Surface modeling: **SURFEX** system

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CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

St Petersburg, September 2008

METEO FRANCE
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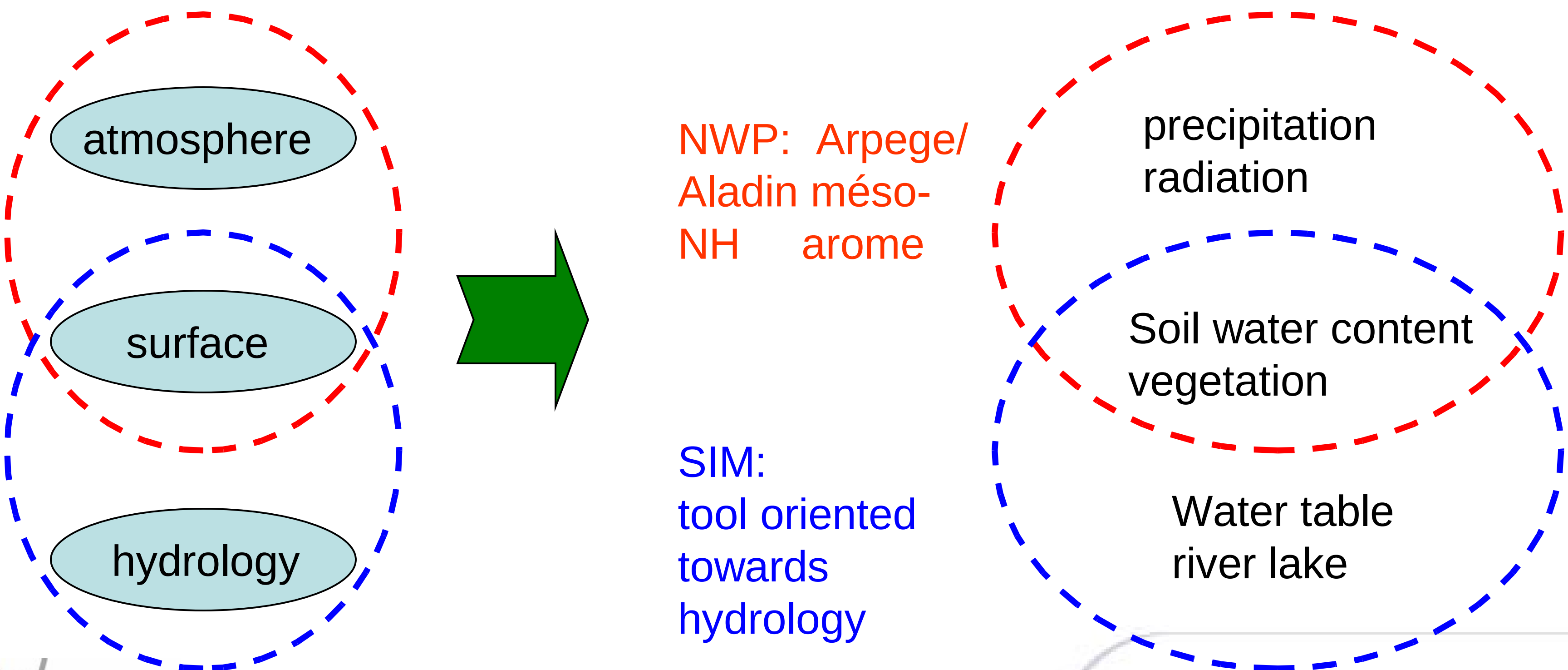
Surface processes modeling at Météo-France (1)

- Represent the exchange of water, energy and carbon between the surface and atmosphere on a wide range of spatial and temporal scales
- Surface: an indispensable step and often misunderstood to characterize the complex cycle of water, energy and carbon in the earth system

