Recent developments on SURFEX – Applications within ALADIN/LACE

Jean-François Mahfouf

(Météo-France/CNRM)

Outline

- Latest news about SURFEX
- Evaluation of SURFEX within ALADIN/France
- Revised soil and vegetation databases in AROME
- Evaluation of ISBA-DIF at local scale (Le Fauga - SMOSREX)
- Developments on near-surface analysis parameters
- Summary on land surface data assimilation activities

Latest news about SURFEX

- Version 7 available since June 2011
- Publication process : documentation of SURFEX in a special issue of GMD (Geoscientific Model Development) – 4 papers are planned by the end of 2011:
  - General presentation of SURFEX
  - Presentation of ECOCLIMAP2
  - Snow scheme CROCUS within SURFEX
  - Evaluation of ISBA-Ags against crop yields
- Surfex training (in French) : 10-12 October 2011 in Toulouse
- Creation of a SURFEX steering committee for the coordination of developments between Météo-France, ALADIN and HIRLAM consortia : will take decisions regarding technical and scientific evolutions of the system (first meeting 6th October 2011 in Toulouse)

ALADIN/France with SURFEX

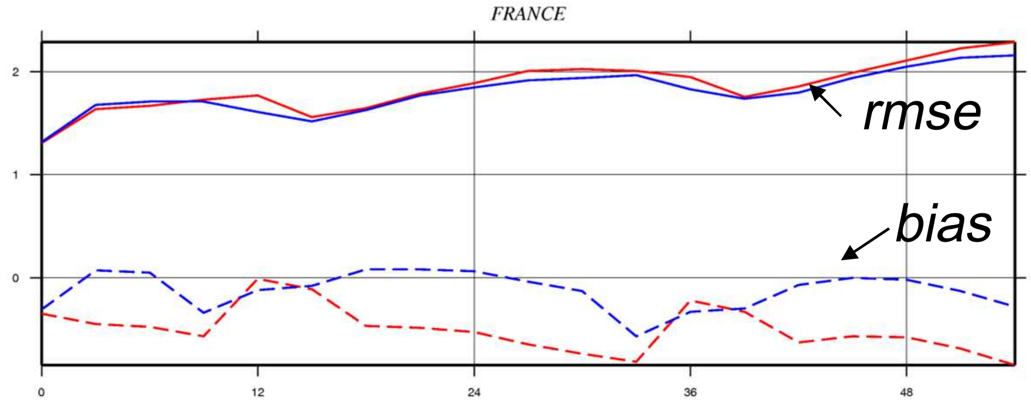
- Most important changes to the surface:
  - Physiographic databases : ECOCLIMAP (vegetation) and FAO (soil)
  - Mosaïc approach for surface fluxes with 3 tiles (oceans, lakes, nature) [town not yet included]
  - 3-layer version of ISBA (Boone et al., 2009)
  - Use of prognostic CANOPY scheme for variables in the surface boundary layer (Masson and Seity, 2009)

Evaluation of CANOPY (1)

Winter period :

01/12/2010 -> 02/01/2011

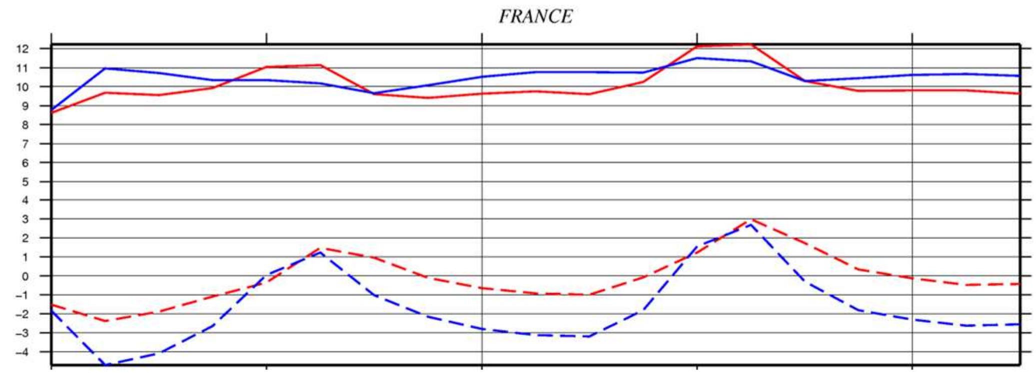
T2m



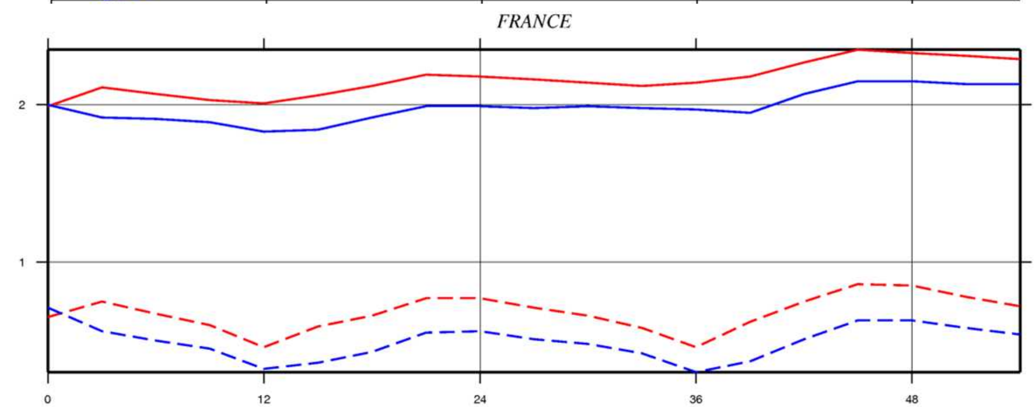
Without CANOPY

With CANOPY

RH2m



Wind speed



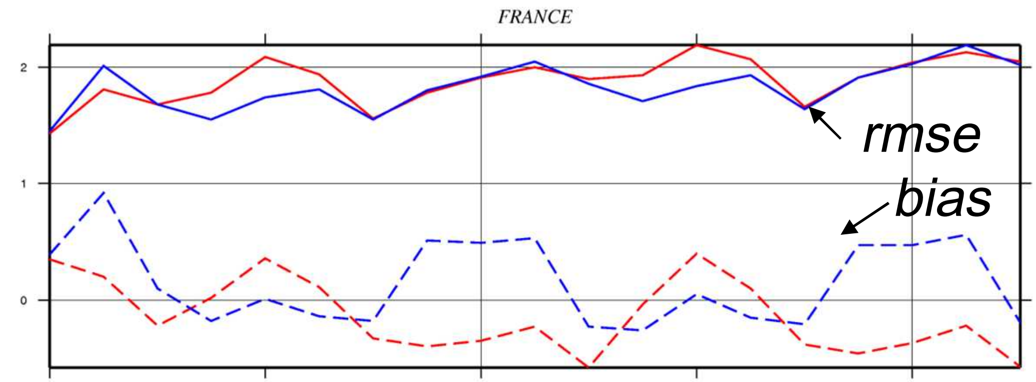
Surface observations (RADOME+SYNOP) over France

Evaluation of CANOPY (2)

Summer period :

01/08/2010 -> 02/09/2010

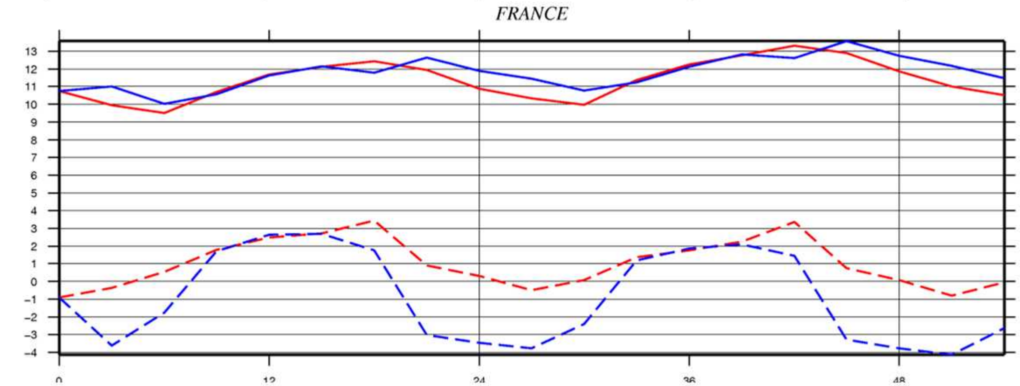
T2m



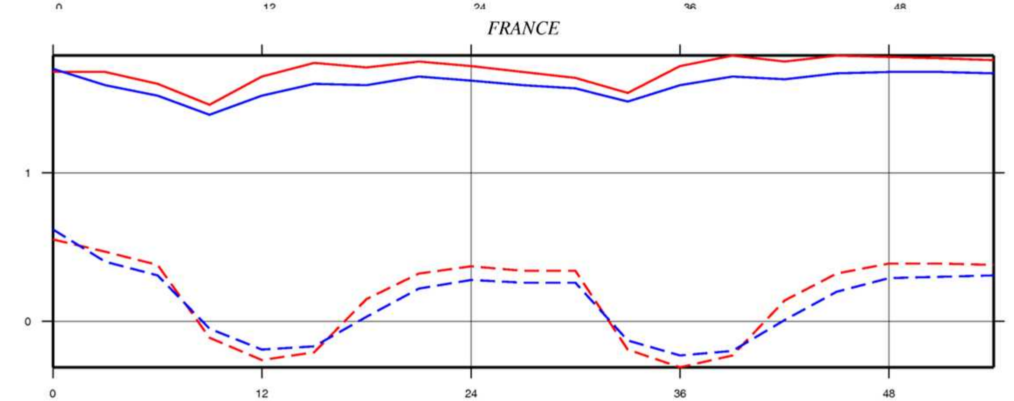
Without CANOPY

With CANOPY

RH2m



Wind speed

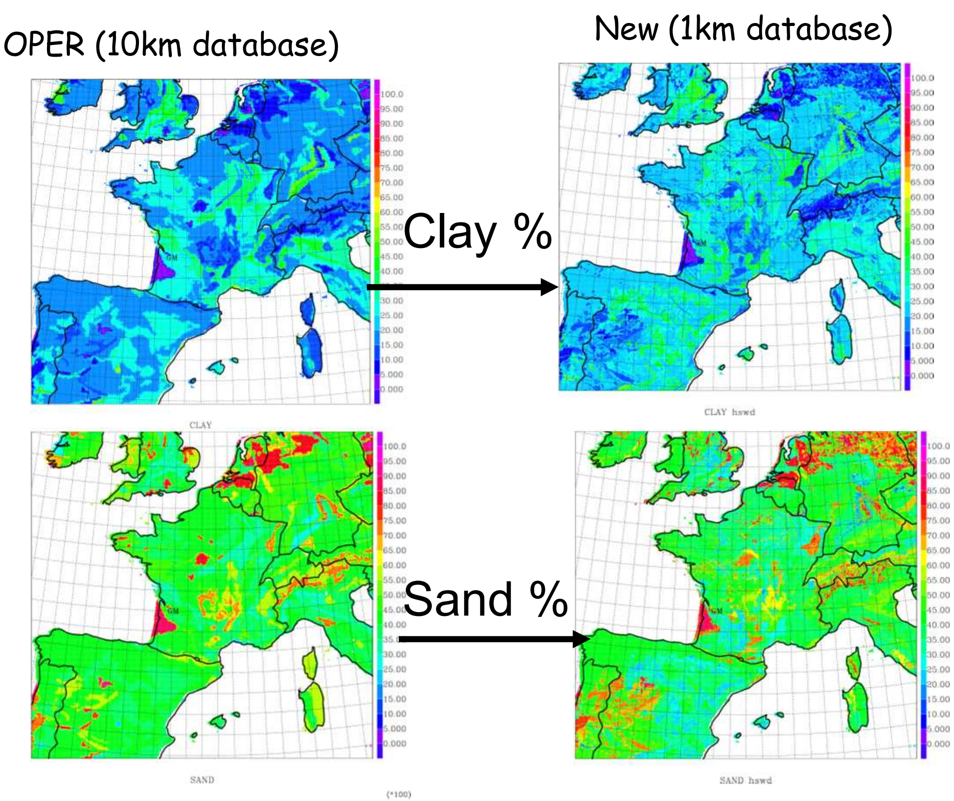


Surface observations (RADOME+SYNOP) over France

Revised surface climatologies in AROME

New soil texture climatology

- OPER : FAO 10 km resolution
- NEW : HWSD 1 km resolution



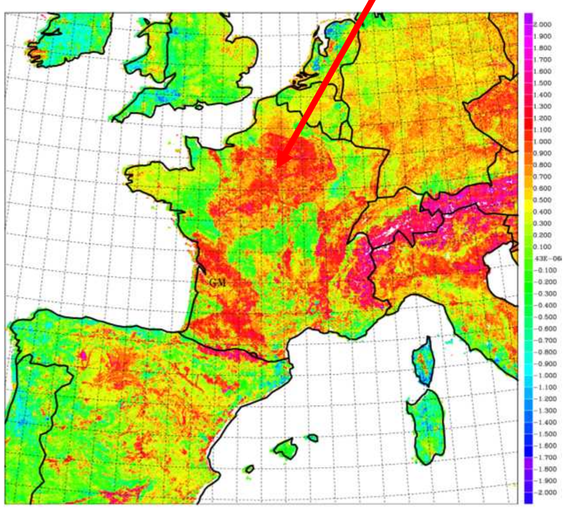
Neutral impact on forecast in dynamical adaptation (no data assimilation)

