Assessing a Dry Soil Layer parameterization for bare soil evaporation during the LIAISE field campaign with SURFEX-ISBA

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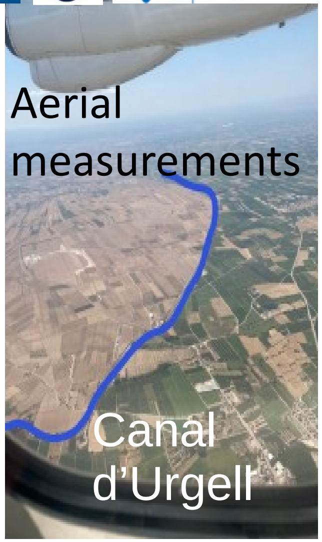
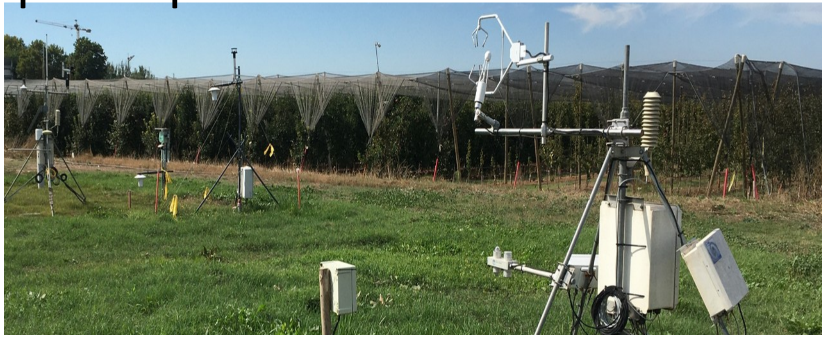
Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE)



Campaign at Lleida in Catalunya, north west of the Iberian Peninsula with a large international collaboration:

-Short Operational Period (SOP): 15th-30th July

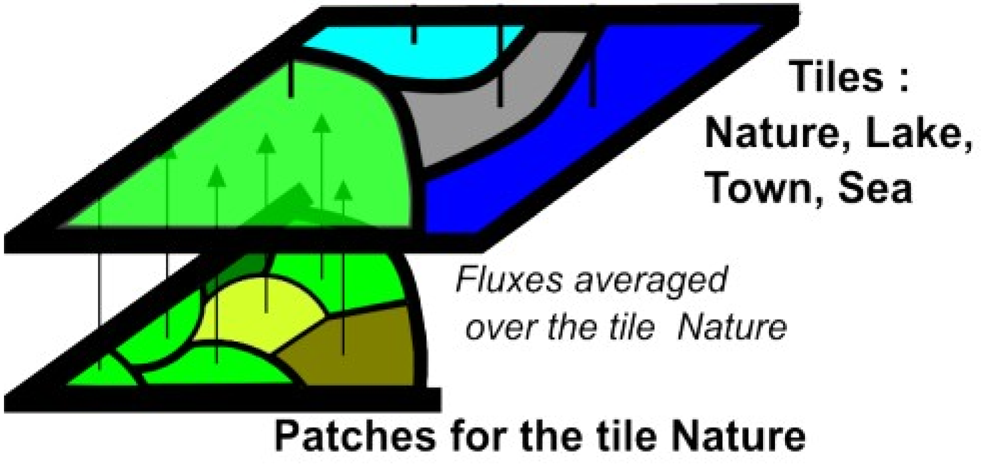
-Long Operational Period (LOP): April-Sept 2021



LIAISE's webpage:
https://www.hymex.fr/liaise/wg.html
https://liaise.aeris-data.fr/page-catalogue/

Surfex-ISBA

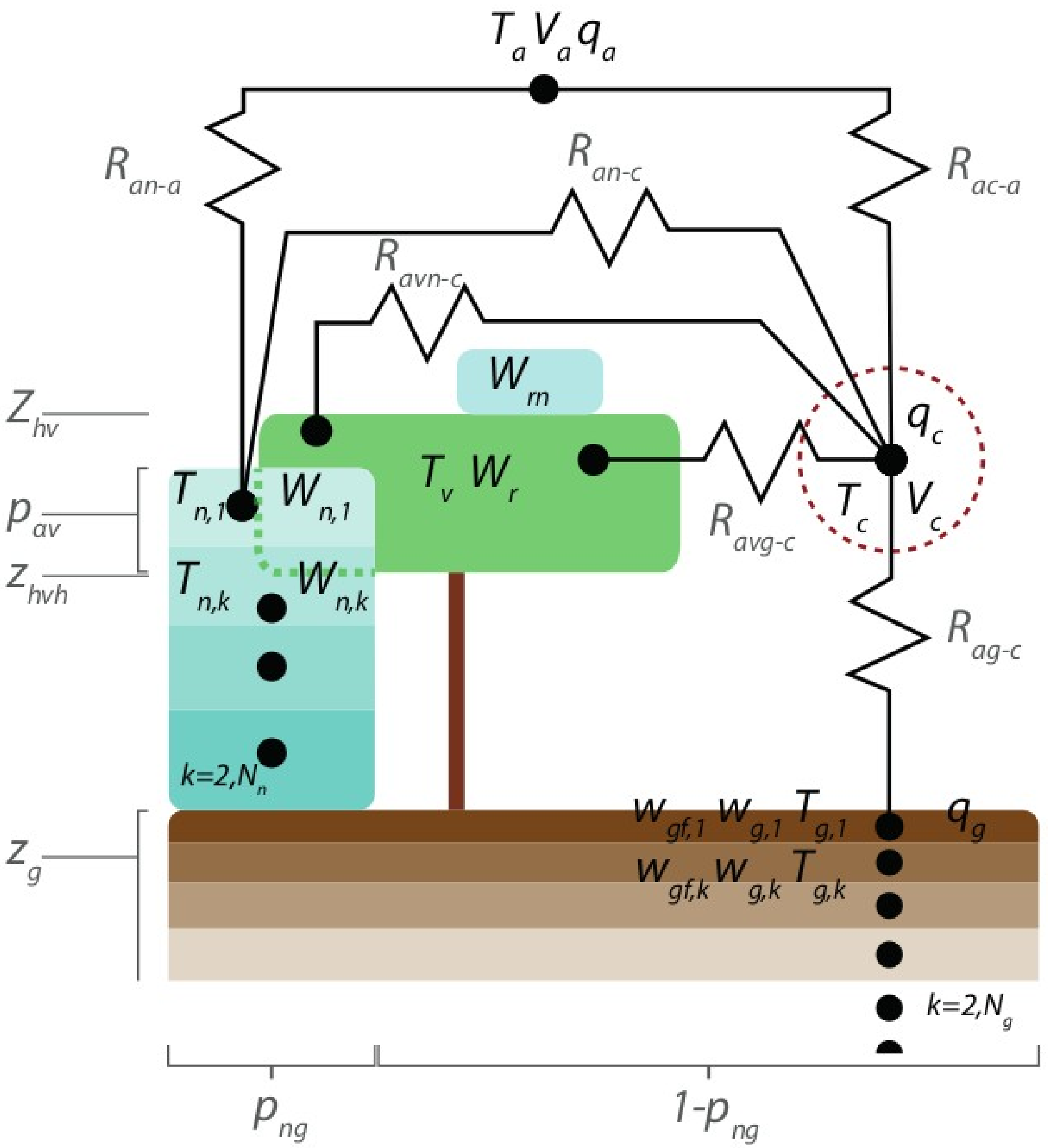
- SURFEX: surface modeling platform by Météo-France
  - Tiles represent the physics of very different surfaces (water, cities, natural surfaces)



- http://www.umr-cnrm.fr/surfex/

Surfex-ISBA

- Within ISBA:
  - Exchanges of energy and water between soil-vegetation-snow and the atmosphere.
  - Patches represent different conditions: rock, snow, tree species, C3 or C4 crops, …
    with associated properties of rugosity, plant conductance, ...
- Solved equations for canopy, ground and vegetation
- MEB scheme resolves independently vegetation and canopy
- Multiple layers of soil



- http://www.umr-cnrm.fr/surfex/

Soil water evaporation

- Models overestimation on ET on semiarid environments

    CLM, CABLE, ISBA

- Partitioning of evaporation and transpiration in semiarid
  - Ground evaporation (MOST)
  - Plant evaporation (A-gs)
- Liquid and vapour water transport differ
- Rates of evapotranspiration change due to tranport differences

→ Use of a soil resistance

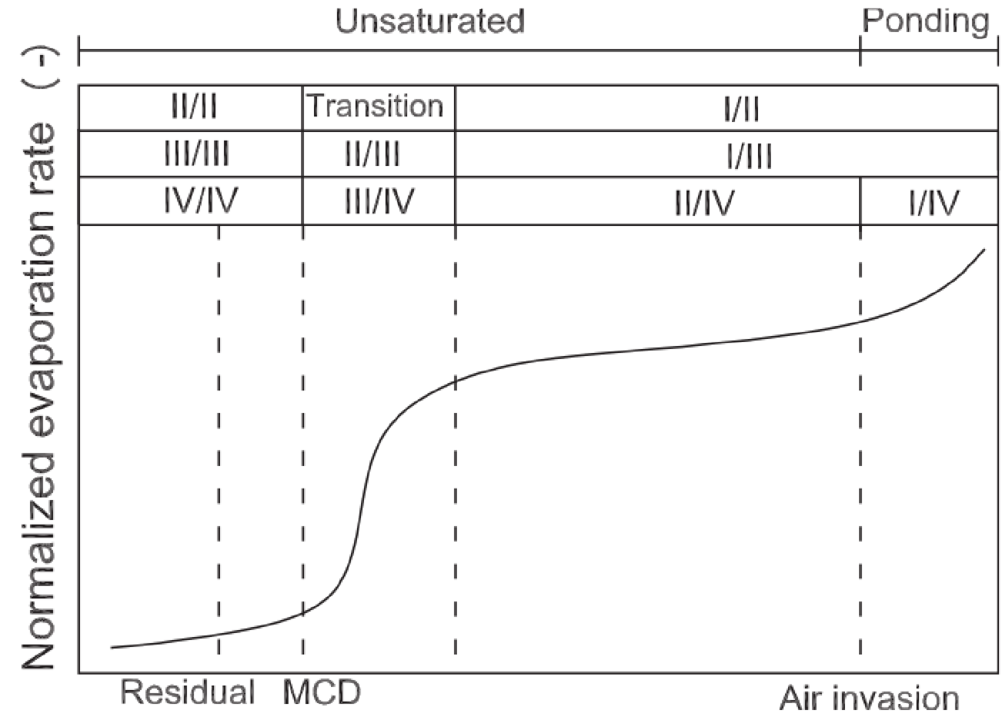


Figure 1. Schematic illustration of the normalized evaporation rate from bare soil without external water supply [e.g., *Le Bray and Prat*, 1999; *Yiotis et al.*, 2004]. Four stages are identified: stage I, the initial drying period; stage II, the constant rate period; stage III, the fast falling rate period; and stage IV, the thickening of dry soil layer period. The drying curve is also classified by the two-stage definition [e.g., *Lehmann et al.*, 2008; *Shokri and Or*, 2011] and three-stage definition [e.g., *Idso et al.*, 1974; *Wilson et al.*, 1994; *Rose et al.*, 2005; *Smits et al.*, 2011] for reference.

