Assessing A Dry Soil Layer Parameterization For Bare Soil Evaporation During The LIAISE Field Campaign With SURFEX-ISBA In Semiarid Environment

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Land surface **I**nteractions with the **A**tmosphere over the **I**berian **S**emi-arid **E**nvironment (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/

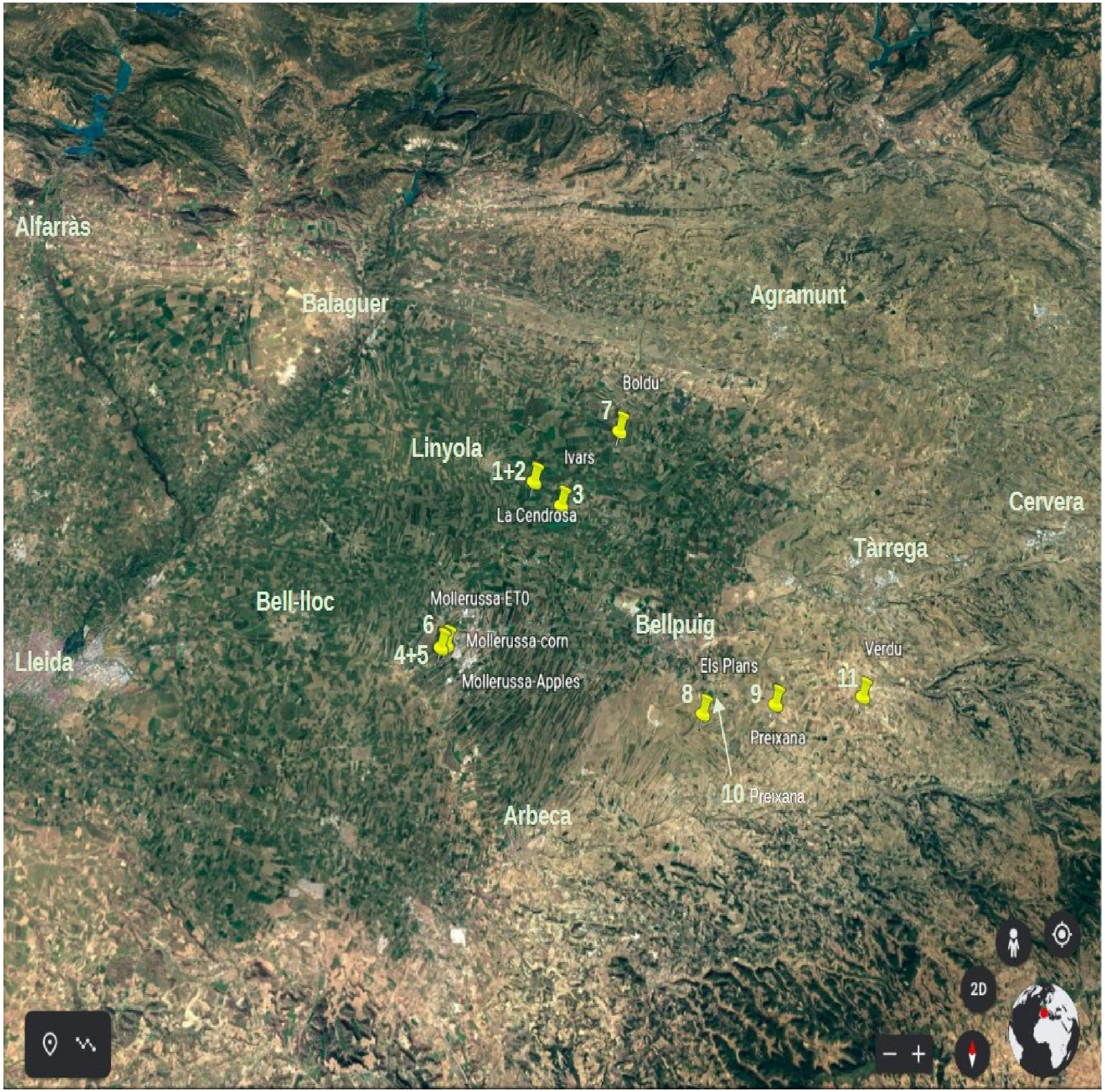
Scientific Questions

1. What are the key natural and anthropogenic semi-arid surface processes that modulate or control infiltration and runoff and **govern turbulent fluxes** and their spatial heterogeneity?

2. How does the highly heterogeneous (natural and anthropized) surface impact boundary layer development, mesoscale circulations and potentially precipitation recycling over this region via feedbacks with the atmosphere?

3. What is the sustainability of ground water and reservoirs in the face of expanding agricultural and farming activities, especially in light of projected future warming and drying over this region?

The LIAISE campaign



Some topics of study:

-Energy, water and carbon balances
-Evapotranspiration and sensible heat fluxes - P20
-Remote sensing applications and products
-Mesoscale applications: Model Intercomparison Marinada study – July 12th S11
-Offline simulations to characterize particular sites
- Flux-gradient relationships over a variety of surfaces - P23
- Nocturnal LE and condensation
-Irrigation & streamflow/discharge

Surfex-ISBA

- SURFEX: surface modeling platform by Météo-France
- ISBA scheme:

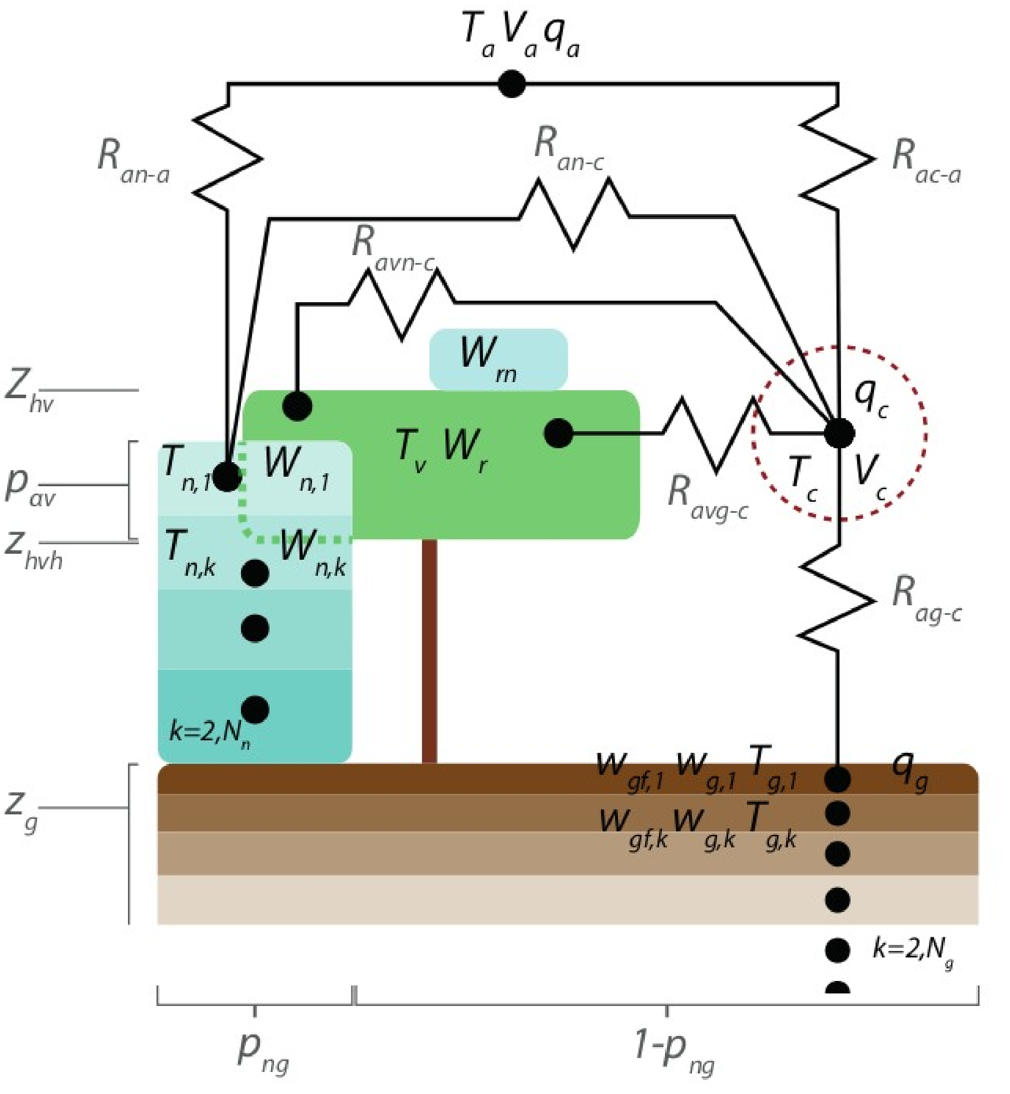
  - Exchanges of energy and water between soil-vegetation-snow and the atmosphere.