To be done : tests with data assimilation (given the long time constants of soil variables)

New ECOCLIMAP climatology (1)

Comparison between ECOCLIMAP 2 and ECOCLIMAP 1 (Masson et al., 2003) : lower fraction of C3 crops, larger fraction of grassland and bare soils.
In ECOCLIMAP 2 vegetation growth starts later in spring

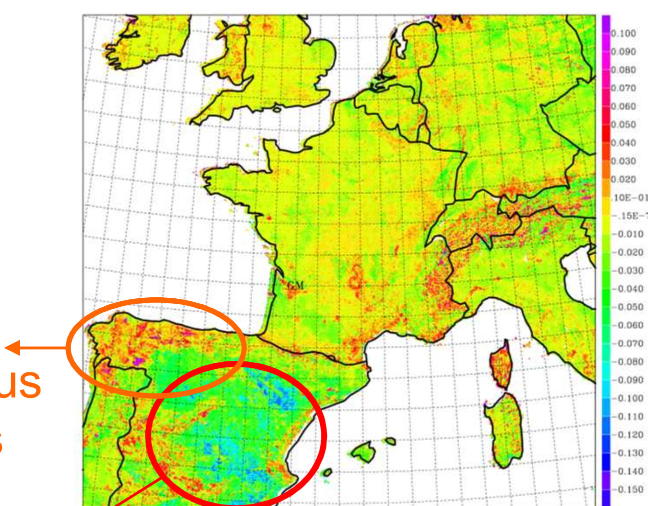
LAI in March ECO1-ECO2 :



LAI ECOCLIMAP1 – LAI ECOCLIMAP2

Impact on land surface parameters

Albedo in March ECO1-ECO2 :



ALBEDO ECOCLIMAP1 – ALBEDO ECOCLIMAP2

More coniferous forests

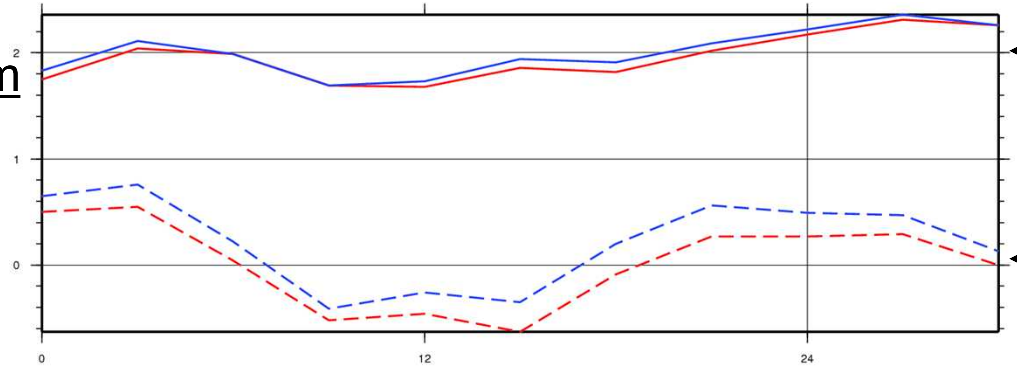
More bare soil

New ECOCLIMAP climatology (2)

Impact on AROME forecasts : ECOCLIMAP1 / ECOCLIMAP2 :

(12 days in 2007 (1 per month) no clouds over France r0+30h)

T2m

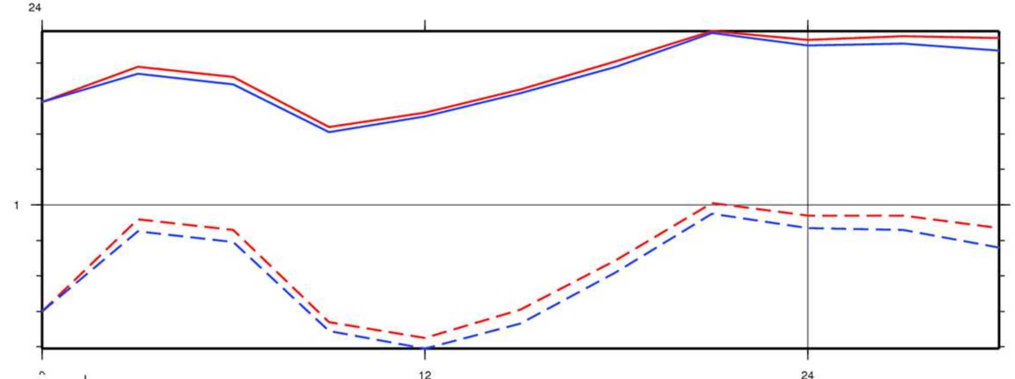


RMSE

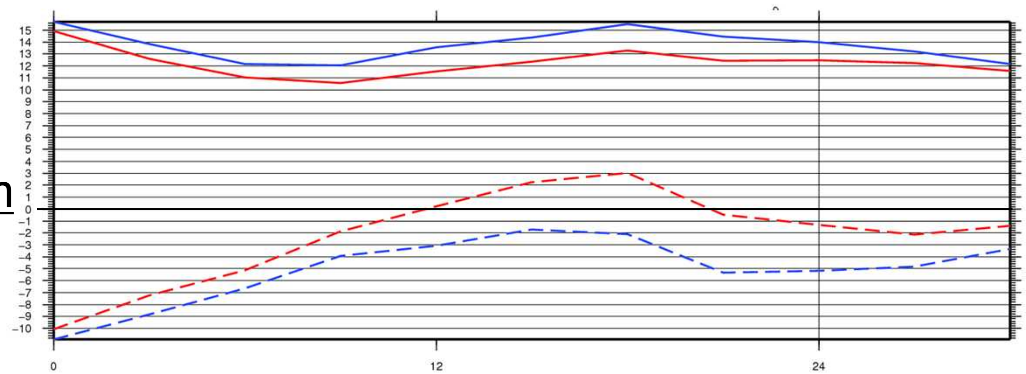
Bias

Forecast time

V10m



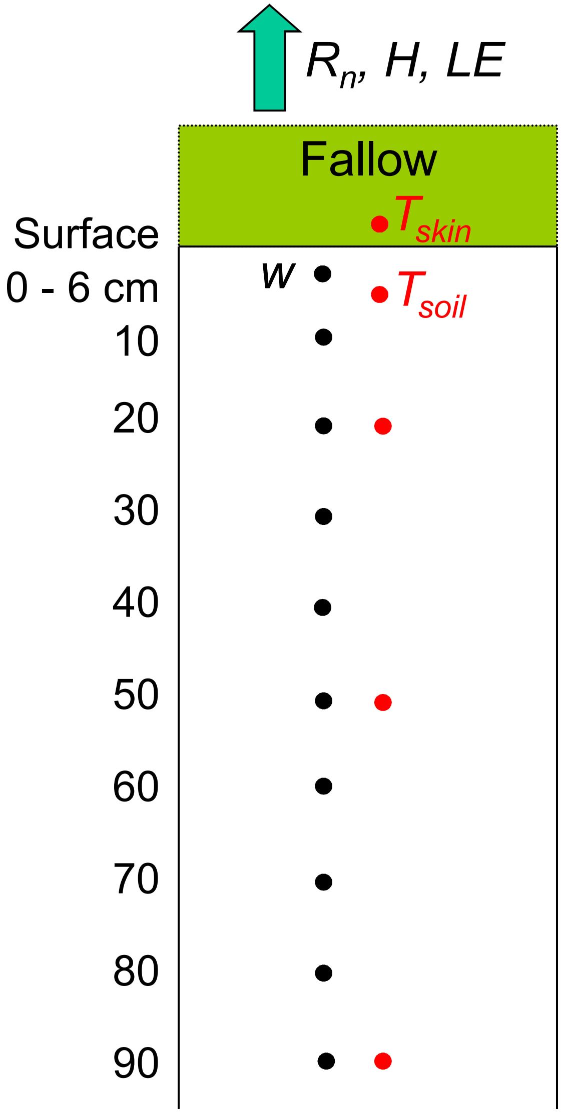
Hu2m



+ on V_{10m}, - on Hu_{2m}, +/- T_{2m}

More extended evaluation will be done (including data assimilation experiments)

