Recent efforts for better representing bare soil evaporation (BSE) in ORCHIDEE

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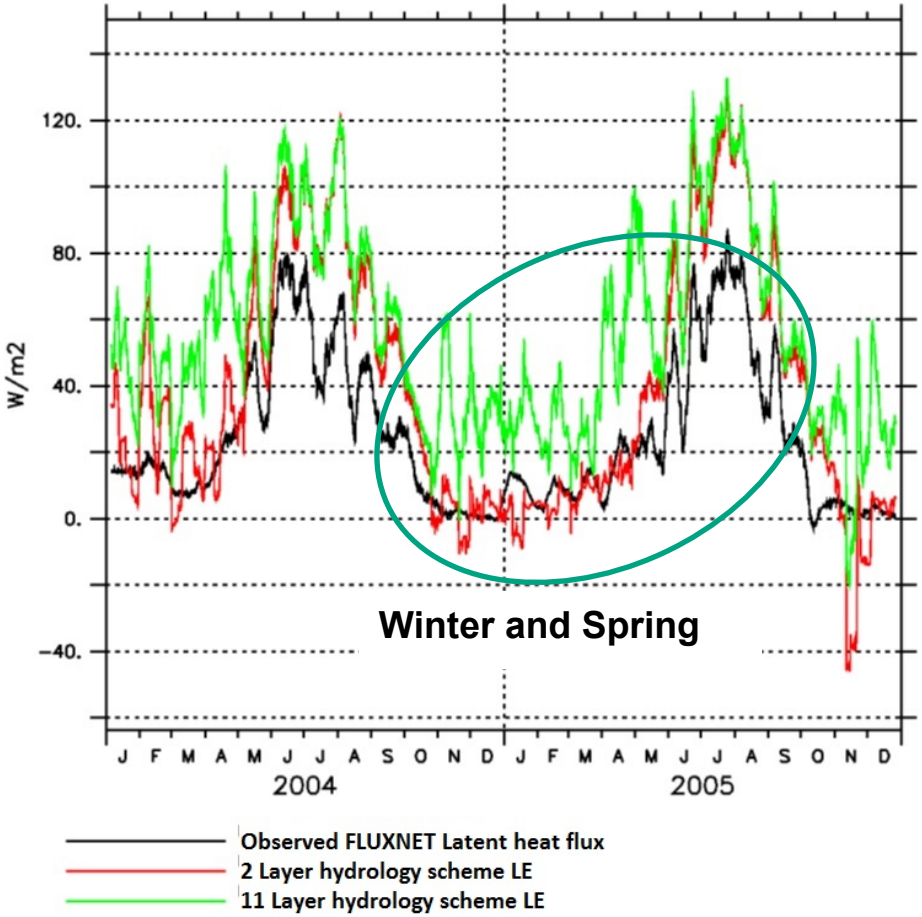
Context

- Shifting from the 2-layer hydrological scheme to the 11-layer one increases latent heat flux for some PFT's
  - That is due to the evaporative component
  - It acts at winter time for deciduous trees when no canopy coverage



US-Bar - Temperate deciduous forest
Servettaz, 2014 (L3 report)

2-layer : BSE depends on soil resistance

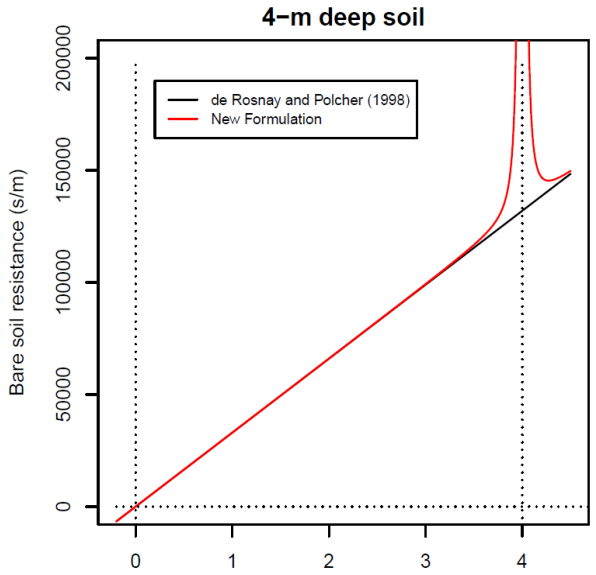
- r_{sol} is the main control of water stress onto bare soil evaporation

