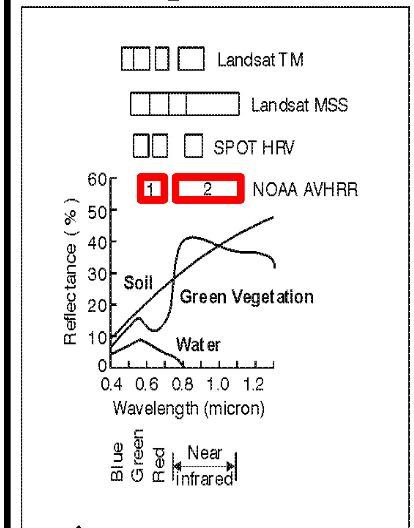
1km: 15 classes



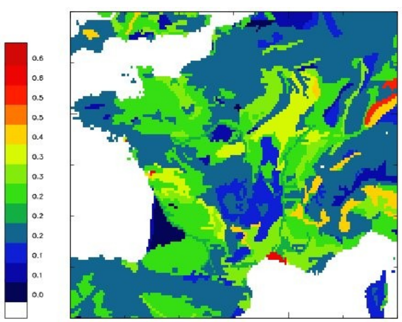
Corine land cover

« 250m »: 44 cl.

NDVI profiles



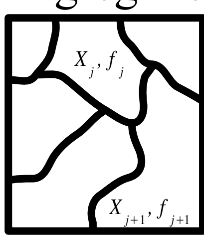
Texture: FAO-10km



215 vegetation types over the globe

Other data base

Agrégation



$$X = \frac{\sum (f_j . X_j)}{\sum (f_j)}$$

Data base for surface parameters

(Masson et al. J. Climate, 2003)

Physics

ISBA:

Soil options:
- **Force restore, 2 layers , temp, water, ice**
- Force restore, 3 layers , temp, water, ice
- Diffusion, N layers , temp, water, ice *Boone, 2000*

Vegetation options:

One surface energy budget for vegetation and bare ground
- **Rs formulation (~Jarvis)** *Noilhan and Planton 89*
- AGS (photsynthesis and CO2 exchanges) *Calvet et al. 1998,*
- AGS and interactive vegetation *Calvet, 2000*

Hydrology options:
- **no subgrid process**
- subgrid runoff, subgrid drainage *Habets et al. 98*

Snow options:
- (i) 'Arpege' scheme (1layer, varying albedo)
- (ii) **1 layer, varying albedo,** varying density *Douville 95*
- (iii)3 layers, albedo, density, liquid water in snow pack *Boone and Etchevers 2000*

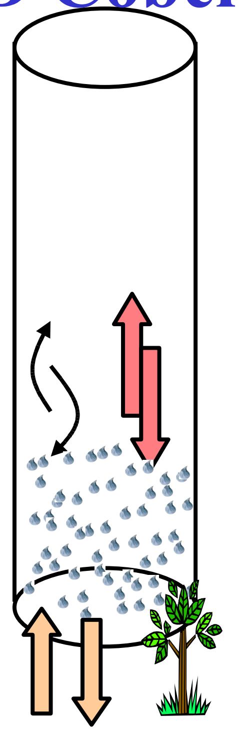
Dust emission/deposition: *Grini et al. 2006*

Biogenics emissions, chemical dry deposition: *Tulet et al. 2003*

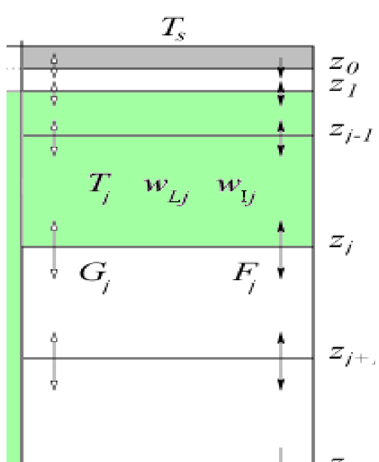
Fog forecasting at Paris CDG using the 1D Cobel – Isba model