Zhang et al. (2015) A physically based surface resistance model for evaporation from bare soils

Soil resistance parametrization

Change LE parametrization of soil from an alpha formulation to a mixed formulation
Show impact of a (higher) soil resistance

$$E_g = \frac{\rho_a}{R_a + R_{soil}}(h_u q_{sat} - q_a)$$

$$R_{soil} = exp(A - B\frac{\theta}{\theta_{sat}})$$

Sellers et al. (1992)

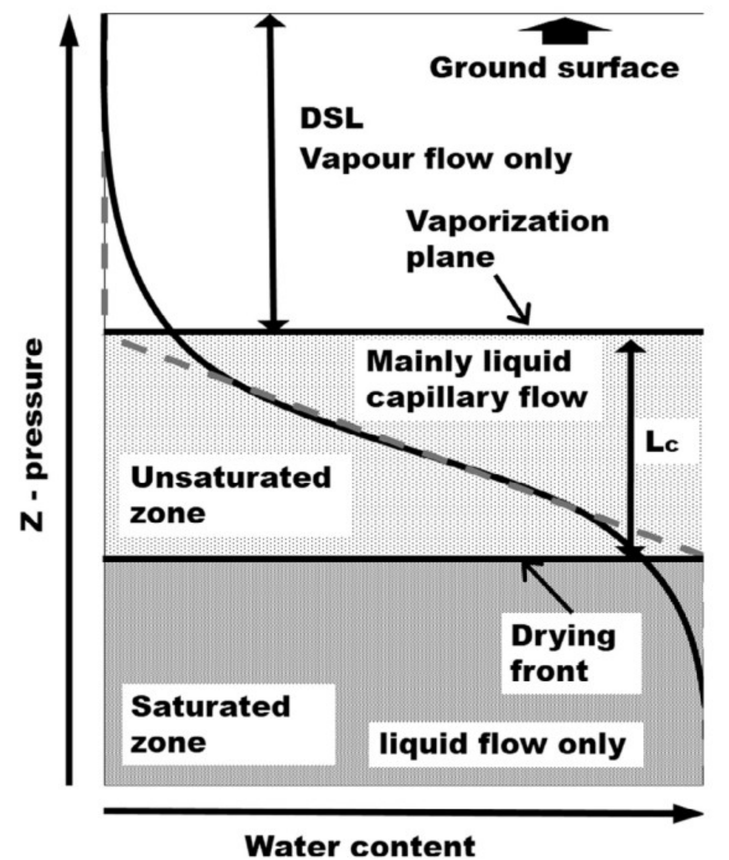
$$Rsoil = \frac{DSL}{D_\nu \tau}$$

$$\theta_{dsl0} = K\Phi$$

$$\Phi\text{: Porosity}$$

$$DSL = \begin{cases} \Delta z \frac{\theta_{dsl0}-\theta_{top}}{\theta_{dsl0}-\theta_{air}}, & \theta_{top} < \theta_{dsl0} \\ 0, & \theta_{top} \geq \theta_{dsl0} \end{cases}$$

Swenson and Lawrence (2014)



Magnitude of the resistance

- DSL resistance tied to a physical interpretation made a priori
- DSL higher resistance of the literature found

$$R_{soil} = exp(A - B\frac{\theta}{\theta_{sat}})$$

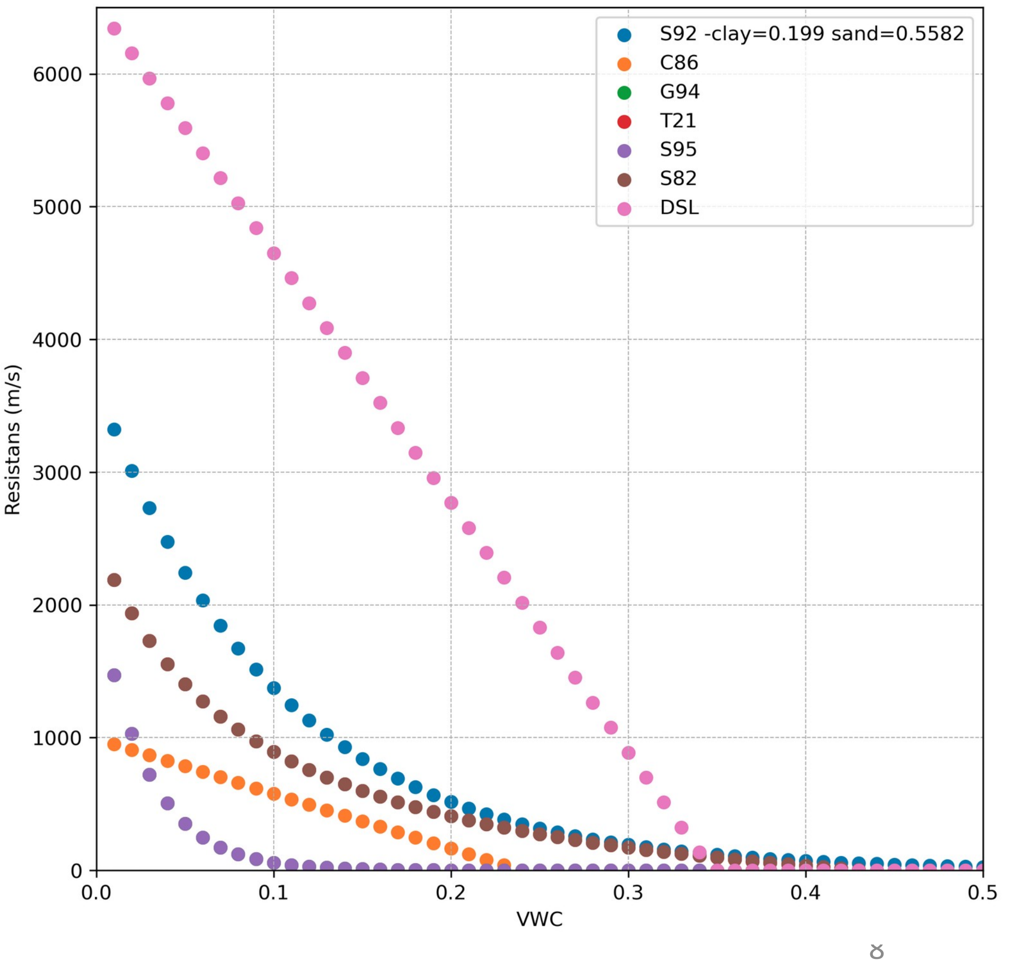
Sellers et al. (1992)

$$Rsoil = \frac{DSL}{D_\nu \tau} \qquad \theta_{dsl0} = K\Phi$$

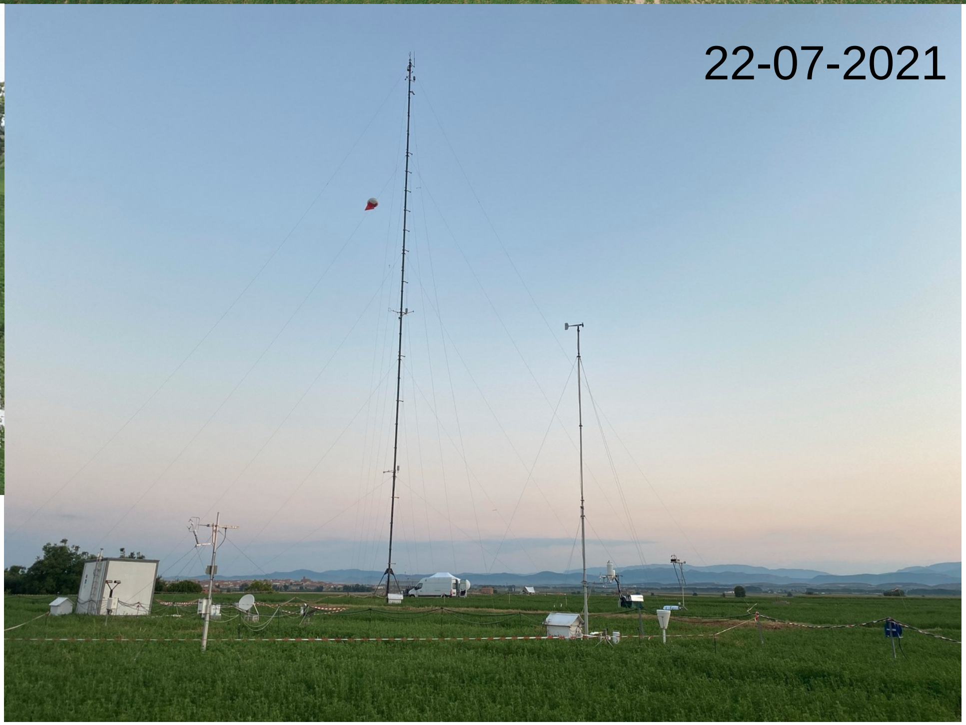
Φ: Porosity

$$DSL = \begin{cases} \Delta z \frac{\theta_{dsl0} - \theta_{top}}{\theta_{dsl0} - \theta_{air}}, & \theta_{top} < \theta_{dsl0} \\ 0, & \theta_{top} \geq \theta_{dsl0} \end{cases}$$