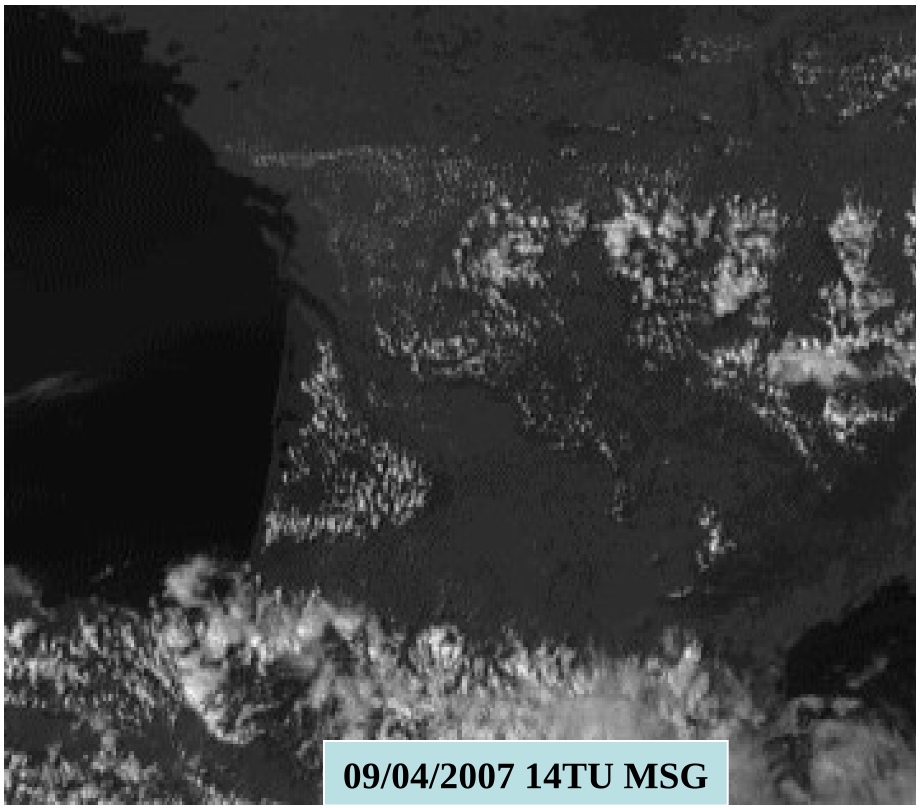


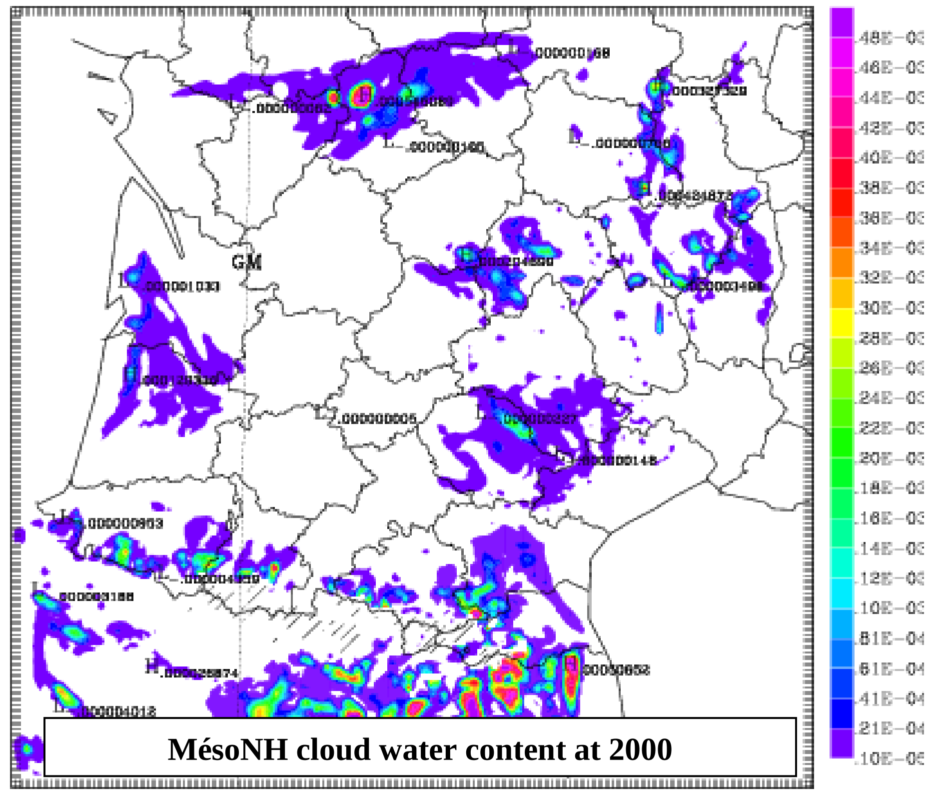
Surface processes modeling at Météo-France (2)

- A particular effort to represent the heterogeneity
  - of surfaces
    - By distinguishing vegetation, cities and water
  - of associated processes
    - By developing physics-based models for continental or artificial surfaces as well as for surface water
    - By treating certain processes as sub-mesh: hydrological processes
- The problem of sensitivity to initial conditions in NWP
  - leads to develop an analysis of surface variables (priority to soil water content)
- The willingness to pool efforts led to develop SURFEX, a surface model for NWP and research
- Validation methods
  - Field experiment: local scale $\Rightarrow$ regional scale ($\Rightarrow$climat)
    - (Hapex, Murex, Capitoul, Ceres, AMMA, …)
  - International model inter-comparison exercices (PILPS, SNOWMIP, …)

An example of the influence of surface fluxes on meso-scale circulation

Development of boundary layer clouds on the Landes forest as a result of vegetation breezes