The 1D

Cobel model

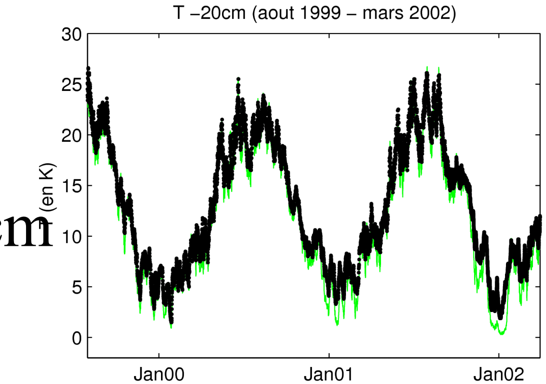


The Isba-df Multi_soil layer version

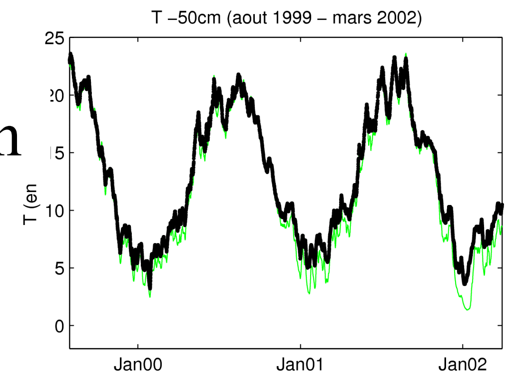


Soil temperature forecast

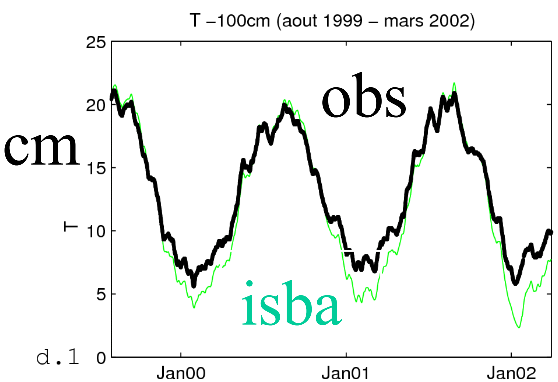
- 20 cm



- 50 cm

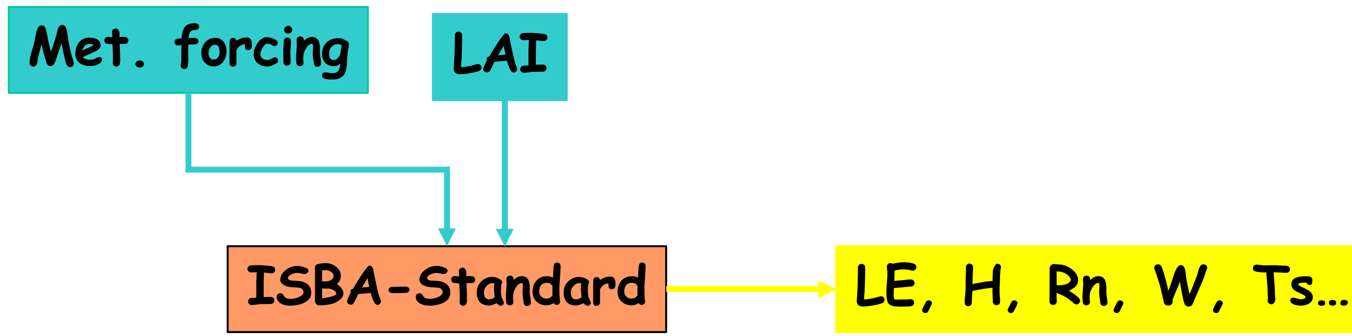


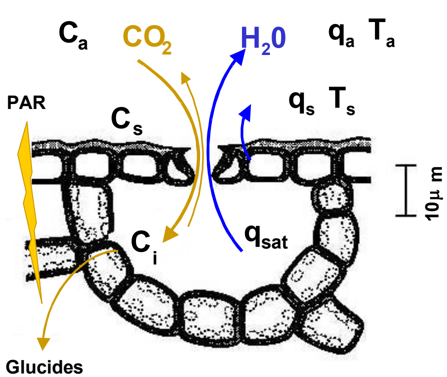
- 100 cm

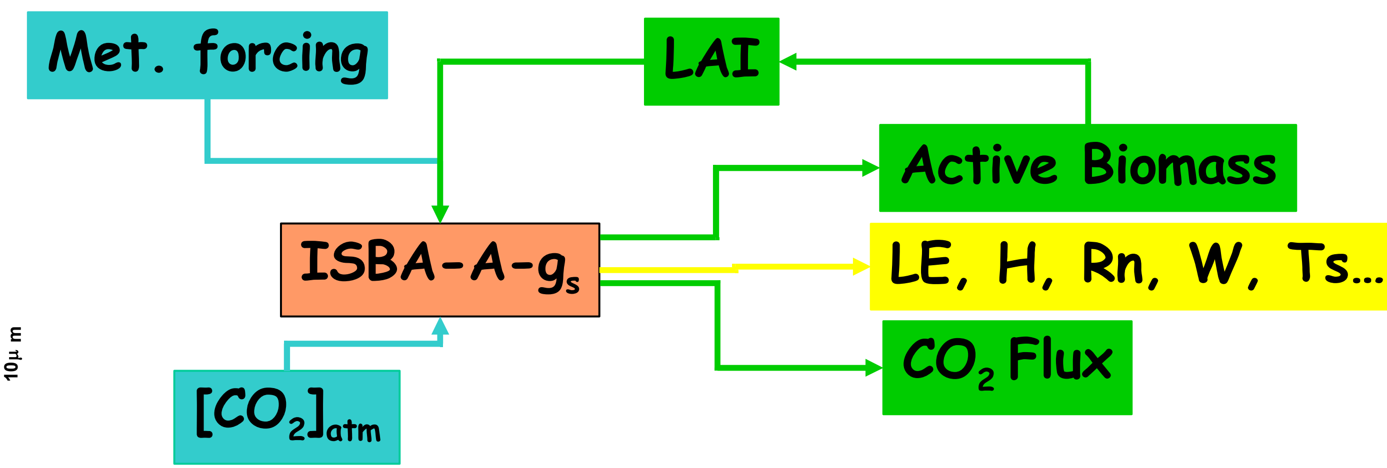


Bergot et al. 2005

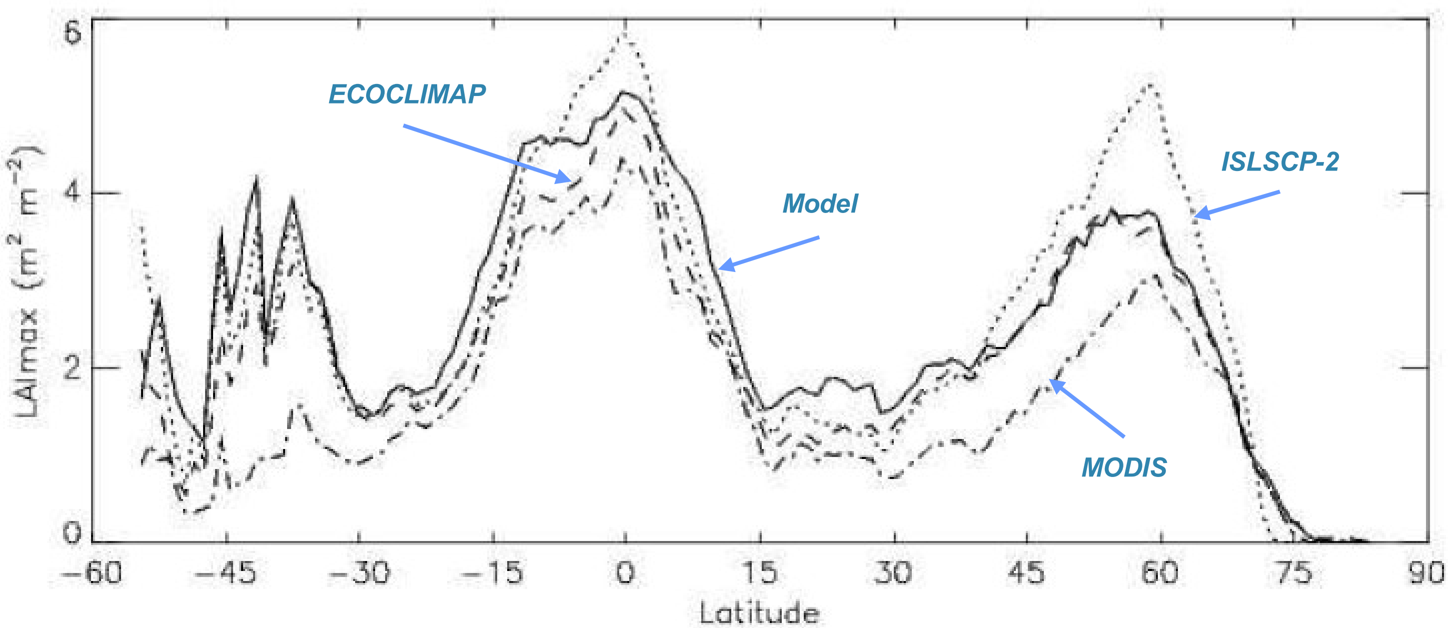
The ISBA-**A-gs** version for water/carbon exchanges







A simulation of LAI at the global scale with ISBA – A – gs (off line run with GSWP2 atmos. forcing and ISLSCP data set)

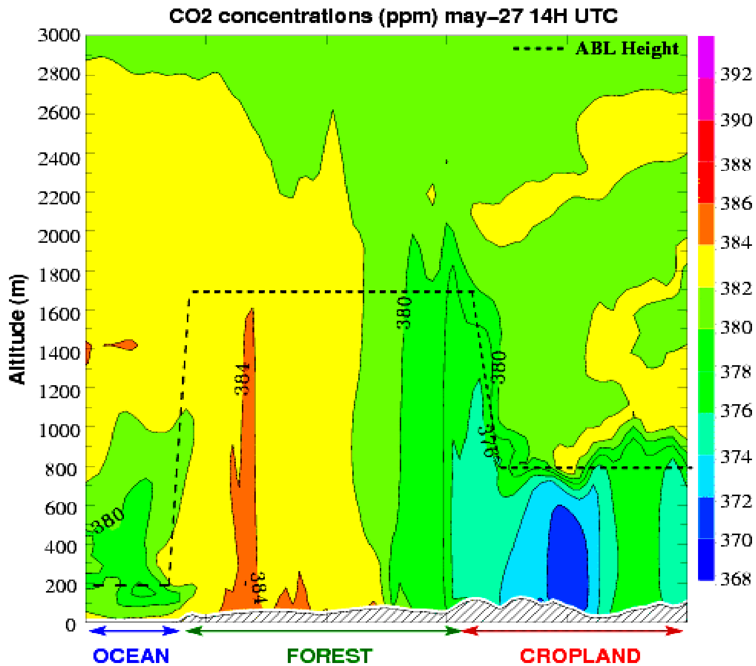


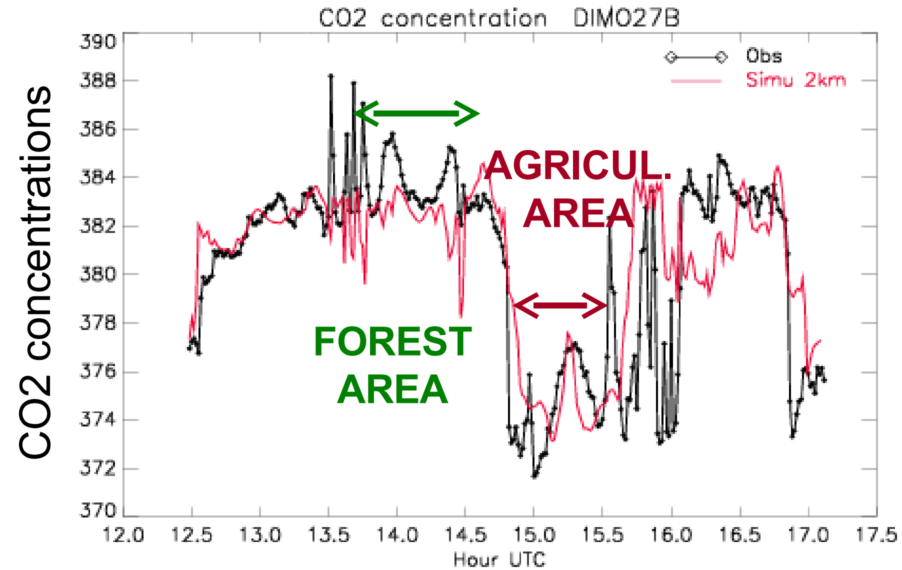
Zonal mean of the maximum of LAI

simulated by ISBA-A-gs (mean 1986-1995), ISLSCP-II data set (mean 1986-1995), MODIS data set (mean 2001-2004), ECOCLIMAP data set (climatology).