Within ISBA:

- Solved equations for canopy, ground and vegetation

- **MEB scheme** resolves independently vegetation and canopy

- Multiple layers of soil



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

Why add a soil resistance?

- Models overestimation on ET on semiarid environments

  (15 % of land surface)

  CLM, CABLE, ISBA

- Land surface models validated outside semiarid areas, worse representation du to missing processes and lack of characterization

- 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 transport differences

  → Use of a soil resistance

Soil evaporation

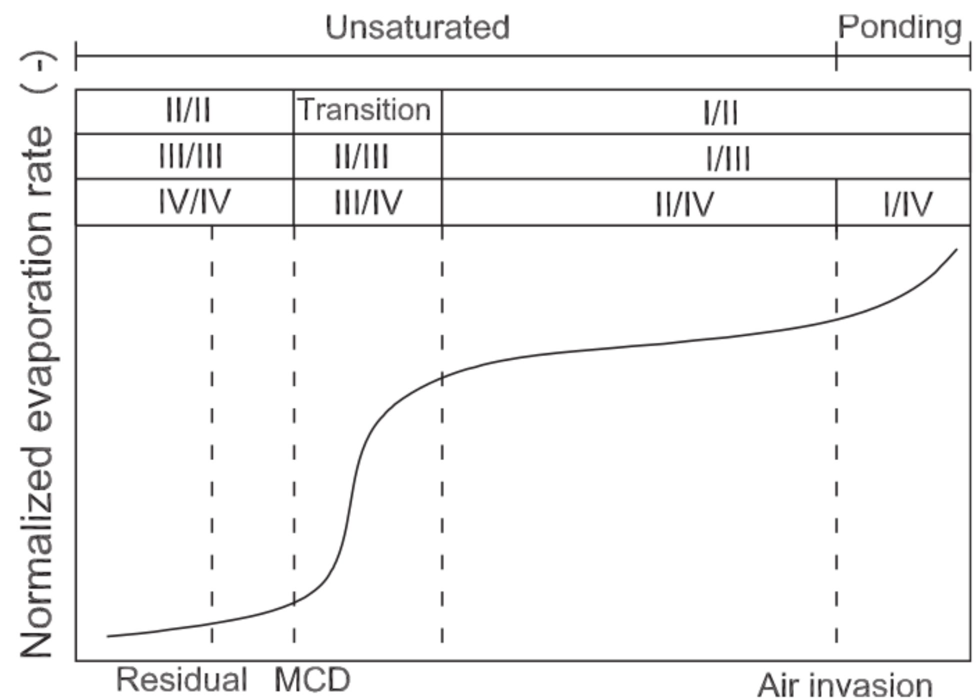


Figure 1. Schematic illustration of the normalized evaporation rate from bare soil without external water supply [e.g., *Le Bray and Prat*, 1999; *Yiotis et al.*, 2004]. Four stages are identified: stage I, the initial drying period; stage II, the constant rate period; stage III, the fast falling rate 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

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

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

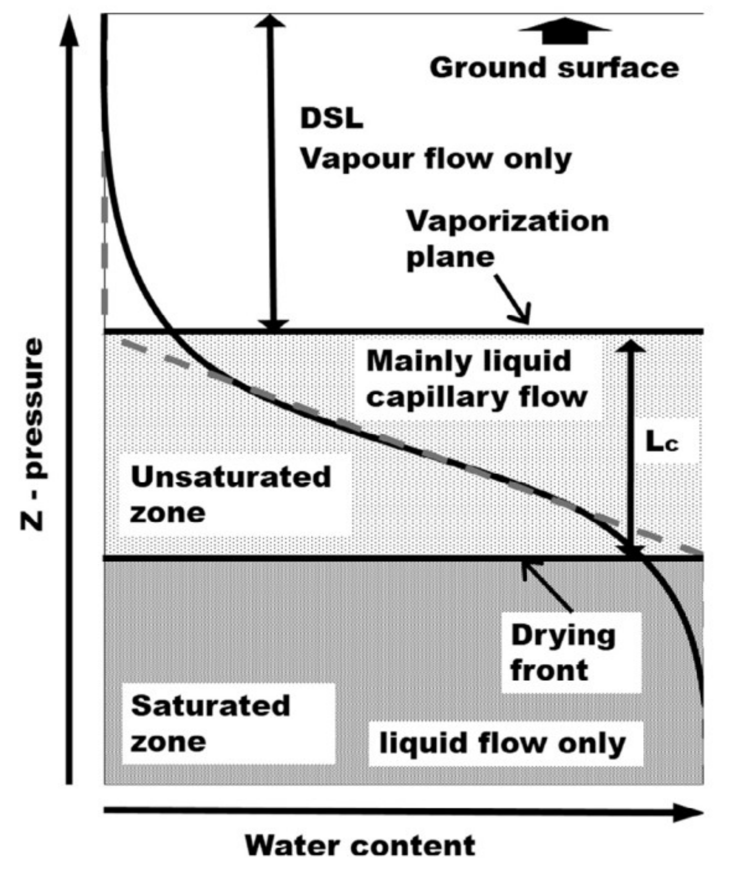
Sellers et al. (1992)

