



SURFEX

Patrick Le Moigne *et al.*

Aladin & Hirlam ASM – April 16-20/2018, Toulouse

Overview of recent SURFEX developments

- ❑ Introduction to SURFEX

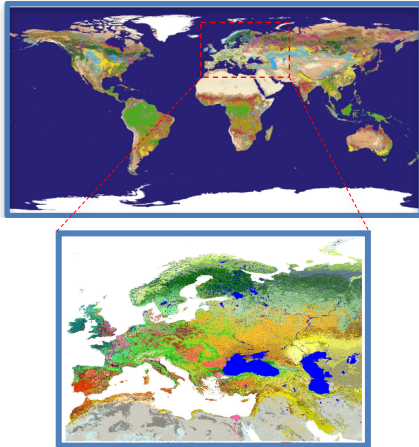
- ❑ Scientific developments
 - DA & Physics
 - EcoSG
 - Evaluation

- ❑ Impact of pedo-transfer function

- ❑ Summary and outlook

SURFEX basis

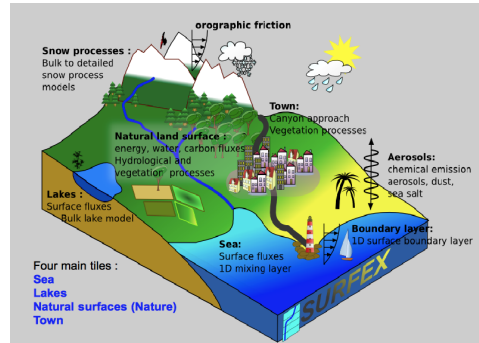
Land cover database



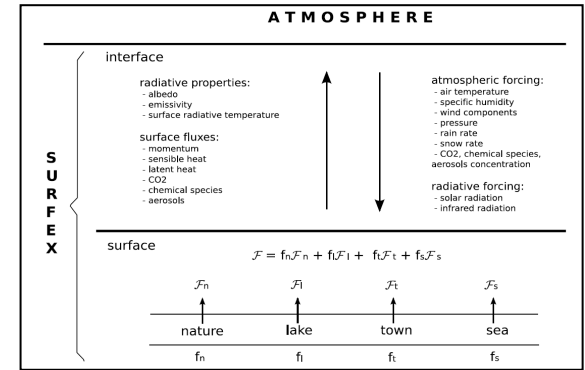
Tile %



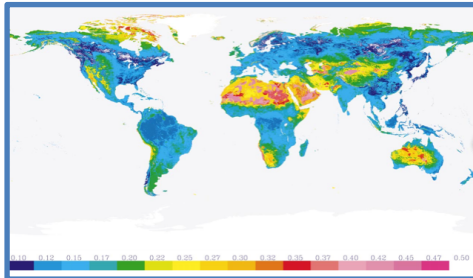
Tiling approach



Flux calculation



Model parameters



Models



Seas and oceans:

Prescribed SST, Charnock formulation
ECUME (multi-campaign parameterization), 1D Ocean Mixed Layer model



Lakes :

Prescribed LST, Charnock formulation
Flake lake model



Soil and vegetation: ISBA

Force restore or diffusion for heat and water transfers in the soil



Town: TEB

Canyon concept, detailed radiative scheme
Vegetated buildings, impact of trees in canyon

Introduction: SURFEX cycles

SFX	Date of Release	NWP	Meso-NH	CNRM-CM	Sci-Doc
v1	2005				
v4.8	2008	CY35t2	m4.8		V5.0
v5.8		CY36t1		CNRM-CM5 (CY32+v5.8)	
v6	2010	CY37t1			
v7.1	2011		m4.9		
v7.2	Feb 2012	CY38t1			V7.2
v7.2.1	Jan. 2013	CY39t1			
v7.3	Feb. 2013	CY40t1 CY41t1 (end 2015) CY42_op2 (Nov. 2017)	m4.10 m5.1 (2014) m5.2 (01/2015)		
v8	May 2016	CY42 (test) CY43t1 (test)	m5.3 (08/2016)	CNRM-CM6 (CY37t2+v8+)	
v8.1	Feb. 2018		m5.4		V8.1
v9	2019?				

Scientific developments

A constant need to improve model physics to fully benefit from data assimilation... and conversely...

But the compatibility between operational constraints and advanced schemes isn't straight foreword.

❑ Surface Analysis

- Operationally @MF: T2M, RH2M
- Assimilation of new observation types: LAI, SSM, snow coverage, etc.
 - Albergel, C., et al.: Sequential assimilation of satellite-derived vegetation and soil moisture products using SURFEX_v8.0: LDAS-Monde assessment over the Euro-Mediterranean area, Geosci. Model Dev., 10, 3889-3912, <https://doi.org/10.5194/gmd-10-3889-2017>, 2017.
- Develop new methods complementary to the OI: EKF, EnKF, particle filter algo.

❑ Model physics

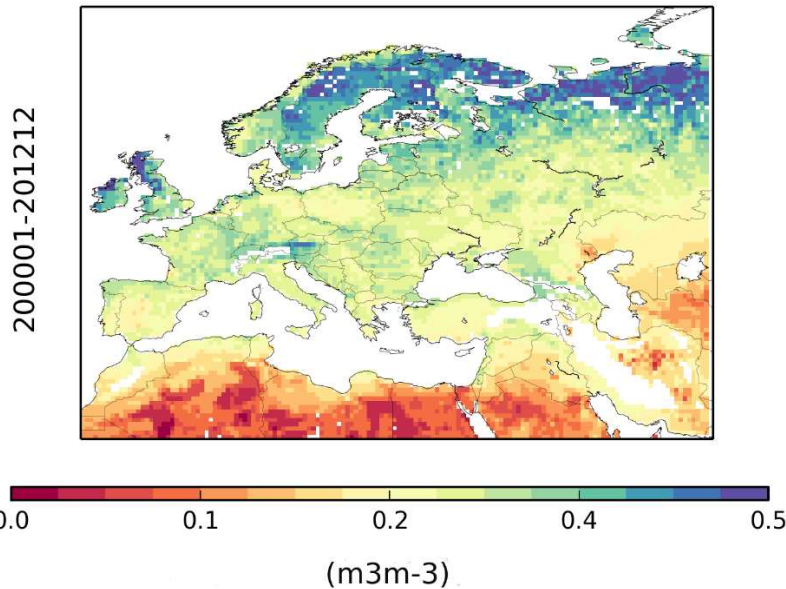
- Urban TEB model
- Lake FLake model
- ECUME parameterization
- Sea-Ice Gelato-1d model
- Soil-Vegetation ISBA model
- Snow models: CROCUS, ISBA-ES