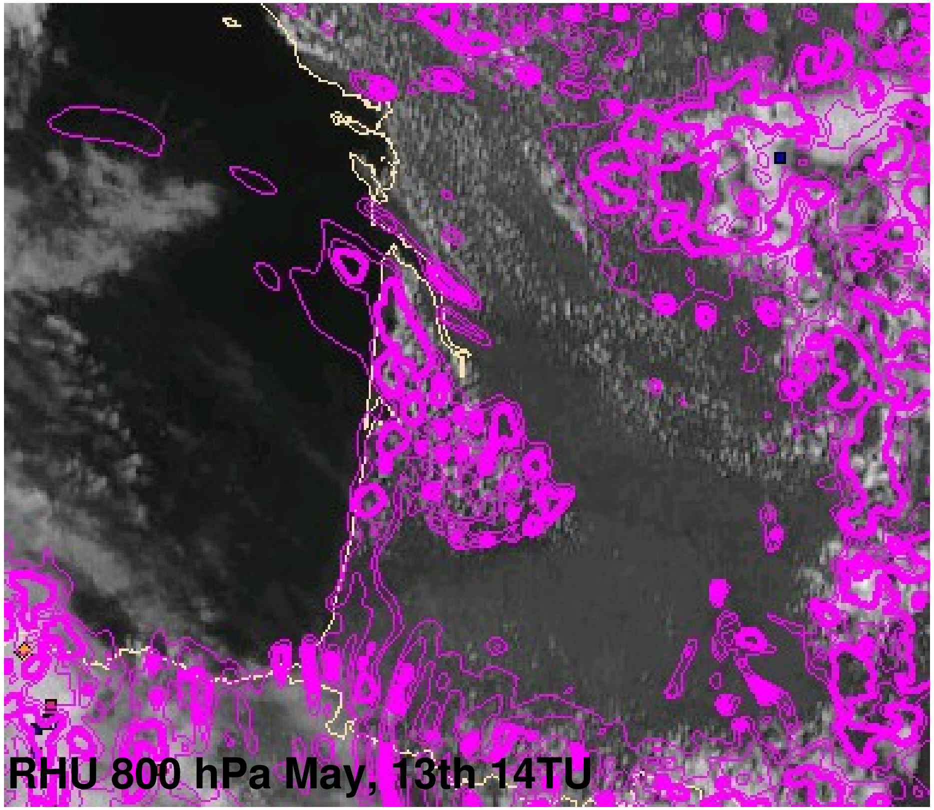




Source, S. Malardel

An other example of relative humidity forecast made with Arome model

Good moisture field forecast on Landes forest made with Arome France:



Source, T. Lefort, Y. Seity

The externalized surface model SURFEX

- Normalized interface for coupling between surface and atmosphere for meteorological and hydrological models

- Surfex gathers developments made on surface physics at CNRM for 20 years, in collaboration with French national scientific community

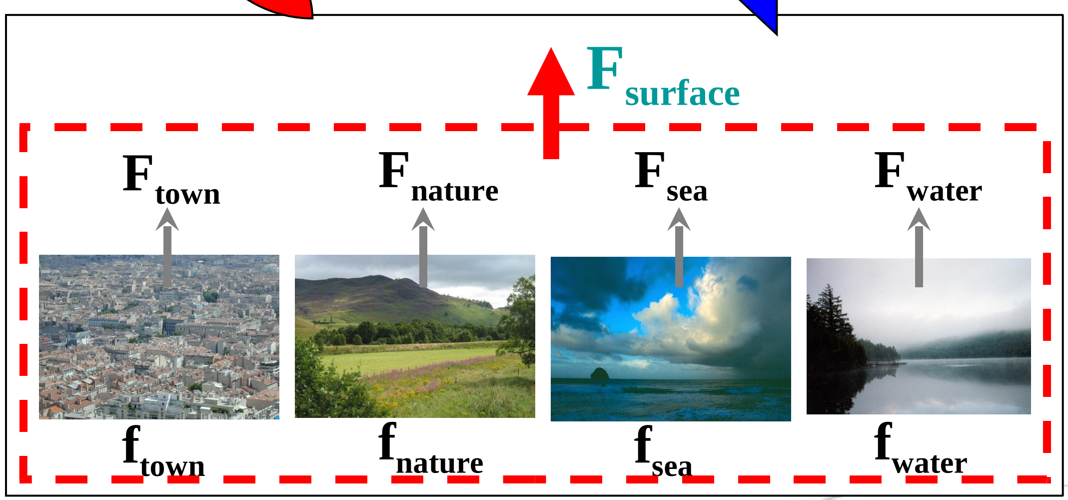
surface-atmosphere exchanges within surfex

Méso-NH
AROME
Arpège / Aladin

albedo
emissivity
radiative temperature

Flux:
- **momentum**
- **sensible heat**
- **latent heat**
- **CO2 flux**
- **chemical species**
- **aerosols** (sea salt, dust)