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

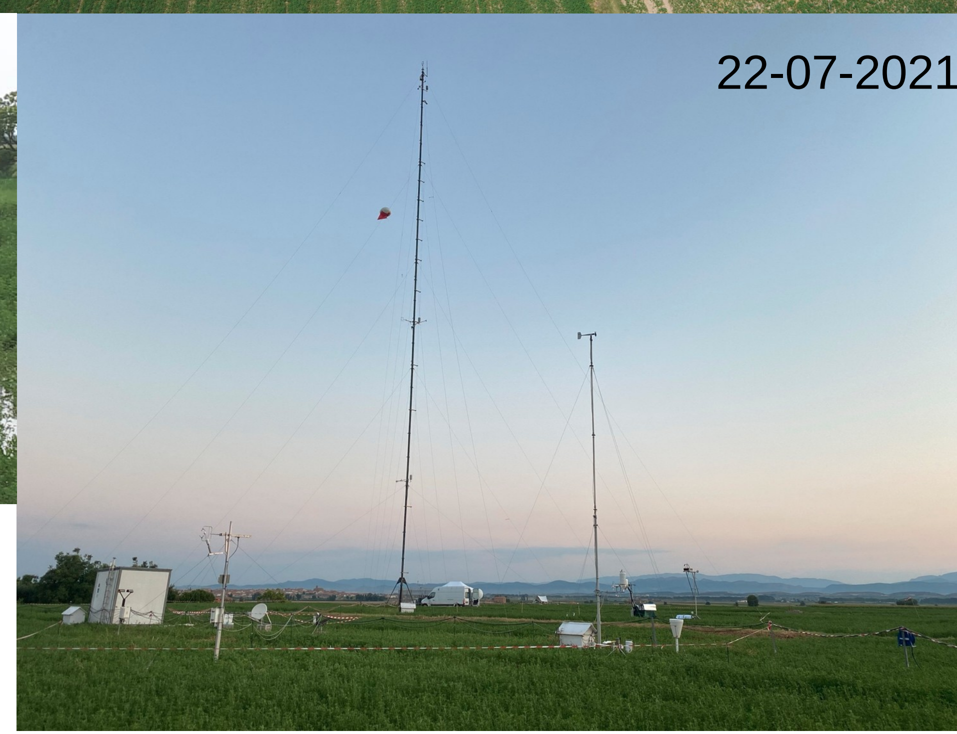
Φ: Porosity

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

Swenson and Lawrence (2014)



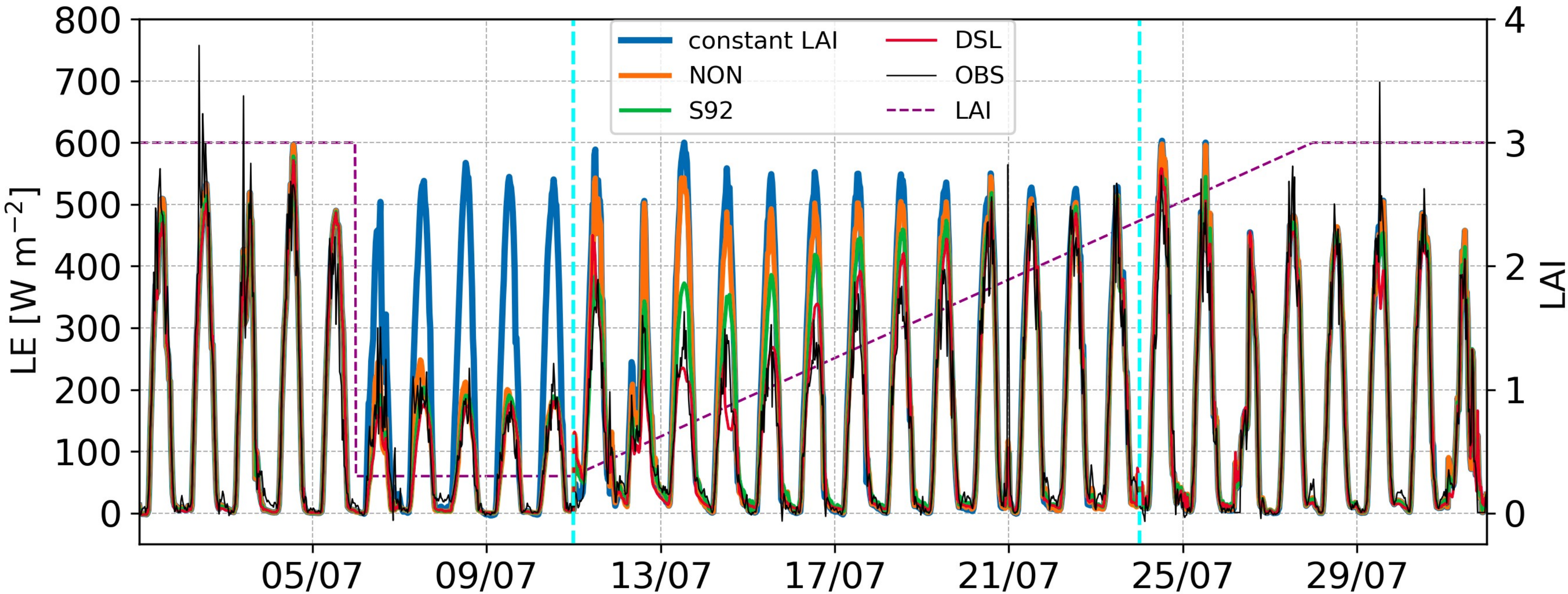
La Cendrosa : Alfalfa, periodically flooded site