Data Assimilation: LDAS system

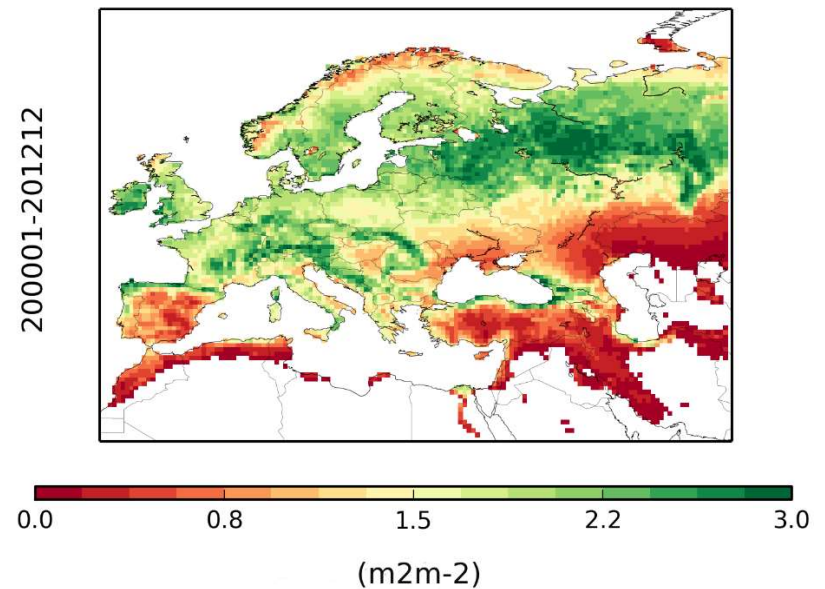
Open-loop & Analysis experiments over 2000-2012
Spin-up (20 times 1990 + 1990-1999)

Model	Domaine	Atm. Forcing	DA Method	Assimilated Obs.	Observation Operator	Control Variables	Additional Option
ISBA-DF CO ₂ -responsive version (Interactive veg.)	Europe and the Mediterranean basin (0.5°)	Earth2Observe WRR1 (Schellekens et al., 2017)	SEKF	SSM (ESA-CCI) LAI	Second layer of soil (1-4cm) LAI	Layers of soil 2 to 8 (1-100cm) LAI	Coupling with CTRIP (0.5°)

ESA-CCI SSM_v03.0



GEOV1 LAI



Data Assimilation: results

SEKF : uses finite differences in the observation operator Jacobians (H) to relate the observations to the model variables

→ Model sensitivity to the observations over 24h assimilation window

2000-2012	$\partial \text{SSM} / \partial \text{LAI}$	$\partial \text{SSM} / \partial w_2$	$\partial \text{SSM} / \partial w_3$	$\partial \text{SSM} / \partial w_4$	$\partial \text{SSM} / \partial w_5$	$\partial \text{SSM} / \partial w_6$	$\partial \text{SSM} / \partial w_7$	$\partial \text{SSM} / \partial w_8$
Median	-0.0010	0.1719	0.1543	0.0694	0.0275	0.0043	0.0006	0.0001
	$\partial \text{LAI} / \partial \text{LAI}$	$\partial \text{LAI} / \partial w_2$	$\partial \text{LAI} / \partial w_3$	$\partial \text{LAI} / \partial w_4$	$\partial \text{LAI} / \partial w_5$	$\partial \text{LAI} / \partial w_6$	$\partial \text{LAI} / \partial w_7$	$\partial \text{LAI} / \partial w_8$
Median	0.2220	0.0006	0.0015	0.0032	0.0068	0.0038	0.0011	0.0006

Assimilation of SSM

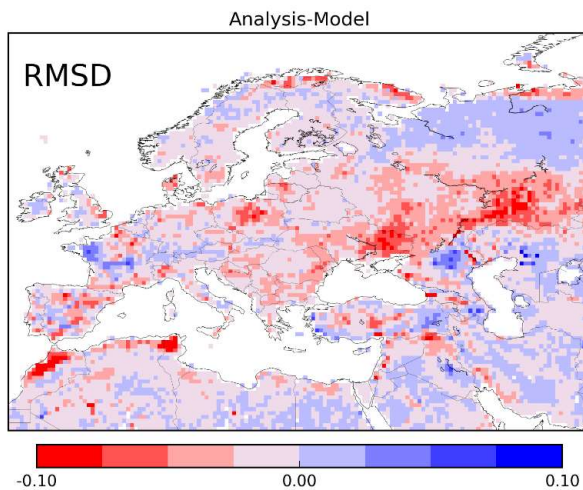
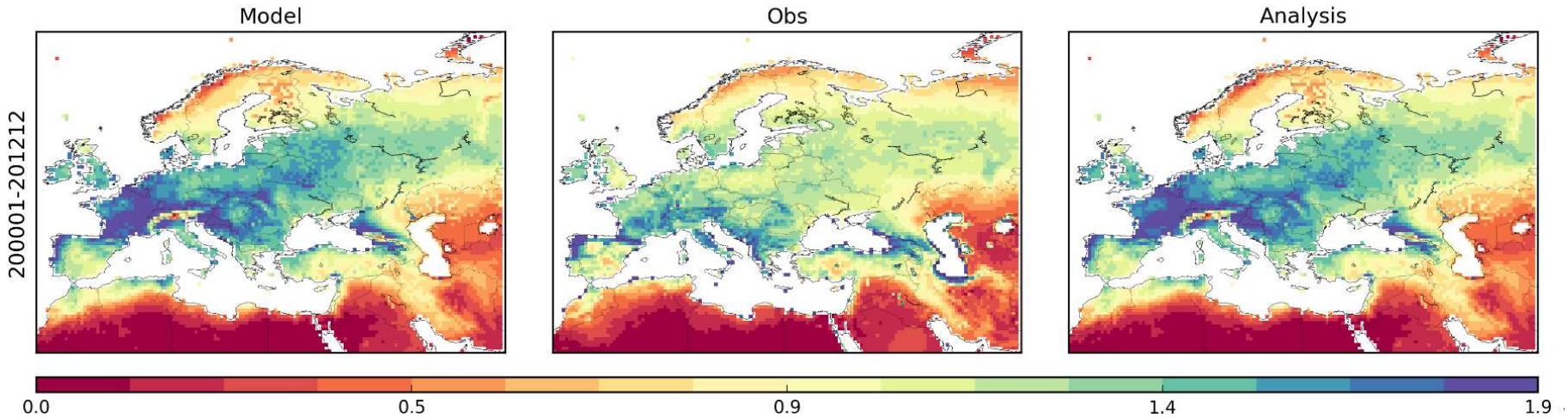
→ LDAS will be more effective in modifying SM from the first layers of soil as model sensitivity to SSM decreases with depth