Swenson and Lawrence (2014)



La Cendrosa : Alfalfa, periodically flooded site



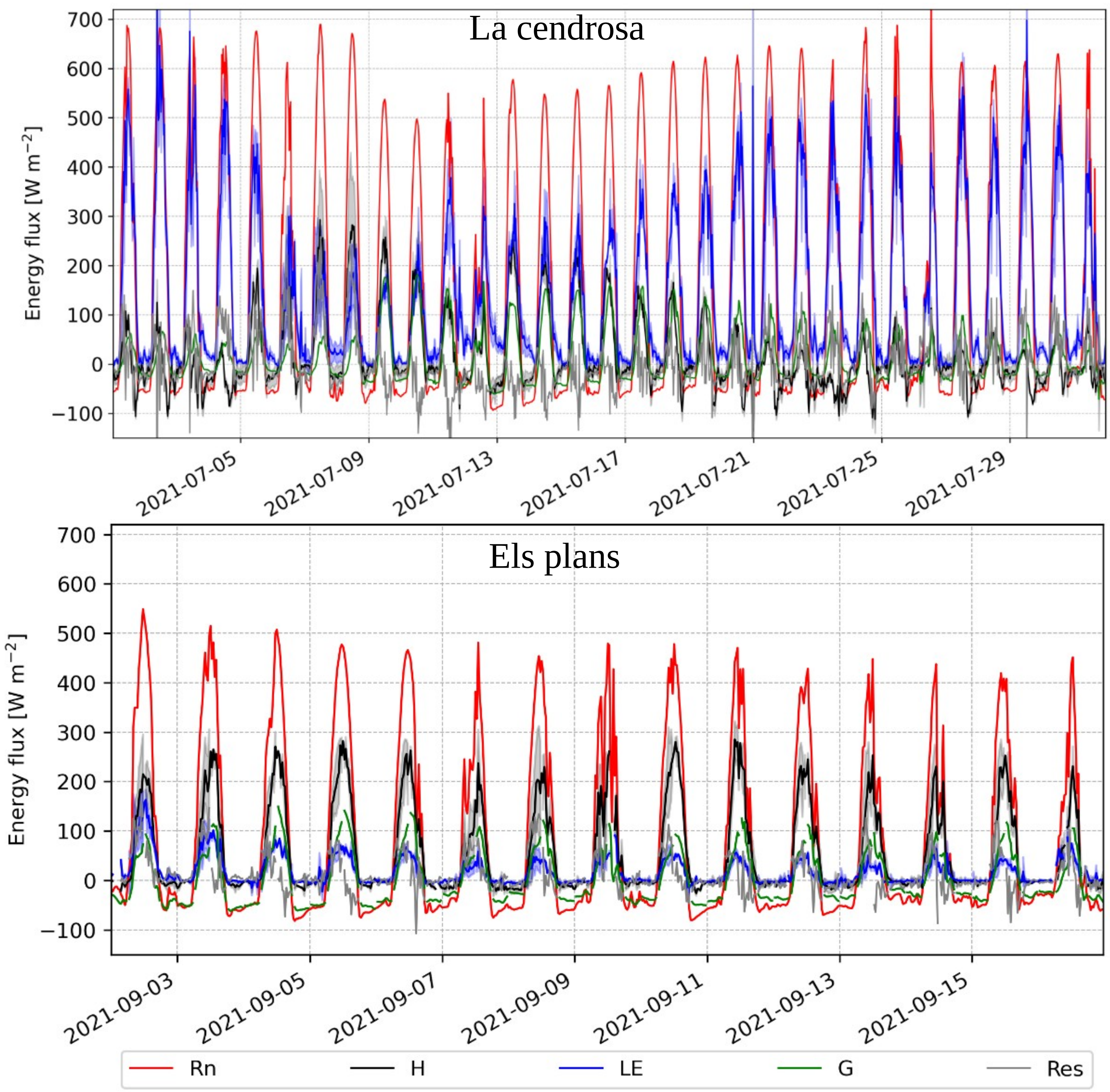
Simulated as C3 crop

Photos courtesy of G. Canut

Els Plans: a dry rainfed site

Simulated as Grass

Surface energy budget



- 4 terms observed to the energy budget with the residue

-Predominant flux depends on the presence or not of vegetation

-Closure is imposed in SURFEX and most LSM

Setting up the simulations

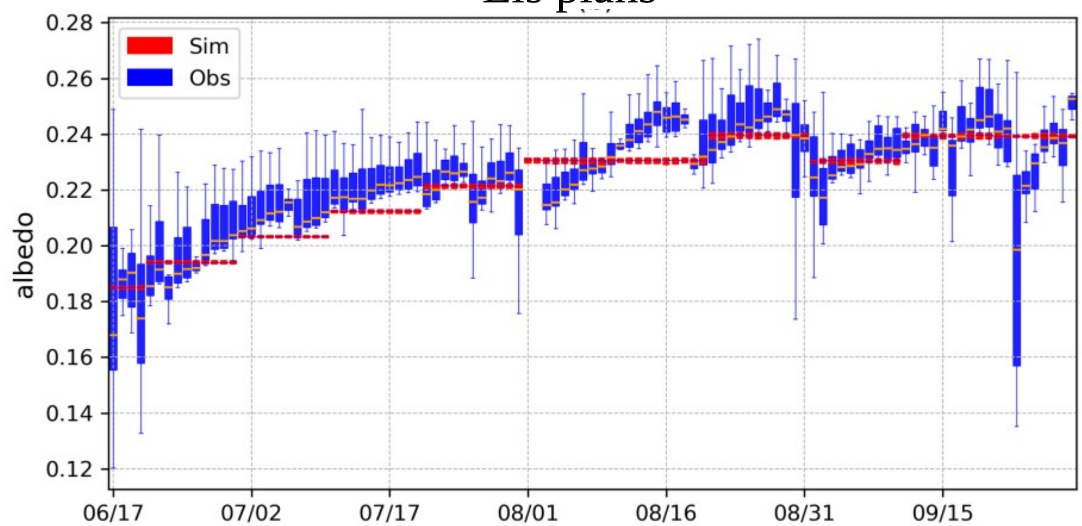
- Make forcing files
- Indicate properties of the site (albedo, z0, z0h, LAI, vegetation height, conductances, sand, clay,…)

La Cendrosa

Variable	symbol	units	default value	simulated value	tested range	literature range
Mesophylic conductance	g_m^*	$\mathrm{mm\,s^{-1}}$	0.001	0.005	0.0005-0.2	0.002-0.01
Cuticular conductance	g_c	$\mathrm{mm\,s^{-1}}$	0.00025	0.00025	0.00007-0.006	0.00007
Quantum efficiency	ϵ_0	$\mathrm{mg\,J^{-1}}$	0.017	0.0265	0.017-0.0265	0.017-0.0265
Maximum assimilation	A_{max}	$\mathrm{mg\,m^{-2}s^{-1}}$	2.2	3.02	1.4-3.02	1.4-3.02

- Indicate parameterizations to use (PTF, diffusive soil, A-gs…)
- Limits on temporal resolution