Simulated as C3 crop

Photos courtesy of G. Canut

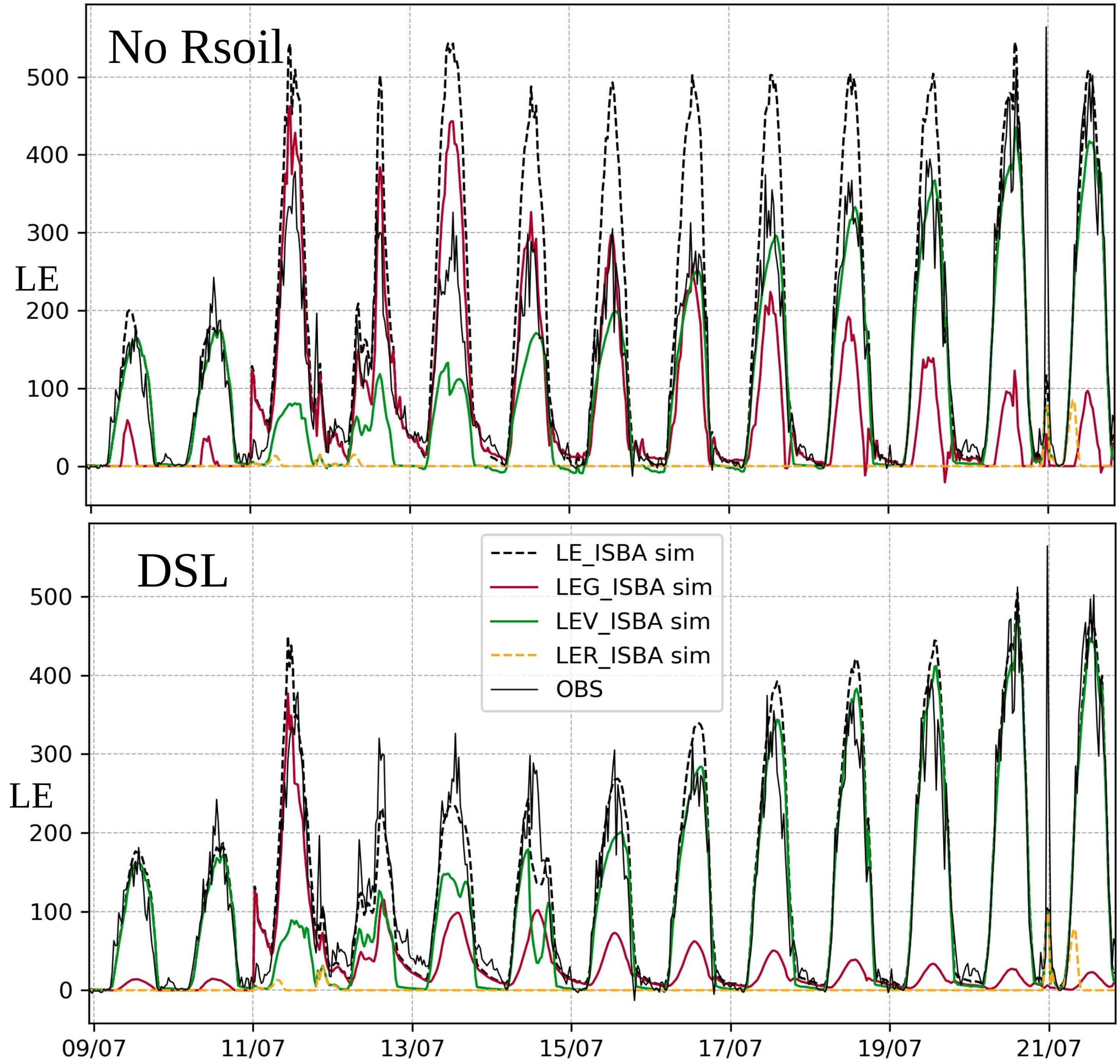
Irrigated site : Impact of growing vegetation

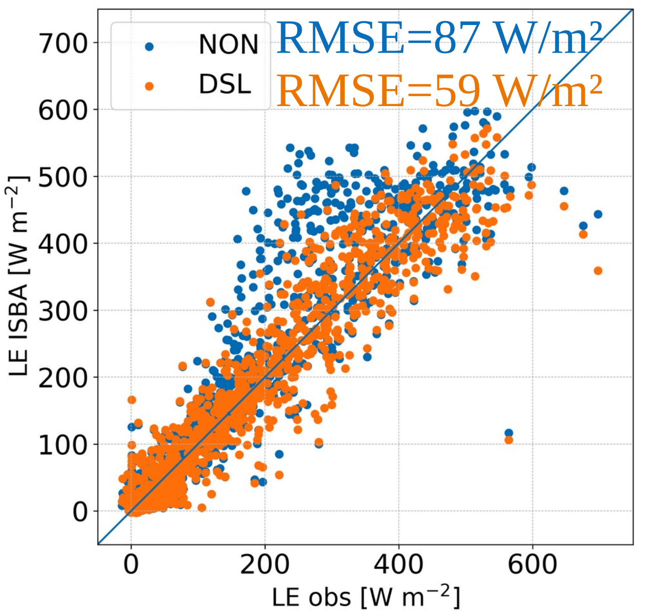


-LAI matching human intervention allows to match the transpiration component.

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

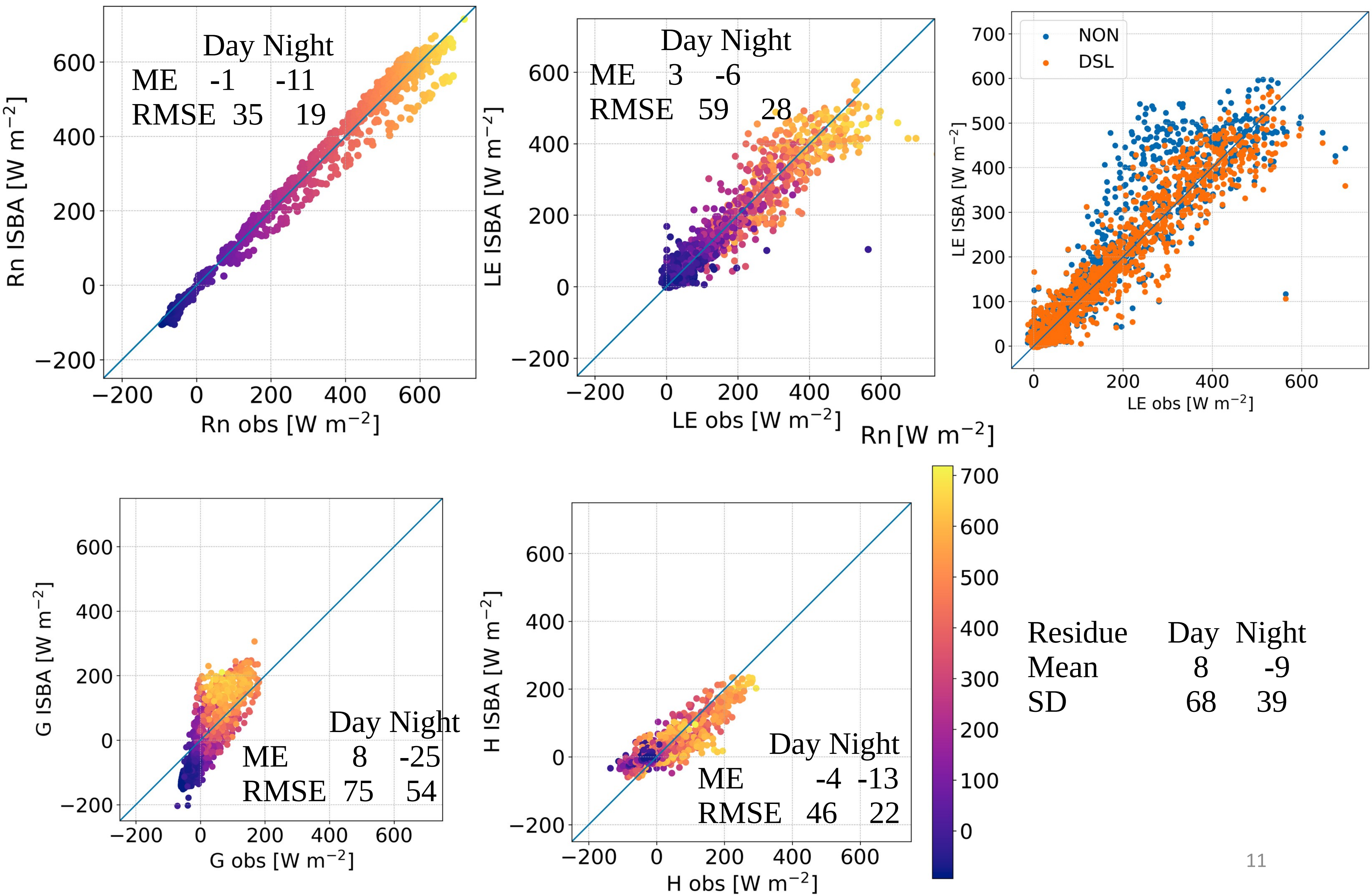
Irrigated site : transpiration and ground evaporation