$$E_{sol} = \rho U_s \frac{q_{sat}(T_s) - q_{air}}{r_a + r_{sol}}$$

- r_{sol} depends on the dry soil height of PFT 1

$$r_{\mathrm{soil}} = r^{\mathrm{m}}_{\mathrm{soil}} \left(h_{\mathrm{dry}} + \frac{1}{100(h_{\mathrm{tot}} - h_{\mathrm{dry}})^2} \right)$$

1 cm of dry soil exerts r_{soil} = 330 s/m

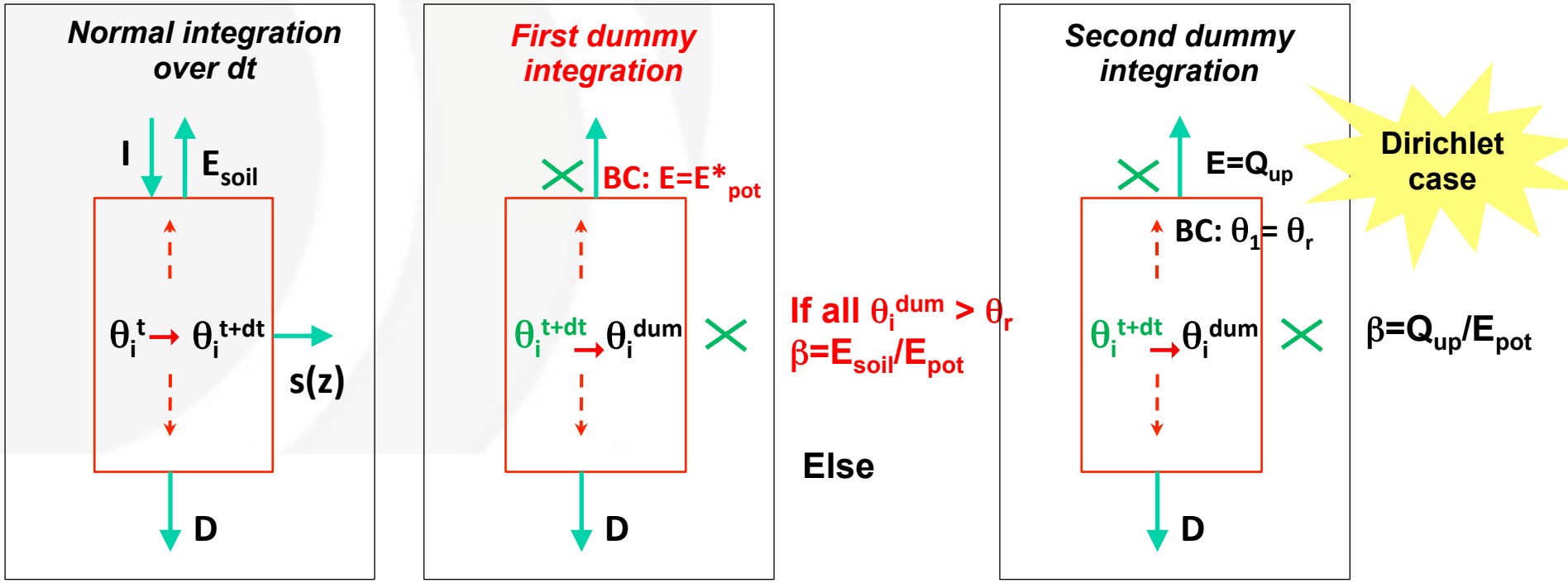


11-layer : BSE controlled by demand/supply