Gibelin et al. 2006

Atmospheric CO_2 modeling with MesoNH coupled with Isba-A-gs
(Ceres , may-June 2005)





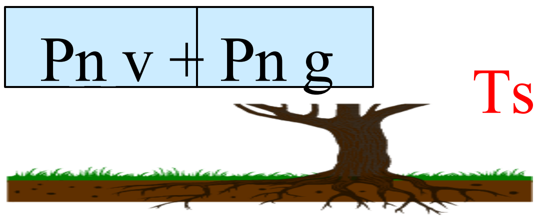
Comparison of Simulated and obesrved CO2 concentrations (ppm) 14HUTC

Simulated CO2 concentrations (ppm) 14HUTC

(Sarrat et al., JGR, 2006)

The 3 snow schemes available in ISBA - Surfex

The oper snow scheme (e.g. EBA scheme)

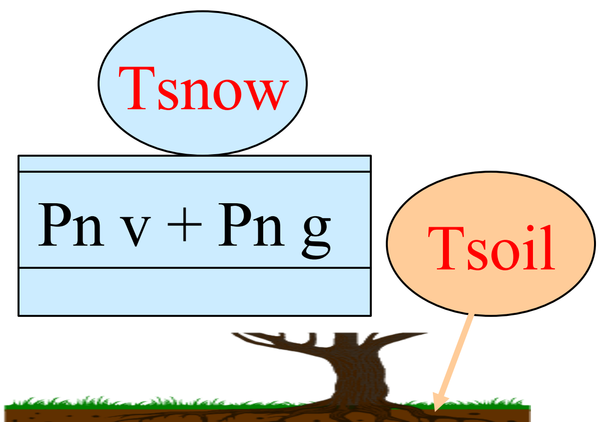


Ts (snow + soil), SWE (t) , ρ snow = cst, alb (t)

The Douville (1995) snow scheme used in Arpege –Climat/ Arome

Ts (snow + soil), SWE (t) , ρ (t), alb (t)

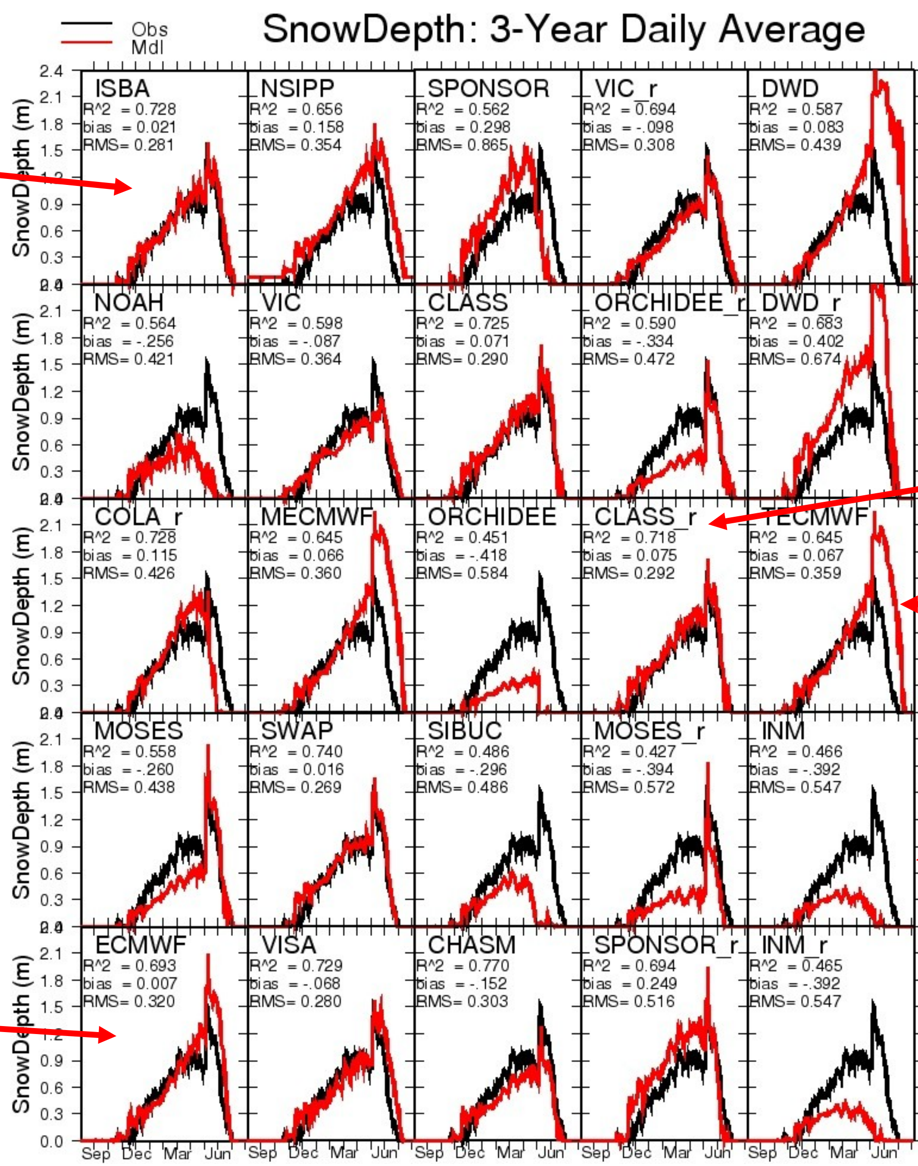
The 3 layer explicit snow scheme used in Arome (Boone Etchevers, 2001)



Three pronostic variables for:

- Snow water equivalent SWE (t)
- Snow density , ρ (t)
- Snow heat content, H (t)

Intercomparison of observed/simulated snow depth in the Alps during the Rhône aggreg intercomparison experiment (Boone et al. J. Climate 2004)