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

La Cendrosa : Balance of energy



Residue	Day	Night
Mean	8	-9
SD	68	39

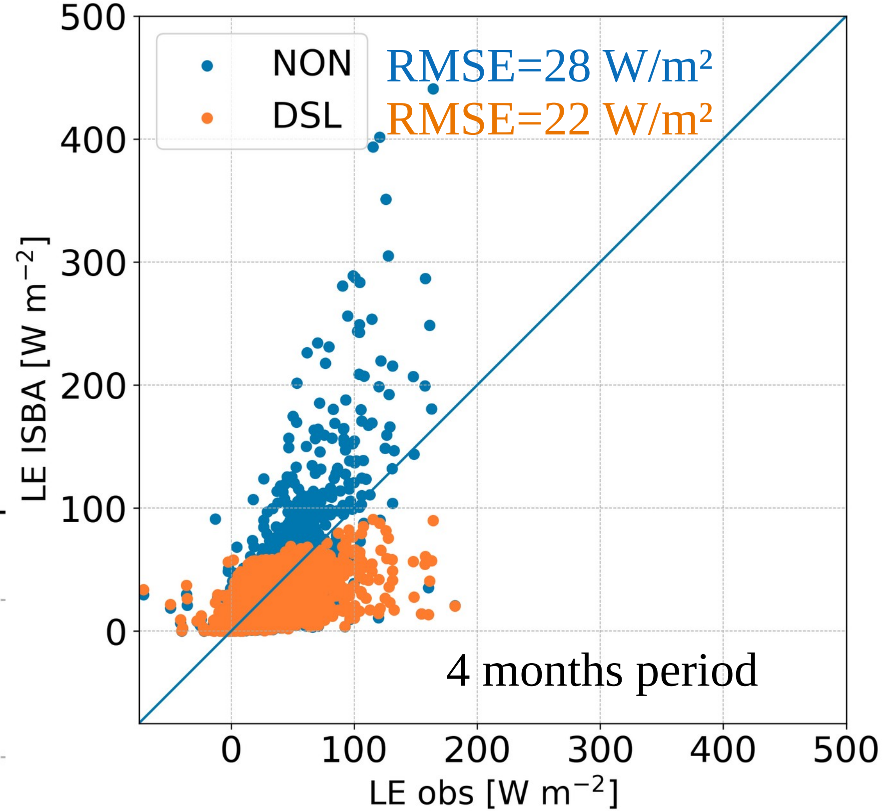
Els Plans: a dry rainfed site

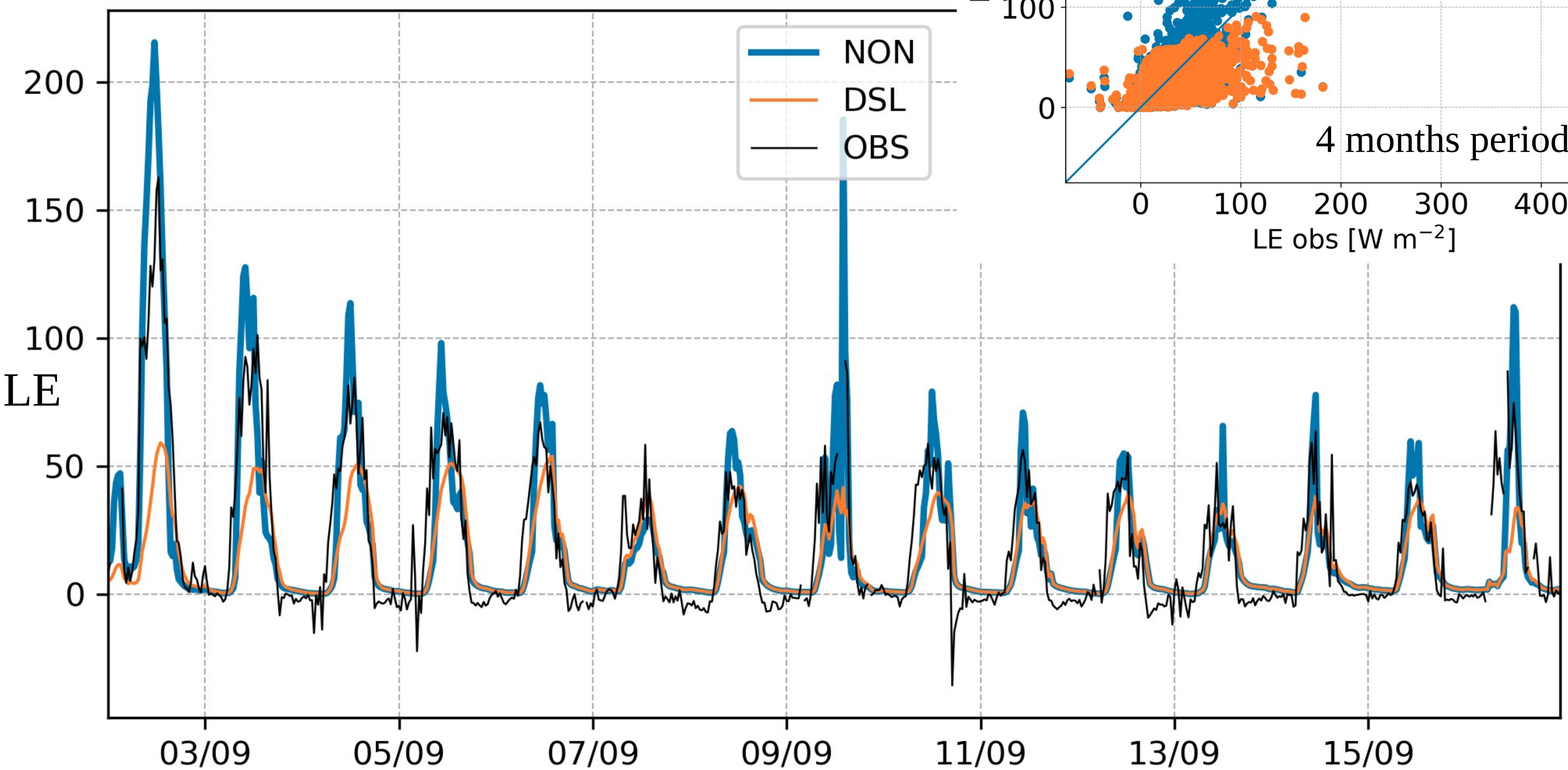
Simulated as Grass

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

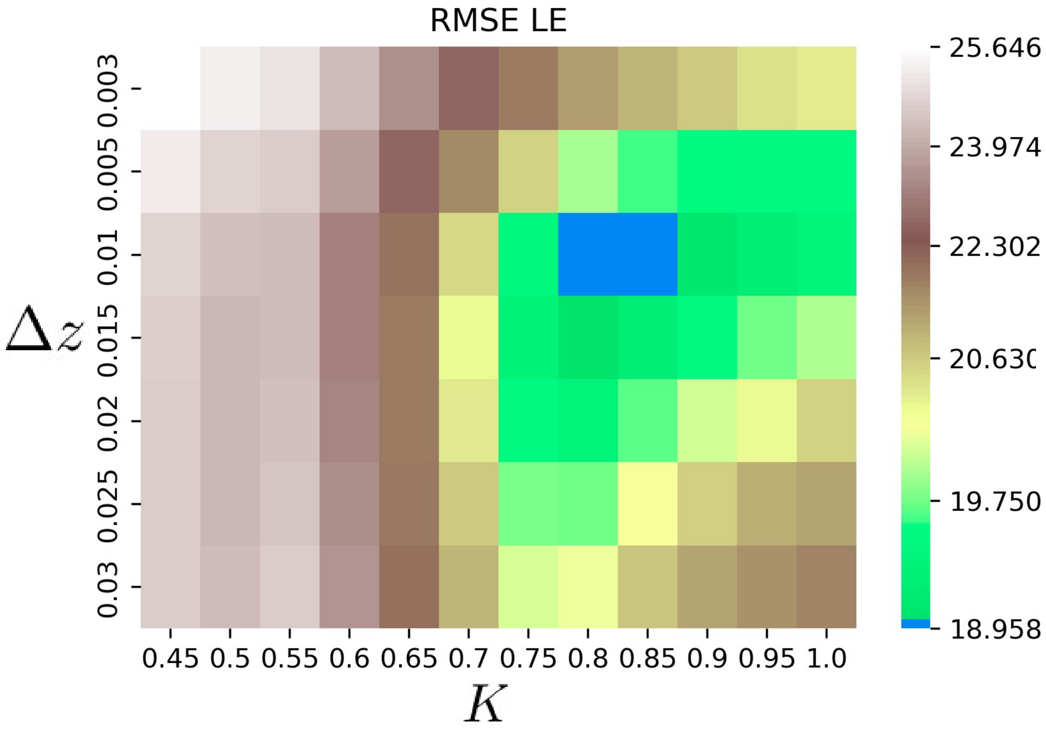
$$Rsoil = \frac{DSL}{D_\nu \tau} \qquad DSL = \begin{cases} \Delta z \frac{\theta_{dsl0} - \theta_{top}}{\theta_{dsl0} - \theta_{air}}, & \theta_{top} < \theta_{dsl0} \\ 0, & \theta_{top} \geq \theta_{dsl0} \end{cases}$$