- The principle is that soil evaporation follows a supply/ demand approach

$$E_{soil} = \min(E^{*}_{pot}, Q_{up})$$

- In practice, this relies on dummy integrations of the water diffusion scheme



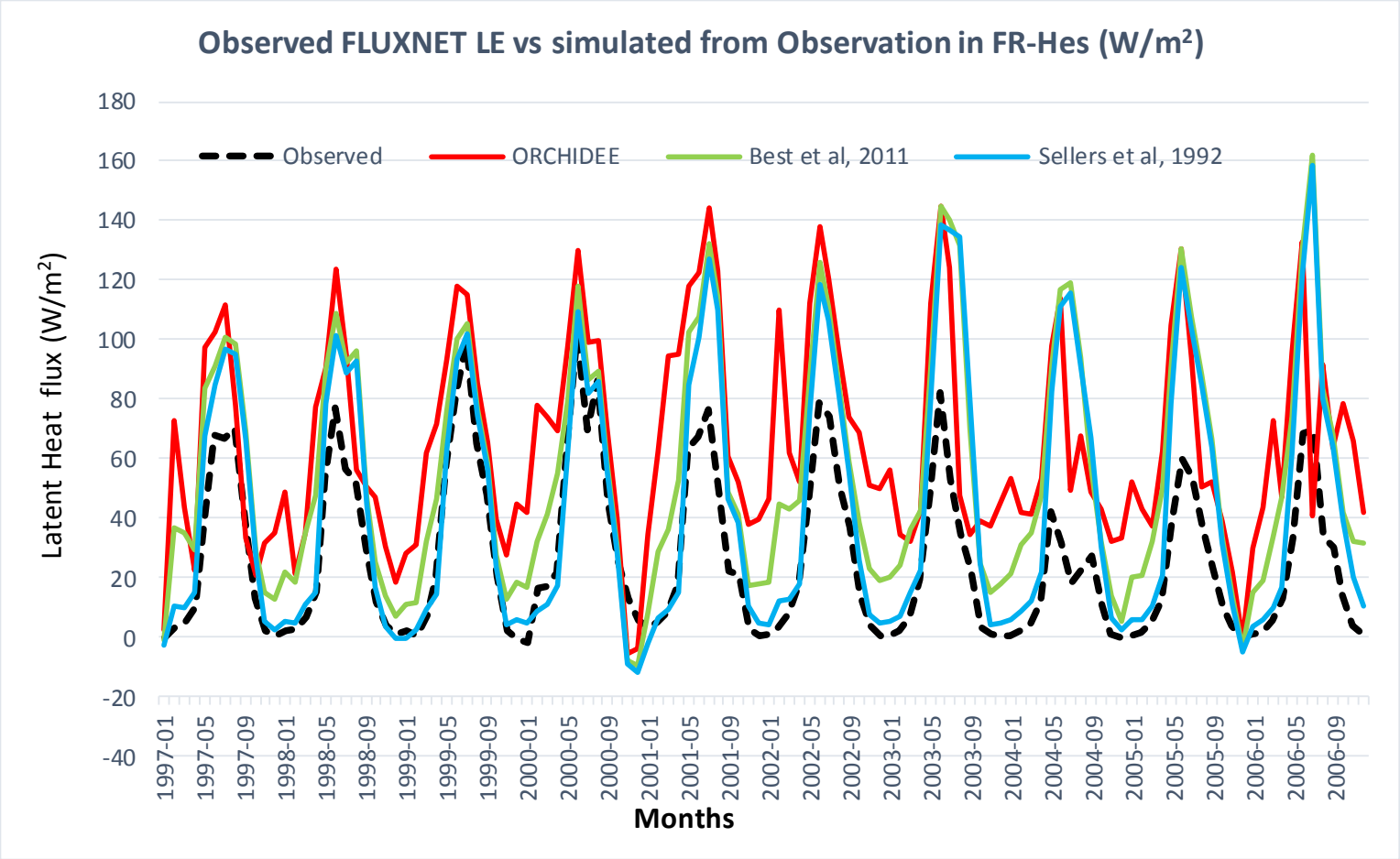
Work on soil resistance

- Work performed by A. Tootchi (Master 2)
- Testing 2 formulas for E_{soil} with a soil resistance