Atmospheric forcing
Solar time
Radiative fluxes



TEB ISBA CMO1D FLake

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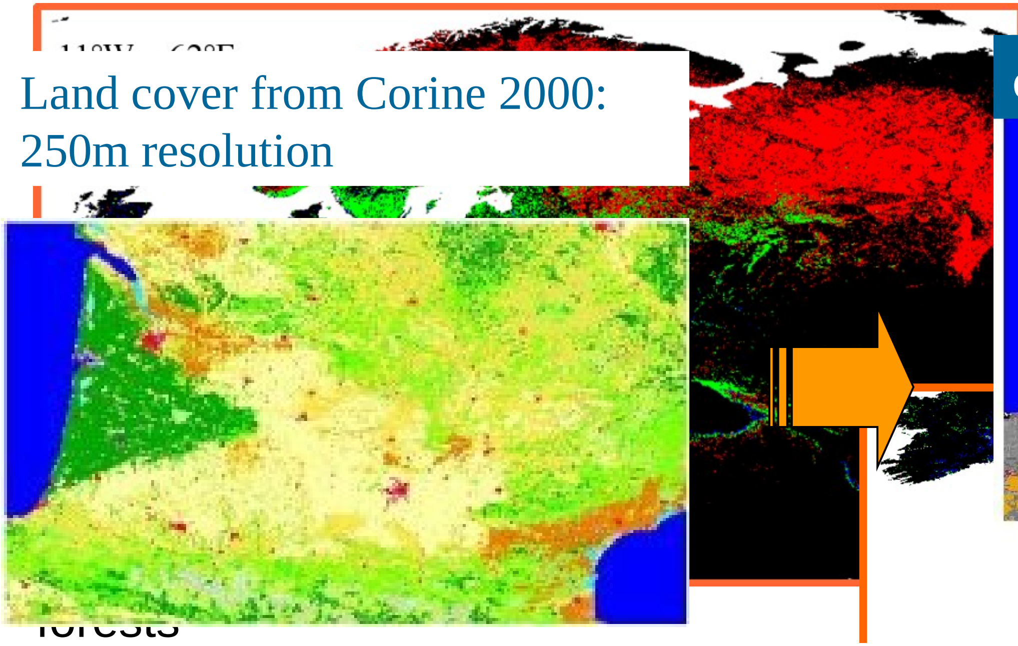
Description of ecosystems in Arome: ECOCLIMAP

- Database used to prepare necessary surface parameters for modeling
  - Based on land use and its associated satellite reflectances measured during year 2000.
  - Global, 1km horizontal mesh
  - Classification of surfaces in ~250 species including natural, artificial and water areas.

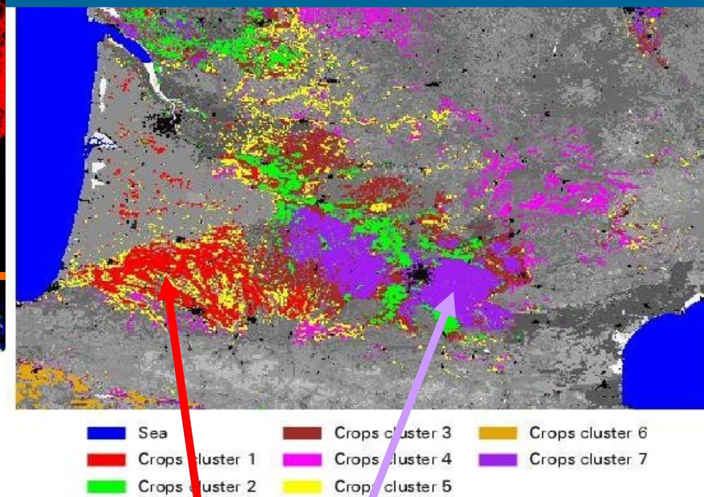
- Evolution towards a more accurate database
  - Regional, 1km horizontal mesh
  - More accurate satellite reflectances, covering a longer time period
  - Classification of surfaces in ~570 species

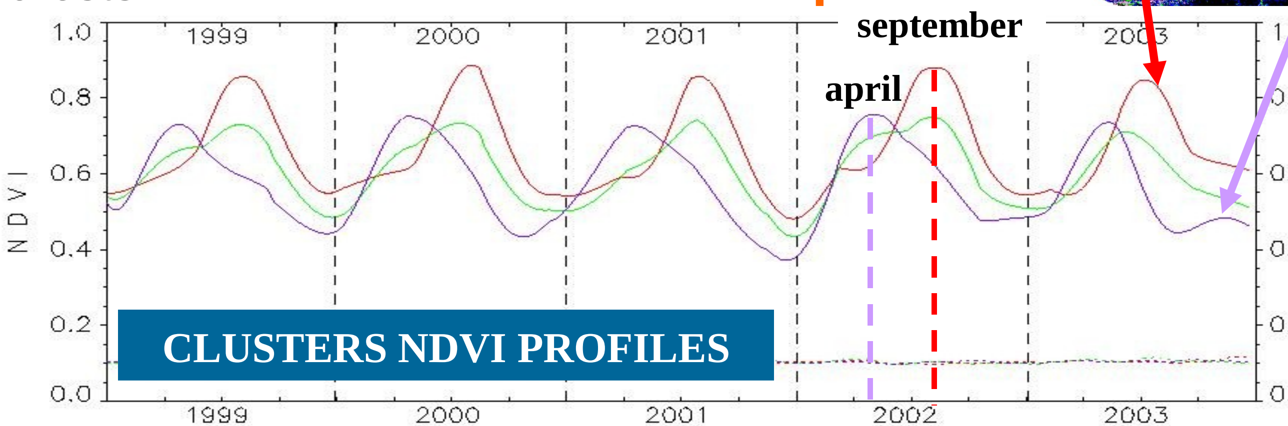
Towards a more accurate vegetation database