$\theta_{dsl0} = K\Phi$

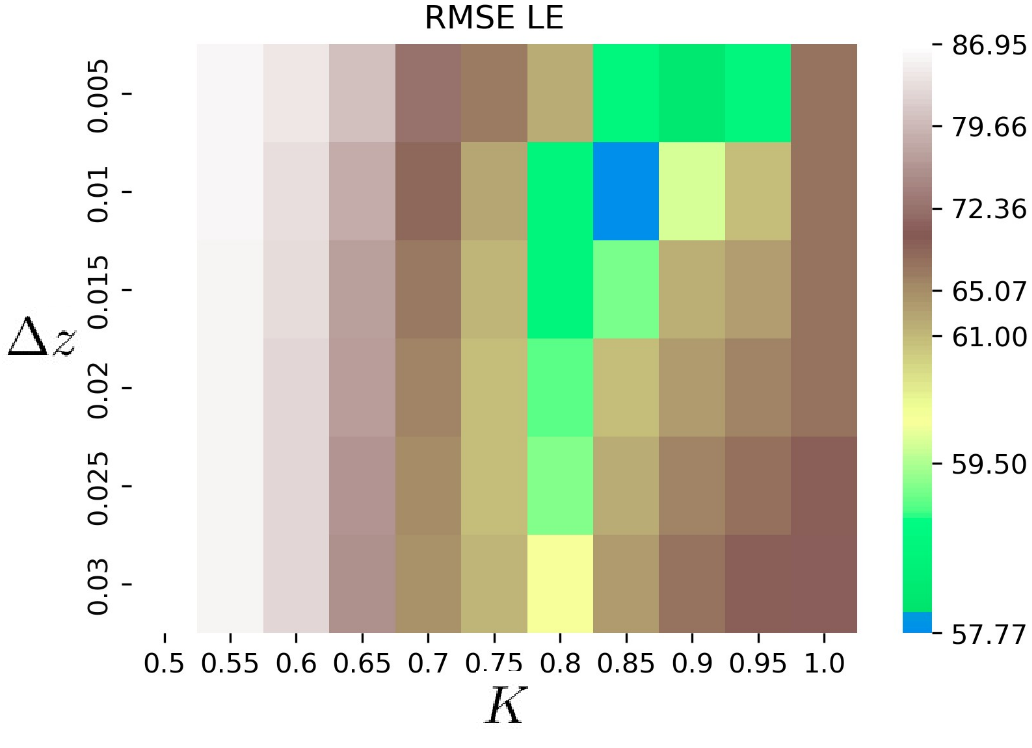
Φ: Porosity

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

Rainfed dry site



Irrigated site



Conclusions

- Study of semiarid environments is key for water loss assessment.

- 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

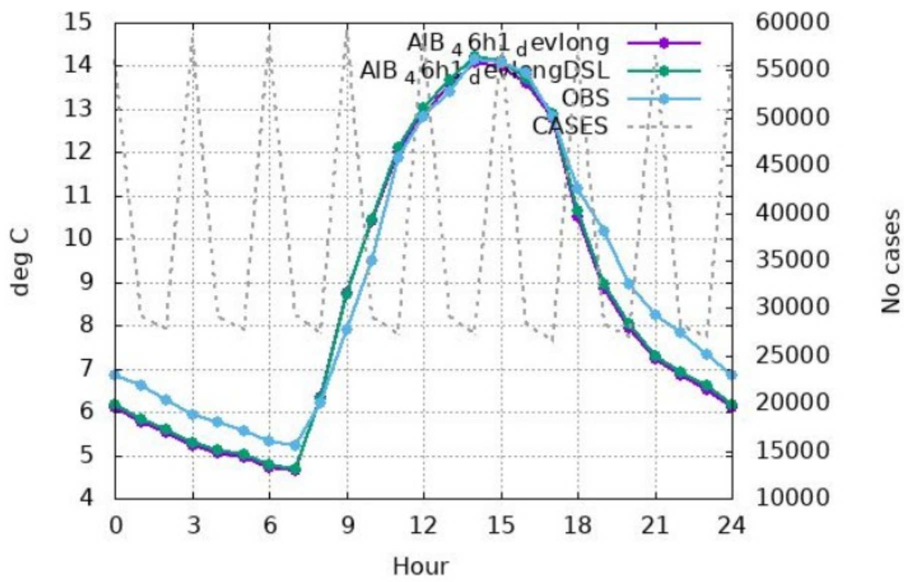
- The alfalfa cycle growth cycle is well captured after LAI, irrigation and a dry surface layer are considered.