Type	Reference	Formulation
Standard ORCHIDEE (11 layer)	Several references of the ORCHIDEE team	$E_{soil} = \rho_a \frac{1}{r_a}[q_s(T_w) - q_a]$
Resistance terms	Best et al, 2011	$E_{soil} = \rho_a \frac{1}{r_a + r_s}[q_s(T_s) - q_a]$ $r_s = 100\,(\frac{\theta_c}{\theta_1})^2$
	Sellers et al, 1992	$E_{soil} = \rho_a \frac{1}{r_a + r_s}[q_s(T_s) - q_a]$ $r_s = e^{8.206 - 4.255\,\frac{\theta_1 - \theta_r}{\theta_s - \theta_r}}$

Tests at Fluxnet sites

- Over a deciduous forest



Bias on Latent heat at winter time

PFT	Station	Winter LE Fluxnet observation ($W/m^2.s$)	LE winter bias ($W/m^2.s$)		
			ORCHIDEE	Best et al, 2011	Sellers et al, 1992
Temperate deciduous broadleaf forest	DK-Sor	2.3	36.6	8.8	-1.0
	FR-Hes	1.8	52.9	17.1	2.4
	IT-Col	2.8	2.5	-1.3	-4.7
	US-WCr	1.8	25.0	16.4	9.6
	US-Ha1	7.4	4.6	-3.4	-11.9
Cropland C4	US-Ne1	10.2	2.4	1.8	0.3
	US-Bo1	16.0	38.7	33.1	21.2
Grassland C3	HU-Bug	6.2	-4.0	-4.5	-7.4
	US-Fpe	3.6	3.4	-1.6	-10.0
	US-Var	21.2	19.7	17.3	13.5

Improved	
Deteriorated	

Work on E_{pot} via the aerodynamic resistance

$$E_{pot} = \rho \frac{q_{sat}(T_s) - q_{air}}{r_a}$$

$$r_a = \frac{1}{\kappa^2 u_a}\left[\ln\left(\frac{z-d_0}{z_{0m}}\right)\ln\left(\frac{z-d_0}{z_{0v}}\right)\right]$$