Land cover from Corine 2000: 250m resolution



cropland divided in 7 clusters





CLUSTERS NDVI PROFILES

Summer crops (maïze)

Winter crops (wheat)

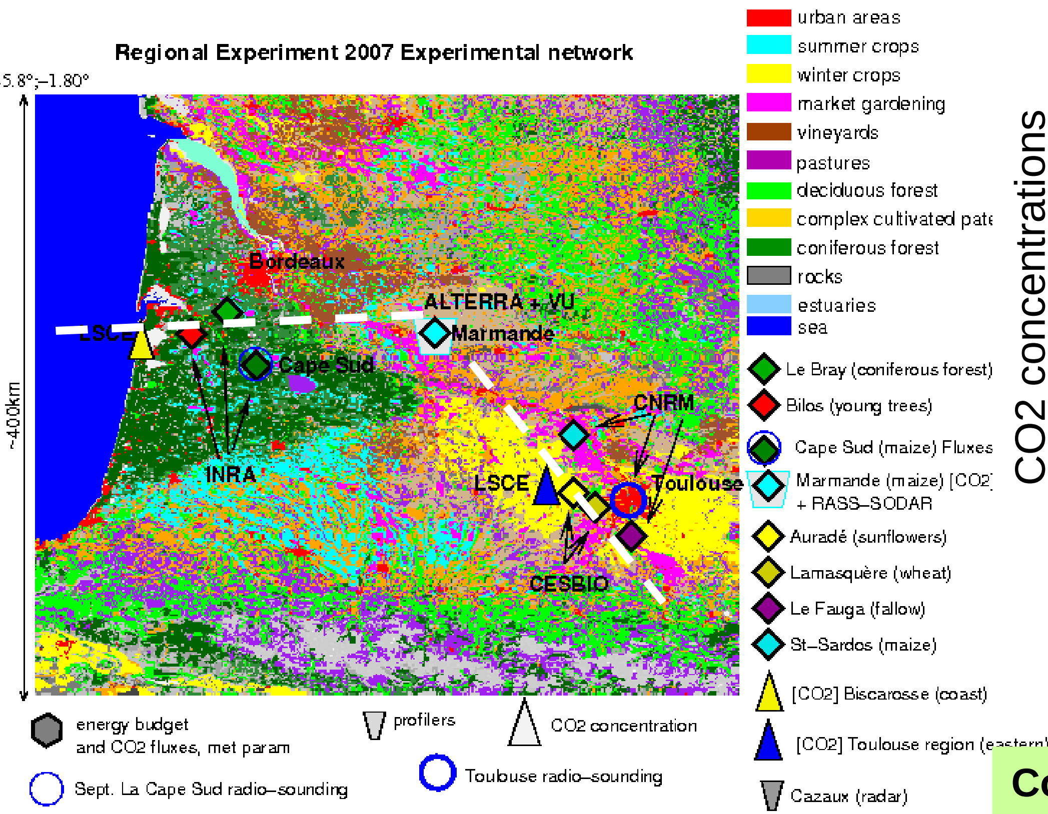
polycrops

Surface physics examples and derived applications (1)

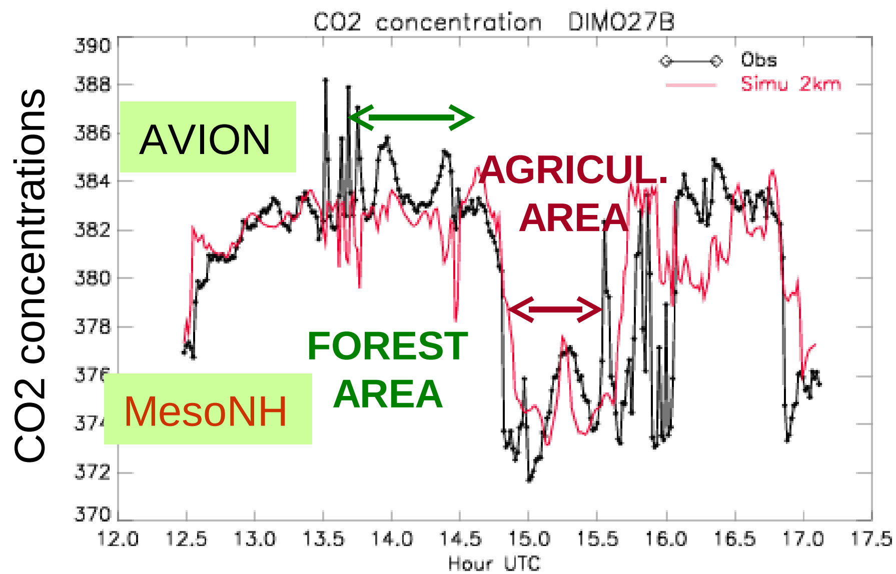
- Surface scheme for continental areas: ISBA
  - Vegetation scheme – simplified photosynthesis (CO2) – interactive vegetation
  - 3 soil schemes including ice, 3 snow schemes
  - Sub-grid parameterization for hydrology and turbulent fluxes
  - Emission for soil particles, chemical and biogenic species