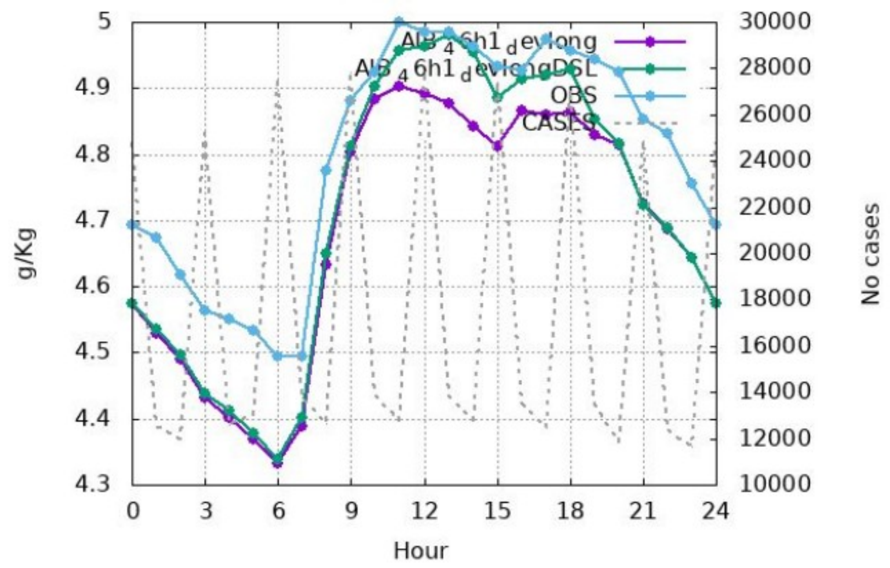
- The simulation of the dry rainfed site is improved although the DSL effect seems to be inferior than in the irrigated site.

Ongoing and future work

- DSL Article to be sent soon :
  Examining evapotranspiration partitioning at two contrasting semiarid sites
- Test (winter) of the DSL on Harmonie with the Aemet (Samuel Viana) within ACCORD

  - Slightly hotter and more humid





- Simulations offline with a larger domain and with GCM configuration
- Study of the other sites with a master student (April- Sept)
- Intercomparison with LSM JULES (UK Metoffice)

Acknowledgements

ANR project HILIAISE

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

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)

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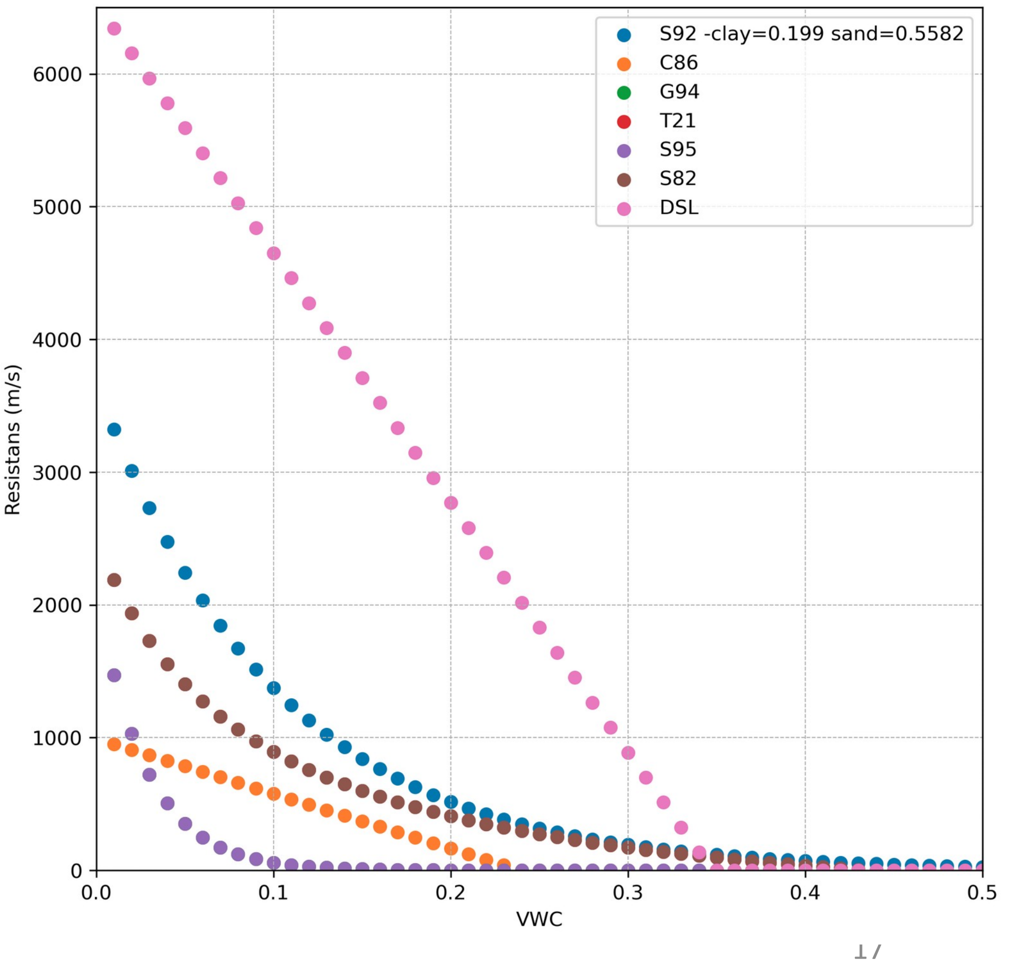
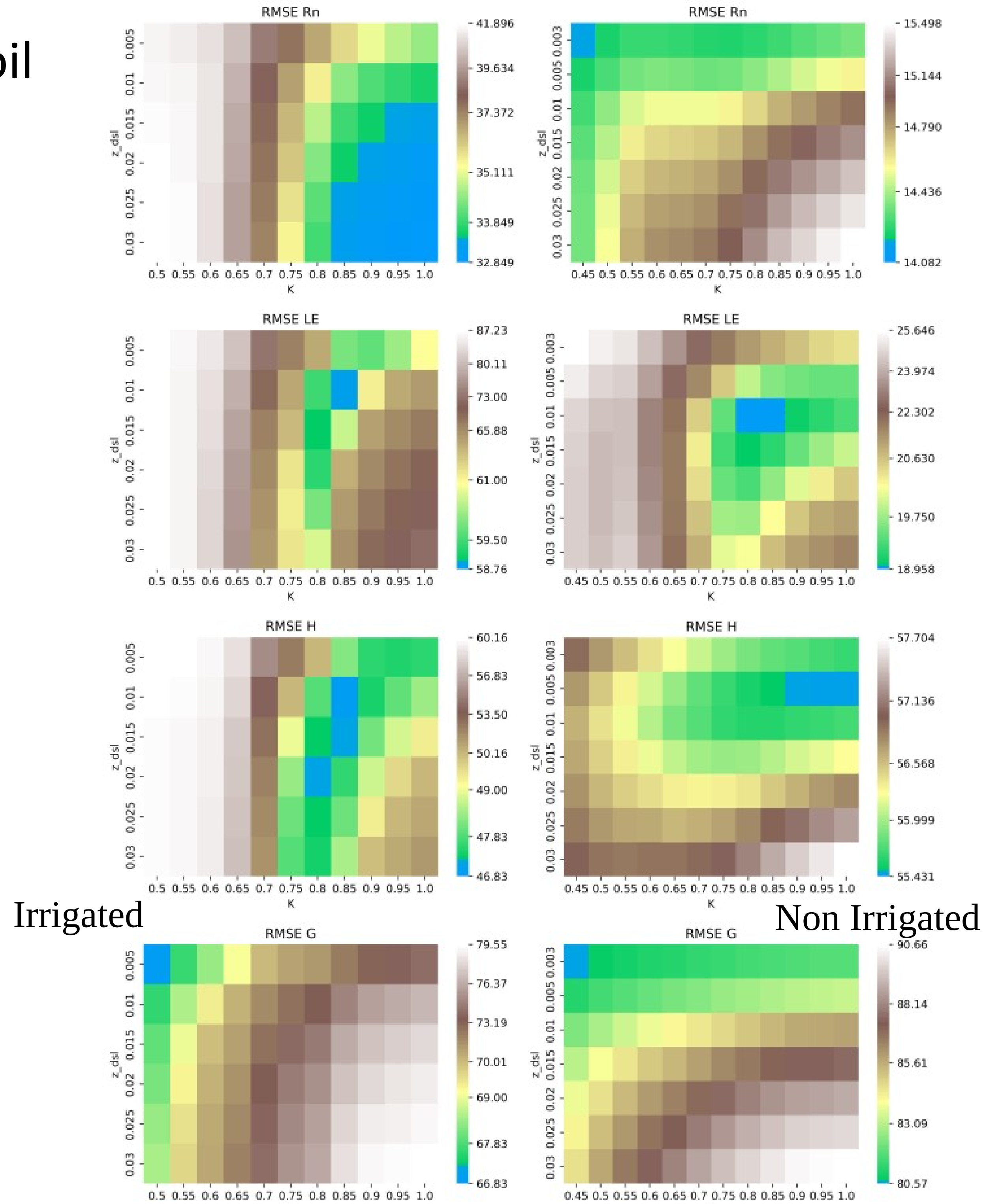