Assimilation of LAI

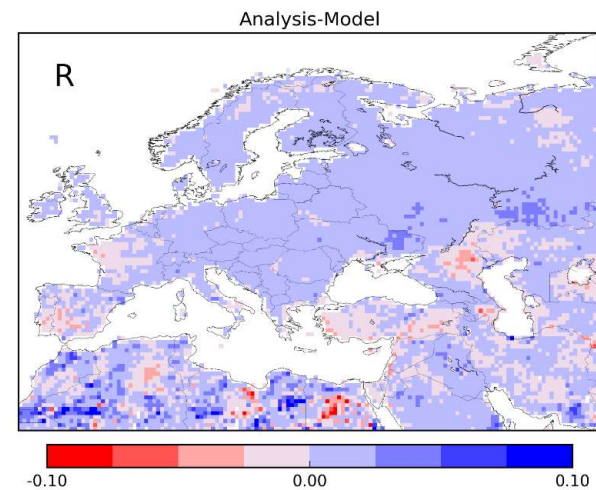
→ LDAS will be more effective in modifying SM from layers four to six where most of the roots are present

Evaluation of simulated evaporation

Evaluation of analysis impact 2000-2012: evapotranspiration vs. GLEAM dataset (Global Land Evaporation Amsterdam Model, www.gleam.eu)



Red: Analysis is better



Blue: Analysis is better

SURFEX physics

Illustration of some specific developments

☐ TEB

- Adding effect of trees in urban-vegetated TEB model
- Hydrology in TEB
- Building Energy Model

☐ Ocean

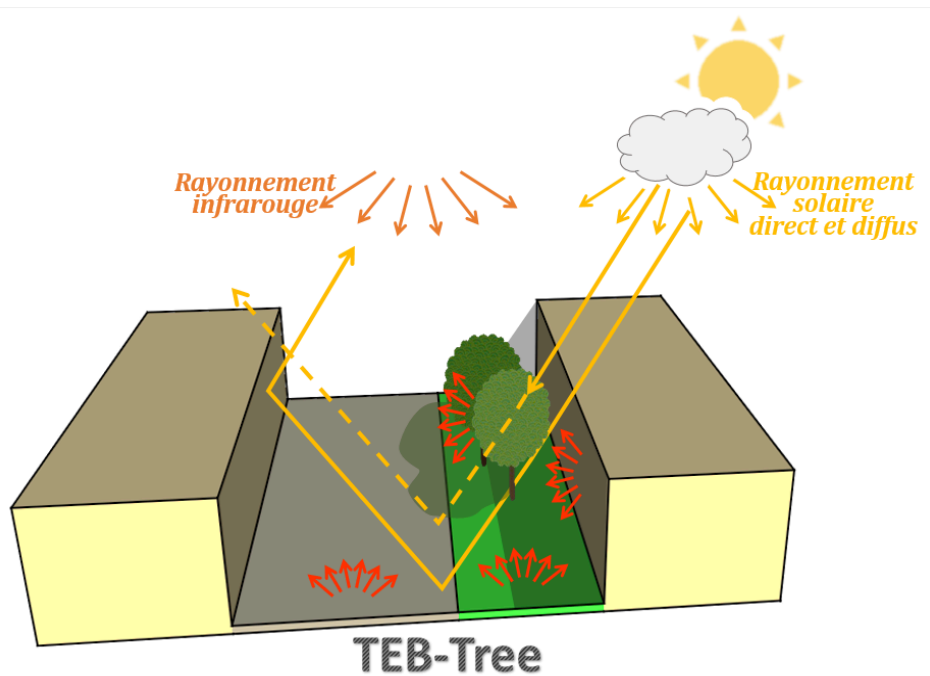
- Revised ECUME parameterization

☐ ISBA

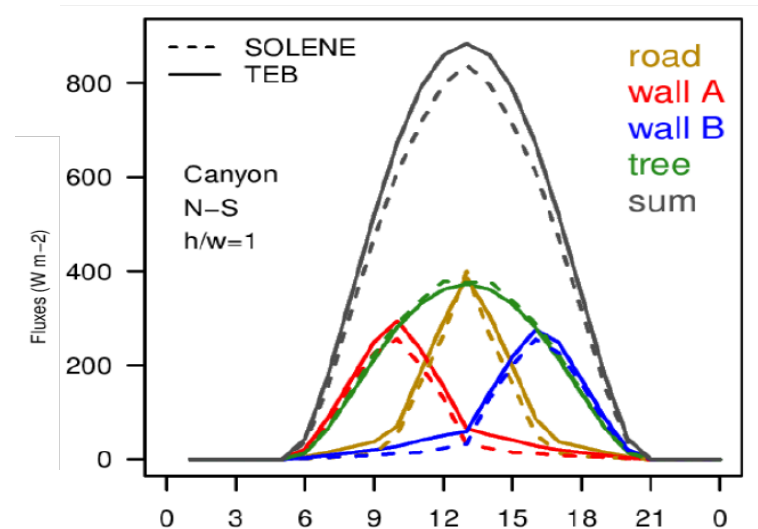
- Improvements of ISBA-DF, ISBA-ES
- Developments of ISBA-MEB