ISBA SNOW - ES

DWD

CRB-Canada

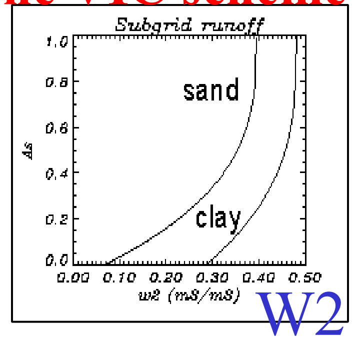
ECMWF 2

Hirlam INM SNOW scheme

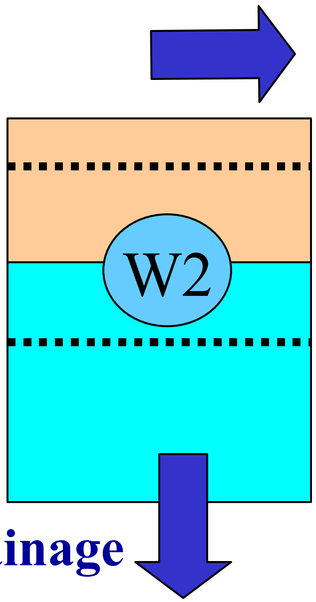
ECMWF 1

Surface Run off and drainage parameterizations

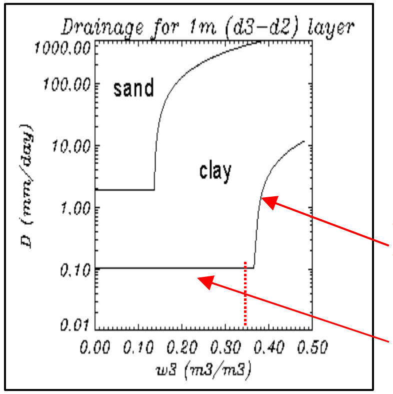
The VIC scheme



Surface runoff

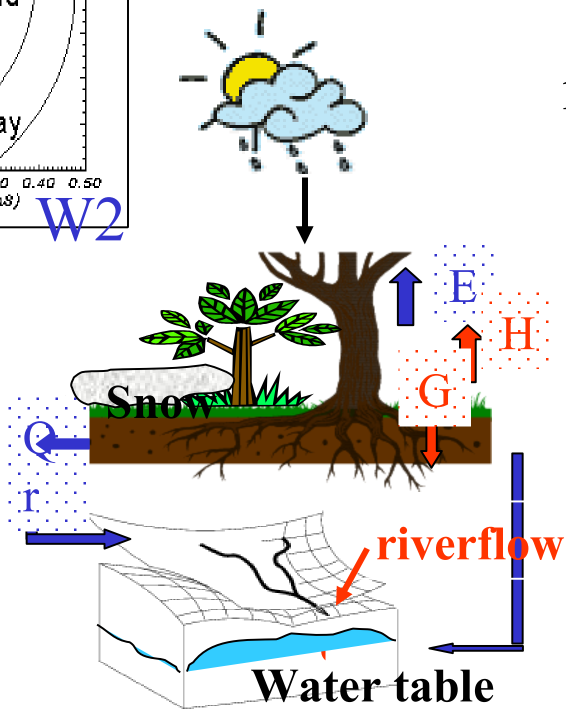


Drainage



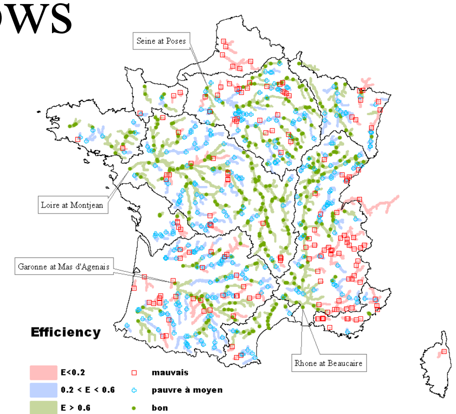
MN91

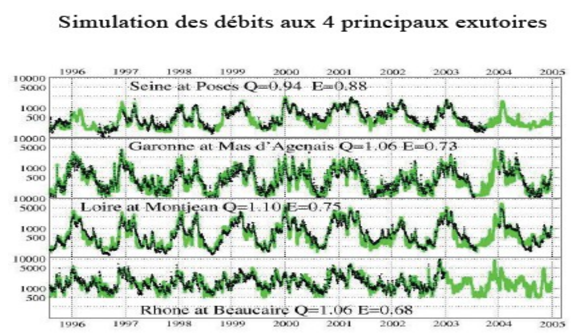
Base flow



the SIM model

Validation with observed river flows

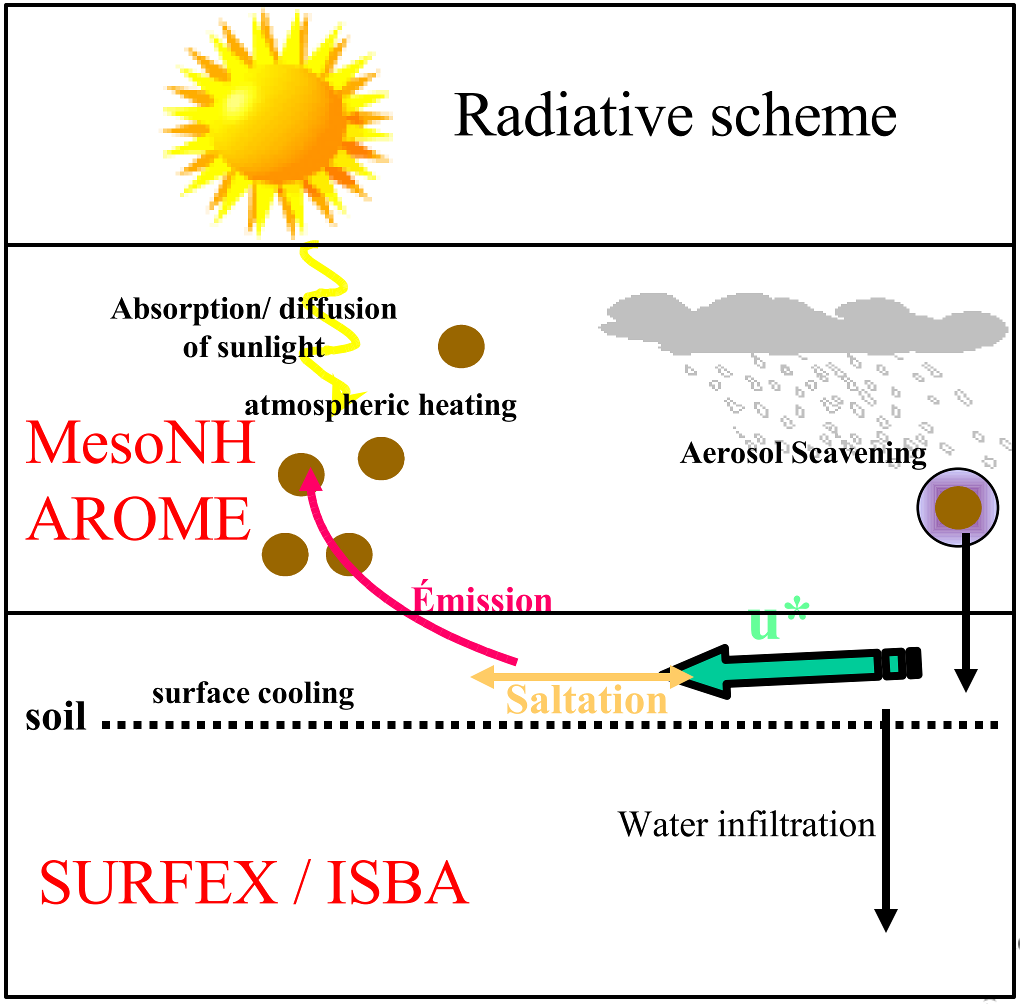


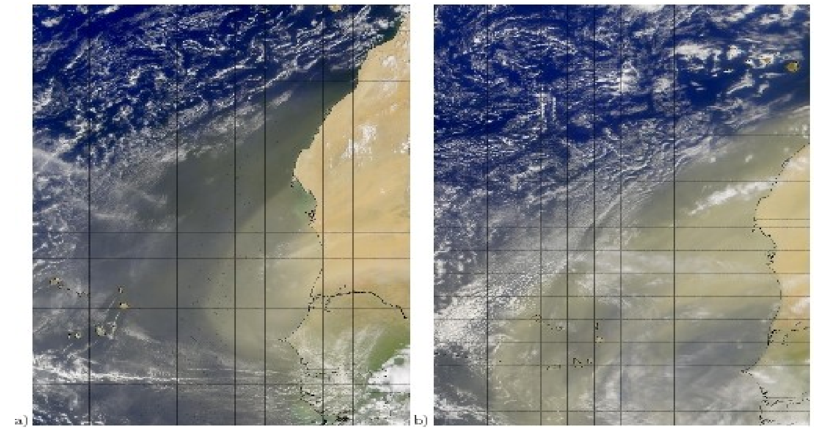


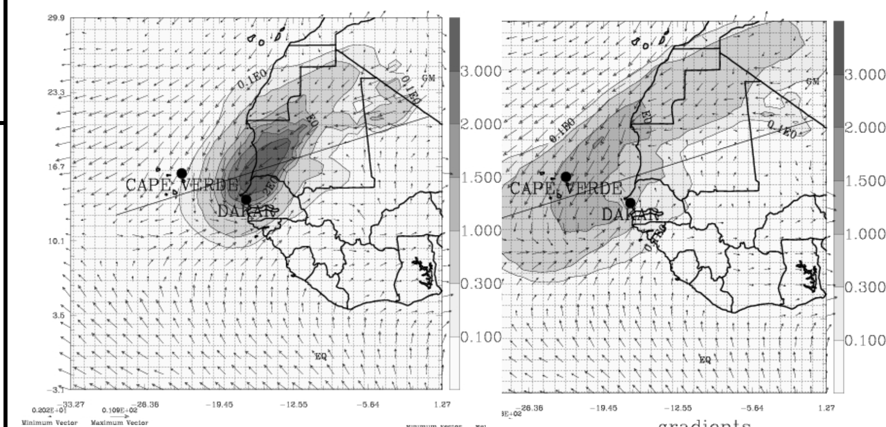
Simulated riverflows of large basins

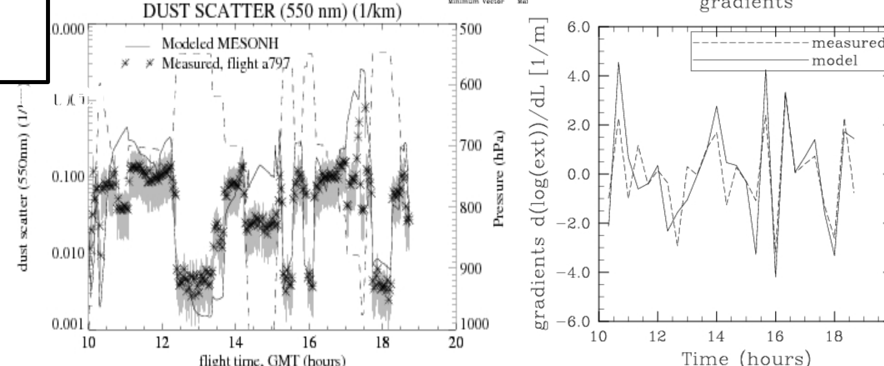
(Habets et al. 99)

Desertic Dust (on-line coupling)





