The new multi-energy-balance (MEB) ISBA option in SURFEXv8

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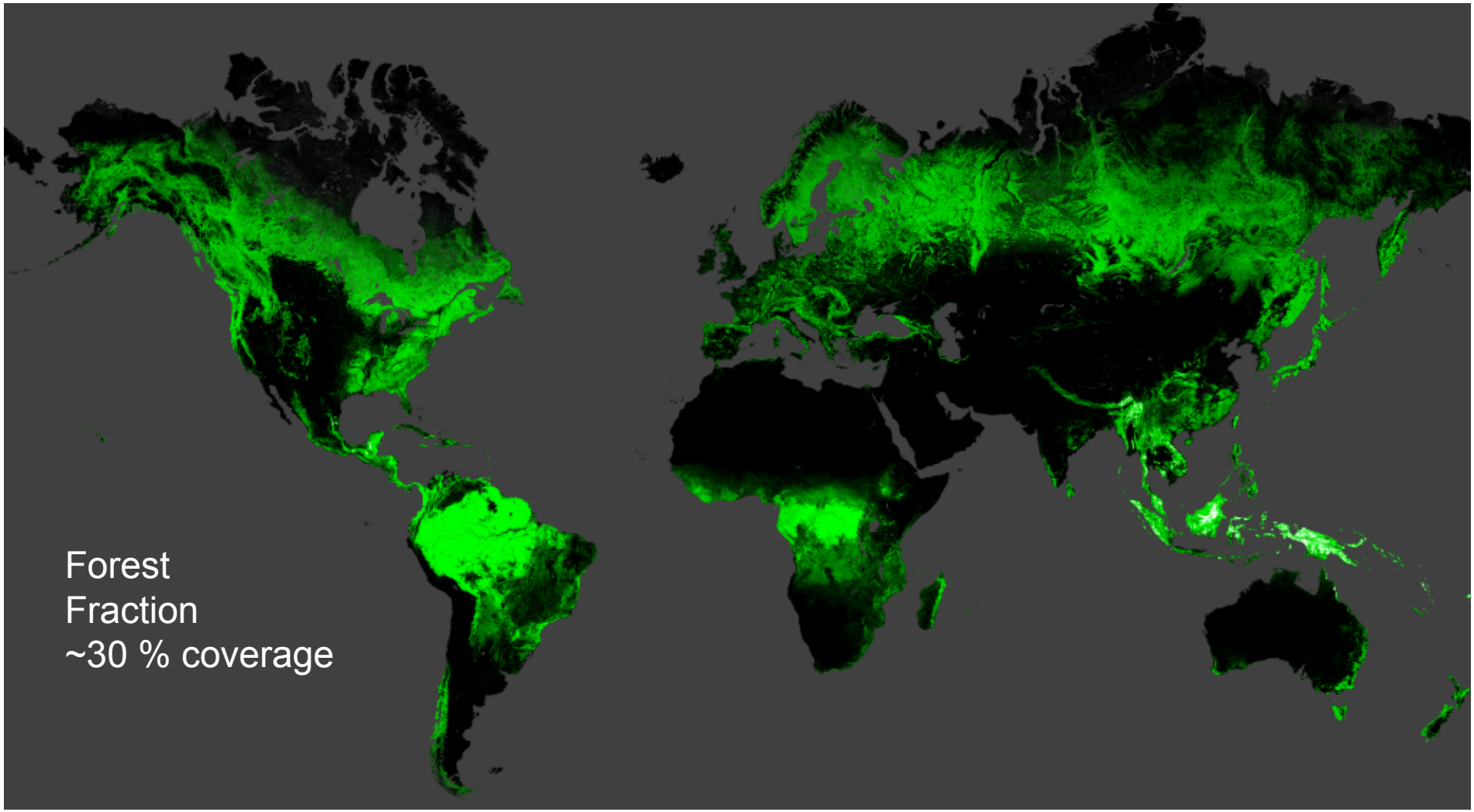
3 CESBIO, Toulouse

1st SURFEX Workshop, Feb. 2017, Toulouse

Introduction : Why develop MEB ?

GMME



Introduction : Why develop MEB ?

GMME

- Distinguish the soil, snow and vegetation surface temperatures since they can have very different amplitudes and phases in terms of the diurnal cycle.

- Simulate the snowpack beneath forests in a robust and a physically consistent manner and snow-canopy processes explicitly

- Accurately modeling canopy radiative transfer, within or below canopy turbulent fluxes and soil heat fluxes

- More conceptually consistent photosynthesis and Carbon allocation model

Introduction : Additions compared to RCA (original SMHI scheme) :

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- Snow fraction can gradually bury the vegetation vertically - transitioning the turbulence coupling from the canopy air space directly to the atmosphere (fully implicit numerical scheme)

- A slightly more detailed treatment of canopy snow interception and unloading processes and a coupling with the ISBA physically-based multi-layer snow scheme

- More detailed radiative transfer (SW & LW) : Fully implicit Jacobean matrix for the LW fluxes from multiple surfaces

- Polcher-Best coupling methodology: All of the energy budgets are numerically implicitly coupled with each other and the atmosphere (turbulence)

- Explicit forest litter layer model (which also acts as the below-canopy surface energy budget when litter covers the soil)

Introduction : Basic difference with composite ISBA

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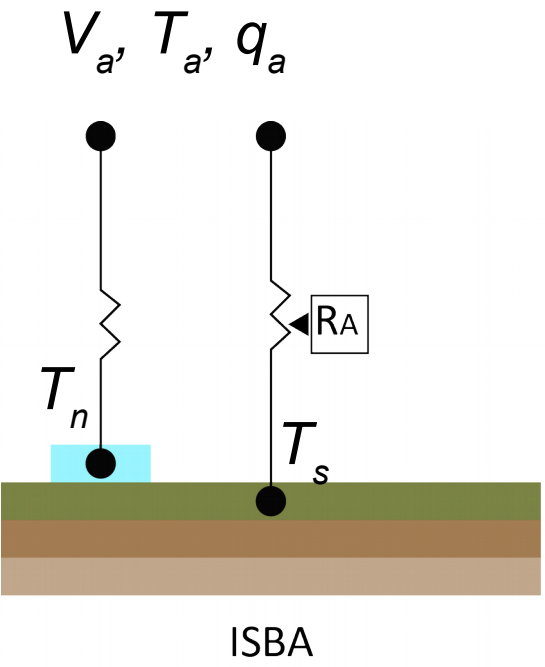
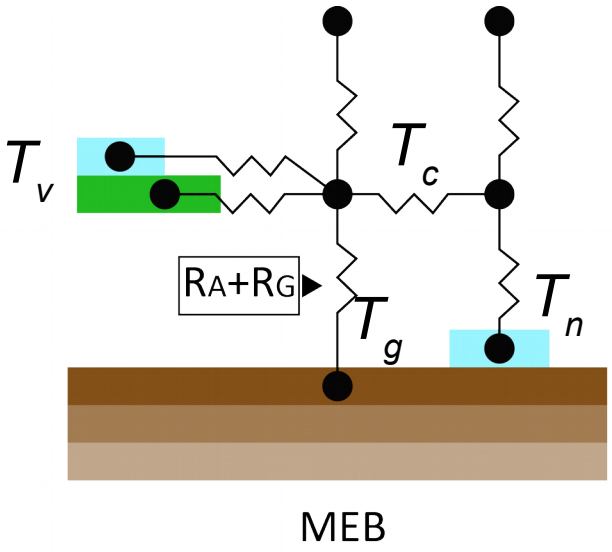
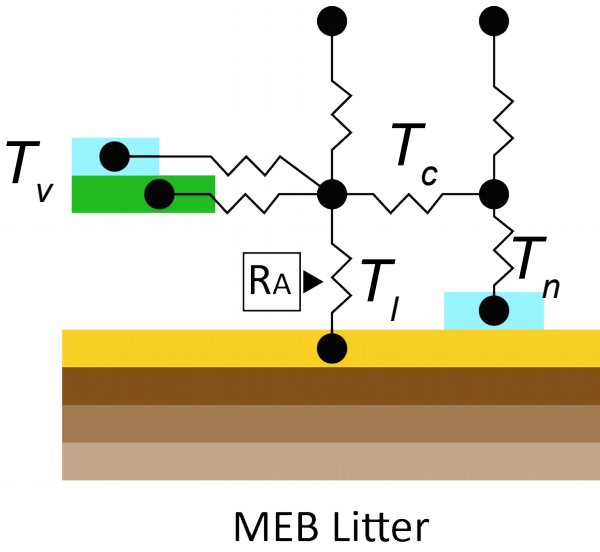
ISBA with DIF (soil) and ES (snow) options :