Els plans

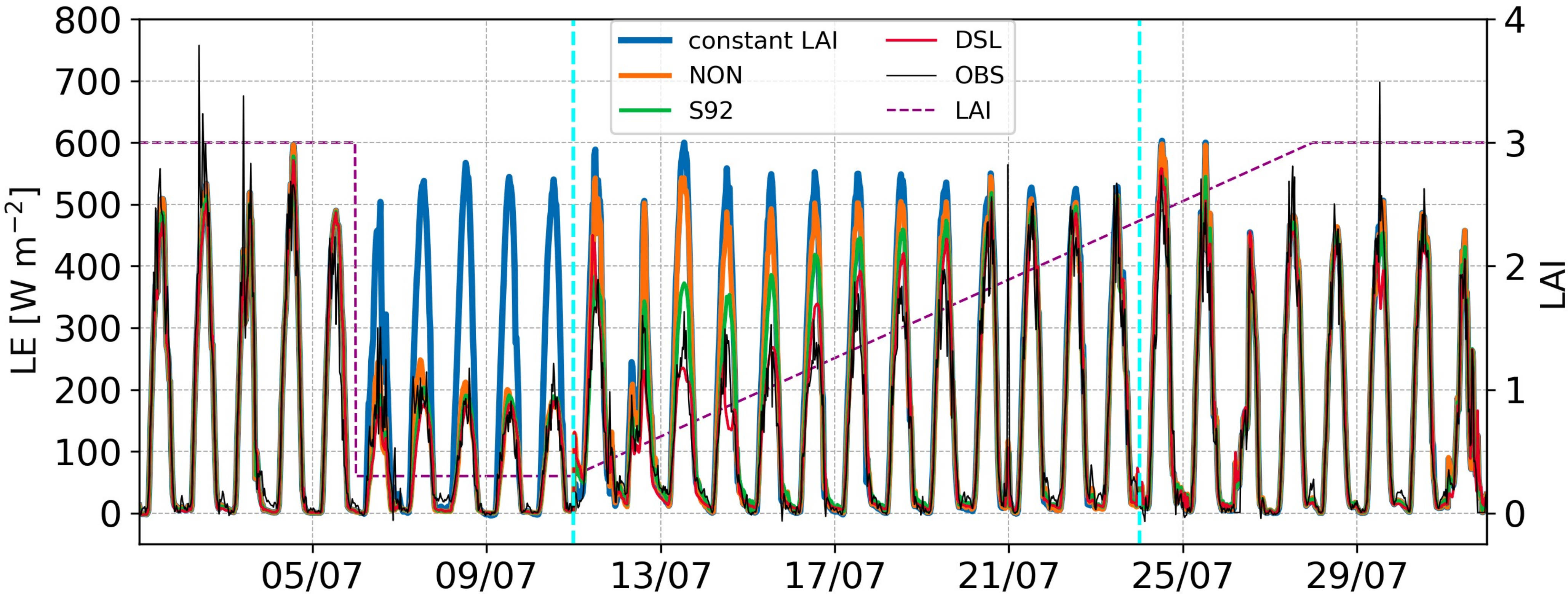


La Cendrosa : Alfalfa, periodically flooded site

Simulated as C3 crop

Photos courtesy of G. Canut

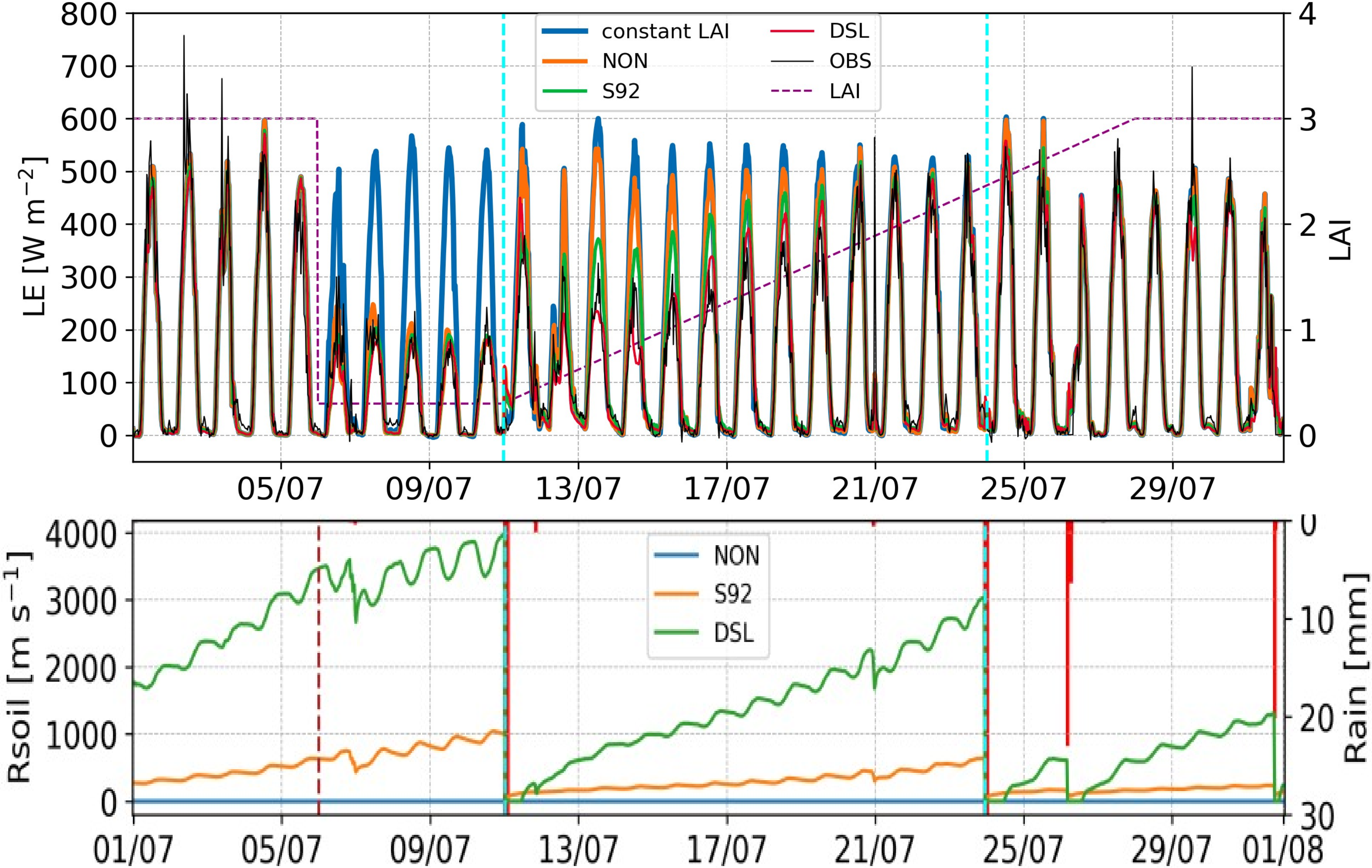
Irrigated site : Impact of growing vegetation



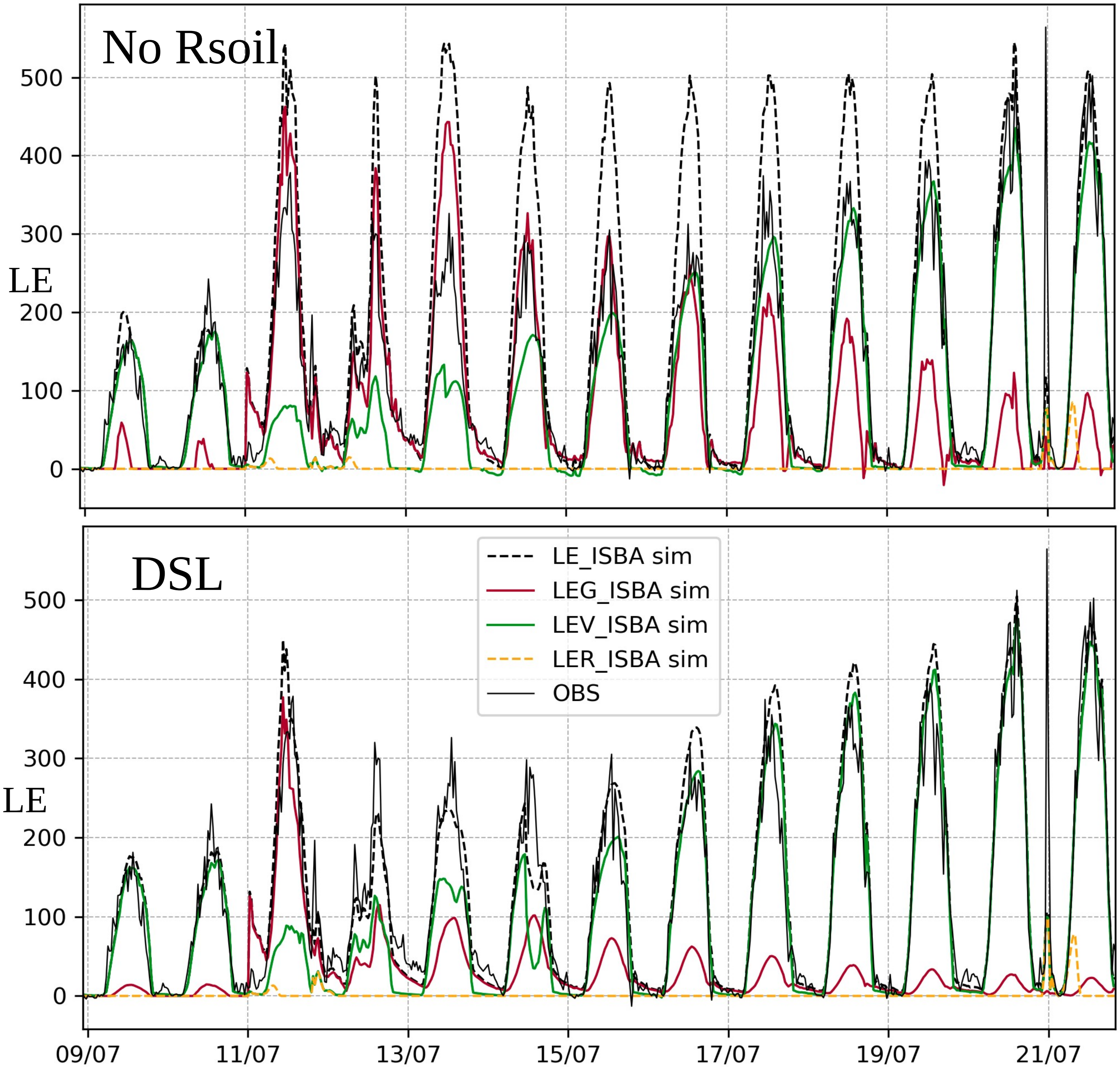
-LAI matching human intervention allows to match the transpiration component.

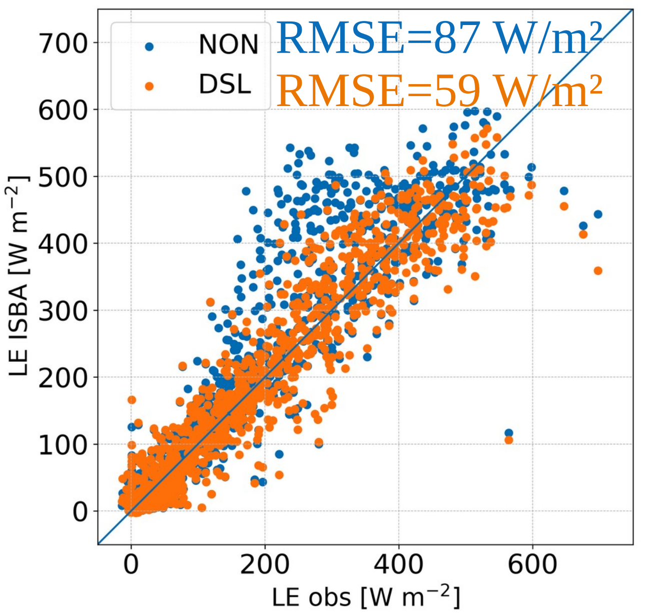
-Reduction of ET through a DSL captures the growth of the alfalfa.