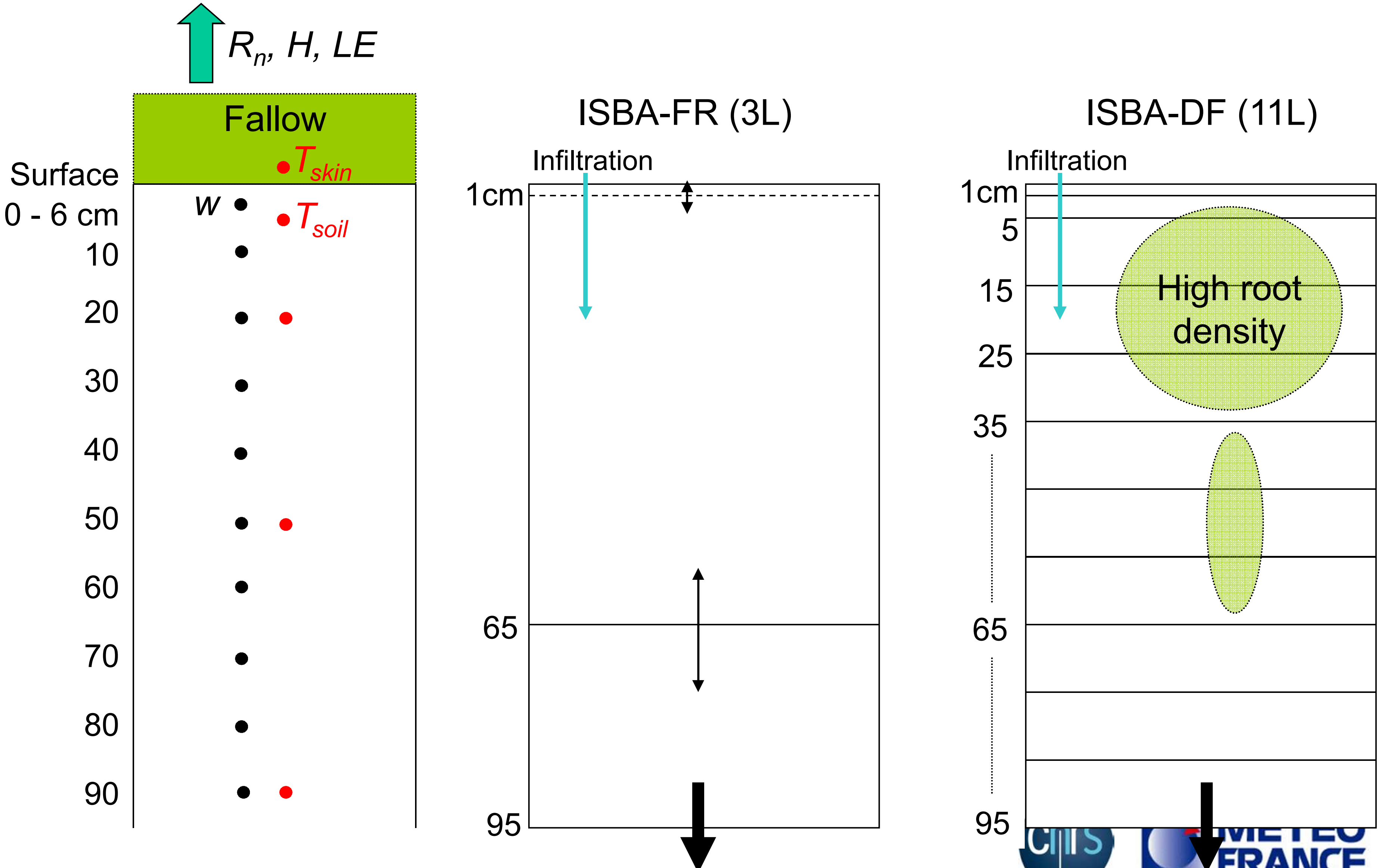
ISBA-DF evaluation at SMOSREX



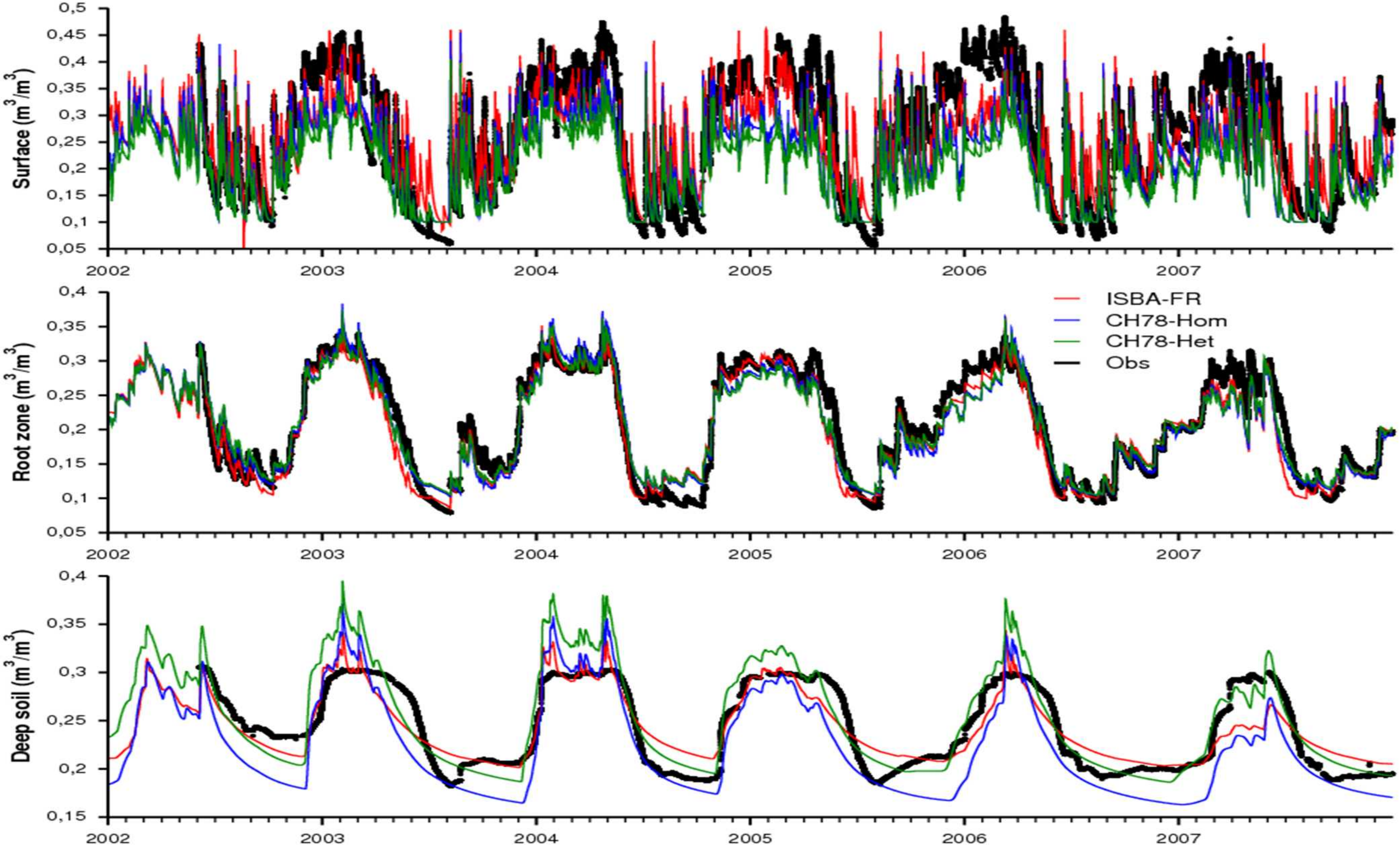
- Forcing 2001-2007, 30min
- Observed parameters:
  - Soil texture for individual layers
  - LAI
  - Root zone 65cm
- Tuned parameters:
  - $w_{fc} = 0.3$; $w_{wilt} = 0.1$
  - Veg = 1
- Evaluation using:
  - Fluxes (2005-2007)
  - Soil temperature (2002-2007)
  - Soil moisture content (2002-2007)

CNRS METEO FRANCE

Configuration

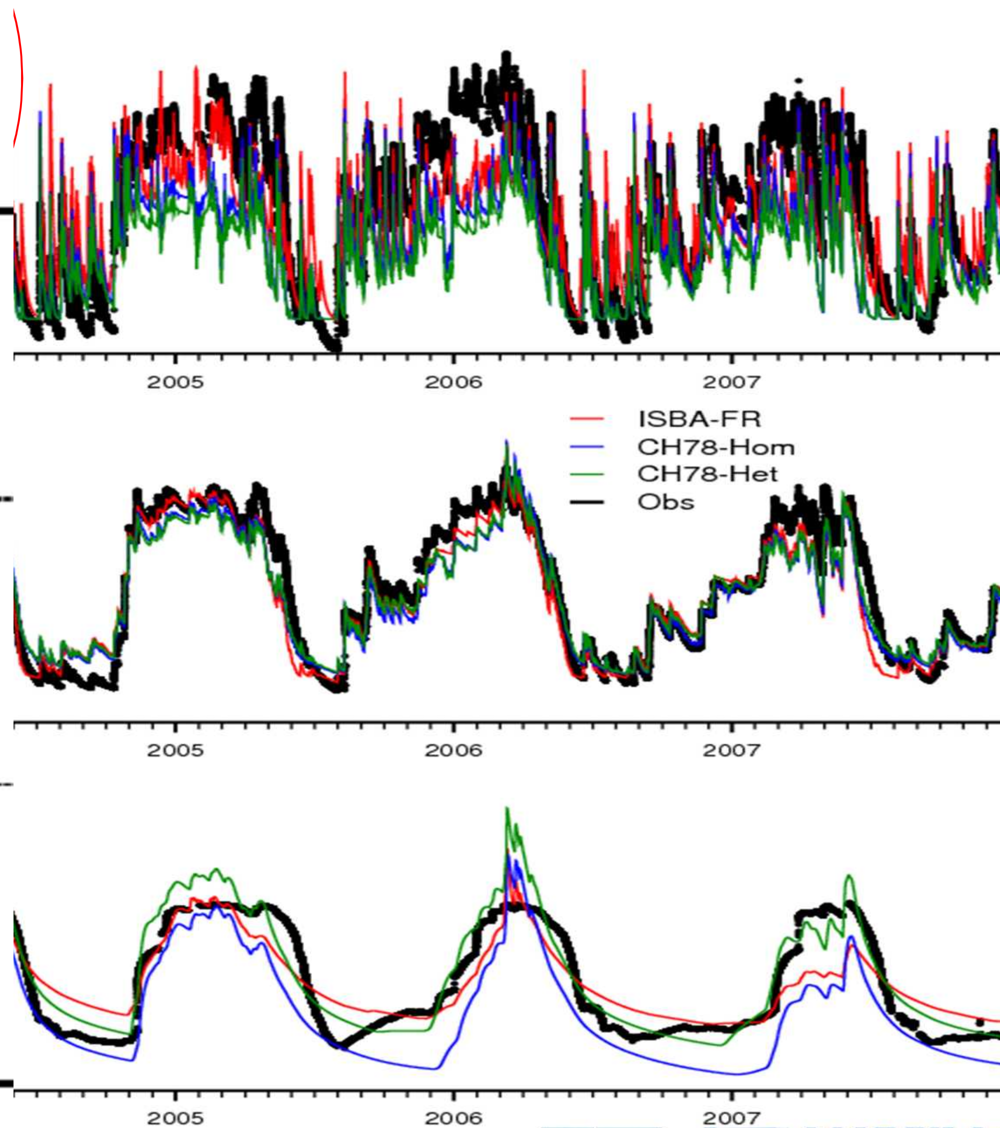


Soil moisture contents (2002-2007)

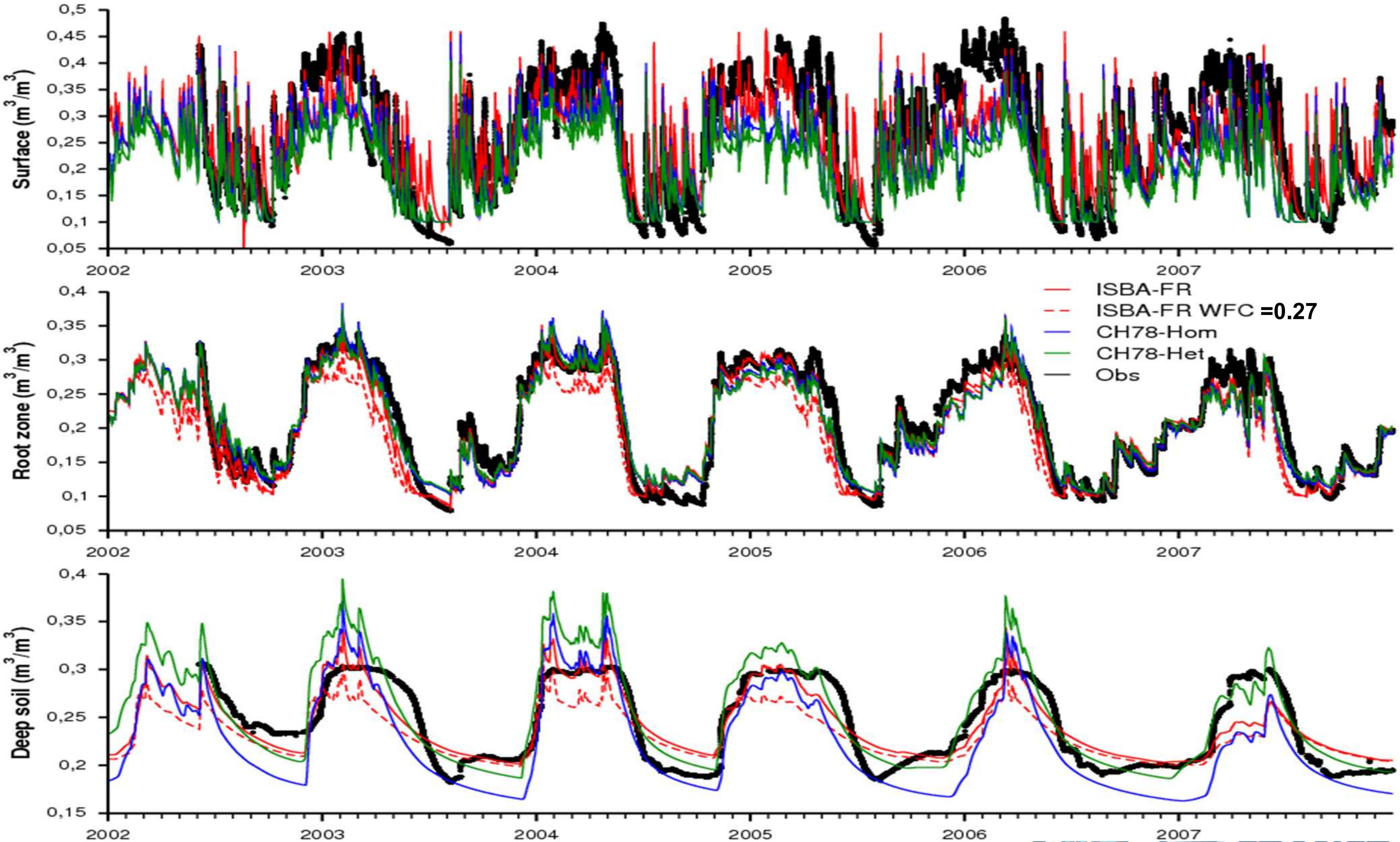


ontents (2002-2007)