Effect of trees in TEB

- Recent developments allow to take into account **the radiative effects associated to the presence of vegetation and trees inside the canyon**
 - Shadowing and attenuation through the tree cover
 - Inter-reflections with trees
 - Infra-red emission of trees



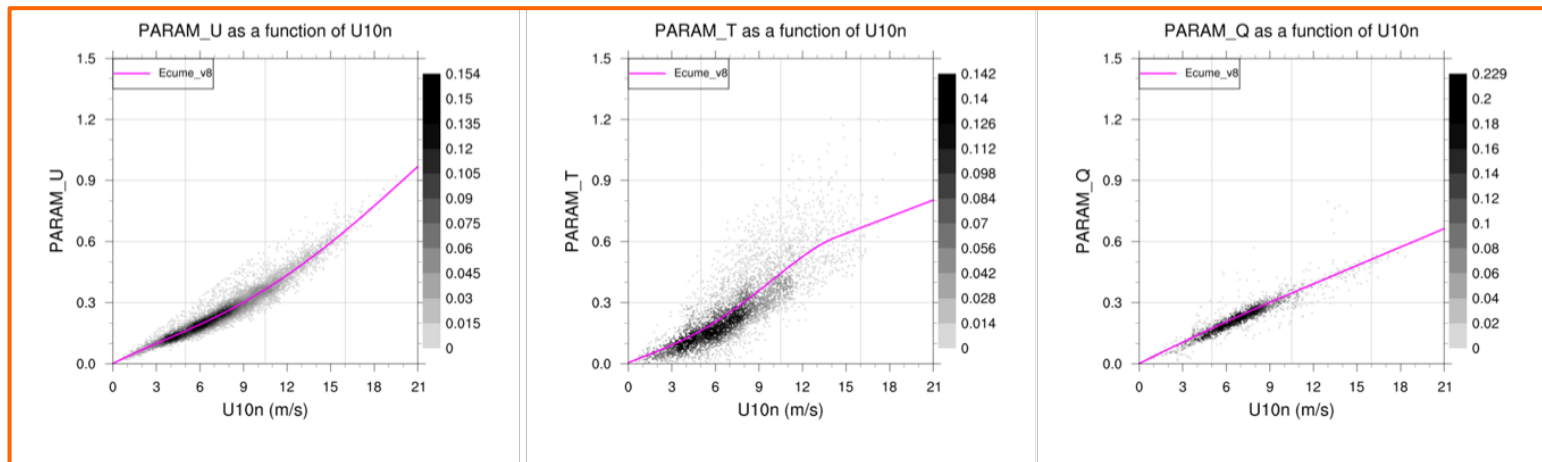
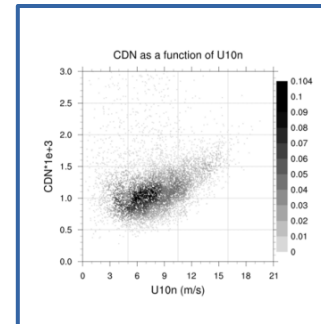
SOLENE: architectural software



Revision of ECUME parameterization

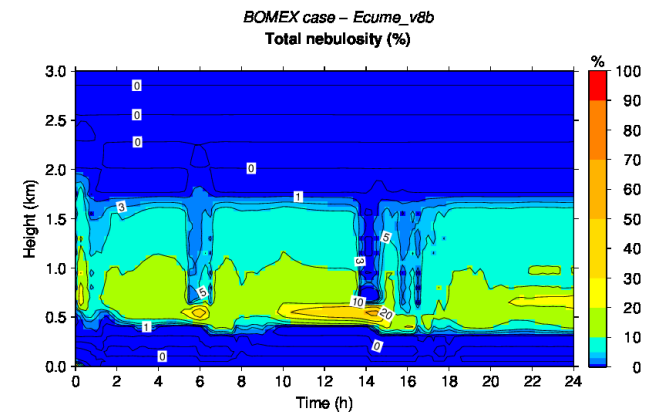
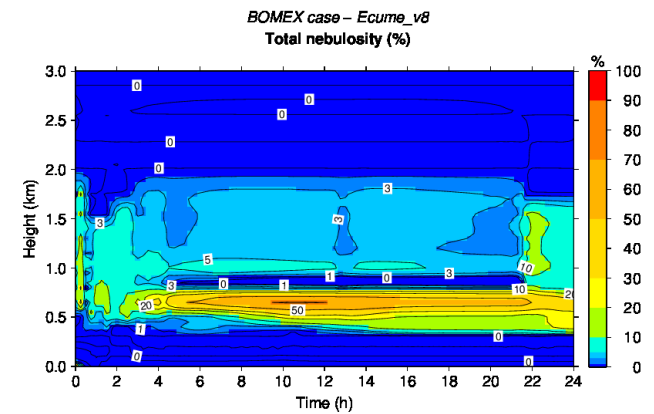
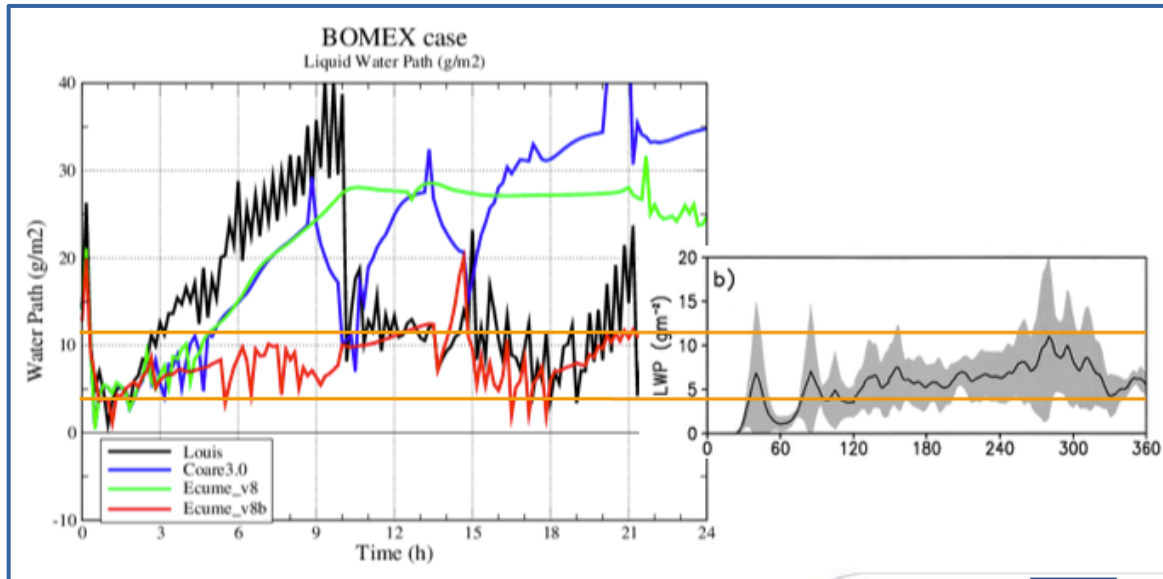
- ❑ To low evaporation leading to cold biases in the tropo
- ❑ To high sensible heat flux in case of Mistral wind
- ❑ New algorithm for C_{dn} , C_{hn} , C_{en} based on new parameters:

$$Param_U = \left(\frac{C_{dn}}{\sqrt{C_{dn}}} \right) \times \Delta U_{10n}$$
$$Param_T = \left(\frac{C_{hn}}{\sqrt{C_{dn}}} \right) \times \Delta U_{10n}$$
$$Param_Q = \left(\frac{C_{en}}{\sqrt{C_{dn}}} \right) \times \Delta U_{10n}$$

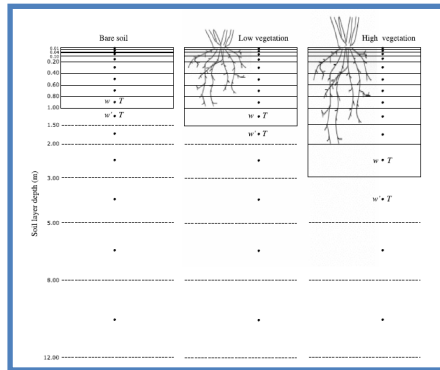


Revision of ECUME parameterization

- Bias correction of heat fluxes, more realistic neutral exchange coefficients: less dispersion in case of low wind speed, etc.
- BOMEX 1D-case – 21-23 June 1969 – (ocean)



ISBA land surface model: diffusion of heat and water



Fourier law for temperature
 Richard's equation for moisture

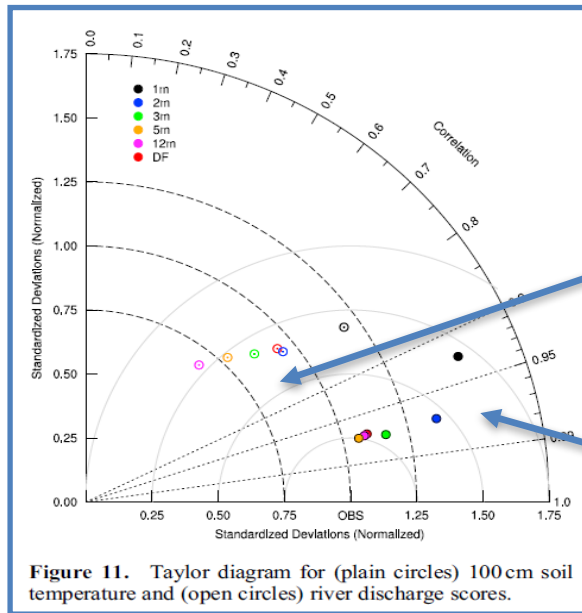
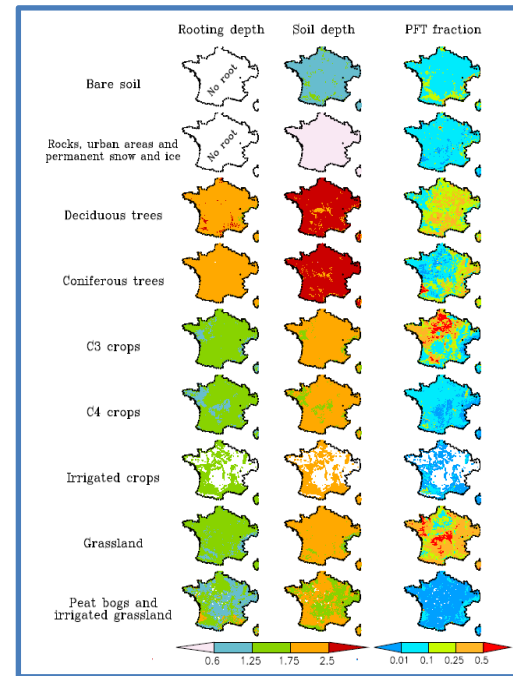


Figure 11. Taylor diagram for (plain circles) 100cm soil temperature and (open circles) river discharge scores.