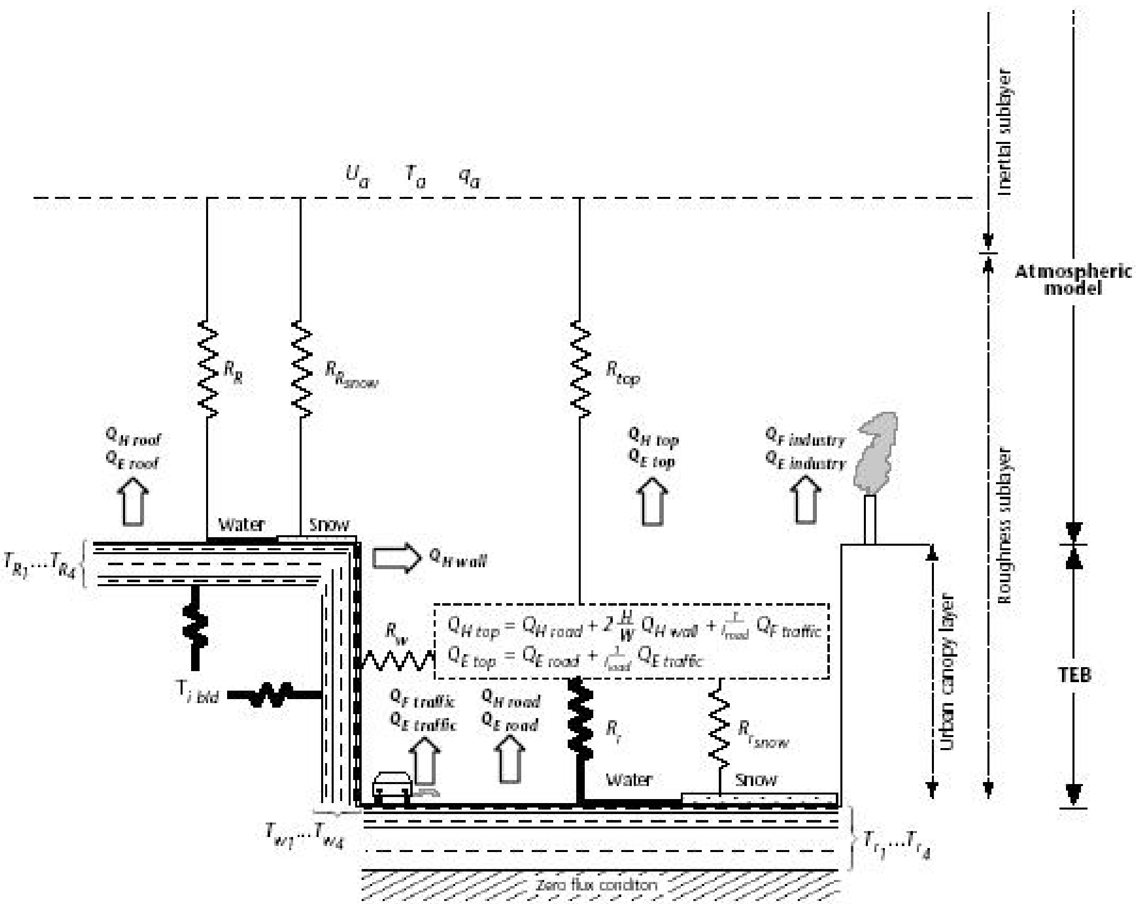




Grini et al, 2006

Town Energy Balance : physics

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



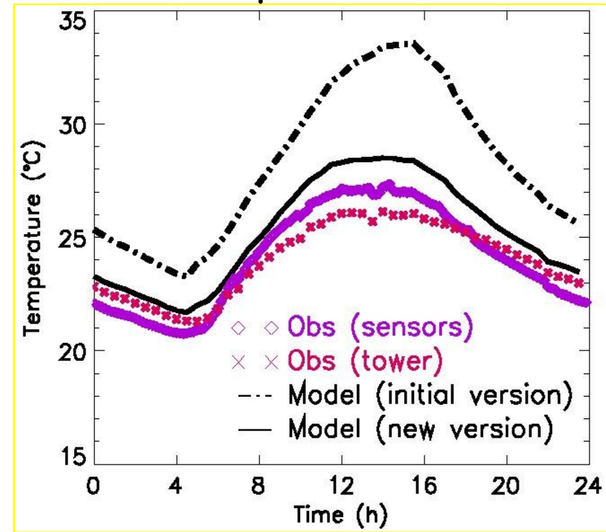
- Only 1 road, 1 roof, and 2 *identical* facing walls
→ ONLY ONE WALL SEB
→ Only one wall temp.
→ Only one road temp.

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

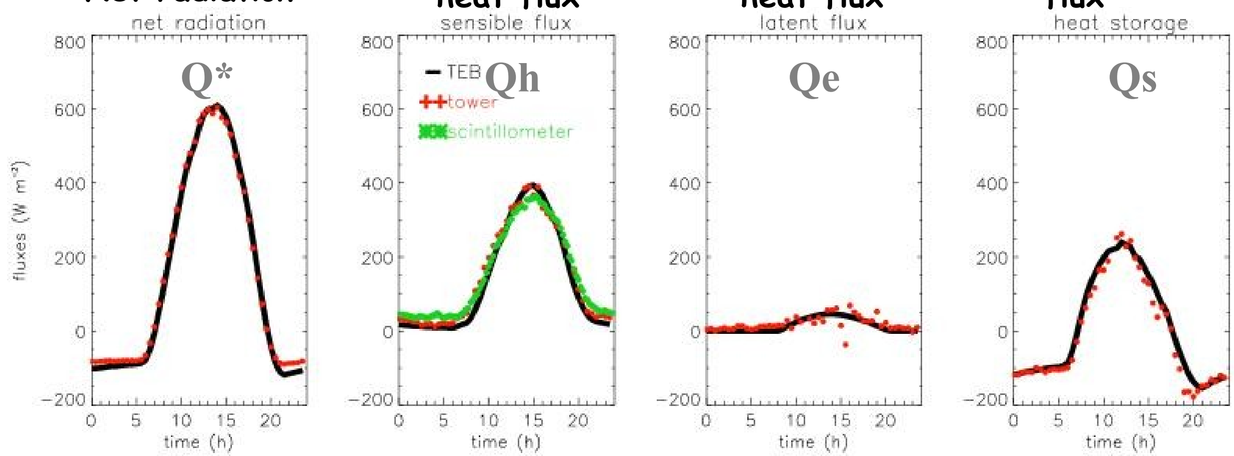
TEB has been validated on several urban sites:

Mexico City, Vancouver (Masson et al 2002)
Marseilles (Lemonsu et al 2003)

Air temperature



Net radiation | Sensible heat flux | Latent heat flux | Storage flux



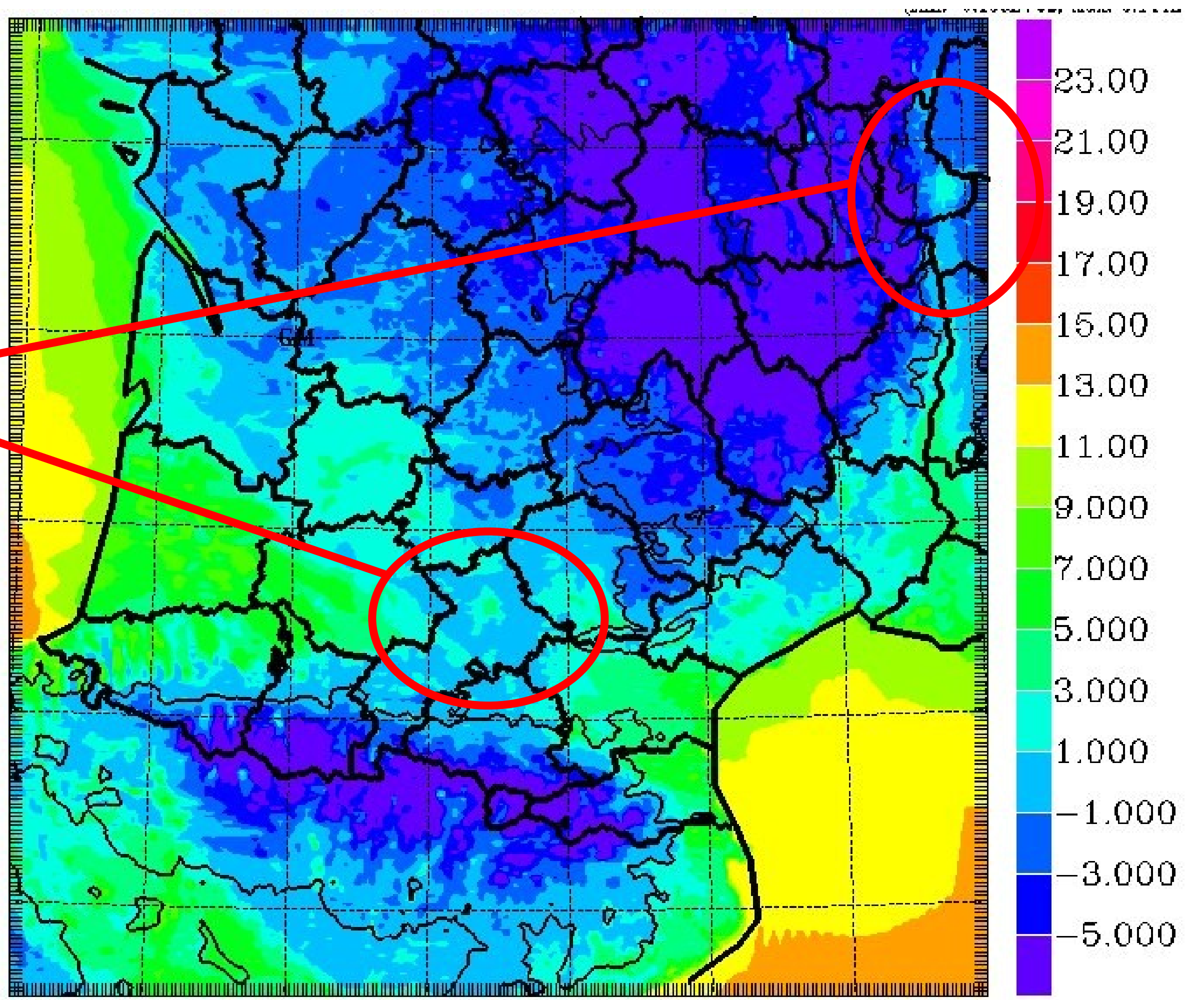
Surface energy budget, observed and simulated