Soil	Criteria	*FR*	CH78 Hom	CH78 Het
Total (92120)	Bias (10^{-2} m^3/m^3)	*-0.59*	-1.03	-0.03
	r^2	*0.91*	0.90	0.93
	RMSE (m^3/m^3)	*0.020*	0.022	0.017
	Eff	*0.90*	0.88	0.93
Surface 0-6cm (92131)	Bias (10^{-2} m^3/m^3)	*-0.89*	-4.36	-6.05
	r^2	*0.68*	0.80	0.81
	RMSE (m^3/m^3)	*0.064*	0.069	0.084
	Eff	*0.65*	0.59	0.40
Root 0-65cm (92120)	Bias (10^{-2} m^3/m^3)	*-0.85*	-0.48	-0.37
	r^2	*0.93*	0.92	0.93
	RMSE (m^3/m^3)	*0.022*	0.022	0.021
	Eff	*0.92*	0.92	0.92
Deep 65-95cm (92120)	Bias (10^{-2} m^3/m^3)	*-0.04*	-2.21	0.72
	r^2	*0.79*	0.80	0.83
	RMSE (m^3/m^3)	*0.020*	0.032	0.024
	Eff	*0.78*	0.44	0.70

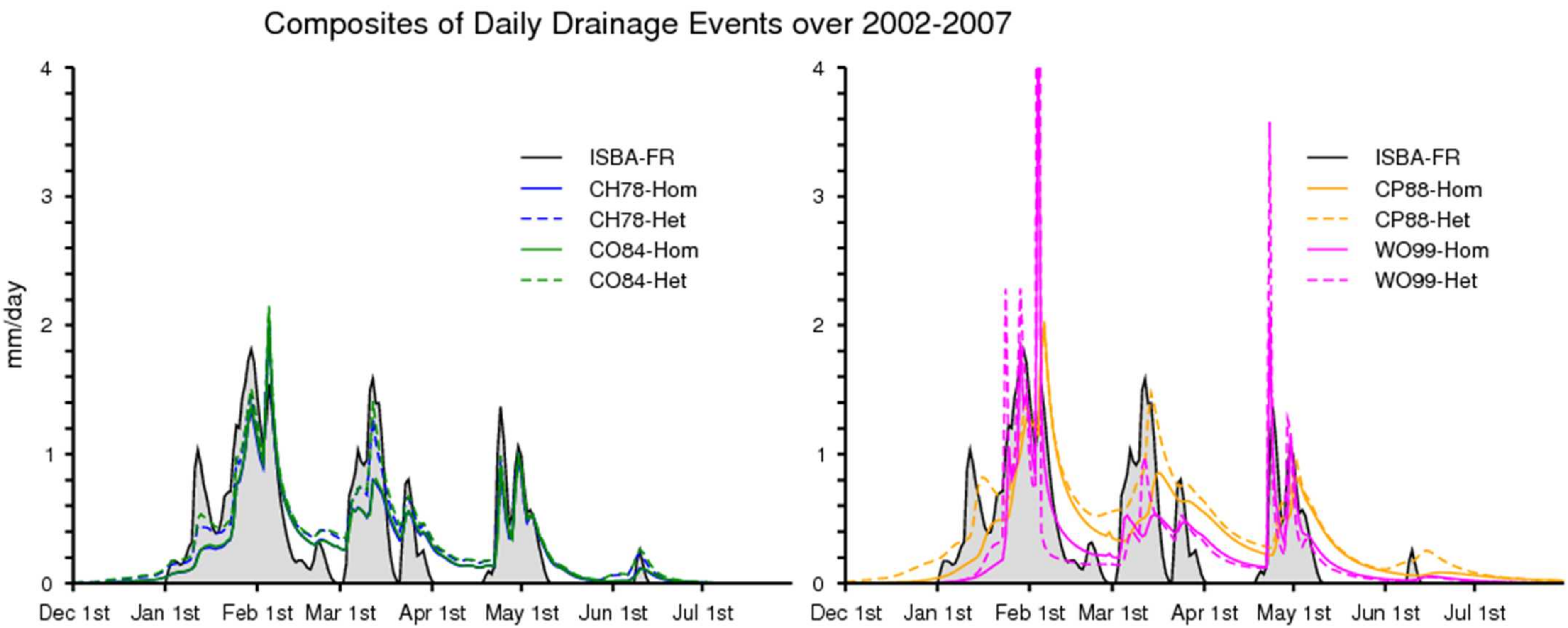


Soil moisture contents (2002-2007)



FRANCE

Drainage (Composites 2002-2007)

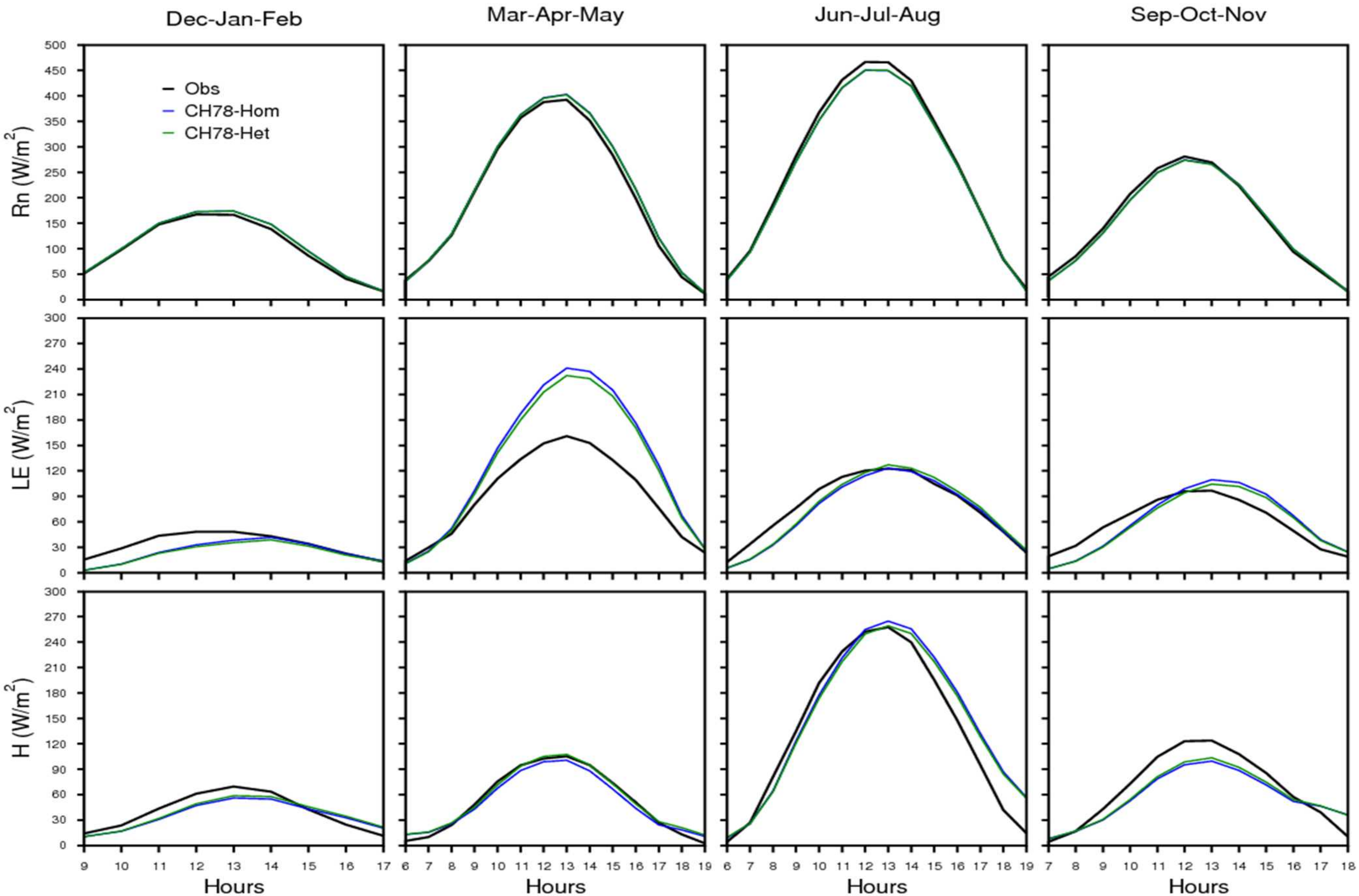


Relations conductivity- water potential vs . soil moisture : Brook and Corey (1966)