River discharge
 500 stations

T @ 100cm
 120 stations



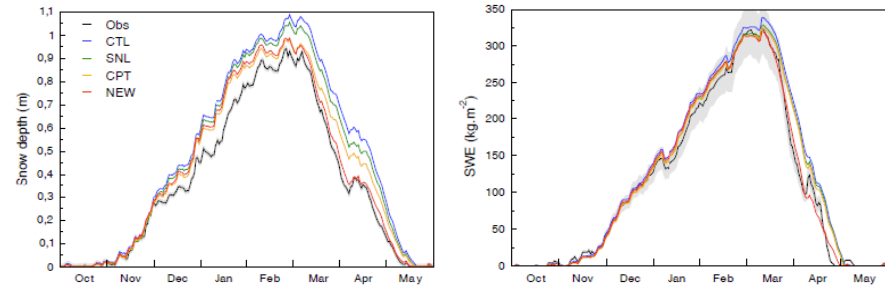
ISBA Explicit Snow Model

Layering: 12 layers. Thin layers at surface (diurnal cycle) and coarser layers below

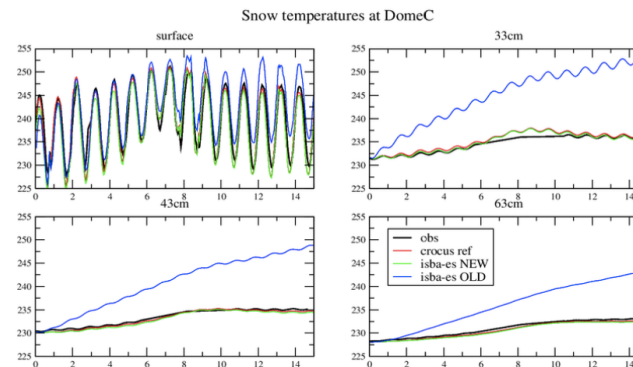
Compaction: due to changes in viscosity and surface wind-induced densification

Absorption of SW down: depends on snow albedo and extinction coefficients (function of snow optical diameter, density, age)

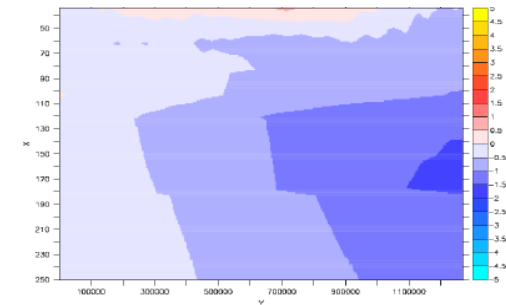
Validation @ Col de Porte - French Alps



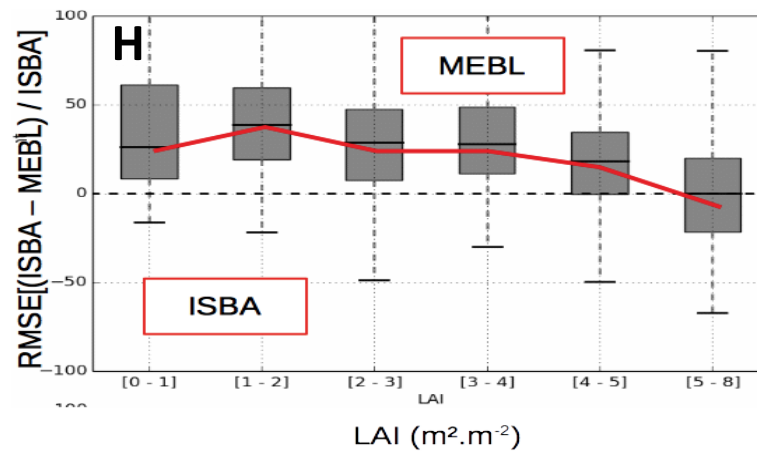
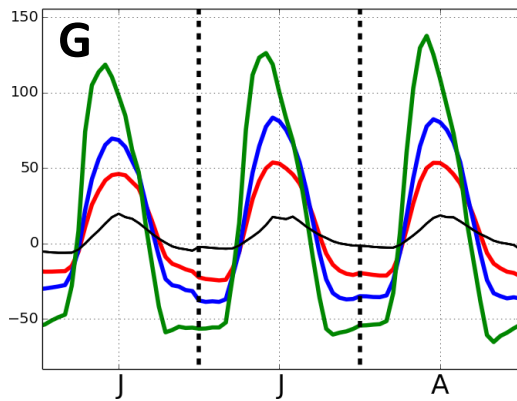
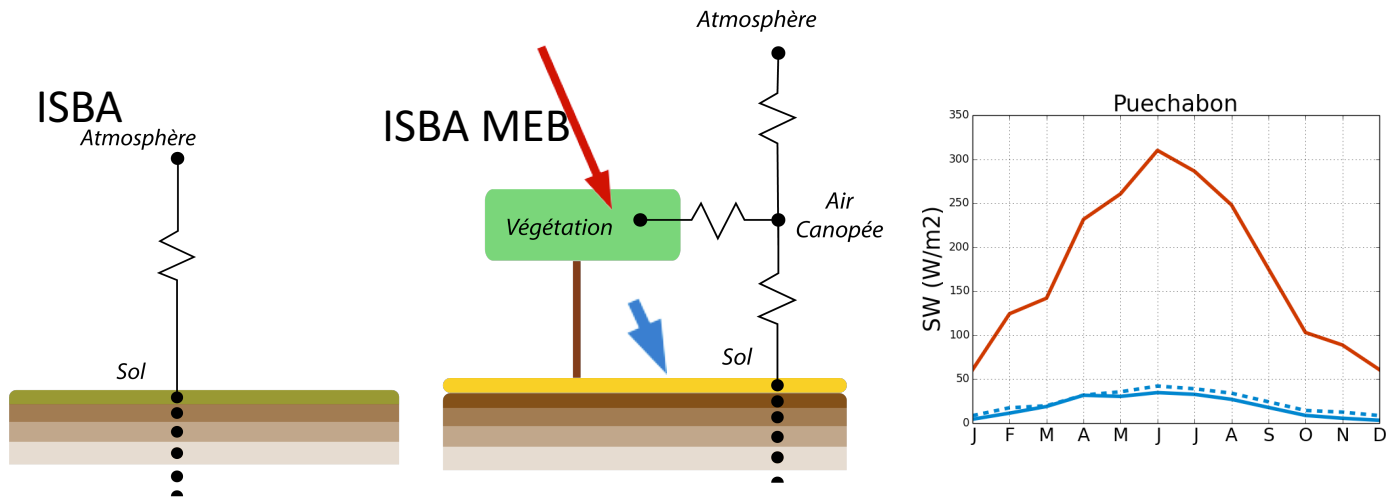
Validation @ DomeC - Antarctica