C3. Organization of physical computations

► TEB : Town Energy Balance

Arome forecast valid for 18th of November 2005 midnight

Urban heat Island around Lyon and Toulouse cities



(Y. Seity)

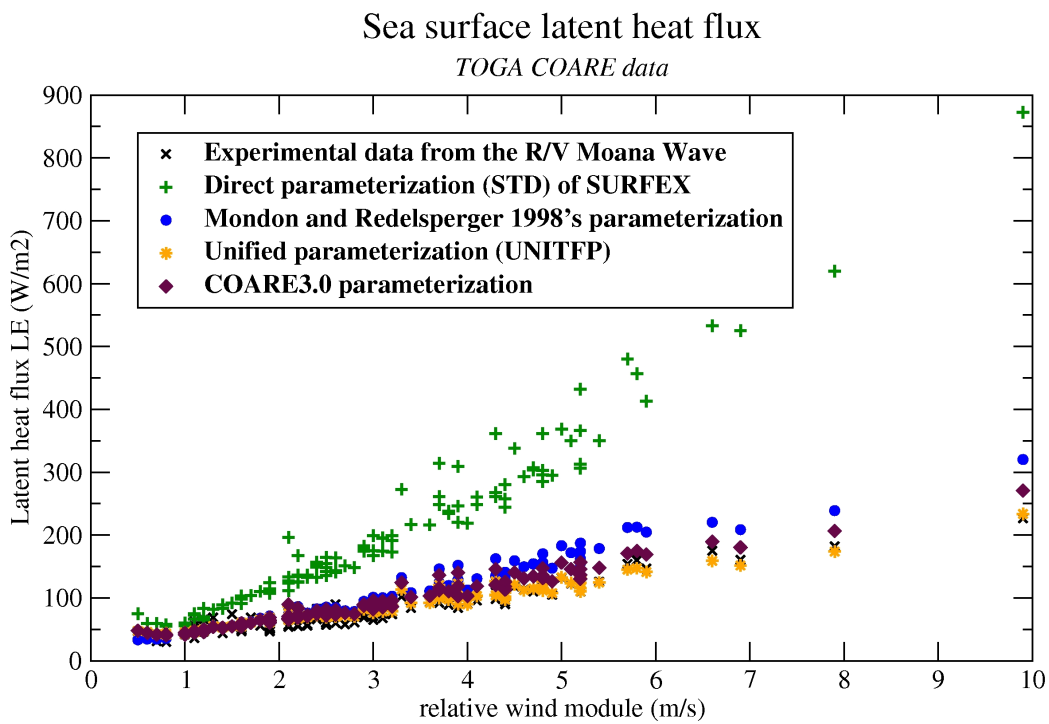
Sea surface fluxes parameterizations

Bulk parameterizations u*, θ *, q*:

-Louis – 79 - formulation f (Zo, Ri)

-'Unified' formulation from multi campaign calib. of CdN 10 m (Belamari 2005)

- Toga – **Coare** parameterization (Fairall et al 2003)

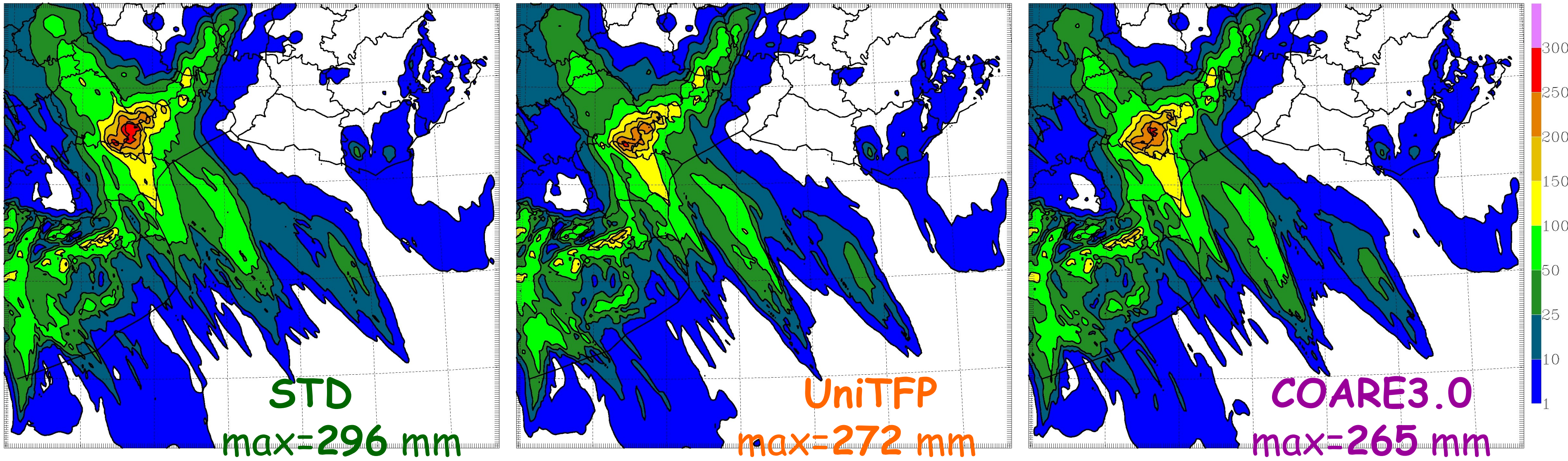


Off-line validation on TOGA-COARE data

(Lebeaupin, 2006)

Sensitivity of simulated convective precipitation on the sea flux formulations in MesoNH: the Aude case

18 h accumulated precipitation



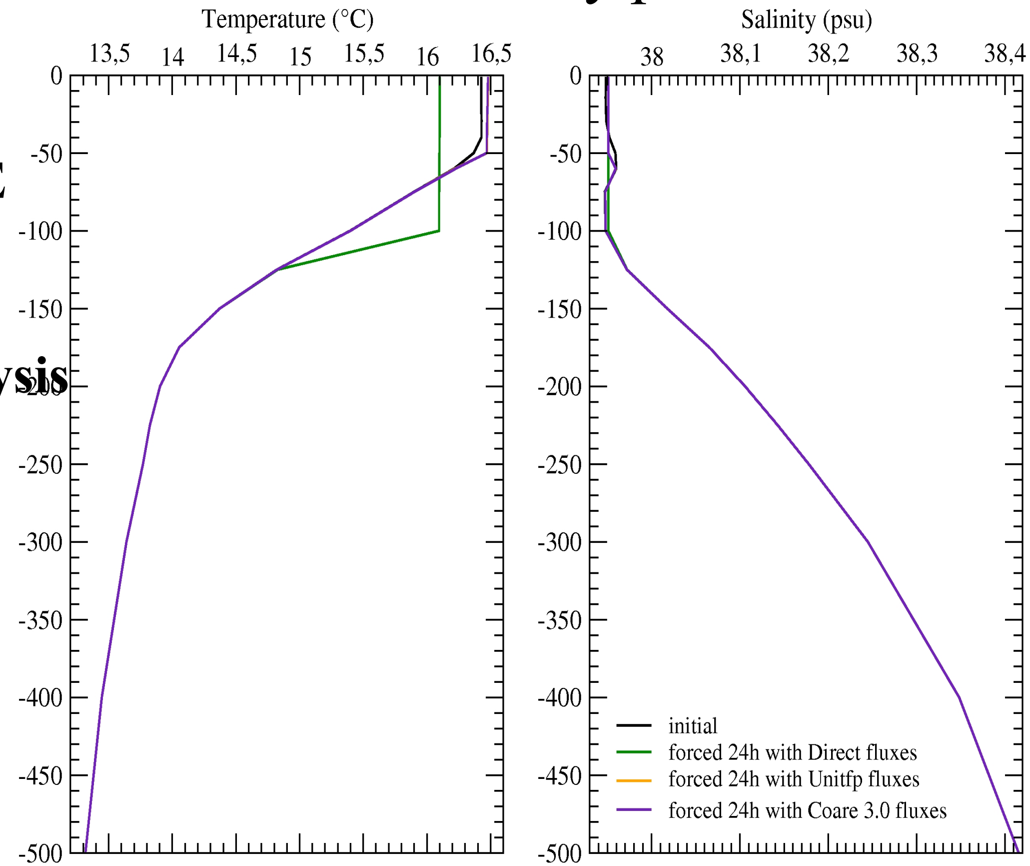
(i) Reduction of momentum and evaporation with UniTFP and Coare formulations

(ii) Low differences in term of precipitation patterns, decrease of precip. accumulation

(Lebeaupin, Ducrocq)

Developpent of a 1D oceanic boundary layer based on TKE (Gaspard et al 1990) in SURFEX

Off line simulation of temperature And Salinity profile



. **Equation for T, Salinity, and TKE**

. **Included the topography**

. **Initialization from Mercator analysis**

(Lebeaupin, 2006)

Status of Surfex implementation at Meteo – France

Arome and MesoNH: implementation with explicite coupling (Isba – 3L + snow 3L + TEB + Ecoclimap)

Aladin, Arpege, Arpege Climat: implementation in 2007 with implicite coupling (Isba 2L +snow OPER + Ecoclimap/923)

SIM and Cobel – Isba : Isba 3L, snow ES, hydrology, A-gs and Isba Df Physics implemented (Off line coupling): Surfex interface be implemented in 2007(?) in SIM

Discussing possible model developments during the workshop:

- Vegetation: Temperature of vegetation canopy?, water stress functions, biomass and carbone components, irrigation module …
- Improvement of the snow/vegetation interactions
- Soils: implementation of the soil diffusion for heat, water and ice, formulation of runoff and drainage…
- Lake modeling (including ice) ?
- Sea ice?
- Urban modelling: improvement of hydrology, canyon meteorology, …
- Sea fluxes, 1D ocean model, 3D ocean model, ?
- Others….