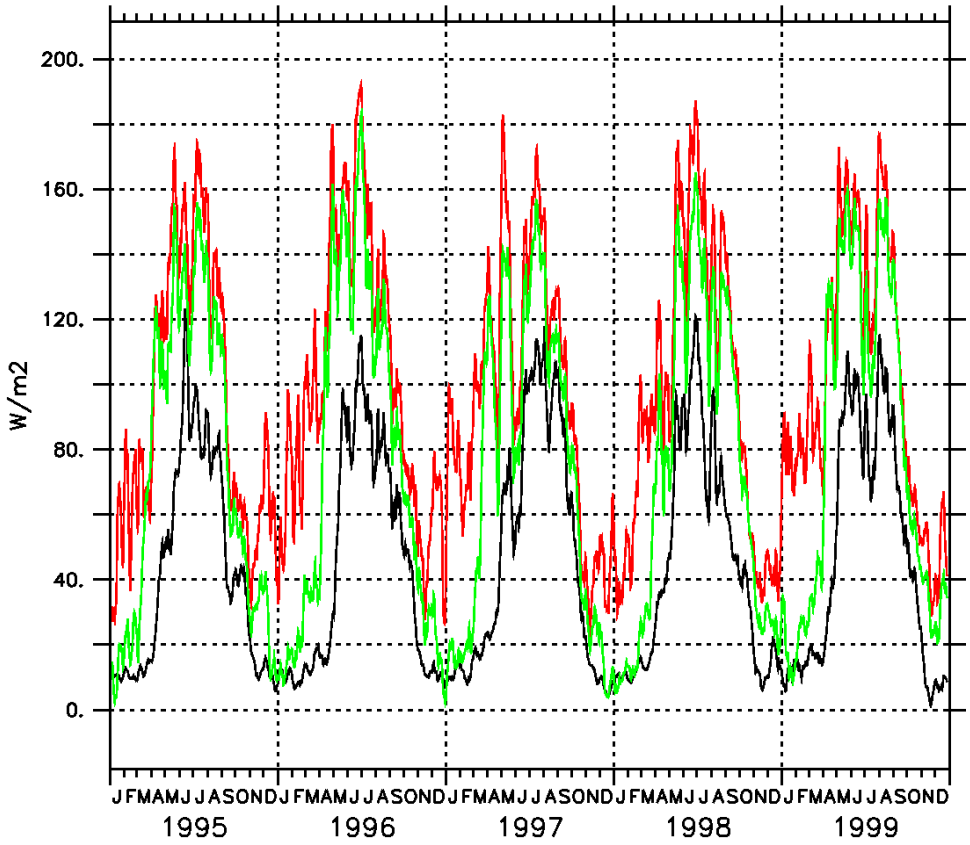
where

- z is measurement height (m)
- u_a is wind speed (ms^{-1})
- k von Karman's constant
- d_0 is displacement height
- z_{0m} and z_{0v} the roughness heights for momentum and water vapor transfer

⇒*One assumes that the trunk and the branches impact as a full canopy coverage on z_0*

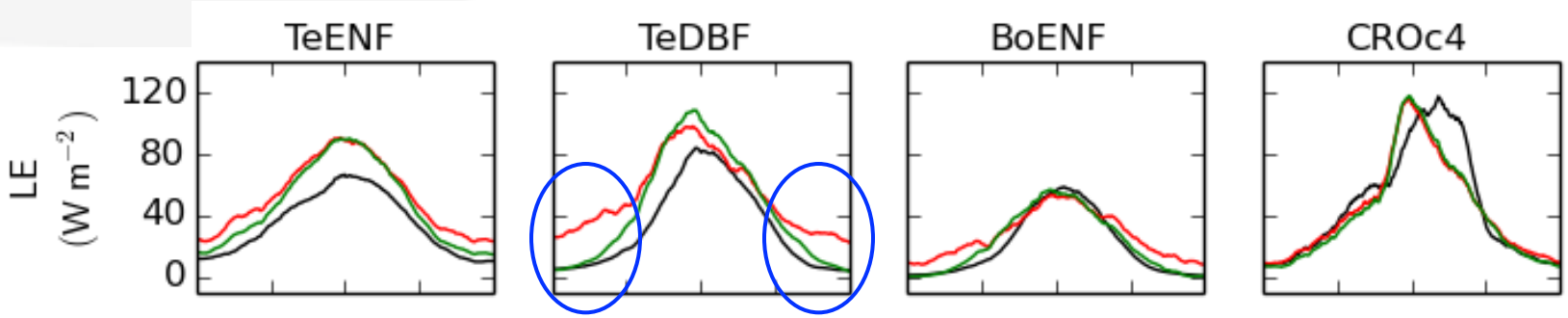
- Search for literature supporting that z_0 varies with LAI
  - Ershadi et al. (2015) uses the formulation of Su et al. (2001)

Evaluation at site level (1)