- Application:
  - Carbon cycle modelling:
    - Carbon rapid cycle: coupling between evapotranspiration and assimilation
    - Carbone slow cycle: towards an interactive vegetation in climate models
    - Evolution of atmospheric CO2

CERES experiment 2005-2007: CO2 regional budget
Influence of surface processes and boundary layer



Experimental network 2007



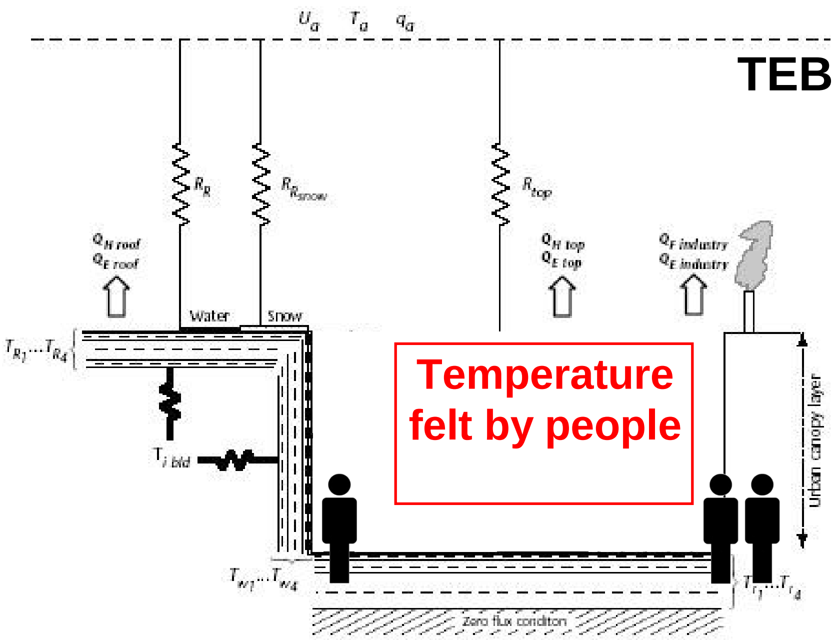
Comparaison of simulated and observed CO2 (ppm) 14HUTC

(Sarrat et al., JGR, 2006)

Surface physics examples and derived applications (2)

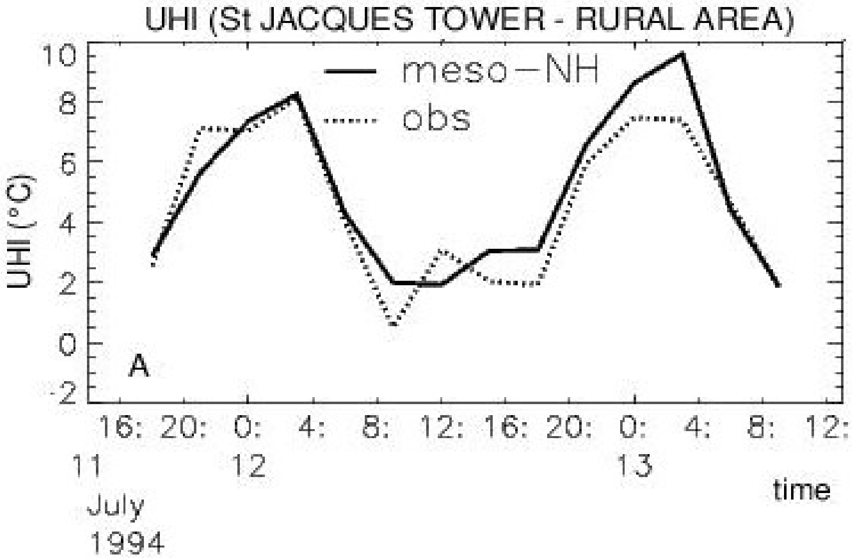
- Town scheme TEB
  - 3 energy budgets, heat storage in buildings, snow
  - Simulation of the roads ‘climate’
  - Anthropogenic fluxes
- Application:
  - Urban heat island due to heat storage in buildings