ISBA



MEB



MEB Litter

Introduction : New (vertical) snow fraction notion and coupling

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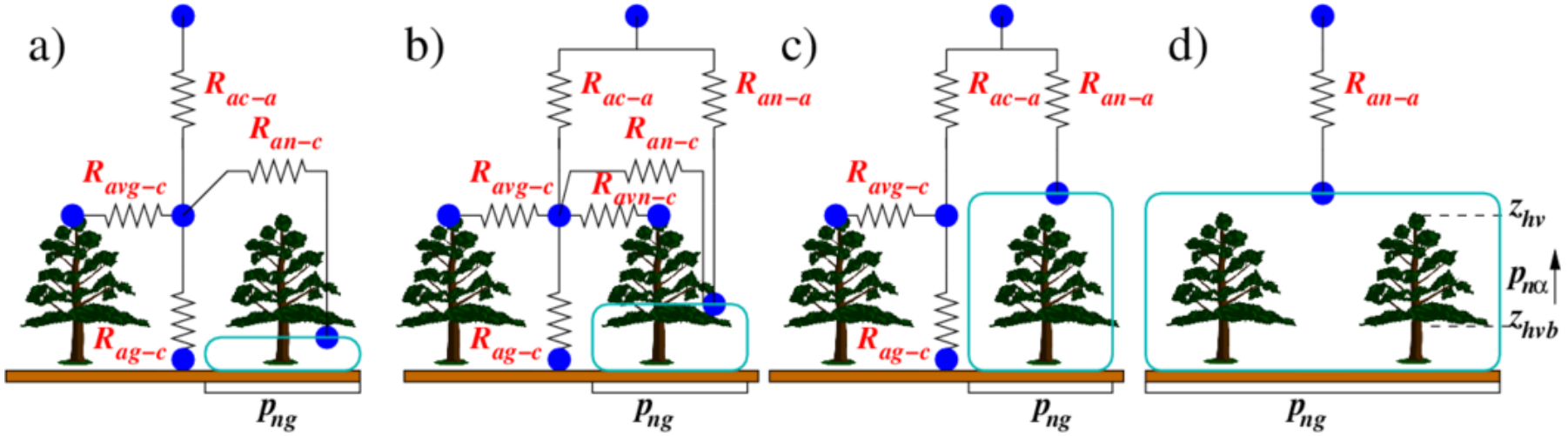

Gradual burying of the vegetation...collapse to snow-air-only coupling (maximum of 6 resistances to 1)

Boone, A., S. Samuelsson, S. Golvik, A. Napoly, L. Jarlan, E. Brun, and B. Decharme, 2017: The Interactions between Soil-Biosphere-Atmosphere (ISBA) land surface model with a multi-energy balance (MEB) option in SURFEXv8 - Part 1: Model description. Geoscientific Model Development, 10, 1-30. doi:10.5194/gmd-10-1-2017

Evaluation : Detailed local scale

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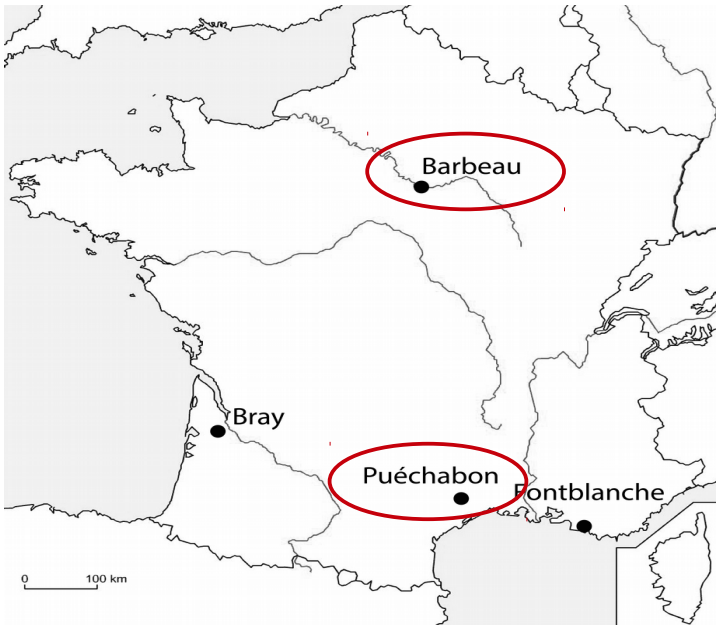
Local scale evaluation (Napoly et al, 2017)

4 French sites (part of FluxNet)

- Multiple annuel cycles
- Contrasting sites/climates

Ecologie Systématique et Evolution

Prévost-Bouré et al. 2009



CEFE/CNRS

Grote et al. 2009

Evaluation : Detailed local scale

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Local scale evaluation

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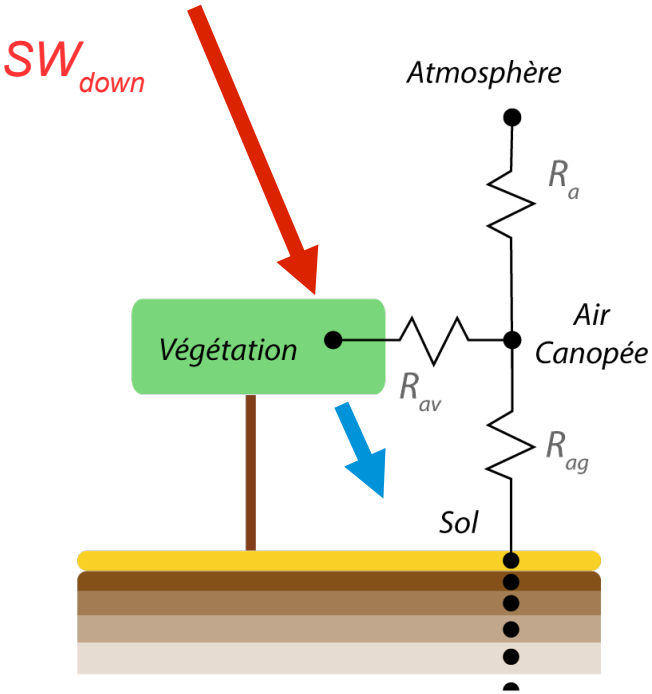
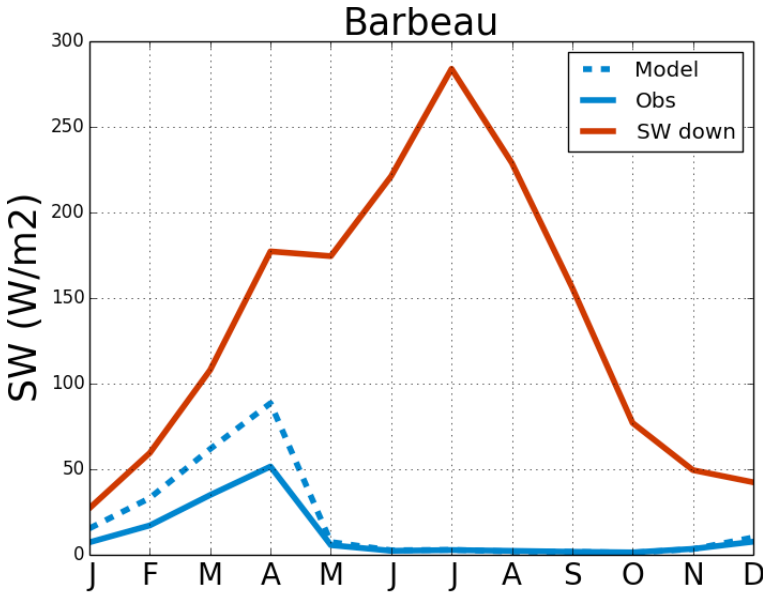
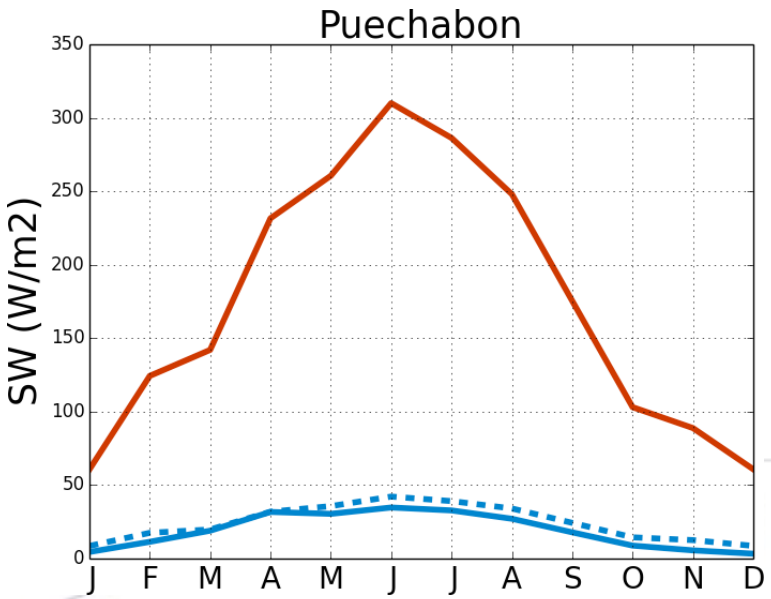
Carrer et al., (2013)