Data set used for the development of Surfex

Snow: Pilps – Valdai + Snowmip 1 and 2

Frozen soils: Illinois -1998

Vegetation: the 'Hapex' experiments, PILPS (HM86, Cabauw, Lobos,), Murex and Smosrex (fallow sites), Flux net sites, …

Hydrology: SIM, Rhone-AGG, Red - Arkansas, Thornes,…

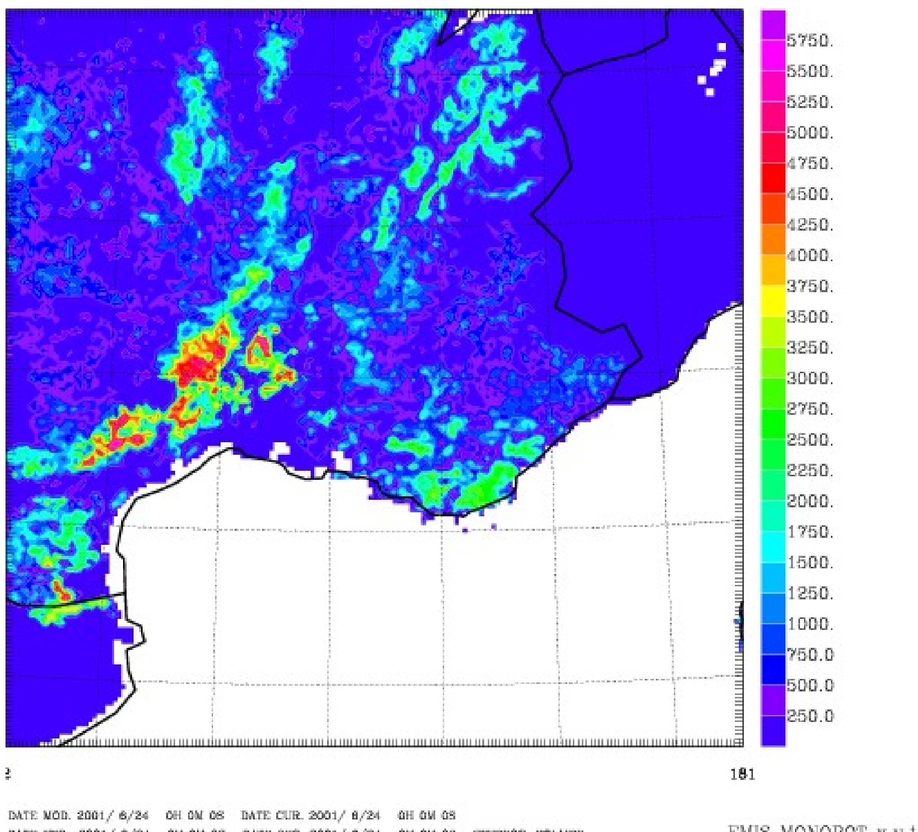
Urban physics: Escompte-Marseille, Capitoul: Toulouse, Mexico, Vancouver,

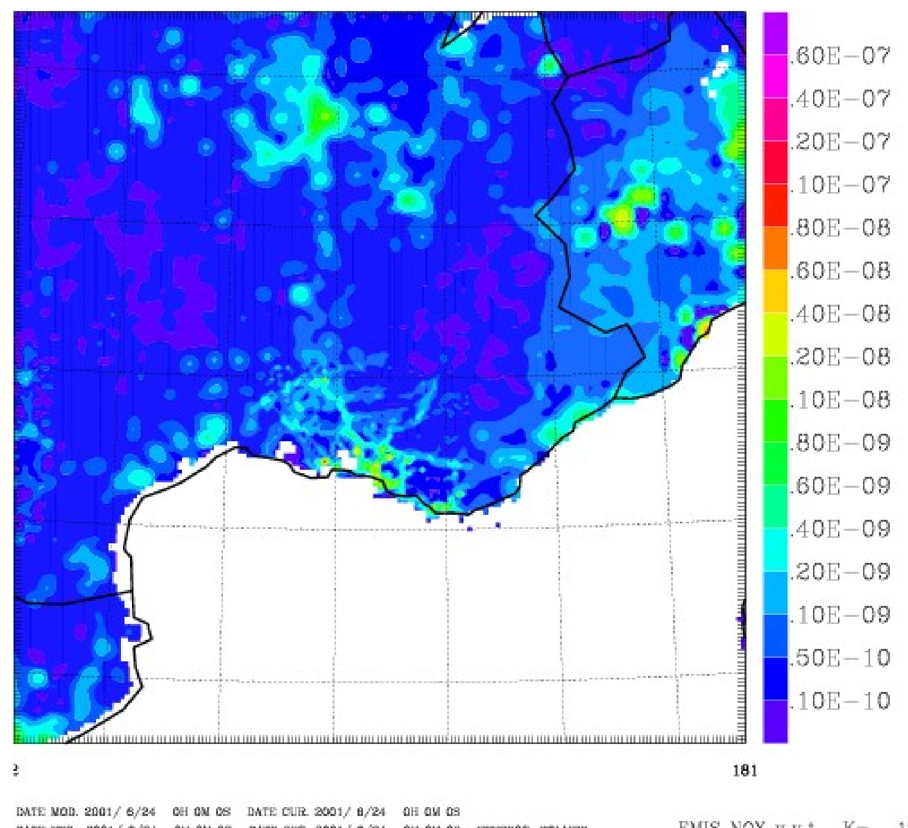
Sea fluxes: Toga-Cooare, Albatros data base (5 field experiments)

Lakes: ?