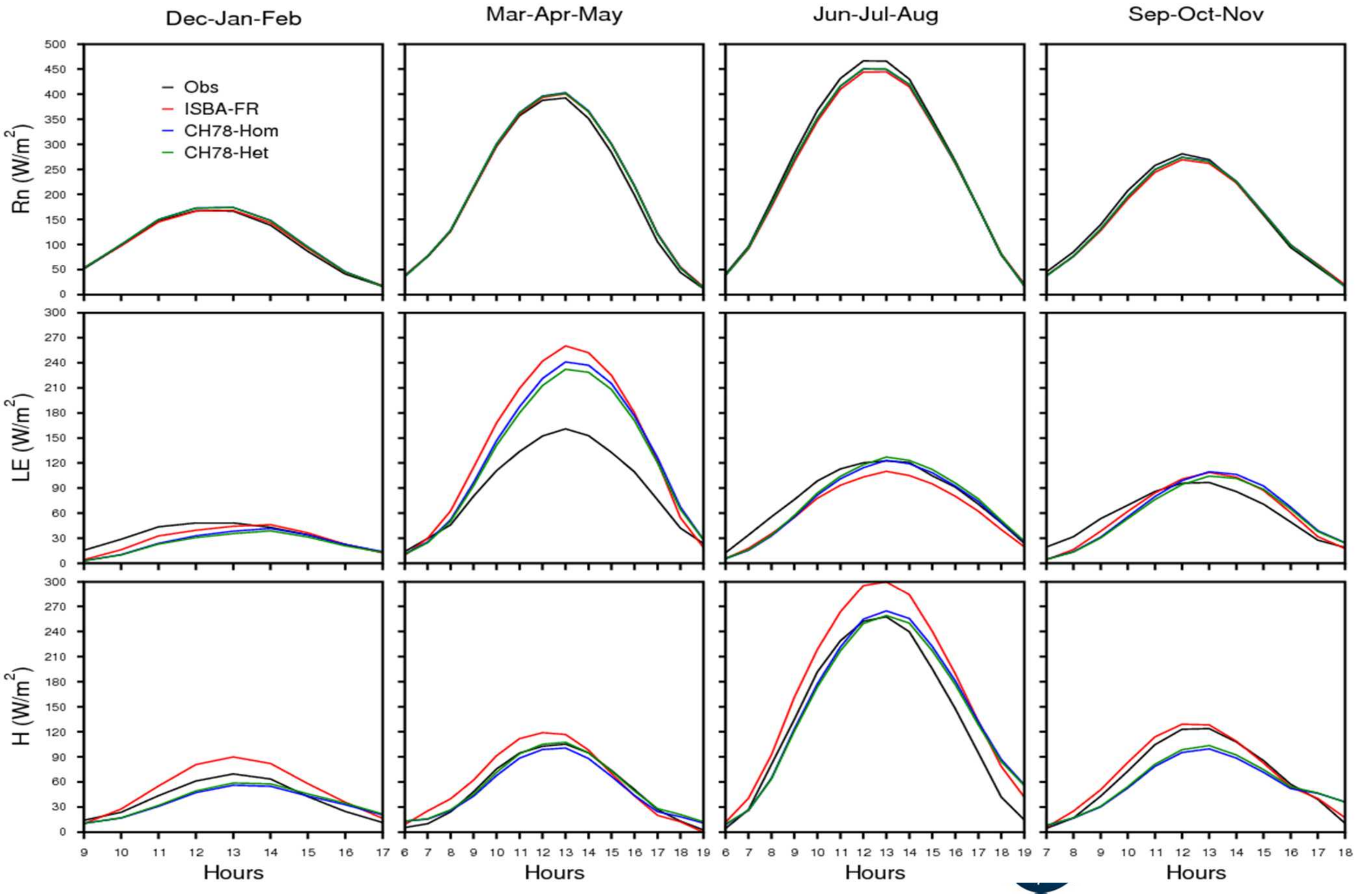
Relations conductivity- water potential vs . soil moisture: Van Genuchten (1980)

Surface fluxes

(mean diurnal cycle averaged seasonally 2005-2007)

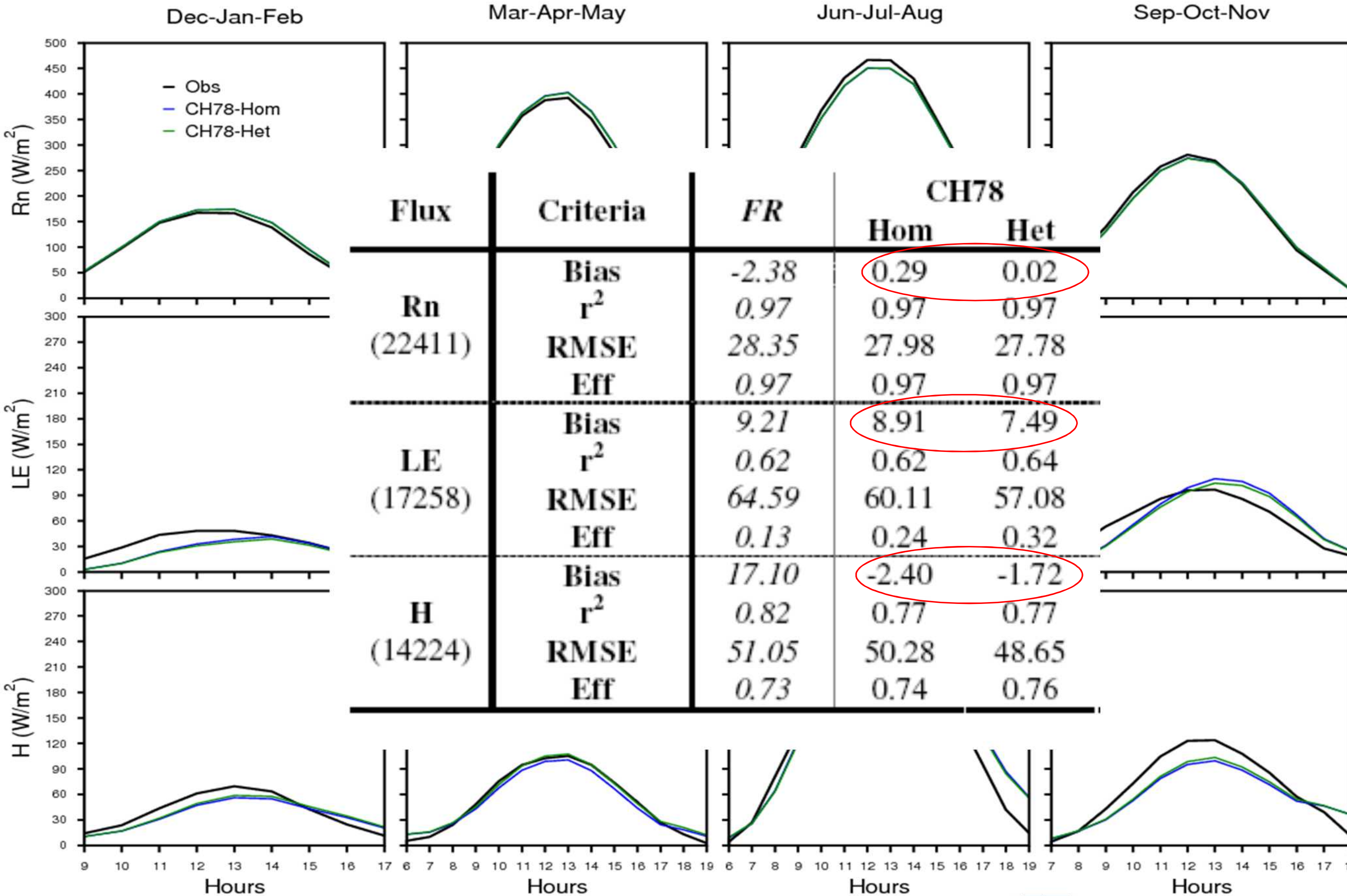


Surface fluxes (2005-2007)



Surface fluxes

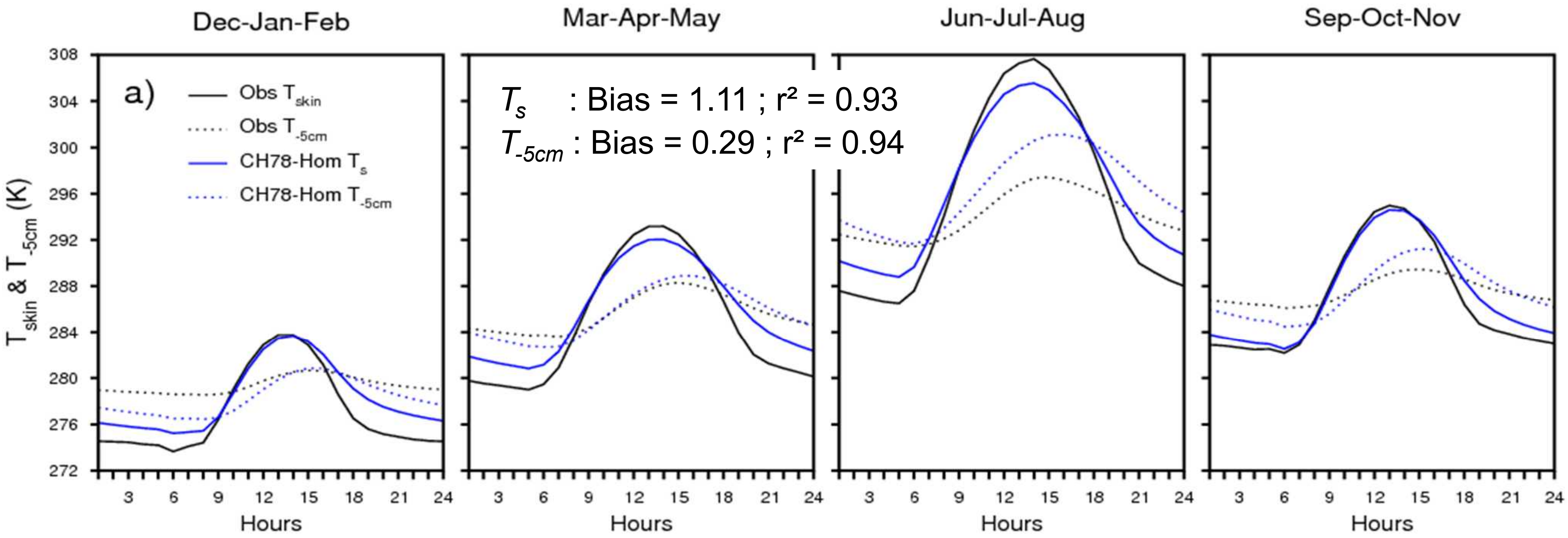
(mean diurnal cycle averaged seasonally 2005-2007)



Flux	Criteria	*FR*	CH78 Hom	CH78 Het
Rn (22411)	Bias	*-2.38*	0.29	0.02
	r^2	*0.97*	0.97	0.97
	RMSE	*28.35*	27.98	27.78
	Eff	*0.97*	0.97	0.97
LE (17258)	Bias	*9.21*	8.91	7.49
	r^2	*0.62*	0.62	0.64
	RMSE	*64.59*	60.11	57.08
	Eff	*0.13*	0.24	0.32
H (14224)	Bias	*17.10*	-2.40	-1.72
	r^2	*0.82*	0.77	0.77
	RMSE	*51.05*	50.28	48.65
	Eff	*0.73*	0.74	0.76

Soil temperatures

(mean diurnal cycle averaged seasonally 2002-2007)



- T_{skin} observation only representative of vegetation
- but T_s depends on both soil and vegetation properties

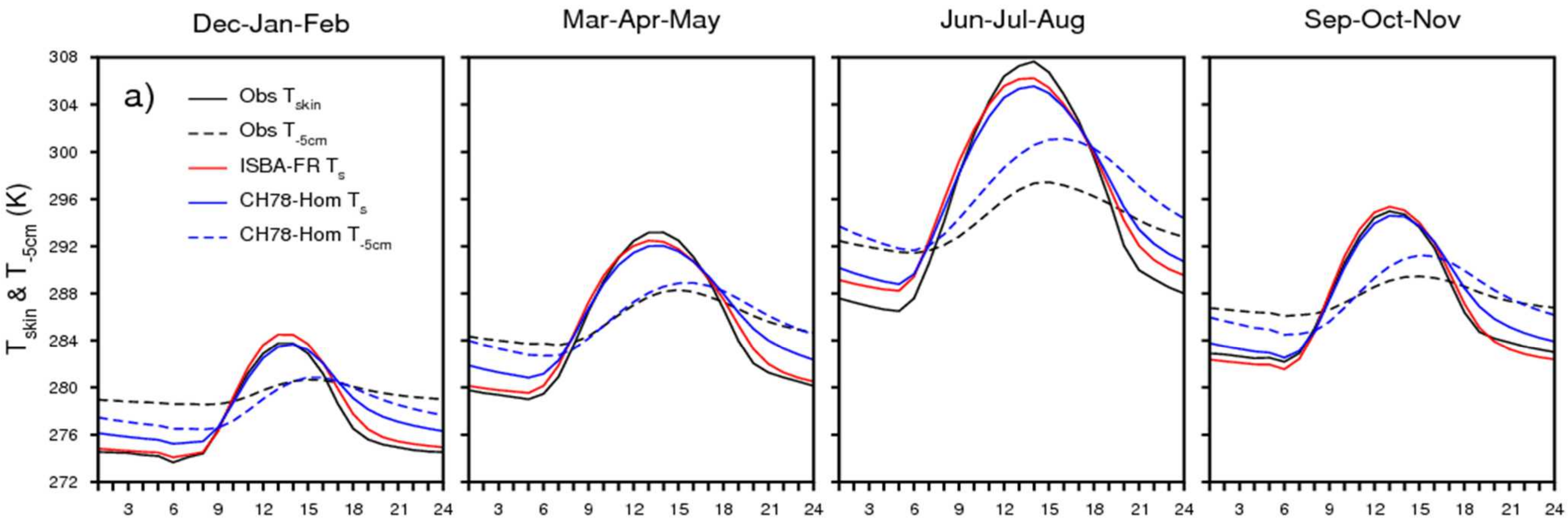
$$\frac{\partial T_s}{\partial t} = C_T \left[G - \frac{\overline{\lambda}_1}{\Delta \tilde{z}_1} (T_s - T_2) \right]$$

$$\frac{\partial T_i}{\partial t} = \frac{1}{c_{g_i}} \frac{1}{\Delta z_i} \left[\frac{\overline{\lambda}_{i-1}}{\Delta \tilde{z}_{i-1}} (T_{i-1} - T_i) - \frac{\overline{\lambda}_i}{\Delta \tilde{z}_i} (T_i - T_{i+1}) \right] \quad \forall i = 2, N$$