Irrigated site : Resistance effect



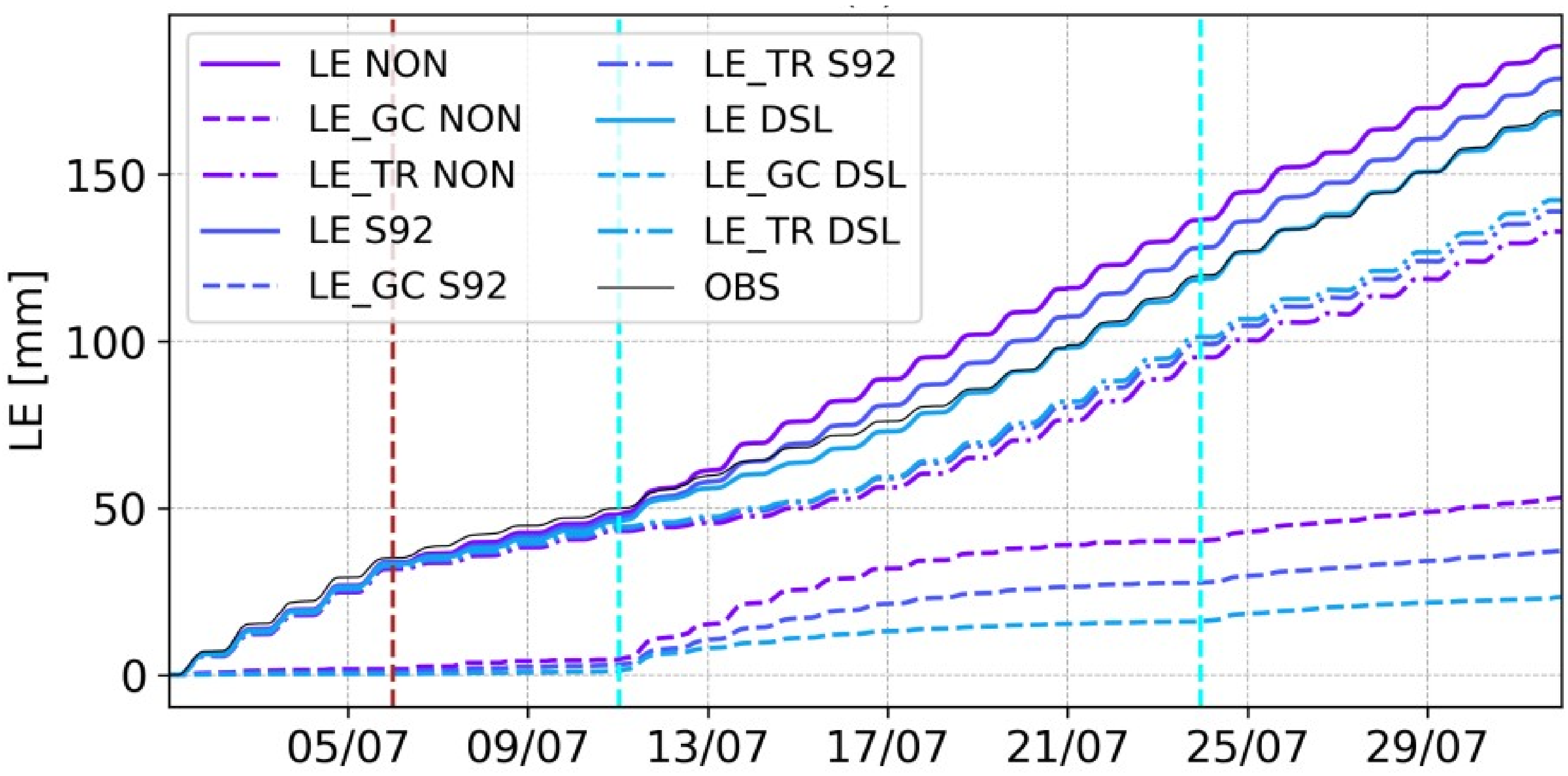
Irrigated site : transpiration and ground evaporation