Town modelling for meteorology



Temperature felt by people

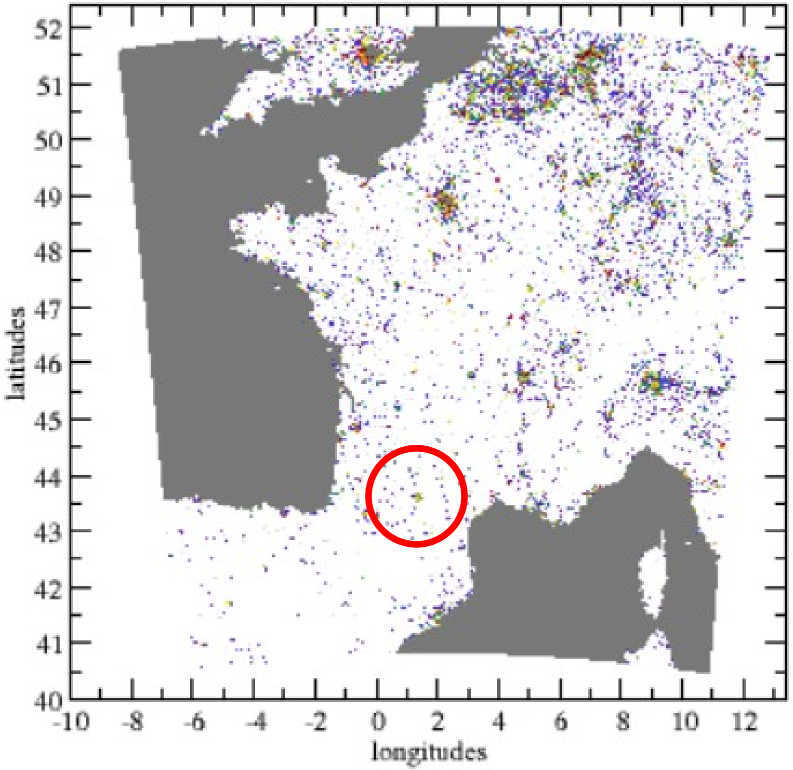
Urban heat island over Paris simulated with MésoNH model coupled with TEB



Maximum heat island during night

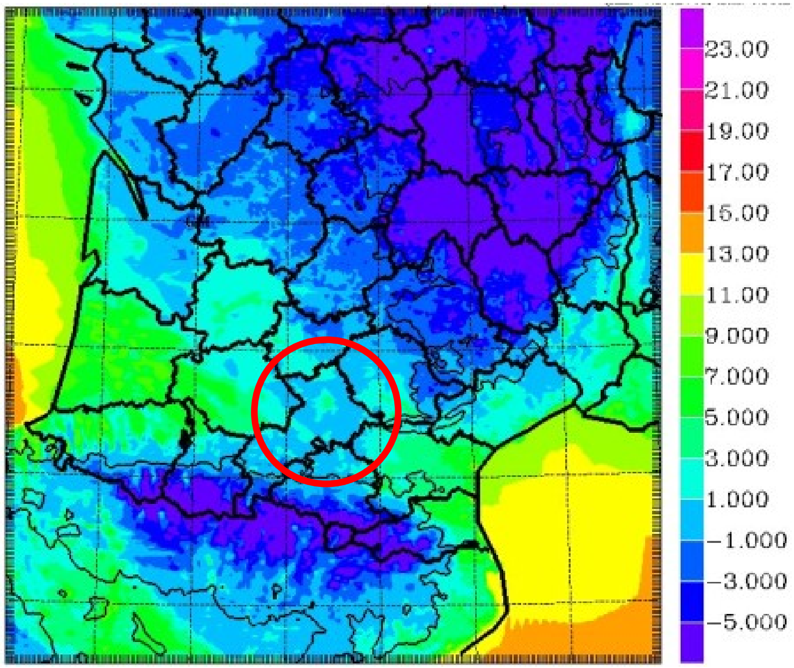
Lemonsu et Masson (2002)

TEB scheme in Arome model



Town fraction in Arome model

Prévision Arome Sud-Ouest
18 novembre 2005 00TU

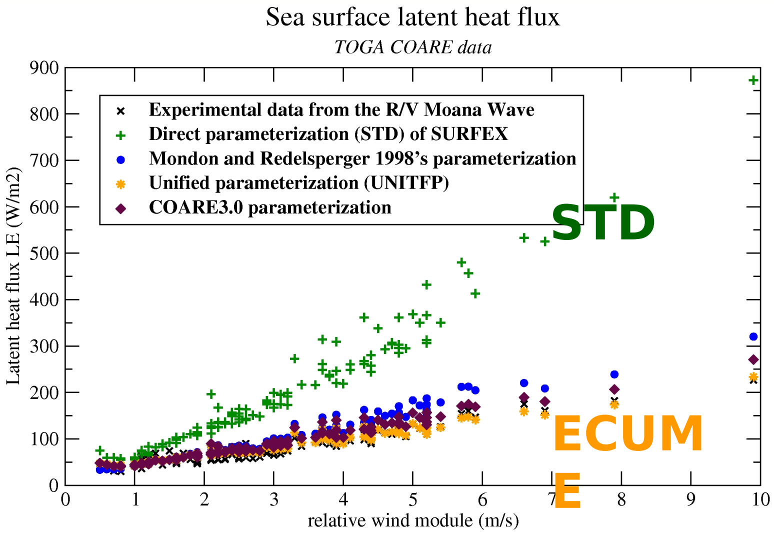


Urban heat island (~6°) forecated by Arome model near Toulouse city

Surface physics examples and derived applications (3)