C_T = vegetation thermal inertia
λ_1 = soil therma conductivity
Δz_1 = distance between two first nodes

Need of MEB or « mulch »

Soil temperatures (2002-2007)



	Criteria	*FR*	CH78 Hom	CH78 Het
T_{skin} (63324)	Bias (K)	*0.56*	1.11	1.16
	r^2	*0.94*	0.93	0.94
	RMSE (K)	*2.43*	2.82	2.82
	Eff	*0.94*	0.92	0.92
T_{-5cm} (92429)	Bias (K)	/	0.29	0.33
	r^2		0.94	0.94
	RMSE (K)		2.47	2.49
	Eff		0.85	0.85

Soil temperatures

ISBA-FR

$$\begin{cases} \dfrac{\partial T_s}{\partial t} = C_T G - \dfrac{2\pi}{\tau}(T_s - T_2) \\ \dfrac{\partial T_2}{\partial t} = \dfrac{1}{\tau}(T_s - T_2) \end{cases}$$

C_T = thermal inertia of vegetation layer

λ_1 = soil thermal conductivity

Δz_1 = distance between first 2 nodes

ISBA-DF

$$\begin{cases} \dfrac{\partial T_s}{\partial t} = C_T \left[G - \dfrac{\overline{\lambda}_1}{\Delta \tilde{z}_1}(T_s - T_2) \right] \\ \dfrac{\partial T_i}{\partial t} = \dfrac{1}{c_{g_i}} \dfrac{1}{\Delta z_i} \left[\dfrac{\overline{\lambda}_{i-1}}{\Delta \tilde{z}_{i-1}}(T_{i-1} - T_i) - \dfrac{\overline{\lambda}_i}{\Delta \tilde{z}_i}(T_i - T_{i+1}) \right] \quad \forall i = 2, N \end{cases}$$

ISBA-FR only takes into account thermal properties of the vegetation layer

$\longrightarrow$ Better performance

<u>During daytime</u>, $C_T G$ is dominant even if the restore term towards T_2 is non negligible.

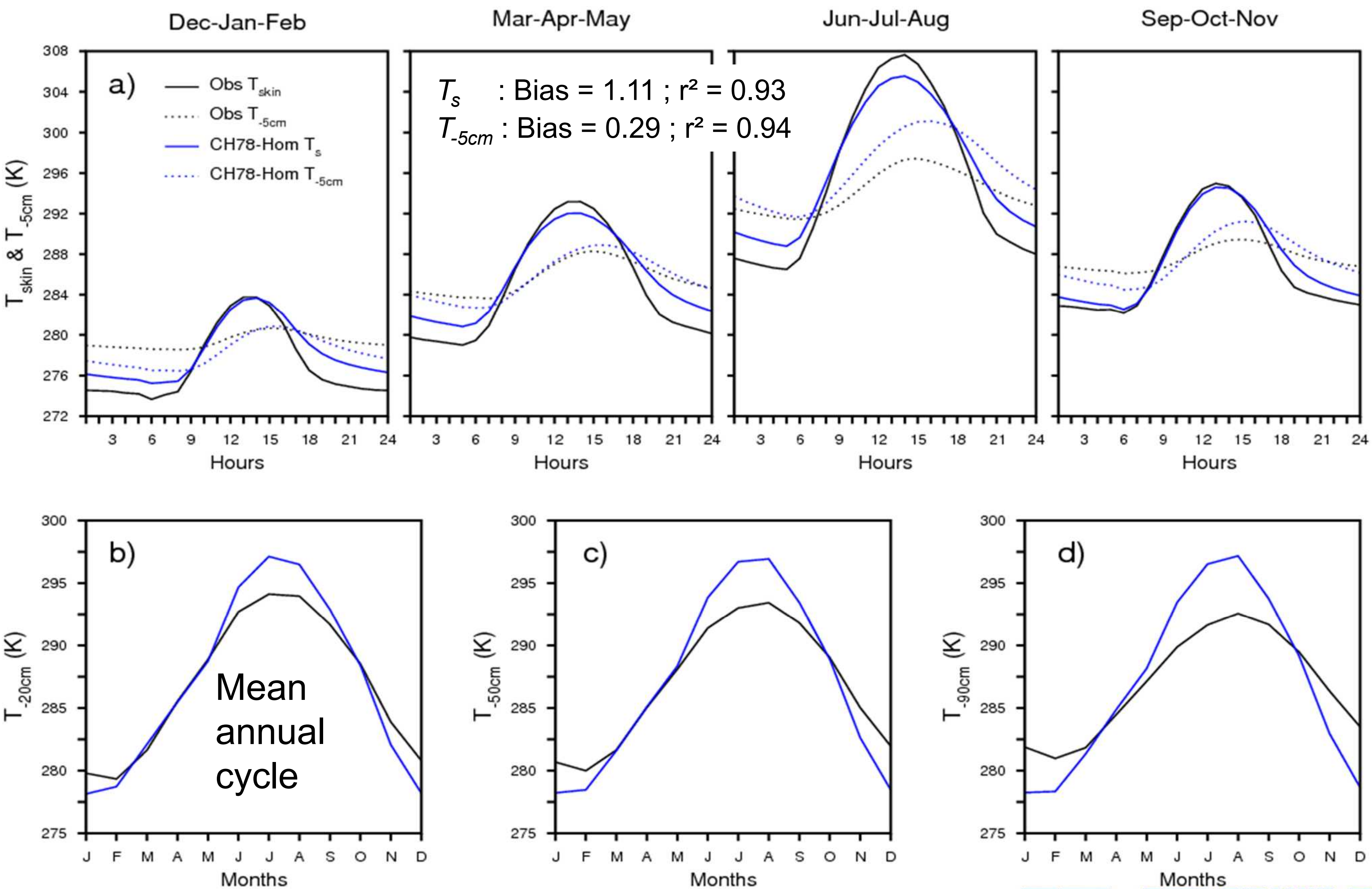
$\longrightarrow$ Small difference

<u>Durant nightime</u> restore term dominates $C_T \overline{\lambda}_1 / \Delta \tilde{z}_1 >> 2\pi / \tau$

$\longrightarrow$ Large difference

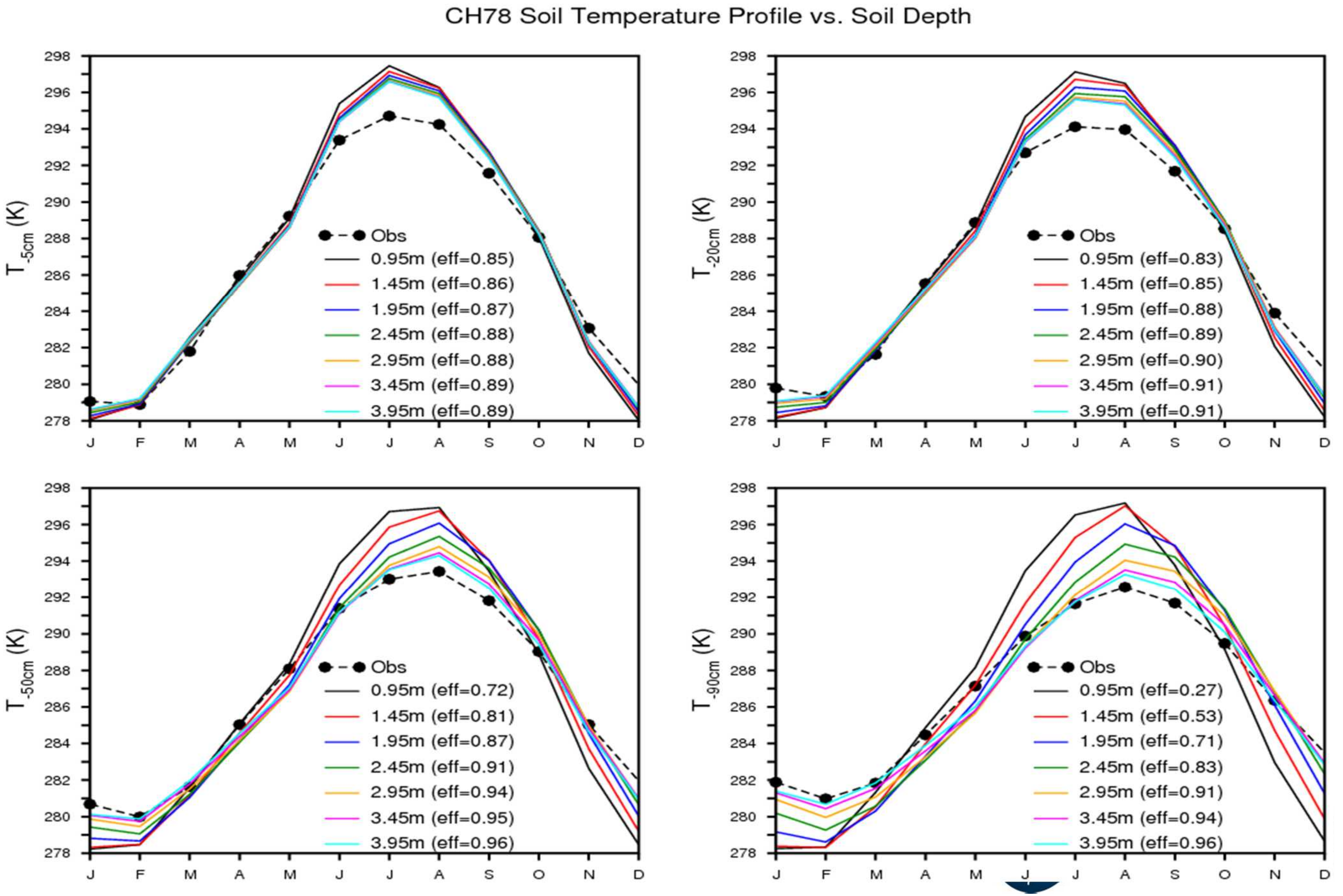
Soil temperatures

(mean diurnal cycle averaged seasonally 2002-2007)