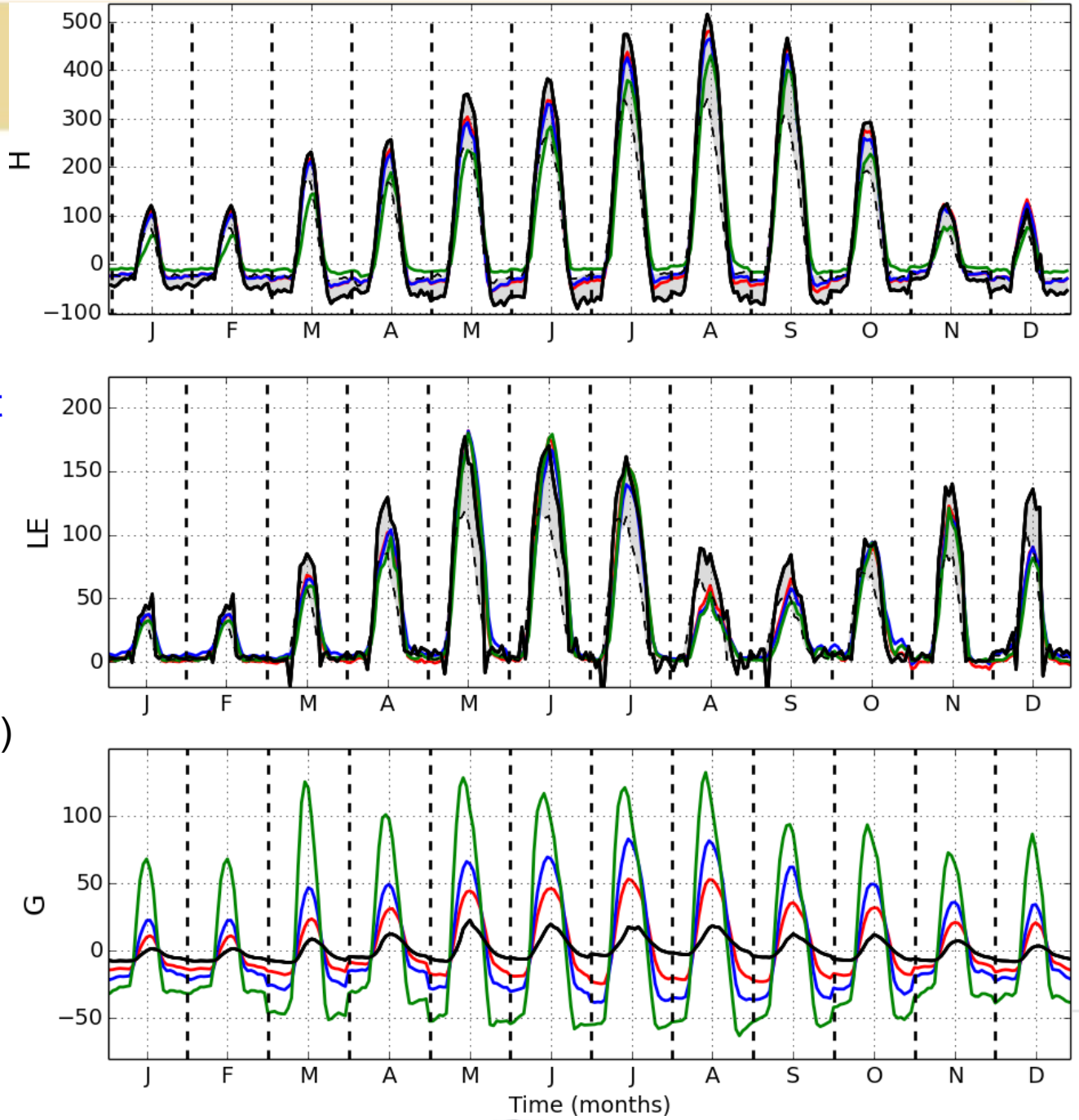


Puechabon

- Monthly average diurnal cycle
- Sensible (*H*), latent (*LE*) and conduction (*G*) heat fluxes (W m^{-2})

Observations
(gray zone- «adjusted» obs and measurements)

ISBA-FR
ISBA-MEB
ISBA-MEBL



Evaluation : Detailed local scale

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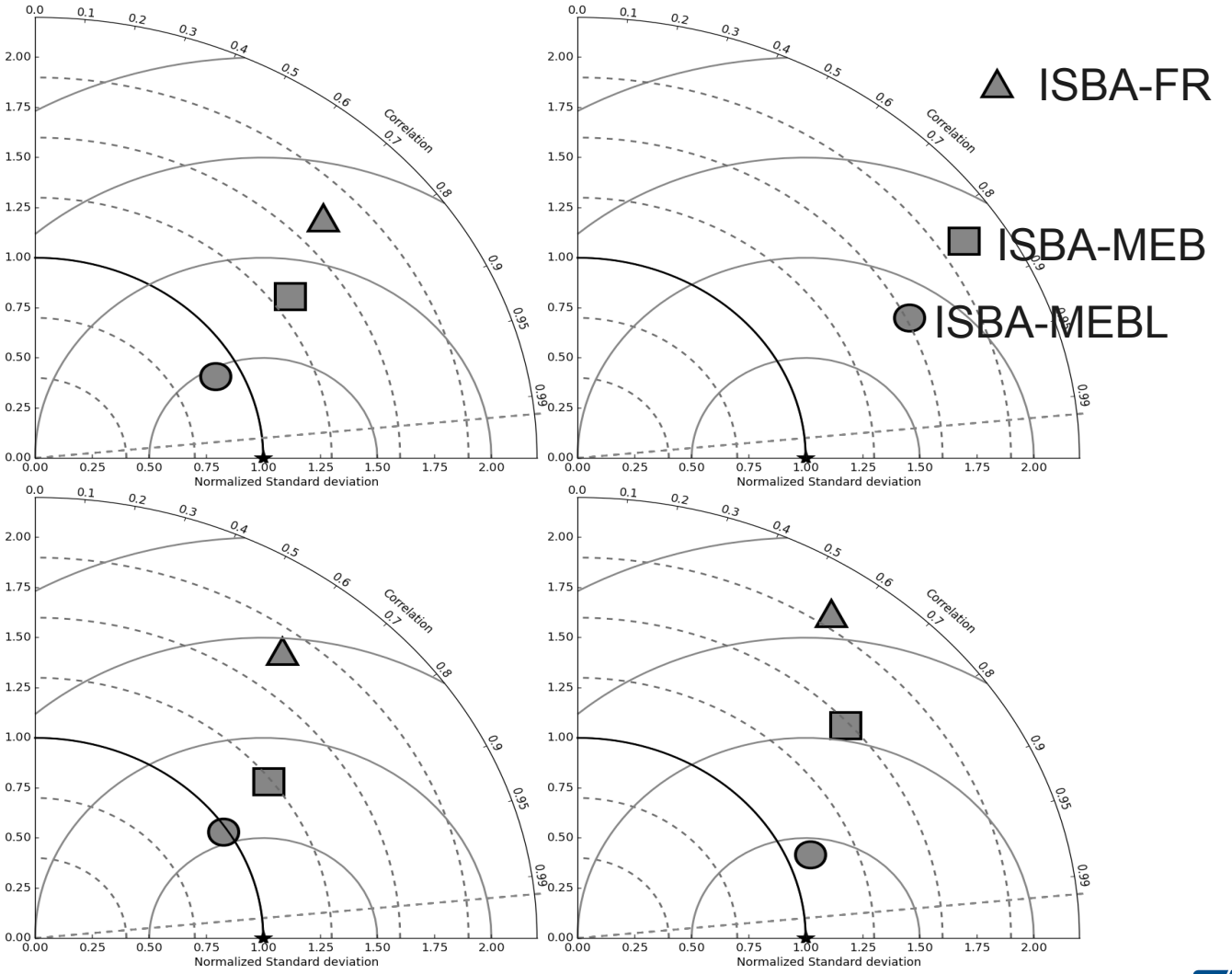
Taylor diagrams for *G* for all 4 sites (using hourly values)



RMSE (W/m²)

ISBA	57
MEB	29
MEBL	16

Evaluation : Detailed local scale

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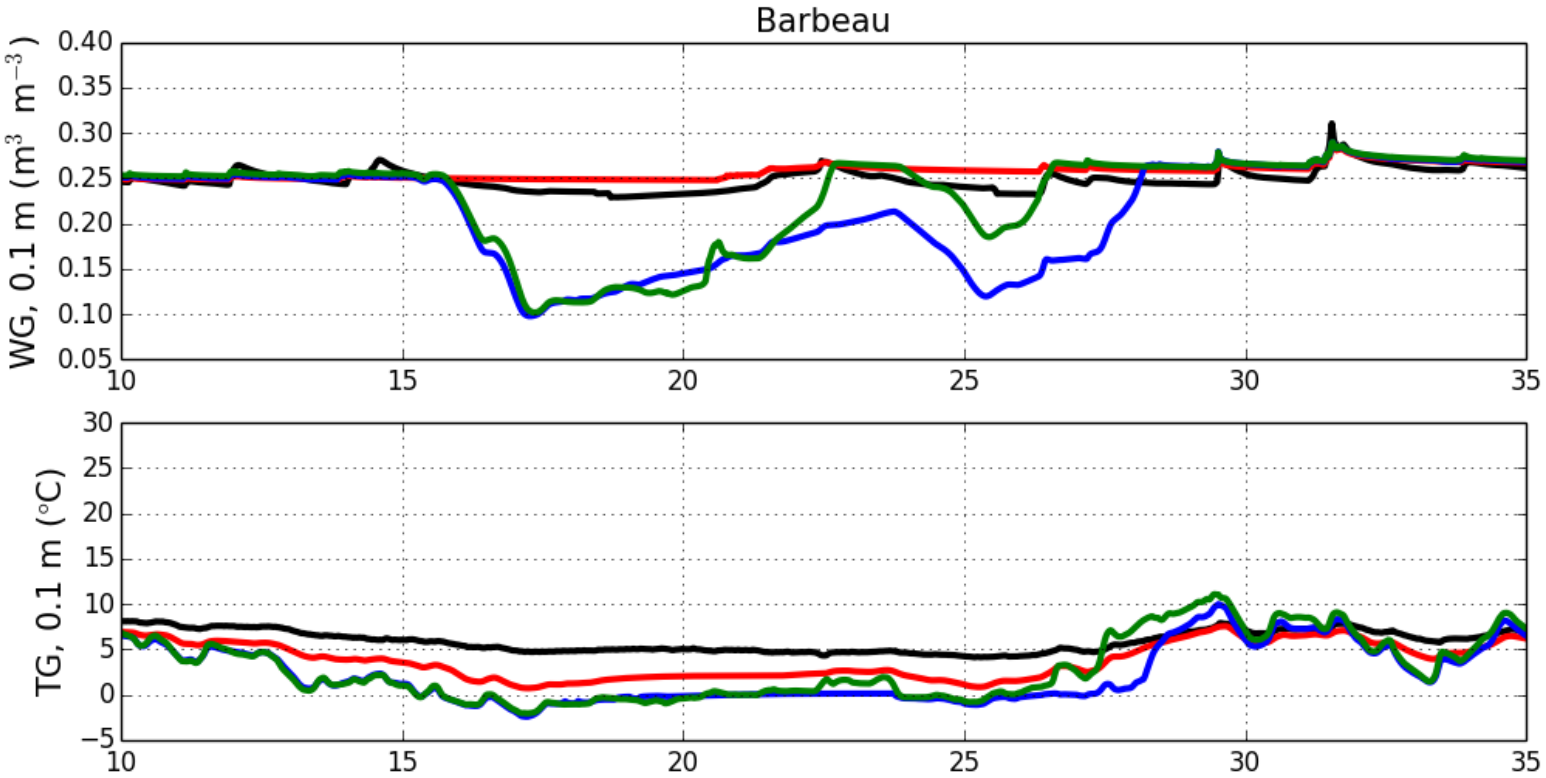
Improved insulation with litter : reduced/improved soil freezing