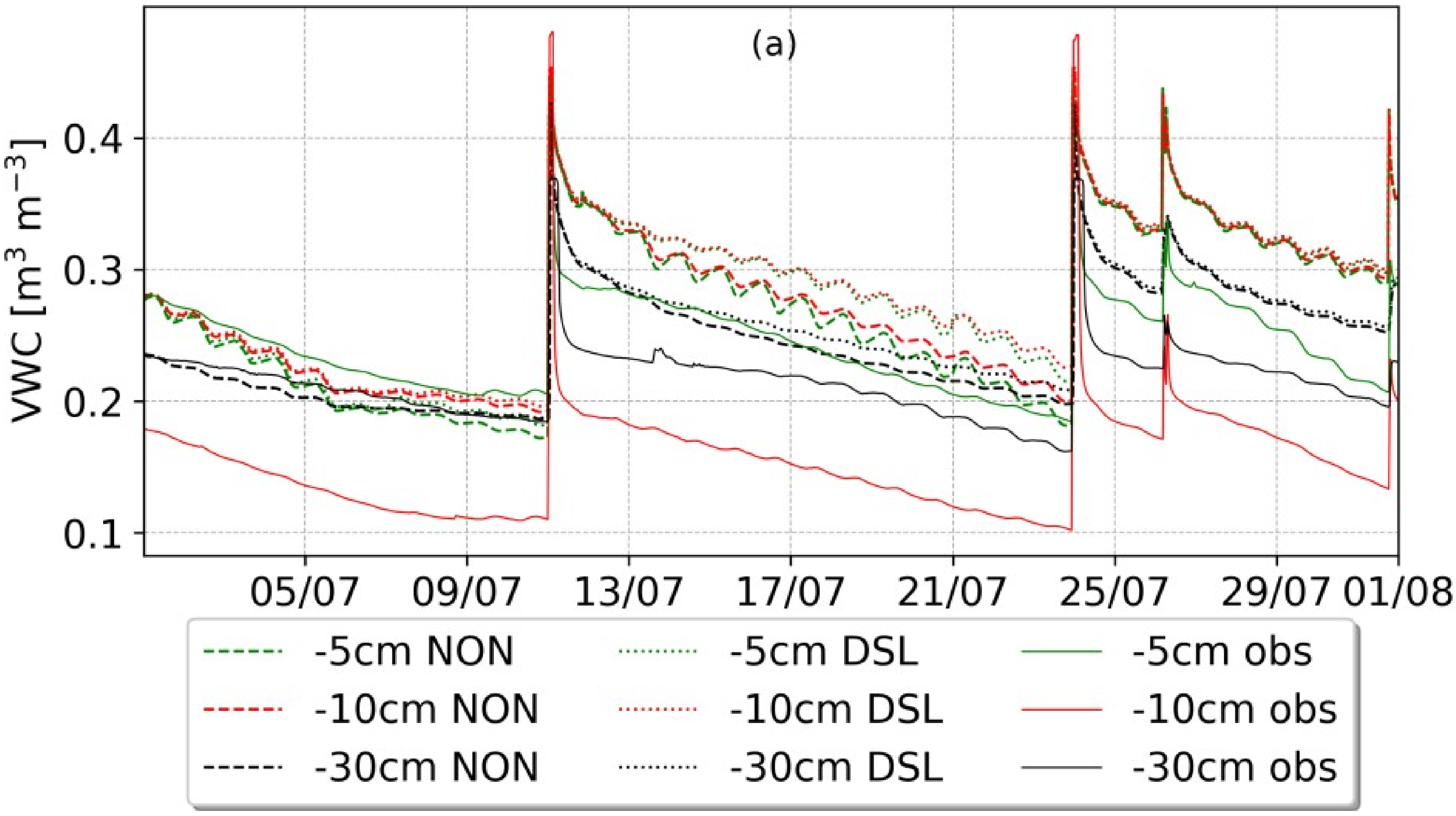


-After the DSL is applied the ground component of LE is well represented

Irrigated site :Transpiration/evaporation balance

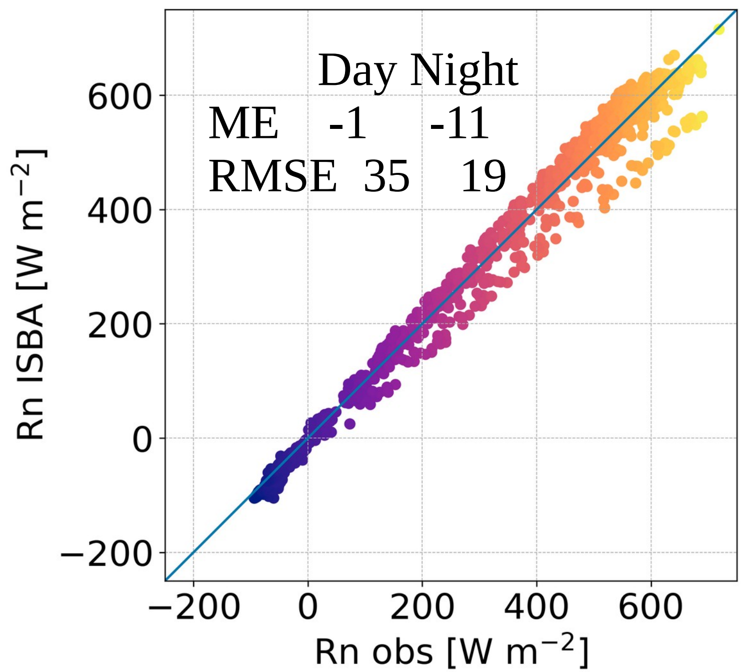


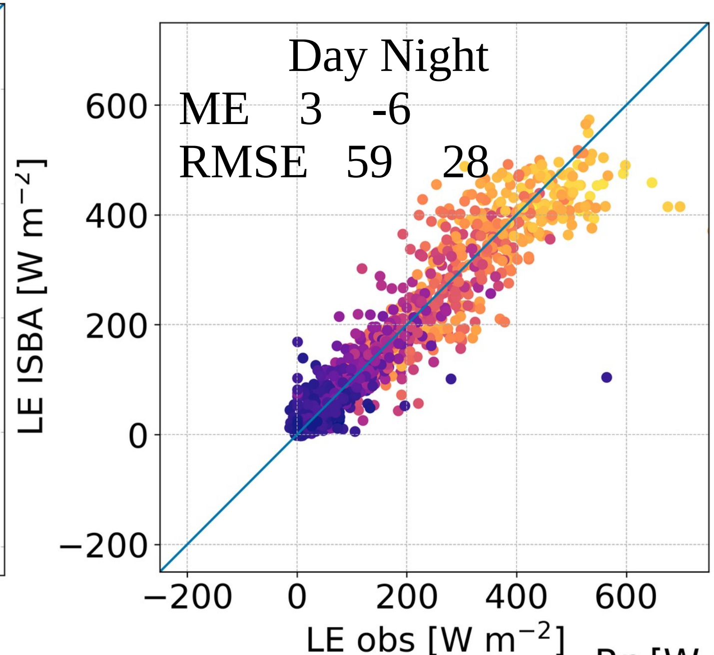
Irrigated site : VWC

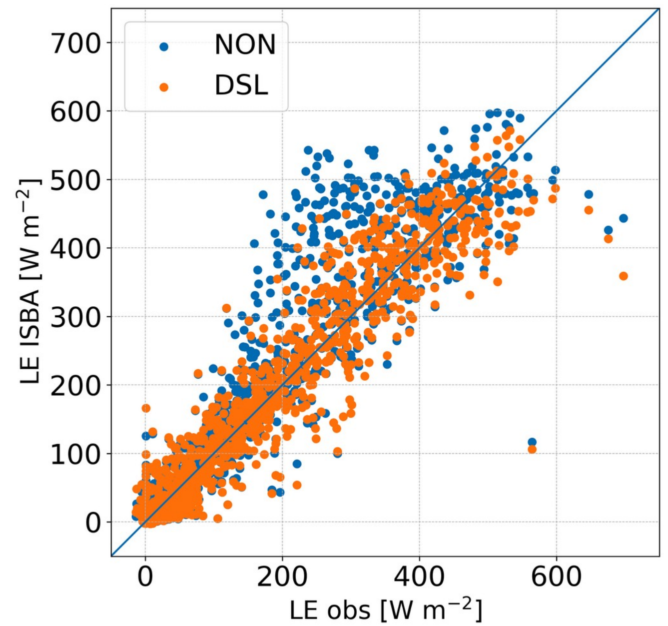


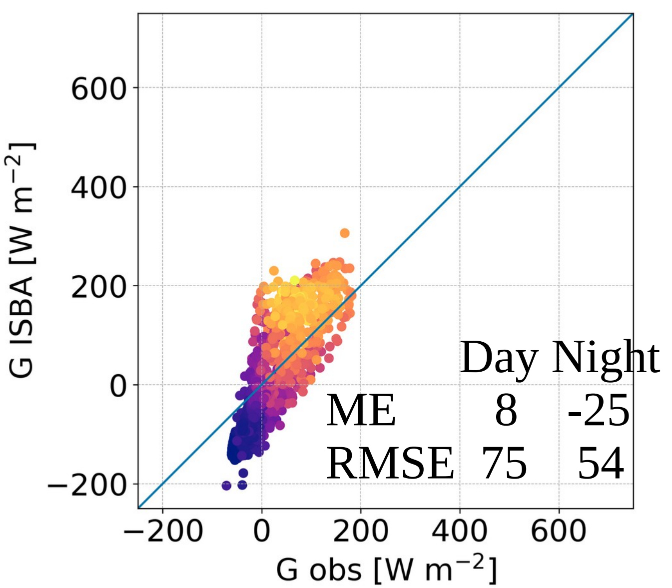
Less water is lost in the soil with the use of a resistance
Tendency improve but an offset is present in both simulations