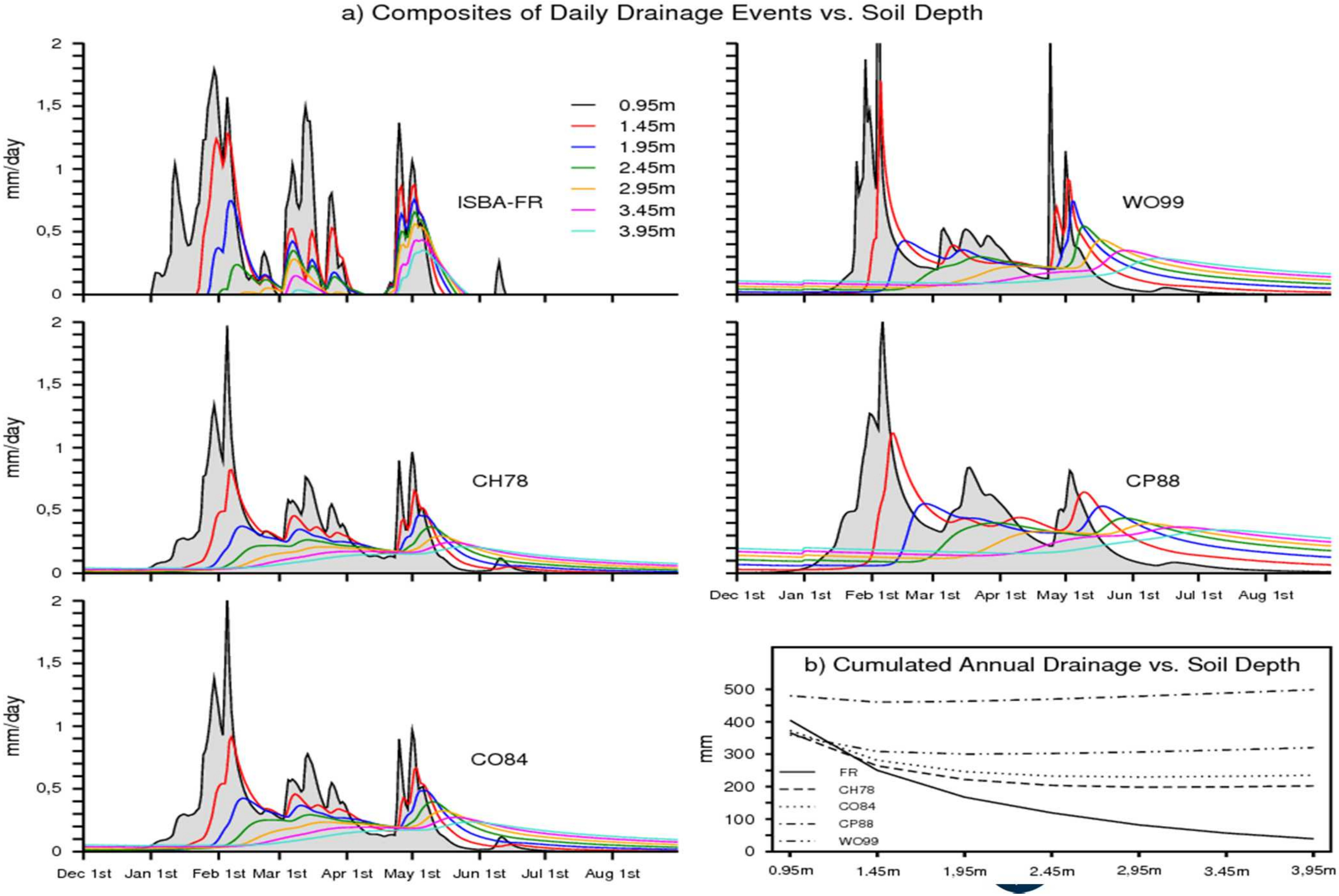
Soil temperature vs. soil depth

(2002-2007)



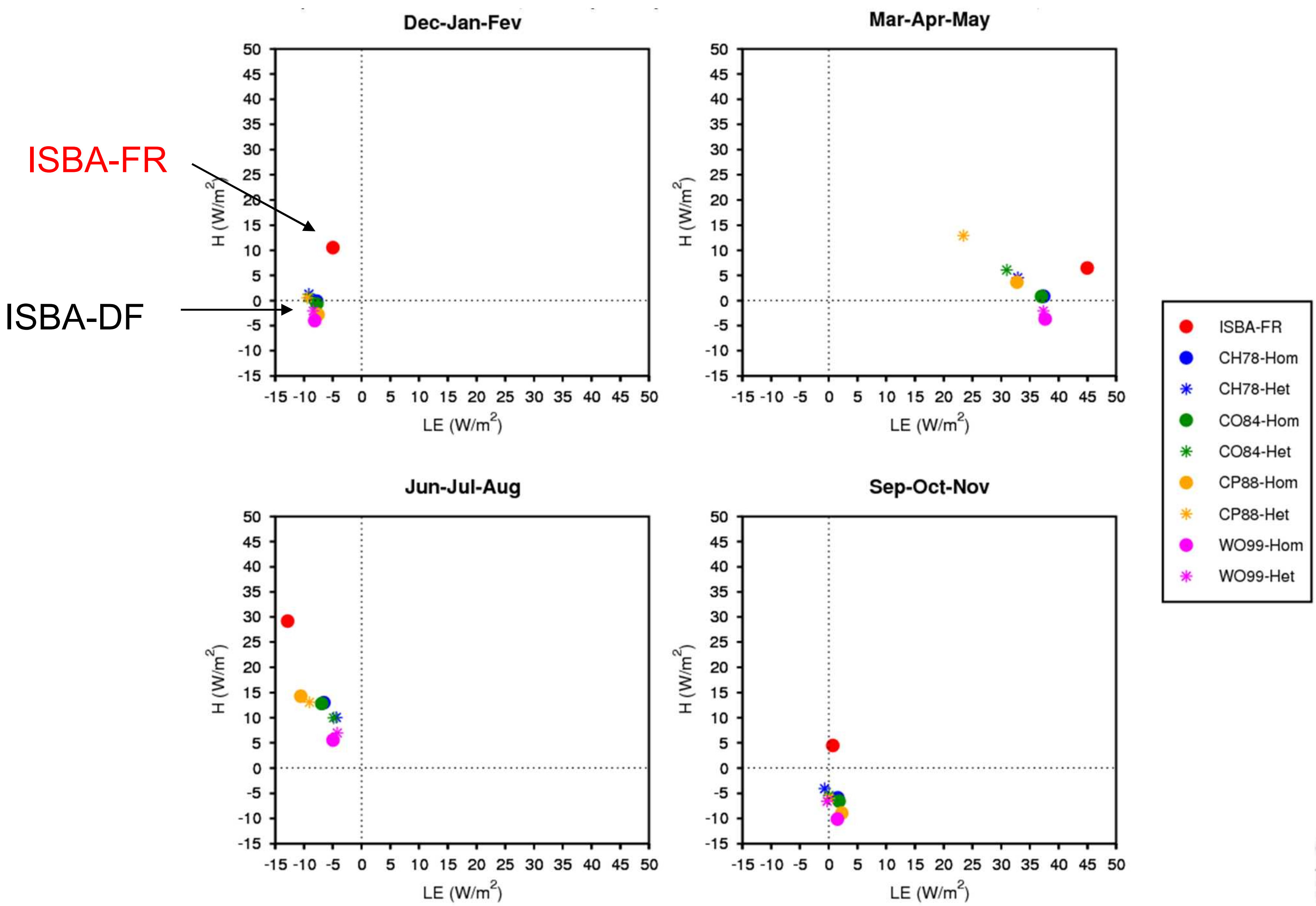
Drainage vs. soil depth

(mean diurnal cycle averaged seasonally 2002-2007)



Conclusions and perspectives

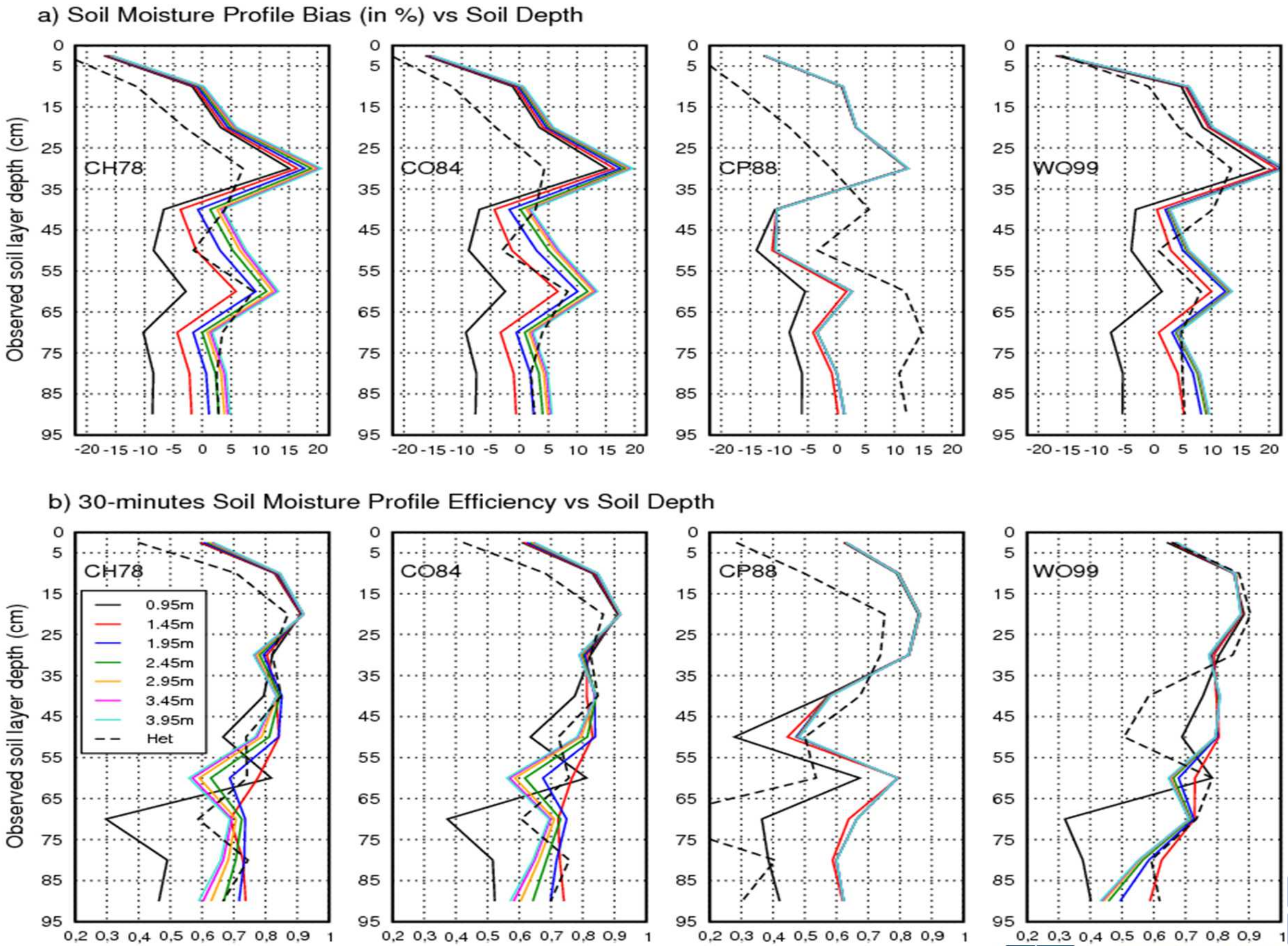
- **ISBA-DF provides realistic simulations of fluxes and soil moisture**
  - Differences with FR < uncertainties from parameter and atmospheric forcing specifications
- **Improvements needed for the description of surface temperature (MEB…** or « mulch »**)**
- **Accounting for soil texture heterogeneities can be important**
  - HWSD gives two soil horizons (0 - 0.3m and 0.3 -1m) globally and at 1km resolution
- **Sensitivity to soil depth**
  - ISBA-DF less sensitive than FR (soil moisture and fluxes); Best simulation with 1.45m depth.
  - Accurate simulation of soil temperatures within the first meter requires a very deep soil (~ 10m - 100m for permafrost)
    - Difficulty: not compatible with hydrology
    - Solution : Add temperatures below the « hydrological » soil
- **Vertical discretization (number of layers)**
  - ISBA-DF not very sensitive but …
  - First 10cm and root zone require a fine discretization (temperature and surface fluxes)
  - Avoid too coarse resolutions in the soil for :
    - Hydrology : damping of drainage response
    - Temperature : too weak thermal transfers
- **Regional evaluation with SIM (river discharges + temperatures)**