Parameter sensitivity of Rsoil

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



Sensitivity test : correlations

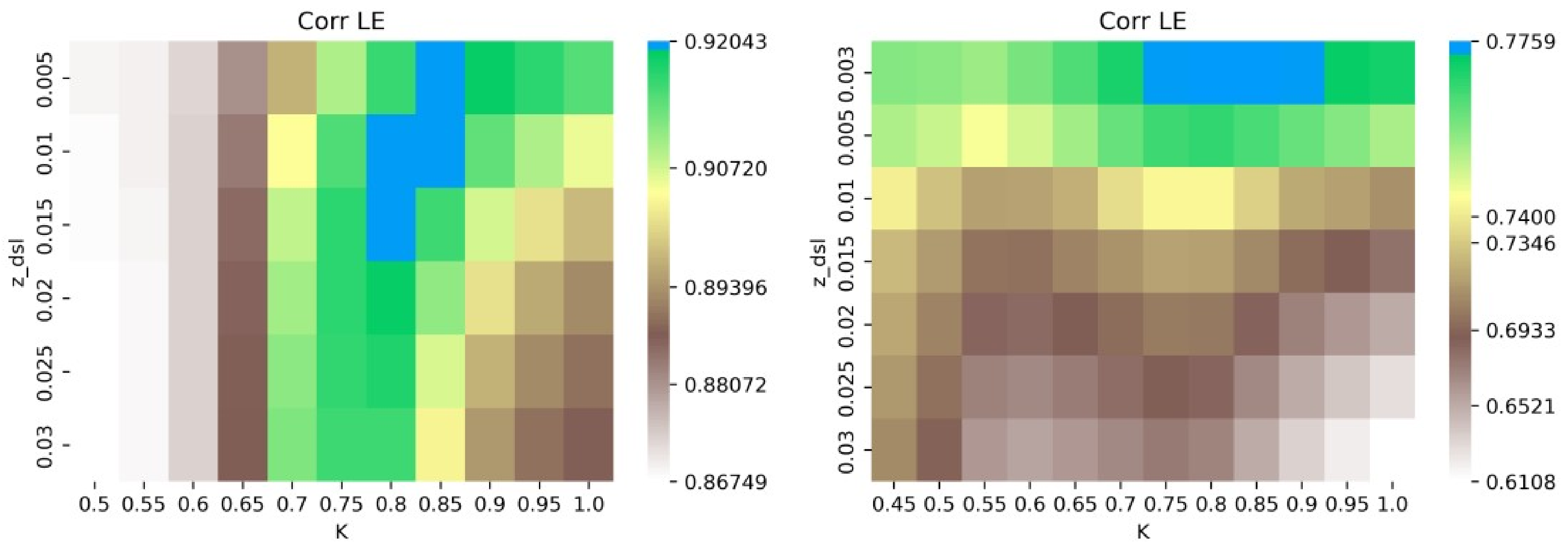


Fig. 17 Maps of correlation of LE for la cendrosa (right) and Els plans (left).

Setting up the simulation

- Make forcing files
- Indicate properties of the site (albedo, z0, z0h, LAI, vegetation height, conductances, sand, clay,...)
- Indicate parameterizations to use (PTF, diffusive soil, A-gs…)
- Limits on temporal resolution
- Global or regional simulations need this information every point of the grid

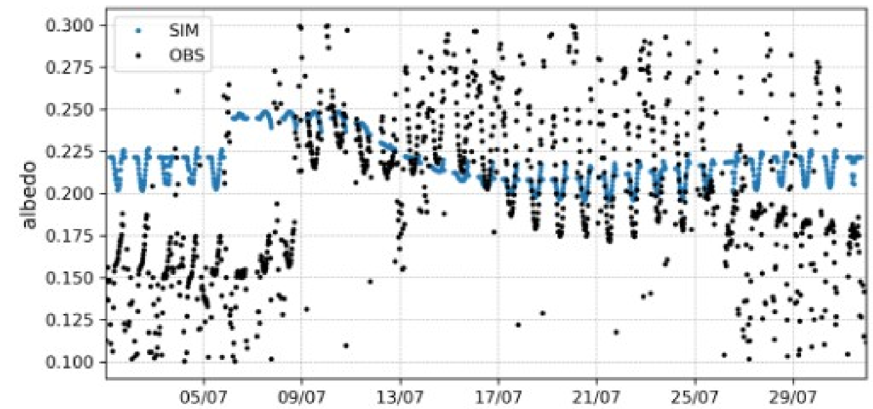


Fig. 12 Observed and simulated albedo for La cendrosa.