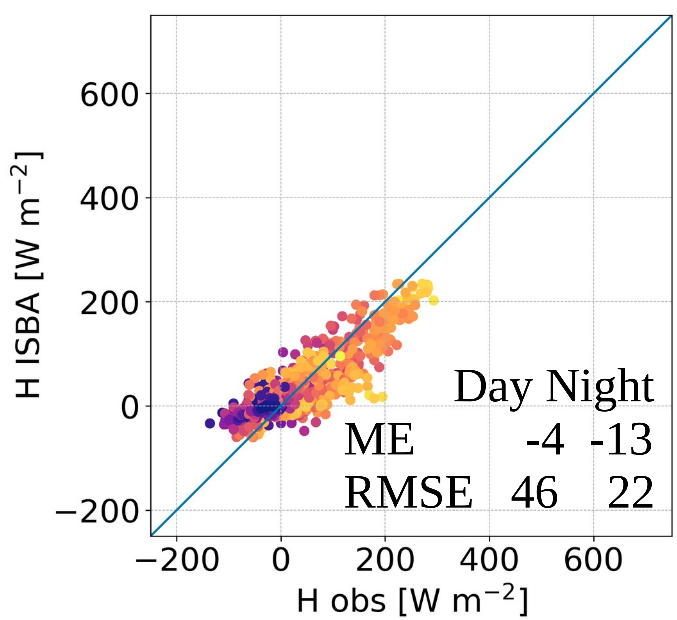
La Cendrosa : Balance of energy

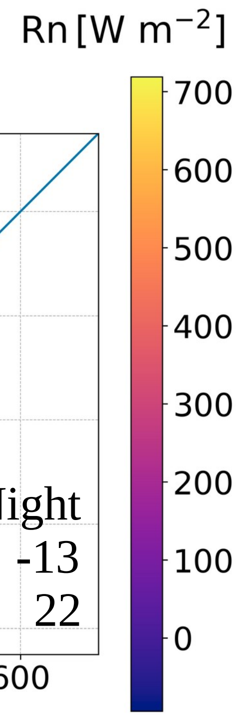












Residue	Day	Night
Mean	8	-9
SD	68	39

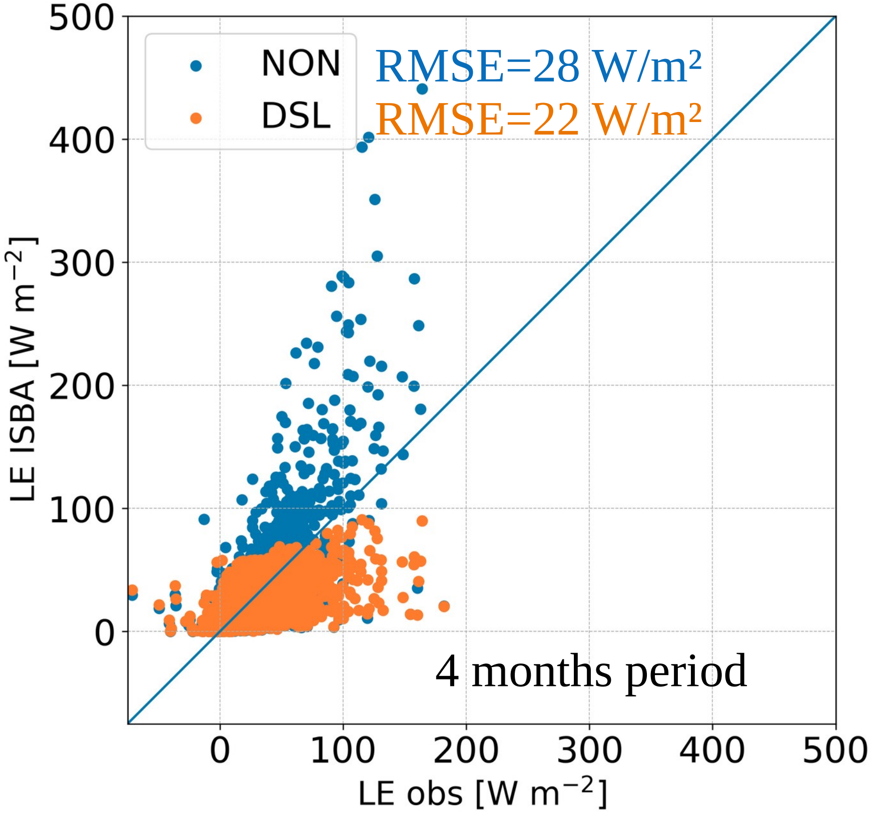
Els Plans: a dry rainfed site

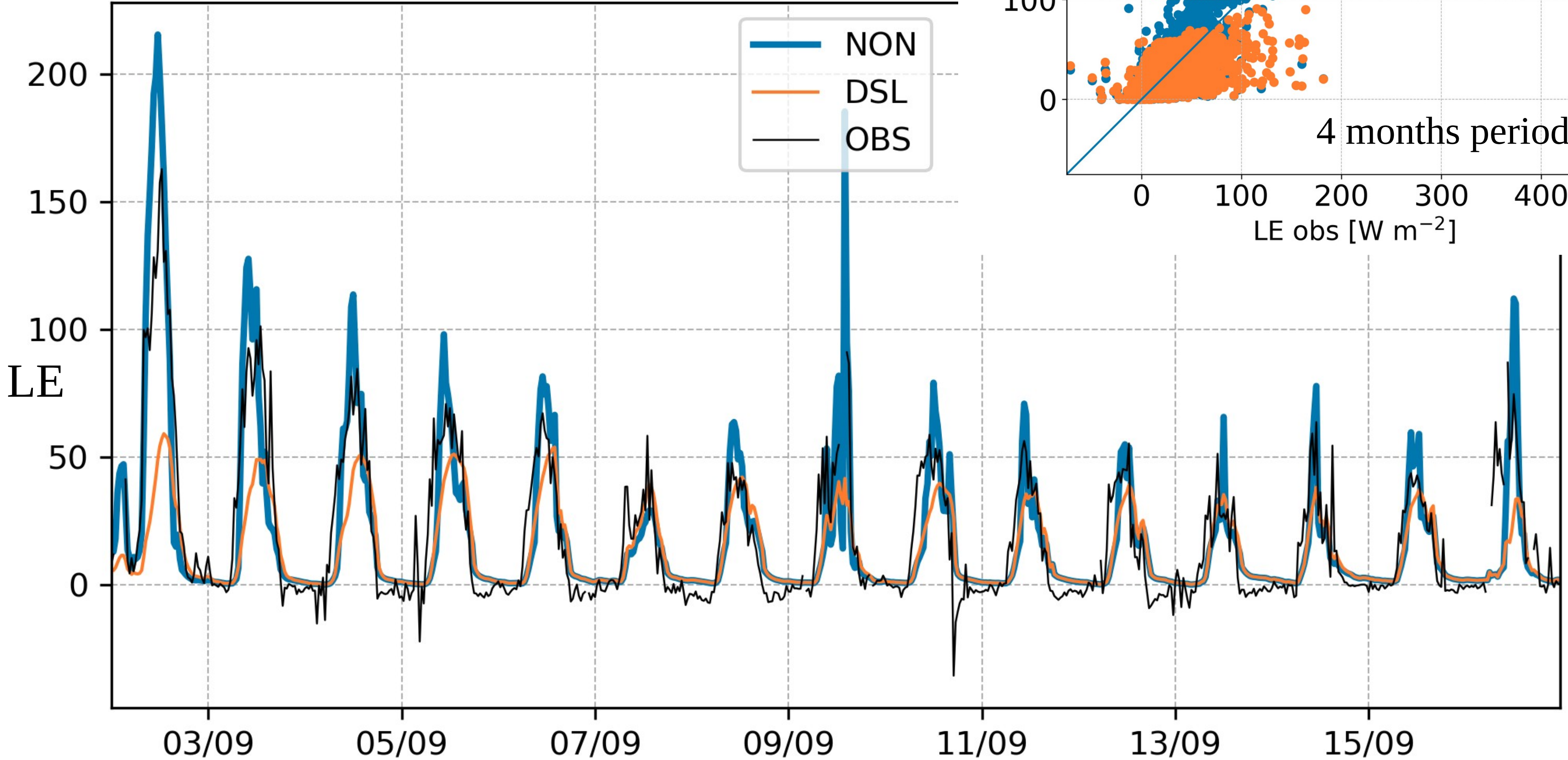
Simulated as Grass

Rainfed dry site: LE and Rsoil

-DSL improves the estimation of LE

-For dry down periods at Els Plans site the DSL results too dampening





Parameter sensitivity test of new Rsoil

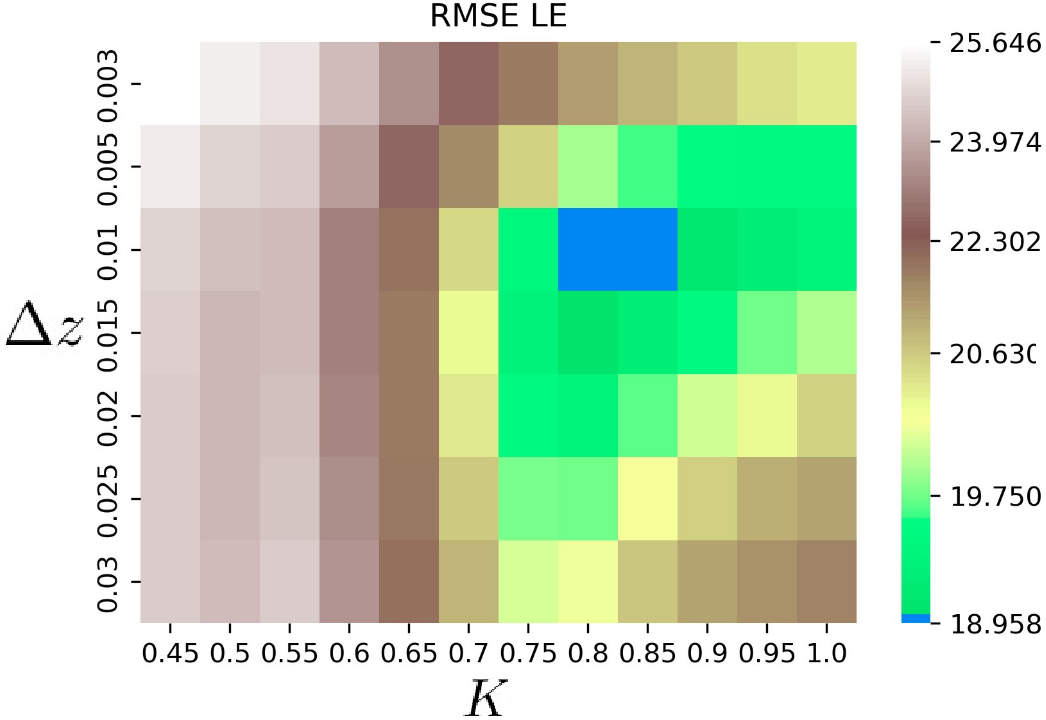
$$Rsoil = \frac{DSL}{D_\nu \tau} \qquad DSL = \begin{cases} \Delta z \frac{\theta_{dsl0} - \theta_{top}}{\theta_{dsl0} - \theta_{air}}, & \theta_{top} < \theta_{dsl0} \\ 0, & \theta_{top} \geq \theta_{dsl0} \end{cases}$$