Evaluation : Local scale - global

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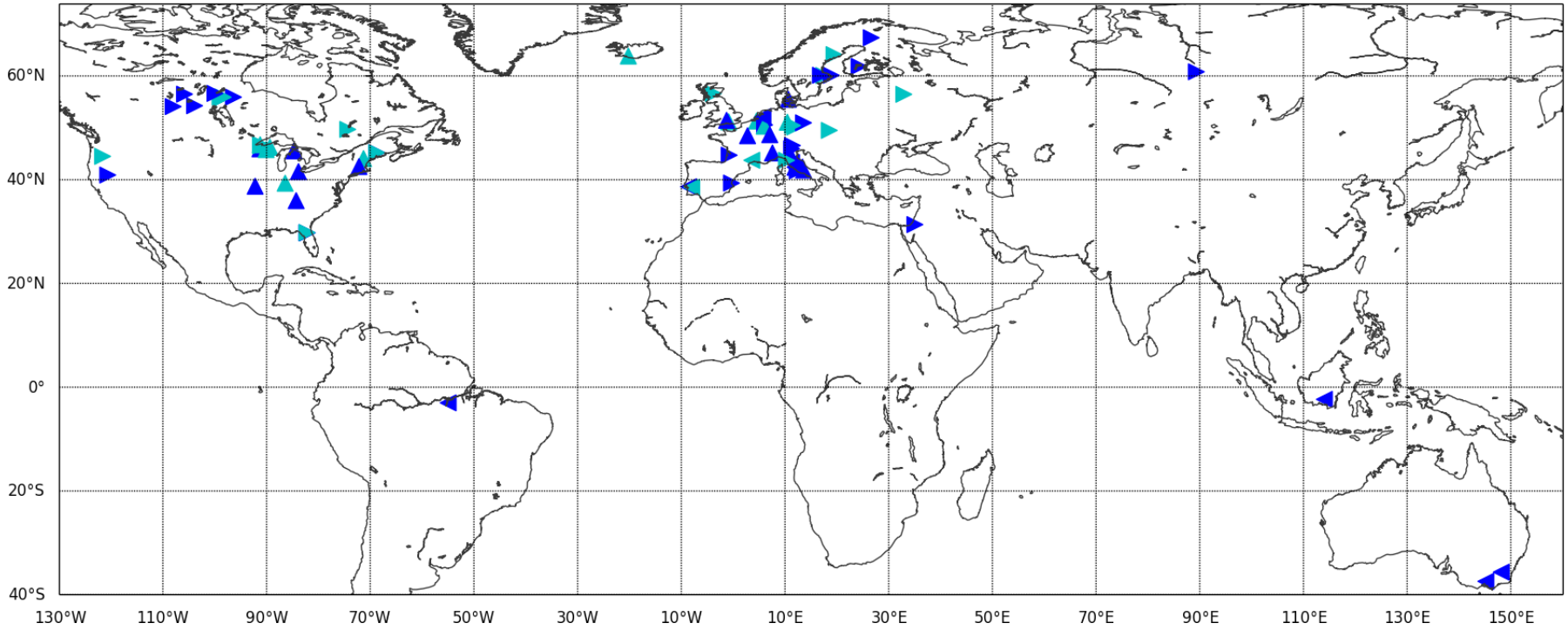
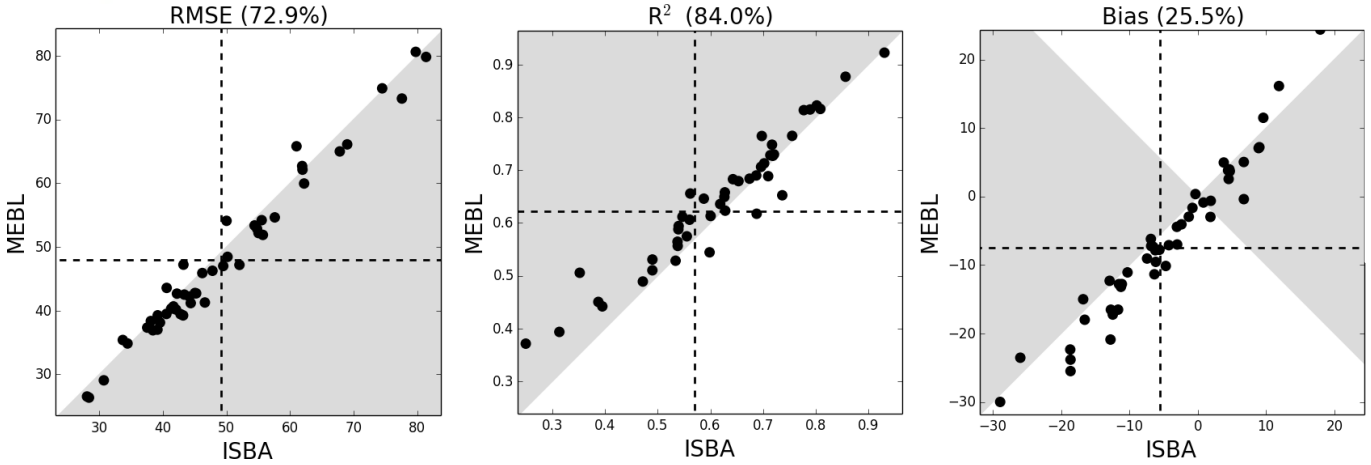
- Evaluation using *H, LE* (42 sites) and *G* (30 sites)
- Multiple annual cylces, range in forest types, climate
- Dark blue sites retained : i) energy budget closure error < 20 % & ii) radiation forcing quality criteria met



(Napoly et al, 2017)