ISBA ES - OBS



ISBA Multi Energy Balance Model

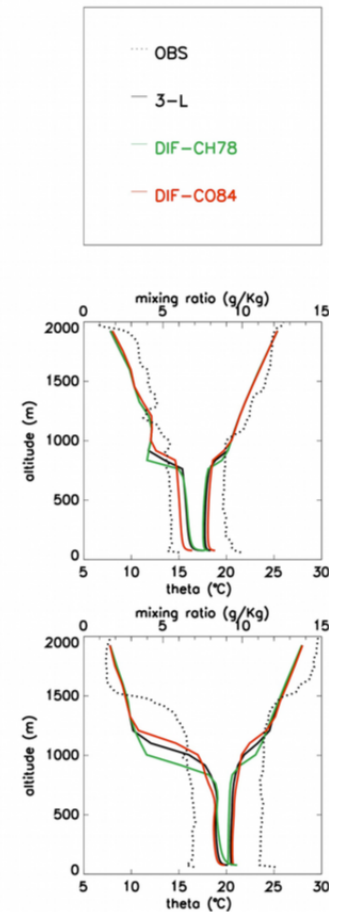
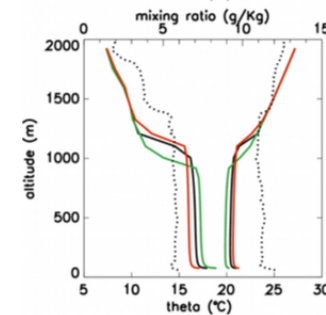
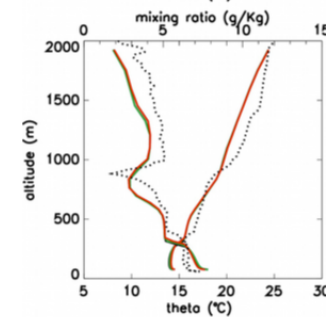
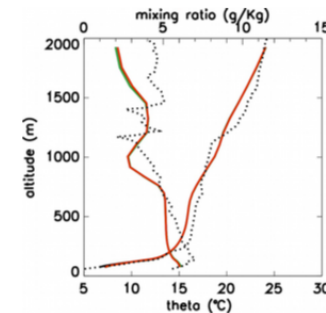
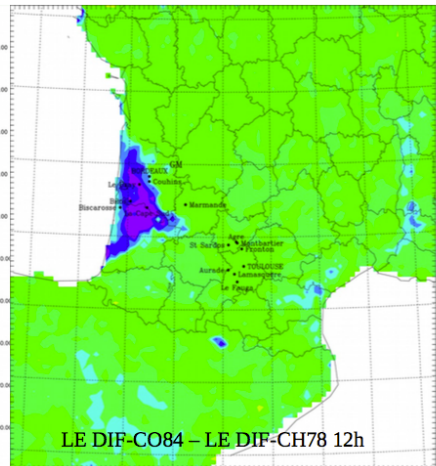
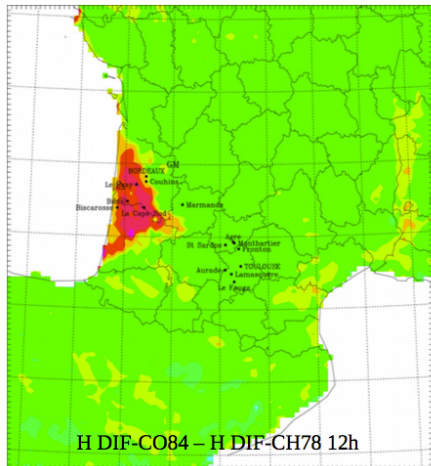
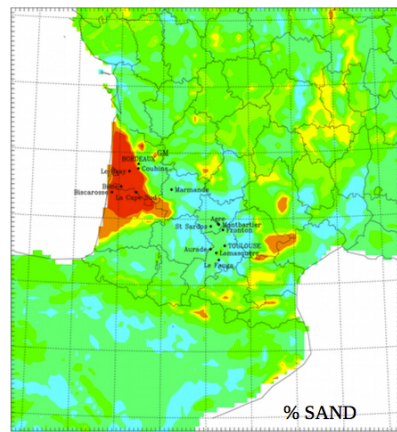
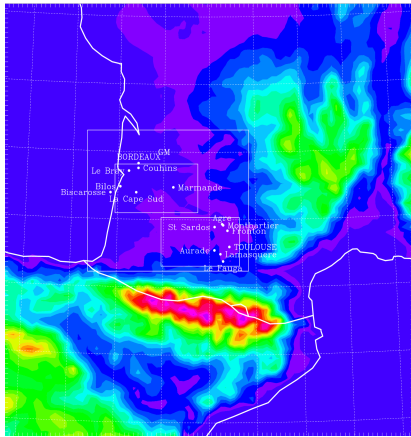


Ongoing study on the impact of pedo-transfer function

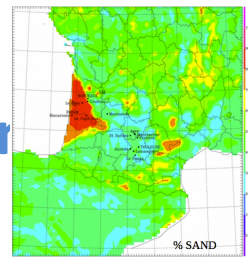
Pedo-transfer function used to compute W_{fc} , W_{wilt} , ... as a function of soil texture

Case study: Carbo-Europe IOP 24 May 2005

Model: ISBA-DF, 12 patches, PTF=CH78 (reference) or CO84 (tested)