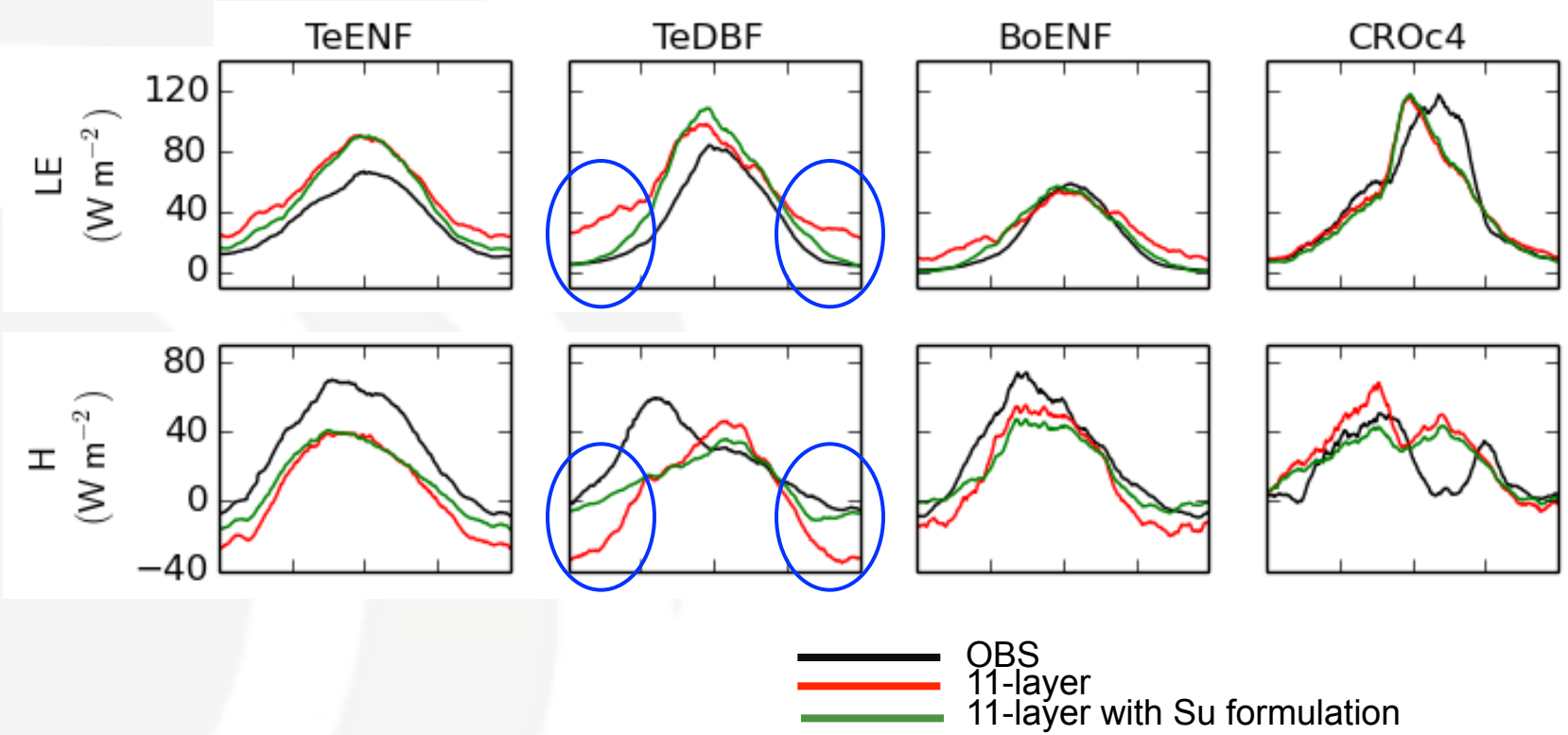
Latent Heat flux @ Walker Branch site (TeDBF)

Evaluation at site level (2)



OBS
11-layer
11-layer with Su formulation

Evaluation at site level (2)



Conclusion & Perspectives

- Complementary works performed for reducing bare soil evaporation
  - Soil resistance
  - Aerodynamic resistance via a dynamic roughness height
- Accounting for a roughness height varying with the canopy coverage
  - can correct alone for the bias on evaporation
  - a soil resistance can be added but it is not needed
- Studies in arid regions could be envisaged or under dried conditions