ISBA-FR
ISBA-DF
Dec-Jan-Fev
Mar-Apr-May
Jun-Jul-Aug
Sep-Oct-Nov
H (W/m2)
LE (W/m2)
ISBA-FR
CH78-Hom
CH78-Het
CO84-Hom
CO84-Het
CP88-Hom
CP88-Het
WO99-Hom
WO99-Het

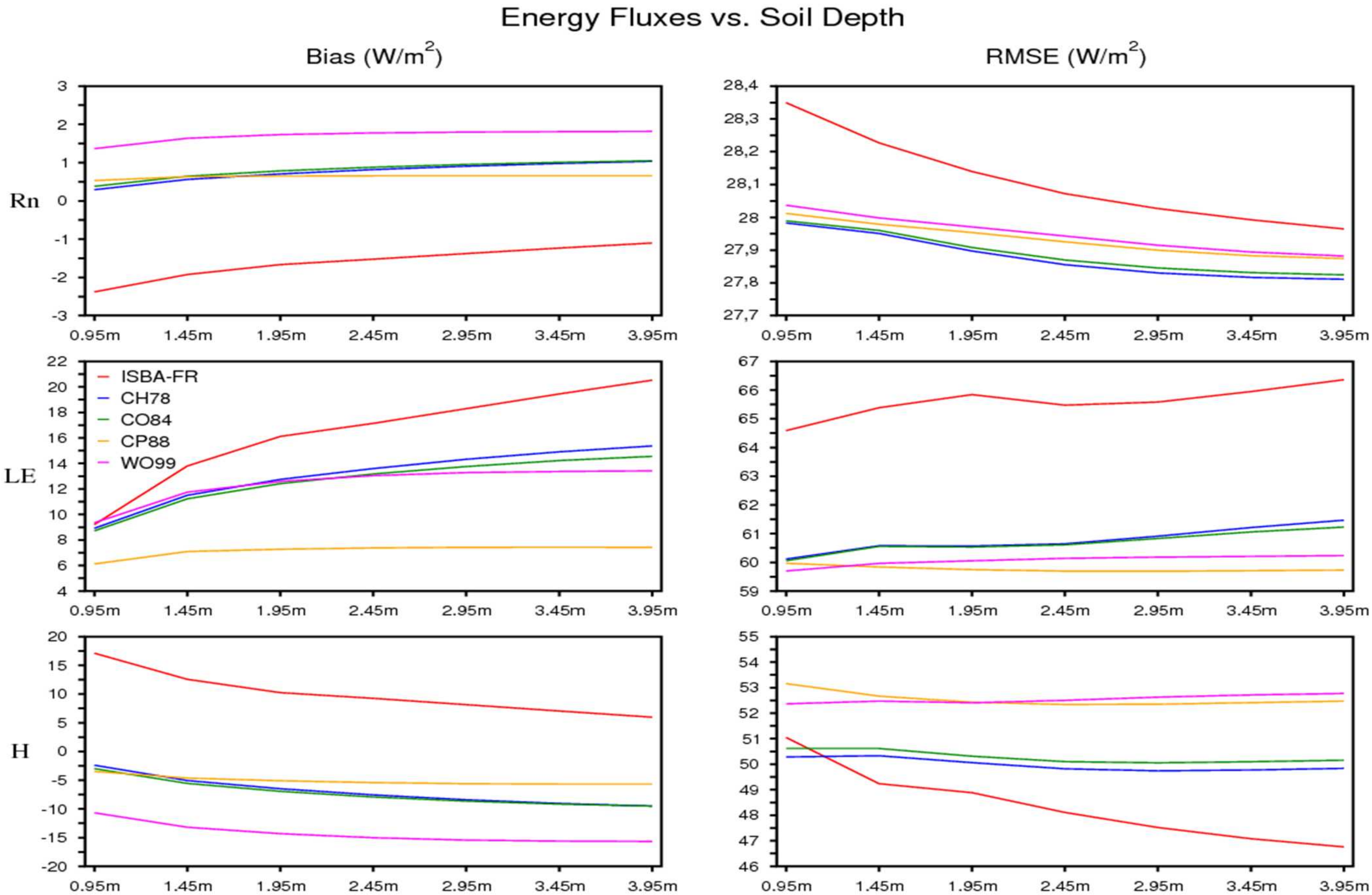
Soil moisture vs. soil depth

(2002-2007)



Fluxes vs. soil depth

(2005-2007)



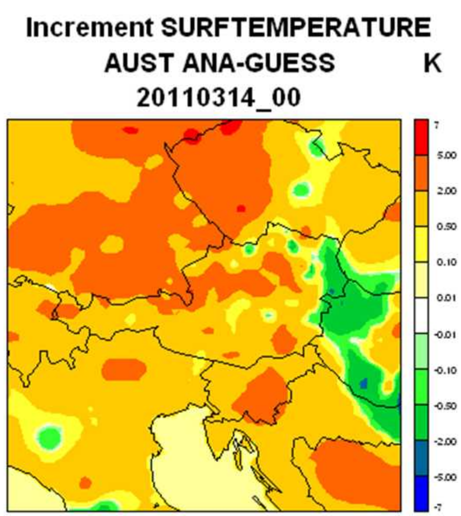
Developments on surface aspects within LACE

- *Hungary* : Evaluation of the « SURFEX version » of the OI soil analysis within ALADIN
- *Slovenia* : Analysis of Land SAF albedo within ALADIN (paper submitted to JAMC)
- *Austria* : Revisit of screen-level OI analysis (CANARI) background errors for ALARO (5 km) – Assimilation of ASCAT soil moisture in ALADIN using a SEKF

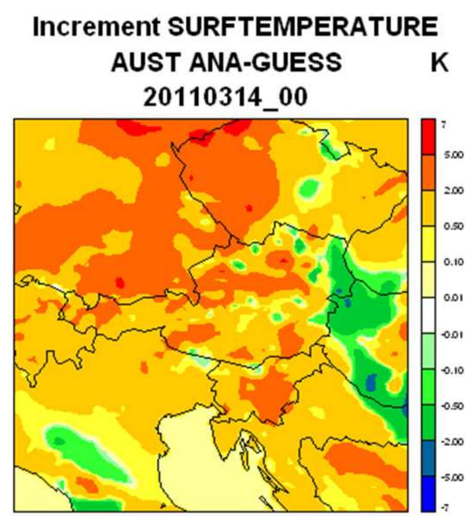
Modification of CANARI background error statistics

CANARI increments are quite smooth especially in Alpine areas and even in ALARO5 -> reduction of background horizontal correlation length and introduction of vertical correlation function

$$\mu(r,p) = e^{\left(-0.5*\sqrt{\frac{r_{ij}^2}{d^2}}\right)} * e^{\left(-0.5*\ln\left(\frac{p_i}{p_j}\right)*\frac{1}{P_c}\right)}$$



Ts standard CANARI



Ts CANARI +vert. corr.

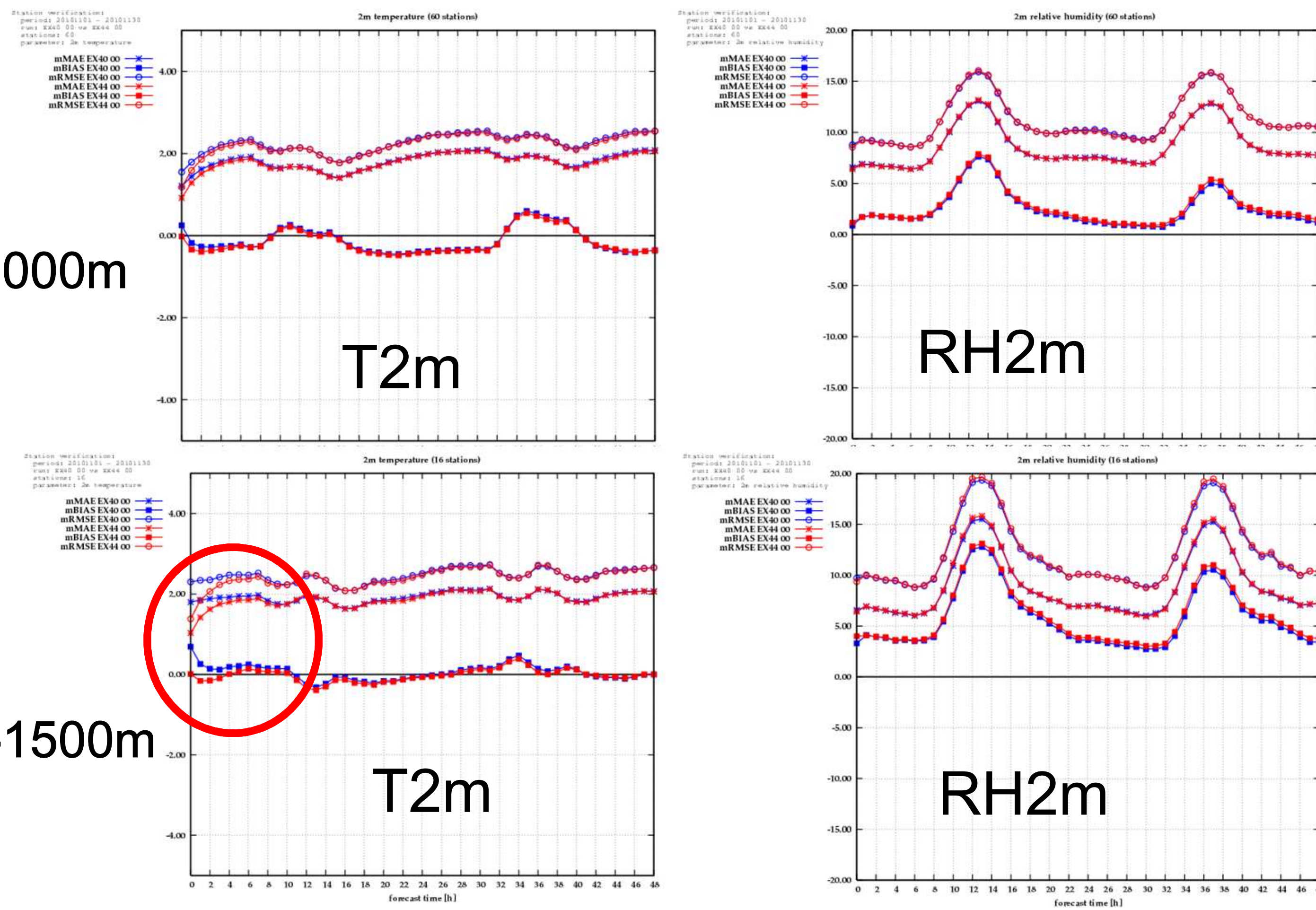
REF
d=60km
P_c=0.0

EXP
d=45km
P_c=0.05

Impact on forecast scores

500-1000m

1000-1500m



vert. corr.

reference

FP7 EURO4M Project

- 4-Year EU funded project (started in April 2010)
- Develop assimilation tools (atmosphere and surface) and collect observational data sets for regional reanalyses over Europe
- *Météo-France and SHMI* : evaluation and improvement of surface analysis systems (CANARI, SAFRAN, MESAN) at fine scale (5 km) - variables of interest : T2m, RH2m, precipitation, Tmin, Tmax, V10m, radiative fluxes

Land surface assimilation

- *Météo-France* :
  - Operational OI soil analysis for AROME since December 2010
  - SEKF assimilation of ASCAT soil moisture within the hydrometeorological SIM (impact on river discharges) – H-SAF visiting scientist (C. Draper)
  - SEKF assimilation of ASCAT SM and CYCLOPES LAI in ISBA-Ags – FP7 GEOLAND2 (A. Barbu)
- *ZAMG* :
  - SEKF assimilation of ASCAT soil moisture within ALADIN
- *NILU* :
  - Development of an EnKF within SURFEX (assimilation of AMSR-soil moisture)