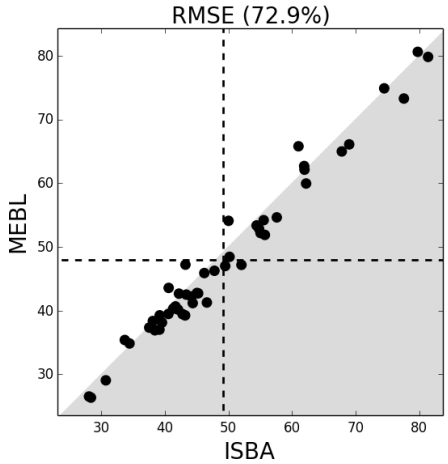
LE

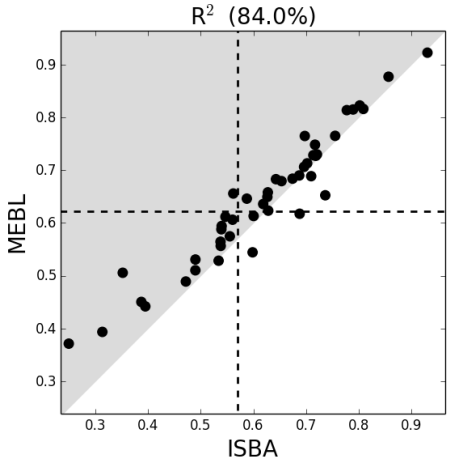


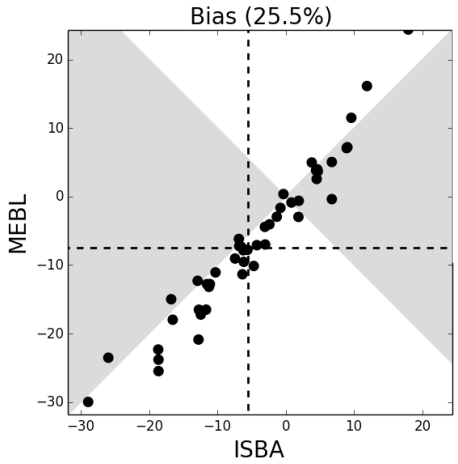
Each point represents a site and a year

Gray zone : Results improved using ISBA-MEBL

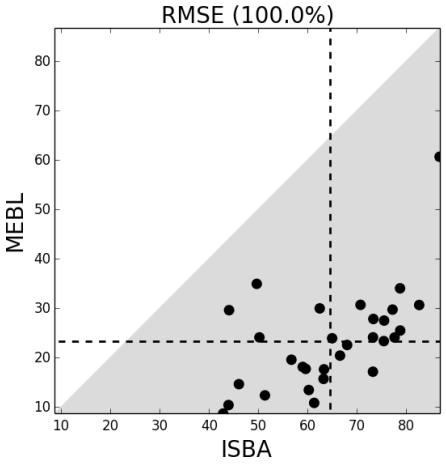
LE

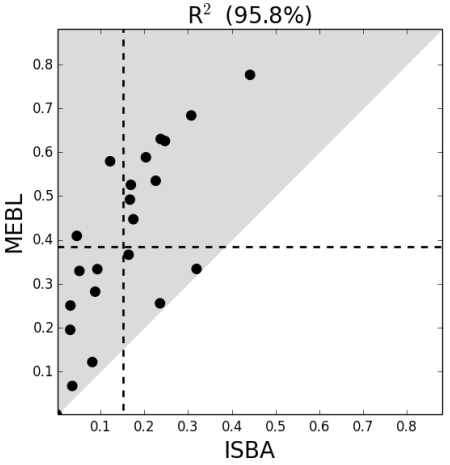


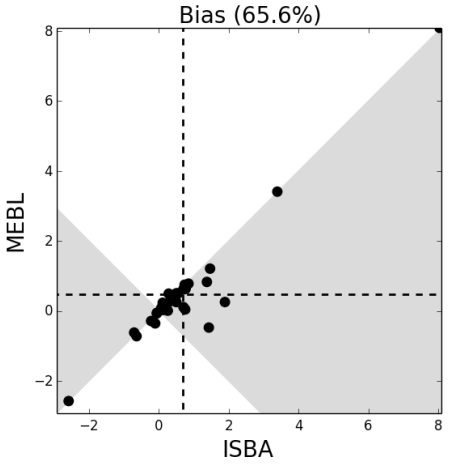




G

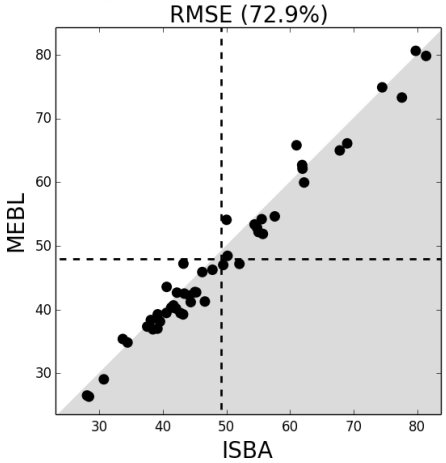


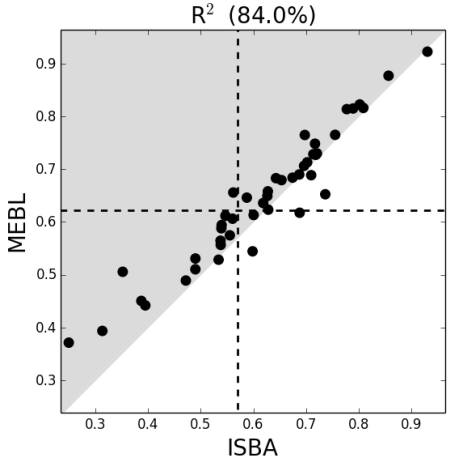


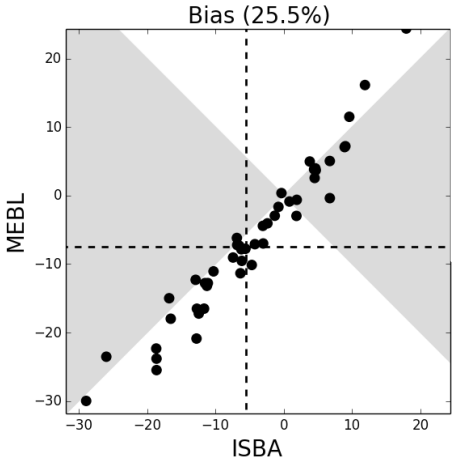


Each point represents a site and a year

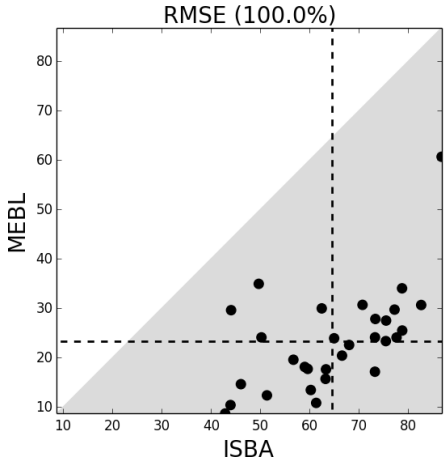
LE

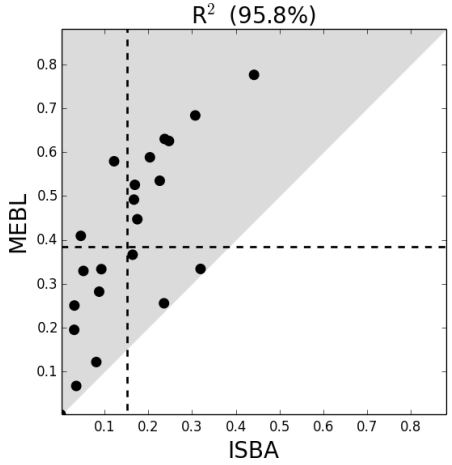


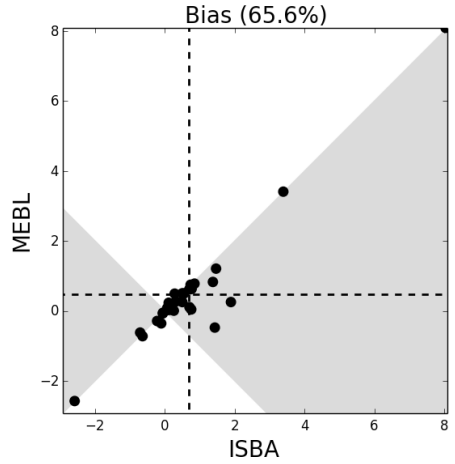




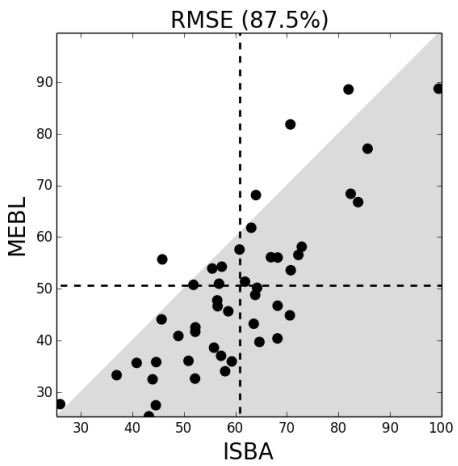
G

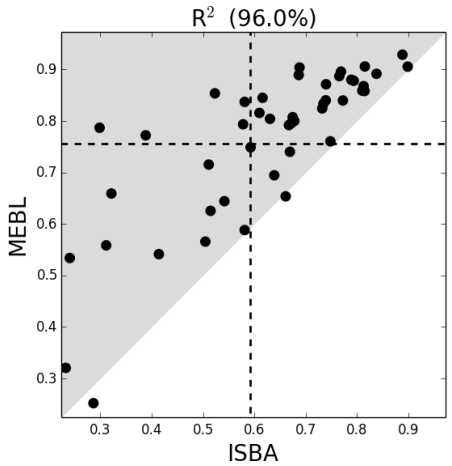


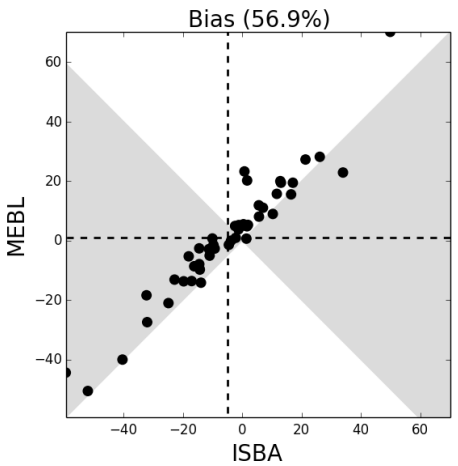




H







Each point represents a site and a year

Evaluation : Local scale - global

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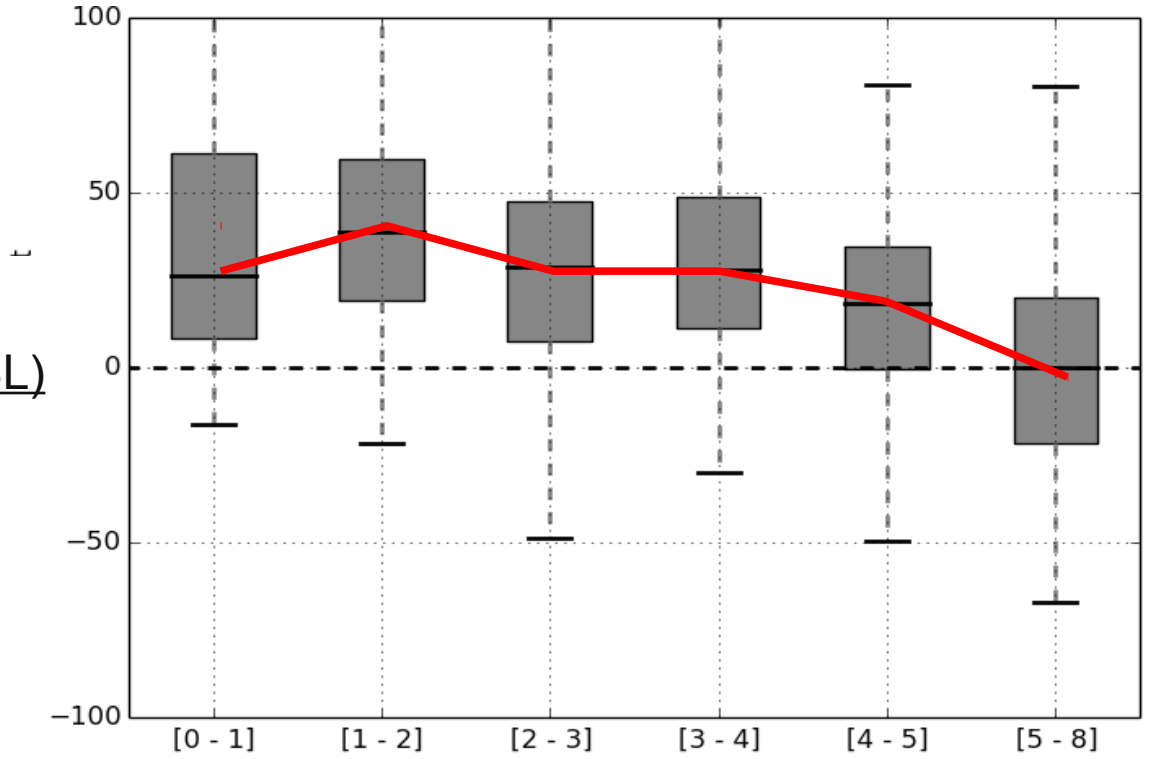
RMSE : $\frac{\text{(ISBA-MEBL)}}{\text{ISBA}}$