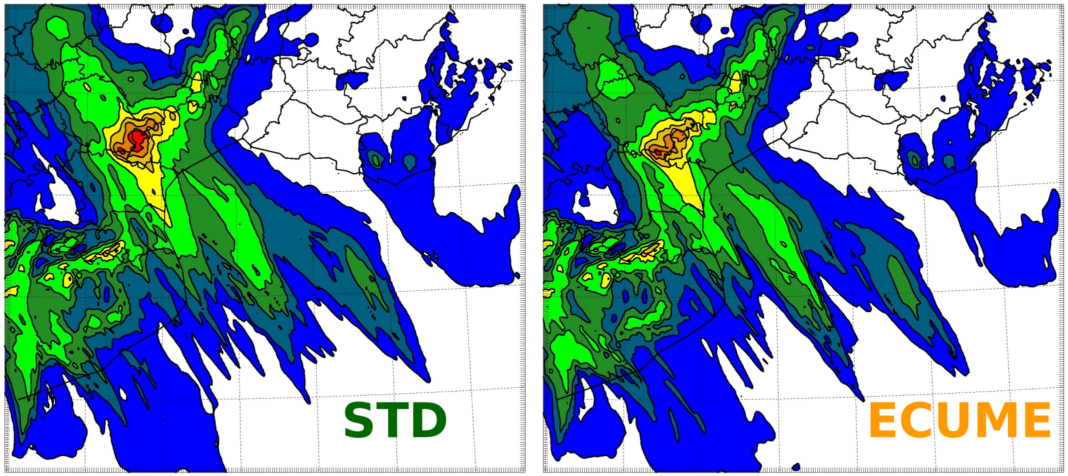
- Ocean-Atmosphere scheme
  - Parameterization of fluxes with **Ecume**
  - 1D **Ocean Mixing Layer** model based on a TKE scheme
- Application :
  - Impact of ECUME parameterization on evaporation flux

Sensibility of simulated convective precipitation to surface fluxes at the land-sea interface



- Decrease of the evaporation with ECUME

- Decrease of accumulated forecasted precipitation



max=**296** mm

max=**272** mm

(Lebeaupin, 2007)

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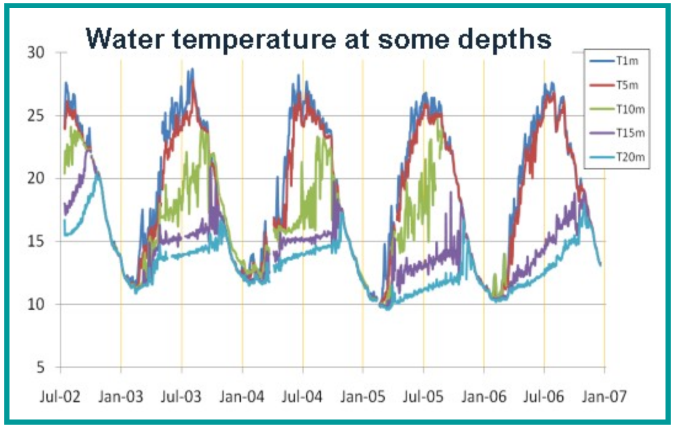
Surface physics examples and derived applications (4)

- Lake scheme FLake (collaboration with Hirlam community)
  - 1D thermal budget
  - Snow and ice
  - Sediment layer included

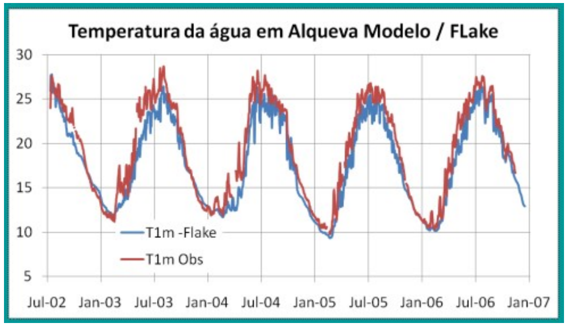
- Application:
  - Scheme validation

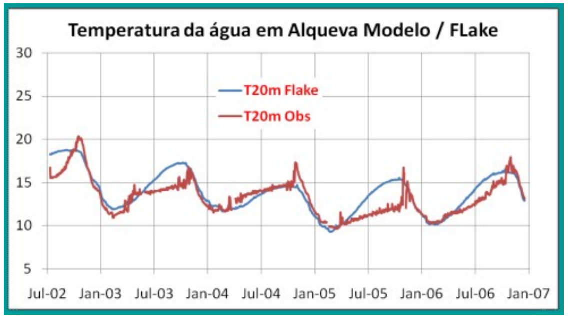
Use and validation of Flake model: Alqueva lake

Experimental system: instrumentation of Alqueva lake



Off-line validation of the model





Conclusion

- Detailed modelling of the exchanges with town
  - Anthopogenic fluxes: traffic, industry, domestic heating
  - Introduction of vegetation areas in towns
- Modelling of the exchanges with natural areas
  - More accurate database
  - Carbon cycle
- Modelling of the exchanges with water surfaces
  - Will allow to retrieve an evolutionary surface temperature:
    - Sea/ocean: using a 1D model for the Ocean Mixing Layer representation
    - lakes: **FLake 1D model** already widely used in the scientific community