$\theta_{dsl0} = K\Phi$

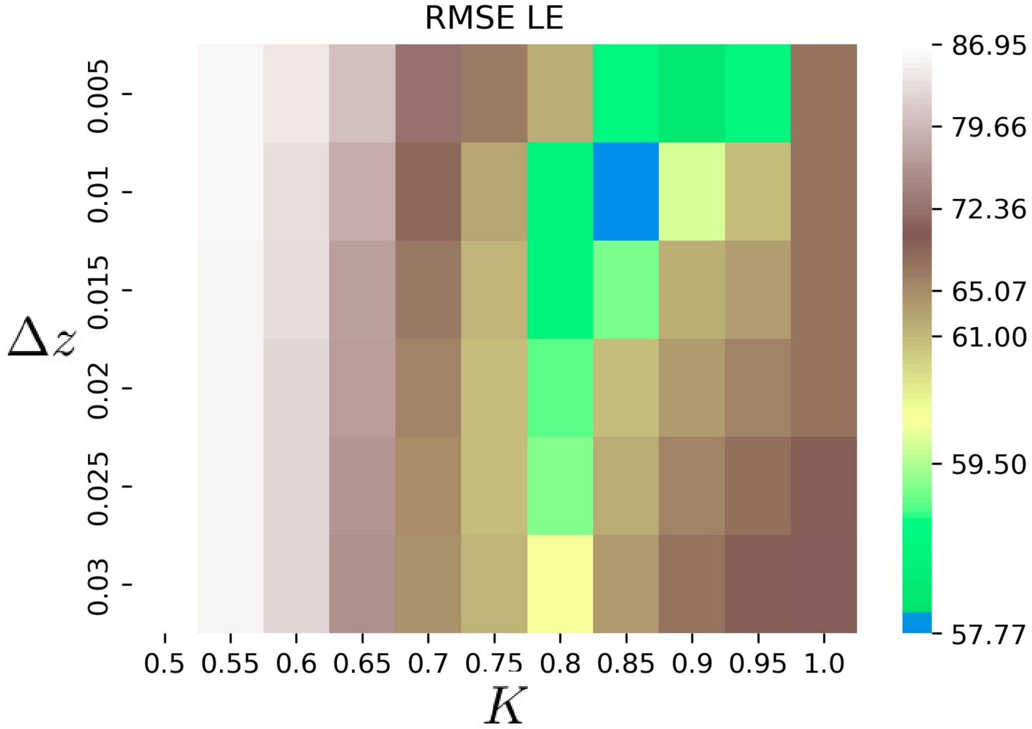
Φ: Porosity

CLM values : $\Delta z = 15$ mm $K = 0.8$

Rainfed dry site

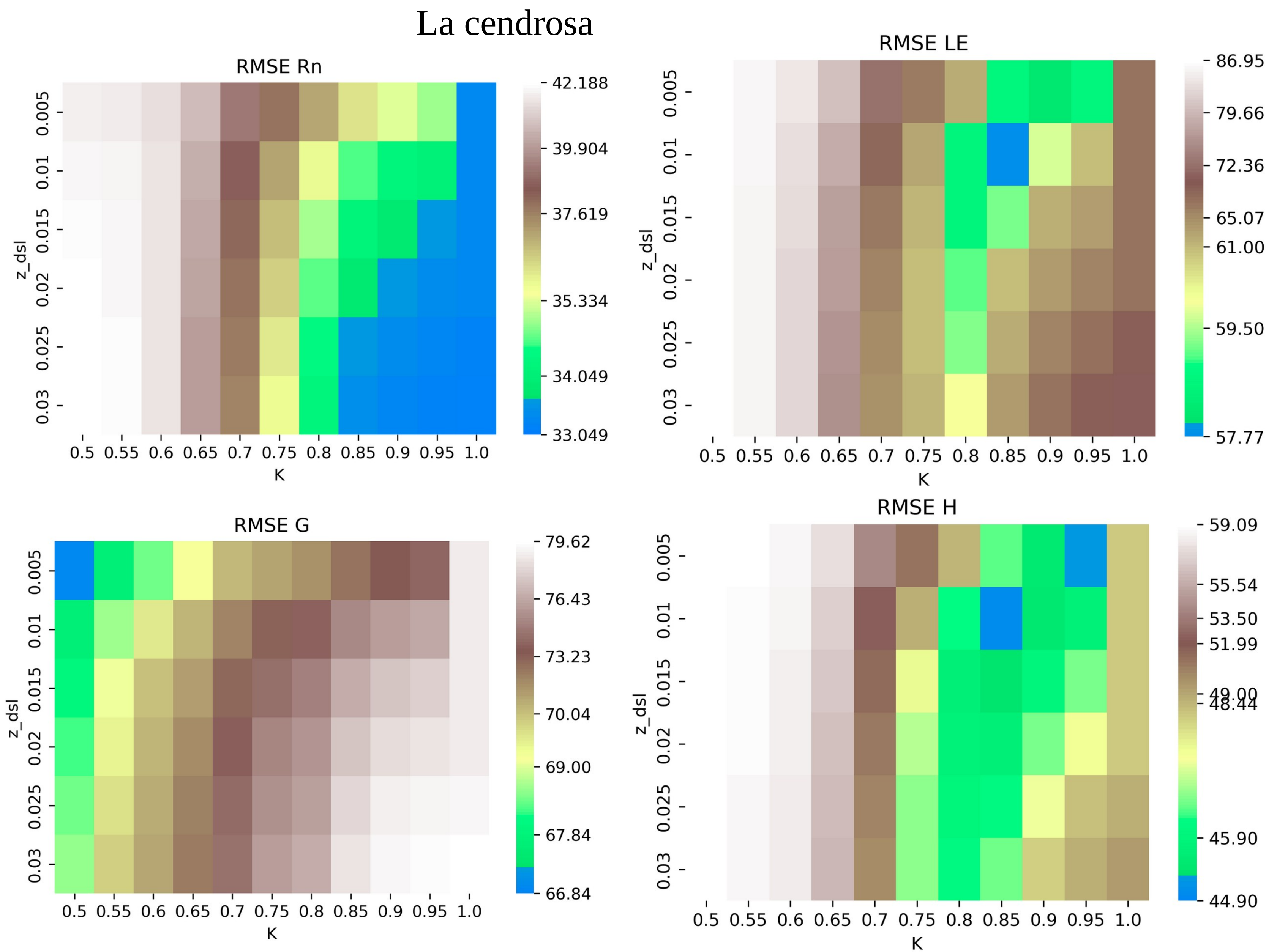


Irrigated site



Parameter sensitivity of Rsoil

- Effect is different in magnitude for each flux and may not be linear
- Drying periods are the most changed



Sensitivity test : correlations

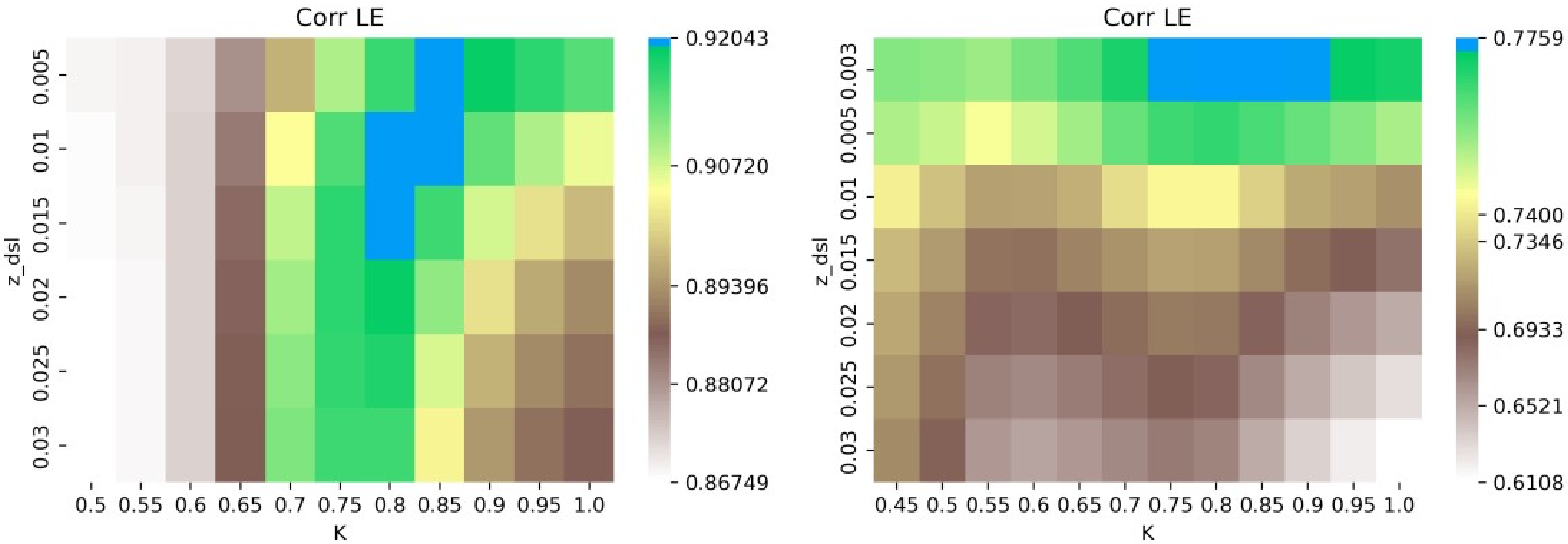


Fig. 17 Maps of correlation of LE for la cendrosa (right) and Els plans (left).

Conclusions

- The simulation of latent heat flux during periods of recharge with intense evaporation are overestimated in dry and humid conditions.

- The parameterization of a dry soil layer has been tested following Swenson and Lawrence 2014, finding improved results with the use of the soil resistance for both sites

- The alfalfa cycle growth cycle is well captured after LAI, irrigation and a dry surface layer are considered.

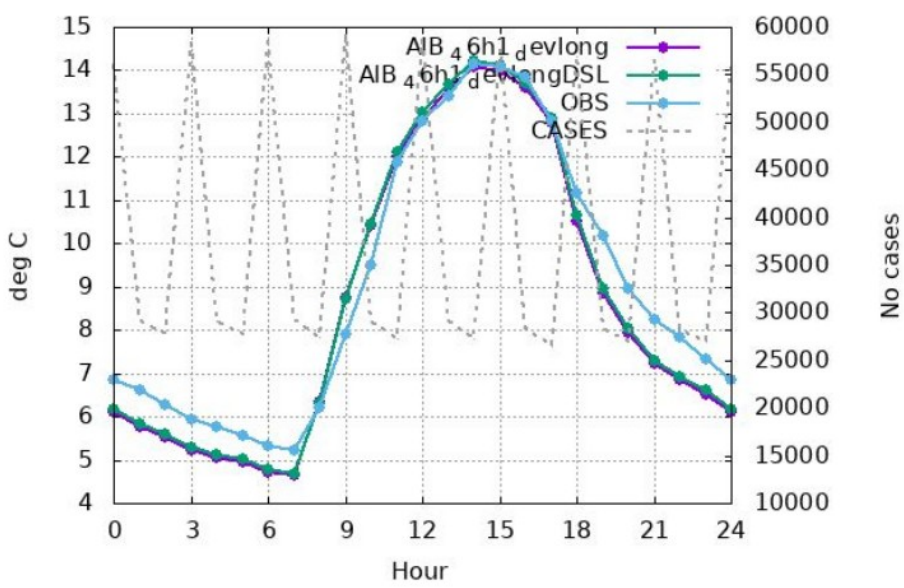
- The simulation of the dry rainfed site is improved although the DSL effect seems to be inferior than in the irrigated site.

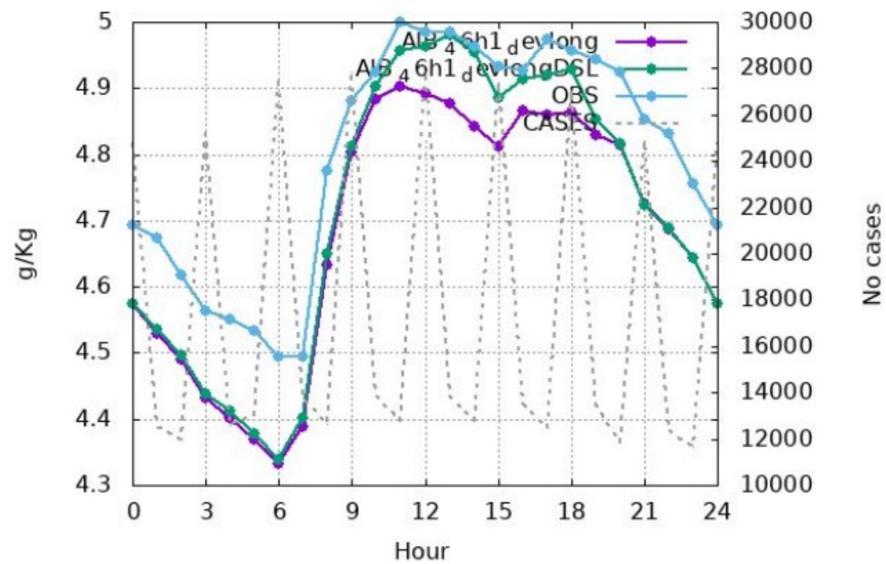
DSL Article in preprint at GMD journal:
https://egusphere.copernicus.org/preprints/2025/egusphere-2025-1783/
Implementation of a dry surface layer soil resistance in two contrasting semi-arid sites with SURFEX-ISBA V9.0

Parallel projects

- Test (winter) of the DSL on Harmonie with the Aemet (Samuel Viana)

  - Slightly hotter and more humid





- Study of the other sites with a master student (April- Sept)
- Intercomparison with LSM JULES (UK Metoffice)

Acknowledgements

ANR project HILIAISE

D. Martinez-Villagrasa, J. Cuxart, J. Price and G. Canut for the data of the stations of Els Plans and La Cendrosa