Sensible heat flux, *H*, differences as a fn of LAI

Conclusions and Perspectives :

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Local scale sites in France :

- Improved *G* translating to better *H*.
- More realistic E_g-E_{tr} (E_g in forests no longer depends on tuned *veg* and uses more realistic z_0, limited by transmitted SW_{down}, LW_{down})
- Improved soil temperatures (also freezing using limited data)-consistent with improved *G*

Benchmark/FluxNet :

- Coherence with 4 detailed French sites for many contrasting years/sites globally!
- Notable gains especially for low to medium *LAI*

NOT shown herein :

- Improved discharge (modest) for majority of discharge stations and 30 year period in France using SIM (Napoly, 2016, PhD thesis)
- SnowMIP2 revisited: Improved snowpack in forests : duration generally 2-4 weeks longer (Canac, 2010, masters)

Conclusions and **Perspectives** :

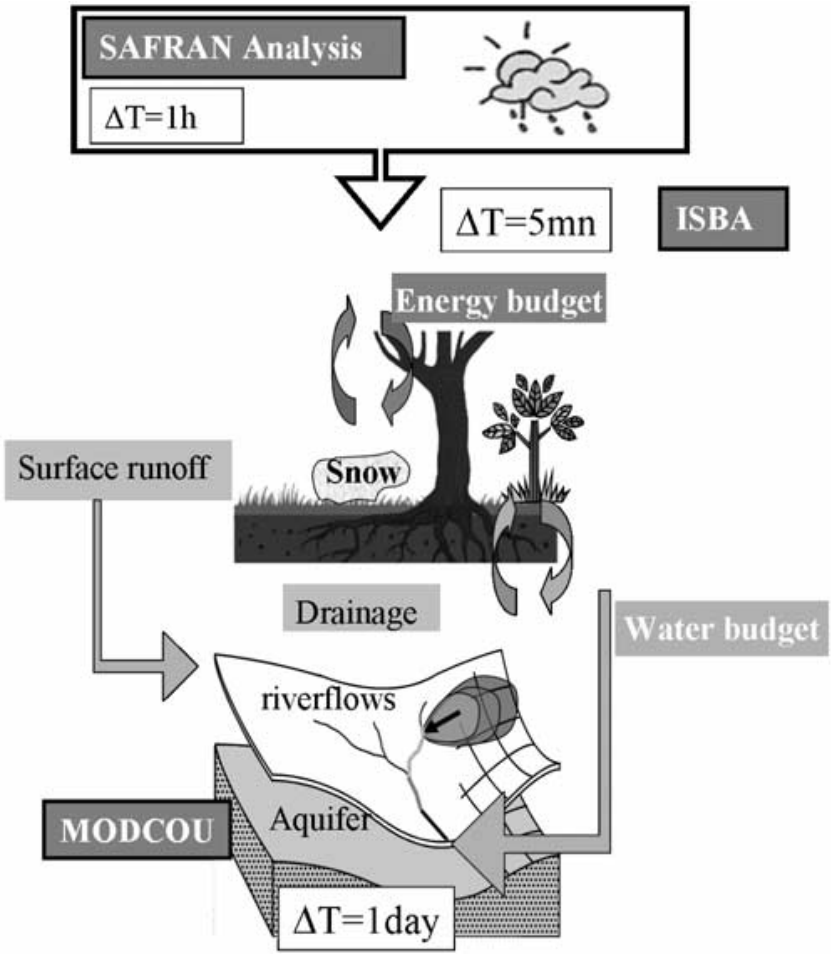
GMME

- **Activate/test Carbon options (Delire, Calvet, Seferian...)**
- **Use/test MEB for low vegetation/crops (Garrigues, Boone...)**
- **More advanced radiative interactions, detailed site eval (Carrer, Jarlan, Boone)**
- **Local scale snow evaluation (Samuelsson...)**
- **Coupling to CROCUS (Lafayesse...)**
- **Global offline (Decharme, Boone, Garrigues...)**
- **Tests coupled with ARPEGE Climat (Decharme, Colin...)**
- **NWP testing (Samuelsson...)**
- **Coupled to MesoNH (Donnier, LeMoigne, Boone...)**

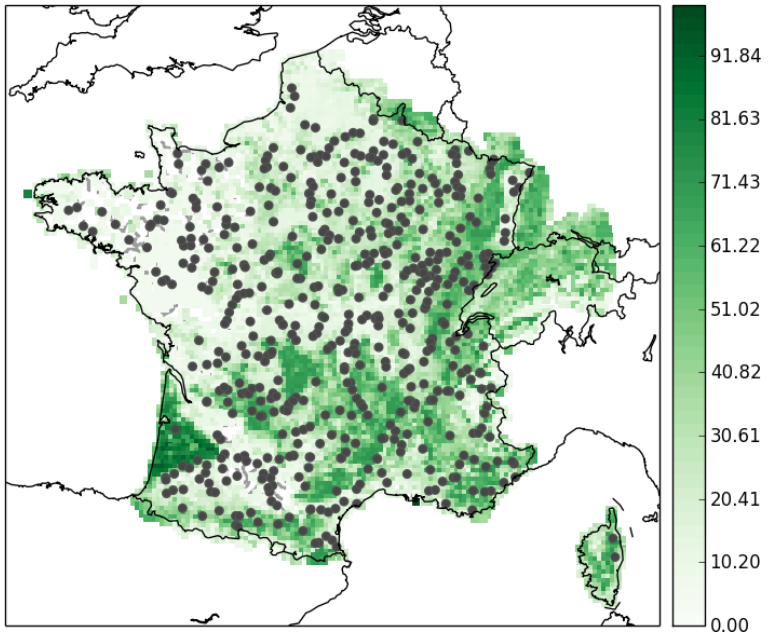
Also thanks to G. Boulet, E. Martin, J.-C. Calvet,
P. Le Moigne, S. Faroux, C. Canac, and G. Aouad (& J. Noilhan)

Extra.....