POTENTIAL EMISSION OF MONOTERPENES

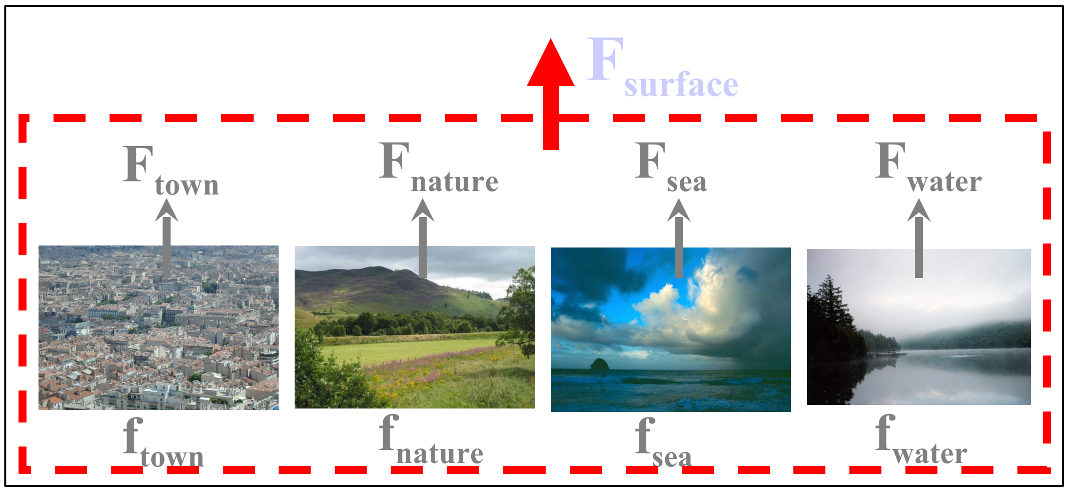
NOX EMISSION at 12 UTC in ppp.m/s





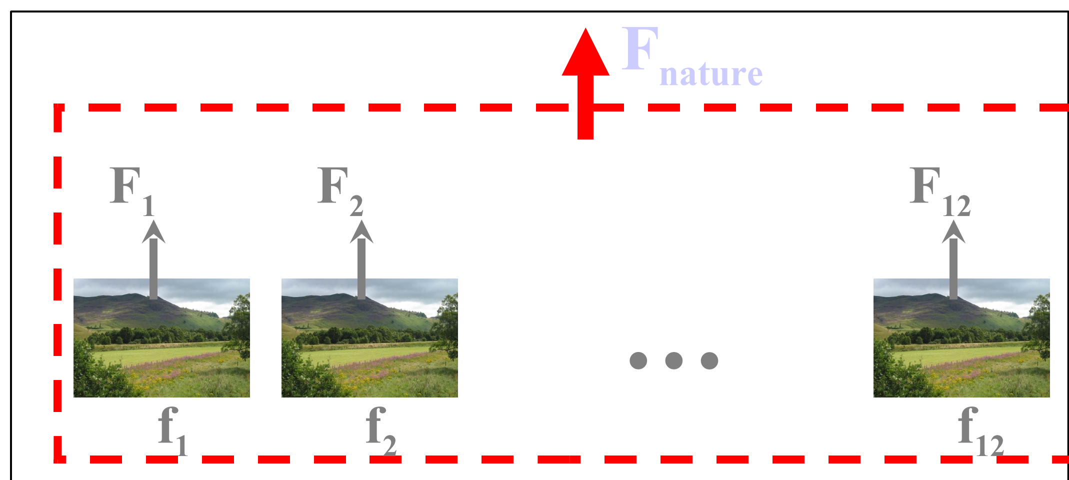
General principle

Each model grid box is composed by 4 tiles



4 tiles

1 to 12 patches for the vegetation



« Bulk » sea surface fluxes parameterizations:

$$\begin{cases} HF = \rho_a c_{p_a} u_* T_* \\ HF = \rho_a c_{p_a} C_H s(T_0 - T) \end{cases} \quad \begin{cases} EF = \rho_a \mathcal{L}_e u_* q_* \\ EF = \rho_a \mathcal{L}_e C_E s(q_0 - q) \end{cases} \quad \begin{cases} |\vec{\tau}| = -\rho_a u_*^2 \\ \tau_i = -\rho_a C_D s(u_{si} - u_i) \end{cases}$$

$$\Rightarrow C_H = \frac{u_* T_*}{s(T_0 - T)} \qquad \Rightarrow C_E = \frac{u_* q_*}{s(q_0 - q)} \qquad \Rightarrow C_D = (\frac{u_*}{s})^2 \qquad s = MAX(|\vec{v}_{rel}|, 1)$$

- **Direct** « bulk » parameterizations: *Relationship for the wind between u_*, q_*, T_* and the rugosity z_0 and the Richardson number Ri (ex. Louis, 1979)*

- **Iterative** « bulk » parameterizations: *u_*, θ_* and q_* from iterations*

  - **UNITFP**: unified parameterization with multi-campain calibration of the exchange coefficients CD_{10n}, CH_{10n}, and CE_{10n}, (*Belamari, 2005*);
  - **COARE**: developped from the TOGA-COARE campain (*Fairall et al, 1996*), then updated in version 3.0 (*Fairall et al, 2003*), existing also in a version with a variation of the gustiness parameter β (*Mondon et Redelsperger 1998*);

  ...

The externalized surface algorithm ?

During run, at each timestep

Radiative fluxes
Sun position
Atm. Forcing
Rain, snow fall

Albedo,
Emissivity,
radiative temp.

Momentum fluxes
Heat flux
Water vapor flux
CO2 flux
Chemical fluxes

Surface run

Atmospheric model

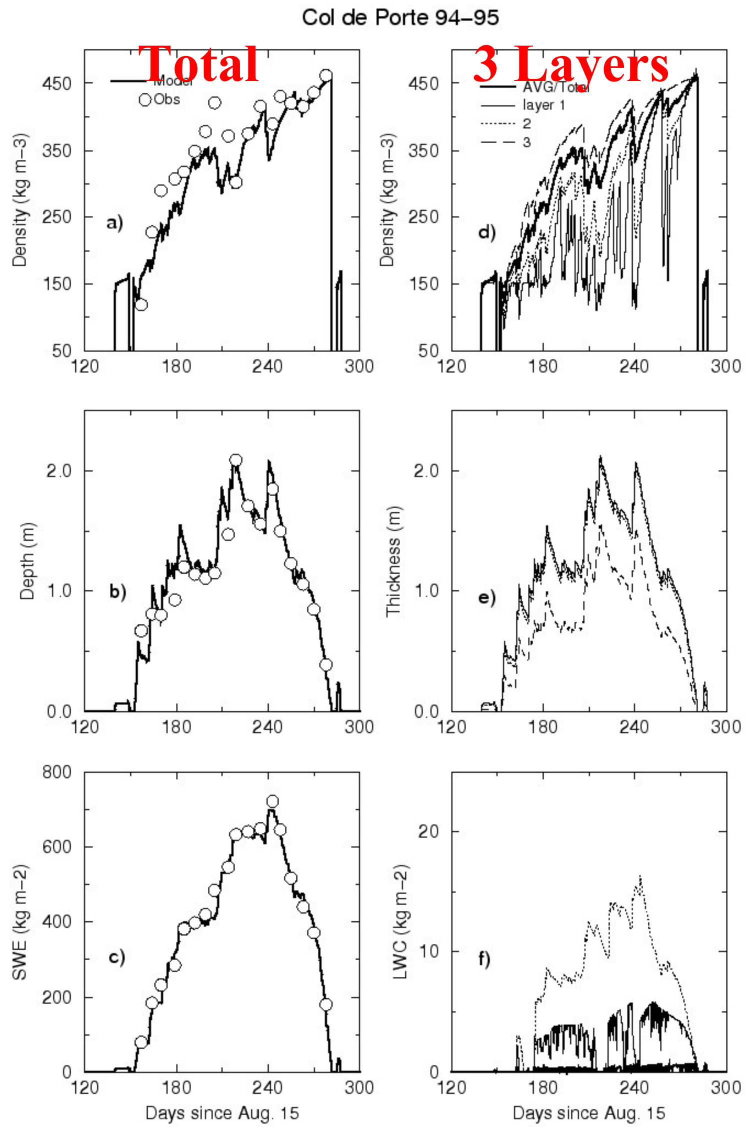
surface

A simulation of the snow pack with a Three-layer snow scheme at Col de Porte (Boone, personal communication)

Snow density

Snow depth

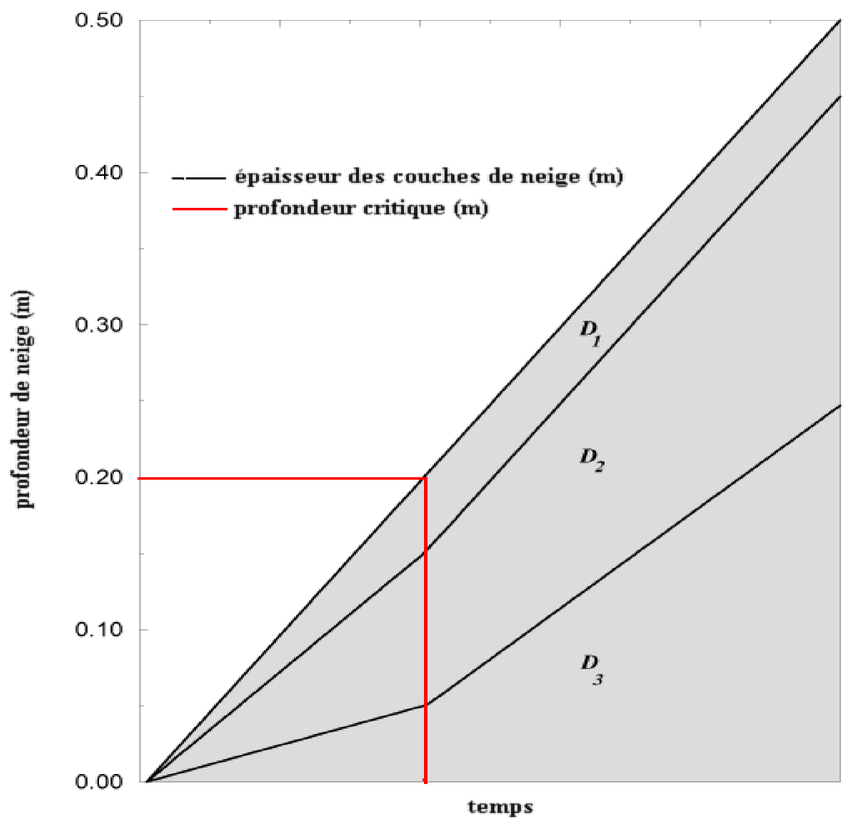
Snow Water equi.



SURFEX Workshop, december 2006

Vertical discretisation of the explicit snow scheme

- 3 variable layers
- resolution of thermal and density gradients in snow pack
- liquid water in snow pack and refreezing
- Heat flux at base of snow pack
- Solar flux transmission through snowpack



C3. Organization of physical computations

► ISBA : basic equations

A-gs approach: ***the role of stomatal control***

The stomatal aperture controls the ratio:

Photosynthesis/Transpiration

according to the environment conditions

Light, temperature , air humidity soil moisture , atmospheric [CO_2]