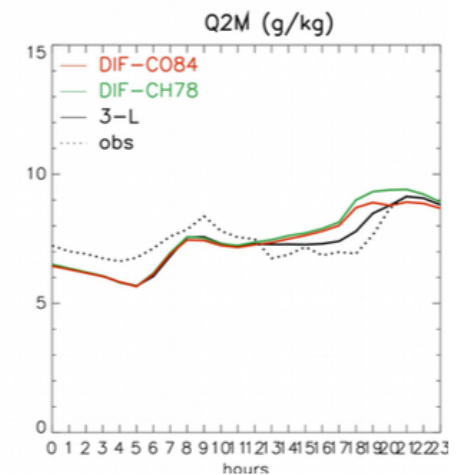
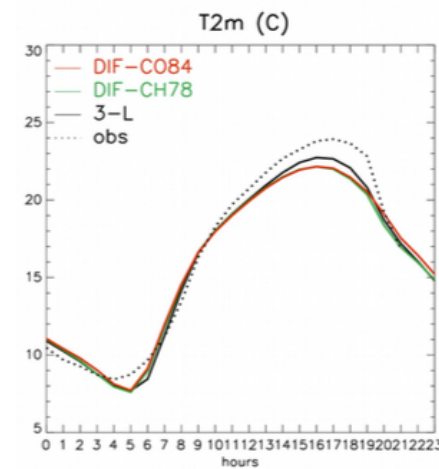
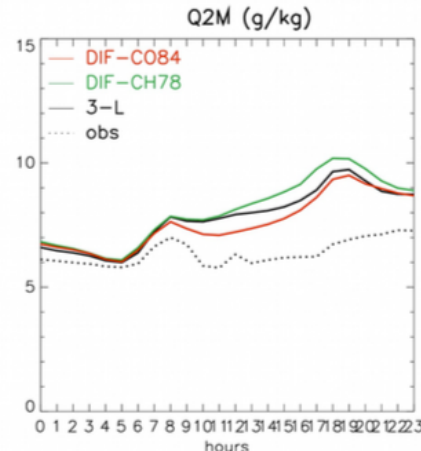
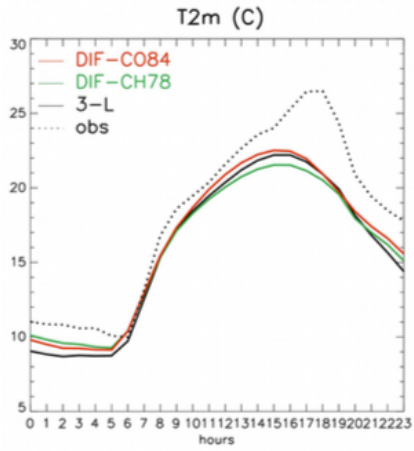
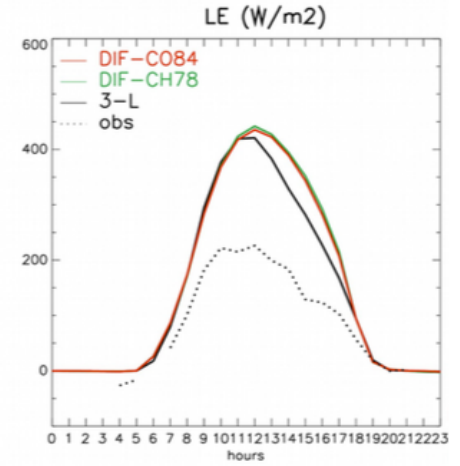
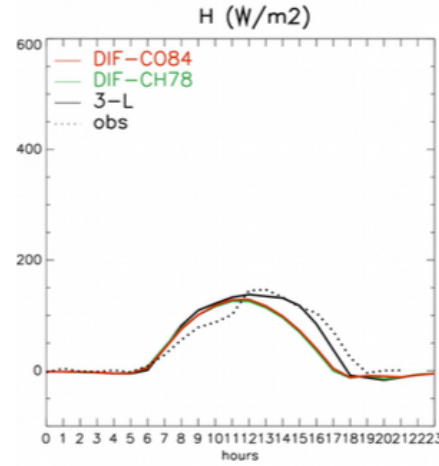
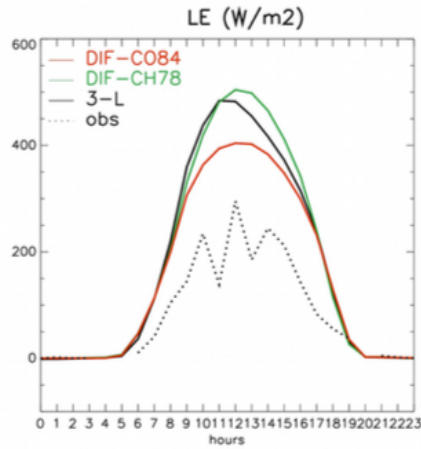
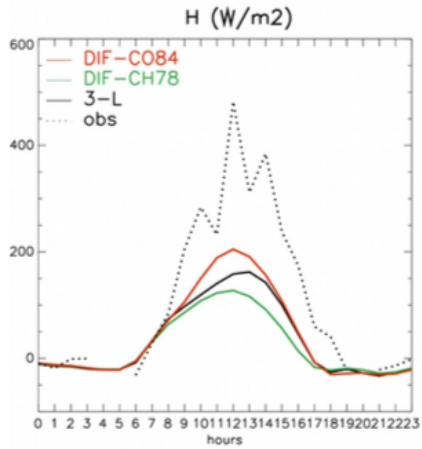


Ongoing study on the impact of pedo-transfer function



LE BRAY (conifer forest)
CLAY=0.04 SAND=0.87

MARMANDE (maize)
CLAY=0.23 SAND=0.38



Summary and Outlook

- ❑ Lot of new features available in v8.0 and v8.1
 - Physics, databases, surface DA
 - Scientific documentation available
 - Large validation phase offline and coupled
- ❑ Which surface analysis for NWP do we want?
 - OI, Kalman Filter
 - What are the pros and cons of using one or the other approach?
 - See Camille's talk
- ❑ How to progress and use more new developments in NWP?
 - AROME surface physics has (almost) not changed from the time it has been put into ops.
 - SURFEX is now operational in ARPEGE
 - Ideal env. for testing new parameterizations
 - Gelato1d, FLake, ...
 - CNRM-CM climate model is a pioneer in integrating new physics parameterizations
 - Is it only a DA issue? If yes, how to circumvent it?
 - ALARO will start working with SURFEX
 - HIRLAM uses advanced features from SURFEX: are the constraints weaker in HARMONIE env.?
 - See Patrick's talk ;)
- ❑ 2018-2019
 - Work on physics (MEB, TEB, etc.), DA (EnKF, particle filter), Databases (ECOSG)
 - Building next SURFEX release has started (Summer 2019?)
 - SUW2019 to be planned

Thanks for your attention!