SIM Chain

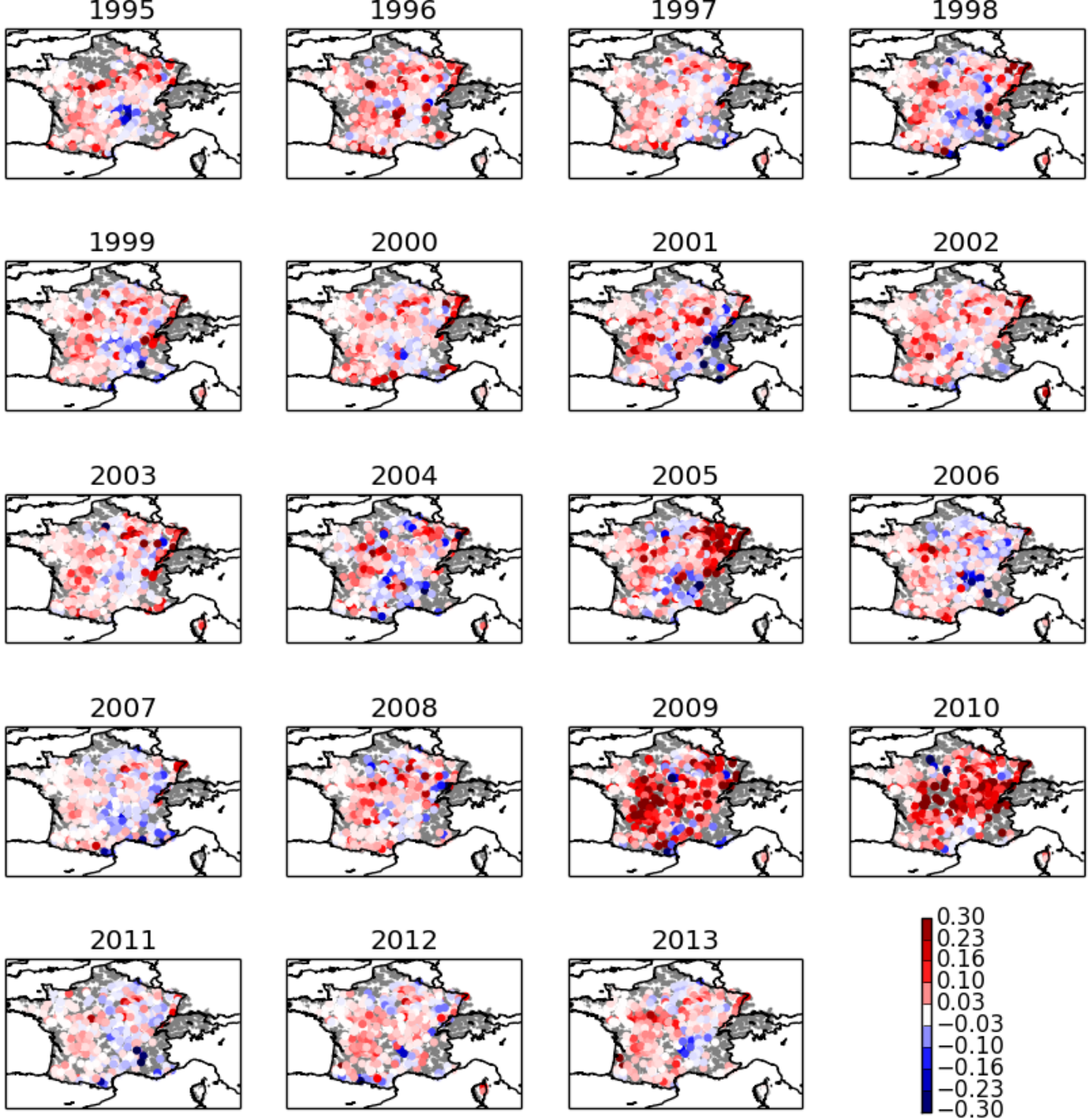


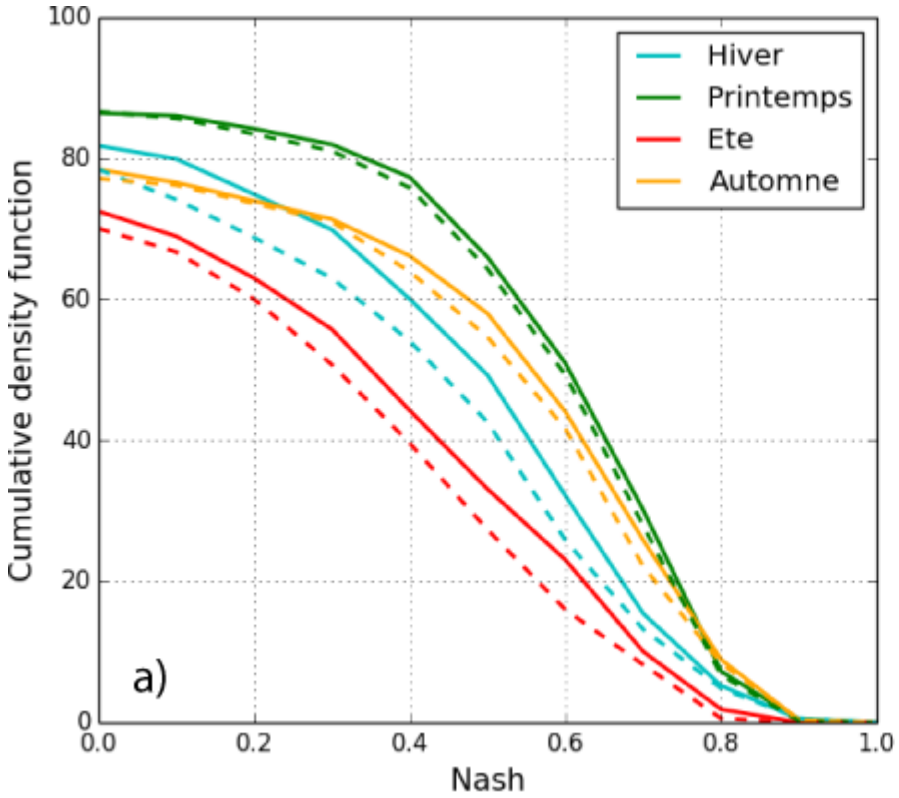
SIM Domain



29 % of surface
55 % deciduous trees
+500 gauging stations (discharge)
8km resolution (ISBA)

Change in daily Nash values




Hiver
Printemps
Ete
Automne
Cumulative density function
Nash
a)
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80
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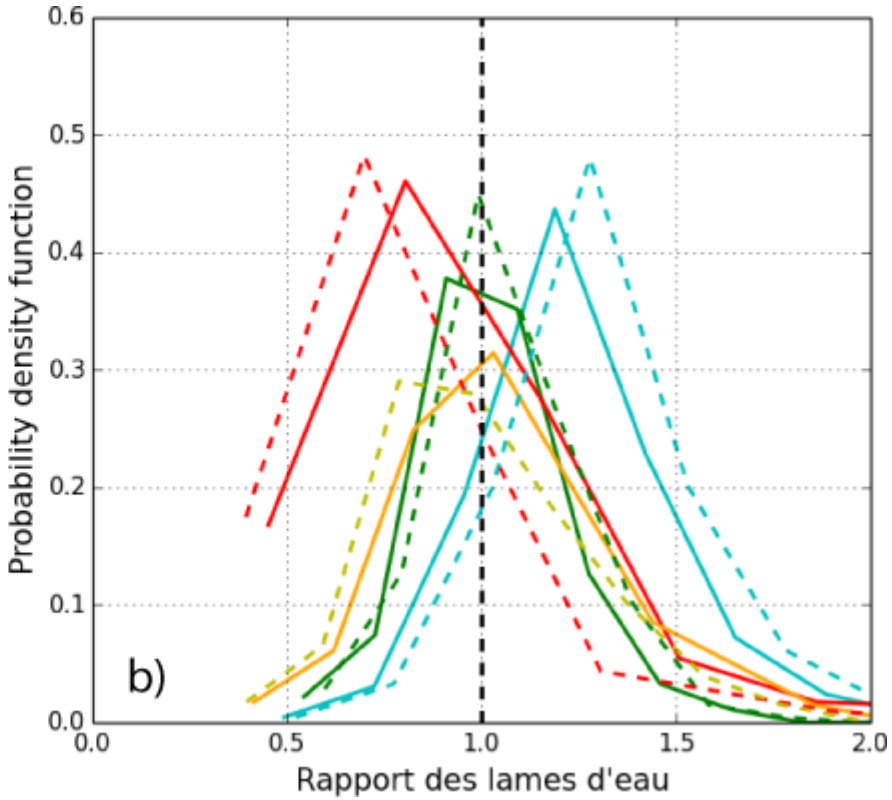
Probability density function
Rapport des lames d'eau
b)
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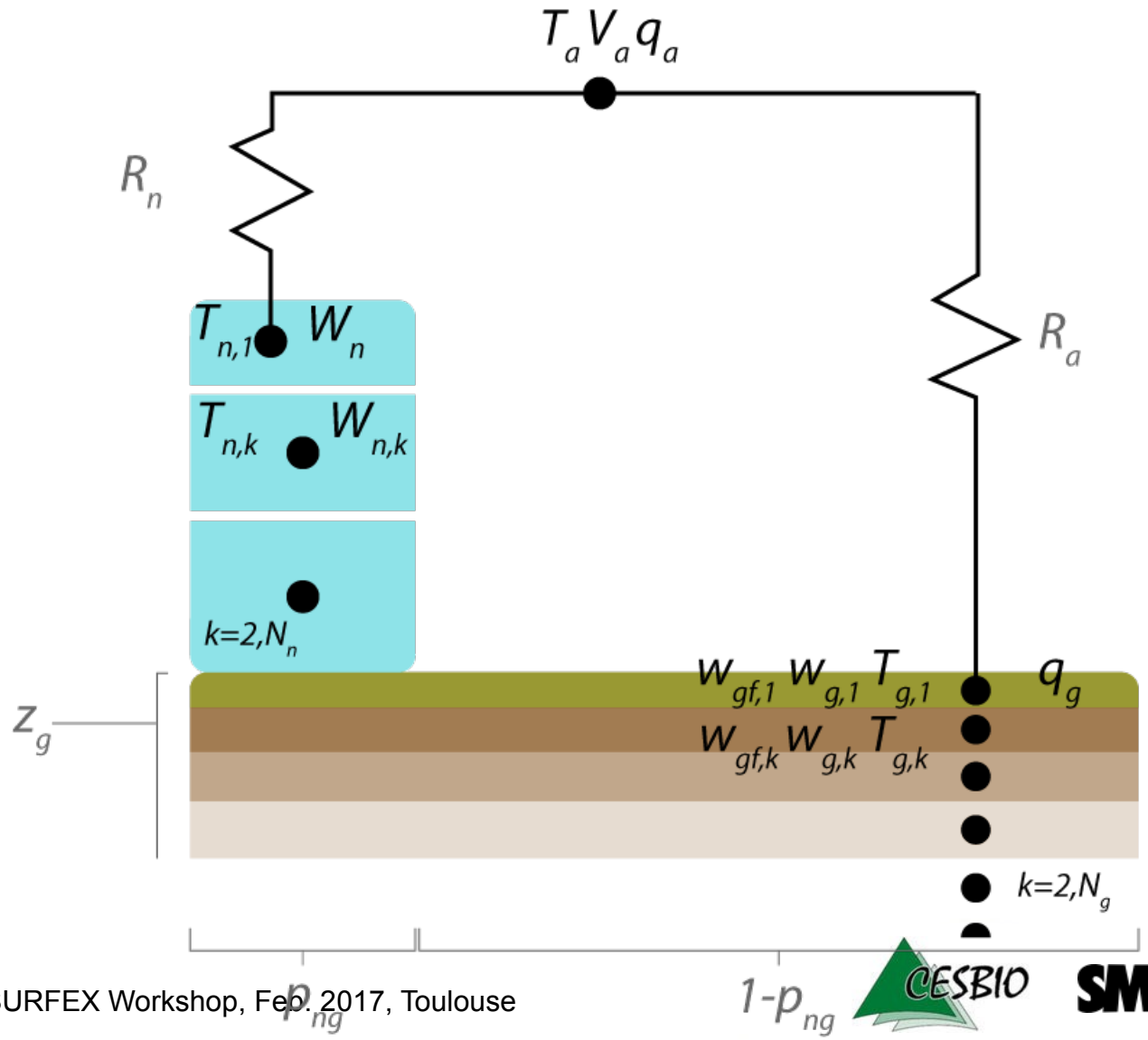
$T_a V_a q_a$
R_n
$T_{n,1}$ W_n
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$k=2,N_n$
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$w_{gf,k}$ $w_{g,k}$ $T_{g,k}$
z_g
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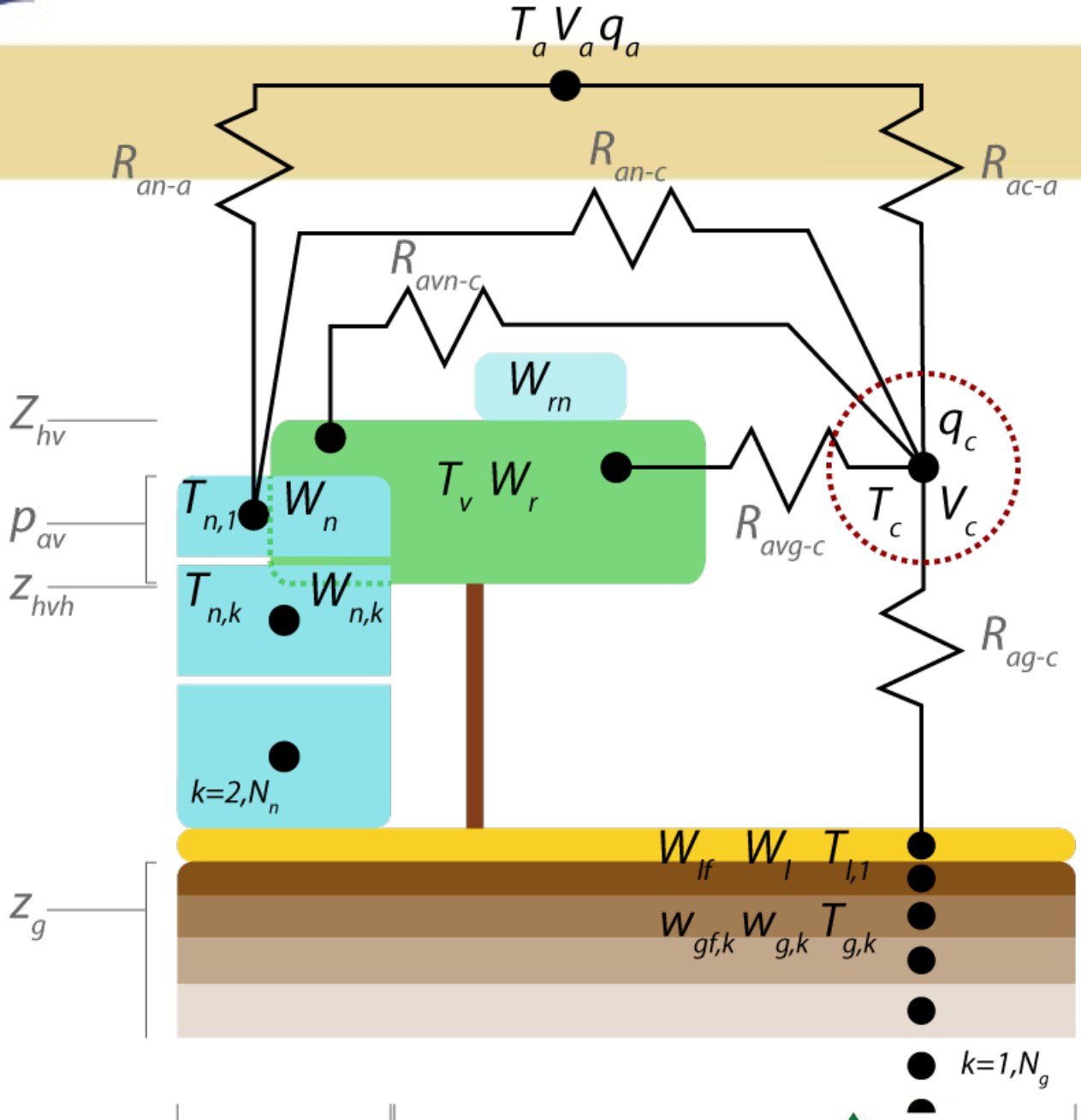
p_{ng}
$1-p_{ng}$


T_a V_a q_a
R_{an-a}
R_{an-c}
R_{ac-a}
R_{avn-c}
W_{rn}
Z_{hv}
p_{av}
z_{hvh}
$T_{n,1}$ W_n
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q_c
T_c V_c
R_{avg-c}
$T_{n,k}$ $W_{n,k}$
R_{ag-c}
$k=2,N_n$
W_{lf} W_l $T_{l,1}$
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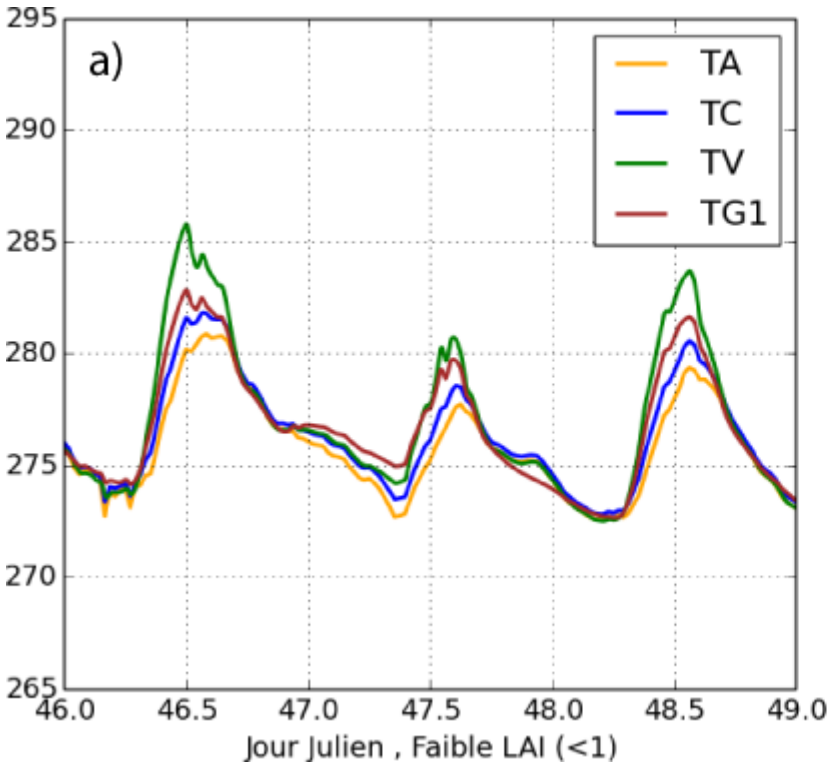
$w_{gf,k}$ $w_{g,k}$ $T_{g,k}$
$k=1,N_g$
p_{ng}
$1-p_{ng}$


a)
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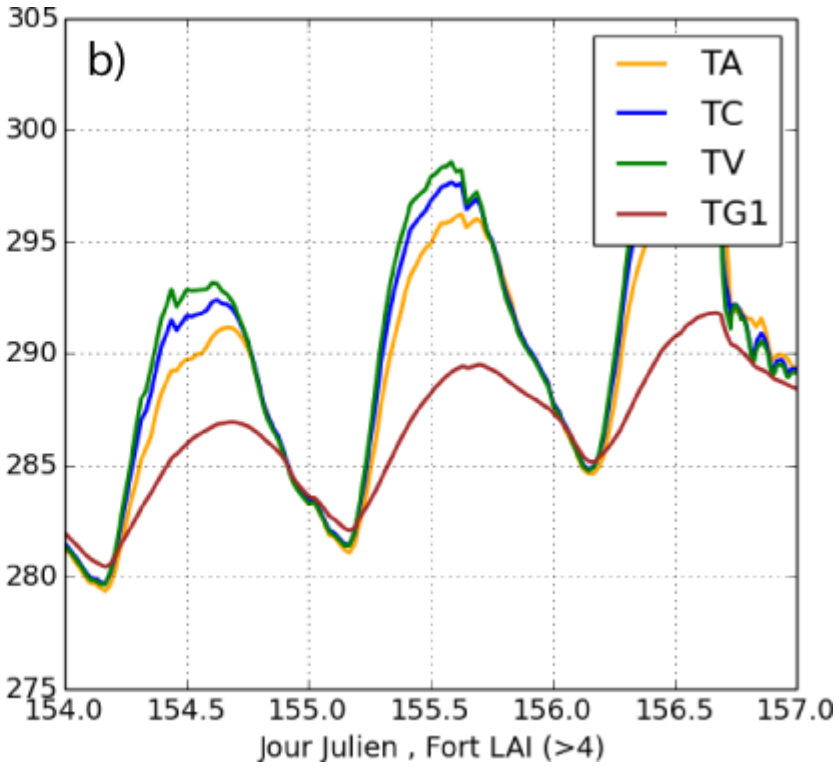
Jour Julien , Faible LAI (<1)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Jour Julien , Fort LAI (>4)